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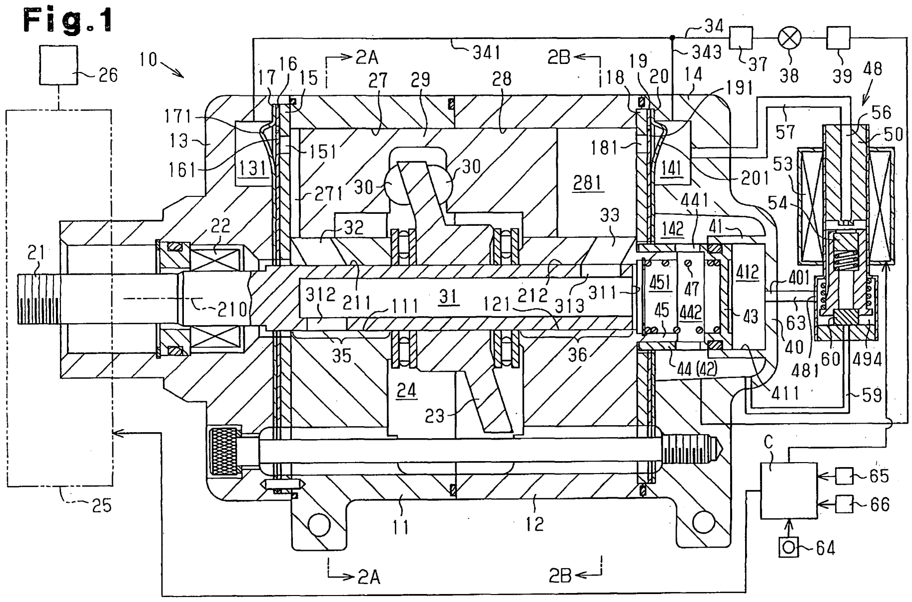
(54) **Refrigerant suction structure in fixed displacement type piston compressor, and operation control method in fixed displacement type piston compressor**

(57) An introduction passage (31) of rotary valve (35, 36) has outlets (312, 313) for feeding out refrigerant in a suction pressure zone (142) toward each of compression chambers (271, 281). A switch portion in a shutoff state shuts off a portion (142) of the suction pressure zone within a compressor (10) from the outlets (312, 313) of the introduction passage (31). The switch portion includes a valve body (42), a working pressure chamber (412), and a working pressure applying portion (48, 67-68). The working pressure chamber (412) introduces a working pressure that is applied to the valve body (42) so as to arrange the valve body (42) at a communication position. The pressure in the suction pressure zone (142) acts against the pressure in the working pressure chamber (412) through the valve body (42).

Fig.1



EP 1 978 251 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a refrigerant suction structure in a fixed displacement type piston compressor provided with a rotary valve. The piston defines a compression chamber within a cylinder bore. The rotary valve has an introduction passage for introducing refrigerant from a suction pressure zone to the compression chamber. The rotary valve integrally rotates with a rotary shaft. Further, the present invention relates to an operation control method in the fixed displacement type piston compressor.

[0002] Japanese Laid-Open Patent Publication Nos. 7-119631 and 2006-83835 each disclose a piston compressor using a rotary valve. Japanese Laid-Open Patent Publication Nos. 64-88064 and 2000-145629 each disclose a piston compressor using a reed valve type suction valve. The piston compressor using the rotary valve has a less suction resistance at a time of drawing suction gas into a cylinder bore and is excellent in an energy efficiency in comparison with the piston compressor using the reed type suction valve.

[0003] Japanese Laid-Open Patent Publication No. 7-119631 discloses a starting impact which may be generated at a time of starting a compressor. If torque is rapidly increased in accordance with compression of gas at a time of starting the compressor, a load is applied to an internal combustion engine, which serves as a vehicle engine. As a result, a traveling speed of the vehicle may be lowered for a moment. In this case, a vehicle occupant feels a shock.

[0004] The rotary valve in Japanese Laid-Open Patent Publication No. 7-119631 can be moved in an axial direction of a rotary shaft in correspondence to a pressure in a control pressure chamber. The compressor has a suction port, which is a suction pressure zone positioned in a center portion of a cylinder block. The rotary valve has a bypass groove which can connect the cylinder bore with the suction port. The rotary valve is moved in the axial direction in such a manner that the bypass groove connects almost all the cylinder bores with the suction port at a time when the operation of the compressor is stopped and when the compressor is started. Accordingly, even if the piston actuates so as to compress the gas within the cylinder bore at a time of starting the compressor, the gas within the cylinder bore flows to the suction port via the bypass groove. As a result, the starting impact is suppressed.

[0005] It is necessary to minimize a clearance in a peripheral surface of the rotary valve, so that the gas does not leak along a peripheral surface of the rotary valve, and that the rotary valve can be rotated. Further, it is necessary that the clearance allows the rotary valve to move in the axial direction. However, it is very difficult to control the clearance mentioned above.

[0006] The piston compressor in Japanese Laid-Open Patent Publication No. 2000-145629 has a differential pressure sensitive on-off valve which is opened and closed on the basis of a differential pressure between a discharge pressure and a suction pressure. The differential pressure sensitive on-off valve is arranged between a low pressure refrigerant conduit introducing the refrigerant to the compressor from the outside of the compressor, and a suction chamber positioned within the compressor. If the compressor is started from a pressure balanced state, the differential pressure sensitive on-off valve comes to a closed state, and stops an inflow of the refrigerant from the outside of the compressor to the suction chamber. As a result, the starting impact is reduced.

[0007] However, even if the differential pressure sensitive on-off valve comes to the closed state, the refrigerant is left in the suction chamber, and the residual refrigerant is drawn to the cylinder bore so as to be compressed. Since the volumetric capacity of the suction chamber is large so as to suppress a suction pulsation of the compressor, the amount of the refrigerant drawn into the cylinder bore in a state in which the differential pressure sensitive on-off valve is closed is large. Accordingly, the effect of reducing the starting impact obtained by the differential pressure sensitive on-off valve is not sufficient.

SUMMARY OF THE INVENTION

[0008] An objective of the present invention is to improve the effect of reducing the starting impact.

[0009] According to one aspect of the invention, a refrigerant suction structure in a fixed displacement type piston compressor is provided. The compressor includes a rotary shaft coupled to an external drive source via a clutch. A plurality of cylinder bores are arranged around the rotary shaft. A plurality of pistons define compression chambers in the cylinder bores by being respectively accommodated in the cylinder bores. A cam body is integrated with the rotary shaft. The cam body converts a rotation of the rotary shaft into reciprocation of each of the pistons. A rotary valve has an introduction passage for introducing a refrigerant from a suction pressure zone to each of the compression chambers. The rotary valve integrally rotates with the rotary shaft. The suction pressure zone has a portion within the compressor. The introduction passage has outlets for feeding out the refrigerant toward each of the compression chambers. The refrigerant suction structure has a switch portion capable of being switched between a communication state and a shutoff state. The switch portion in the communication state allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The switch portion in the shutoff state shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The switch portion includes a valve body, a working pressure chamber, and a working pressure applying portion. The valve body is capable of being switched between a communication position and a shutoff position. The valve body in the communication position allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The valve body in the shutoff position shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The working pressure chamber introduces a working pressure that is applied to the valve body so as to arrange the valve body at the communication position. The-working pressure applying portion applies the working pressure to the working pressure chamber. The pressure in the suction pressure zone acts against the pressure in the working pressure chamber through the valve body.

[0010] Further, according to another aspect of the invention, a refrigerant suction structure in a fixed displacement type piston compressor is provided. The refrigerant suction structure has a switch portion capable of being switched between a communication state and a shutoff state. The switch portion in the communication state allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The switch portion in the shutoff state shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The switch portion includes a valve body capable of being switched between a communication position and a shutoff position. The valve body in the communication position allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The valve body in the shutoff position shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. An electromagnetic driving portion drives the valve body on the basis of an electromagnetic force.

[0011] Further, another aspect of the invention, an operation control method in a fixed displacement type piston compressor is provided. The operation control method includes preparing a switch portion capable of being switched between a communication state and a shutoff state. The switch portion in the communication state allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The switch portion in the shutoff state shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The switch portion is provided with a valve body, a working pressure chamber, and a working pressure applying portion. The valve body is capable being switched between a communication position allowing the portion of the suction pressure zone within the compressor to communicate with the outlet of the introduction passage, and a shutoff position shutting off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The working pressure chamber introduces a working pressure applied to the valve body to arrange the valve body at the communication position. The working pressure applying portion applies the working pressure to the working pressure chamber. The working pressure applying portion is provided with a switch valve that is switched between a first state, in which the refrigerant in the discharge pressure zone can be fed to the working pressure chamber and a second state, in which the refrigerant in the discharge pressure chamber cannot be fed to the working pressure chamber. The operation control method further includes setting the clutch to a coupled state after setting the switch valve to the second state, at a time of switching the clutch from the shutoff state to the coupled state. The operation control method further includes switching the switch valve to the first state after setting the clutch to the coupled state.

[0012] Further, according to another aspect of the invention, an operation control method in a fixed displacement type piston compressor is provided. The operation control method includes preparing a switch portion capable of being switched between a communication state and a shutoff state. The switch portion in the communication state allows the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage. The switch portion in the shutoff state shuts off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The switch portion is provided with a valve body and an electromagnetic driving portion. The valve body is capable being switched between a communication position allowing the portion of the suction pressure zone within the compressor to communicate with the outlets of the introduction passage, and a shutoff position shutting off the portion of the suction pressure zone within the compressor from the outlets of the introduction passage. The electromagnetic driving portion is capable of driving the valve body on the basis of an electromagnetic force. The electromagnetic driving portion is capable of switching the valve body between a first state, in which the valve body is arranged at the communication position, and a second state, in which the valve body is arranged at the shutoff position. The operation control method further includes setting the clutch to the coupled state after setting the electromagnetic driving portion to the second state, at a time of switching the clutch from the shutoff state to the coupled state. The operation control method further includes setting the electromagnetic driving portion to the first state after setting the clutch to the coupled state.

[0013] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a side cross-sectional view of a whole of a compressor, showing a first embodiment;
Fig. 2A is a cross-sectional view taken along line 2A-2A in Fig. 1;
Fig. 2B is a cross-sectional view taken along line 2B-2B in Fig. 1;
Fig. 3 is a partial enlarged view of Fig. 1;
Fig. 4 is an enlarged view showing a state in which the valve body is moved from the position shown in Fig. 3;
Fig. 5 is a flowchart showing an operation control program of the compressor in Fig. 1;
Fig. 6 is a timing chart showing a torque fluctuation in accordance with a program in Fig. 5;
Fig. 7 is a timing chart showing a second embodiment;
Fig. 8 is a side cross-sectional view of a whole of a compressor in accordance with a third embodiment;
Fig. 9A is a partial enlarged view showing a state in which the electromagnetic valve is switched from the state shown in Fig. 8;
Fig. 9B is a timing chart of the compressor in Fig. 8;
Fig. 10 is a partial enlarged side cross-sectional view of a compressor in accordance with a fourth embodiment;
Fig. 11A is a cross-sectional view showing a state in which the electromagnetic valve is switched from the state shown in Fig. 10;
Fig. 11B is a timing chart of the compressor in Fig. 10;
Fig. 12A is a partial enlarged side cross-sectional view of a compressor in accordance with a fifth embodiment;
Fig. 12B is a cross-sectional view showing a state in which the electromagnetic valve is switched from the state shown in Fig. 12A;
Fig. 13 is a side cross-sectional view of a whole of a compressor in accordance with a sixth embodiment;
Fig. 14 is a cross-sectional view showing a state in which the electromagnetic valve is switched from the state shown in Fig. 13;
Fig. 15A is a partial enlarged side cross-sectional view of a compressor in accordance with a seventh embodiment;
Fig. 15B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 15A;
Fig. 16A is a partial enlarged side cross-sectional view of a compressor in accordance with an eighth embodiment;
Fig. 16B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 16A;
Fig. 17 is a side cross-sectional view of a whole of a compressor in accordance with a ninth embodiment;
Fig. 18A is a partial enlarged view of Fig. 17;
Fig. 18B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 18A;
Fig. 19A is a partial enlarged side cross-sectional view of a compressor in accordance with a tenth embodiment;
Fig. 19B is a cross-sectional view showing a state in which the electromagnetic valve is switched from the state shown in Fig. 19A;
Fig. 20 is a side cross-sectional view of a whole of a one-headed piston compressor in accordance with an eleventh embodiment;
Fig. 21 is a side cross-sectional view of a whole of a compressor in accordance with a twelfth embodiment;
Fig. 22A is a cross-sectional view taken along line 22A-22A in Fig. 21;
Fig. 22B is a cross-sectional view taken along line 22B-22B in Fig. 21;
Fig. 23 is a partial enlarged cross-sectional view of Fig. 21;
Fig. 24 is an enlarged view showing a state in which the valve body is moved from the position shown in Fig. 23;
Fig. 25 is a flowchart showing an operation control program of the compressor in Fig. 21;
Fig. 26 is a timing chart showing a torque fluctuation in accordance with a program in Fig. 25;
Fig. 27 is a timing chart showing a thirteenth embodiment;
Fig. 28A is a partial enlarged cross-sectional view of a compressor in accordance with a fourteenth embodiment;
Fig. 28B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 28A;
Fig. 29A is a partial enlarged cross-sectional view of a compressor in accordance with a fifteenth embodiment;
Fig. 29B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 29A;
Fig. 30A is a partial enlarged cross-sectional view of a compressor in accordance with a sixteenth embodiment;
Fig. 30B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 30A;
Fig. 31A is a partial enlarged side cross-sectional view of a compressor in accordance with a seventeenth embodiment;
Fig. 31B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 31A;

Fig. 32A is a partial enlarged side cross-sectional view of a compressor in accordance with an eighteenth embodiment;

Fig. 32B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 32A;

Fig. 33A is a partial enlarged side cross-sectional view of a compressor in accordance with a nineteenth embodiment;

Fig. 33B is a cross-sectional view showing a state in which the valve body is moved from the position shown in Fig. 33A; and

Fig. 34 is a side cross-sectional view of a whole of a compressor in accordance with a twentieth embodiment.

DETAILED DESCRIPTION OF PREFERABLE EMBODIMENTS

[0015] Figs. 1 to 6 show a fixed displacement type piston compressor 10 in accordance with a first embodiment obtained by embodying the present invention.

