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(71) Applicant: **Fujikoki Corporation**
**Tokyo 158-0082 (JP)**

(72) Inventors:
- **Morisawa, Daisuke**
  **Tokyo 158-0082 (JP)**
- **Kume, Yoshiyuki**
  **Tokyo 158-0082 (JP)**
- **Imai, Masayuki**
  **Tokyo 158-0082 (JP)**

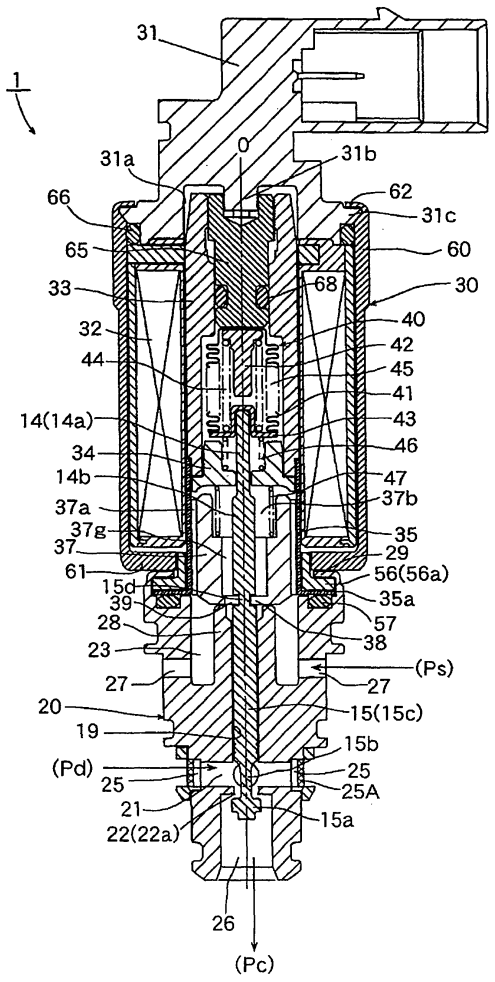
(74) Representative: **Grosse, Rainer et al**
**Gleiss Grosse Schrell & Partner**
**Leitzstrasse 45**
**70469 Stuttgart (DE)**

## (54) Control valve for variable capacity compressors and method for manufacturing the same

(57) A control valve for a variable capacity compressor allowing for obviating any adverse influence due to the discharge pressure "Pd" on the control of the compressor without sophisticating the structure and a method for manufacturing thereof are provided.

The control valve comprising a valve main body (20) constituted by a valve rod (15) having a shank portion (15c), an intermediate small diameter portion (15b) which is made smaller in diameter than the shank portion (15c), wherein the bore diameter of the valve aperture (22) enables the shank portion (15c) of valve rod (15) to pass therethrough before the assembling of valve but, after the assembly (after the shank portion (15c) is inserted into the guide hole (19) through the valve aperture (22)), the outer peripheral portion of the valve seat (22a) is beaten with a punch, etc. for instance, thereby reducing the bore diameter of valve seat (22a) and hence the effective aperture area of valve aperture (22).

FIG. 1

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## Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

**[0001]** The present invention relates to a control valve for variable capacity compressors which is designed to be employed in air conditioners for vehicles, etc., and in particular to a control valve for variable capacity compressors which is designed such that a valve rod which is slidably and snugly inserted into a guide hole can be scarcely brought into a state of malfunction, and to a method for manufacturing such a control valve.

2. Description of the Related Art

**[0002]** The control valve for variable capacity compressors which is designed to be employed in air conditioners for vehicles, etc. is generally constructed such that a cooling medium having a discharge pressure "Pd" is permitted to enter into the crank chamber of compressor from the discharge chamber of compressor so as to adjust the pressure "Pc" inside the crank chamber. In this case, the flow rate of cooling medium having a discharge pressure "Pd" to the crank chamber is restricted in such a manner that the quantity of supply (throttling volume) of cooling medium to the crank chamber is controlled depending on the suction pressure "Ps" of compressor. For this purpose, various proposals where an electromagnetic actuator (solenoid) is employed have been suggested or put into practice as seen from JP Patent Laid-open Publication (Kokai) No. 2006-291867.

**[0003]** FIG. 7 illustrates one example of such a conventional control valve for a variable capacity compressor. The control valve 5 shown herein comprises a valve main body 20, and an electromagnetic actuator 30; wherein the valve main body 20 comprises a valve rod 15 constituted by a shank portion 15c, an intermediate small diameter (neck) portion 15b which is made smaller in diameter than the shank portion 15c, and a valve body portion 15a which is made larger in diameter than the shank portion 15c; a guide hole 19 into which the shank portion 15c of valve rod 15 can be slidably and snugly inserted; and a valve chamber 21 having a valve aperture 22 whose lower portion (valve seat portion 22a) the valve body portion 15a is enabled to detachably contact with; the valve main body 20 being further provided with a plurality of filter(25A)-attached cooling medium inlet ports 25 formed along the outer circumferential wall of the valve chamber 21 (i.e. locating on an upstream side of the valve aperture 22) for receiving a cooling medium having a discharge pressure "Pd" from the compressor, and with a cooling medium outlet port 26 disposed below the valve aperture 22 (i.e. on its downstream side) and communicated with a crank chamber of the compressor.

**[0004]** This electromagnetic actuator 30 is equipped with a coil 32 having a connector 31 for electroexcitation, with a cylindrical stator 33 disposed on the inner circumferential wall side of the coil 32, with an attractor 34 having U-shaped cross-section and being press-inserted into an inner circumferential lower end portion of the stator 33, with a flange(35a)-attached pipe 35 which is joined, through an upper edge portion thereof, by means of TIG welding, to an outer circumferential lower end portion (step portion) of the stator 33, with a plunger 37 slidably disposed so as to enable itself to move up and down inside the pipe 35 and placed below the attractor 34, and with a cylindrical housing 60 with an opening in its bottom and being disposed to cover the outer circumferential wall of the coil 32.

**[0005]** Additionally, a hexagon socket head adjusting screw 65 is screwed on an upper portion of the stator 33. A pressure sensitive chamber 45 into which the suction pressure "Ps" of compressor is to be introduced is formed between the adjusting screw 65 and the attractor 34 in the inner circumferential wall of stator 33. In this pressure sensitive chamber 45, there is disposed, as a pressure sensitive actuating member, a bellows main body 40 consisting of a bellows 41, a downwardly projected upper stopper 42, a reversed U-shaped lower stopper 43 and a compression coil spring 44. Further, a compression coil spring 46 for urging the bellows main body 40 to contract (in the direction to contract it toward the adjusting screw 65) is disposed between the bellows main body 40 and the attractor 34. Further, a step-attached operating rod 14 piercing through the attractor 34 is disposed between the reversed U-shaped lower stopper 43 of bellows main body 40 and a U-shaped portion 37c of plunger 37. Additionally, a valve-opening spring 47 made of a compression coil spring for urging the valve rod 15 downward (in the direction to open the valve) by way of the plunger 37 is disposed between the attractor 34 and the U-shaped portion 37b of plunger 37.

**[0006]** On the other hand, a convex stopper 28 for regulating the lowermost descending position of the plunger 37 is projected upward from an upper central portion of the valve main body 20. A guide hole 19 in which the valve rod 15 is slidably and snugly inserted is formed at a central portion of valve main body 20 over the valve chamber, this guide hole 19 being formed also piercing through the convex stopper 28. A suction pressure cooling medium-introducing chamber 23 for enabling a cooling medium of suction pressure of the compressor to be introduced therein is formed between the plunger 37 and an upper outer circumferential wall of the valve main body 20 (an outer circumferential wall of the convex stopper 28). A plurality of suction pressure cooling medium-introducing ports 27 are formed in the outer circumferential wall of the suction pressure-introducing chamber 23. A cooling medium of suction pressure "Ps" that has been introduced into the suction pressure cooling medium-introducing chamber 23 from the cooling medium-introducing ports 27 is designed to be introduced into the pressure sensitive chamber 45 via longitudinal grooves 37a, 37a, ... formed on the outer circumferential wall of plung-

er 37, via a communication hole 37d formed at a central axis of plunger 37 and via a communication hole 39 formed in the attractor 34.

