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(54) **Control valve for variable displacement compressor**

(57) In a control valve for a variable displacement compressor, for controlling the compressor to the minimum capacity without using an electromagnetic clutch, and without a solenoid provided in a pressure chamber a plunger assembly of a solenoid is formed by a first plunger 21 and a second plunger 32, and a diaphragm 26 in-between for sensing the suction pressure P_s , such that the first plunger 21 controls a valve element 16 via a shaft 25. Component elements of the solenoid except the first plunger 21 are arranged on an atmospheric pressure side of the diaphragm 26. When the solenoid is deenergized, high suction pressure P_s urges the second plunger 32 toward the core 31 via the diaphragm 26, and a spring 24 causes the first plunger 21 to urge the valve element 16 to a fully open position to adjust the compressor to the minimum capacity operation.

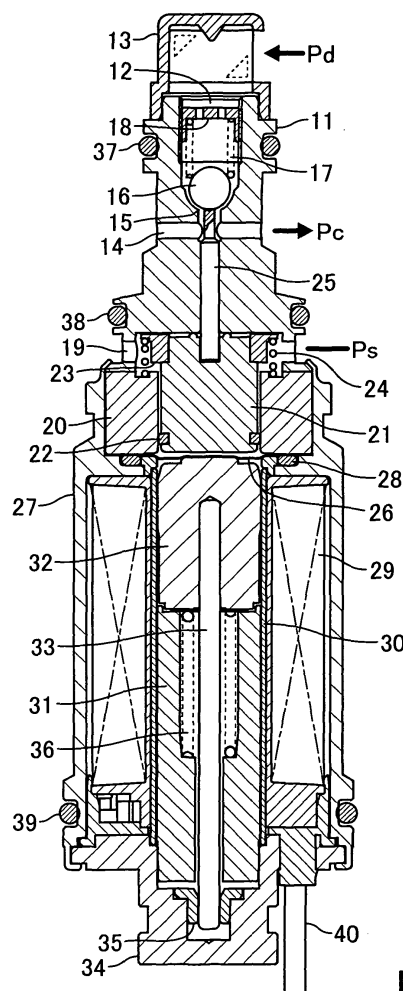


FIG. 1

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Description

[0001] The invention relates to a control valve for a variable displacement compressor, according to the preamble of claims 1 and 19, particularly of an automotive air conditioner.

[0002] In an automotive air conditioner in general, a variable displacement compressor is employed so as to obtain an adequate refrigerating capacity without being constrained by the rotational speed of the engine driving the compressor. In a known variable displacement compressor a wobble plate having a variable inclination angle is disposed within a gastight crank chamber for driving pistons to perform reciprocating motions in respective cylinders to suck in refrigerant from a suction chamber, to compress the refrigerant, and then to discharge it into a discharge chamber. The inclination angle of the wobble plate is varied by changing the pressure in the crank chamber by a control valve, whereby the refrigerant discharge capacity is varied. In general, a known control valve operates to introduce part of the discharged refrigerant (discharge pressure P_d) into the crank chamber, such that the pressure P_c in the crank chamber is controlled. The control is carried out according to the suction pressure P_s in the suction chamber. The control valve senses the initial suction pressure P_s , and controls the flow rate of refrigerant introduced from the discharge chamber into the crank chamber to hold the suction pressure P_s at a constant level. The control valve is equipped with a suction-pressure-sensing section and a valve section for opening and closing a passage leading from the suction chamber to the crank chamber according to the sensed suction pressure P_s . Further, a known type of the control valve allows to freely externally set the value of the suction pressure P_s to be assumed, at the start of the variable displacement operation, by a solenoid enabling the configuration of settings of the pressure-sensing section by electric current.

[0003] Conventional externally controlled control valves include a type for control of the compressor to which the engine is directly connected without an electromagnetic clutch (JP-A-2000-110731). In the known control valve the solenoid generates an electromagnetic force in the valve closing direction. The pressure-sensing section operates in the valve opening direction when the suction pressure P_s drops below e.g. the atmospheric pressure. When the solenoid is not energized, the valve section is in a fully open state, whereby the pressure P_c in the crank chamber is held at a pressure close to the discharge pressure P_d . The wobble plate is adjusted substantially at right angles to the driving shaft. The compressor operates with minimum capacity. The discharge capacity can be substantially reduced to approximately zero even when the running engine is directly connected to the driving shaft without an electromagnetic clutch. In the known control valve the solenoid is interposed between the pressure-sensing section and the valve section. The suction pressure P_s is introduced

via the solenoid to the pressure-sensing section which compares the suction pressure P_s and the atmospheric pressure. The solenoid in its entirety has to be accommodated within a pressure chamber, and hence components of the solenoid need to be designed with considerations given to resistance to pressure.

[0004] It is an object of the invention to provide a control valve which is capable of controlling the variable displacement compressor to the minimum capacity e.g. without separating the compressor by an electromagnetic clutch from the engine, and can be constructed without a pressure resistant solenoid in a pressure chamber.

[0005] The above problem is solved by a control valve according to claim 1 or claim 19.

[0006] In this control valve the pressure-sensing member is disposed between a first plunger and a part of the solenoid except the first plunger. The pressure-sensing member separates the pressure within the variable displacement compressor from the atmospheric pressure, which enables the control valve to be constructed without accommodating the solenoid in a pressure chamber. When the solenoid is not energized, the first plunger adjusts the full-open position of the valve section. The suction pressure urges, via the pressure-sensing member, the second plunger in a direction away from the first plunger. This allows to control the variable displacement compressor to the minimum capacity. The control valve then is applicable when the compressor permanently is driven without an electromagnetic clutch.

[0007] With the divided plunger of the solenoid and the pressure-sensing member disposed in-between, only one of the divisional plungers performs the valve opening control for controlling the pressure in the crank chamber. Components ranging from the valve section to a portion where the pressure-sensing member is disposed, including one of the plungers which controls the valve lift of the valve section need to be designed as components which can stand applied pressure. A part of the solenoid exclusive to this one plunger can be constructed as part open to the atmospheric pressure without accommodation in a pressure chamber or an encapsulation.

[0008] A consequence of the structure is. when the solenoid is not energized, the pressure-sensing member is moved away from this one plunger, so that any displacements of the pressure-sensing member are not transmitted to the valve section, and at the same time, the valve section remains in the fully open state. This allows to adjust the compressor to minimum capacity without using an electromagnetic clutch.

[0009] Embodiments of the invention will be described with reference to the drawings. In the drawings is:

Fig. 1 a longitudinal cross-section of a control valve for a variable displacement compressor (first

- embodiment),
- Fig. 2 cross-section of the control valve in a state when the variable compressor is started,
- Fig. 3 a cross-section of the control valve in a state when the compressor is in steady operation,
- Fig. 4 a cross-section of a further control valve (second embodiment),
- Fig. 5 a cross-section of a further control valve (third embodiment),
- Fig. 6 a cross-section of a further control valve (fourth embodiment),
- Fig. 7 a cross-section of a further control valve (fifth embodiment),
- Fig. 8 a cross-section of a further control valve (sixth embodiment),
- Fig. 9 a cross-section of a further control valve (seventh embodiment),
- Fig. 10 a cross-section of a further control valve (eighth embodiment),
- Fig. 11 a cross-section of a further control valve (ninth embodiment),
- Fig. 12 a partial enlarged cross-section of a valve section of a further control valve (tenth embodiment), and
- Fig. 13 a cross-section of a further control valve (eleventh embodiment).

[0010] The control valve of Fig. 1 for a variable displacement compressor includes a valve section within in which an opening in the top of a body 11 forms a port 12 communicating with a not shown discharge chamber of the compressor to receive a discharge pressure Pd. A strainer 13 is provided on the port 12. The port 12 communicates with a port 14 communicating with a crank chamber of the compressor. Port 12 is formed in the body 11 so as to guide controlled pressure Pc out into the crank chamber. A valve seat 15 is formed in a refrigerant passage between the port 12 and the port 14, as an integral part of the body 11. At the side of the valve seat 15 where the discharge pressure Pd is received, a valve element 16 is disposed axially movably. The valve element 16 is urged in valve-closing direction by a spring 17 which has its load adjusted by an adjustment screw 18 screwed into the port 12. Below the body 11 a port 19 communicates with a suction chamber of the compressor to receive a suction pressure Ps.

[0011] A hollow cylindrical member 20 is disposed at a lower end of the body 11, and a first plunger 21 is axially movably disposed within the hollow cylindrical member 20. The first plunger 21 is located in a guide 22, made e.g. of polytetrafluoroethylene, i.e. a material having a low sliding resistance. The guide 22 is fitted along the periphery at a lower housing part location. The periphery of the guide 22 is in sliding contact with the inner wall of the hollow cylindrical member 20. When the first plunger 21 moves axially, the guide 22 guides the first plunger 21 and maintains it at a predetermined distance from the inner wall of the hollow cylindrical member 20. It should be noted that the guide 22 does not circumscribe the entire circumference of the first plunger 21, but has one portion thereof cut open (passage slit), allowing the suction pressure Ps to be introduced into a space at a lower end side of the first plunger 21.

[0012] The first plunger 21 has an upper end flange 23 fixed by press-fitting. A spring 24 is interposed between the flange 23 and an upper end face of the hollow cylindrical member 20. An axially movably shaft 25, disposed within the body 11 with almost no clearance, has a lower end thereof fixed at an upper axial location to the first plunger 21, e.g. by press-fitting. The shaft 25 and the guide 22 position the first plunger 21 on the axis of the body 11. The upper end of the shaft 25 extends through a valve hole into contact with the valve element 16.