[0016] As shown in Fig. 1, a front cylinder block 11 is coupled to a rear cylinder block 12. A front housing member 13 is coupled to the front cylinder block 11, and a rear housing member 14 is coupled to the rear cylinder block 12. The front cylinder block 11, the rear cylinder block 12, the front housing member 13 and the rear housing member 14 construct a whole housing of the compressor 10.

[0017] A front discharge chamber 131 is formed in the front housing member 13. A rear discharge chamber 141 and a suction chamber 142 are formed in the rear housing member 14. Each of the front discharge chamber 131 and the rear discharge chamber 141 is a portion of a discharge pressure zone within the compressor 10. The suction chamber 142 is a portion of a suction pressure zone within the compressor 10. The inside of the compressor refers to the inside of the entire housing of the compressor 10, and the outside of the compressor refers to the outside of the entire housing of the compressor 10.

[0018] As shown in Fig. 1, a valve plate 15, a valve forming plate 16, and a retainer forming plate 17 are arranged between the front cylinder block 11 and the front housing member 13. A valve plate 18, a valve forming plate 19, and a retainer forming plate 20 are formed between the rear cylinder block 12 and the rear housing member 14. Discharge ports 151 and 181 are formed respectively in the valve plates 15 and 18, and discharge valves 161 and 191 are formed respectively in the valve forming plates 16 and 19. The discharge valves 161 and 191 respectively open and close the discharge ports 151 and 181. Retainers 171 and 201 are formed respectively in the retainer forming plates 17 and 20. The retainer 171 and 201 limit opening degrees of the discharge valves 161 and 191.

[0019] As shown in Fig. 1, a rotary shaft 21 is rotatably supported to the front cylinder block 11 and the rear cylinder block 12. A front shaft hole 111 and a rear shaft hole 121 extend through the front cylinder block 11 and the rear cylinder block 12, respectively, and the rotary shaft 21 is put through the front shaft hole 111 and the rear shaft hole 121. An outer peripheral surface of the rotary shaft 21 comes into contact with an inner peripheral surface of the front shaft hole 111 and the rear shaft hole 121, and the rotary shaft 21 is directly supported by the front cylinder block 11 and the rear cylinder block 12 at the inner peripheral surface of the front shaft hole 111 and the rear shaft hole 121. An outer peripheral surface portion of the rotary shaft 21 which comes into contact with the front shaft hole 111 is a front seal peripheral surface 211, and an outer peripheral surface portion of the rotary shaft 21 which comes into contact with the rear shaft hole 121 is a rear seal peripheral surface 212.

[0020] A swash plate 23, which serves as a cam body, is firmly attached to the rotary shaft 21. The swash plate 23 is accommodated in a swash plate chamber 24 defined by the front cylinder block 11 and the rear cylinder block 12. A lip seal type shaft seal member 22 is arranged between the front housing member 13 and the rotary shaft 21. The shaft seal member 22 prevents a gas leakage through clearance between the front housing member 13 and the rotary shaft 21. A protruding end portion of the rotary shaft 21 protruding to the outside from the front housing member 13 is connected to a vehicle engine 26, which is an external drive source, via an electromagnetic clutch 25. The rotary shaft 21 obtains a rotary driving force from the vehicle engine 26 via the electromagnetic clutch 25.

[0021] As shown in Fig. 2A, a plurality of front cylinder bores 27 are formed in the front cylinder block 11 so as to be arranged around the rotary shaft 21. As shown in Fig. 2B, a plurality of rear cylinder bores 28 are formed in the rear cylinder block 12 so as to be arranged around the rotary shaft 21. Double headed pistons 29 are accommodated respectively in the front cylinder bore 27 and the rear cylinder bore 28 forming a pair back and force.

[0022] As shown in Fig. 1, a rotational motion of the swash plate 23 integrally rotating with the rotary shaft 21 is transmitted to the double headed pistons 29 via shoes 30, and each double headed piston 29 reciprocates back and forth within the front cylinder bore 27 and the rear cylinder bore 28. Each double headed piston 29 defines a front compression chamber 271 within the front cylinder bore 27, and defines a rear compression chamber 281 within the rear cylinder bore 28.

[0023] As shown in Fig. 1, the rotary shaft 21 has in it an in-shaft passage 31 extending along a rotation axis 210 of the rotary shaft 21. An inlet 311 of the in-shaft passage 31 is positioned in a rear end surface of the rotary shaft 21, and is open to the suction chamber 142. The in-shaft passage 31 has a front outlet 312 and a rear outlet 313. The front outlet 312 is open to a front seal peripheral surface 211 of the rotary shaft 21. The rear outlet 313 is open to a rear seal peripheral surface 212.

[0024] As shown in Fig. 2A, the front cylinder block 11 has the same number of front communication passages 32 as that of the front cylinder bores 27. Each of the front communication passages 32 connect each of the front cylinder bores 27 with the front shaft hole 111. As shown in Fig. 2B, the rear cylinder block 12 has the same number of rear communication passages 33 as that of the rear cylinder bores 28. Each of the rear communication passage 33 communicates each of the rear cylinder bores 28 with the rear shaft hole 121. In accordance with the rotation of the rotary shaft 21, the front outlet 312 of the in-shaft passage 31 intermittently communicates with each of the front communication passage 32, and the rear outlet 313 intermittently communicates with each of the rear communication passage 33.

[0025] In Fig. 1, in the case of a stroke in which the double headed piston 29 moves from a left side to a right side, that is, in the case of a state in which the double headed piston 29 sets a certain front cylinder bore 27 to a suction stroke, the front outlet 312 communicates the corresponding front communication passage 32. As a result, a refrigerant within the in-shaft passage 31 of the rotary shaft 21 is drawn into the corresponding front compression chamber 271 via the front outlet 312, and the corresponding front communication passage 32.

[0026] In Fig. 1, in the case of a stroke in which the double headed piston 29 moves from the right side to the left side, that is, in the case of a state in which the double headed piston 29 sets a certain front cylinder bore 27 to a discharge stroke, the front seal peripheral surface 211 shuts off the front outlet 312 from the corresponding front communication passage 32. As a result, the refrigerant within the front compression chamber 271 is discharged to the front discharge chamber 131 while pushing the discharge valve 161 from the discharge port 151. The refrigerant discharged to the front discharge chamber 131 flows out to an external refrigerant circuit 34 via a discharge passage 341.

[0027] In Fig. 1, in the case of a stroke in which the double headed piston 29 moved from the right side to the left side, that is, in the case of a state in which the double headed piston 29 sets a certain rear cylinder bore 28 to a suction stroke, the rear outlet 313 communicates with the corresponding rear communication passage 33. As a result, the refrigerant within the in-shaft passage 31 of the rotary shaft 21 is drawn into the corresponding rear compression chamber 281 via the rear outlet 313 and the corresponding rear communication passage 33.

[0028] In Fig. 1, in the case of a stroke in which the double headed piston 29 moves from the left side to the right side, that is, in the case of a state in which the double headed piston 29 sets a certain rear cylinder bore 28 to a discharge stroke, the rear seal peripheral surface 212 shuts off the rear outlet 313 from the corresponding rear communication passage 33. As a result, the refrigerant within the rear compression chamber 281 is discharged to the rear discharge chamber 141 while pushing the discharge valve 191 from the discharge port 181. The refrigerant discharged to the rear discharge chamber 141 flows out to the external refrigerant circuit 34 via a discharge passage 343.

[0029] As shown in Fig. 1, a heat exchanger 37, an expansion valve 38, and a heat exchanger 39 are arranged in the external refrigerant circuit 34. The heat exchanger 37 absorbs heat from the refrigerant. The expansion valve 38 controls the flow rate of the refrigerant in correspondence to a fluctuation of a gas temperature measured in an outlet of the heat exchanger 39. The heat exchanger 39 transfers the peripheral heat to the refrigerant. The refrigerant flowing out to the external refrigerant circuit 34 flows back to the suction chamber 142.

[0030] As shown in Fig. 1, a portion of the front seal peripheral surface 211 of the rotary shaft 21 serves as a first rotary valve 35. A portion of the rear seal peripheral surface 212 of the rotary shaft 21 serves as a second rotary valve 36. In other words, the rotary shaft 21 is a rotary valve. Each of the first rotary valve 35 and the second rotary valve 36 is integrally formed in the rotary shaft 21. The rotation axis 210 of the rotary shaft 21 is a rotation axis of the first rotary valve 35, and also is a rotation axis of the second rotary valve 36.

[0031] As shown in Fig. 1, a rear end surface of the rotary shaft 21, that is, a rear end surface of the second rotary valve 36 intersects the rotation axis 210 of the rotary valve. The in-shaft passage 31 and the front outlet 312 construct an introduction passage of the first rotary valve 35. The in-shaft passage 31 and the rear outlet 313 construct an introduction passage of the second rotary valve 36. The front shaft hole 111 is a first valve accommodation chamber accommodating the first rotary valve 35. The rear shaft hole 121 is a second valve accommodation chamber accommodating the second rotary valve 36.

[0032] As shown in Figs. 3 and 4, the rear housing member 14 has an end wall 40 forming the suction chamber 142. A cylinder 41 is integrally formed in an inner surface of the end wall 40. A cylinder interior of the cylinder 41 is referred to as a working pressure recess 411, which serves as a working pressure chamber forming recess. A spool-shaped valve body 42 is slidably fitted into the working pressure recess 411. The valve body 42 is provided with a disc-shaped piston portion 43, and a cylinder portion 44. The piston portion 43 defines a working pressure chamber 412 within the working pressure recess 411. A pressure within the suction chamber 142, that is, a suction pressure acts against the pressure within the working pressure chamber 412 through the valve body 42. A peripheral wall of the cylinder portion 44 has an introduction port 441. In other words, the introduction port 441 is open to an outer peripheral surface of the cylinder portion 44, and communicates with a cylinder interior 442 of the cylinder portion 44. The cylinder interior 442 is an inside passage of the valve body 42.

[0033] As shown in Figs. 3 and 4, a guide cylinder 45 is integrally formed in an end surface of the rear cylinder block 12 in such a manner as to face the cylinder 41. A cylinder interior 451 of the guide cylinder 45 communicates with an inlet 311 of an in-shaft passage 31, which serves as an introduction passage. A distal end of the guide cylinder 45 is away from a distal end of the cylinder 41. The cylinder portion 44 of the valve body 42 is slidably fitted to the guide cylinder 45. A snap ring 46 is attached to an inner peripheral surface of the guide cylinder 45, and a first return spring 47 is arranged between the snap ring 46 and the piston portion 43. The first return spring 47 urges the valve body 42 in such a manner that the valve body 42 comes close to the end wall 40 of the rear housing member 14. The closer the valve body 42 to the end wall 40, the less the volumetric capacity of the working pressure chamber 412 becomes.

[0034] Fig. 3 shows a state in which the valve body 42 is located at a communication position in such a manner that the valve body 42 allows the in-shaft passage 31 to communicate with the suction chamber 142. Fig. 4 shows a state in which the valve body 42 is located at a shutoff position in such a manner that the valve body 42 shuts off the suction chamber 142 from the in-shaft passage 31. In other words, in the state shown in Fig. 3, a whole of the introduction port 441 of the valve body 42 is exposed to the interior of the suction chamber 142. The in-shaft passage 31 communicates with the suction chamber 142 via the cylinder interior 451 of the guide cylinder 45, the cylinder interior 442 of the cylinder portion 44, and the introduction port 441. In the state shown in Fig. 4, a whole of the introduction port 441 enters the working pressure recess 411. As a result, the cylinder portion 44 of the valve body 42 shuts off the in-shaft passage 31 from the suction chamber 142.

[0035] As shown in Figs. 3 and 4, a communication port 401 extends through the end wall 40 of the rear housing member 14. The communication port 401 is open to the interior of the working pressure chamber 412. A feed port 481 of an electromagnetic three-way valve 48 communicates with the communication port 401 via a conduit 63. The electromagnetic three-way valve 48 serves as a switch valve constructing a working pressure applying portion.

[0036] As shown in Figs. 3 and 4, the electromagnetic three-way valve 48 has a tubular valve housing 49. The valve housing 49 is provided with a small-diameter cylindrical portion 491 and a large-diameter cylindrical portion 492, and a fixed iron core 50 is accommodated within the small-diameter cylindrical portion 491 in a fixed manner. A movable iron core 51 is slidably fitted into the small-diameter cylindrical portion 491. The movable iron core 51 has a flange 511 positioned in the large-diameter cylindrical portion 492. An urging spring 52 is arranged between a step 493 between the small-diameter cylindrical portion 491 and the large-diameter cylindrical portion 492, and a flange 511. The urging spring 52 urges the movable iron core 51 in a direction moving the movable iron core 51 away from the fixed iron core 50. A coil 53 is wound around the small-diameter cylindrical portion 491 in such a manner as to overlap both of the fixed iron core 50 and the movable iron core 51. If an electric current is fed to the coil 53, the fixed iron core 50 is excited so as to attract the movable iron core 51 against a spring force of the urging spring 52.

[0037] As shown in Figs. 3 and 4, the movable iron core 51 accommodates in it a first valve body 54. The first valve body 54 faces the fixed iron core 50, and selectively contacts and separates from the fixed iron core 50. A valve seat 501 is integrally formed in an end surface of the fixed iron core 50 facing the movable iron core 51. An urging spring 55 urges the first valve body 54 toward the valve seat 501. The fixed iron core 50 has in it a passage 56. The passage 56 extends through the valve seat 501. An inlet 561 of the passage 56 communicates with the rear discharge chamber 141 via a conduit 57.

[0038] As shown in Figs. 3 and 4, a lid 58 is fitted to the large-diameter cylindrical portion 492 of the valve housing 49. A second valve body 60 is fastened to an end surface of the movable iron core 51 facing the lid 58. The second valve body 60 selectively contacts and separates from the lid 58. A discharge port 581 extends through the lid 58. The second valve body 60 shuts off the discharge port 581 from the cylinder interior 494 of the large-diameter cylindrical portion 492 in the case that the second valve body 60 comes into contact with the lid 58. The discharge port 581 communicates with the suction chamber 142 via the conduit 59.

[0039] As shown in Figs. 3 and 4, a groove 61 is formed in a peripheral surface of the movable iron core 51. The groove 61 communicates with a space 62 between the fixed iron core 50 and the movable iron core 51. The cylinder interior 494 of the large-diameter cylindrical portion 492 communicates with the space 62 via the groove 61. The cylinder interior 494 of the large-diameter cylindrical portion 492 communicates with the working pressure chamber 412 via a feed port 481 provided in a penetrating manner in the large-diameter cylindrical portion 492 and a conduit 63.