**[0007]** A valve-closing spring 48 made of a conical compression spring for urging the valve rod 15 upward is disposed at a lower portion (a cooling medium outlet port 26) of the valve main body 20. By the effect of urging force of this valve-closing spring 48, an upper end portion of the valve rod 15 is always brought into press-contact with the communication hole 37d portion of plunger 37.

**[0008]** A lower flange portion 35a of the pipe 35 is mounted, through an 0-ring 57, on an upper end of the valve main body 20. A flange (56a)-attached short cylindrical pipe holder 56 is disposed between the flange portion 35a and the coil 32. These flange portions 35a and 56a are both fixed to each other by means of the upper outer circumferential caulking portion 29 of the valve main body 20. An open bottom portion 61 of the housing 60 is press-inserted in and fixed to an upper end portion of the pipe holder 56. An upper end portion 62 of the housing 60 is calked to the flange portion 31c of the connector 31. An O-ring 66 is interposed between the housing 60 and the connector 31 and the coil 32. By the way, at a lower central portion of the connector 31, there is formed a recessed portion 31a in which a projected portion 31b to be engaged with the hexagonal hole of the adjusting screw 65 is formed. An upper portion of the stator 33 as well as an upper portion of the adjusting screw 65 is inserted into this recessed portion 31a.

**[0009]** In the control valve 5 constructed as described above, when the solenoid portion consisting of the coil 32, the stator 33 and the attractor 34 is electroexcited, the plunger 37 is drawn toward the attractor 34, thereby the valve rod 15 being moved upward (in the valve-closing direction) by the urging force of the valve-closing spring 48. On the other hand, the cooling medium of suction pressure "Ps" that has been introduced into the suction pressure cooling medium-introducing ports 27 from the compressor is introduced from the suction pressure cooling medium-introducing chamber 23 into the pressure sensitive chamber 45 via longitudinal grooves 37a, 37a, ... formed on the outer circumferential wall of plunger 37 and via a communication hole 39 formed in the attractor 34. As a result, the bellows main body 40 (the interior thereof is kept in vacuum) is caused to displace, i.e. contract or expand depending on the pressure (the suction pressure "Ps") inside the pressure sensitive chamber 45 (when the suction pressure "Ps" is high, the bellows main body 40 is contracted, and when the suction pressure "Ps" is low, the bellows main body 40 is expanded). Then, this displacement is transmitted, via the operating rod 14 and the plunger 37, to the valve rod 15, thereby making it possible to adjust the degree of opening of valve (the lifting height of the valve body portion 15a from the valve seat portion 22a of valve aperture 22). Namely, the degree of opening of valve will be determined depending on the attracting force of the plunger 37 to be effected by the solenoid portion consisting of the coil 32, the stator 33 and the attractor 34, on the urging force of the bellows main body 40, on the urging force of the valve-opening spring 47 and the valve-closing spring 48, and on the load in the valve-opening direction and the load in the valve-closing direction to be imposed by the discharge pressure "Pd" on the valve rod 15. Further, depending on this degree of opening of valve, the magnitude of restriction of cooling medium of discharge pressure "Pd" that has been introduced from the discharge pressure cooling medium inlet port 25 into the valve chamber 21, i.e. the quantity of cooling medium to be introduced into the crank chamber (magnitude of restriction) can be adjusted. In other words, depending on the degree of opening of valve, the pressure "Pc" of cooling medium outlet port 26 side (hereinafter referred to as an outlet port pressure Pc), i.e. the pressure inside the crank chamber, can be controlled. As a result, the inclination angle of the wobble plate of compressor as well as the stroke of piston can be adjusted, thus increasing or decreasing the quantity of cooling medium to be discharged.

**[0010]** As described above, the conventional control valve 5 for variable capacity compressors is accompanied with the following problems to be overcome.

**[0011]** As described above, this control valve 5 is constructed such that the discharge pressure cooling medium inlet port 25 is provided on the upstream side of the valve aperture 22 and the cooling medium outlet port 26 is provided on the downstream side of the valve aperture 22, and that the valve body portion 15a is provided at an lower end portion of the shank portion 15c of valve rod 15 and designed to open and close the valve aperture 22 through the movement thereof from the underside of valve aperture 22, thus enabling the discharge pressure "Pd" to be acted on the valve rod 15. In this case, as schematically shown in FIGs. 4(A) and 4(B), for the convenience of assembling the valve, the bore diameter "Da" of valve aperture 22 is made slightly larger than the outer diameter "Db" of the shank portion 15c so as to enable the shank portion 15c of valve rod 15 to be inserted from the underside of valve aperture 22. At the same time, for the purpose of enabling the valve body portion 15a to open and close the valve aperture 22 from the underside of valve aperture 22 (i.e. for the purpose of enabling the valve body portion 15a to detachably contact with the valve seat portion 22a provided at a lower end portion of valve aperture 22), the outer diameter "Dc" of the valve body portion 15a is made larger than the bore diameter "Da" of valve aperture 22 ($Db \leq Da < Dc$).

**[0012]** In this case, while the load in the valve-closing direction (lifting force) "A" to be imposed on the valve rod 15 by the discharge pressure "Pd" is proportional to the pressure-receiving area (outer diameter "Db") of the shank portion 15c, the load in the valve-opening direction (downward pushing force) "B" is a total of both the load "Ba" corresponding to the bore diameter "Da" of valve aperture 22 (valve seat portion 22a) and the load "Bb" corresponding to the outer diameter "Dc" (Dc-Da) of valve

body portion 15a.

**[0013]** In this case, since "Da" can be assumed as being approximately the same as the "Db", the load to be imposed on the valve rod 15 by the discharge pressure "Pd" in the valve-opening direction (downward pushing force) becomes larger than the load in the valve-closing direction (lifting force) by a magnitude of the aforementioned load "Bb" or so. For this reason, when the electric current "I" to be supplied to the coil 32 of electromagnetic actuator 30 is made constant, as indicated by the "Pd-Ps" characteristics shown in FIG. 6, not only the outlet port pressure "Pc" but also the suction pressure "Ps" (in the actual use of the compressor, the outlet port pressure "Pc" becomes approximately the same as the suction pressure "Ps") tends to become higher (rising rightwards) as the discharge pressure "Pd" becomes higher, thereby giving adverse influence to the control of compressor (inviting the deterioration in accuracy of control, etc.) and raising a problem.

## SUMMARY OF THE INVENTION

**[0014]** The present invention has been made in view of the circumstances mentioned above and, therefore, an object of the present invention is to provide a control valve for a variable capacity compressor, which makes it possible to obviate any adverse influence on the control of compressor that may be caused by the discharge pressure "Pd" without sophisticating the structure. Another object of the present invention is to provide a method of manufacturing such a control valve.

**[0015]** With a view to achieving the aforementioned objects, there is provided, according to one aspect of the present invention, a control valve for a variable capacity compressor, which fundamentally comprises a valve main body constituted by a valve rod having a shank portion, an intermediate small diameter portion which is made smaller in diameter than the shank portion, and a valve body portion which is made larger in diameter than the shank portion, by a guide hole into which the shank portion of valve rod can be slidably and snugly inserted, and by a valve chamber having a valve aperture with which the valve body portion is enabled to detachably contact, the valve main body being further provided with a discharge pressure cooling medium inlet port which is disposed on an upstream side of the valve aperture and designed to receive a cooling medium having a discharge pressure "Pd" from the compressor, and with a cooling medium outlet port which is disposed on a downstream side of the valve aperture and communicated with a crank chamber of the compressor; an electromagnetic actuator for driving the valve rod to move in the direction of opening or closing the valve aperture; and a pressure sensitive actuating member for driving the valve rod to move in the direction of opening or closing the valve aperture in response to a suction pressure "Ps" of the compressor.

