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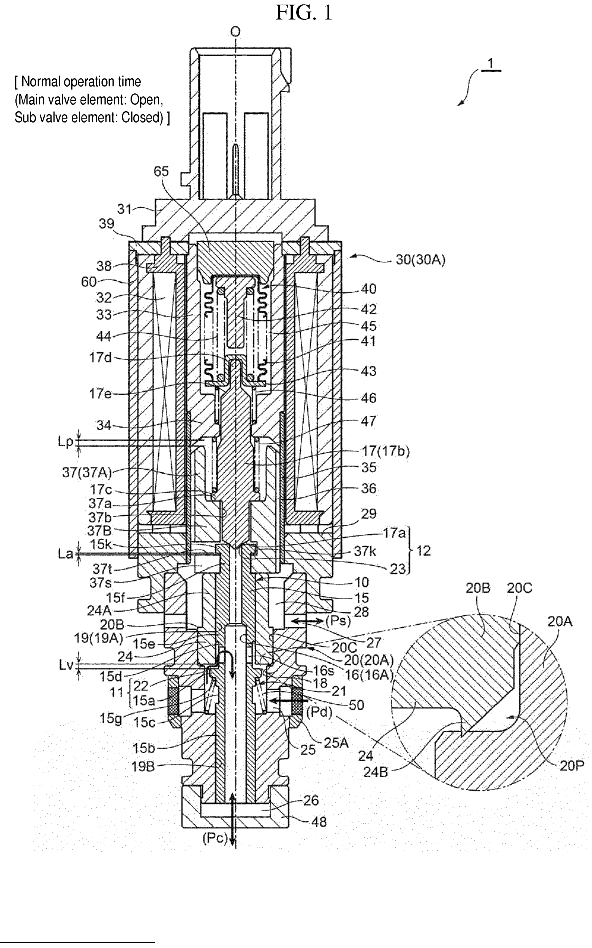
(54) VARIABLE-CAPACITY COMPRESSOR CONTROL VALVE

(57) Provided is a variable-capacity compressor control valve where a valve body can be easily machined and the machining time and machining cost can be reduced without a decrease in the valve closing property or a decrease in the slidability of the valve element due to shaft misalignment. The valve body includes a support member having formed therein a valve orifice and a guide hole into which the valve element is adapted to be slidably fitted and inserted; and a body member having formed therein a Ps inlet/outlet port, a Pd introduction port, and a Pc inlet/outlet port. The support member is fixedly inserted into a recess hole provided in the body member. In addition, a chip sealing portion (pocket portion) for sealing chips of the body member and/or the support member is provided between the body member and the support member.

FIG. 1



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Description

CLAIM OF PRIORITY

[0001] The present application claims priority from Japanese patent application JP 2015-244968 filed on December 16, 2015, the content of which is hereby incorporated by reference into this application.

BACKGROUND

Technical Field

[0002] The present invention relates to a variable-capacity compressor control valve for use in an automotive air conditioner or the like.

Background Art

[0003] Conventionally, a variable-capacity swash plate compressor such as the one schematically shown in FIG. 11 has been used as a compressor for an automotive air conditioner. The variable-capacity swash plate compressor 100 includes a rotating shaft 101 that is rotationally driven by an on-vehicle engine, a swash plate 102 that is attached to the rotating shaft 101, a crank chamber 104 in which the swash plate 102 is disposed, a piston 105 that is reciprocated by the swash plate 102, a discharge chamber 106 for discharging refrigerant compressed by the piston 105, a suction chamber 107 for sucking refrigerant, an in-compressor release passage (fixed orifice) 108 for releasing a pressure Pc in the crank chamber 104 to the suction chamber 107, and the like.

[0004] Meanwhile, a control valve 1' used for the aforementioned variable-capacity compressor receives the discharge pressure Pd from the discharge chamber 106 of the compressor 100 and is configured to control the pressure Pc in the crank chamber 104 by controlling the discharge pressure Pd in accordance with the suction pressure Ps of the compressor 100. Such a control valve 1' has, as the basic configuration, a valve body that includes a valve chamber with a valve orifice, a Ps introduction port communicating with the suction chamber 107 of the compressor 100, a Pd introduction port arranged upstream of the valve orifice and communicating with the discharge chamber 106 of the compressor 100, and a Pc outlet port arranged downstream of the valve orifice and communicating with the crank chamber 104 of the compressor 100; a valve element (valve stem) for opening or closing the valve orifice; an electromagnetic actuator with a plunger for moving the valve element in the direction to open or close the valve orifice (in the vertical direction); a pressure-sensitive chamber that receives the suction pressure Ps from the compressor 100 via the Ps introduction port; and a pressure-sensitive reaction member that urges the valve element in the direction to open or close the valve orifice in accordance with the pressure in the pressure-sensitive chamber. The valve element and the valve orifice form a valve unit indicated by reference numeral 11' in FIG. 11 (for example, see Patent Document 1 below).

[0005] In the control valve 1' with such a configuration, when current is flowed through a solenoid portion including a coil, a stator, an attractor, and the like of the electromagnetic actuator, the plunger is attracted by the attractor, and along with this, the valve element is moved in the direction to close the valve such that it follows the plunger by the urging force of a valve closing spring. Meanwhile, the suction pressure Ps introduced from the compressor 100 via the Ps introduction port is introduced into the pressure-sensitive chamber from an inlet/outlet chamber via a gap formed between the plunger and a guide pipe arranged around the outer periphery of the plunger or the like. Then, the pressure-sensitive reaction member (e.g., a bellows device) is expansively or contractively displaced in accordance with the pressure (suction pressure Ps) in the pressure-sensitive chamber (contracts if the suction pressure Ps is high, and expands if it is low), and the displacement (urging force) is then transmitted to the valve element, whereby the valve element portion of the valve element moves up or down with respect to the valve orifice to regulate the valve opening of the valve unit 11'. That is, the valve opening is determined by the force of attracting the plunger with the solenoid portion, the urging force (expansion or contraction force) that acts with the expansive or contractive displacement of the pressure-sensitive reaction member, the urging force of a plunger spring (valve opening spring) and the valve closing spring. The pressure Pc in the crank chamber 104 (hereinafter also referred to as a crank chamber pressure Pc or simply referred to as a pressure Pc) is controlled in accordance with the valve opening.

[0006] In response to the aforementioned variable-capacity compressor, an improved variable-capacity swash plate compressor, such as the one schematically shown in FIGS. 12A and 12B, for example, has already been proposed that is intended to reduce the time required to increase the discharge capacity at the compressor actuation time, and suppress or reduce a decrease in the operation efficiency of the compressor at the normal control time.

[0007] A control valve 2' used for such an improved variable-capacity swash plate compressor 200 has a valve element (valve stem) including a main valve element and a sub valve element, and has an in-valve release passage 16' in the main valve element. The control valve 2' basically has a valve body that includes a valve chamber with a valve orifice, a Ps inlet/outlet port communicating with a suction chamber 107 of the compressor 200, a Pd introduction port arranged upstream of the valve orifice and communicating with a discharge chamber 106 of the compressor 200, and a Pc inlet/outlet port arranged downstream of the valve orifice and communicating with a crank chamber 104 of the compressor 200; a main valve element for opening or closing the valve orifice; an electromagnetic actuator with a plunger for moving the main valve element in the direction to open or close the valve orifice; a pressure-sensitive chamber that receives the suction pressure Ps from the compressor 200 via the Ps inlet/outlet port; and a pressure-sensitive reaction member that urges the main valve element in the direction to open or close the valve orifice in accordance with the pressure in the pressure-sensitive chamber. Further, the in-valve release passage 16' for releasing the pressure Pc in the crank chamber 104 to the suction chamber 107 of the compressor 200 via the Ps inlet/outlet port is provided in the main valve element, and the sub valve element for opening or closing the in-valve release passage 16' is also provided so that when the plunger is continuously moved upward from the lowest position by the attraction force of the electromagnetic actuator, the sub valve element moves upward together with the plunger while closing the in-valve release passage 16', and the main valve element is also moved upward so as to follow the sub valve element. Then, after the valve orifice is closed by the main valve element, if the plunger is further moved upward, the sub valve element is configured to open the in-valve release passage 16'. The main valve element and the valve orifice form a main valve unit indicated by reference numeral 11' in FIGS. 12A and 12B, while the sub valve element and the in-valve release passage form a sub valve unit indicated by reference numeral 12' (for example, see Patent Document 2 below).

[0008] At the normal control time (Pd → Pc control time) of the control valve 2' with such a configuration, when current is flowed through a solenoid portion including a coil, a stator, an attractor, and the like of the electromagnetic actuator, the plunger is attracted by the attractor, and along with this, the sub valve element moves upward integrally with the plunger, and following the movement of the sub valve element, the main valve element is moved in the direction to close the valve by the urging force of a valve closing spring. Meanwhile, the suction pressure Ps introduced from the compressor 200 via the Ps inlet/outlet port is introduced into the pressure-sensitive chamber from an inlet/outlet chamber via a horizontal hole in the plunger or the like, and the pressure-sensitive reaction member (e.g., a bellows device) is expansively or contractively displaced in accordance with the pressure (suction pressure Ps) in the pressure-sensitive chamber (contracts if the suction pressure Ps is high, and expands if it is low), and the displacement (urging force) is then transmitted to the main valve element, whereby the main valve element portion of the main valve element moves up or down with respect to the valve orifice to regulate the valve opening of the main valve unit 11'. That is, the valve opening is determined by the force of attracting the plunger with the solenoid portion, the urging force (expansion or contraction force) that acts with the expansive or contractive displacement of the pressure-sensitive reaction member, the urging force of a plunger spring (valve opening spring) and the valve closing spring, and force that acts on the main valve element in the valve opening direction and in the valve closing direction. The pressure Pc in the crank chamber 104 is controlled in accordance with the valve opening. In such a case, the main valve element is always urged upward by the urging force of the valve closing spring, while the sub valve element is always urged downward by the urging force of the valve opening spring. Thus, the sub valve unit 12' is closed and the in-valve release passage 16' is blocked in the main valve element. Therefore, there is no possibility that the crank chamber pressure Pc may be released to the suction chamber 107 via the in-valve release passage 16'.

[0009] In contrast, at the compressor actuation time, current is flowed through the solenoid portion so that the plunger is attracted by the attractor and the sub valve element moves upward together with the plunger. Following the upward movement of the sub valve element, the main valve element is moved in the direction to close the valve by the urging force of the valve closing spring, and after the valve orifice is closed by the main valve element portion of the main valve element, the plunger is further moved upward, whereby the sub valve element opens the in-valve release passage 16'. Then, the crank chamber pressure Pc is released to the suction chamber 107 via two passages that are an in-compressor release passage 108 and the in-valve release passage 16' (for details, see Patent Document 2 below and the like).

RELATED ART DOCUMENTS

Patent Documents

[0010]

Patent Document 1: JP 2010-185285 A

Patent Document 2: JP 2013-130126 A

SUMMARY

[0011] By the way, in a variety of types of variable-capacity compressor control valves descried above, the entire valve body is typically produced from a material with high hardness, such as stainless steel, to suppress shaft misalignment between the valve orifice (valve seat portion) and a guide hole (sliding portion) into which the valve element is slidably fitted and inserted and thus ensure erosion resistance. In other words, the valve body is composed of a single part produced from a material with high hardness. Therefore, there have been problems in that the valve body is difficult to machine and the cost is increased.

[0012] The present invention has been made in view of the foregoing, and it is an object of the present invention to provide a variable-capacity compressor control valve where a valve body can be easily machined and the machining time and machining cost can be reduced without a decrease in the valve-closing property or a decrease in the slidability of the valve element due to shaft misalignment.

[0013] In order to achieve the aforementioned object, a variable-capacity compressor control valve in accordance with the present invention basically includes a valve body including a valve chamber with a valve orifice, a Ps inlet/outlet port communicating with a suction chamber of a compressor, a Pd introduction port arranged upstream of the valve orifice and communicating with a discharge chamber of the compressor, and a Pc inlet/outlet port arranged downstream of the valve orifice and communicating with a crank chamber of the compressor; a valve element adapted to open or close the valve orifice; an electromagnetic actuator with a plunger for moving the valve element in a direction to open or close the valve orifice; a pressure-sensitive chamber adapted to receive a suction pressure Ps from the compressor via the Ps inlet/outlet port; and a pressure-sensitive reaction member adapted to urge the valve element in the direction to open or close the valve orifice in accordance with a pressure in the pressure-sensitive chamber. The valve body includes a support member and a body member, the support member having formed therein the valve orifice and a guide hole into which the valve element is adapted to be slidably fitted and inserted, and the body member having formed therein the Ps inlet/outlet port, the Pd introduction port, and the Pc inlet/outlet port. The support member is fixedly inserted into a recess hole provided in the body member.