[0040] As shown in Fig. 1, a control computer C controls magnetization and demagnetization of each of the electromagnetic three-way valve 48 and the electromagnetic clutch 25. An air conditioner actuating switch 64, a room temperature setting device 65, and a room temperature detector 66 are connected to the control computer C so that signals can be transmitted therebetween. The room temperature setting device 65 sets a target room temperature, and the room temperature detector 66 detects a room temperature. In the case that the air conditioner actuating switch 64 is in an ON state, the control computer C controls a current feed, that is, a magnetization and demagnetization with respect to the electromagnetic three-way valve 48 and the electromagnetic clutch 25 on the basis of a temperature difference between the target room temperature and the detected room temperature.

[0041] In the case that the detected temperature is lower than the target temperature, or in the case that the detected temperature is higher than the target temperature and the temperature difference between the detected temperature,and the target temperature is equal to or less than an allowable difference, the control computer C stops feeding the electric current to the electromagnetic clutch 25. In this case, the electromagnetic clutch 25 comes to a shut-off state, and a rotational driving force of the vehicle engine 26 is not transmitted to the rotary shaft 21. Further, in the case that the detected temperature is higher than the target temperature, and the temperature difference between the detected temperature and the target temperature gets over the allowable difference, the control computer C feeds the electric current to the electromagnetic clutch 25. In this case, the electromagnetic clutch 25 comes to a coupled state, and the rotational driving force of the vehicle engine 26 is transmitted to the rotary shaft 21.

[0042] A timing chart in Fig. 6 shows a clutch waveform K1, a three-way valve waveform V and a torque waveform T1. The clutch waveform K1 indicates a feed timing of the electric current with respect to the electromagnetic clutch 25. The clutch waveform K1 indicates a clutch starting time t1, which is a time for starting a current application to the electromagnetic clutch 25, and a clutch ending time t2, which is a time for finishing the current application to the electromagnetic clutch 25. The three-way valve waveform V indicates a feed timing of the electric current to the electromagnetic three-way valve 48. The three-way valve waveform V has a first exciting period section V1 set in correspondence to the clutch starting time t1, and a second exciting period section V2 set in correspondence to the clutch ending time t2. A starting time t3 of the first exciting period section V1 is before the clutch starting time t1, and an ending time t4 of the first exciting period section V1 is after the clutch starting time t1. In other words, the control computer C first carries out the current feed to the electromagnetic three-way valve 48 and thereafter carries out the current feed to the electromagnetic clutch 25, at a time of starting the current feed to the electromagnetic clutch 25. A starting time t5 of the second exciting period section V2 is before the clutch ending time t2, and the ending time of the second exciting period section V2 is identical with the clutch ending time t2.

[0043] Fig. 5 is a flowchart showing an operation control program for controlling an operation of the compressor 10. The control computer C controls the operation of the compressor 10 on the basis of an operation control program shown by the flowchart. A description will be given below of the operation control of the compressor 10 in accordance with the operation control program shown by the flowchart.

[0044] It is assumed that the compressor 10 is in an operation stop state (a state in which the electromagnetic clutch 25 is shut off), and the electromagnetic three-way valve 48 is in a demagnetized state (a state in which the current application is stopped). In a state in which the electromagnetic three-way valve 48 is demagnetized, the first valve body 54 is away from the valve seat 501 and the second valve body 60 closes the discharge port 581, as shown in Fig. 3. In the case that the interior of the working pressure chamber 412 comes to a pressure corresponding to the discharge pressure, the valve body 42 exists at a communication position shown in Fig. 3. However, in the case that the interior of the working pressure chamber 412 comes to a pressure corresponding to the suction pressure, the valve body 42 exists at a shut-off position shown in Fig. 4.

[0045] In step S1, the control computer C determines on the basis of a comparison between the detected temperature and the target temperature whether a compressor operation starting mode (a mode for starting the current application to the electromagnetic clutch 25) is established. In the case of YES in step S1, that is, in the case that the compressor operation starting mode is established, the control computer C starts the current application to the electromagnetic three-way valve 48 in step S2. If the electric current is fed to the electromagnetic three-way valve 48, the first valve body 54 comes into contact with the valve seat 501 and the passage 56 is closed, as shown in Fig. 4. Further, the second valve body 60 is away from the lid 58 and the discharge port 581 is opened. In this state, the working pressure chamber 412 communicates with the suction chamber 142 via the discharge passage constituted by the communication port 401, the conduit 63, the feed port 481, the cylinder interior 494, the discharge port 581 and the conduit 59. Accordingly, the interior of the working pressure chamber 412 becomes the same pressure zone as the interior of the suction chamber 142. Therefore, the valve body 42 is securely arranged at the shutoff position shown in Fig. 4 on the basis of a spring force of the first return spring 47, and the communication between the introduction port 441 and the suction chamber 142 is shut off.

[0046] In step S3, the control computer C determines whether a period ta [(t1 - t3) = ta in the case illustrated in Fig. 6] has elapsed from the start of the current application to the electromagnetic three-way valve 48. In the case of YES in step S3, that is, in the case that the period ta has elapsed from the start of the current application to the electromagnetic three-way valve 48, the control computer C starts the current application to the electromagnetic clutch 25 in step S4. Accordingly, the electromagnetic clutch 25 gives way to the coupled state from the shutoff state, and the rotary shaft 21 and the swash plate 23 start rotating.

[0047] In step S5, the control computer C determines whether a period tb [(t4 - t1) = tb in the case illustrated in Fig. 6] has elapsed from the start of the current application to the electromagnetic clutch 25. In the case of YES in step S5, that is, in the case that the period tb has elapsed from the start of the current application to the electromagnetic clutch 25, the control computer C stops the current application to the electromagnetic three-way valve 48 in step S6. If the current feed to the electromagnetic three-way valve 48 is stopped, the first valve body 54 is away from the valve seat 501 and the passage 56 is opened, as shown in Fig. 3. Further, the second valve body 60 comes into contact with the lid 58 and the discharge port 581 is closed. In this state, the communication between the suction chamber 142 and the working pressure chamber 412 is shut off. The working pressure chamber 412 communicates with the rear discharge chamber 141 via the feed passage constituted by the communication port 401, the conduit 63, the feed port 481, the cylinder interior 494, the groove 61, the space 62, the passage 56 and the conduit 57. Accordingly, the refrigerant pressure (the discharge pressure) within the rear discharge chamber 141 is introduced to the working pressure chamber 412, and the interior of the working pressure chamber 412 becomes same pressure zone as the interior of the rear discharge chamber 141. The communication port 401 and the conduit 63 which is a common passage connecting the working pressure chamber 412 to the electromagnetic three-way valve 48.

[0048] The pressure (the working pressure) of the refrigerant within the rear discharge chamber 141 is higher than the pressure within the cylinder interior 442, and the pressure within the working pressure chamber 412 arranges the valve body 42 at the communication position shown in Fig. 3 against the pressure of the cylinder interior 442 and the spring force of the first return spring 47. Accordingly, the introduction port 441 is exposed into the suction chamber 142, and the introduction port 441 communicates with the suction chamber 142. Therefore, the refrigerant within the suction chamber 142 flows into the in-shaft passage 31 via the introduction port 441.

[0049] After stopping the current application to the electromagnetic three-way valve 48, the computer C determines on the basis of the comparison between the detected temperature and the target temperature whether a compressor operation stopping mode (a mode for stopping the current application to the electromagnetic clutch 25) is established, in step S7. In the case of YES in step S7, that is, in the case that the compressor operation stopping mode is established, the control computer C starts the current application to the electromagnetic three-way valve 48 in step S8. If the current application to the electromagnetic three-way valve 48 is started, the communication between the working pressure chamber 412 and the rear discharge chamber 141 is shut off, and the working pressure chamber 412 communicates with the suction chamber 142. In other words, the working pressure corresponding to the discharge pressure within the working pressure chamber 412 is discharged to the suction chamber 142. In other words, the working pressure within the working pressure chamber 412 is released.

[0050] In step S9, the control computer C determines whether a period tc [(t2 - t5) - tc in the case illustrated in Fig. 6] has elapsed from the start of the current application to the electromagnetic three-way valve 48. In the case of YES in step S9, that is, in the case that the period tc has elapsed from the start of the current application to the electromagnetic three-way valve 48, the control computer C stops the current application to the electromagnetic three-way valve 48 and the electromagnetic clutch 25 in step S10. After the process of step S10, the control computer C gives way to step S1.

[0051] The torque waveform T1 in Fig. 6 is one example of the torque fluctuation. In the case that the current application to the electromagnetic clutch 25 is started, the torque is fluctuated. The present embodiment excites the electromagnetic three-way valve 48 before starting the current application to the electromagnetic clutch 25, and stops the current application to the electromagnetic three-way valve 48 after starting exciting the electromagnetic clutch 25, at a time of starting the current application to the electromagnetic clutch 25. As a result, a rapid torque fluctuation [a fluctuation portion T11 in the torque waveform T1] at a time when the current application to the electromagnetic clutch 25 is started is suppressed. Further, even when the current application to the electromagnetic clutch 25 is stopped, the torque is fluctuated. The present embodiment excites the electromagnetic three-way valve 48 before stopping the current application to the electromagnetic clutch 25, at a time of stopping the current application to the electromagnetic clutch 25. As a result, the rapid torque fluctuation at a time when the current application to the electromagnetic clutch 25 is stopped is suppressed.

[0052] The electromagnetic three-way valve 48, the working pressure chamber 412 and the valve body 42 construct a switch portion. The switch portion is capable of switching the suction chamber 142, which is a portion of the suction pressure zone within the compressor 10, to a state in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 of the in-shaft passage 31, which is an introduction passage, and a state in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313. In Figs. 1 and 3, the electromagnetic three-way valve 48 is in a first state (a demagnetized state) in which the three-way valve 48 can feed the refrigerant in the rear discharge chamber 141, which is a discharge pressure zone, to the working pressure chamber 412. In Fig. 4, the electromagnetic three-way valve 48 is in a second state (a magnetized state) in which the three-way valve 48 can feed the refrigerant in the rear discharge chamber 141, which is a discharge pressure zone to the working pressure chamber 412.

[0053] The first embodiment has the following advantages.

(1) In the state in which the pressure within the rear discharge chamber 141, which is the working pressure, is not introduced to the working pressure chamber 412, the valve body 42 is arranged at the shutoff position shown in Fig. 4. If the valve body 42 is arranged at the shutoff position, the suction chamber 142, which is a suction pressure zone within the compressor 10, is shut off from the introduction port 441. Since the rotation of the rotary shaft 21 is started

after the valve body 42 is previously arranged at the shutoff position, at a time when the operation of the compressor 10 is started (at a time when the rotation of the rotary shaft 21 is started), the refrigerant does not flow in the cylinder interior 442 and the in-shaft passage 31 from the suction chamber 142. Accordingly, the rapid torque fluctuation is suppressed, and a starting impact is reduced. Further, since the communication between the suction chamber 142 within the compressor 10 and the introduction port 441 is shut off, the amount of the refrigerant compressed in the front compression chamber 271 and the rear compression chamber 281 at a time when the valve body 42 exists at the shutoff position is small. Therefore, the effect of suppressing the torque fluctuation, that is, the effect of reducing the starting impact is improved.

(2) If the working pressure within the working pressure chamber 412 is released, the valve body 42 is returned to the shutoff position by the spring force of the first return spring 47. The use of the first return spring 47 simplifies the structure for returning the valve body 42 to the shutoff position.

(3) In the case that the valve body 42 exists at the shutoff position, the introduction port 441, which is an inlet of the cylinder interior 442 of the valve body 42, enters the working pressure recess 411 so as to be shielded, and in the case that the valve body 42 exists at the communication position, the introduction port 441 is out of the working pressure recess 411 so as to be exposed to the interior of the suction chamber 142. The structure in which the introduction port 441 comes in and out with respect to the interior of the working pressure recess 411 enlarges the introduction port 441, and is preferable for securing a sufficient passage cross-sectional area of the introduction passage.

[0054] Fig. 7 explains a second embodiment in accordance with the present invention. The structure of the apparatus is the same as the case of the first embodiment.

[0055] In the second embodiment, the structure of the apparatus is the same as the case of the first embodiment, however, the second embodiment is different from the first embodiment in a point that the amount of the current application is gradually increased at a time of starting the current application to the electromagnetic clutch 25, as shown by a current application starting section K21 in a clutch waveform K2. The current application to the electromagnetic three-way valve 48 is stopped after the feed current value becomes maximum. The fluctuation of the fluctuation portion T21 in the torque waveform T2 expressing the torque fluctuation is suppressed more than the case of the first embodiment, on the basis of the current application start mentioned above to the electromagnetic clutch 25.

[0056] For example, in the conventional fixed displacement type piston compressor having no switch portion, the torque at a time of starting is great, that is, the load applied to the electromagnetic clutch 25 is great. Accordingly, if the amount of the current application is gradually increased in the same manner as the present invention, in the conventional compressor, a slip is generated in the electromagnetic clutch 25. Therefore, in the conventional compressor, it is hard to secure a reliability of the electromagnetic clutch 25.

[0057] In the present embodiment, since the torque at a time of starting is small, that is, the load applied to the electromagnetic clutch 25 is small, it is possible to carry out an operation control such as to gradually increase the amount of the current application to the electromagnetic clutch 25.

[0058] Figs. 8 and 9 explain a third embodiment. The same reference numerals are attached to the same components as those of the first embodiment.

[0059] As shown in Fig. 8, a check valve 68 is arranged in a portion 34A of an external refrigerant circuit 34 in an upstream side of the heat exchanger 37, and the portion 34A of the external refrigerant circuit 34 in the upstream side of the check valve 68 is connected to the working pressure chamber 412 by the communication port 401 and the inflow passage L. The check valve 68 is provided in the portion 34A of the external refrigerant circuit 34 in a downstream side of a connection portion between the portion 34A of the external refrigerant circuit 34 and the inflow passage L. The interior of the portion 34A of the external refrigerant circuit 34 is a discharge pressure zone. An electromagnetic on-off valve 67 is arranged in the inflow passage L. The electromagnetic on-off valve 67 and the check valve 68 construct a working pressure applying portion. The electromagnetic on-off valve 67, which serves as a switch valve, is under the magnetizing and demagnetizing control of the control computer C. In Fig. 8, the electromagnetic on-off valve 67 is in a magnetized state, and the electromagnetic on-off valve 67 is in an open state, in which the inflow passage L is opened. In the case that the electromagnetic on-off valve 67 is in the magnetized state, the refrigerant (the discharge refrigerant) in the portion 34A of the external refrigerant circuit 34 in the upstream side of the check valve 68 can flow in the working pressure chamber 412. In Fig. 9A, the electromagnetic on-off valve 67 is in the demagnetized state, and the electromagnetic on-off valve 67 is in a closed state, in which the inflow passage L is shut off. The electromagnetic on-off valve 67 is a normally closed type electromagnetic on-off valve which is closed in a non-excited state (a demagnetized state). However, even in the case that the electromagnetic on-off valve 67 is in the closed state, some amount of gas can leak.