**[0016]** The valve body portion is formed contiguous to the lower side of the intermediate small diameter portion of valve rod and designed to be moved from the underside of the valve aperture so as to close or open the valve aperture. Before the assembling of valve, the bore diameter of the valve aperture is set so as to enable the shank portion of valve rod to pass therethrough but, after the assembling of valve, the effective aperture area thereof is reduced.

**[0017]** In a preferable embodiment, the valve aperture is provided, on the underside thereof, with a valve seat with which the valve body portion can be detachably contacted, this valve seat being restricted in bore diameter as compared with an upper portion of the valve aperture.

**[0018]** Preferably, the outer peripheral portion of the valve seat is beaten or pressed by making use of a punch, etc. so as to reduce the bore diameter thereof.

**[0019]** In a further preferable embodiment, the effective aperture area of the valve aperture is set to such that the suction pressure (Ps) can be maintained at approximately a constant value or slightly lowered even when the discharge pressure "Pd" is increased.

**[0020]** In a more preferable embodiment, the effective aperture area of the valve aperture is set to such that the load in the valve-opening direction to be imposed by the discharge pressure (Pd) on the valve rod becomes approximately the same as the load in the valve-closing direction, or such that the load in the valve-closing direction becomes slightly larger than the load in the valve-opening direction.

**[0021]** On the other hand, the method of manufacturing a control valve for a variable capacity compressor according to the present invention is directed to the manufacture of a control valve for a variable capacity compressor comprising a valve main body constituted by a valve rod having a shank portion, an intermediate small diameter portion which is made smaller in diameter than the shank portion, and a valve body portion which is made larger in diameter than the shank portion, by a guide hole into which the shank portion of valve rod can be slidably and snugly inserted, and by a valve chamber having a valve aperture with which the valve body portion is enabled to detachably contact, the valve main body being further provided with a discharge pressure cooling medium inlet port which is disposed on an upstream side of the valve aperture and designed to receive a cooling medium having a discharge pressure (Pd) from the compressor, and with a cooling medium outlet port which is disposed on a downstream side of the valve aperture and communicated with a crank chamber of the compressor; an electromagnetic actuator for driving the valve rod to move in the direction of opening or closing the valve aperture; and a pressure sensitive actuating member for driving the valve rod to move in the direction of opening or closing the valve aperture in response to a suction pressure (Ps) of the compressor; wherein the method is characterized in that, on the occasion of assembling the control valve, the shank portion of valve rod is inserted, via the valve aperture, into the guide hole and, after finishing the insertion of the shank portion, a step for reduc-

ing the effective aperture area of the valve aperture is performed.

**[0022]** In this case, the outer peripheral portion of the valve seat provided on a lower end portion of the valve aperture is beaten or pressed by making use of a punch, etc. so as to reduce the bore diameter thereof.

**[0023]** In the control valve for a variable capacity compressor according to the present invention, just like the aforementioned conventional control valve for a variable capacity compressor, the bore diameter of valve aperture is made larger than the outer diameter of the shank portion of valve before the assembling of the control valve so as to enable the shank portion to pass through the valve aperture from underside of the valve aperture, and, at the same time, the outer diameter of valve body portion is made larger than the bore diameter of valve aperture in order to open or close the valve aperture from the underside of valve aperture by means of this valve body portion (i.e. the valve body portion is enabled to detachably contact with the valve seat which is provided on an lower end portion of valve aperture). However, after finishing the assembling of the control valve (i.e. after finishing the insertion of shank portion of valve rod into the guide hole through the valve aperture), the outer peripheral portion of the valve seat is beaten or pressed from the underside thereof by making use of a punch, etc. so as to reduce the bore diameter of valve seat, thereby reducing the effective aperture area of the valve aperture.

**[0024]** By reducing the effective aperture area of the valve aperture as described above, it is now possible to make the load in the valve-opening direction (downward pushing force), which will be imposed on the valve rod by the discharge pressure "Pd", approximately the same as or slightly lower than the load in the valve-closing direction (lifting force).

**[0025]** When the electric current "I" to be supplied to the coil of electromagnetic actuator is made constant, as seen from the "Pd-Ps" characteristics shown in FIG. 5, even if the discharge pressure "Pd" becomes higher, it is possible to maintain the suction pressure "Ps" (in the actual use of the compressor, the outlet port pressure "Pc" becomes approximately the same as the suction pressure "Ps") at approximately a constant level as indicated by the solid line "V" or at a slightly lower level as indicated by the dashed-dotted line "U". As a result, it is now possible to obviate any adverse influence that may be caused by the discharge pressure "Pd", on the control of the compressor, without sophisticating the structure.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0026]**

FIG. 1 is a longitudinal sectional view illustrating one embodiment of the control valve for a variable capacity compressor according to the present invention;

FIGs. 2(A), 2(B) and 2(C) are cross-sectional views each illustrating the manufacturing method of the control valve shown in FIG. 1;

FIG. 3 (A) is an enlarged longitudinal sectional view illustrating a main portion of the control valve shown in FIG. 1;

FIG. 3(B) is a diagram illustrating the features of the main portion of the control valve shown in FIG. 3(A);

FIG. 4(A) is an enlarged longitudinal sectional view illustrating a main portion of the conventional control valve for a variable capacity compressor;

FIG. 4(B) is a diagram illustrating the features of the main portion of the control valve shown in FIG. 4(A);

FIG. 5 is a graph illustrating the "Pd-Ps" characteristics of the control valve shown in FIG. 1;

FIG. 6 is a graph illustrating the "Pd-Ps" characteristics of one example of the conventional control valve for a variable capacity compressor; and

FIG. 7 is a longitudinal sectional view illustrating one example of the conventional control valve for a variable capacity compressor.

## DETAILED DESCRIPTION OF THE INVENTION

**[0027]** Next, a specific embodiment of the control valve for a variable capacity compressor according to the present invention will be explained in detail with reference to the drawings.

**[0028]** FIG. 1 shows a longitudinal sectional view illustrating one embodiment of the control valve for a variable capacity compressor according to the present invention. In the control valve 1 for a variable capacity compressor shown in FIG. 1, the parts or components which correspond to those of the conventional control valve 5 for a variable capacity compressor which is shown in FIG. 7 will be identified by the same reference numbers and the features which differ from those of the conventional control valve 5 will be mainly explained as follows.

**[0029]** In the case of the control valve 1 according to the embodiment shown in FIG. 1, before the assembling of the control valve, just like the aforementioned conventional control valve, as shown in FIG. 2(A), for the convenience of assembling the control valve, the bore diameter "Da" of valve aperture 22 is made slightly larger than the outer diameter "Db" of the shank portion 15c of valve rod so as to enable the shank portion 15c of valve rod 15 to pass through the valve aperture 22 from underside of the valve aperture 22, and, at the same time, the outer diameter "Dc" of valve body portion 15a is made larger than the bore diameter "Da" of valve aperture 22 in order to open or close the valve aperture 22 from the underside of valve aperture 22 by means of this valve body portion 15a (i.e. the valve body portion 15a is enabled to detachably contact with the valve seat 22a which is provided on an lower end portion of valve aperture 22). However, after finishing the assembling of the control valve, a step is executed so as to reduce the effective aperture area of the valve aperture 22 as described below.