[0014] In a preferred aspect, the recess hole includes an upper large-diameter hole and a lower small-diameter hole, the support member includes a fit-insertion portion adapted to be inserted into the recess hole, the fit-insertion portion including an upper large-diameter portion and a lower small-diameter portion, and the support member is fixedly inserted into the recess hole in at least one of a posture in which the upper large-diameter portion is fitted into the upper large-diameter hole or a posture in which the lower small-diameter portion is fitted into the lower small-diameter hole.

[0015] In a further preferred aspect, the support member is fixedly inserted into the recess hole in a posture in which the upper large-diameter portion is fitted into the upper large-diameter hole and a gap is provided between an inner periphery of the lower small-diameter hole and an outer periphery of the lower small-diameter portion, the valve orifice is located below a lower end of the lower small-diameter portion, and the lower small-diameter portion has formed therein a horizontal hole communicating with the Pd introduction port of the body member via the gap.

[0016] In another preferred aspect, the control valve further includes a chip sealing portion between the body member and the support member, the chip sealing portion being adapted to seal chips of at least one of the body member or the support member.

[0017] The chip sealing portion is preferably defined by an annular protrusion provided on one of a bottom surface of the recess hole or an opposite surface of the support member that is opposite the bottom surface of the recess hole.

[0018] The chip sealing portion is preferably defined by an annular protrusion provided on one of an upward stepped surface of the recess hole that has a step formed thereon or an opposite surface of the support member that is opposite the upward stepped surface of the recess hole.

[0019] In a further preferred aspect, a tip end of the annular protrusion has an acute angle.

[0020] In another preferred aspect, each of an inner periphery of the recess hole and an outer periphery of the fit-insertion portion, which is adapted to be inserted into the recess hole, of the support member has a step formed thereon, and the chip sealing portion is defined by an annular inclined surface that is provided on a downward stepped surface of the fit-insertion portion such that the annular inclined surface abuts a corner on an inner side of an upward stepped surface of the recess hole.

[0021] The support member is preferably formed of a material with higher hardness than a material of the body member.

[0022] In a preferred aspect, the support member is formed of a stainless steel material, and the body member is formed of one of an aluminum material, a brass material, or a resin material.

[0023] According to the variable-capacity compressor control valve in accordance with the present invention, the valve body includes a support member having formed therein a valve orifice and a guide hole into which the valve element is adapted to be slidably fitted and inserted; and a body member having formed therein a Ps inlet/outlet port, a Pd introduction port, and a Pc inlet/outlet port. The support member is fixedly inserted into a recess hole provided in the body member. That is, as the valve body is composed of two parts that are the support member and the body member, it is possible to easily machine the valve body and effectively reduce the machining time and the machining cost without a decrease in the valve-closing property or a decrease in the slidability of the valve element due to shaft misalignment.

[0024] In such a case, as long as the support member is formed of a material with high hardness, such as a stainless steel material, while the body member is formed of a material with low hardness, such as an aluminum material, a brass material, or a resin material, it is possible to more effectively suppress a decrease in the valve-closing property and a decrease in the slidability of the valve element due to shaft misalignment, and machine the valve body more easily and also reduce the weight of the valve body.

[0025] Further, as a chip sealing portion for sealing chips of the body member and/or the support member is provided between the body member and the support member, it is possible to surely prevent operation failures, which would otherwise occur if chips (e.g., chips of the body member) that can be produced at the time of insertion (assembly) of the support member into the recess hole provided in the body member flow into the valve as the chips are sealed by the chip sealing portion, even when the body member and the support member are formed of different materials, for example (e.g., when the support member is formed of a material with high hardness, such as a stainless steel material, while the body member is formed of a material with low hardness, such as an aluminum material, a brass material, or a resin material).

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

FIG. 1 is a longitudinal sectional view showing the first embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time).

FIG. 2 is a longitudinal sectional view showing the first embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the closed position and the sub valve element is in the closed position (at the time of transition to compressor actuation).

FIG. 3 is a longitudinal sectional view showing the first embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the closed position and the sub valve element is in the open position (at the compressor actuation time).

FIGS. 4A to 4E are views each showing a plunger used for the variable-capacity compressor control valve in accordance with the present invention; specifically, FIG. 4A is a front view, FIG. 4B is a left-side view, FIG. 4C is a bottom view, FIG. 4D is a sectional view along the direction of the arrows X-X in FIG. 4A, and FIG. 4E is a sectional view along the direction of the arrows Y-Y in FIG. 4B.

FIG. 5 is an enlarged sectional view of the main part showing a variation of a chip sealing portion shown in FIG. 1.

FIG. 6 is a longitudinal sectional view showing the second embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time).

FIG. 7 is a longitudinal sectional view showing the second embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the closed position and the sub valve element is in the closed position (at the time of transition to compressor actuation).

FIG. 8 is a longitudinal sectional view showing the second embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the closed position and the sub valve element is in the open position (at the compressor actuation time).

FIGS. 9A and 9B are enlarged sectional views of the main part showing a variation of a chip sealing portion shown in FIG. 5.

FIG. 10 is a longitudinal sectional view showing the third embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time).

FIG. 11 is a view showing the circulation state of a refrigerant pressure between a compressor and a control valve of the first conventional art.

FIGS. 12A and 12B are views each showing the circulation state of a refrigerant pressure between a compressor and a control valve of the second conventional art; specifically, FIG. 12A is a view at the normal operation time and FIG. 12B is a view at the compressor actuation time.

DETAILED DESCRIPTION

[0027] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

<First Embodiment>

[0028] FIGS. 1 to 3 are longitudinal sectional views each showing the first embodiment of the variable-capacity compressor control valve in accordance with the present invention. Specifically, FIG. 1 is a view in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time), FIG. 2 is a view in which the main valve element is in the closed position and the sub valve element is in the closed position (at the time of transition to compressor actuation), and FIG. 3 is a view in which the main valve element is in the closed position and the sub valve element is in the open position (at the compressor actuation time).

[0029] It should be noted that in the present specification, descriptions indicating the positions or directions, such as upper, lower, top, bottom, left, right, front, and rear, are used for the sake of convenience in accordance with the drawings to avoid complexity in the description, but such descriptions do not necessarily indicate the actual positions or directions when the control valve of the present invention is incorporated into a compressor.

[0030] In addition, in each drawing, a gap formed between members, a clearance between members, and the like may be depicted larger or smaller than their actual dimensions to help understand the present invention and also for the sake of convenience to create the drawing.

[0031] A control valve 1 in the shown embodiment has a valve body 20 with a valve orifice 22; a valve element 10 with a main valve element 15 for opening or closing the valve orifice 22; an electromagnetic actuator 30 for moving the valve element 10 (main valve element 15) in the direction to open or close the valve orifice (in the vertical direction); and a bellows device 40 that serves as a pressure-sensitive reaction member.

[0032] The electromagnetic actuator 30 includes a bobbin 38, an energization coil 32 wound around the bobbin 38, a connector head 31 attached to the upper side of the bobbin 38 with an attachment plate 39 interposed therebetween, a stator 33 and an attractor 34 arranged on the inner peripheral side of the coil 32, a guide pipe 35 whose upper end portion is joined by welding to the outer periphery of the lower end portion (a step portion) of the stator 33 and the attractor 34, a plunger 37 having a recessed cross section and arranged vertically slidably on the inner peripheral side of the guide pipe 35 below the attractor 34, a cylindrical housing 60 externally arranged around the coil 32, and a holder 29 arranged between the lower end portion of the housing 60 and the guide pipe 35 and adapted to fix them to the top of the valve body 20. In the present example, the attractor 34 with a recessed cross section is integrally molded with the inner periphery of the bottom of the cylindrical stator 33. Herein, a portion of the electromagnetic actuator 30 including the coil 32, the stator 33, the attractor 34, and the like and excluding the plunger 37 is referred to as a solenoid portion 30A.

[0033] A stator 65 in a short columnar shape is attached to the top of the stator 33 by press fitting or the like, and a pressure-sensitive chamber 45, which receives a suction pressure Ps in a compressor 100, is formed between the stator 65 and the attractor 34 on the inner peripheral side of the stator 33. The pressure-sensitive chamber 45 has arranged therein the bellows device 40 that serves as a pressure-sensitive reaction member and includes bellows 41, an upper stopper 42 in an inverted projection shape, a lower stopper 43 in an inverted recessed shape, and a compression coil spring 44. Further, a top small-diameter portion 17d (an end portion on the side opposite to a sub valve element portion 17a) of a sub valve element 17 described below is fitted and inserted in and supported by the recess of the lower stopper 43, and a compression coil spring 46, which urges the bellows device 40 in the direction to contract the bellows device 40, is provided in a compressed state between the lower stopper 43 and the attractor 34.

[0034] The plunger 37 has a cylindrical upper half portion 37A and a columnar lower half portion 37B. Provided in the center of the columnar lower half portion 37B is an insertion hole 37b through which a waist portion 17b of the sub valve element 17 that extends downward through the attractor 34 and a top small-diameter portion 15f (described in detail below) of the main valve element 15 are inserted. The outer peripheral portion of the insertion hole 37b on the upper surface of the columnar lower half portion 37B serves as a latch portion 37a to which an intermediate large-diameter latch portion 17c of the sub valve element 17 is latched.

[0035] In addition, a plunger spring (valve opening spring) 47 constructed from a cylindrical compression coil spring, which urges the sub valve element 17 and the plunger 37 downward (in the direction to open the valve), is provided in a compressed state between the attractor 34 and the intermediate large-diameter latch portion 17c of the sub valve element 17 (plunger 37) so that the sub valve element 17 (or the intermediate large-diameter latch portion 17c thereof) is pressed against the plunger 37 by the plunger spring 47 and thus is caused to move up or down with the plunger 37.

[0036] Further, as can be understood well from FIGS. 4A to 4E, the bottom of the columnar lower half portion 37B of the plunger 37 (a portion that is above the lower end portion by a predetermined distance) has a cut-in 37t with an approximately semicircular shape in plan view (in the horizontal direction) that is formed so as to overlap the insertion hole 37b. On the side below the cut-in 37t (i.e., at a portion between the cut-in 37t and the lower end portion of the columnar lower half portion 37B), a slit 37s with approximately the same width as the hole diameter of the insertion hole 37b is formed that extends linearly from the edge portion at the lower end of the columnar lower half portion 37B to the insertion hole 37b. The height (in the vertical direction) of the cut-in 37t is slightly larger than the height of a flanged latch portion 15k of the main valve element 15, and the height (in the vertical direction) of the slit 37s is slightly smaller than the height of the top small-diameter portion 15f of the main valve element 15. The main valve element 15 is movable in the vertical direction with respect to the plunger 37 (which will be described in detail below). The width (in the horizontal direction) of the slit 37s is set slightly larger than the outside diameter of the top small-diameter portion 15f of the main valve element 15 and smaller than the outside diameter of the flanged latch portion 15k of the main valve element 15 taking into consideration the assembling properties and the like.

[0037] The valve element 10 has the main valve element 15 and the sub valve element 17 arranged in the vertical direction (along the direction of the axial line O).

[0038] The main valve element 15 arranged on the lower side has, sequentially arranged from the bottom side, a bottom fit-insertion portion 15b, a lower small-diameter portion 15c, a main valve element portion 15a, an intermediate small-diameter portion 15d, a top fit-insertion portion 15e, the top small-diameter portion 15f, and the flanged latch portion 15k. A stepped release through-hole 16A forming part of an in-valve release passage 16 is provided in the center of the main valve element 15 such that it penetrates the center of the main valve element 15 in the vertical direction, and the upper end portion of the release through-hole 16A serves as a sub valve seat portion 23 with/from which the lower end portion (sub valve element portion) 17a of the sub valve element 17 is moved into contact or away. The intermediate small-diameter portion 15d of the main valve element 15 has a plurality of horizontal holes 16s.

[0039] The top small-diameter portion 15f of the main valve element 15 is loosely fitted in the insertion hole 37b (or a portion below the cut-in 37t thereof), and the flanged latch portion 15k of the main valve element 15 has a larger diameter than that of the insertion hole 37b so that when the plunger 37 is moved upward with respect to the main valve element 15, the flanged latch portion 15k is lathed to an inner flanged latch portion 37k that is formed by the outer peripheral portion of the insertion hole 37b, and thus, latching is achieved and slippage is prevented.

[0040] The sub valve element 17 arranged above the main valve element 15 has, sequentially arranged from the bottom side, an inverted conical tapered portion 17a, which is moved into contact with or away from the sub valve seat portion 23 that is the edge portion at the upper end of the release through-hole 16A, the waist portion 17b having the intermediate large-diameter latch portion 17c formed thereon, a truncated conical portion 17e, and a top small-diameter portion 17d that is inserted in and supported by the recess of the lower stopper 43. The tapered portion 17a serves as the sub valve element portion that opens or closes the in-valve release passage 16. Herein, the sub valve seat portion 23 and the sub valve element portion 17a form the sub valve unit 12. In the present example, a portion below the intermediate large-diameter latch portion 17c of the waist portion 17 is inserted into the insertion hole 37b of the plunger 37 with a small gap therebetween, and a portion above the intermediate large-diameter latch portion 17c and below the attractor (a portion arranged inside the cylindrical upper half portion 37A) has a slightly larger diameter than those of the other portions.