[0060] A waveform W1 in a timing chart in Fig. 9B shows a feed timing of the electric current with respect to the electromagnetic on-off valve 67. The current application to the electromagnetic on-off valve 67 is started after [for example, after one second, (t6-t1) after in the illustrated example] the current application to the electromagnetic clutch 25 is started, and the current application stop after the current application to the electromagnetic on-off valve 67 is the same as the ending time with respect to the electromagnetic clutch 25 [the current application is stopped at a clutch ending time t2 in the example in Fig. 9B].

[0061] In the case that the current application to the electromagnetic clutch 25 is stopped, the current application to the electromagnetic on-off valve 67 is simultaneously stopped, and the electromagnetic on-off valve 67 gives way to the closed state from the open state. If the current application to the electromagnetic clutch 25 is stopped, that is, if the operation of the compressor 10 is stopped, the refrigerant is not discharged, so that the check valve 68 is closed. Accordingly, the balancing of the pressure within the compressor 10 is rapidly advanced.

[0062] In the case that the operation of the compressor 10 is stopped, the electromagnetic on-off valve 67 is in the closed state. However, since some amount of gas can leak in the electromagnetic on-off valve 67, the refrigerant having the discharge pressure remaining within the working pressure chamber 412 and within a portion of the inflow passage L between the communication port 401 and the electromagnetic on-off valve 67 leaks out to the portion 34A in the external refrigerant circuit 34 in the upstream side of the check valve 68 via the electromagnetic on-off valve 67. Accordingly, the balancing of the pressure within the working pressure chamber 412 is advanced. Therefore, the valve body 42 is arranged at the shutoff position shown in Fig. 9A on the basis of the spring force of the first return spring 47 by a time point [a time t1 in the example in Fig. 9B] when the current application to the electromagnetic clutch 25 is next started.

[0063] The electromagnetic on-off valve 67 is in the demagnetized state (the closed state) before the current application to the electromagnetic clutch 25 is started, and the current application to the electromagnetic on-off valve 67 is started after the current application to the electromagnetic clutch 25. Accordingly, the valve body 42 is in a state of being at the shutoff position for some amount of time after the current application to the electromagnetic clutch 25 is started, and the refrigerant within the suction chamber 142 does not flow in the in-shaft passage 31. Therefore, the starting impact at a time of starting the compressor 10 is reduced.

[0064] If the current application to the electromagnetic on-off valve 67 is started after the current application to the electromagnetic clutch 25 is started, the electromagnetic on-off valve 67 gives way to the open state from the closed state, and the portion 34A of the external refrigerant circuit 34 in the upstream side of the check valve 68 communicates with the working pressure chamber 412. After starting the current application to the electromagnetic clutch 25 (that is, after the operation of the compressor 10 is started), the check valve 68 is maintained in the open state on the basis of the discharge of the refrigerant, and the discharged refrigerant is circulated to the suction chamber 142 via the external refrigerant circuit 34. In the case in which the current application to the electromagnetic clutch 25 is maintained (that is, a state in which the compressor 10 is operated), the electromagnetic on-off valve 67 is maintained in the open state, and the refrigerant pressure (the discharge pressure) in the portion 34A of the external refrigerant circuit 34 in the upstream side of the check valve 68 is applied to the working pressure chamber 412 via the inflow passage L and the electromagnetic on-off valve 67. Accordingly, the valve body 42 is arranged at a communication position shown in Fig. 8.

[0065] The check valve 68, the electromagnetic on-off valve 67, the working pressure chamber 412, and the valve body 42 construct a switch portion. The switch portion is capable of switching the suction chamber 142, which is a portion of the suction pressure zone within the compressor 10, to a communication state, in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 in the introduction passage, and a shutoff state, in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313. In Fig. 8, the electromagnetic on-off valve 67 is in a first state (a magnetized state), in which the on-off valve 67 can feed the refrigerant in the portion 34A of the external refrigerant circuit 34, which is a discharge pressure zone, to the working pressure chamber 412. In Fig. 9A, the electromagnetic on-off valve 67 is in a second state (a demagnetized state), in which the on-off valve cannot feed the refrigerant in the portion of the external refrigerant circuit 34 to the working pressure chamber 412.

[0066] The third embodiment has the same advantages as those of the first embodiment.

[0067] Figs. 10 to 11B explain a fourth embodiment. The same reference numerals are attached to the same components as those of the third embodiment.

[0068] In the fourth embodiment, a normally open type electromagnetic on-off valve 67A is used in place of the normally closed type electromagnetic on-off valve 67 in the third embodiment. The normally open type electromagnetic on-off valve 67A is opened in the non-excited state, and is closed in the excited state. In Fig. 10, the electromagnetic on-off valve 67A, which serves as a switch valve, opens the inflow passage L in the non-excited state. In Fig. 11A, the electromagnetic on-off valve 67A closes the inflow passage L in the excited state. The electromagnetic on-off valve 67A and the check valve 68 construct the working pressure applying portion.

[0069] A waveform W2 in a timing chart in Fig. 11B shows a current feed timing with respect to the electromagnetic on-off valve 67A. At a time when the current application to the electromagnetic clutch 25 is started, the current application to the electromagnetic on-off valve 67A has already been started [at a time t3 in the illustrated example] before the current application to the electromagnetic clutch 25 is started [at a time t1 in the illustrated example], and the current application to the electromagnetic on-off valve 67A is stopped [at a time t4 in the illustrated example] after the current application to the electromagnetic clutch 25 is started.

[0070] If the operation of the compressor 10 is stopped, the refrigerant is not discharged, so that the check valve 68 is closed. Accordingly, the balancing of the pressure within the compressor 10 is rapidly advanced. In the case that the operation of the compressor 10 is stopped, the electromagnetic on-off valve 67A is in the open state. Accordingly, the refrigerant having the discharge pressure remaining within the working pressure chamber 412, and within a portion of the inflow passage L between the communication port 401 and the electromagnetic on-off valve 67A leaks out to the portion 34A of the external refrigerant circuit 34 in the upstream side of the check valve 68 via the electromagnetic on-off valve 67A. Therefore, the balancing of the pressure within the working pressure chamber 412 is rapidly advanced. Accordingly, the valve body 42 is arranged at a shutoff position shown by Fig. 11A on the basis of the spring force of the first return spring 47 by a time point when the current application to the electromagnetic clutch 25 is next started. The valve body 42 is located at the shutoff position over a time period from before the current application to the electromagnetic clutch 25 is started [(t1 - t3) before in the illustrated example] to after the current application is started [(t4 - t1) after in the illustrated example], and the refrigerant within the suction chamber 142 does not flow in the in-shaft passage 31. Accordingly, the starting impact at a time of starting the compressor 10 is reduced.

[0071] The check valve 68, the electromagnetic on-off valve 67A, the working pressure chamber 412 and the valve body 42 construct a switch portion. The switch portion is capable of switching the suction chamber 142, which is a portion of the suction pressure zone within the compressor 10, to a state in which the suction chamber 142 communicates with the outlet of the introduction passage, and a state in which the suction chamber 142 is shut off. In Fig. 10, the electromagnetic on-off valve 67A is in a first state (a demagnetized state), in which the refrigerant in the portion 34A of the external refrigerant circuit 34, which is a discharge pressure zone, can be fed to the working pressure chamber 412. In Fig. 11A, the electromagnetic on-off valve 67 is in a second state (a magnetized state), in which the refrigerant in the portion 34A of the external refrigerant circuit 34 cannot be fed to the working pressure chamber 412.

[0072] The fourth embodiment has the same advantages as those of the first embodiment.

[0073] Figs. 12A and 12B explain a fifth embodiment in accordance with the present invention. The same reference numerals are used in the same components as those of the first embodiment.

[0074] A guide cylinder 45A fitted to the cylinder portion 44 of the valve body 42 is formed as a closed-end cylindrical shape, and is formed independently from the rear cylinder block 12, the rotary shaft 21 and the like. A bottom wall of the guide cylinder 45A comes into contact with an end surface 122 of the rear cylinder block 12. The guide cylinder 45A is fitted to the cylinder portion 44 of the valve body 42 in such a manner as to be allowed to move in a radial direction of the rotary shaft 21 with respect to the rotary shaft 21. A communication port 452 is formed in a bottom wall of the guide cylinder 45A in such a manner as to connect the cylinder interior 451 of the guide cylinder 45A with the in-shaft passage 31. The first return spring 47 is arranged between the bottom wall of the guide cylinder 45A and the piston portion 43. The valve body 42 is arranged at a communication position in Fig. 12A, and the valve body 42 is arranged at a shutoff position in Fig. 12B. The magnetizing and demagnetizing timings of the electromagnetic three-way valve 48 are identical with the case of the first embodiment.

[0075] On the assumption that the refrigerant leaks through clearance between the valve body 42 and the cylinder 41 or clearance between the valve body 42 and the guide cylinder at a time when the valve body 42 is in a state of being at the shutoff position, the effect of reducing the starting impact is lowered.

[0076] However, the guide cylinder 45A of the present embodiment is fitted to the cylinder portion 44 of the valve body 42 in such a manner that the guide cylinder 45A is allowed to move in the radial direction of the rotary shaft 21 with respect to the rotary shaft 21. Accordingly, an axis 413 of the working pressure recess 411 is allowed to come into line with an axis 453 of the guide cylinder 45A. Therefore, it is possible to reduce a clearance between the cylinder portion 44 of the valve body 42 and the cylinder 41 and a clearance between the cylinder portion 44 of the valve body 42 and the guide cylinder 45A, and it is possible to prevent the refrigerant from leaking along a peripheral surface of the cylinder portion 44 of the valve body 42.

[0077] Figs. 13 and 14 explain a sixth embodiment. The same reference numerals are used in the same components as those of the first embodiment.

[0078] A piston 69 is slidably fitted to the cylinder 41, and a transmission rod 70 is coupled to the piston 69. The piston 69 defines the working pressure chamber 412 within the working pressure recess 411. The transmission rod 70 enters an in-shaft passage 31A. The in-shaft passage 31A is provided with a small-diameter passage 314, and a large-diameter passage 315 having a larger diameter than the small-diameter passage 314. A cylindrical small circumferential surface body 71 is fastened to a portion of the transmission rod 70 positioned within the small-diameter passage 314. A cylindrical large circumferential surface body 72 is fastened to a portion of the transmission rod 70 positioned within the large-diameter passage 315. The cylindrical small circumferential surface body 71 is fitted to the small-diameter passage 314 in such a manner as to be slidable in a direction of a rotation axis 210 of the rotary shaft 21, and be capable of opening and closing the front outlet 312, and the cylindrical large circumferential surface body 72 is fitted to the large-diameter passage 315 in such a manner as to be slidable in the direction of the rotation axis 210 of the rotary shaft 21, and be capable of opening and closing the rear outlet 313. The interior of the cylindrical large circumferential surface body 72 communicates a portion of the in-shaft passage 31A between the small circumferential surface body 71 and the large circumferential surface body 72 with a portion of the in-shaft passage 31A between the inlet 311 of the in-shaft passage 31A and the large circumferential surface body 72.

[0079] A first return spring 73 is arranged between a step 316 between the small-diameter passage 314 and the large-diameter passage 315, and the large circumferential surface body 72. The first return spring 73 urges a whole of the small circumferential surface body 71, the large circumferential surface body 72, the transmission rod 70 and the piston 69 toward the working pressure chamber 412 in such a manner as to press the piston 69 to the working pressure recess 411. The small circumferential surface body 71, the large circumferential surface body 72, the transmission rod 70 and the piston 69 construct a valve body defining the working pressure chamber 412 within the working pressure recess 411.

[0080] Fig. 14 shows a state in which the small circumferential surface body 71 closes the front outlet 312, and the large circumferential surface body 72 closes the rear outlet 313. The front outlet 312 and the rear outlet 313 are shut off from the in-shaft passage 31A. Fig. 13 shows a state in which the small circumferential surface body 71 opens the front outlet 312, and the large circumferential surface body 72 opens the rear outlet 313. The front outlet 312 and the rear outlet 313 communicate with the in-shaft passage 31A. If the current application to the electromagnetic three-way valve 48 is carried out, the small circumferential surface body 71 and the large circumferential surface body 72 are arranged at a shutoff position shown in Fig. 14 from a communication position shown in Fig. 13, on the basis of a spring force of the first return spring 73. The magnetizing and demagnetizing timings of the electromagnetic three-way valve 48 are identical with the case of the first embodiment.

[0081] The sixth embodiment has the same advantages as those of the first embodiment. Further, in the sixth embodiment, since the refrigerant which can flow in the front compression chamber 271 and the rear compression chamber 281 at a time when the small circumferential surface body 71 and the large circumferential surface body 72 are at the shutoff position is constituted only by the refrigerant within the front outlet 312, within the rear outlet 313, within the front communication passage 32, and within the rear communication passage 33, the effect of reducing the starting impact is more noticeable than the case of the first embodiment.

[0082] In the case that the piston 69 is structured such as to be relatively rotatable with respect to the transmission rod 70, the piston 69 prevents the relative rotation between the first return spring 73 and the rotary shaft 21. Accordingly, it is possible to avoid an abrasion and damage of the first return spring 73 or the rotary shaft 21 caused by the relative rotation between the first return spring 73 and the rotary shaft 21. Alternatively, the large circumferential surface body 72 may be structured such as to be relatively rotatable with respect to the first return spring 73.

[0083] Figs. 15A and 15B explain a seventh embodiment. The same reference numerals are used in the same components as those of the sixth embodiment.