**[0030]** Further, while the valve rod 15 is urged upward

by means of the valve-closing spring 48 to push the valve rod against the plunger 37 in the aforementioned conventional control valve, this embodiment is featured in that the valve rod 15 is formed integral with the operating rod 14, that the valve-closing spring 48 is not employed, and that an annular groove portion (small diameter portion) 15d is formed at a boundary region between the shank portion 15c of valve rod 15 and the large diameter portion 14b (which is the same in diameter as the shank portion 15c) of operating rod 14, and an engaging portion 38 which is provided at a bottom portion of hole 37g of the plunger 37 is fitted in the annular groove portion 15d, thereby enabling the plunger 37 to move up and down together with the movement of valve rod 15.

**[0031]** The reason for constructing the control valve in this manner can be explained as follows. Namely, when the control valve is constructed such that the valve rod 15 is enabled to move in the valve-closing direction by means of only the urging force of the valve-closing spring 48, foreign material may be caught in the slide-contacting interface between the valve rod 15 and the guiding hole 19, or the sliding resistance of valve rod 15 may be caused to increase due to the oil-seizing, etc., thereby giving rise to the malfunctioning of the valve rod 15 such as locking of valve rod 15. For example, there may be generated a situation wherein the valve rod 15 cannot be moved in the valve-closing direction and is left behind even if the plunger is pulled close to the attractor. If such a situation occurs, it is no longer possible to suitably control the opening degree of valve. Whereas, when the valve rod 15 is substantially directly connected with the plunger as described above, it is possible to obviate the aforementioned problems and, at the same time, it is possible to dispense with the valve-closing spring 48.

**[0032]** In the case of the control valve 1 of this embodiment, after finishing the assembling of valve, i.e. after the insertion of the operating rod 14 as well as the shank portion of valve rod 15, via the valve aperture 22, into the guide hole 19, a cylindrical punch 80 is introduced into the coolant discharge port 26 formed below the valve aperture 22 as shown in FIG. 2(B). Then, by making use of an annular molding portion 81 having a wedge-like or triangular cross-section and projected from the top end face of the punch 80, a lower end portion of the valve aperture 22 (or the outer peripheral portion of the valve seat portion 22a disposed below the lower end portion of the valve aperture 22) is beaten from the underside of valve seat portion 22a. In this case, the outer diameter "Dm" and inner diameter "Dn" of the punch 80 are dimensioned such that the punch 80 can be slidably inserted into an annular space defined by both the inner wall of the coolant discharge port 26 and the outer wall of valve body portion 15a. Further, the diameter of the distal end of annular molding portion 81 is set larger, by a predetermined dimension, than the bore diameter "Da" of valve aperture (or the bore diameter of the valve seat portion 22a disposed below the lower end portion of the valve aperture 22).

**[0033]** By beating the lower end portion of the valve aperture 22 (or the outer peripheral portion of the valve seat portion 22a disposed below the lower end portion of the valve aperture 22) from the underside of valve seat portion 22a by making use of the punch 80 as described above, the annular molding portion 81 is enabled to thrust into the lower end portion of the valve aperture 22 (or the outer peripheral portion of the valve seat portion 22a), thereby creating an annular recessed portion 22c and, at the same time, pushing the lower end portion (or the valve seat portion 22a) inwards to reduce the bore diameter of the valve seat portion 22a as shown in FIG.2 (C) and FIG.3(A). As a result, the bore diameter "Dd" of the valve seat portion 22a that has been pushed inwards and reduced in inner diameter is made smaller than the bore diameter "Da" of upper portion of valve aperture 22 (Dd<Db<Da<Dc), thus reducing the effective aperture area of valve aperture 22.

**[0034]** Since the effective aperture area of valve aperture 22 is reduced as described above, as shown in FIG. 3(B), the load in the valve-closing direction (lifting force) "A" to be imposed on the valve rod 15 by the discharge pressure "Pd" would become the same level as that of conventional control valve shown in FIG. 4 (corresponding to the outer diameter "Db" of shank portion 15c). However, the load in the valve-opening direction (downward pushing force) "B' " becomes a total of both the load "Ba' " (Ba'<Ba) corresponding to the bore diameter "Dd" of valve aperture 22 (valve seat portion 22a) that has been reduced in effective aperture area and the load "Bb' " (Bb'>Bb) corresponding to the outer diameter "Dc" (Dc-Da) of valve body portion 15a. Therefore, by suitably reducing the bore diameter of valve seat portion 22a, the load in the valve-opening direction "B' " to be imposed on the valve rod 15 by the discharge pressure "Pd" can be made approximately the same in level as the load in the valve-closing direction "A", or the load in the valve-closing direction "A" can be set slightly larger than the load in the valve-opening direction "B' ".

**[0035]** In the case of the control valve 1 of this embodiment which is constructed as described above, when the electric current "I" to be supplied to the coil 32 of electromagnetic actuator 30 is made constant, as seen from the "Pd-Ps" characteristics shown in FIG. 5, even if the discharge pressure "Pd" becomes higher, it is possible to maintain the suction pressure "Ps" (in the actual use of the compressor, the outlet port pressure "Pc" becomes approximately the same as the suction pressure "Ps") at approximately a constant level as indicated by the solid line "V" or at a slightly lower level as indicated by the dashed-dotted line "U". As a result, it is now possible to obviate any adverse influence that may be caused by the discharge pressure "Pd", on the control of the compressor, without sophisticating the structure.

**[0036]** By the way, in the above embodiment, after finishing the assembling of the valve, the punch 80 is employed for reducing the effective aperture area of the valve aperture 22. However, it is of course possible to

employ any other means for reducing the effective aperture area of the valve aperture 22.

## Claims

1. A control valve for a variable capacity compressor comprising:

   a valve main body constituted by a valve rod having a shank portion, an intermediate small diameter portion which is made smaller in diameter than the shank portion, and a valve body portion which is made larger in diameter than the shank portion, by a guide hole into which the shank portion of valve rod can be slidably and snugly inserted, and by a valve chamber having a valve aperture with which the valve body portion is enabled to detachably contact, the valve main body being further provided with a discharge pressure cooling medium inlet port which is disposed on an upstream side of the valve aperture and designed to receive a cooling medium having a discharge pressure (Pd) from the compressor, and with a cooling medium outlet port which is disposed on a downstream side of the valve aperture and communicated with a crank chamber of the compressor;
   an electromagnetic actuator for driving the valve rod to move in the direction of opening or closing the valve aperture; and
   a pressure sensitive actuating member for driving the valve rod to move in the direction of opening or closing the valve aperture in response to a suction pressure (Ps) of the compressor;

   wherein the valve body portion is formed contiguous to the lower side of the intermediate small diameter portion of valve rod and designed to be moved from the underside of the valve aperture so as to close or open the valve aperture, and before the assembling of valve, the bore diameter of the valve aperture is set to enable the shank portion of valve rod to pass therethrough but, after the assembling of valve, the effective aperture area thereof is reduced.

2. The control valve for a variable capacity compressor according to claim 1, wherein the valve aperture is provided, on the underside thereof, with a valve seat with which the valve body portion can be detachably contacted, the valve seat being restricted in bore diameter as compared with an upper portion of the valve aperture.

3. The control valve for a variable capacity compressor according to claim 2, wherein, after the assembling of the valve, the outer peripheral portion of the valve seat is beaten or pressed by making use of a punch, etc., thereby reducing the bore diameter thereof.

4. The control valve for a variable capacity compressor according to any one of claims 1 to 3, wherein the effective aperture area of the valve aperture is set to such that the suction pressure (Ps) is enabled to be maintained at approximately a constant value or slightly lowered even if the discharge pressure (Pd) is increased.