[0013] The spring 24 urging the first plunger 21 upward has a larger spring force than the spring 17 urging the valve element 16 in the valve-closing direction. When the solenoid is not energized, the first plunger 21 abuts the ceiling of a chamber communicating with the port 19, and the valve element 16 is in its fully open position.

[0014] Below the first plunger 21, a diaphragm 26 constituting a pressure-sensing section is disposed. An outer peripheral edge of the diaphragm 26 is sandwiched between the hollow cylindrical member 20 and a casing 27 of the solenoid, and is sealed by a gasket 28. The sandwiching is realized by swaging an upper end edge of the casing 27 onto the lower end of the body 11, with the hollow cylindrical member 20 held therebetween. Thus, a part forming a pressure chamber of the control valve extends up to a portion partitioned by the diaphragm 26, and a part below this portion receives the atmospheric pressure. The diaphragm 26 is formed e.g. of one piece of polyimide film. However, instead by using a plurality of pieces overlaid one upon the other, it is possible to increase the resistance of the diaphragm 26 against breakage which might be caused by repeated collisions of the first plunger 21.

[0015] Within the casing 27, a magnet coil 29 is disposed, and inside the magnet coil 29 is disposed a sleeve 30. The sleeve 30 contains a fixed core 31. Between the core 31 and the diaphragm 26 is disposed a second plunger 32 which is axially movable within the sleeve 30. The second plunger 32 holds the upper end

of a central shaft 33 e.g. by press-fitting. The lower end of the shaft 33 is supported in a bearing 35 disposed within a knob 34 which closes the lower open end of the casing 27. Disposed between the second plunger 32 and the core 31 is a spring 36 which urges the second plunger 32 toward the diaphragm 26.

[0016] The body 11 carries an O-ring 37 at a location between the port 12 (discharge pressure P_d) and the port 14 (pressure P_c). A further O-ring 38 is fitted at a location between the port 14 (pressure P_c) and the port 19 (suction pressure P_s). The lower end of the casing 27 carries an O ring 39 for separating the suction pressure P_s from the atmospheric pressure. The magnet coil 29 may be supplied with control current via a harness 40.

[0017] The hollow cylindrical member 20, the casing 27, and the knob 34 are of magnetic materials and serve as a yoke of a magnetic circuit of the solenoid. The magnetic force lines extend through the casing 27, the hollow cylindrical member 20, the first plunger 21, the second plunger 32, the core 31, and the knob 34.

[0018] In Fig. 1 the solenoid is not energized. The suction pressure P_s is high, i.e., the air conditioner is not in operation, and the diaphragm 26 is displaced downward against the load of the spring 36. The second plunger 32 abuts the core 31. The first plunger 21 is urged upward by the spring 24 and is moved away from the diaphragm 26, and hence is free from influences of the diaphragm 26 which may be displaced by variations of the suction pressure P_s . The first plunger 21 urges the valve element 16 via the shaft 25 toward the fully open position. Even when the compressor is driven by the engine, it is operated with minimum discharge capacity.

[0019] If maximum control current is supplied to the magnet coil 29 when the compressor has been started (Fig. 2), the second plunger 32 is pressed downward by the high suction pressure P_s into abutment with the core 31, so that even if the second plunger 32 is attracted by the core 31, it remains in the same position. Therefore, in this case, the second plunger 32 and the core 31 behave as if they were a fixed core, so that the second plunger 32 attracts the first plunger 21, causing the first plunger 21 to be attached to the second plunger 32 via the diaphragm 26, whereby the shaft 25 is pulled downward. The spring 17 seats the valve element 16 on the valve seat 15, to fully close the valve section. The passage extending from the discharge chamber to the crank chamber is blocked. The compressor is promptly shifted into operation with maximum capacity.

[0020] The compressor continuously operating with maximum capacity lowers the suction pressure P_s and the diaphragm 26 tends to move upward. If then the control current is decreased according to the set temperature of the air conditioner, (Fig. 3), the first plunger 21, the diaphragm 26, and the second plunger 32 in attracted state move in unison upward to a position where the suction pressure P_s , the loads of the springs 17, 24, and 36, and the attractive force of the solenoid are balanced.

This pushes the valve element 16 upward from the valve seat 15 by the shaft 25 to adjust a predetermined valve lift. Refrigerant having discharge pressure P_d is introduced into the crank chamber at a flow rate controlled to a value dependent on the valve lift. The compressor is adjusted to operate with a capacity corresponding to the value of the control current.

[0021] When the control current is constant, the diaphragm 26 senses the suction pressure P_s and controls the valve lift of the valve section. When the refrigerating load is increased, the suction pressure P_s will displace the diaphragm 26 to decrease the valve lift. The compressor is adjusted to increase the discharge capacity. When the refrigerating load is decreased, the suction pressure P_s will displace the diaphragm 26 is displaced upward to increase the valve lift. The compressor is adjusted in a direction to decrease the discharge capacity. Thus, the compressor operates to maintain the suction pressure P_s constant.

[0022] The control valve of Fig. 4 differs from the first embodiment in that the locations of the port 12 (discharge pressure P_d) and the port 14 (controlled pressure P_c) are inverted.

[0023] The valve element 16 in Fig. 4 is integral with a pressure-sensing piston 41, and the discharge pressure P_d is introduced into a reduced-diameter portion connecting the valve element 16 and the pressure-sensing piston 41. The pressure-sensing piston 41 has an outer diameter equal to the inner diameter of a valve hole forming the valve seat 15, whereby the pressure-receiving area of the valve element 16 and the pressure-receiving area of the pressure-sensing piston 41 are equal. The force generated by the discharge pressure P_d at the valve element 16 and at the pressure-sensing piston 41 are compensated. The solenoid and the diaphragm 26 control the valve element 16 without influence by the relatively high discharge pressure P_d .

[0024] The pressure-sensing piston 41 has a dual function of canceling the influences of the discharge pressure P_d and of a shaft transmitting the motions of the solenoid and the diaphragm 26 to the valve element 16, as in the first embodiment.

[0025] The control valve in Fig. 5 differs from the first and second embodiments in that it additionally controls the flow rate of refrigerant (pressure P_c) escaping from the crank chamber to the suction chamber, and also controls the flow rate of refrigerant (discharge pressure P_d) introduced into the crank chamber.

[0026] In this control valve of Fig. 5 the passage communicating with the crank chamber is divided in two. That is, the body 11 has a port 14a (controlled pressure P_{c1} for the crank chamber) and a port 14b (pressure P_{c2} from the crank chamber). This is for forming a passage allowing refrigerant introduced from the discharge chamber and controlled by the valve section to once enter the crank chamber and then to flow from the crank chamber into the suction chamber, so as to positively transport lubricating oil mixed with the refrigerant for the

lubrication of the compressor.

[0027] The port 14b via which refrigerant returns from the crank chamber opens, via a communication passage 42, into a space communicating with the port 19 leading to the suction chamber. The passage 42 is opened and closed by a valve closure member structure 21c of the first plunger 21. When the valve section is fully closed, a passage between the crank chamber and the suction chamber is opened, to maximize the flow rate of refrigerant allowed to flow from the crank chamber to the suction chamber, thereby enabling the compressor to perform prompt transition to the maximum capacity operation. When the valve section is fully open, the passage between the crank chamber and the suction chamber is closed, to maximize the flow rate of refrigerant introduced from the discharge chamber into the crank chamber, thereby enabling the compressor to perform prompt transition to the minimum capacity operation.

[0028] The control valve of Fig. 6 includes cushioning means for softening the impacts of collisions of the first plunger 21 with the diaphragm 26 occurring when the first plunger 21 is attracted to the second plunger 32 upon energization of the solenoid. A disk 43 is interposed between the first plunger 21 and the diaphragm 26, and a spring 44 is interposed between the first plunger 21 and the disk 43. This arrangement has not only the function of constantly bringing the disk 43 into contact with the diaphragm 26, but also has the function of the spring 24 urging the first plunger 21 toward the valve section in the first to third embodiments. The disk 43 is held by a downwardly protruding guide 22 on the lower end periphery of the first plunger 21.

[0029] The disk 43 is urged by the spring 44, so that the second plunger 32, the diaphragm 26, and the disk 43 remain in contact, and move in unison. When the solenoid is not energized (Fig. 6), the first plunger 21 and the disk 43 are separated by the spring 44. When the solenoid is energized, the first plunger 21 is attracted by the disk 43 integrated therewith and attached to the disk 43 by collision. The force of impact of the collision is transmitted to the diaphragm 26 after being absorbed for cushioning by the disk 43, so that the impact on the diaphragm 26 itself is reduced.

[0030] The control valve in Fig. 7 includes a mechanism for adjusting the load of the spring 36 and differs from the second embodiment. An adjustment screw 45 is screwed into the knob 34. The adjustment screw 45 axially movably supports the lower end of the shaft 33. A retaining ring 46 is fitted on an intermediate portion of the shaft 33, and a spring retainer 47 is provided such that the upward motion of the spring retainer 47 is limited by the retaining ring 46. A spring 36 is interposed between the spring retainer 47 and the adjustment screw 45. The screw-in depth of the adjustment screw 45 into the knob 34 can be adjusted to adjust the load of the spring 36 and in turn the set value for the control valve.