[0084] A disc-shaped circular plate 74 is fastened to a distal end of the transmission rod 70. As shown in Fig. 15A, in the case that the large circumferential surface body 72 is located at a position at which the large circumferential surface body 72 closes the rear outlet 313, the circular plate 74 is located in an upstream side of the front outlet 312 within the in-shaft passage 31A, and the refrigerant in the in-shaft passage 31A cannot flow in the front compression chamber 271 via the front outlet 312. As shown in Fig. 15B, in the case that the large circumferential surface body 72 is located at a position at which the large circumferential surface body 72 opens the rear outlet 313, the circular plate 74 is located in a downstream side of the front outlet 312 within the in-shaft passage 31A, and the refrigerant in the in-shaft passage 31A can flow in the front compression chamber 271 via the front outlet 312. If the electromagnetic three-way valve 48 [refer to Fig. 14] is excited, the circular plate 74 is arranged at a shutoff position shown in Fig. 15A from a communication position shown in Fig. 15B, on the basis of the spring force of the first return spring 73. The circular plate 74, the large circumferential surface body 72, the transmission rod 70 and the piston 69 construct the valve body defining the working pressure chamber 412 within the working pressure recess 411.

[0085] The seventh embodiment has the same advantages as those of the sixth embodiment.

[0086] Figs. 16A and 16B explain an eighth embodiment. The same reference numerals are used in the same components as those of the sixth embodiment.

[0087] A cylinder 75 is coupled to the piston 69 so as to be relatively rotatable with respect to the piston 69. The cylinder 75 is slidably fitted to the in-shaft passage 31A. An end wall 752 is formed in a distal end of the cylinder 75. An angular pin 76 is fastened to an inner end which is a dead end of the in-shaft passage 31A, and the angular pin 76 is inserted to the end wall 752 of the cylinder 75 so as to be relatively slidable. The cylinder 75 and the angular pin 76 are integrally rotated with the rotary shaft 21, and can slide within the in-shaft passage 31A in a state in which the angular pin 76 is inserted to the end wall 752.

[0088] The cylinder 75 is provided with a small-diameter cylindrical portion 77, which is fitted into the small-diameter passage 314, and a large-diameter cylindrical portion 78, which is fitted to the large-diameter passage 315. An introduction port 751 is formed in a portion of the large-diameter cylindrical portion 78 positioned within the suction chamber 142 so as to be capable of connecting the suction chamber 142 with a cylinder interior 750 of the cylinder 75.

[0089] A communication port 771 is formed in a portion of the small-diameter cylindrical portion 77 within the small-diameter passage 314 so as to communicate with the inside of the small-diameter cylindrical portion 77. A communication port 781 is formed in the large-diameter cylindrical portion 78 so as to communicate with the interior of the large-diameter cylindrical portion 78.

[0090] The first return spring 73 is arranged between a step 753 between the small-diameter cylindrical portion 77 and the large-diameter cylindrical portion 78, and the step 316 of the rotary shaft 21. The first return spring 73 urges the cylinder 75 toward the working pressure chamber 412 in such a manner as to press the piston 69 to the working pressure recess 411. The piston 69 and the cylinder 75 construct a valve body defining the working pressure chamber 412 within the working pressure recess 411.

[0091] Fig. 16B shows a state in which the small-diameter cylindrical portion 77, which serves as a valve body, closes the front outlet 312, and shows a state in which the large-diameter cylindrical portion 78, which serves as a valve body, closes the rear outlet 313. Accordingly, the front outlet 312 and the rear outlet 313 are shut off from the cylinder interior 750 of the cylinder 75. Fig. 16A shows a state in which the communication port 771 of the small-diameter cylindrical portion 77 communicates with the front outlet 312, and shows a state in which the communication port 781 of the large-diameter cylindrical portion 78 communicates with the rear outlet 313, and the front outlet 312 and the rear outlet 313 communicate with the cylinder interior 750. The refrigerant in the suction chamber 142 can flow in the front compression chamber 271 via the introduction port 751, the cylinder interior 750, the communication port 771, the front outlet 312, and the front communication passage 32, and the refrigerant in the suction chamber 142 can flow in the rear compression chamber 281 via the introduction port 751, the cylinder interior 750, the communication port 781, the rear outlet 313, and the rear communication passage 33. If the electromagnetic three-way valve 48 [refer to Fig. 14] is excited, the cylinder 75 is arranged from a communication position shown in Fig. 16A to a shutoff position shown in Fig. 16B on the basis of the spring force of the first return spring 73. The magnetizing and demagnetizing timings of the electromagnetic three-way valve 48 are the same as those of the first embodiment.

[0092] The eighth embodiment has the same advantages as those of the sixth embodiment.

[0093] Figs. 17 to 18B explain a ninth embodiment. The same reference numerals are used in the same components as those of the fifth embodiment.

[0094] As shown in Fig. 17, a check valve built-in type oil separator 79 is arranged in the portion 34A of the external refrigerant circuit 34 which is located in an upstream side of the heat exchanger 37.

[0095] As shown in Figs. 18A and 18B, a refrigerant swirling cylinder 81 is fixed in a fitting manner into a housing 80 constructing the oil separator 79. The refrigerant swirling cylinder 81 defines an oil separation chamber 82 and a valve accommodation chamber 83 in the housing 80. The oil separation chamber 82 communicates with the portion 34A of the external refrigerant circuit 34 which is located in the upstream side of the oil separator 79, and the refrigerant in the portion 34A of the external refrigerant circuit 34 flows into the oil separation chamber 82. The refrigerant flowing into the oil separation chamber 82 from the portion 34A of the external refrigerant circuit 34 swirls around the refrigerant swirling cylinder 81. The refrigerant swirling around the refrigerant swirling cylinder 81 flows in a cylinder interior 812 from a cylinder port 811 of the refrigerant swirling cylinder 81 facing the oil separation chamber 82.

[0096] A valve body 85 is accommodated in the valve accommodation chamber 83. The valve body 85 is capable of opening and closing the other cylinder port 813 of the refrigerant swirling cylinder 81. The valve body 85 is urged toward a position closing the cylinder port 813 by a compression spring 86. If a pressure of the refrigerant within the cylinder interior 812 overcomes a spring force of the compression spring 86, the refrigerant of the cylinder interior 812 pushes the valve body 85 so as to flow out to the valve accommodation chamber 83. The refrigerant swirling cylinder 81, the valve body 85 and the compression spring 86 construct a check valve 87. The refrigerant in the valve accommodation chamber 83 flows in the heat exchanger 37.

[0097] A constriction hole 402 extends through the end wall 40. The constriction hole 402, which serves as a constriction, connects the working pressure chamber 412 with a conduit 84. The oil separation chamber 82 communicates with the working pressure chamber 412 via the conduit 84 and the constriction hole 402. The pressure (the discharge pressure) within the oil separation chamber 82 is applied to the working pressure chamber 412 via the conduit 84 and the constriction hole 402. The constriction hole 402 and the conduit 84 construct a portion of an inflow passage which is located in a downstream side of the oil separator 79.

[0098] The oil is charged within the circuit constituted by the compressor 10 and the external refrigerant circuit 34, and the oil flows with the refrigerant.

[0099] The refrigerant flowing in the oil separation chamber 82 from the portion 34A of the external refrigerant circuit 34 swirls around the refrigerant swirling cylinder 81, and a mist-like oil flowing together with the refrigerant is separated within the oil separation chamber 82. The refrigerant swirling around the refrigerant swirling cylinder 81 flows in the cylinder interior 812, and the oil separated from the refrigerant can flow in the working pressure chamber 412 via the conduit 84 and the constriction hole 402. The conduit 84 and the constriction hole 402 construct an inflow passage reaching the portion 34A of the external refrigerant circuit 34, which is a discharge pressure zone, from the working pressure chamber 412.

[0100] In the case that the operation of the compressor 10 stops and the pressure within the compressor 10 is balanced, the valve body 42 is retained at a shutoff position shown in Fig. 18B on the basis of the spring force of the first return spring 47. In the case that the operation of the compressor 10 is started, the refrigerant does not flow in the in-shaft passage 31 from the suction chamber 142, so that the starting impact is reduced.

[0101] If the pressure within the oil separation chamber 82 is increased in accordance with the start of the operation of the compressor 10, the pressure within the working pressure chamber 412 is also increased, and the valve body 42 is arranged at the communication position shown in Fig. 18A against the spring force of the first return spring 47. Since the constriction hole 402 narrows a passage cross-sectional area between the conduit 84 and the working pressure chamber 412, the pressure within the working pressure chamber 412 is not rapidly increased even if the pressure within the front discharge chamber 131 and the rear discharge chamber 141 is increased. Further, since the oil separated by the oil separator 79 enters the constriction hole 402, the oil entering the constriction hole 402 generates a passage resistance so as to contribute to a suppression of a rapid increase of the pressure within the working pressure chamber 412. Since the rapid increase of the pressure within the working pressure chamber 412 is suppressed, the valve body 42 is not moved from the shutoff position to the communication position in a moment of time. Accordingly, the reducing effect of the starting impact is increased.

[0102] Since the ninth embodiment does not use the electromagnetic three-way valve 48 and the electromagnetic on-off valve 67, the ninth embodiment is advantageous in cost compared with those of the first to the fifth embodiments.

[0103] Figs. 19A and 19B explain a tenth embodiment. The same reference numerals are used in the same components as those of the first embodiment.

[0104] A communication chamber 88 and a valve hole 891 are formed in the rear housing member 14, and a plate-shaped opening and closing plate 90 is accommodated within the communication chamber 88 in such a manner as to be capable of opening and closing the valve hole 891. The valve hole 891 extends through a partition wall 89 which separates the communication chamber 88 and the suction chamber 142. An inlet 311 of the in-shaft passage 31 is positioned at an end surface of the rotary shaft 21 within the rear cylinder block 12, and is open to the communication chamber 88 within the rear housing member 14.

[0105] A piston 91 is fitted into the working pressure recess 411, and a transmission rod 92 is integrally formed in the piston 91. The opening and closing plate 90 is fastened to a distal end of the transmission rod 92. A flat valve seat surface 892 is formed in a surface of the partition wall 89 facing the communication chamber 88. The opening and closing plate 90 selectively contacts and separates from the valve seat surface 892. A seal surface 901 of the opening and closing plate 90 coming into contact with the valve seat surface 892 is formed as a flat surface. In other words, in the case that the opening and closing plate 90 closes the valve hole 891, the seal surface 901 of the opening and closing plate 90 comes into surface contact with the valve seat surface 892. The piston 91, the transmission rod 92 and the opening and closing plate 90 define the working pressure chamber 412 within the working pressure recess 411, and construct a valve body 93 opening and closing the valve hole 891.

[0106] A first return spring 94 is arranged between the piston 91 and the partition wall 89. The first return spring 94 urges the piston 91 in a direction in which the first return spring 94 presses the piston 91 to the working pressure recess 411. The valve body 93 in Fig. 19B is located at a communication position at which the valve body 93 connects the communication chamber 88 with the suction chamber 142 by opening the valve hole 891, and the valve body in Fig. 19A is located at a shutoff position at which the valve body 93 shuts off the communication chamber 88 from the suction chamber 142 by closing the valve hole 891. The first return spring 94 urges the valve body 93 from the communication position toward the shutoff position.

[0107] A plurality of stoppers 902 are provided in a protruding manner in a back surface of the opening and closing plate 90 facing the end surface of the rotary shaft 21. The stopper 902 selectively contacts and separates from a distal end of a cylindrical portion 123 provided in a protruding manner in an end surface 122 of the rear cylinder block 12. In a state in which the valve body 93 is arranged at the communication position shown in Fig. 19B, the stopper 902 is brought into contact with the distal end of the cylindrical portion 123, and in a state in which the valve body 93 is arranged at the shutoff position shown in Fig. 19A, the stopper 902 is away from the distal end of the cylindrical portion 123.

[0108] In a state in which the electromagnetic three-way valve 48 is magnetized, the valve body 93 is arranged at the shutoff position shown in Fig. 19A, and the refrigerant within the suction chamber 142 cannot flow in the communication chamber 88. In a state in which the electromagnetic three-way valve 48 is demagnetized, the valve body 93 is arranged at the communication position shown in Fig. 19B, and the refrigerant within the suction chamber 142 can flow in the front compression chamber 271 (refer to Fig. 1) and the rear compression chamber 281 via the communication chamber 88 and the in-shaft passage 31.

[0109] The magnetizing and demagnetizing timings of the electromagnetic three-way valve 48 are the same as the case of the first embodiment. Accordingly, the tenth embodiment also obtains the reducing effect of the starting impact. Further, since it is possible to reduce the volumetric capacity of the communication chamber 88 accommodating the plate-shaped opening and closing plate 90, the reducing effect of the starting impact is noticeable in the same manner as the case of the first embodiment.

[0110] Fig. 20 shows a fixed displacement type piston compressor 10A in accordance with an eleventh embodiment. The compressor 10A has a plurality of one headed pistons 95. The same reference numerals are used in the same components as those of the first embodiment.

[0111] A whole housing of the compressor 10A is constituted by the cylinder block 12, the front housing member 13, and the rear housing member 14. The swash plate 23 is accommodated in the swash plate chamber 24 defined between the cylinder block 12 and the front housing member 13. A one headed piston 95 linked to the swash plate 23 reciprocates within the cylinder bore 28 in accordance with the rotation of the swash plate 23. The rotary valve 36 is provided in the rotary shaft 21 so as to correspond to the cylinder block 12. The valve body 42 is provided in the rear housing member 14 so as to define the working pressure chamber 412.

[0112] The eleventh embodiment also has the same advantages as those of the first embodiment.

[0113] Figs. 21 to 26 show a twelfth embodiment in accordance with the present invention.

[0114] As shown in Fig. 21, the in-shaft passage 31 is formed within the rotary shaft 21 so as to be along the rotation axis 210 of the rotary shaft 21. The communication chamber 88 and the valve hole 891 are formed in the rear housing member 14, and the plate-shaped opening and closing plate 90 is accommodated within the communication chamber 88 in such a manner as to be capable of opening and closing the valve hole 891. The valve hole 891 extends through the partition wall 89 which separates the communication chamber 88 and the suction chamber 142. The inlet 311 of the in-shaft passage 31 is positioned in the end surface of the rotary shaft 21 within the rear cylinder block 12, and is open to the communication chamber 88 within the rear housing member 14.

[0115] As shown in Figs. 23 and 24, an electromagnetic solenoid 248, which serves as an electromagnetic drive portion, is attached to the end wall 40 of the rear housing member 14. The rear housing member 14 is made of aluminum and forms the suction chamber 142. An installation recess 404 is formed in a recessed manner in an outer surface of the end wall 40. The electromagnetic solenoid 248 includes a fixed iron core 250, a movable iron core 251, a second return spring 252, and a coil 253.