5. The control valve for a variable capacity compressor according to any one of claims 1 to 3, wherein the effective aperture area of the valve aperture is set to such that the load in the valve-opening direction to be imposed by the discharge pressure (Pd) on the valve rod becomes almost the same as the load in the valve-closing direction, or such that the load in the valve-closing direction becomes slightly larger than the load in the valve-opening direction.

6. A method of manufacturing a control valve for a variable capacity compressor, wherein the control valve comprises:

   a valve main body constituted by a valve rod having a shank portion, an intermediate small diameter portion which is made smaller in diameter than the shank portion, and a valve body portion which is made larger in diameter than the shank portion, by a guide hole into which the shank portion of valve rod can be slidably and snugly inserted, and by a valve chamber having a valve aperture with which the valve body portion is enabled to detachably contact, the valve main body being further provided with a discharge pressure cooling medium inlet port which is disposed on an upstream side of the valve aperture and designed to receive a cooling medium having a discharge pressure (Pd) from the compressor, and with a cooling medium outlet port which is disposed on a downstream side of the valve aperture and communicated with a crank chamber of the compressor;
   an electromagnetic actuator for driving the valve rod to move in the direction of opening or closing the valve aperture; and
   a pressure sensitive actuating member for driving the valve rod to move in the direction of opening or closing the valve aperture in response to a suction pressure (Ps) of the compressor; and the method is **characterized in that**, on the occasion of assembling the control valve, the shank portion of valve rod is inserted, via the valve aperture, into the guide hole and, after finishing the insertion of the shank portion, a step for reducing the effective aperture area of the valve aperture is performed.

**7.** The method according to claim 6, wherein the outer peripheral portion of the valve seat provided on a lower end portion of the valve aperture is beaten or pressed by making use of a punch, etc., thereby reducing the bore diameter thereof.

FIG. 1

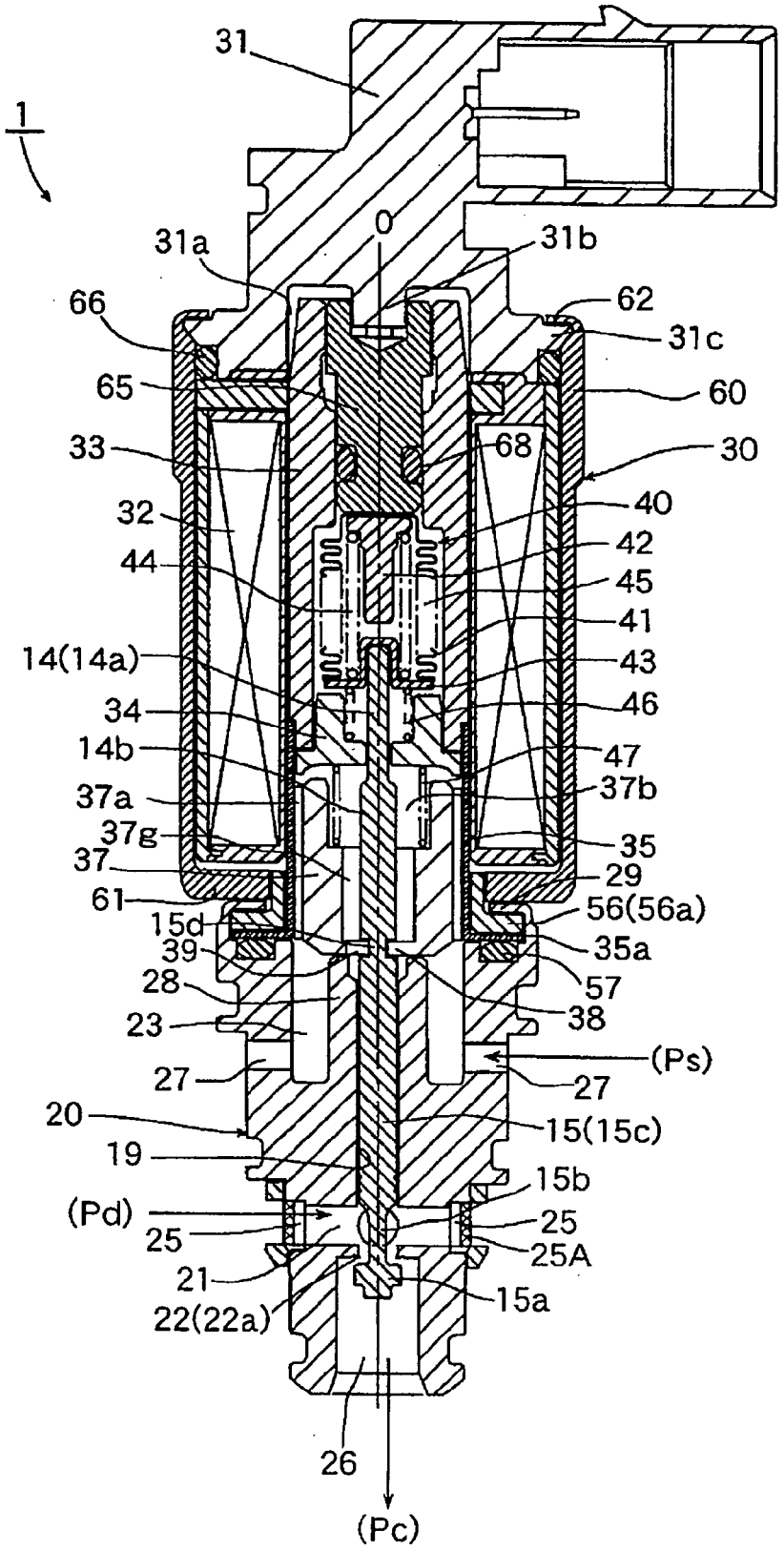

1
31
O
31a
31b
62
66
31c
65
60
33
68
30
32
40
44
42
45
41
14(14a)
43
34
46
14b
47
37a
37b
37g
35
37
29
61
56(56a)
15d
35a
39
57
28
38
23
(Ps)
27
27
20
15(15c)
19
15b
(Pd)
25
25
25A
21
15a
22(22a)
26
(Pc)

FIG. 2(C)

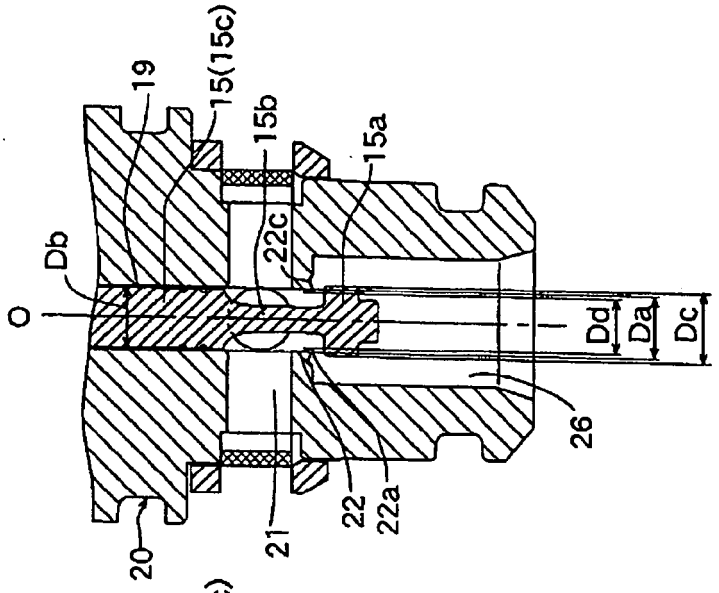



FIG. 2(B)