[0031] The control valve in Fig. 8 is configured such

that the first plunger 21 and the disk 43 are axially movably guided by a sleeve 48 fixed to the hollow cylindrical member 20 by press-fitting. The first plunger 21 is in contact with the pressure-sensing piston 41 which is integral with the valve element 16. The hollow cylindrical member 20 has a lower expanded part such that an annular space is defined between the part and the sleeve 48. At least one lateral communication hole 49 is formed through a stepped portion of the member 20 for communication between the port 19 (suction pressure P_s) and a space above the diaphragm 26. The lower end of the solenoid is provided with a connector 50 for connecting the harness. The connector 50 contains the adjustment screw 45 for the adjustment of the load of the spring 36, and has a communication hole 51 for communicating the inside of the solenoid with the atmosphere. The valve element 16 has a tapered shape in this embodiment.

[0032] The control valve of Fig. 9 differs from the sixth embodiment in that the centering of the first plunger 21 and the disk 43 is performed by another method. The first plunger 21 is centered by being fitted on the pressure-sensing piston 41 which is integral with the valve element 16. The disk 43 is centered by having a convex portion on an end face facing toward the diaphragm 26. The convex portion is fitted into a concave portion formed in the center of the diaphragm 26 and the second plunger 32.

[0033] The control valve of Fig. 10 differs from the fifth embodiment in that the shape of the first plunger 21 is changed such that it can be more promptly brought into contact with the diaphragm 26.

[0034] The first plunger 21 is axially movably held by two C-shaped guides 22 which are in sliding contact with the inner wall of the hollow cylindrical member 20 with a predetermined distance, i.e. a relatively large clearance maintained between the first plunger 21 and the inner wall. The end face 21a of the first plunger 21 opposed to the diaphragm 26 is flat in a central portion 21b and has a gently tapered surrounding portion. Instead the cross-section of the end face 21a may have the shape of an arc having a large radius.

[0035] If the guide 22 consists of a material, e.g. polytetrafluoroethylene, having the characteristic to expand and contract depending on temperature or the type of refrigerant, when the solenoid is energized to cause the first plunger 21 and the second plunger 32 to attract each other, the guide 22 sometimes may cause the first plunger 21 to first tilt into an inclined position and then to establish contact with the diaphragm 26. In this case, the convexly rounded or tapered end face of the first plunger 21 reliably will abut the diaphragm to cause the valve element 16 to promptly close the valve section. This end face design prevents occurrence of a two-step operation occurring in the case of a purely flat plunger end face, i.e. a two-step operation during which first only a peripheral portion of the flat end face of the first plunger 21 contacts the diaphragm 26 by the attractive force,

and only then after a stop delay the flat end face is brought into full contact with the diaphragm 26. The special end face design allows to promptly close the valve element 16, and to close the valve element 16 with accuracy since the phenomenon of the stop after the first step of the two-step operation does not occur.

[0036] Otherwise, the control valve of Fig. 10 has a similar construction to the fifth embodiment in Fig. 7.

[0037] The control valve of Fig. 11 differs from Fig. 10 in that a bellows is used as the pressure-sensing member for sensing the suction pressure P_s .

[0038] The bellows 52 is disposed between the first and second plungers 21, 32. The bellows 52 has a flange portion radially extending from an upper end face. The flange portion is sandwiched between the hollow cylindrical member 20 and the casing 27 and is sealed by the gasket 28. The lower end face of the bellows 52 is closed and in contact with the second plunger 32. The first plunger 21 has an integral columnar member 53 at a lower portion. The columnar member 53 is positioned in a hollow space of the bellows 52. When the solenoid is not energized, and the first plunger 21 is urged by the spring 24 in the upward direction, the columnar member 53 of the first plunger 21 is spaced from the bellows 52.

[0039] The control valve of Fig. 11 is similar to the eighth embodiment in Fig. 10.

[0040] The control valve of Fig. 12 is configured such that even when the suction pressure P_s is in any condition, making the receiving pressure unbalanced with the discharge pressure P_d received at the valve section, it is possible to promptly fully open the valve.

[0041] In the control valves in Figs 4, 7 to 11, the ports of the valve section are arranged from the solenoid side in the order of the respective ones for the suction pressure P_s , the discharge pressure P_d , and the pressure P_c for the crank chamber, to prevent the discharge pressure P_d , which is the highest pressure, from affecting the control of the valve element 16. This is achieved by designing the inner diameter A of the valve hole equal to the outer diameter B of the pressure-sensing piston 41, as mentioned. The valve element 16 controls the valve section by the differential pressure ($P_c - P_s$) between the pressure P_c for the crank chamber and the suction pressure P_s .

[0042] The differential pressure ($P_c - P_s$) between the pressure P_c acting on the valve element 16 and the suction pressure P_s acting on the pressure-sensing piston 41 may impose a load on the valve element 16 and the pressure-sensing piston 41 in a self-closing direction since the pressure P_c is higher than the suction pressure P_s . When the solenoid is de-energized to fully open the valve section, the spring 24 urging the first plunger 21 in the valve-opening direction presses the pressure-sensing piston 41 to separate the valve element 16 from the valve seat 15. However, when the differential pressure ($P_c - P_s$) increases, the load in the self-closing direction also increases, which may cause a difficulty to open the valve section. In some cases, it even may oc-

cur that the valve section cannot open. Particularly, in the case of compressors which are driven without an electromagnetic clutch, no matter the suction pressure P_s may be in what pressure condition, when the power supply to the solenoid is stopped, it may be necessary to forcibly fully open the control valve to minimize the discharge capacity of the compressor.

[0043] For that reason, in the control valve of Fig. 12 the inner diameter A of the valve hole is made e.g. approximately 3 % larger than the outer diameter B of the pressure-sensing piston 41, to make the pressure-receiving area of the valve element 16 larger than the pressure-sensing area of the pressure-sensing piston 41, whereby the pressure-receiving balance related to the discharge pressure P_d is thrown off in the valve-opening direction. This reduces the load in the self-closing direction even when the differential pressure ($P_c - P_s$) increases, so that it is possible to positively fully open the valve section by the urging force of the spring 24 when the solenoid is de-energized.

[0044] The control valve of Fig. 13 is configured such that in addition to the control method in Fig. 10, (the flow rate into the crank chamber is controlled while the influence of the discharge pressure P_d of refrigerant introduced into the crank chamber is cancelled), the control valve of Fig. 13 controls the flow rate of refrigerant having pressure P_c allowed to escape from the crank chamber into the suction chamber.

[0045] The body 11 is provided in Fig. 13 with a port 14a for guiding refrigerant out into the crank chamber and a port 14b for introducing refrigerant from the crank chamber. The port 14b communicates with a space accommodating the first plunger 21 via a refrigerant passage 54 coaxial with the pressure-sensing piston 41. The solenoid side end of the pressure-sensing piston 41 has an integral valve element 55 an end face of which is in contact with the first plunger 21. The valve element 55 has the valve element structure of a spool valve. When the valve element 16 is lifted from the valve seat 15, the valve element 55 closes the refrigerant passage 54 to block the flow from the crank chamber to the suction chamber. When the valve element 16 is seated on the valve seat 15, the valve element 55 opens the refrigerant passage 54 to allow refrigerant in the crank chamber to escape via the port 19 into the suction chamber. This makes it possible to promptly increase or decrease the pressure P_c in the crank chamber, whereby the variable displacement compressor can be promptly shifted to the minimum capacity operation or the maximum capacity operation, respectively.

Claims

1. A control valve for a variable displacement compressor for controlling the pressure in a gastight crank chamber to change the compressor refrigerant discharge capacity,

characterized in that a plunger assembly of a solenoid of the control valve is divided into a first plunger (21) and a second plunger (32), and that a pressure-sensing member is disposed between the first and second plungers (21, 32), for sensing the suction pressure (Ps) in a suction chamber of the compressor.

2. The control valve according to claim 1, **characterized in that** the first plunger (21) is disposed between a valve section for the controlling pressure (Pc) within the crank chamber and the pressure-sensing member in a state urged to open the valve section, and that the second plunger (32) is attracted upon energization of the solenoid to the first plunger (21) via the pressure-sensing member to form an integral member, and that the second plunger (32) is urged by the suction pressure (Ps) via the pressure-receiving member in a direction away from the first plunger (21) when the solenoid is deenergized.

3. The control valve according to claim 1, **characterized in that** the pressure-sensing member is a diaphragm (26) or a bellows (32)..

4. The control valve according to claim 3, **characterized in that** the diaphragm (26) either is formed of a single plastic material, or by laminating a plurality of plastic material film pieces, preferably of polyimide.

5. The control valve according to claim 2, **characterized in that** the valve section is disposed between first and second ports (12, 14) communicating respectively with a discharge chamber and the crank chamber of the variable displacement compressor.

6. The control valve according to claim 5, **characterized in that** the valve section includes a movable valve element (16) disposed at the side of the first port (12) of a valve seat (15) formed in a passage between the first port (12) and the second port (14), and that a motion transmitting shaft (25) is disposed between the valve element (12) and the first plunger (21).

7. The control valve according to claim 5, **characterized in that** the valve section includes a movable valve element (16) at the side of the second port (14) of a valve seat (15) formed in a passage between the first port (12) and the second port (14), that a pressure-sensing piston (41) is integrally formed with the valve element (16), that the pressure-sensing piston (41) has an outer diameter substantially equal to an inner diameter of a valve hole forming the valve seat (15), that the pressure-sensing piston (41) receives discharge pressure (Pd)

from the discharge chamber, at a pressure-receiving area equal to a pressure-receiving area of the valve element (16), in a direction opposite to a direction from which the valve element (16) receives the discharge pressure (Pd), and that the pressure sensing piston (1) receives the suction pressure (Ps) at an end face facing toward the solenoid, for transmitting motion of the first plunger (21) to the valve element (16).