[0041] The dimensions and the shape of each part around the sub valve element 17 (e.g., a gap between the waist portion 17b and the insertion hole 37b) are designed such that even when the sub valve element 17 is slightly tilted at a position where it has been moved upward with respect to the main valve element 15 (i.e., a position where the in-valve release passage 16 is open), the lower end portion of the sub valve element portion (a tapered portion) 17a in an inverted conical shape enters the release through-hole 16A, and the sub valve element 17 is thus aligned with the main valve element 15 by the sub valve element portion 17a as the sub valve element 17 moves closer to the main valve element 15 (i.e., when the sub valve element 17 closes the in-valve release passage 16). More specifically, the dimensions and the shape of each part are designed such that part of the sub valve element portion 17a in an inverted conical shape is located in the release through-hole 16A when the sub valve element 17 is at the highest elevated position with respect to the main valve element 15 (see FIG. 3, in particular).

[0042] When the valve element 10 (the main valve element 15 and the sub valve element 17) and the plunger 37 are assembled, for example, the main valve element 15 is moved horizontally with respect to the plunger 37 so that the flanged latch portion 15k and the top small-diameter portion 15f of the main valve element 15, which has been assembled in advance to the valve body 20 (or a guide hole 19 thereof), are inserted into the cut-in 37t and the slit 37s of the plunger 37, respectively, and the top small-diameter portion 15f is fitted and inserted into the insertion hole 37b provided in the center of the plunger 37, and thereafter, the sub valve element 17 (or a portion below the intermediate large-diameter latch portion 17c thereof) may be inserted into the insertion hole 37b from above.

[0043] Meanwhile, the valve body 20 has a two-split structure that includes a body member 20A having a fit recess hole 20C in the center at the top thereof, and a support member 20B that is fixedly inserted into the recess hole 20C by press fitting or the like.

[0044] The support member 20B is produced from a material with relatively high hardness, such as stainless steel (SUS), and has a protruding stopper portion 24A for defining the lowest position of the plunger 37, on the upper side of a fit-insertion portion 24 that is fitted and inserted in the recess hole 20C. In addition, the guide hole 19 (an upper guide hole 19A) into which the top fit-insertion portion 15e of the main valve element 15 is slidably fitted and inserted is formed in the center of the support member 20B such that it penetrates the support member 20B in the vertical direction, and the lower end portion of the upper guide hole 19A serves as the valve orifice 22 (a valve seat portion) that is opened or closed by the main valve element portion 15a of the main valve element 15. Herein, the main valve element portion 15a and the valve orifice 22 form a main valve unit 11. As the support member 20B is produced from a material with high hardness, such as stainless steel, as described above, the specific gravity of the support member 20B is also high.

[0045] The body member 20A is produced from a material, such as aluminum, brass, or resin, that has relatively low specific gravity (a material with relatively low hardness) as compared to stainless steel and the like. An inlet/outlet chamber 28 for the suction pressure Ps in the compressor 100 is formed around the outer periphery of the stopper portion 24A, and a plurality of Ps inlet/outlet ports 27 are formed around the outer peripheral side of the inlet/outlet chamber 28 in a state in which the support member 20B (or the fit-insertion portion 24 thereof) is inserted in the recess hole 20C of the body member 20A. The suction pressure Ps introduced into the inlet/outlet chamber 28 from the Ps inlet/outlet ports 27 is introduced into the pressure-sensitive chamber 45 via the slit 37s and the cut-in 37t formed at the bottom of the plunger 37, a gap formed between the waist portion 17b of the sub valve element 17 and the insertion hole 37b of the plunger 37, a gap 36 formed between the outer periphery of the plunger 37 and the guide pipe 35, and the like.

[0046] A reception hole 18, which has a larger diameter than those of the guide hole 19 and the main valve element portion 15a and has a smaller diameter than that of the recess hole 20C and is adapted to store the main valve element portion 15a of the main valve element 15, is provided continuously with the center of the bottom of the recess hole 20C of the body member 20A, and the guide hole 19 (a lower guide hole 19B) into which the bottom fit-insertion portion 15b of the main valve element 15 is slidably fitted and inserted is formed in the center of the bottom of the reception hole 18. A valve closing spring 50 constructed form a conical compression coil spring is provided in a compressed state between the corner on the outer periphery of the bottom of the reception hole 18 and a stepped portion (terrace portion) 15g provided on the outer periphery of the bottom of the main valve element portion 15a of the main valve element 15. Thus, with the urging force of the valve closing spring 50, the main valve element 15 (or a step portion between the top fit-insertion portion 15e and the top small-diameter portion 15f thereof) is pressed against the plunger 37.

[0047] The inside of the reception hole 18 (a portion below the valve orifice 22 of the support member 20B) is the valve chamber 21. The valve chamber 21 has a plurality of Pd introduction ports 25 communicating with a discharge chamber 106 of the compressor 100. A ring-like filter member 25A is arranged around the outer periphery of the Pd introduction ports 25 of the body member 20A.

[0048] The lower end portion of the body member 20A has a lid-like member 48, which functions as a filter, fixed thereto by engagement, press fitting, or the like. A Pc inlet/outlet chamber (inlet/outlet port) 26, which communicates with a crank chamber 104 of the compressor 100, is provided on the side above the lid-like member 48 below the main valve element 15. The Pc inlet/outlet chamber (inlet/outlet port) 26 communicates with the Pd introduction ports 25 via the release through-hole 16A → the horizontal holes 16s → a gap between the bottom of the upper guide hole 19A and the intermediate small-diameter portion 15d → a gap between the valve orifice 22 and the main valve element portion 15a → the valve chamber 21.

[0049] In this embodiment, as shown in the enlarged view of FIG. 1, a chip sealing portion (pocket portion) 20P for sealing chips (in particular, chips of the body member 20A with relatively low hardness) that can be produced during assembly of the body member 20A and the support member 20B is provided between the body member 20A and the support member 20B of the valve body 20.

[0050] Specifically, an annular protrusion 24B with an acute-angled tip end is provided in a protruding manner on the bottom surface (opposite surface) of the support member 20B (or the fit-insertion portion 24 thereof) that is opposite the bottom surface of the recess hole 20C. Thus, when the fit-insertion portion 24 is inserted into the recess hole 20C, the annular protrusion 24B is made to abut the bottom surface of the recess hole 20C (in this case, part of the annular protrusion 24B digs into the bottom surface of the recess hole 20C as the annular protrusion 24B is harder than the bottom surface of the recess hole 20C). Therefore, chips (in particular, chips of the body member 20A with relatively low hardness) that are produced upon sliding of the recess hole 20C (or the inner wall surface thereof) and the fit-insertion portion 24 (or the outer peripheral surface thereof) with respect to each other during assembly are stored in and sealed by the chip sealing portion 20P that is defined by the annular protrusion 24B and the corner on the outer periphery of the bottom of the recess hole 20C.

[0051] Although FIG. 1 shows an example in which the annular protrusion 24B that defines the chip sealing portion 20P is formed on the fit-insertion portion 24 of the support member 20B, it is also possible to form an annular protrusion 20D that defines the chip sealing portion 20P on the bottom surface of the recess hole 20C of the body member 20A (or the inner edge of the bottom surface in the shown example) as shown in FIG. 5, for example. In such case, as the annular protrusion 20D is softer than the bottom surface of the fit-insertion portion 24, the annular protrusion 20D is made to abut the bottom surface of the fit-insertion portion 24 in a state in which part (the tip end portion) of the annular protrusion 20D is bent, and the chip sealing portion 20P is defined by the annular protrusion 20D and the corner on the outer periphery of the bottom of the recess hole 20C.

[0052] In addition, in this embodiment, the in-valve release passage 16 for releasing the pressure Pc in the crank chamber 104 to a suction chamber 107 of the compressor 100 via the Ps inlet/outlet ports 27 is formed by the release through-hole 16A formed in the main valve element 15, the cut-in 37t and the slit 37s provided in the plunger 37, the inlet/outlet chamber 28, and the like. The in-valve release passage 16 is adapted to be opened or closed as the sub valve element portion 17a of the sub valve element 17 is moved into contact with or away from the sub valve seat portion 23 that is the upper end portion of the release through-hole 16A of the main valve element 15.

[0053] Herein, in the control valve 1 in this embodiment, when the plunger 37, the main valve element 15, and the sub valve element 17 are at the lowest position (when the bottom end surface of the plunger 37 abuts the stopper portion 24A, the main valve unit 11 is in the fully open position, and the sub valve unit 12 is in the fully closed position) as shown in FIG. 1, the clearance in the vertical direction between the main valve element portion 15a of the main valve element 15 and the valve orifice 22 (valve seat portion) is represented by a first lift amount Lv, and the clearance between the inner flanged latch portion 37k of the plunger 37 and the flanged latch portion 15k of the main valve element 15 is represented by a predetermined amount La. The maximum lift amount (second lift amount) Lp of the plunger 37 (the lift amount of from the lowest position to the highest position of the plunger 37) corresponds to the first lift amount Lv + the predetermined amount La.

[0054] Next, the operation of the control valve 1 with the aforementioned configuration will be generally described.

[0055] At the normal control time (Pd $\rightarrow$ Pc control time), the lift amount of the plunger 37 is slightly greater than the first lift amount Lv at the maximum, and at the compressor actuation time (Pc $\rightarrow$ Ps control time), the lift amount of the plunger 37 is the second lift amount Lp.

[0056] That is, at the normal control time (Pd $\rightarrow$ Pc control time), when the solenoid portion 30A including the coil 32, the stator 33, the attractor 34, and the like is supplied with current and energized, the plunger 37 is attracted by the attractor 34, and along with this, the intermediate large-diameter latch portion 17c of the sub valve element 17 is latched to the latch portion 37a of the plunger 37. Thus, the sub valve element 17 moves upward integrally with the plunger 37, and following the movement of the sub valve element 17, the main valve element 15 is moved upward (in the direction to close the valve) by the urging force of the valve closing spring 50. Meanwhile, the suction pressure Ps introduced into the Ps inlet/outlet ports 27 from the compressor 100 is introduced into the pressure-sensitive chamber 45 from the inlet/outlet chamber 28 via the slit 37s and the cut-in 37t of the plunger 37 and the like, and the bellows device 40 (the inside thereof is at a vacuum pressure) is expansively or contractively displaced in accordance with the pressure (suction pressure Ps) in the pressure-sensitive chamber 45 (contracts if the suction pressure Ps is high, and expands if it is low), and the displacement is then transmitted to the main valve element 15 via the plunger 37 and the sub valve element 17, whereby the valve opening (the clearance between the valve orifice 22 and the main valve element portion 15a) is regulated, and the pressure Pc in the crank chamber 104 is controlled in accordance with the valve opening. Along with this, the inclination angle of the swash plate 102 and the stroke of the piston 105 in the compressor 100 are controlled to increase or decrease the discharge capacity.

[0057] In this case, the main valve element 15 is always urged upward by the urging force of the valve closing spring 50, while the sub valve element 17 is always urged downward by the urging force of the valve opening spring 47. Therefore, the sub valve element portion 17a is in a state of being pressed against the sub valve seat portion 23 (the sub valve unit 12 is closed), and the in-valve release passage 16 is blocked in the main valve element 15. Therefore, there is no possibility that the crank chamber pressure Pc may be released to the suction chamber 107 via the in-valve release passage 16.

[0058] In contrast, at the compressor actuation time, the solenoid portion 30A is supplied with current and energized, and the plunger 37 is attracted by the attractor 34 so that the sub valve element 17 moves upward together with the plunger 37. Following such vertical movement of the sub valve element 17, the main valve element 15 is also moved upward and the valve orifice 22 is closed by the main valve element portion 15a of the main valve element 15. After that, the plunger 37 is further moved upward, whereby the sub valve element 17 is caused to open the in-valve release passage 16. Thus, the pressure Pc in the crank chamber 104 is released into the suction chamber 107 via two passages that are an in-compressor release passage 108 and the in-valve release passage 16.

[0059] Specifically, until the upward movement amount of the plunger 37 reaches the first lift amount Lv, the main valve element 15 moves in the direction to close the valve such that it follows the upward movement of the plunger 37 and the sub valve element 17 by the urging force of the valve closing spring 50. Then, when the upward movement amount reaches the first lift amount Lv, the valve orifice 20 is closed by the main valve element portion 15a of the main valve element 15 (the state shown in FIG. 2), and the plunger 37 is further moved upward by the predetermined amount La with the main valve unit 11 in the closed valve state (the state shown in FIG. 3). In other words, after the upward movement amount of the plunger 37 has reached the first lift amount Lv, the sub valve element 17 is elevated by the predetermined amount La until the inner flanged latch portion 37k of the plunger 37 is latched to the flanged latch portion 15k of the main valve element 15 (the first lift amount Lv + the predetermined amount La = the second lift amount Lp). In such a case, the main valve element 15 remains still in the closed valve state. Thus, the sub valve element portion 17a of the sub valve element 17 is lifted from the sub valve seat portion 23 by the predetermined amount La, whereby the in-valve release passage 16 is opened. When the inner flanged latch portion 37k of the plunger 37 is latched to the flanged latch portion 15k of the main valve element 15, neither the plunger 37 nor the sub valve element 17 is lifted any further even if the solenoid portion 30A generates an attraction force.