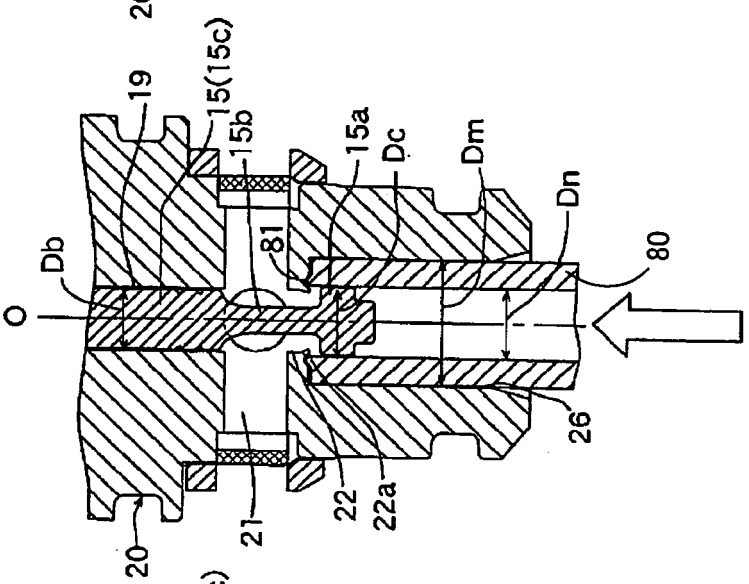



FIG. 2(A)

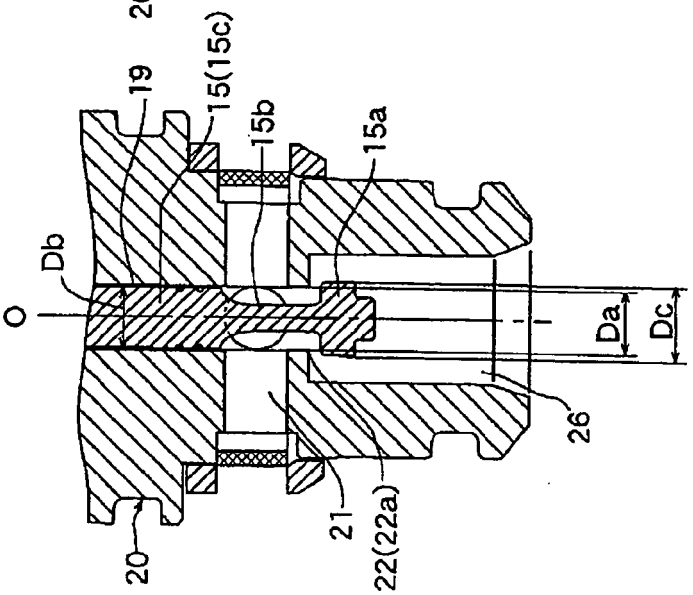


FIG. 3(A)

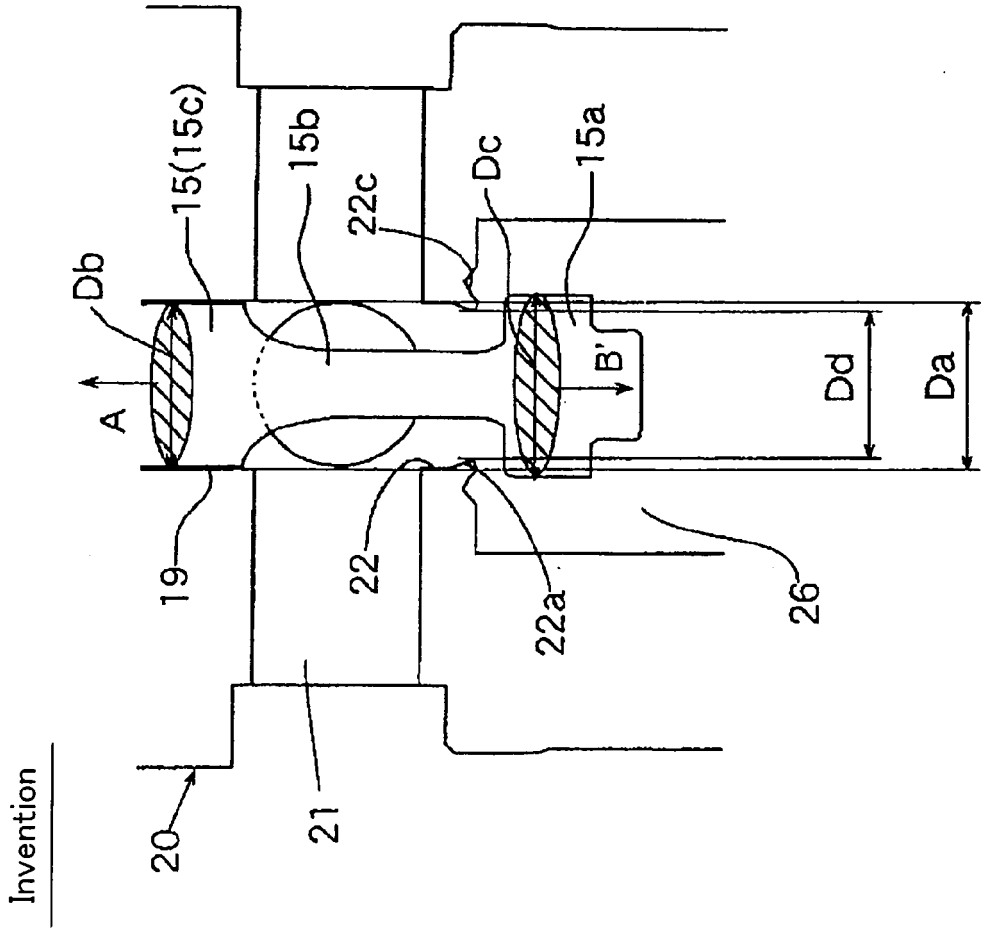

Invention
Db
A
15(15c)
15b
22c
Dc
15a
B'
Dd
Da
19
22
22a
26
20
21

FIG. 3(B)

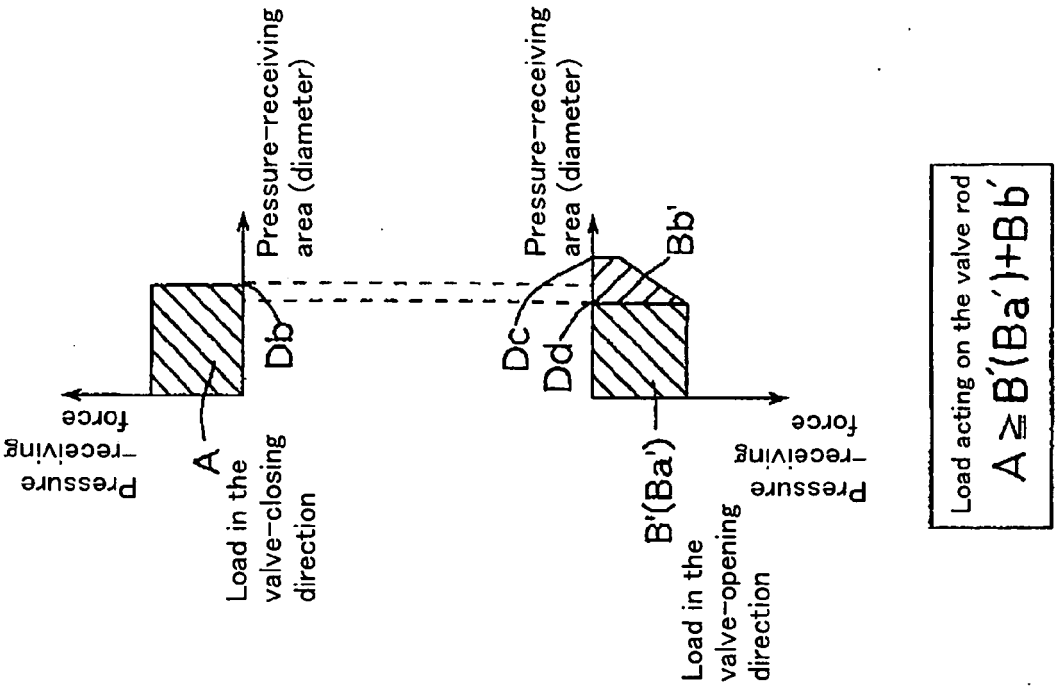

Pressure-receiving area (diameter)
Db
A
Pressure -receiving force
Load in the valve-closing direction
Pressure-receiving area (diameter)
Dc
Dd
Bb'
B'(Ba')
Pressure -receiving force
Load in the valve-opening direction
Load acting on the valve rod
A ≧ B'(Ba')+Bb'