8. The control valve according to claim 1, **characterized in that** shock-absorbing means is disposed between the pressure-sensing member and the first plunger (21).

9. The control valve according to claim 8, **characterized in that** the shock-absorbing means includes a disk (43) disposed between the pressure-sensing member and the first plunger (21), and that a spring (44) is provided for constantly urging the disk (43) into abutment with the pressure-sensing member.

10. The control valve according to claim 9, **characterized in that** the first plunger (21) and the disk (43) are centered by a sleeve (48).

11. The control valve according to claim 9, **characterized in that** the first plunger (21) is centered by being fixed to a pressure-sensing piston (41) integrally formed with the valve element (16), and that the disk (43) is centered through fitting of a convex or concave portion formed in a center of the end face of the disk (43) opposed to the pressure-sensing member and a concave or convex portion formed in a center of the pressure-sensing member and the second plunger (32).

12. The control valve according to claim 1, **characterized in that** the first plunger (21) is fixed to a pressure-sensing piston (41) integrally formed with the valve element (16) of the valve section, and that the first plunger (21) is held at a side facing the pressure-sensing member by a C-shaped guide (22).

13. The control valve according to claim 1, **characterized in that** the first plunger (21) is axially movably held by two surrounding axially spaced C-shaped guides (22).

14. The control valve according to claim 13, **characterized in that** the first plunger (21) has a tapered shape end surface (21a) for contacting the pressure-sensing member, the end face (21a) defining a central flat portion (21b) opposed to the pressure-sensing member, the central flat portion (21b) having a smaller dimension than the entire end face (21a).

15. The control valve according to claim 5, **characterized in that** the valve section includes a movable valve element (16) at the side of the second port (14) of valve seat (15) formed in a passage between the first port (12) and the second port (14), that a pressure-sensing piston (41) is integrally formed with the valve element (16), that the pressure-sensing piston (41) has an outer diameter (B) smaller than an inner diameter (A) of a valve hole forming the valve seat (15), and that the pressure-sensing piston (41) receives discharge pressure (Pd) at a pressure-receiving area smaller than a pressure-receiving area of the valve element (16), from a direction opposite to a direction from which the valve element (16) receives the discharge pressure (Pd), and receives the suction pressure (Ps) at an end face facing toward the solenoid, for transmitting motion of the first plunger (21) to the valve element (16).
16. The control valve according to claim 2, **characterized in that** the valve section includes a movable valve element (16) at the side of a first port (12) of a valve seat (15) formed in a first passage between the first port (12) and a second port (14a) communicating respectively with a discharge chamber and the crank chamber of the compressor, that a third port (14b) and a fourth port (19) are provided respectively communicating with the crank chamber and the suction chamber, and that a shaft (25) for transmitting motion of the first plunger (21) to the valve element (16) is disposed between the valve element (16) and the first plunger (21) in a second passage (42) between the third port (14b) and the fourth port (19) and that the first plunger (21) is formed with a valve closure structure (21c) opening and closing the second passage (22).
17. The control valve according to claim 2, **characterized in that** the valve section includes a first movable valve element (16) at the side of the second port (14a) of a valve seat (15) formed in a first passage between first and second ports (12, 14a) communicating respectively with a discharge chamber and a crank chamber of the compressor, that a third port (14b) and a fourth port (19) respectively communicating with the crank chamber and the suction chamber are provided connected by a second passage (54), that a pressure-sensing piston (41) is integrally formed with the first valve element (16), that the pressure-sensing piston (41) has an outer diameter substantially equal to an inner diameter of a valve hole forming the valve seat (15), and receives discharge pressure (Pd) at a pressure-receiving area equal to a pressure-receiving area of the valve element (16) from a direction opposite to a direction from which the valve element (16) receives the discharge pressure (Pd), that a second valve element

(55) is integrally formed with the pressure-sensing piston (41) to open and close the second passage (54), and that the first plunger (21) receives the suction pressure (Pc) at an end face facing toward the solenoid, for transmitting motion of the first plunger (21) via the piston (41) to the valve element (16).

18. The control valve according to claim 1, **characterized in that** the solenoid includes a spring (36) urging the second plunger (32) toward the first plunger (21) against the suction pressure (Ps) received by the pressure-sensing member, and that an adjustment screw (45) is provided for adjusting the load of the spring (36).

19. A control valve for a variable displacement compressor, particularly in an automotive air conditioning system, for controlling the pressure (Pc) in a gastight crank chamber to vary the compressor refrigerant discharge capacity,

the control valve comprising a valve section, a solenoid section, and a pressure sensing section for comparing a suction pressure (Ps) in a suction chamber of the compressor with the atmospheric pressure,

characterized in that

a plunger assembly of a solenoid (29, 31) for selectively actuating the valve section comprises first and second separated coaxial plungers (21, 32), that a pressure sensing member (26, 52) of the pressure sensing section is disposed between the first and second plungers (21, 32), and that the pressure sensing member (26, 52) constitutes a gastight separation in the control valve between the pressurized valve section and the solenoid section which is exposed to the atmospheric pressure.