[0060] As described above, in the control valve 1 in this embodiment, the valve body 20 includes a support member 20B having formed therein the valve orifice 22 and the guide hole 19 into which the valve element 10 is slidably fitted and inserted; and the body member 20A having formed therein the Ps inlet/outlet ports 27, the Pd introduction ports 25, and the Pc inlet/outlet port 26. The support member 20B is fixedly inserted into the recess hole 20C provided in the body member 20A. That is, as the valve body 20 is composed of two parts that are the support member 20B and the body member 20A, it is possible to easily machine the valve body 20 and effectively reduce the machining time and the machining cost without a decrease in the valve closing property or a decrease in the slidability of the valve element 10 due to shaft misalignment.

[0061] In addition, as the support member 20B is formed of a material with high hardness, such as a stainless steel material, while the body member 20A is formed of a material with low hardness, such as an aluminum material, a brass material, or a resin material, it is possible to more effectively suppress a decrease in the valve closing property or a decrease in the slidability of the valve element 10 due to shaft misalignment, and further facilitate the machining of the valve body 20 and reduce the weight of the valve body 20.

[0062] In addition, as the chip sealing portion 20P for sealing chips of the body member 20A and/or the support member 20B is provided between the body member 20A and the support member 20B, it is possible to surely prevent operation failures, which would otherwise occur if chips (e.g., chips of the body member 20A) that can be produced at the time of insertion (assembly) of the support member 20B into the recess hole 20C provided in the body member 20A flow into the valve as the chips are sealed by the chip sealing portion 20P, even when the support member 20B is formed of a material with high hardness, such as a stainless steel material, and the body member 20A is formed of a material with low hardness, such as an aluminum material, a brass material, or a resin material, for example.

<Second Embodiment>

[0063] FIGS. 6 to 8 are longitudinal sectional views each showing the second embodiment of the variable-capacity compressor control valve in accordance with the present invention. Specifically, FIG. 6 is a view in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time); FIG. 7 is a view in which the main valve element is in the closed position and the sub valve element is in the closed position (at the time of transition to compressor actuation), and FIG. 8 is a view in which the main valve element is in the closed position and the sub valve element is in the open position (at the compressor actuation time).

[0064] The control valve 2 in the second embodiment basically differs from the control valve 1 in the aforementioned first embodiment only in the configurations of the valve body and the main valve element of the valve element. Thus, configurations with the same functions as those in the first embodiment are denoted by the same reference numerals and the detailed description thereof will thus be omitted. Hereinafter, only the differences will be discussed in detail.

[0065] In the control valve 2 in this embodiment, the top fit-insertion portion 15e and the intermediate small-diameter portion 15d of the main valve element 15 are formed longer than those of the control valve 1 in the first embodiment, while the lower small-diameter portion 15c and the bottom fit-insertion portion 15b on the lower side of the main valve element portion 15a are omitted.

[0066] In addition, the fit-insertion portion 24 of the support member 20B of the valve body 20 has a step formed thereon, and at a position below an upper large-diameter portion 24a (an outer shape corresponding to the fit-insertion portion 24 in the first embodiment), a lower small-diameter portion 24b, which is longer than the upper large-diameter portion 24a in the vertical direction, is provided, and at a lower end of the lower small-diameter portion 24b, a flanged abutment portion 24c adapted to abut the stepped portion (terrace portion) between the recess hole 20C and the reception hole 18 of the body member 20A is provided such that it protrudes outward.

[0067] Meanwhile, the recess hole 20C of the body member 20A of the valve body 20 also has a step formed thereon, and has an upper large-diameter hole 20Ca (an outer shape corresponding to the recess hole 20C in the first embodiment) into which the upper large-diameter portion 24a is fitted and inserted, and a lower small-diameter hole 20Cb into which the lower small-diameter portion 24b is fitted and inserted, and further has a stepped reception hole 18 for storing the main valve element portion 15a of the main valve element 15 in a manner continuous with the center of the bottom of the lower small-diameter hole 20Cb. A valve closing spring 50 constructed from a conical compression coil spring is provided in a compressed state between the stepped portion provided on the inner periphery of the reception hole 18 and the stepped portion (terrace portion) 15g provided on the outer periphery of the bottom of the main valve element portion 15a of the main valve element 15.

[0068] The inside of the reception hole 18 (a portion below the valve orifice 22 of the support member 20B) is the valve chamber 21. Herein, the lower small-diameter hole 20Cb in the recess hole 20C has a plurality of Pd introduction ports 25 communicating with the discharge chamber 106 of the compressor 100. A ring-like filter member 25A is arranged around the outer periphery of the Pd introduction ports 25 thereof, and the lower small-diameter portion 24b of the fit-insertion portion 24 (instead of the intermediate small-diameter portion 15d of the main valve element 15) has a plurality of horizontal holes 25a communicating with the Pd introduction ports 25. The Pc inlet/outlet chamber (inlet/outlet port) 26, which communicates with the crank chamber 104 of the compressor 100, communicates with the Pd introduction ports 25 via the valve chamber 21 $\rightarrow$ a gap between the valve orifice 22 and the main valve element portion 15a $\rightarrow$ a gap between the bottom of the guide hole 19 (upper guide hole 19A) and the intermediate small-diameter portion 15d $\rightarrow$ the horizontal holes 25 in the lower small-diameter portion 24b$\rightarrow$ a gap between the lower small-diameter portion 24b and the lower small-diameter hole

20Cb (which will be discussed in detail below).

[0069] In addition, in this embodiment, the outer periphery of the upper large-diameter portion 24a abuts the inner periphery of the upper large-diameter hole 20Ca (that is, the upper large-diameter portion 24a is fitted into (fits snugly inside) the upper large-diameter hole 20Ca), and the support member 20B is fixedly inserted into the recess hole 20C of the body member 20A in a posture in which a small gap is provided between the outer periphery of the lower small-diameter portion 24b and the inner periphery of the lower small-diameter hole 20Cb. In addition, as shown in the enlarged view of FIG. 6, an annular protrusion 24B with an acute-angled tip end is provided in a protruding manner on the bottom surface (opposite surface) of the upper large-diameter portion 24a that is opposite the stepped portion (upward stepped surface) between the upper large-diameter hole 20Ca and the lower small-diameter hole 20Cb. Chips that are produced upon sliding of the recess hole 20C (or the inner wall surface of the upper large-diameter hole 20Ca thereof) and the fit-insertion portion 24 (or the outer peripheral surface of the upper large-diameter portion 24a thereof) with respect to each other during assembly (in particular, chips of the body member 20A with relatively low hardness) are stored in and sealed by the chip sealing portion 20P that is defined by the annular protrusion 24B and the corner on the outer periphery of the bottom of the upper large-diameter hole 20Ca.

[0070] Although FIG. 6 shows an example in which the annular protrusion 24B that defines the chip sealing portion 20P is formed on the upper large-diameter portion 24a of the fit-insertion portion 24 of the support member 20B, it is also possible to form an annular protrusion 24D that defines the chip sealing portion 20P on the upward stepped surface of the recess hole 20C of the body member 20A as shown in FIG. 9A, for example (at the inner edge of the stepped surface in the shown example). Alternatively, as shown in FIG. 9B, for example, it is also possible to, by forming an annular inclined surface 24C at the inner edge of the stepped portion (downward stepped surface) of the fit-insertion portion 24 that has a step formed thereon (between the upper large-diameter portion 24a and the lower small-diameter portion 24b), and causing the annular inclined surface 24C to abut the corner on the inner side of the stepped portion (upward stepped surface) of the recess hole 20C, define the chip sealing portion 20P by the annular inclined surface 24C and the corner on the outer periphery of the bottom of the upper large-diameter hole 20Ca of the recess hole 20C.

[0071] Though not shown, if the outer periphery of the lower small-diameter portion 24b of the fit-insertion portion 24 (the outer periphery of the flanged abutment portion 24c in the shown example) abuts the inner periphery of the lower small-diameter hole 20Cb of the recess hole 20C (that is, if the lower small-diameter portion 24b is fitted into (fits snugly inside) the lower small-diameter hole 20Cb), it is obviously possible to form an annular protrusion that defines the chip sealing portion 20P on the bottom surface of the recess hole 20C (or the lower small-diameter portion 20Cb thereof) or the bottom surface (opposite surface) of the lower small-diameter portion 24b of the support member 20B that is opposite the bottom surface of the recess hole 20C.

[0072] Needless to say, the control valve 2 in the second embodiment with the aforementioned configuration can also obtain operational effects that are similar to those of the control valve 1 in the first embodiment.

<Third Embodiment>

[0073] FIG. 10 is a longitudinal sectional view showing the third embodiment of the variable-capacity compressor control valve in accordance with the present invention in which the main valve element is in the open position and the sub valve element is in the closed position (at the normal control time).

[0074] The control valve 3 in the third embodiment basically differs from the control valve 2 in the second embodiment only in the configuration of the valve element. It should be noted that in the control valve 3 in the third embodiment, the other configurations (e.g., the configuration of the electromagnetic actuator) also differ from those of the control valve 2 in the aforementioned second embodiment. However, to avoid complexity of the description, configurations with the same functions as those in the second embodiment are denoted by the same reference numerals and the detailed description thereof will thus be omitted (for the detailed structure, see also Patent Document 1, for example). Hereinafter, only the differences will be discussed in detail.

[0075] In the control valve 3 in the third embodiment, the main valve element 15 and the sub valve element 17 of the valve element 10 are integrally formed, the release through-hole in the main valve element 15 (and the in-valve release passage accordingly) is omitted, and the valve element 10 engages with the plunger 37 such that the valve element 10 is vertically immovable with respect to the plunger 37. When the plunger is moved upward (in the valve-closing direction) upon energization of the solenoid portion 30A of the electromagnetic actuator 30, the inner flanged latch portion 37k provided at the bottom of the plunger 37 engages with the flanged latch portion 15k of the valve element 10 provided above the inner flanged latch portion 37k, whereby the valve element 10 is moved together with the plunger 37. It should be noted that for the operation and function of the control valve 3, see also Patent Document 1, for example.

[0076] Although the control valve 3 in the third embodiment with the aforementioned configuration cannot obtain operational effects with the function of the in-valve release passage, it is obviously possible to obtain operational effects that are similar to those of the control valves 1 and 2 in the aforementioned first and second embodiments.

DESCRIPTION OF SYMBOLS

[0077]

1	Variable-capacity compressor control valve (first embodiment)
2	Variable-capacity compressor control valve (second embodiment)
3	Variable-capacity compressor control valve (third embodiment)
10	Valve element
11	Main valve unit
12	Sub valve unit
15	Main valve element
15a	Main valve element portion
15k	Flanged latch portion
16	In-valve release passage
17	Sub valve element
17a	Sub valve element portion (tapered portion)
19	Guide hole
19A	Upper guide hole
19B	Lower guide hole
20	Valve body
20A	Body member
20B	Support member
20C	Recess hole
20P	Chip sealing portion
21	Valve chamber
22	Valve orifice
23	Sub valve seat portion
25	Pd introduction port
26	Pc inlet/outlet port
27	Ps inlet/outlet port
30	Electromagnetic actuator
30A	Solenoid portion
37	Plunger
37k	Inner flanged latch portion
37s	Slit
37t	Cut-in
40	Bellows device (pressure-sensitive reaction member)
45	Pressure-sensitive chamber
50	Valve closing spring
Lv	First lift amount
La	Predetermined amount
Lp	Second lift amount

Claims

1. A variable-capacity compressor control valve comprising:

a valve body including a valve chamber with a valve orifice, a Ps inlet/outlet port communicating with a suction chamber of a compressor, a Pd introduction port arranged upstream of the valve orifice and communicating with a discharge chamber of the compressor, and a Pc inlet/outlet port arranged downstream of the valve orifice and communicating with a crank chamber of the compressor;

a valve element adapted to open or close the valve orifice;

an electromagnetic actuator with a plunger for moving the valve element in a direction to open or close the valve orifice;

a pressure-sensitive chamber adapted to receive a suction pressure Ps from the compressor via the Ps inlet/outlet port; and

a pressure-sensitive reaction member adapted to urge the valve element in the direction to open or close the valve orifice in accordance with a pressure in the pressure-sensitive chamber, wherein

the valve body includes a support member and a body member, the support member having formed therein the valve orifice and a guide hole into which the valve element is adapted to be slidably fitted and inserted, and the body member having formed therein the Ps inlet/outlet port, the Pd introduction port, and the Pc inlet/outlet port, and

the support member is fixedly inserted into a recess hole provided in the body member.