FIG. 4(B)

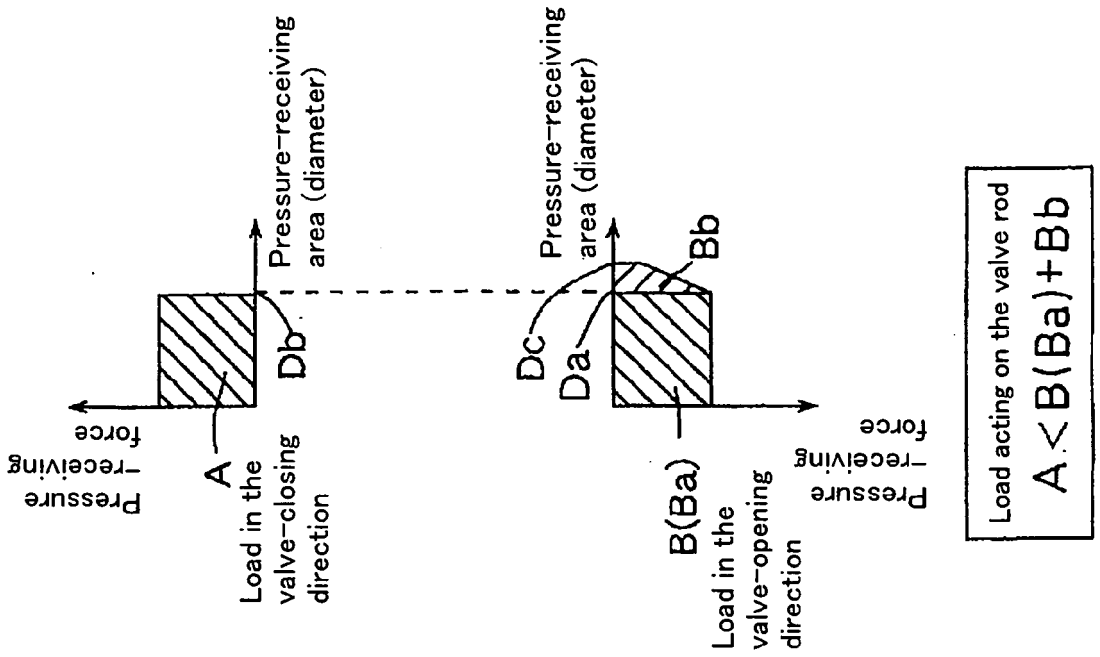

Pressure-receiving area (diameter)
Db
A
Pressure -receiving force
Load in the valve-closing direction
Pressure-receiving area (diameter)
Dc
Da
Bb
B(Ba)
Pressure -receiving force
Load in the valve-opening direction
Load acting on the valve rod
A<B(Ba)+Bb

FIG. 4(A)