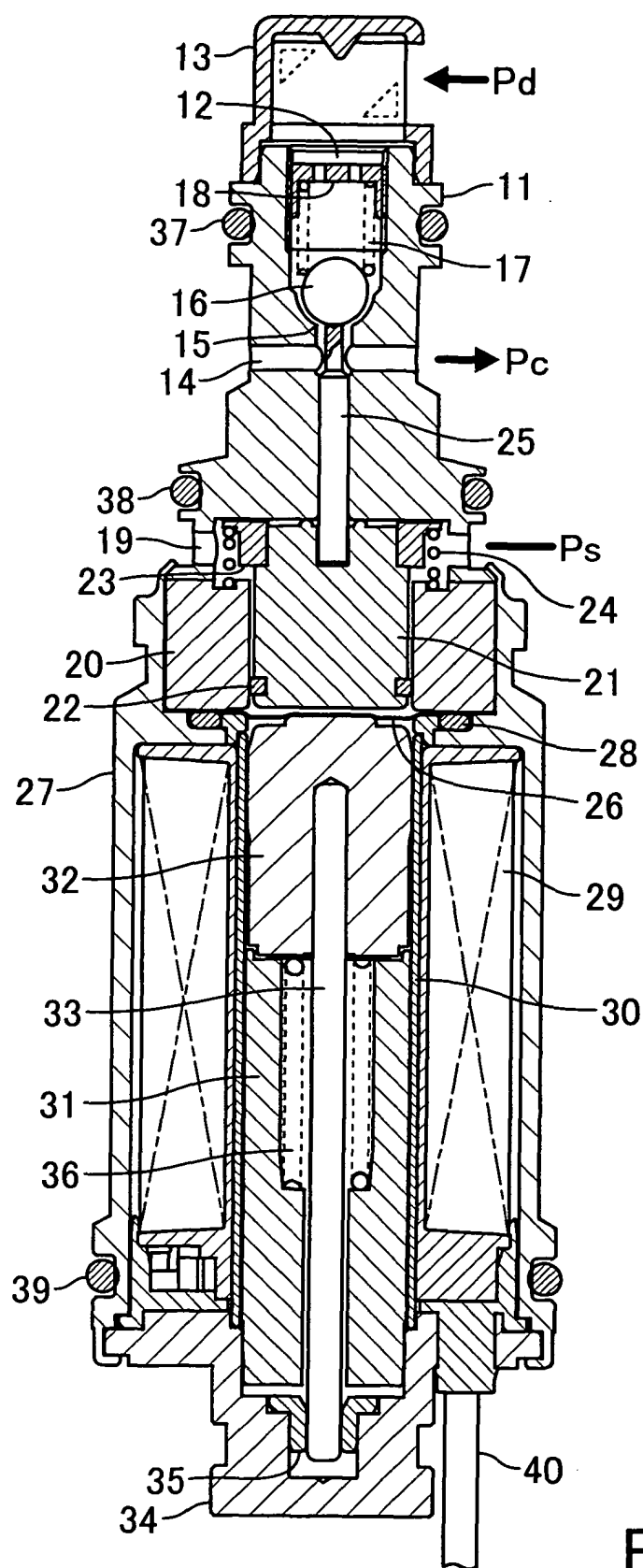
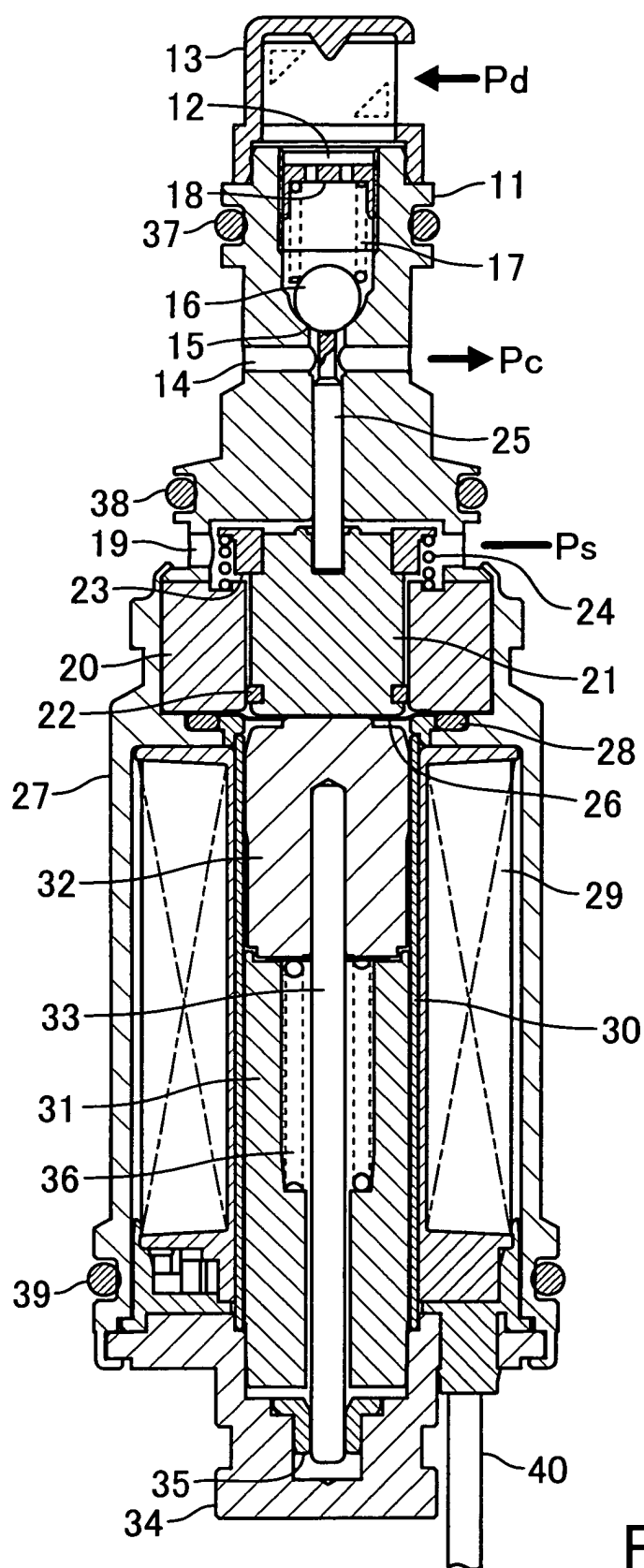
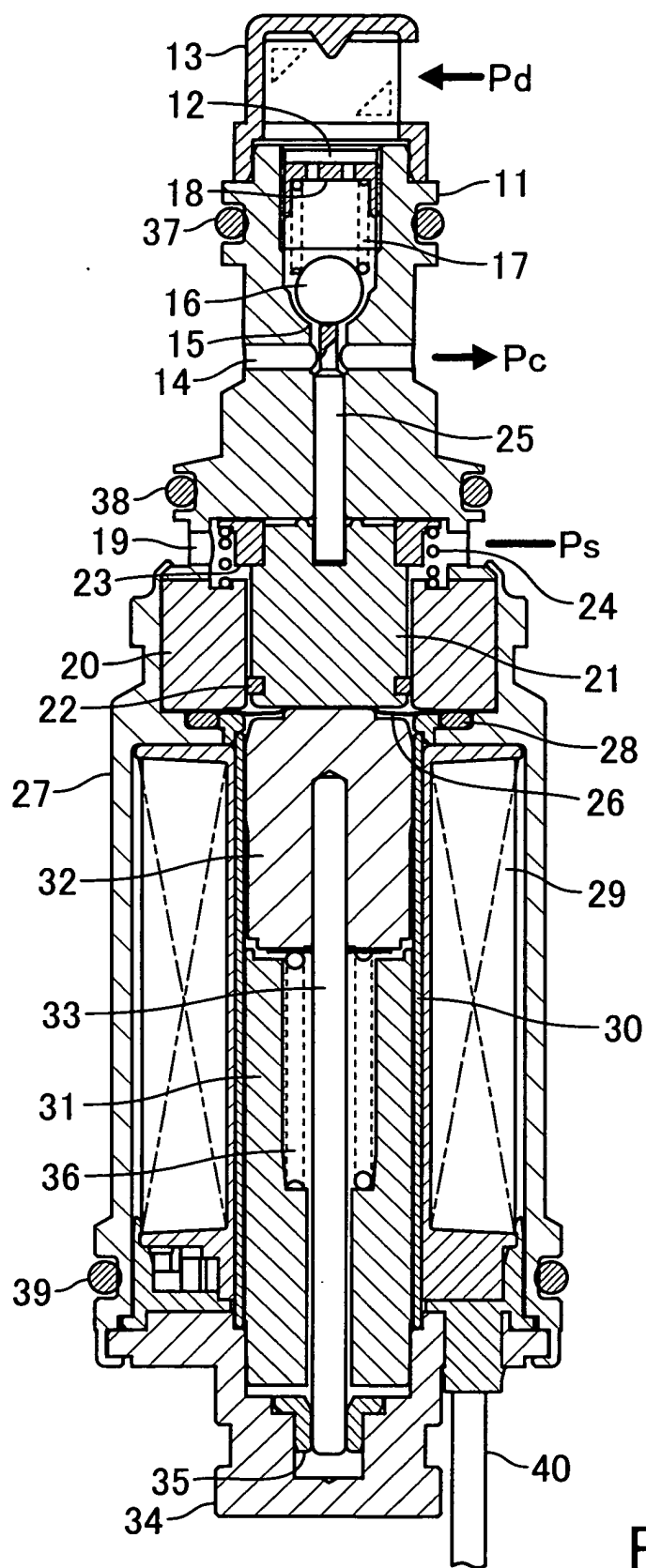