2. The variable-capacity compressor control valve according to claim 1, wherein

the recess hole includes an upper large-diameter hole and a lower small-diameter hole,

the support member includes a fit-insertion portion adapted to be inserted into the recess hole, the fit-insertion portion including an upper large-diameter portion and a lower small-diameter portion, and

the support member is fixedly inserted into the recess hole in at least one of a posture in which the upper large-diameter portion is fitted into the upper large-diameter hole or a posture in which the lower small-diameter portion is fitted into the lower small-diameter hole.

3. The variable-capacity compressor control valve according to claim 2, wherein

the support member is fixedly inserted into the recess hole in a posture in which the upper large-diameter portion is fitted into the upper large-diameter hole and a gap is provided between an inner periphery of the lower small-diameter hole and an outer periphery of the lower small-diameter portion, and

the valve orifice is located below a lower end of the lower small-diameter portion, and the lower small-diameter portion has formed therein a horizontal hole communicating with the Pd introduction port of the body member via the gap.

4. The variable-capacity compressor control valve according to claim 1, further comprising a chip sealing portion between the body member and the support member, the chip sealing portion being adapted to seal chips of at least one of the body member or the support member.

5. The variable-capacity compressor control valve according to claim 4, wherein the chip sealing portion is defined by an annular protrusion provided on one of a bottom surface of the recess hole or an opposite surface of the support member that is opposite the bottom surface of the recess hole.

6. The variable-capacity compressor control valve according to claim 4, wherein the chip sealing portion is defined by an annular protrusion provided on one of an upward stepped surface of the recess hole that has a step formed thereon or an opposite surface of the support member that is opposite the upward stepped surface of the recess hole.

7. The variable-capacity compressor control valve according to claim 5 or 6, wherein a tip end of the annular protrusion has an acute angle.

8. The variable-capacity compressor control valve according to claim 4, wherein

each of an inner periphery of the recess hole and an outer periphery of the fit-insertion portion, which is adapted to be inserted into the recess hole, of the support member has a step formed thereon, and
the chip sealing portion is defined by an annular inclined surface that is provided on a downward stepped surface of the fit-insertion portion such that the annular inclined surface abuts a corner on an inner side of an upward stepped surface of the recess hole.

9. The variable-capacity compressor control valve according to any one of claims 1 to 8, wherein the support member is formed of a material with higher hardness than a material of the body member.

10. The variable-capacity compressor control valve according to claim 9, wherein

the support member is formed of a stainless steel material, and
the body member is formed of one of an aluminum material, a brass material, or a resin material.

FIG. 1

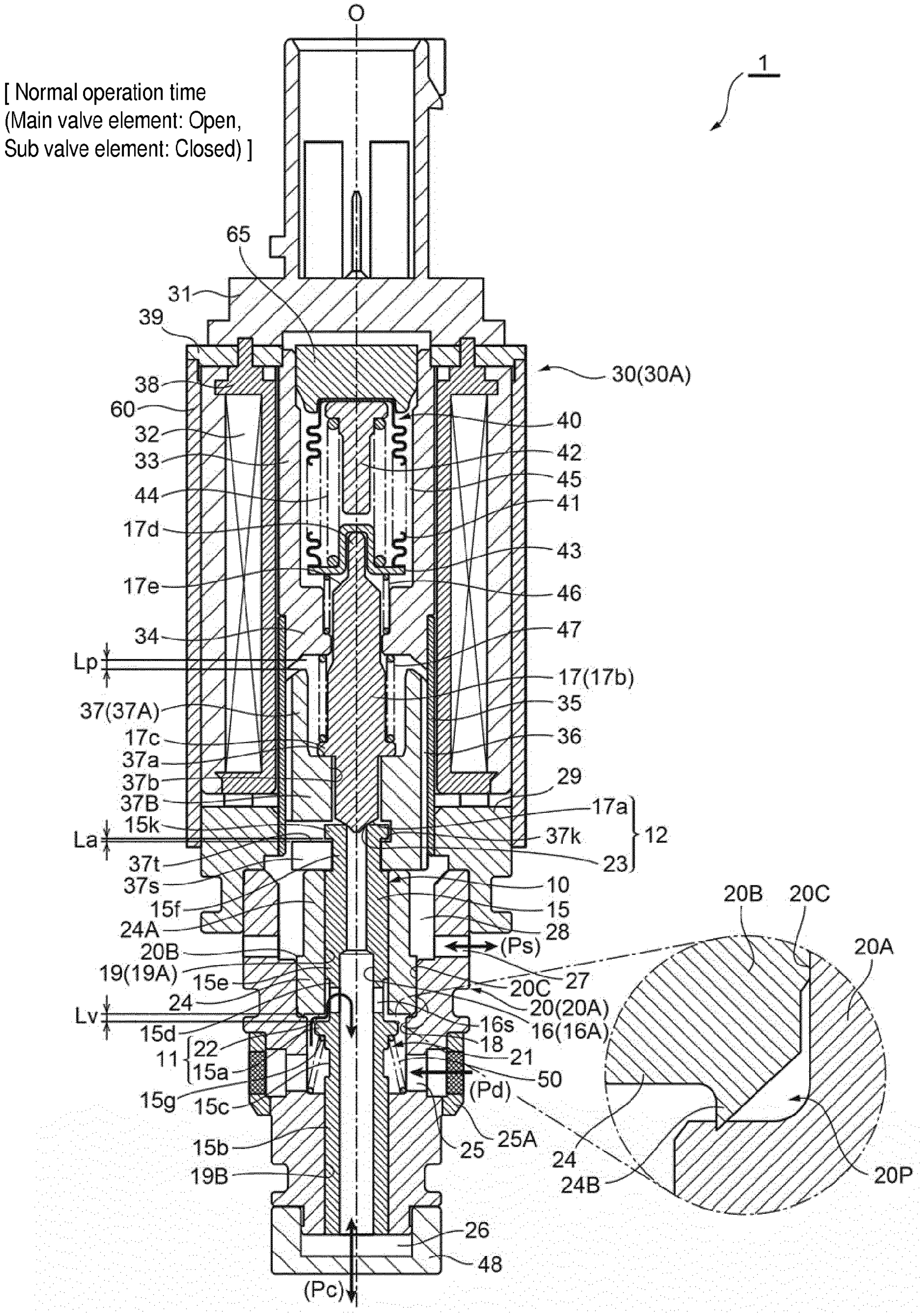

[Normal operation time
(Main valve element: Open,
Sub valve element: Closed)]
O
1
65
31
39
38
60
32
33
44
17d
17e
34
Lp
37(37A)
17c
37a
37b
37B
15k
La
37t
37s
15f
24A
20B
19(19A)
15e
24
Lv
15d
11
22
15a
15g
15c
15b
19B
(Pc)
30(30A)
40
42
45
41
43
46
47
17(17b)
35
36
29
17a
12
37k
23
10
15
28
(Ps)
27
20C
20(20A)
16s
16(16A)
18
21
50
(Pd)
25A
25
26
48
20B
20C
20A
24
24B
20P

FIG. 2

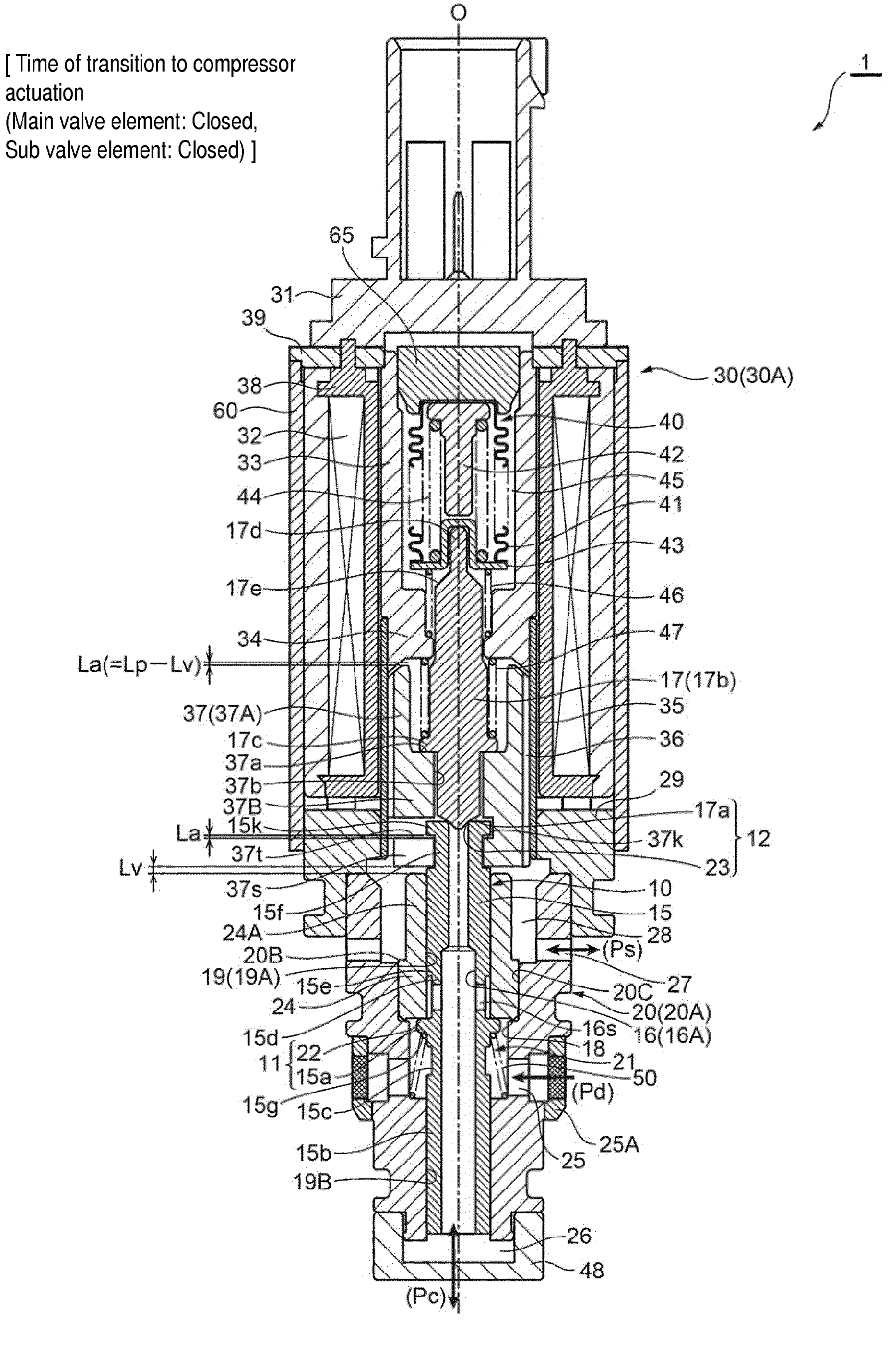

[Time of transition to compressor
actuation
(Main valve element: Closed,
Sub valve element: Closed)]
O
1
65
31
39
38
60
32
33
44
17d
17e
34
La(=Lp−Lv)
37(37A)
17c
37a
37b
37B
15k
La
37t
Lv
37s
15f
24A
20B
19(19A)
15e
24
15d
22
11
15a
15g
15c
15b
19B
(Pc)
30(30A)
40
42
45
41
43
46
47
17(17b)
35
36
29
17a
37k
12
23
10
15
28
(Ps)
27
20C
20(20A)
16s
16(16A)
18
21
50
(Pd)
25A
25
26
48