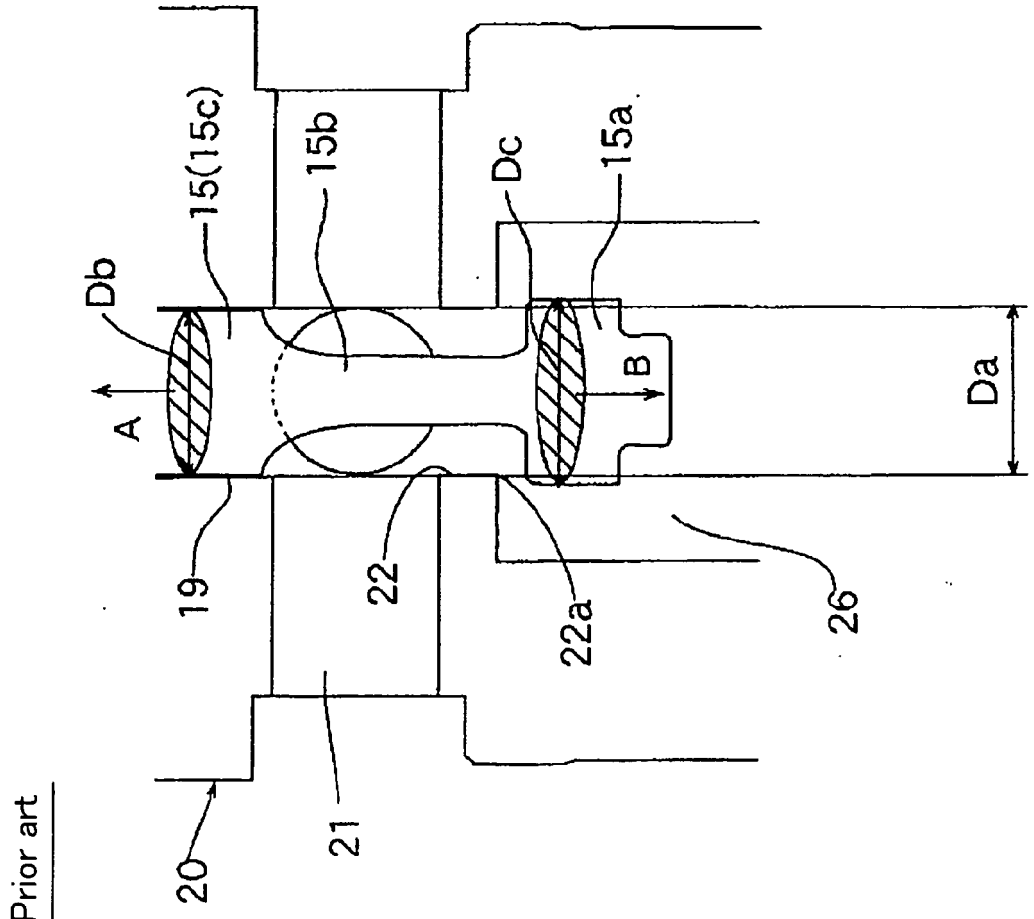

Prior art
Db
A
15(15c)
15b
Dc
15a
B
Da
19
22
22a
26
20
21

FIG. 5

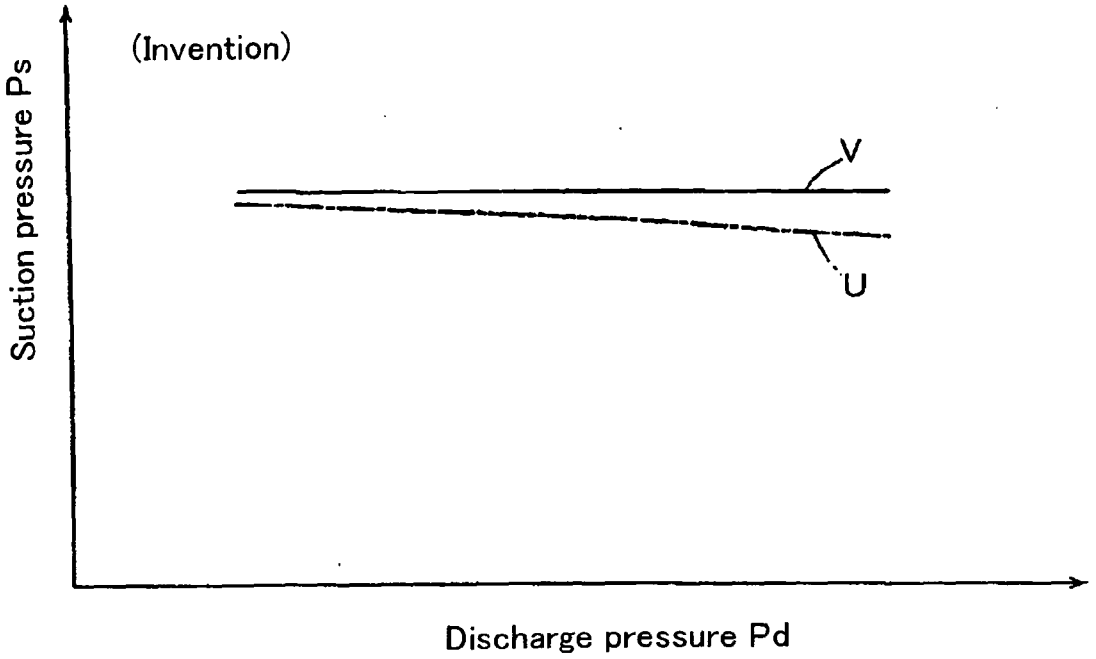

(Invention)
Suction pressure Ps
V
U
Discharge pressure Pd

FIG. 6

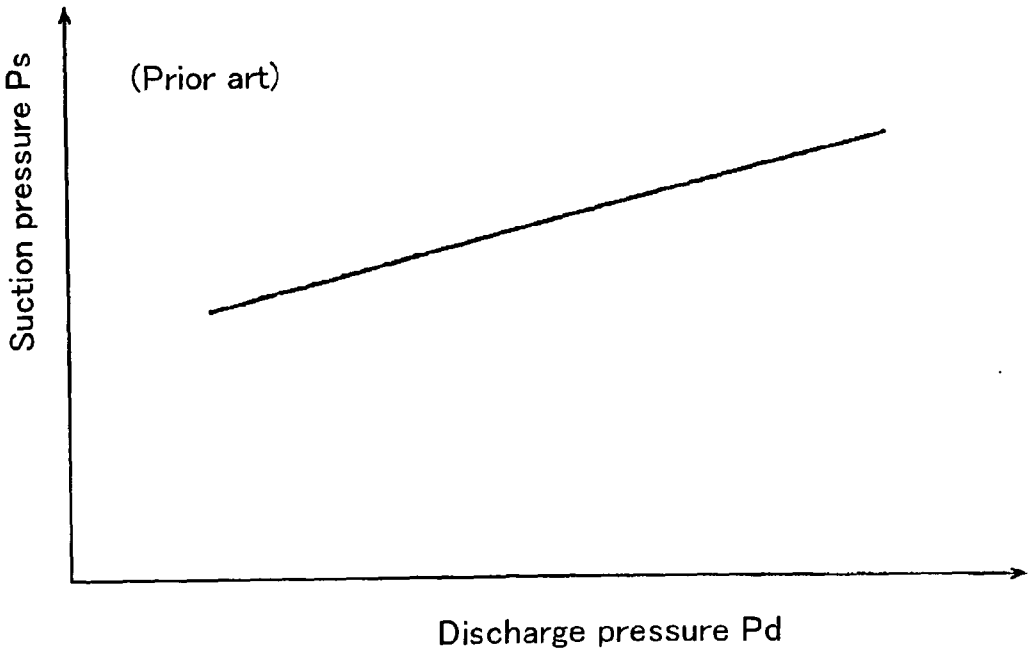
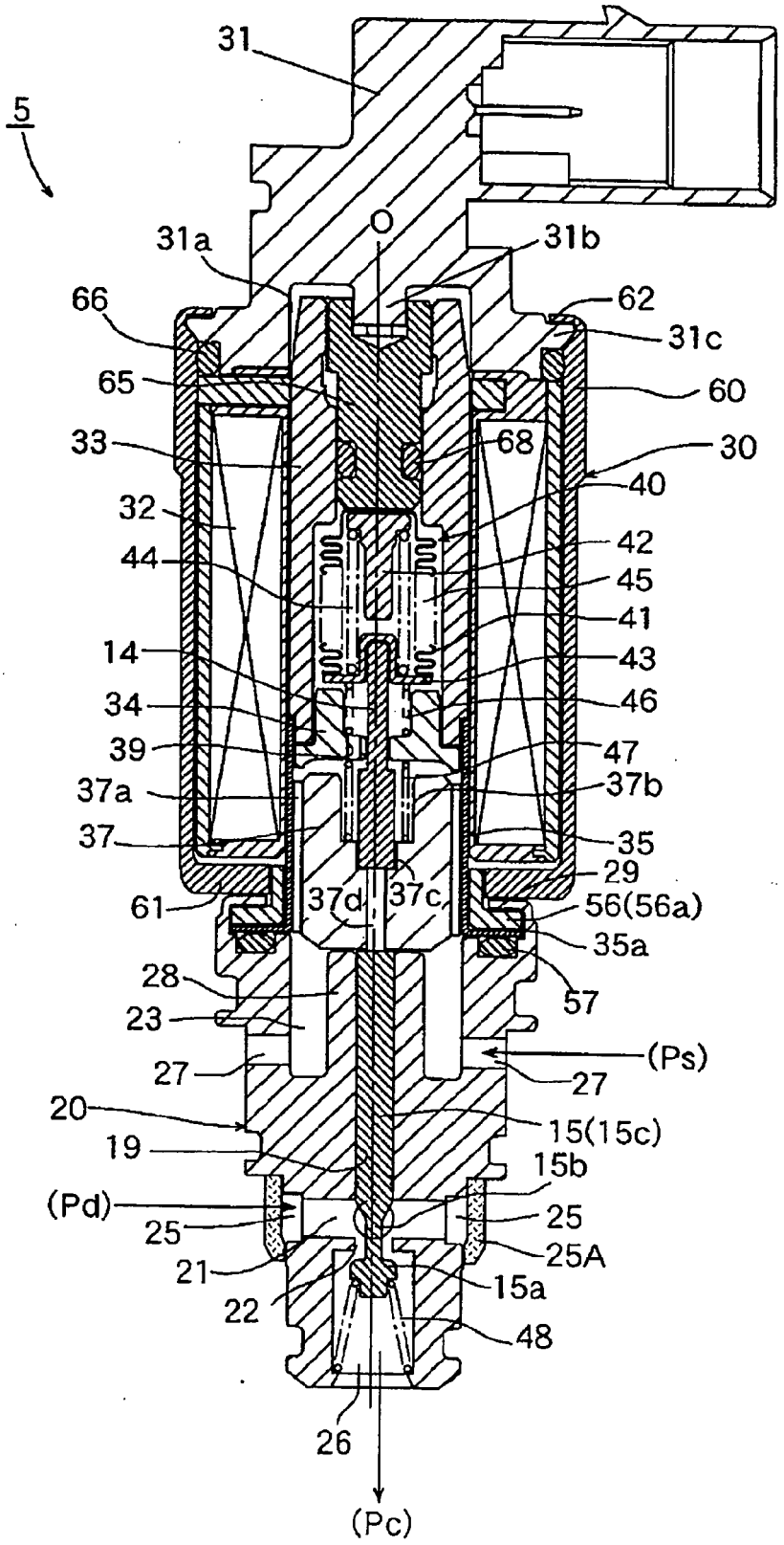

(Prior art)
Suction pressure Ps
Discharge pressure Pd

FIG. 7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34
46
39
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37a
37b
37
35
29
61
37d
37c
56(56a)
35a
28
57
23
(Ps)
27
27
20
15(15c)
19
15b
(Pd)
25
25
25A
21
15a
22
48
26
(Pc)

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2006291867 A **[0002]**