[0116] The fixed iron core 250 is fitted to the installation recess 404, and a coil 253 is embedded in the fixed iron core 250. The installation recess 404 is connected to the suction chamber 142. A pressure recess 260, which serves as a pressure chamber forming recess, is formed in a recessed manner in the fixed iron core 250. The pressure recess 260 is open toward the suction chamber 142. The movable iron core 251 is slidably fitted to the pressure recess 260. The movable iron core 251 defines a pressure chamber 262 within the pressure recess 260. A groove 254 is formed in a peripheral surface of the movable iron core 251. The groove 254 connects the pressure recess 260 with the suction chamber 142. Accordingly, the pressure within the pressure chamber 262 corresponds to the pressure within the suction chamber 142. The pressure of the suction chamber 142, that is, the suction pressure acts against a pressure in the pressure chamber 262 via the movable iron core 251. A lid 258 fastened to the outer surface of the end wall 40 retains the fixed iron core 250 and the coil 253 within the installation recess 404.

[0117] The movable iron core 251 has an attaching hole 255, which serves as a through hole. The attaching hole 255 extends through the movable iron core 251 in such a manner as to be connected to the suction chamber 142 from the pressure recess 260. The transmission rod 92 is press fitted to the attaching hole 255 from an opening of the attaching hole 255 facing the suction chamber 142, and is fixed thereto. The opening and closing plate 90 is fastened to a distal end of the transmission rod 92.

[0118] The movable iron core 251, the transmission rod 92 and the opening and closing plate 90 construct the valve body 242 opening and closing the valve hole 891. The valve body 242 defines the pressure chamber 262 within the pressure recess 260.

[0119] The second return spring 252 is arranged between the transmission rod 92 and a bottom 261 of the pressure recess 260. The second return spring 252 urges the transmission rod 92 in a direction in which the second return spring 252 moves the transmission rod 92 away from the bottom 261. In other words, the movable iron core 251 is urged in a direction in which the movable iron core 251 pops out of the pressure recess 260 toward the suction chamber 142, on the basis of the spring force of the second return spring 252. The electromagnetic solenoid 248, the valve body 242 and the second return spring 252 construct a switch portion. The switch portion is capable of switching the suction chamber 142, which serves as a portion of the suction pressure zone within the compressor 10, to a communication state, in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 of the in-shaft passage 31, and a shutoff state, in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313.

[0120] In Fig. 23, the valve body 242 is located in the communication position, at which the valve body 242 connects the communication chamber 88 with the suction chamber 142, by opening the valve hole 891. In Fig. 24, the valve body 242 is located at the shutoff position at which the valve body 242 shuts off the communication chamber 88 from the suction chamber 142 by closing the valve hole 891. The second return spring 252 urges the valve body 242 from the shutoff position toward the communication position. In other words, the switch portion is capable of switching the suction chamber 142 to a communication state [a state shown in Fig. 23], in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 of the in-shaft passage 31, and a shutoff state [a state shown in Fig. 24], in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313 of the in-shaft passage 31.

[0121] If the electric current is fed to the coil 253, the fixed iron core 250 attracts the movable iron core 251 against a spring force of the second return spring 252. In other words, an electromagnetic force generated by exciting the coil 253 drives the valve body 242 from the communication position toward the shutoff position. The electromagnetic solenoid 248 can be switched to a first state, in which the electromagnetic solenoid 248 arranges the valve body 242 at the communication position by being demagnetized, and a second state, in which the electromagnetic solenoid 248 arranges the valve body 242 at the shutoff position by being magnetized.

[0122] The magnetizing and demagnetizing of the electromagnetic solenoid 248 and the electromagnetic clutch 25 are controlled by the control computer C.

[0123] A valve waveform W in a timing chart in Fig. 26 shows a current feeding timing with respect to the electromagnetic solenoid 248. A first exciting period section V1 in the valve waveform W is set in correspondence to a clutch starting time t1. A starting time t3 of the first exciting period section V1 is before the clutch starting time t1, and an ending time t4 of the first exciting period section V1 is after the clutch starting time t1. In other words, the control computer C first carries out the current feed to the electromagnetic solenoid 248 and thereafter carries out the current feed to the electromagnetic clutch 25, at a time of starting the current feed to the electromagnetic clutch 25.

[0124] Fig. 25 is a flowchart showing an operation control program for controlling the operation of the compressor 10, and the control computer C controls the operation of the compressor 10 on the basis of the operation control program shown by the flowchart. A description will be given below of the operation control of the compressor 10 in accordance with the operation control program shown by the flowchart. Fig. 25 has steps S1 to S7 and S18. Steps S1 to S7 are the same as the case of Fig. 5 except the matter that the electromagnetic three-way valve 48 is replaced by the electromagnetic solenoid 248.

[0125] If the compressor 10 is in the operation stop state, and the electromagnetic solenoid 248 is in the demagnetized state, the valve body 242 is arranged at the communication position shown in Fig. 23 on the basis of the spring force of the second return spring 252.

[0126] As shown in Fig. 23, in the case of YES in step S1, that is, in the case of the compressor operation starting mode, the control computer C starts the current application to the electromagnetic solenoid 248 in step S2. If the electric current is fed to the electromagnetic solenoid 248, the valve body 242 is arranged at the shutoff position shown in Fig. 24 against the spring force of the second return spring 252, and the valve hole 891 is closed. Accordingly, the suction chamber 142 is shut off from the communication chamber 88.

[0127] In the case of YES in step S3, that is, in the case that a period ta has elapsed after starting the current application to the electromagnetic solenoid 248, the control computer C starts the current application to the electromagnetic clutch 25 in step S4. Accordingly, the electromagnetic clutch 25 gives way to the coupled state from the shutoff state, and the rotary shaft 21 and the swash plate 23 start rotating.

[0128] In the case of YES in step S5, that is, in the case that a period tb has elapsed after starting the current application to the electromagnetic clutch 25, the control computer C stops the current application to the electromagnetic solenoid 248 in step S6. If the current feed to the electromagnetic solenoid 248 is stopped, the valve body 242 is arranged at the communication position shown in Fig. 23 from the shutoff position shown in Fig. 24, on the basis of the spring force of the second return spring 252. Accordingly, the valve hole 891 is opened, and the communication chamber 88 communicates with the suction chamber 142. Therefore, the refrigerant within the suction chamber 142 flows in the in-shaft passage 31 via the valve hole 891 and the communication chamber 88.

[0129] After stopping the current application to the electromagnetic solenoid 248, the control computer C determines in step S7 whether the compressor operation stopping mode is established, on the basis of the comparison between the detected temperature and the target temperature. In the case of YES in step S7, that is, in the case of the compressor operation stopping mode, the control computer C stops the current application to the electromagnetic clutch 25 in step S18. After the process of step S18, the control computer C gives way to step S1.

[0130] The torque waveform T1 in Fig. 26 is one example of the torque fluctuation. In the case that the current application to the electromagnetic clutch 25 is started, the torque is fluctuated. However, at a time of starting the current application to the electromagnetic clutch 25, it is possible to suppress a rapid torque fluctuation [a fluctuation portion T11 in the torque waveform T1] in the case that the current application to the electromagnetic clutch 25 is started, by exciting the electromagnetic solenoid 248 before starting the current application to the electromagnetic clutch 25 and stopping the current application to the electromagnetic solenoid 248 after starting the current application to the electromagnetic clutch 25.

[0131] The'twelfth embodiment has the following advantages.

(2-1) In the state in which the electromagnetic solenoid 248 is magnetized, the valve body 242 is arranged at the shutoff position shown in Fig. 24. If the valve body 242 is arranged at the shutoff position, the suction chamber 142, which is the suction pressure zone within the compressor 10, is shut off from the communication chamber 88. Accordingly, at a time when the operation of the compressor 10 is started, that is, at a time when the rotation of the rotary shaft 21 is started, the rotation of the rotary shaft 21 is started after the valve body 242 is previously arranged at the shutoff position. Therefore, the refrigerant does not flow in the communication chamber 88 and the in-shaft passage 31 from the suction chamber 142. Accordingly, the rapid torque fluctuation is suppressed and the starting impact is reduced.

(2-2) The opening and closing plate 90 for shutting off the suction chamber 142 within the compressor 10 from the communication chamber 88 is shaped like a plate. Accordingly, it is possible to reduce the volumetric capacity of the communication chamber 88 accommodating the opening and closing plate 90. Therefore, the amount of the refrigerant compressed by the front compression chamber 271 and the rear compression chamber 281 is small at a time when the valve body 242 exists at the shutoff position. As a result, the effect of suppressing the torque fluctuation, that is, the effect of reducing the starting impact is noticeable.

(2-3) If the electromagnetic solenoid 248 is demagnetized, the valve body 242 is returned to the communication position on the basis of the spring force of the second return spring 252. The use of the second return spring 252 simplifies the structure for returning the valve body 242 to the communication position.

(2-4) If it is impossible to magnetize the electromagnetic solenoid 248, the valve body 242 is retained at the communication position on the basis of the spring force of the second return spring 252 within the pressure chamber 262. Accordingly, if the compressor 10 starts being operated, the refrigerant within the suction chamber 142 flows in the front compression chamber 271 and the rear compression chamber 281 via the communication chamber 88 and the in-shaft passage 31. In other words, even in the case that it becomes impossible to magnetize the electromagnetic solenoid 248, the cooling operation is carried out normally.

(2-5) If the refrigerant leaks from the suction chamber 142 to the communication chamber 88 via the valve hole 891 at a time when the valve body 242 closes the valve hole 891, the reducing effect of the starting impact is lowered. However, in accordance with the present embodiment, the communication chamber 88 is securely shut off from the suction chamber 142, in the state in which the flat seal surface 901 of the opening and closing plate 90 comes into surface contact with the flat valve seat surface 892. Accordingly, it is possible to prevent the refrigerant from leaking from the suction chamber 142 to the communication chamber 88 via the valve hole 891, at a time when the valve body 242 closes the valve hole 891.

[0132] Fig. 27 explains a thirteenth embodiment. The apparatus structure is the same as the case of the twelfth embodiment.

[0133] In the thirteenth embodiment, the apparatus structure is the same as the case of the twelfth embodiment, however, as shown by a current application starting section K21 in a clutch waveform K2, the thirteenth embodiment is different from the case of the twelfth embodiment in a point that the amount of current application at a time of starting the current application to the electromagnetic clutch 25 is gradually increased. After the feed current value to the electromagnetic clutch 25 becomes maximum, the current application to the electromagnetic solenoid 248 is stopped. The fluctuation of the fluctuation portion T21 in the torque waveform T2 expressing the torque fluctuation is suppressed in comparison with the case of the twelfth embodiment, on the basis of the start of the current application to the electromagnetic clutch 25.

[0134] For example, in a conventional fixed displacement type piston compressor having no switch portion, the torque at a time of starting is great, that is, the load of the electromagnetic clutch 25 is great. Accordingly, if the amount of current application is gradually increased in the same manner as the present embodiment, slip is generated in the electromagnetic clutch 25. Accordingly, it is hard to ensure the reliability of the electromagnetic clutch 25.

[0135] In the present embodiment, the torque at a time of starting is small, that is, the load applied to the electromagnetic clutch 25 is small. Accordingly, it is possible to carry out such an operation control as to gradually increase the amount of current application to the electromagnetic clutch 25.

[0136] Figs. 28A and 28B explain a fourteenth embodiment. The same reference numerals are attached to the same component as the twelfth embodiment.

[0137] A valve body 242A is provided with the opening and closing plate 90, a movable iron core 251A, and a transmission rod 92. The movable iron core 251A is slidably fitted to a pressure recess 260. The transmission rod 92 is integrally formed in the movable iron core 251A. The movable iron core 251A defines a pressure chamber 262 within the pressure recess 260. The first return spring 94 is arranged between the movable iron core 251A and the partition wall 89. The first return spring 94 urges the valve body 242A in a direction of pressing the movable iron core 251A into the pressure recess 260. If the electromagnetic solenoid 248 is magnetized, an electromagnetic driving force of the electromagnetic solenoid 248 drives the valve body 242A in a direction of pressing the movable iron core 251A into the pressure recess 260. The first return spring 94 serves as a retaining spring retaining the valve body 242A at the shutoff position.

[0138] In Fig. 28A, the valve body 242A exists at the shutoff position at which the valve body 242A closes the valve hole 891, and in Fig. 28B, the valve body 242A exists at the communication position at which the valve body 242A opens the valve hole 891. In the case that the electromagnetic solenoid 248 is in the magnetized state, the valve body 242A exists at the shutoff position shown in Fig. 28A on the basis of the electromagnetic force of the electromagnetic solenoid 248. A timing at which the electromagnetic solenoid 248 is magnetized is the same as the case of the twelfth embodiment. In the case that the operation of the compressor 10 is in the stop state, the valve body 242A is retained at the shutoff position shown in Fig. 28A on the basis of the spring force of the first return spring 94.

[0139] If the electromagnetic solenoid 248 is magnetized before the compressor 10 starts being operated, and the operation of the compressor 10 is started thereafter, the starting impact is reduced in the same manner as the case of the twelfth embodiment because the valve body 242A exists at the shutoff position.

[0140] If the electromagnetic solenoid 248 is demagnetized after starting the operation of the compressor 10, the valve body 242A is released from the electromagnetic force of the electromagnetic solenoid 248. Since the refrigerant within the in-shaft passage 31 and the refrigerant within the communication chamber 88 are drawn into the front compression chamber 271 (refer to Fig. 21) and the rear compression chamber 281, a difference is generated between the pressure within the suction chamber 142 and the pressure within the communication chamber 88. Accordingly, the opening and closing plate 90 separates from the valve seat surface 892 against the spring force of the first return spring 94. If the opening and closing plate 90 separates from the valve seat surface 892, the refrigerant within the suction chamber 142 is drawn to the communication chamber 88 via the valve hole 891. Accordingly, the pressure within the suction chamber 142 becomes lower than the pressure within the pressure chamber 262. In other words, a difference is generated between the pressure within the suction chamber 142 and the pressure within the pressure chamber 262.

[0141] The spring force of the first return spring 94 is set to such a magnitude that the first return spring 94 is compressed by the differential pressure generated between the pressure within the suction chamber 142 and the pressure within the pressure chamber 262 at a time of operating the compressor 10. In other words, the spring force of the first return spring 94 is set such as to yield to the differential pressure mentioned above. Accordingly, the differential pressure generated between the pressure within the suction chamber 142 and the pressure within the pressure chamber 262 at a time of operating the compressor 10 overcomes the spring force of the first return spring 94 and retains the valve body 242A at the communication position shown in Fig. 28B.