FIG. 3

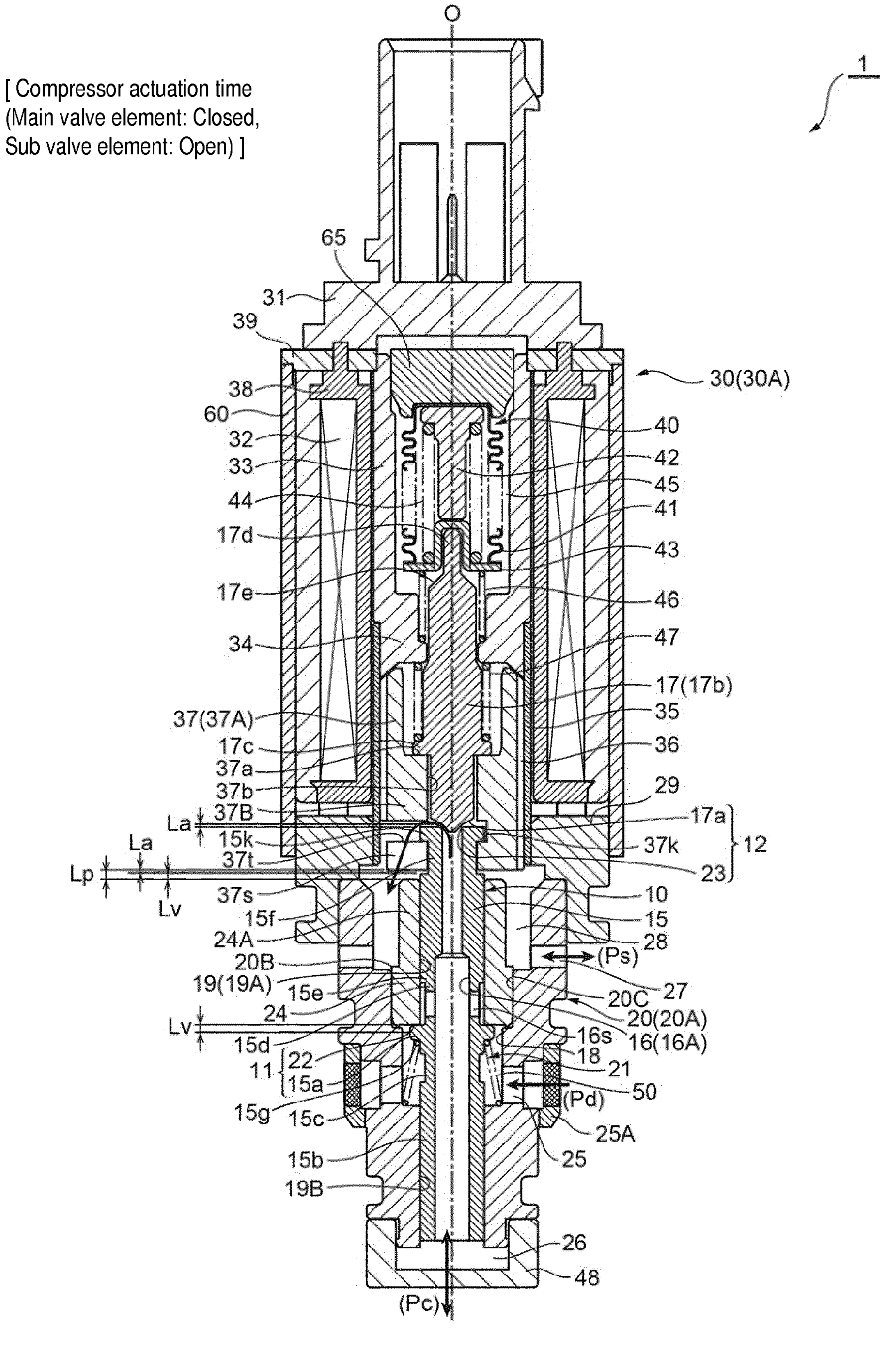

[Compressor actuation time
(Main valve element: Closed,
Sub valve element: Open)]
O
1
65
31
39
30(30A)
38
60
32
33
44
17d
17e
34
40
42
45
41
43
46
47
17(17b)
35
36
37(37A)
17c
37a
37b
37B
29
La
15k
37t
La
Lp
Lv
37s
15f
24A
17a
37k
12
23
10
15
28
(Ps)
20B
19(19A)
15e
24
27
20C
20(20A)
Lv
15d
16s
16(16A)
18
11
22
15a
21
50
(Pd)
15g
15c
25A
25
15b
19B
26
48
(Pc)

FIG. 4A

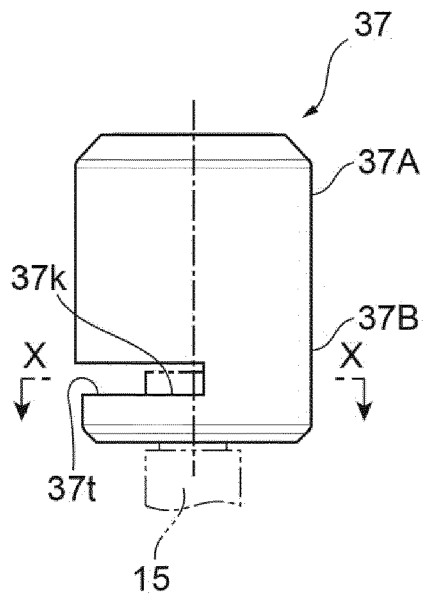


FIG. 4B

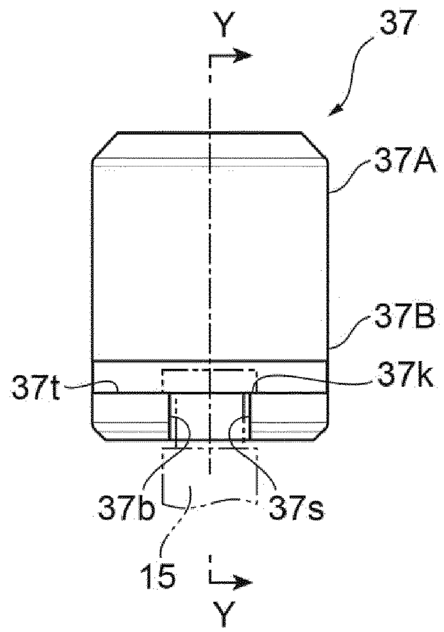


FIG. 4C

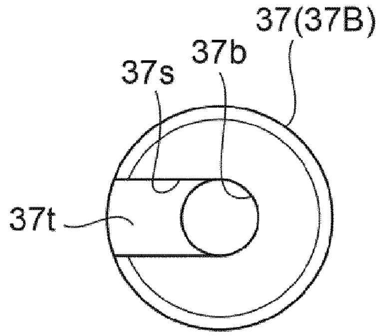
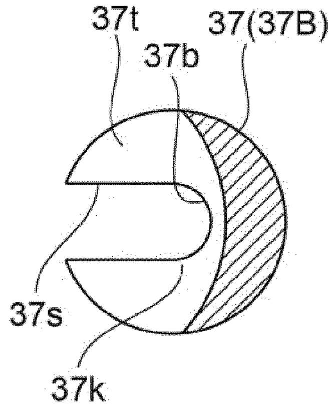
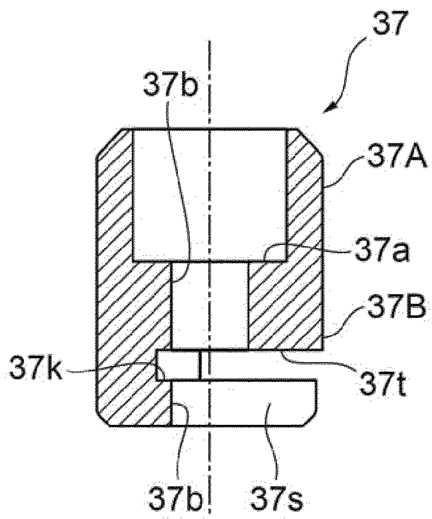


FIG. 4D



X-X cross-section

FIG. 4E



Y-Y cross-section

FIG. 5

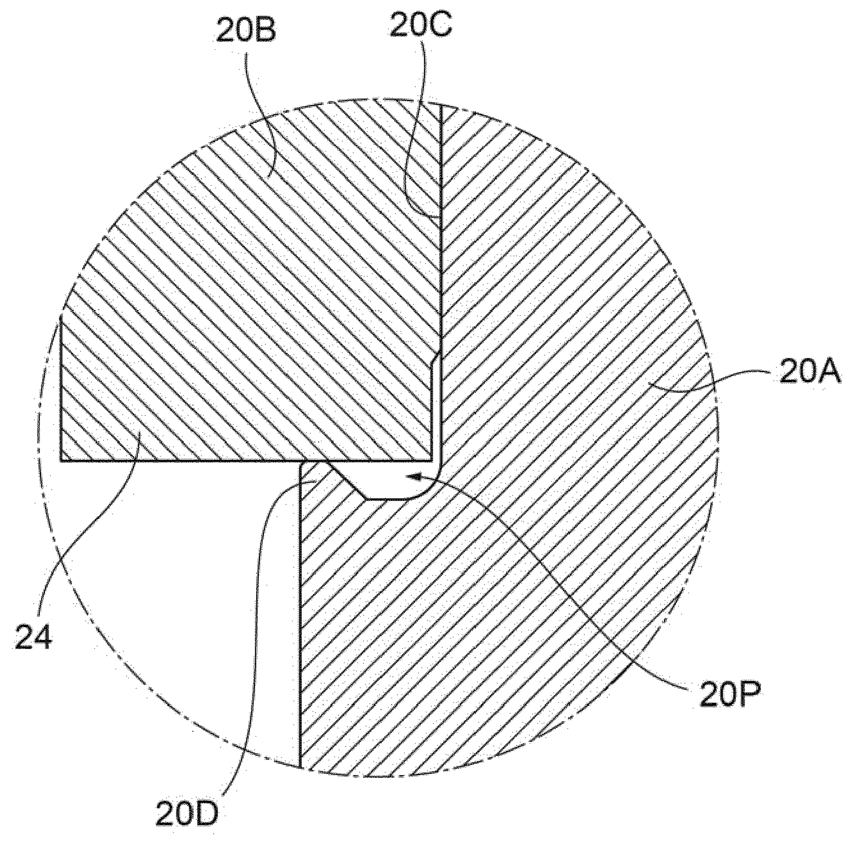


FIG. 6

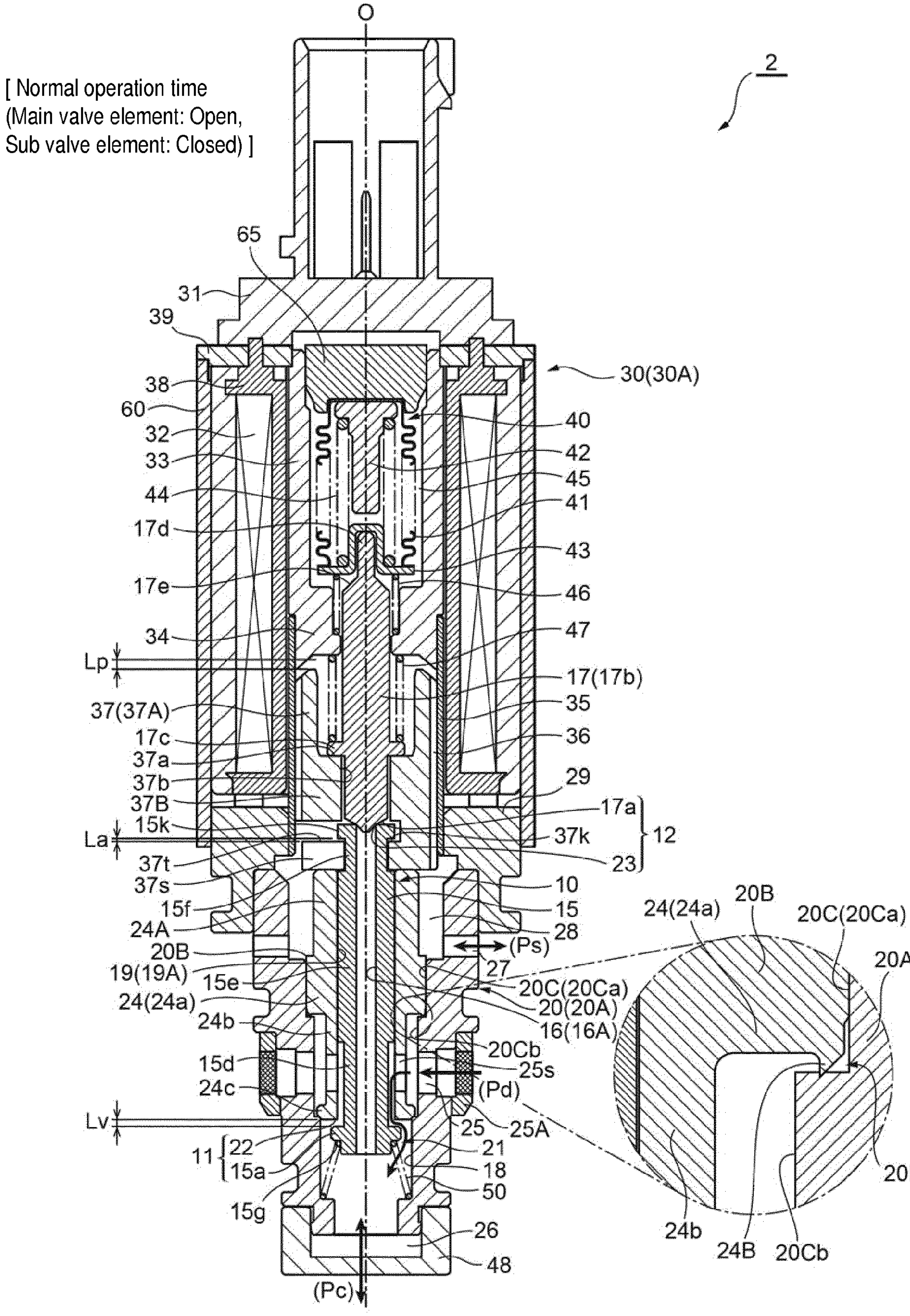

[Normal operation time
(Main valve element: Open,
Sub valve element: Closed)]
O
2
65
31
39
30(30A)
38
60
32
33
44
17d
17e
34
Lp
37(37A)
17c
37a
37b
37B
15k
La
37t
37s
15f
24A
20B
19(19A)
15e
24(24a)
24b
15d
24c
Lv
11
22
15a
15g
40
42
45
41
43
46
47
17(17b)
35
36
29
17a
37k
12
23
10
15
28
(Ps)
27
20C(20Ca)
20(20A)
16(16A)
20Cb
25s
(Pd)
25
25A
21
18
50
26
48
(Pc)
24(24a)
20B
20C(20Ca)
20A
20P
24b
24B
20Cb