FIG. 1





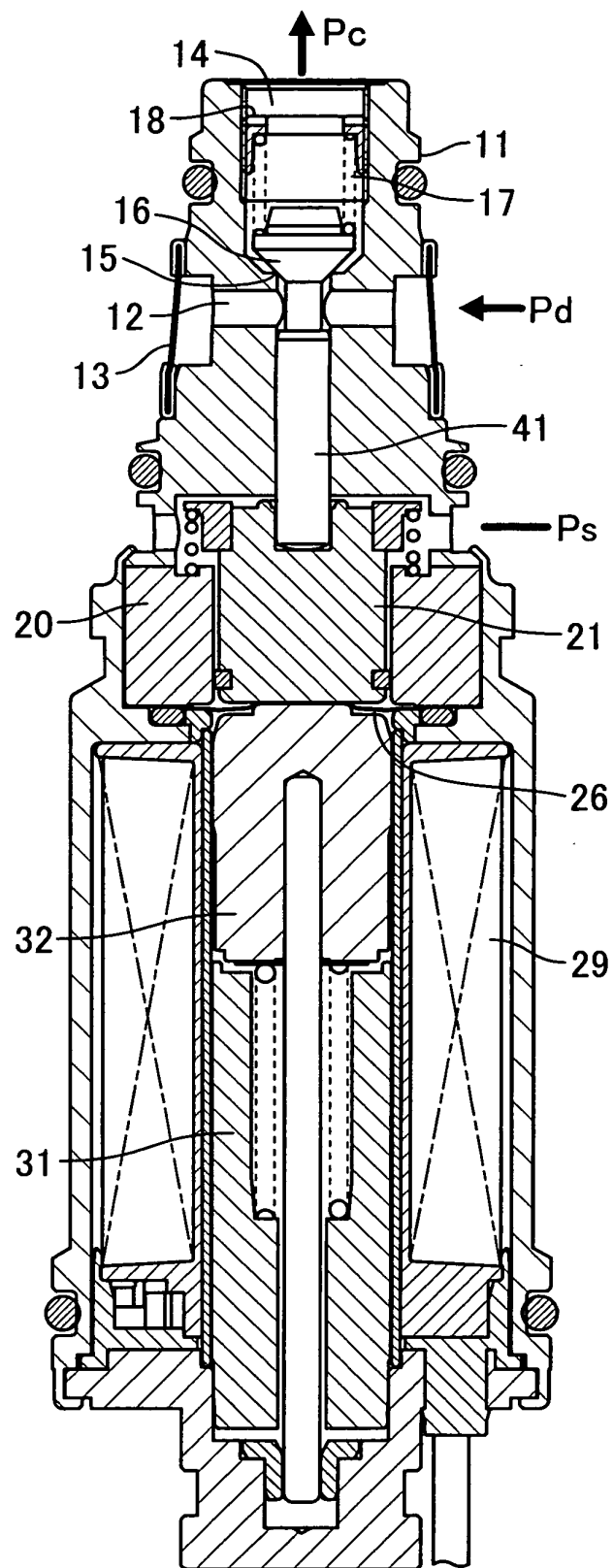


FIG. 4

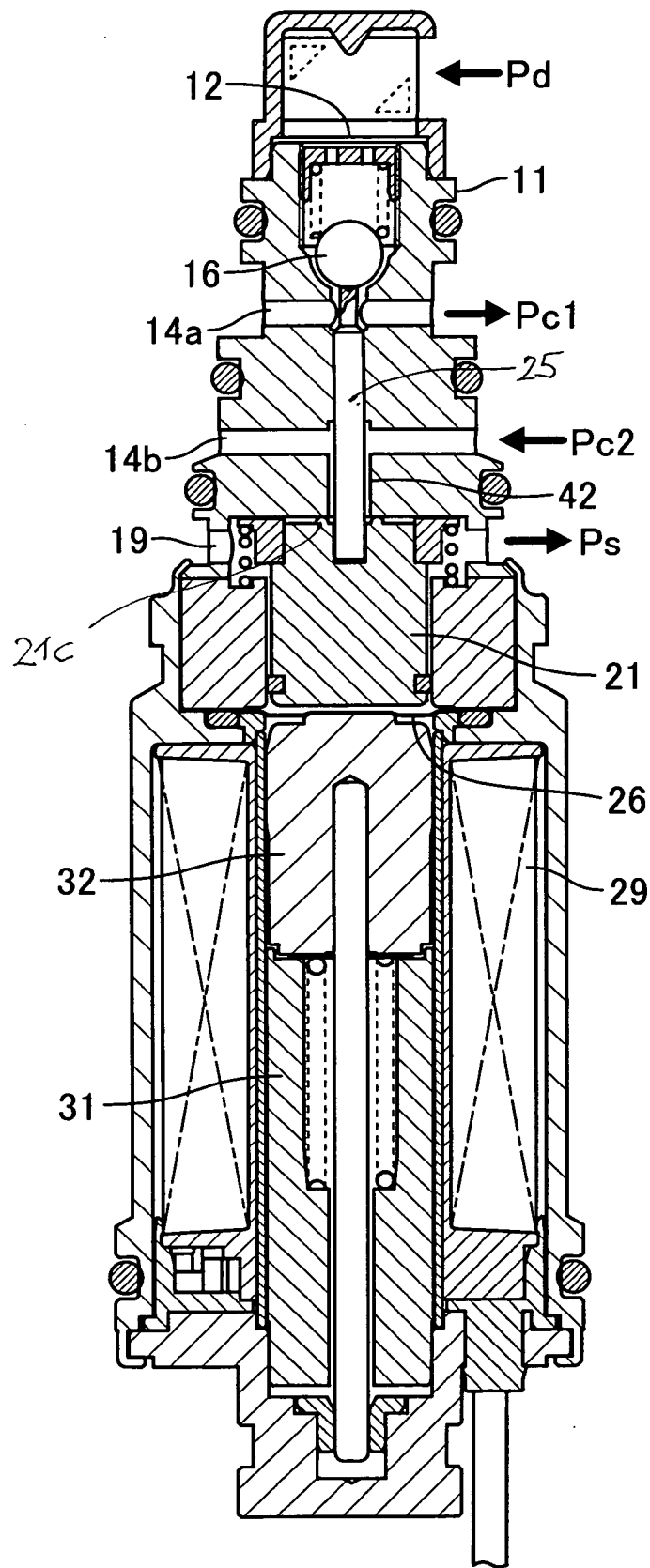


FIG. 5

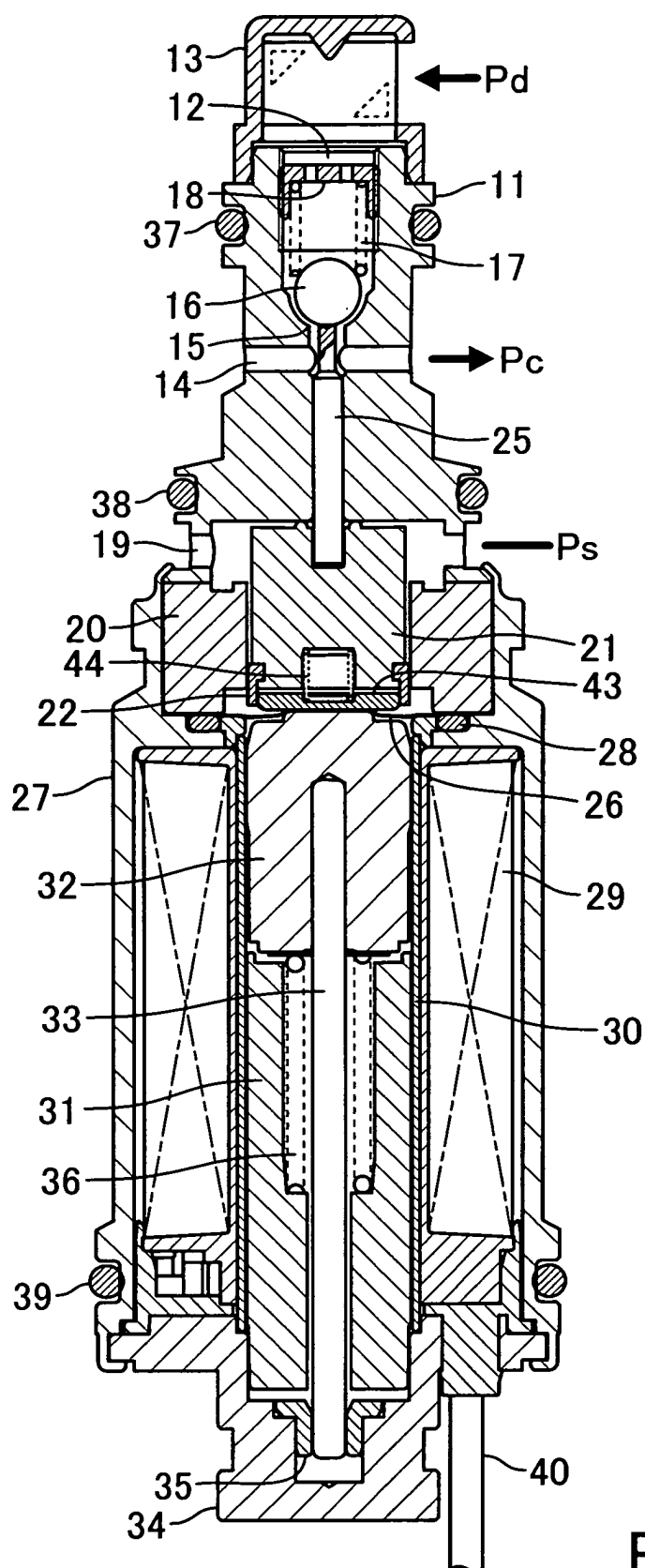


FIG. 6

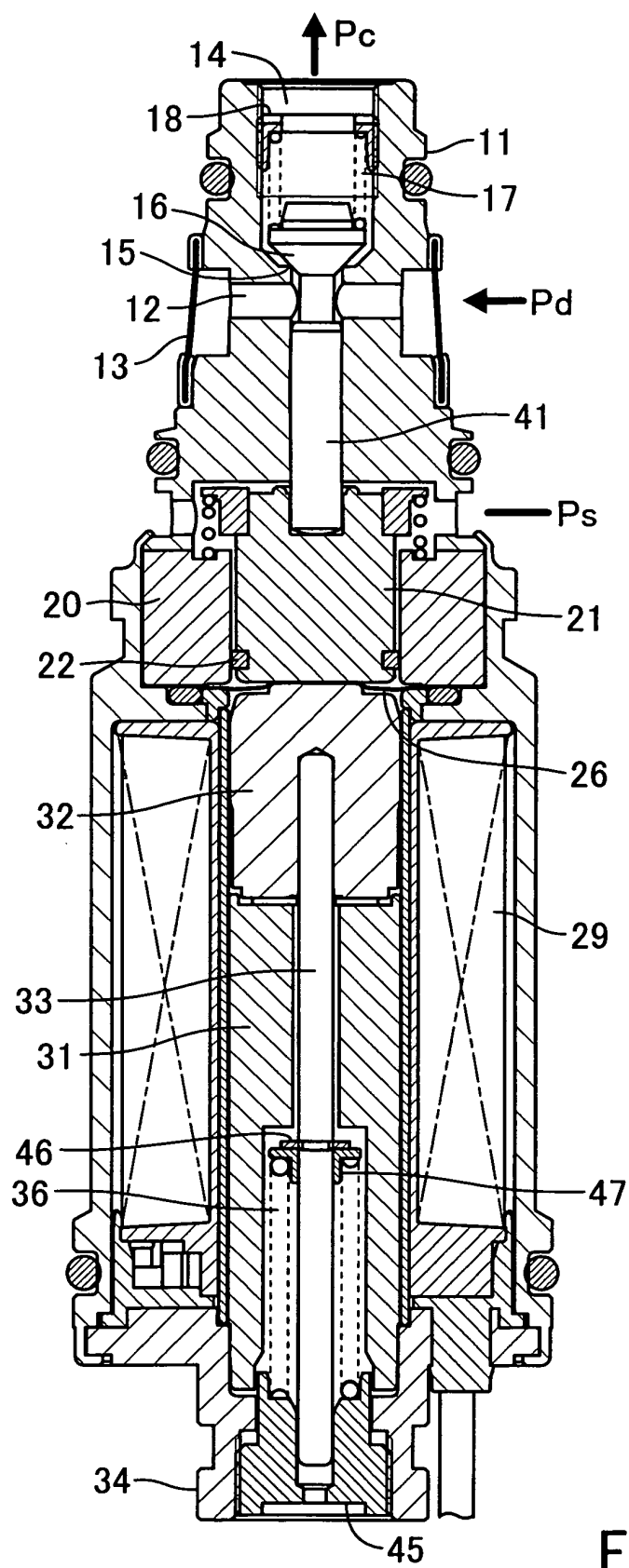


FIG. 7

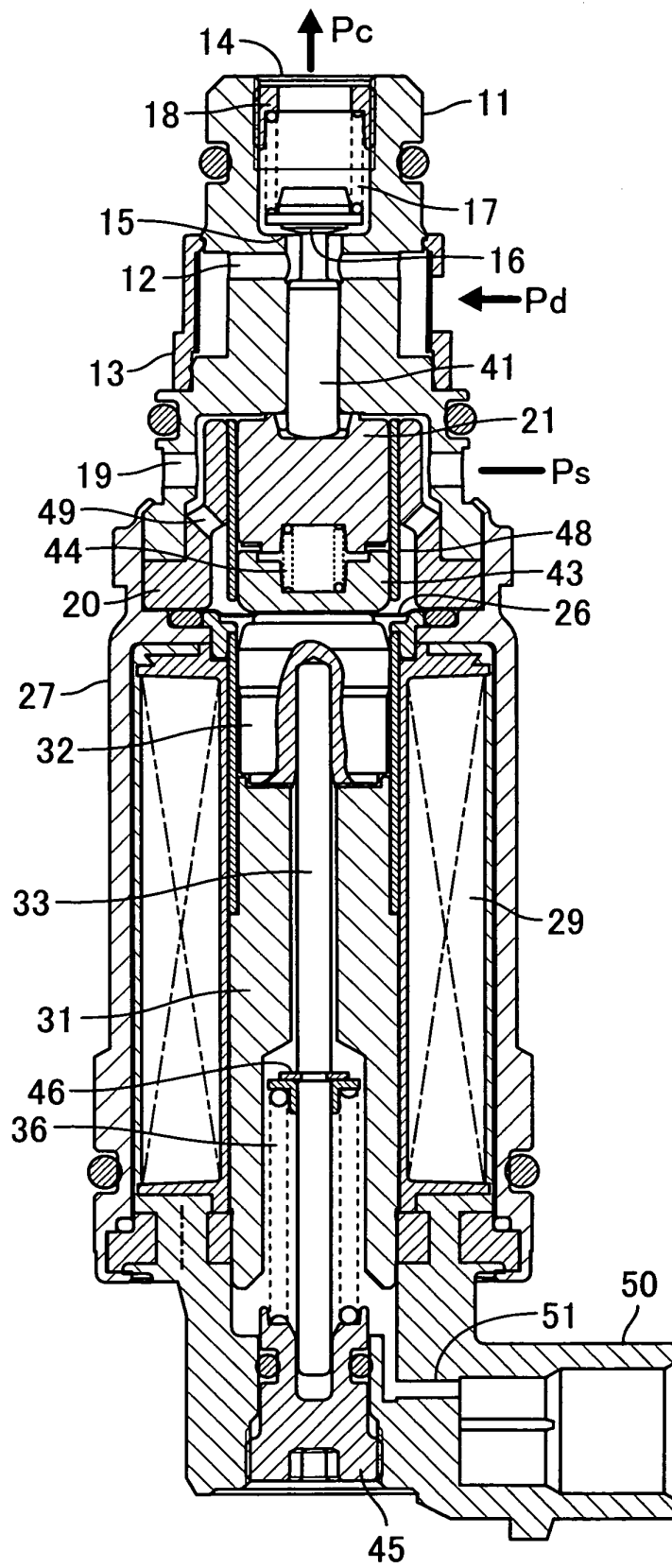


FIG. 8