[0142] The fourteenth embodiment has the same advantages as the items (2-1) and (2-4) in the twelfth embodiment. If the electromagnetic solenoid 248 is magnetized, it is possible to securely retain the valve body 242A at the shutoff position. If the electromagnetic solenoid 248 is in the demagnetized state by appropriately setting the spring force of the first return spring 94, the valve body 242A is arranged at the communication position in the case that the compressor 10 is operated, and the cooling operation is securely carried out.

[0143] Figs. 29A and 29B explain a fifteenth embodiment. The same reference numerals are used in the same components as those of the twelfth embodiment.

[0144] A spool-shaped valve body 342 is slidably fitted into a pressure recess 611 which is the cylinder interior of the cylinder 41, in the end wall 40 of the rear housing member 14. The valve body 342 is provided with the disc-shaped piston portion 43, the cylinder portion 44 and a movable iron core portion 345. A cylinder interior 442 is an internal passage of the valve body 342. The piston portion 43 defines a pressure chamber 612 within the pressure recess 611.

[0145] A groove 443 is formed in an outer peripheral surface of the cylinder portion 44 in such a manner that the groove 443 connects the suction chamber 142 with the pressure chamber 612. A pressure in the pressure chamber 612 corresponds to a pressure in the suction chamber 142, and the pressure (the suction pressure) in the suction chamber 142 acts against the pressure in the pressure chamber 612 via the valve body 342.

[0146] A fitting hole 403 extends through the end wall 40, and an accommodation cylinder 346 is fitted to the fitting hole 403. A fixed iron core 364 is accommodated within the accommodation cylinder 346. The movable iron core portion 345 is fitted into the accommodation cylinder 346 in such a manner as to face the fixed iron core 364. A coil 365 is arranged in an outer peripheral surface of the accommodation cylinder 346. If the coil 365 is excited, the movable iron core portion 345 is attracted to the fixed iron core 364. The fixed iron core 364, the movable iron core portion 345 and the coil 365 construct an electromagnetic solenoid 347, which serves as an electromagnetic driving portion.

[0147] The guide cylinder 45 surrounds the rotation axis 210. If the valve body 342 comes close to the end wall 40, the volumetric capacity of the pressure chamber 612 is reduced. The electromagnetic solenoid 347, the valve body 342 and the first return spring 47 construct the switch portion. The switch portion is capable of switching the suction chamber 142, which is a portion of the suction pressure zone within the compressor 10, to the communication state, in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 of the in-shaft passage 31, and the shutoff state, in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313. The first return spring 47 serves as the retaining spring retaining the valve body 342 at the shutoff position.

[0148] In the state shown in Fig. 29B, a whole of the introduction port 441 is located at a position exposed to the interior of the suction chamber 142, and the in-shaft passage 31 communicates with the suction chamber 142 via the cylinder interior 451 of the guide cylinder 45, the cylinder interior 442 of the cylinder portion 44 and the introduction port 441. In the state shown in Fig. 29A, the introduction port 441 is located at a position at which the entire introduction port 441 enters the pressure recess 611, and the in-shaft passage 31 is shut off from the suction chamber 142. Fig. 29B shows a state in which the valve body 342 is in a state of being at the communication position connects the in-shaft passage 31 and the suction chamber 142, and Fig. 29A shows a state in which the valve body 342 is in a state of being at the shutoff position, at which the valve body 342 shuts off the in-shaft passage 31 and the suction chamber 142.

[0149] In the case that the electromagnetic solenoid 347 is in the magnetized state, the valve body 342 exists at the shutoff position shown in Fig. 29A on the basis of the electromagnetic force of the electromagnetic solenoid 347. The timing at which the electromagnetic solenoid 347 is magnetized is the same as the case of the twelfth embodiment. In the case that the operation of the compressor 10 is in the stop state, the valve body 342 is retained at the shutoff position shown in Fig. 29A on the basis of the spring force of the first return spring 47. In other words, the switch portion is capable of switching the suction chamber 142 to the communication state [the state shown in Fig. 29B] in which the suction chamber 142 communicates with the front outlet 312 and the rear outlet 313 of the in-shaft passage 31, and the shutoff state [the state shown in Fig. 29A] in which the suction chamber 142 is shut off from the front outlet 312 and the rear outlet 313 of the in-shaft passage 31.

[0150] If the electromagnetic solenoid 347 is magnetized before the compressor 10 starts being operated, and the operation of the compressor 10 is started thereafter, the starting impact is reduced in the same manner as the case of the twelfth embodiment because the valve body 342 exists at the shutoff position.

[0151] If the electromagnetic solenoid 347 is demagnetized after starting the operation of the compressor 10, the valve body 342 is released from the electromagnetic force of the electromagnetic solenoid 347. Since the refrigerant within the cylinder interior 451 and the in-shaft passage 31 is drawn to the front compression chamber 271 (refer to Fig. 21) and the rear compression chamber 281, a difference is generated between the pressure in the suction chamber 142 and the pressure in the pressure chamber 612, on the basis of the drawing operation. The spring force of the first return spring 47 is set to such a magnitude that the first return spring 47 is compressed by the differential pressure generated between the pressure within the suction chamber 142 and the pressure within the pressure chamber 612 at a time of operating the compressor 10. Accordingly, the differential pressure generated between the pressure in the suction chamber 142 and the pressure in the pressure chamber 612 at a time of operating the compressor 10 overcomes the spring force of the first return spring 47, and retains the valve body 342 at the communication position shown in Fig. 29B.

[0152] The fifteenth embodiment has the same advantages as those of the twelfth embodiment.

[0153] Figs. 30A and 30B explain a sixteenth embodiment. The same reference numerals are used in the same components as those of the fifteenth embodiment.

[0154] The guide cylinder 45A fitted to the cylinder portion 44 of the valve body 342 is formed as a closed-end cylindrical shape, and is formed independently from the rear cylinder block 12, the rotary shaft 21 and the like. The bottom wall of the guide cylinder 45A comes into contact with the end surface 122 of the rear cylinder block 12, and the guide cylinder 45A is fitted to the cylinder portion 44 of the valve body 342 in such a manner as to be allowed to move in the radial direction of the rotary shaft 21 with respect to the rotary shaft 21. The communication port 452 is formed in the bottom wall of the guide cylinder 45A in such a manner as to connect the cylinder interior 451 of the guide cylinder 45A with the in-shaft passage 31, and the first return spring 47 is arranged between the bottom wall of the guide cylinder 45A and the piston portion 43. In Fig. 30A, the valve body 342 is arranged at the shutoff position, and the valve body 342 is arranged at the communication'position in Fig. 30B.

[0155] On the assumption that the refrigerant leaks through a clearance between the valve body 342 and the cylinder 41 or a clearance between the valve body 342 and the guide cylinder 45A at a time when the valve body 342 exists at the shutoff position, the effect of reducing the starting impact is lowered.

[0156] However, in the present embodiment, the guide cylinder 45A is fitted to the cylinder portion 44 of the valve body 342 in such a manner that the guide cylinder 45A is allowed to move in the radial direction of the rotary shaft 21 with respect to the rotary shaft 21. Accordingly, the axis 413 of the pressure recess 611 is allowed to come into line with the' axis 453 of the guide cylinder 45A. Therefore, it is possible to reduce the clearance between the cylinder portion 44 of the valve body 342 and the cylinder 41 and the clearance between the cylinder portion 44 of the valve body 342 and the guide cylinder 45A, and it is possible to prevent the refrigerant from leaking along the peripheral surface of the cylinder portion 44 of the valve body 342.

[0157] Figs. 31A and 31B explain a seventeenth embodiment. The same reference numerals are used in the same components as those of the fifteenth embodiment.

[0158] The piston 69 is slidably fitted to the cylinder 41, and the movable iron core portion 345 is integrally formed in the piston 69. The piston 69 defines the pressure chamber 612 within the pressure recess 611. The transmission rod 70 is coupled to the piston 69.

[0159] The small circumferential surface body 71, the large circumferential surface body 72, the transmission rod 70 and the piston 69 construct the valve body defining the pressure chamber 612 within the pressure recess 611.

[0160] Fig. 31A shows a state in which the small circumferential surface body 71 closes the front outlet 312, and the large circumferential surface body 72 closes the rear outlet 313, and the front outlet 312 and the rear outlet 313 are shut off from the in-shaft passage 31A. Fig. 31B shows a state in which the small circumferential surface body 71 opens the front outlet 312, and the large circumferential surface body 72 opens the rear outlet 313, and the front outlet 312 and the rear outlet 313 communicate with the in-shaft passage 31A. If the electromagnetic solenoid 347 is excited, the small circumferential surface body 71 and the large circumferential surface body 72 are arranged at the shutoff position shown in Fig. 31A from the communication position shown in Fig. 31B on the basis of the spring force of the first return spring 73. The first return spring 73 serves as the retaining spring retaining the small circumferential surface body 71 and the large circumferential surface body 72 at the shutoff position.

[0161] The seventeenth embodiment has the same advantages as those of the twelfth embodiment. Further, in the seventeenth embodiment, since the refrigerant which can flow in the front compression chamber 271 and the rear compression chamber 281 at a time when the small circumferential surface body 71 and the large circumferential surface body 72 exist at the shutoff position is constituted only by the refrigerant within the front outlet 312 and the rear outlet 313, and within the front communication passage 32 and the rear communication passage 33, the effect of reducing the starting impact is more noticeable than the case of the twelfth embodiment.

[0162] Further, if the piston 69 is structured such as to be relatively rotatable with respect to the transmission rod 70, it is possible to prevent the first return spring 73 from relatively rotating with respect to the rotary shaft 21. Accordingly, it is possible to avoid the abrasion and damage of the first return spring 73 or the rotary shaft 21 caused by the relative rotation between the first return spring 73 and the rotary shaft 21. Alternatively, the large circumferential surface body 72 may be structured such as to be relatively rotatable with respect to the first return spring 73.

[0163] Figs. 32A and 32B explain an eighteenth embodiment. The same reference numerals are used in the same components as those of the seventeenth embodiment.

[0164] As shown in Fig. 32A, in the case that the large circumferential surface body 72 is located at the position at which it closes the rear outlet 313, the circular plate 74 exists at an upstream side of the front outlet 312 within the in-shaft passage 31A. Accordingly, the refrigerant in the in-shaft passage 31A cannot flow in the front compression chamber 271 via the front outlet 312. As shown in Fig. 32B, in the case that the large circumferential surface body 72 is located at the position at which it opens the rear outlet 313, the circular plate 74 exists in a downstream side of the front outlet 312 within the in-shaft passage 31A. Accordingly, the refrigerant in the in-shaft passage 31A can flow in the front compression chamber 271 via the front outlet 312. If the electromagnetic solenoid 347 is excited, the cylinder 75 is arranged at the shutoff position shown in Fig. 32A from the communication position shown in Fig. 32B, on the basis of the spring force of the first return spring 73. The circular plate 74, the large circumferential surface body 72, the transmission rod 70, and the piston 69 construct a valve body which defines the pressure chamber 612 within the pressure recess 611.

[0165] The eighteenth embodiment has the same advantages as those of the seventeenth embodiment.

[0166] Figs. 33A and 33B explain a nineteenth embodiment. The same reference numerals are used in the same components as those of the seventeenth embodiment.

[0167] The cylinder 75 can slide within the in-shaft passage 31A in a state in which the angular pin 76 is inserted to an end wall 752 of the cylinder 75. The cylinder 75 and the piston 69 construct a valve body which defines the pressure chamber 612 within the pressure recess 611.

[0168] Fig. 33B shows a state in which the small-diameter cylindrical portion 77 closes the front outlet 312, and shows a state in which the large-diameter cylindrical portion 78 closes the rear outlet 313. Accordingly, the front outlet 312 and the outlet 313 are shut off from the cylinder interior 750 of the cylinder 75. Fig. 33A shows a state in which the communication port 771 of the small-diameter cylindrical portion 77 communicates with the front outlet 312, and shows a state in which the communication port 781 of the large-diameter cylindrical portion 78 communicates with the rear outlet 313, and the front outlet 312 and the rear outlet 313 communicate with the cylinder interior 750. If the electromagnetic solenoid 347 is excited, the cylinder 75 is arranged at the shutoff position shown in Fig. 33B from the communication position shown in Fig. 33A, on the basis of the spring force of the first return spring 73.

[0169] The nineteenth embodiment has the same advantages as those of the seventeenth embodiment.

[0170] Fig. 34 shows a compressor 10A having one headed pistons 95 in accordance with a twentieth embodiment. The electromagnetic solenoid 248 and the valve body 242 are provided in the rear housing member 14. The twentieth embodiment has the same advantages as those of the twelfth embodiment.

[0171] The embodiments mentioned above may be modified as follows.

[0172] In Figs. 3 and 4, the discharge refrigerant fed to the working pressure chamber 412 may be taken from a portion of the external refrigerant circuit in the upstream side of the heat exchanger 37.

[0173] The electromagnetic three-way valve 48 shown in Figs. 12 and 13 may be incorporated by being coupled to the rear housing member 14.

[0174] The electromagnetic on-off valve 67 in Figs. 8 to 9A may be incorporated in the rear housing member 14. Further, the electromagnetic on-off valve 67A in Figs. 10 to 11A may be incorporated in the rear housing member 14.

[0175] The check valve 68 in Figs. 8 to 11A may be incorporated in the housing of the compressor 10.

[0176] The oil separator 79 in Figs. 17 to 18B may be incorporated in the housing of the compressor 10.

[0177] The valve body 42 may be arranged at the communication position in the case of magnetizing the electromagnetic three-way valve 48 in Figs. 3 and 4, and the valve body 42 may be arranged at the shutoff position in the case of demagnetizing the electromagnetic three-way valve 48.

[0178] The valve body 242 may be arranged at the communication position in the case of magnetizing the electromagnetic solenoid 248 in Figs. 23 and 24, and the valve body 242 may be arranged at the shutoff position in the case of demagnetizing the electromagnetic solenoid 248.

[0179] The valve body 342 may be arranged at the communication position in the case of magnetizing the electromagnetic solenoid 347 in Figs. 29A and 29B, and the valve body 342 may be arranged at the shutoff position in the case of demagnetizing the electromagnetic solenoid 347.

[0180] The pressure chamber 262 in Figs. 23 and 24 may be always shut off from the suction chamber 142, and the pressure chamber 262 may communicate with the atmospheric air.

[0181] Each of the first rotary valve 35 and the second rotary valve 36 may be formed independently from the rotary shaft 21.