FIG. 7

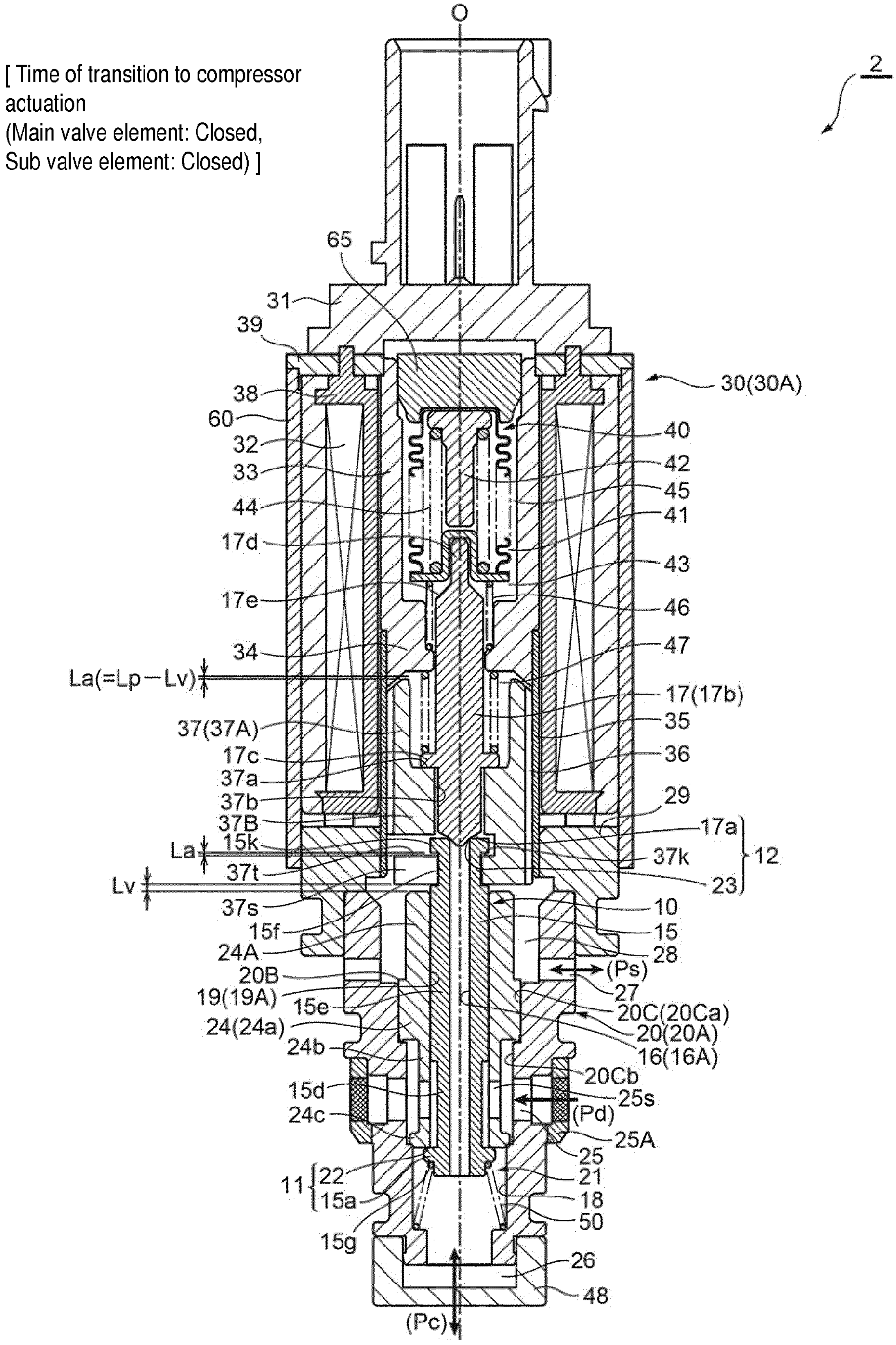

[Time of transition to compressor actuation
(Main valve element: Closed,
Sub valve element: Closed)]
O
2
65
31
39
30(30A)
38
60
32
33
44
17d
17e
34
La(=Lp−Lv)
37(37A)
17c
37a
37b
37B
15k
La
37t
Lv
37s
15f
24A
20B
19(19A)
15e
24(24a)
24b
15d
24c
11
22
15a
15g
40
42
45
41
43
46
47
17(17b)
35
36
29
17a
37k
12
23
10
15
28
(Ps)
27
20C(20Ca)
20(20A)
16(16A)
20Cb
25s
(Pd)
25A
25
21
18
50
26
48
(Pc)

FIG. 8

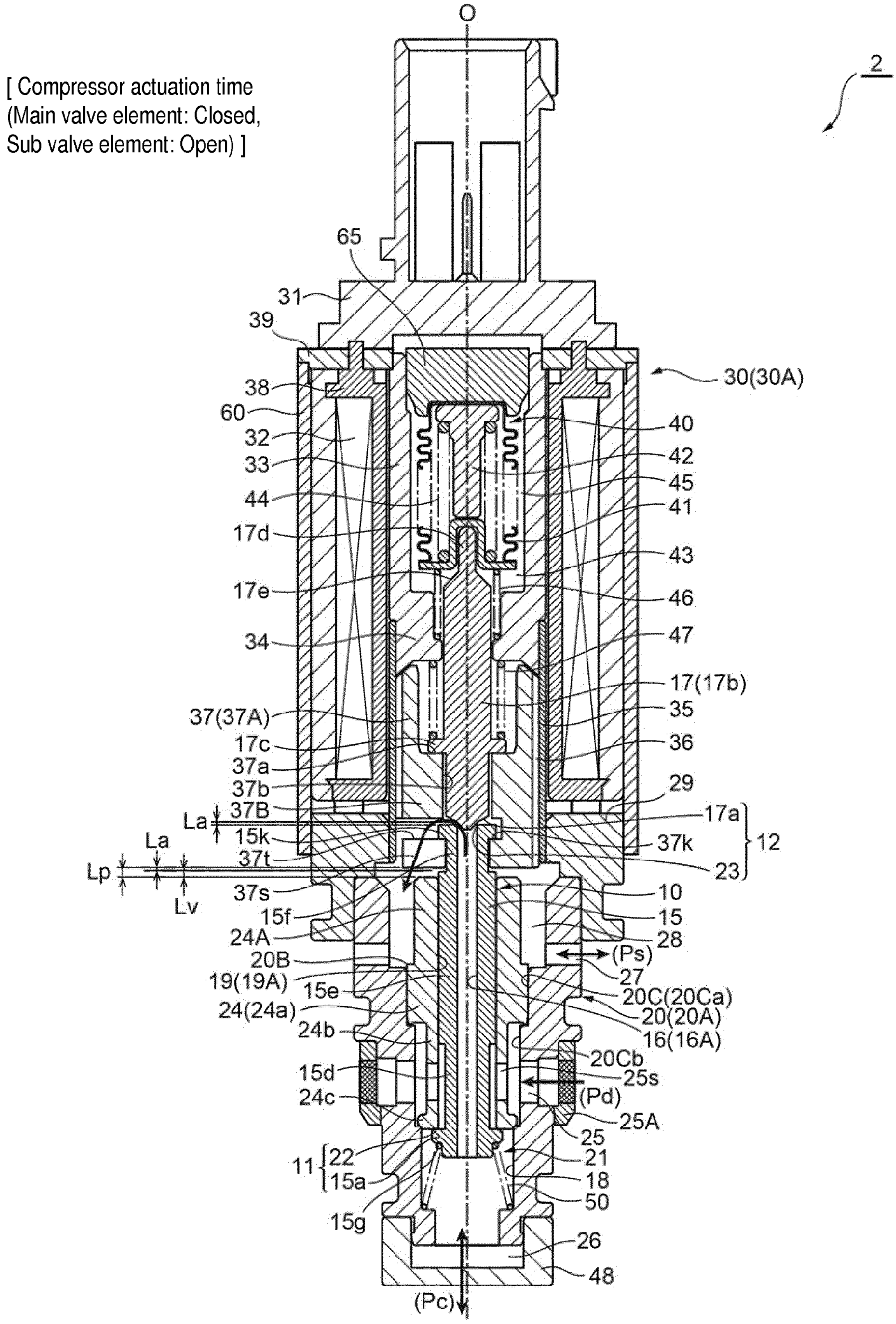

[Compressor actuation time
(Main valve element: Closed,
Sub valve element: Open)]
O
2
65
31
39
38
60
32
33
44
17d
17e
34
37(37A)
17c
37a
37b
37B
La
15k
La
37t
Lp
Lv
37s
15f
24A
20B
19(19A)
15e
24(24a)
24b
15d
24c
11
22
15a
15g
30(30A)
40
42
45
41
43
46
47
17(17b)
35
36
29
17a
37k
12
23
10
15
28
(Ps)
27
20C(20Ca)
20(20A)
16(16A)
20Cb
25s
(Pd)
25A
25
21
18
50
26
48
(Pc)