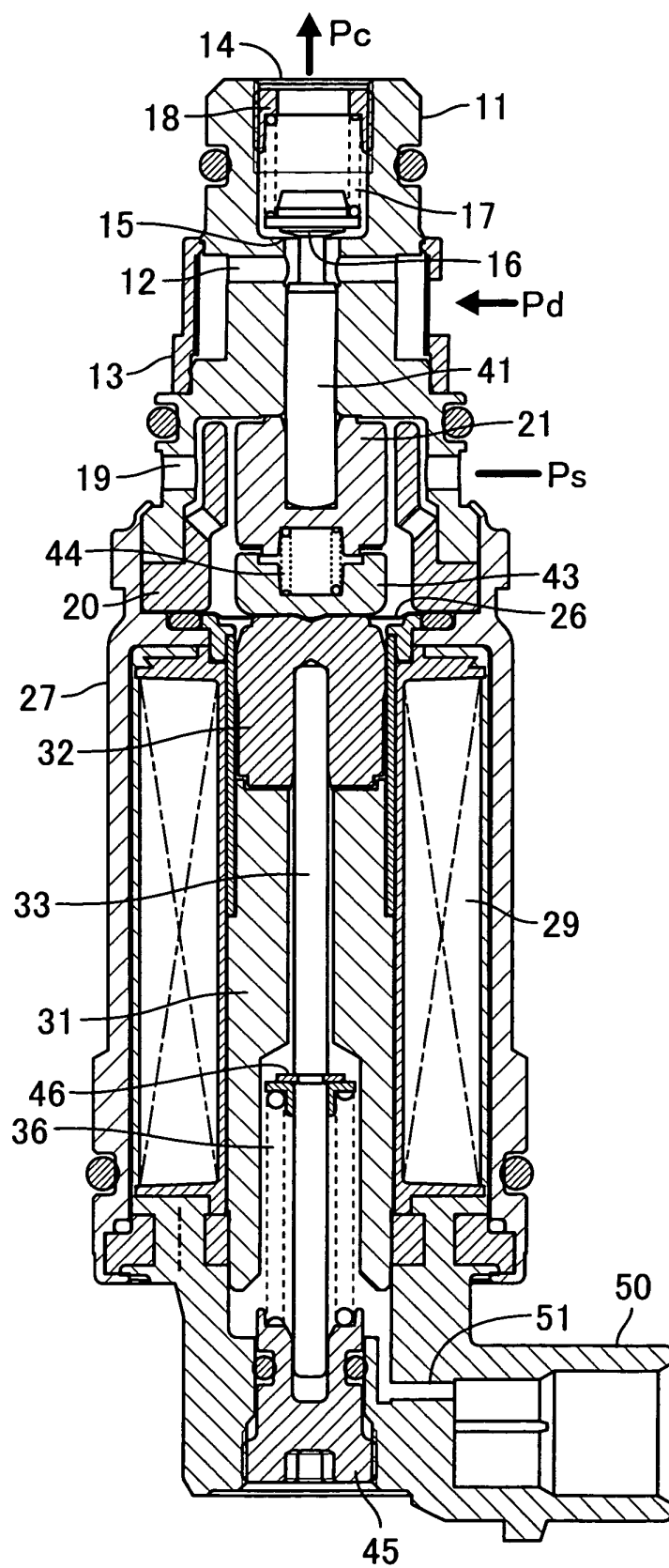


FIG. 9

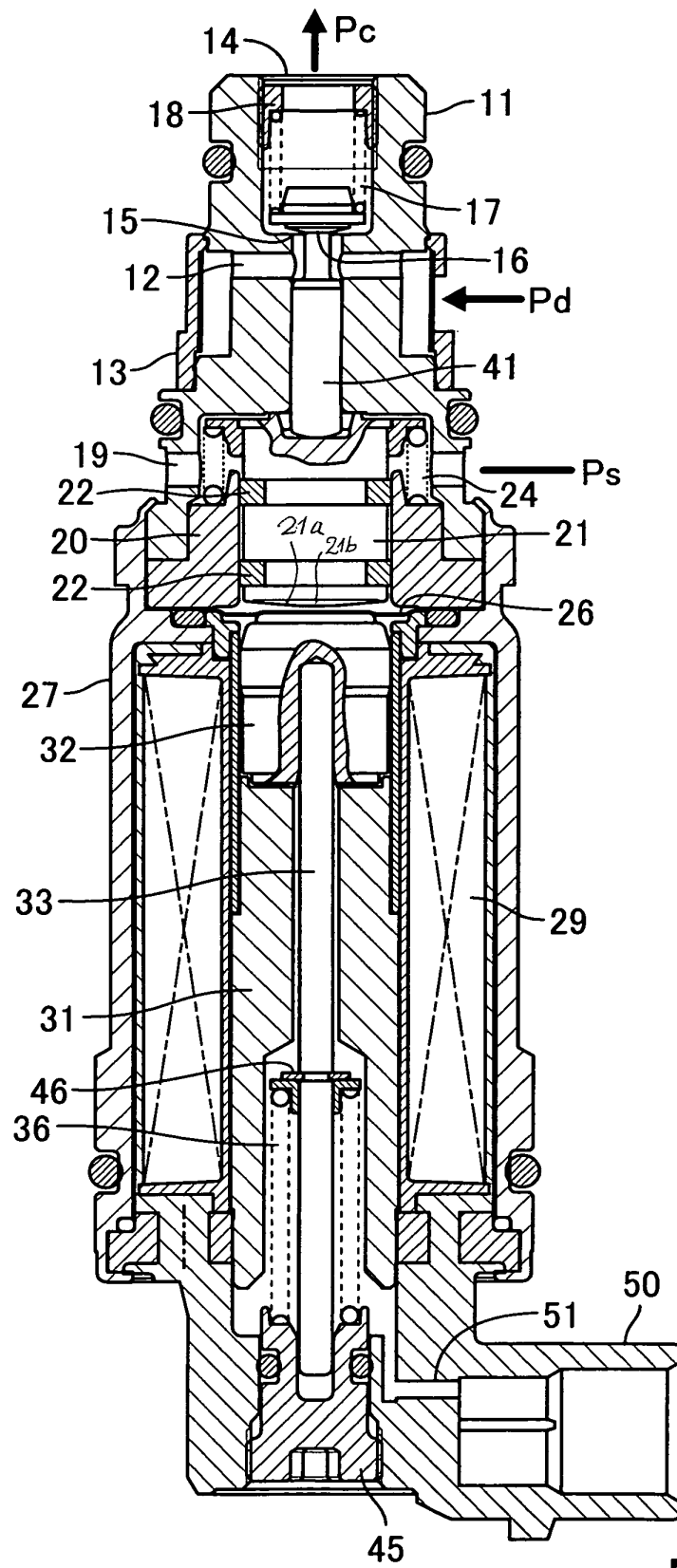


FIG. 10

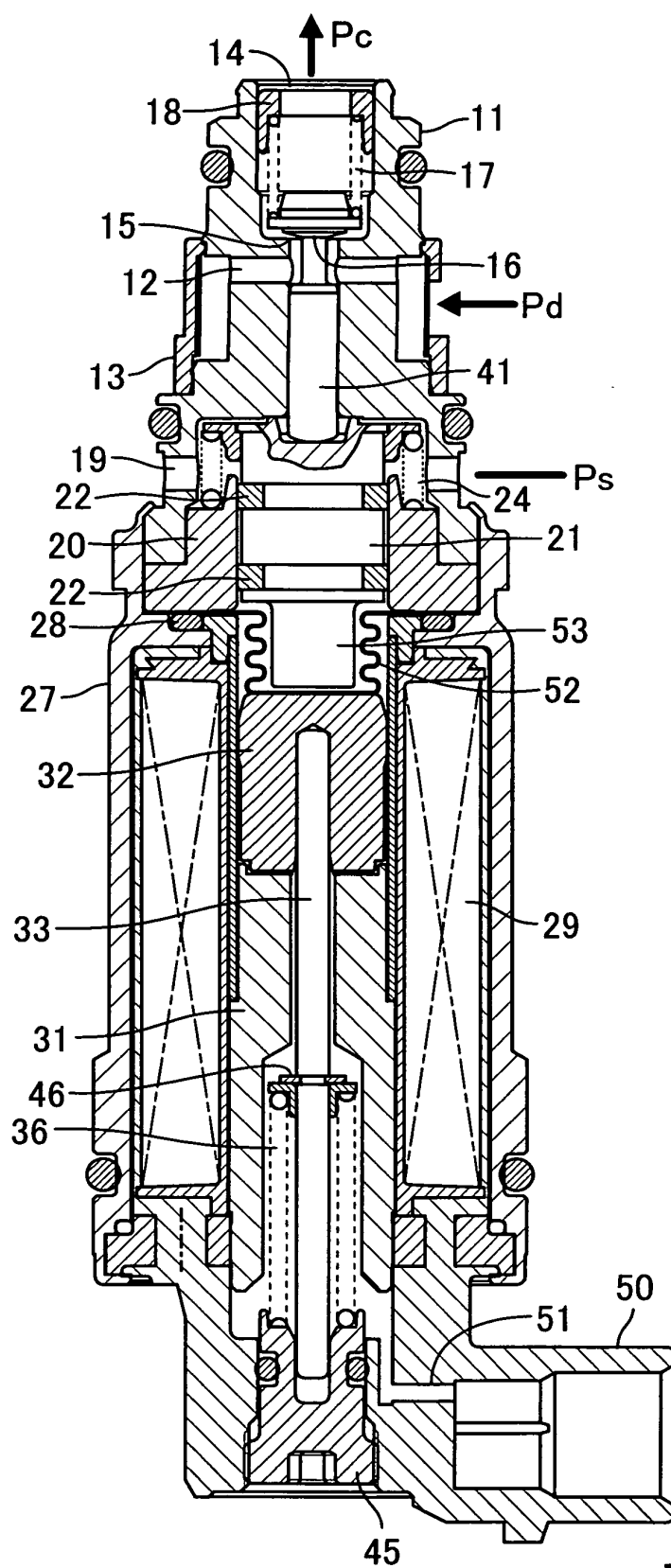


FIG. 11

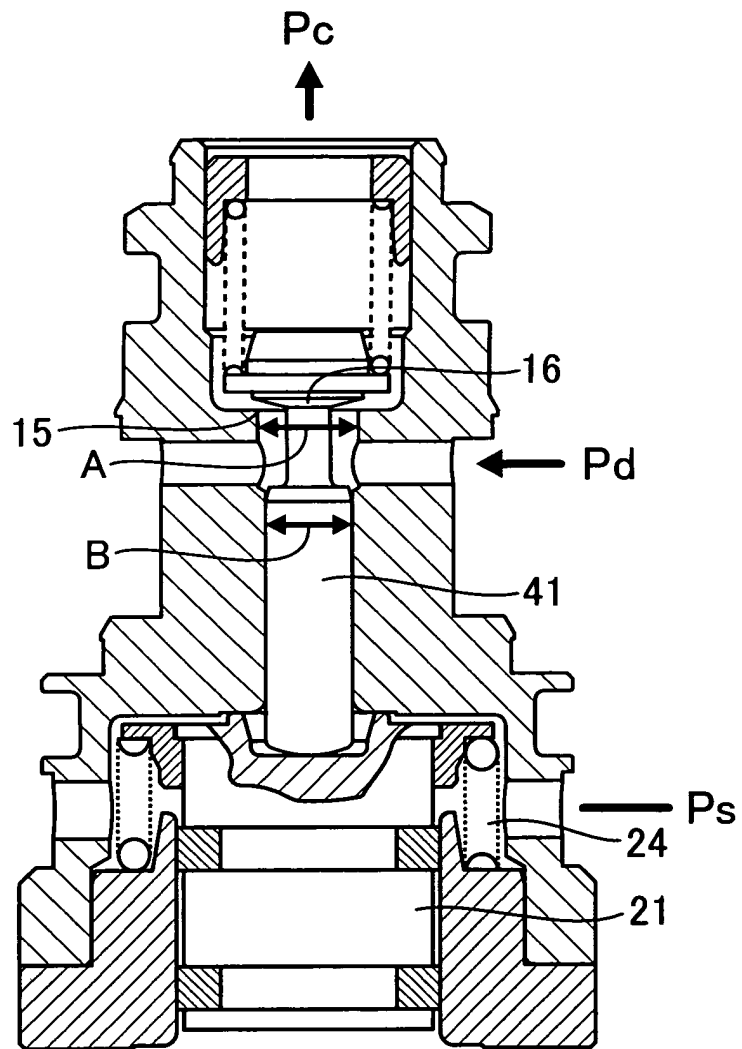


FIG. 12

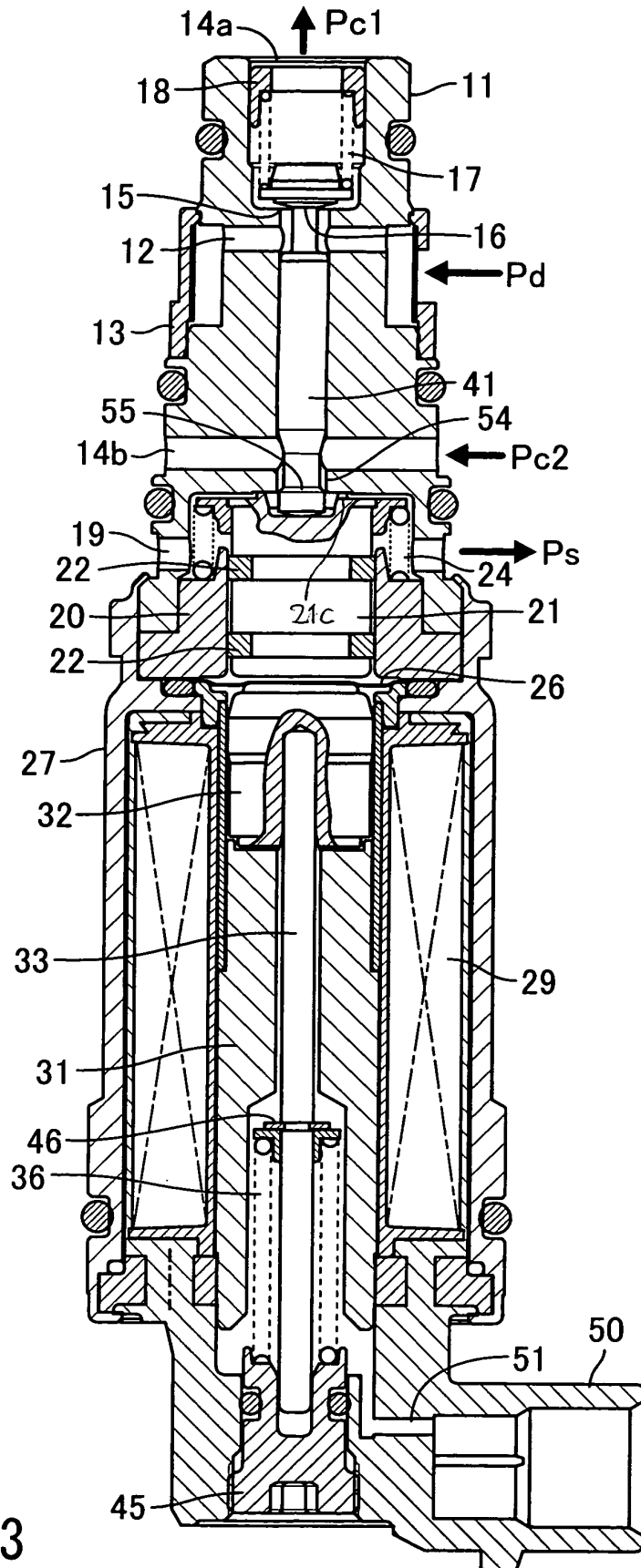


FIG. 13



European Patent
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EUROPEAN SEARCH REPORT

Application Number
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			F04B
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 22 January 2004	Examiner Fistas, N
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