FIG. 9A

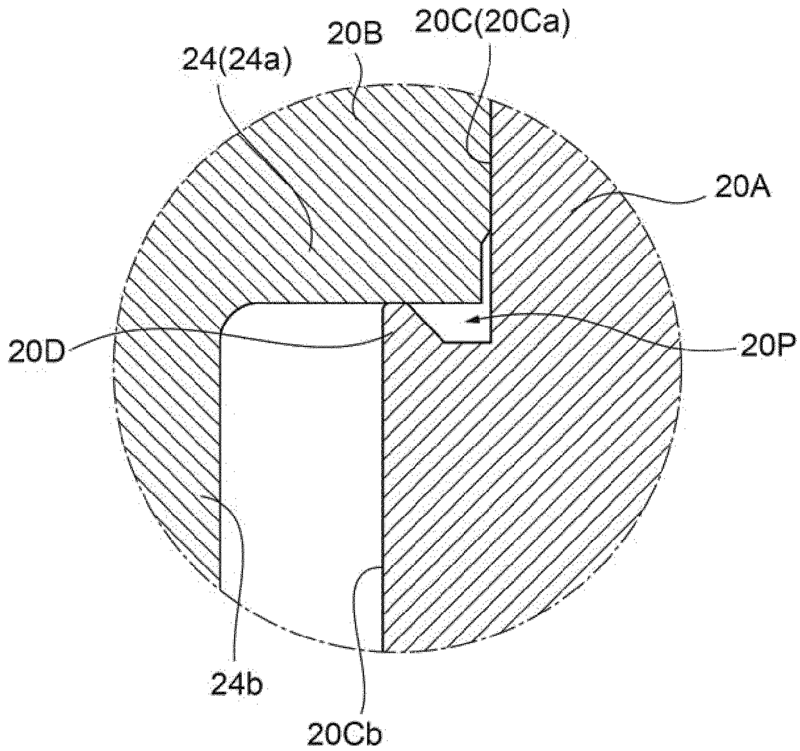

20B
20C(20Ca)
24(24a)
20A
20D
20P
24b
20Cb

FIG. 9B

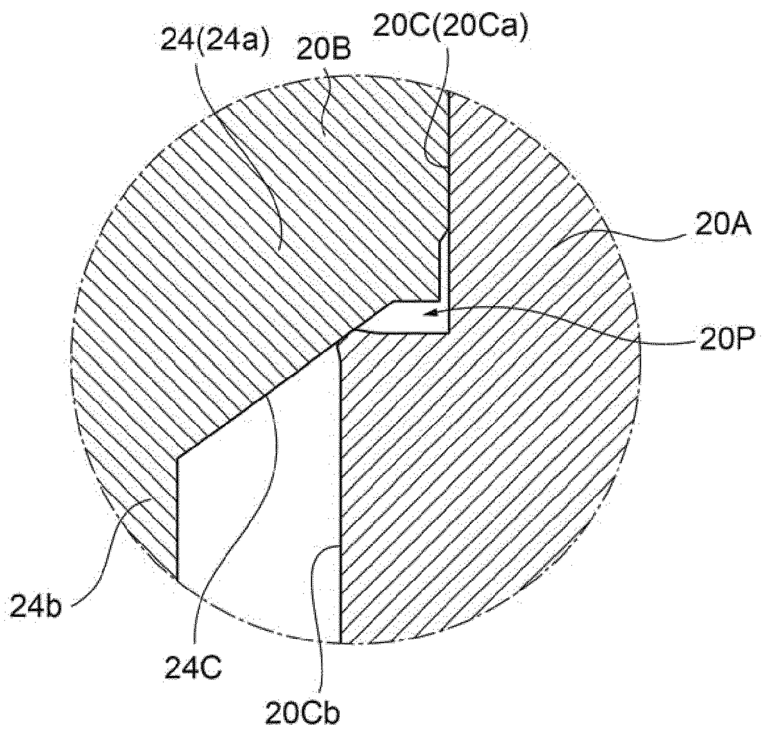

24(24a)
20B
20C(20Ca)
20A
20P
24b
24C
20Cb

FIG. 10

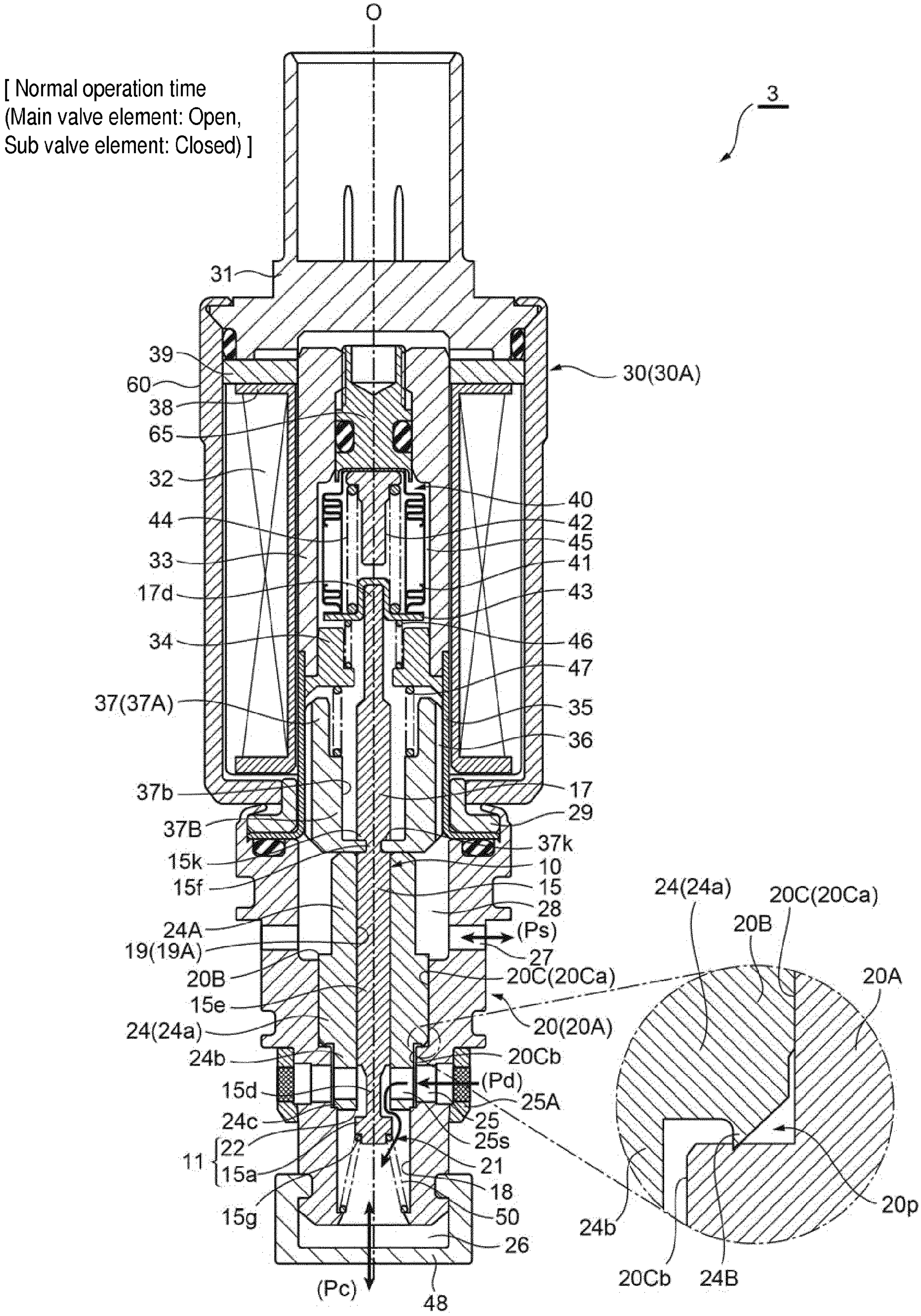

[Normal operation time
(Main valve element: Open,
Sub valve element: Closed)]
O
3
31
39
60
38
65
32
44
33
17d
34
37(37A)
37b
37B
15k
15f
24A
19(19A)
20B
15e
24(24a)
24b
15d
24c
11
22
15a
15g
30(30A)
40
42
45
41
43
46
47
35
36
17
29
37k
10
15
28
(Ps)
27
20C(20Ca)
20(20A)
20Cb
(Pd)
25A
25
25s
21
18
50
26
(Pc)
48
24(24a)
20C(20Ca)
20B
20A
20p
24b
20Cb
24B

FIG. 11

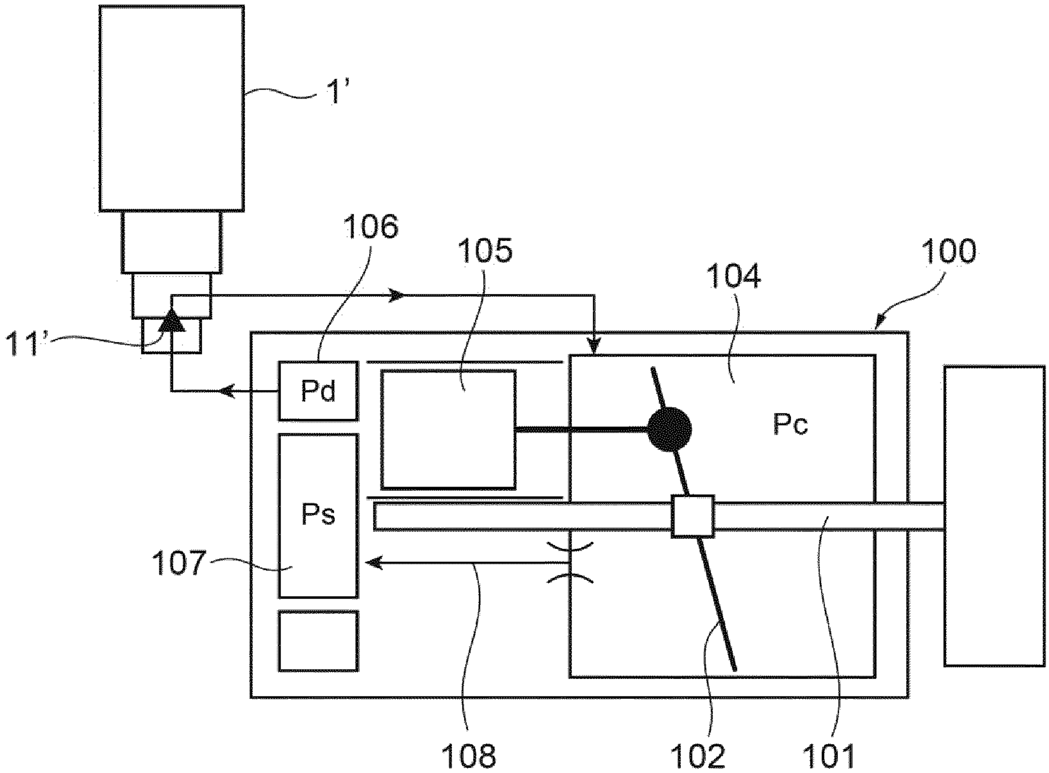


FIG. 12A

[Normal control time]

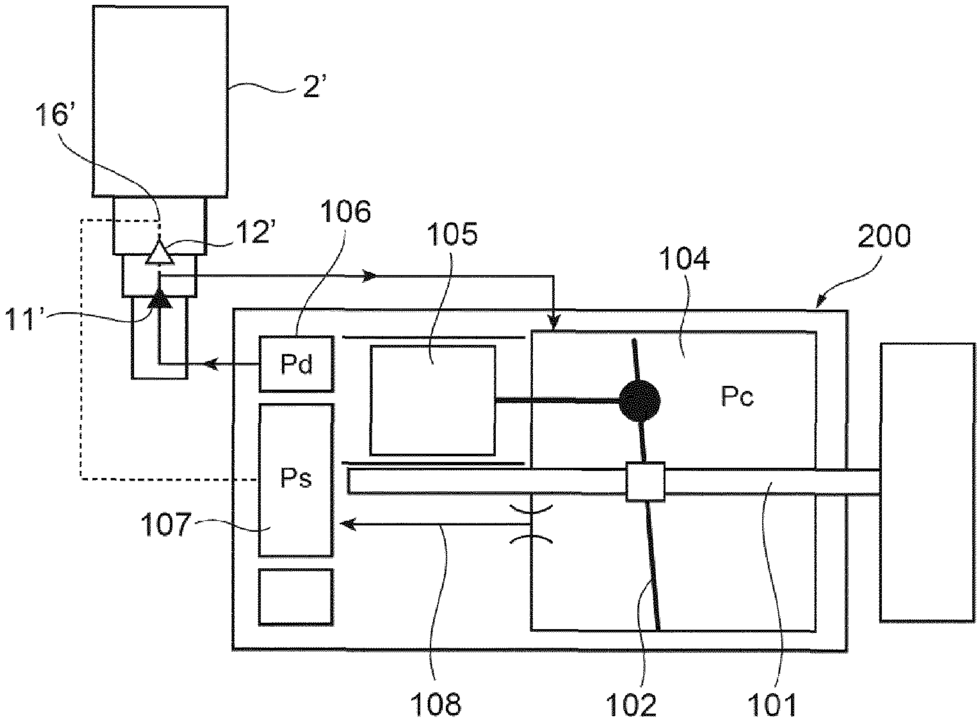
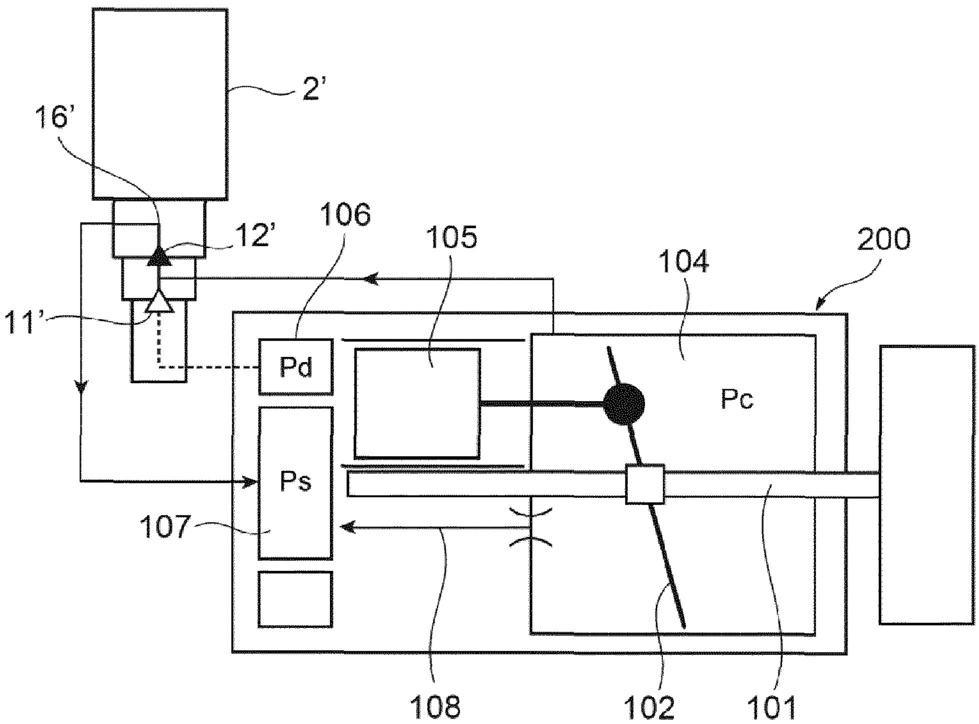


FIG. 12B

[Compressor actuation time]



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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 5697

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 410 220 A2 (FUJIKOKI CORP [JP]) 25 January 2012 (2012-01-25) * abstract; claim 1; figure 1 * * paragraph [0019] * * paragraphs [0025], [0027], [0030] - [0036] *	1,9,10	INV. F04B27/18
A	EP 2 426 358 A2 (FUJIKOKI CORP [JP]) 7 March 2012 (2012-03-07) * figures 1,2 * * paragraphs [0030] - [0036], [0057] - [0058] *	1-10	
A	EP 1 707 811 A2 (TGK CO LTD [JP]) 4 October 2006 (2006-10-04) * figure 1 * * paragraphs [0010] - [0014] *	1-10	
A	US 2003/219344 A1 (SAKAI TAKAYUKI [JP] ET AL) 27 November 2003 (2003-11-27) * figure 1 * * paragraphs [0030], [0031] *	1-10	TECHNICAL FIELDS SEARCHED (IPC) F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 May 2017	Richmond, Robin

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- JP 2013130126 A **[0010]**