Claims

1. A refrigerant suction structure in a fixed displacement type piston compressor (10), wherein the compressor (10) comprises:

    a rotary shaft (21) coupled to an external drive source (26) via a clutch (25);
    a plurality of cylinder bores (27, 28) arranged around the rotary shaft (21);
    a plurality of pistons (29) defining compression chambers (271, 281) in the cylinder bores (27, 28) by being respectively accommodated in the cylinder bores (27, 28);
    a cam body (23) integrated with the rotary shaft (21), the cam body (23) converting a rotation of the rotary shaft (21) into reciprocation of each of the pistons (29);
    a suction pressure zone (142); and
    a rotary valve (35, 36) having an introduction passage (31) for introducing a refrigerant from the suction pressure zone (142) to each of the compression chambers (271, 281), the rotary valve (35, 36) integrally rotating with the rotary shaft (21), the suction pressure zone having a portion (142) within the compressor (10), and the introduction passage (31) having outlets (312, 313) for feeding out the refrigerant toward each of the compression chambers (271, 281), the refrigerant suction structure being **characterized by** a switch portion capable of being switched between a communication state and a shutoff state,

    wherein the switch portion in the communication state allows the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31),
    wherein the switch portion in the shutoff state shuts off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31),
    wherein the switch portion includes:

    a valve body (42) capable of being switched between a communication position and a shutoff position, the valve body (42) in the communication position allowing the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31), and the valve body (42) in the shutoff position shutting off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31);
    a working pressure chamber (412) introducing a working pressure that is applied to the valve body (42) so as to arrange the valve body (42) at the communication position; and
    a working pressure applying portion (48, 67-68) applying the working pressure to the working pressure chamber (412), and

    wherein the pressure in the suction pressure zone (142) acts against the pressure in the working pressure chamber (412) through the valve body (42).

2. The refrigerant suction structure according to claim 1, **characterized in that** the switch portion has a working pressure recess (411), and the valve body (42) is slidably fitted into the working pressure recess (411), whereby the valve body (42) defines the working pressure chamber (412) within the working pressure recess (411),
    wherein the pressure of the portion (142) of the suction pressure zone within the compressor (10) acts against the pressure of the working pressure chamber (412) via the valve body (42), and
    wherein the switch portion is provided with a first return spring (47, 73, 94) for returning the valve body (42) to the shutoff position from the communication position.

3. The refrigerant suction structure according to claim 2, **characterized in that** the introduction passage

(31) has an inlet (311) for accepting the refrigerant from the suction pressure zone (142), and wherein, in the case that the switch portion is in the shutoff state, the valve body (42) is arranged in such a manner as to shut off the inlet (311) of the introduction passage (31) from the portion (142) of the suction pressure zone within the compressor (10).

4. The refrigerant suction structure according to claim 3, **characterized in that** the inlet (311) of the introduction passage (31) is positioned in an end surface of the rotary valve (35, 36), and the outlets (312, 313) of the introduction passage (31) are positioned in a peripheral surface (211, 212) of the rotary valve (35, 36),
wherein a rotation axis (210) of the rotary valve (35, 36) intersects the end surface,
wherein the refrigerant suction structure comprises:

a valve accommodation chamber (111, 121) rotatably accommodating the rotary valve (35, 36); and
a guide cylinder (45) surrounding the rotation axis (210) outside the valve accommodation chamber (111, 121),

wherein a cylinder interior (451) of the guide cylinder (45) communicates with an inlet (311) of the introduction passage (31),
wherein the valve body (42) is slidably fitted to the guide cylinder (45), the valve body (42) has an internal passage (442) communicating with the cylinder interior (451) of the guide cylinder (45), and the internal passage (442) has an inlet (441) for accepting the refrigerant from the suction pressure zone (142),
wherein, in the case that the valve body (42) exists at the shutoff position, the inlet (441) of the internal passage (442) is shut off by entering the working pressure recess (411), and
wherein, in the case that the valve body (42) exists at the communication position, the inlet (441) of the internal passage (442) is positioned outside the working pressure recess (411), so that the inlet (441) is exposed to the interior of the portion (142) of the suction pressure zone within the compressor (10).

5. The refrigerant suction structure according to claim 4, **characterized in that** the guide cylinder (45A) is formed as an independent body from members of the compressor (10) other than the valve body (42), so as to be allowed to move in a radial direction of the rotary shaft (21) with respect to members (12, 21) of the compressor (10) other than the valve body (42).

6. The refrigerant suction structure according to claim 2, **characterized in that** the introduction passage (31) has an inlet (311) for accepting the refrigerant from the suction pressure zone (142), and the inlet (311) of the introduction passage (31) is positioned in an end surface of the rotary valve (36),
wherein the outlets (312, 313) of the introduction passage (31) are positioned in a peripheral surface (211, 212) of the rotary valve (35, 36),
wherein the valve body (71, 72, 74, 75) is fitted into the introduction passage (31) from the inlet (311) of the introduction passage (31), and
wherein, in the case that the switch portion is in the shutoff state, the valve body (71, 72, 74, 75) is arranged in the introduction passage (31) in such a manner as to shut off the outlets (312, 313) of the introduction passage (31) from the portion (142) of the suction pressure zone within the compressor (10).

7. The refrigerant suction structure according to claim 6, **characterized in that** the introduction passage (31) has an in-shaft passage (31) positioned in the rotary shaft (21), and the in-shaft passage (31) extends in a direction of a rotation axis (210) of the rotary shaft (21),
wherein the outlets (312, 313) of the introduction passage (31) extend through a peripheral surface (211, 212) of the rotary shaft (21) so as to communicate with the in-shaft passage (31),
wherein the valve body (71, 72, 74, 75) is fitted into the in-shaft passage (31) in such a manner as to be slidable in a direction of the rotation axis (210) within the introduction passage (31),
wherein the valve body (71, 72, 74, 75) is moved in the direction of the rotation axis (210) within the in-shaft passage (31), so as to be switched between the communication position and the shutoff position, and
wherein the valve body (71, 72, 74, 75) at the shutoff position shuts off the outlets (312, 313) of the introduction passage (31) with respect to the in-shaft passage (31).

8. The refrigerant suction structure according to claim 3, **characterized in that** the switch portion has a flat valve seat surface (892), the valve body (93) has a flat seal surface (901), and the seal surface (901) comes into surface contact with the valve seat surface (892) in a state in which the valve body (93) exists at the shutoff position.

9. The refrigerant suction structure according to any one of claims 1 to 8, **characterized in that** the compressor has a discharge pressure zone (141, 34A), wherein the working pressure applying portion (48, 67-68) has an inflow passage (L, 84) reaching the working pressure chamber (412) from the discharge pressure zone (141, 34A), and
wherein the refrigerant in the discharge pressure zone (141, 34A) is introduced to the working pres-

sure chamber (412) via the inflow passage (L, 84).

10. The refrigerant suction structure according to claim 9, **characterized in that** an oil separator (79) is provided on the inflow passage (84), and the oil separator (79) separates oil from the refrigerant within the discharge pressure zone (34A),
wherein a constriction (402) is provided in a portion (84) of the inflow passage in a downstream side of the oil separator (79), and
wherein the portion (84) of the inflow passage in the downstream side of the oil separator (79) serves as an oil passage introducing the oil separated by the oil separator (79) to the constriction (402).

11. The refrigerant suction structure according to claim 9, **characterized in that** the discharge pressure zone has a portion (141) within the compressor (10), wherein the portion (141) of the discharge pressure zone within the compressor (10) is connected to the portion (142) of the suction pressure zone within the compressor (10) via an external refrigerant circuit (34), and the external refrigerant circuit (34) has a portion (34A) of the discharge pressure zone,
wherein the inflow passage (L) is connected to the portion (34A) of the discharge pressure zone of the external refrigerant circuit (34),
wherein the working pressure applying portion (67-68) is provided with an electromagnetic on-off valve (67) for opening and closing the inflow passage (L), and a check valve (68), and
wherein the check valve (68) is arranged in a portion of the external refrigerant circuit (34) in a downstream side of a connection portion between the portion (34A) of the discharge pressure zone in the external refrigerant circuit and the inflow passage (L).

12. The refrigerant suction structure according to any one of claims 1 to 8, **characterized in that** the working pressure applying portion (48) is provided with an electromagnetic three-way valve (48),
wherein the working pressure chamber (412) is connected to the electromagnetic three-way valve (48) via a common passage (63),
wherein the electromagnetic three-way valve (48) is connected to a discharge pressure zone (34A) via a feed passage (57, 56, 61, 63),
wherein the electromagnetic three-way valve (48) is connected to a suction pressure zone via a discharge passage (63, 494, 581, 59), and
wherein the electromagnetic three-way valve (48) is structured to be switched between a first state, in which the common passage (63) communicates with the feed passage (57, 56, 61), and a second state, in which the common passage (63) communicates with the discharge passage (63, 494, 581, 59).

13. The refrigerant suction structure according to any one of claims 1 to 8, **characterized in that** the compressor (10) comprises:

a cylinder block (12) having the cylinder bores (28) ; and
a rear housing member (14) coupled to the cylinder block (12), and

wherein the rear housing member (14) has in it a suction chamber (142), and the working pressure chamber (412) is defined within the rear housing member (14).

14. A refrigerant suction structure in a fixed displacement type piston compressor (10), wherein the compressor (10) comprises:

a rotary shaft (21) coupled to an external drive source (26) via a clutch (25);
a plurality of cylinder bores (27, 28) arranged around the rotary shaft (21);
a plurality of pistons (29) defining compression chambers (271, 281) in the cylinder bores (27, 28) by being respectively accommodated in the cylinder bores (27, 28);
a cam body (23) integrated with the rotary shaft (21), the cam body (23) converting a rotation of the rotary shaft (21) into reciprocation of each of the pistons (29);
a suction pressure zone (142); and
a rotary valve (35, 36) having an introduction passage (31) for introducing a refrigerant from the suction pressure zone (142) to each of the compression chambers (271, 281), the rotary valve (35, 36) integrally rotating with the rotary shaft (21), the suction pressure zone having a portion (142) within the compressor (10), and the introduction passage (31) having outlets (312, 313) for feeding out the refrigerant toward each of the compression chambers (271, 281), the refrigerant suction structure being **characterized by** a switch portion capable of being switched between a communication state and a shutoff state,

wherein the switch portion in the communication state allows the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31),
wherein the switch portion in the shutoff state shuts off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31),
wherein the switch portion includes:

a valve body (242) capable of being switched between a communication position and a shutoff

position, the valve body (242) in the communication position allowing the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31), and the valve body (242) in the shutoff position shutting off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31); and
an electromagnetic driving portion (248) driving the valve body (242) on the basis of an electromagnetic force.

15. The refrigerant suction structure according to claim 14, **characterized in that** the switch portion is provided with a second return spring (252) returning the valve body (242) to the communication position, and wherein the electromagnetic driving portion (248) drives the valve body (242) from the communication position toward the shutoff position.

16. The refrigerant suction structure according to claim 15, **characterized in that** the switch portion has a pressure recess (260), and the valve body (242) is slidably accommodated within the pressure recess (260), whereby the valve body (242) defines a pressure chamber (262) within the pressure recess (260),
wherein the pressure chamber (262) communicates with the portion (142) of the suction pressure zone within the compressor (10),
wherein the pressure in the portion (142) of the suction pressure zone within the compressor (10) acts against the pressure in the pressure chamber (262) via the valve body (242),
wherein the second return spring (252) is accommodated in the pressure chamber (262), and the second return spring (252) urges the valve body (242) in a direction in which the valve body (242) pops out from the interior of the pressure recess (260), and
wherein the electromagnetic driving portion (248) drives the valve body (242) in such a manner as to push the valve body (242) into the pressure recess (260).

17. The refrigerant suction structure according to claim 14, **characterized in that** the switch portion has a pressure recess (260), and the valve body (242) is slidably accommodated within the pressure recess (260), whereby the valve body (242) defines a pressure chamber (262) within the pressure recess (260),
wherein the pressure chamber (262) communicates with the portion (142) of the suction pressure zone within the compressor (10),
wherein the pressure in the portion (142) of the suction pressure zone within the compressor (10) acts against the pressure in the pressure chamber (262) via the valve body. (242),
wherein the switch portion is provided with a retaining spring (47, 73, 94) which acts to retain the valve body (242) at the shutoff position by pressing the valve body (242) into the pressure recess (260), and wherein the electromagnetic driving portion (248) drives the valve body (242) from the communication position toward the shutoff position.

18. The refrigerant suction structure according to claim 17, **characterized in that** the introduction passage (31) has an inlet (311) for accepting the refrigerant from the suction pressure zone (142), and
wherein, in the case that the switch portion is in the shutoff state, the valve body (242) is arranged in such a manner as to shut off the inlet (311) of the introduction passage (31) from the portion (142) of the suction pressure zone within the compressor (10).

19. The refrigerant suction structure according to claim 18, **characterized in that** the switch portion has a flat valve seat surface (892), the valve body (242) has a flat seal surface (901), and the seal surface (901) comes into surface contact with the valve seat surface (892) in a state in which the valve body (242) exists at the shutoff position.

20. The refrigerant suction structure according to claim 17, **characterized in that** the introduction passage (31) has an inlet (311) for accepting the refrigerant from the suction pressure zone (142), and the inlet (311) of the introduction passage (31) is positioned in an end surface of the rotary valve (35, 36),
wherein the outlets (312, 313) of the introduction passage (31) are positioned in a peripheral surface (211, 212) of the rotary valve (35, 36),
wherein a rotation axis (210) of the rotary valve (35, 36) intersects the end surface,
wherein the refrigerant suction structure comprises:

a valve accommodation chamber (111, 121) rotatably accommodating the rotary valve (35, 36); and
a guide cylinder (45) surrounding the rotation axis (210) outside the valve accommodation chamber (111, 121),

wherein a cylinder interior (451) of the guide cylinder (45) communicates with an inlet (311) of the introduction passage (31),
wherein the valve body (242) is slidably fitted to the guide cylinder (45), the valve body (242) has an internal passage (442) communicating with the cylinder interior (451) of the guide cylinder (45), and the internal passage (442) has an inlet (441) for accepting the refrigerant from the suction pressure zone (142),
wherein, in the case that the valve body (242) exists at the shutoff position, the inlet (441) of the internal passage (442) is shut off by entering the pressure

recess (260), and
wherein, in the case that the valve body (242) exists at the communication position, the inlet (441) of the internal passage (442) is positioned outside of the pressure recess (260), so that the inlet (441) is exposed to the portion (142) of the suction pressure zone within the compressor (10).

21. The refrigerant suction structure according to claim 20, **characterized in that** the guide cylinder (45A) is formed as an independent body from members of the compressor (10) other than the valve body (342), so as to be allowed to move in a radial direction of the rotary shaft (21) with respect to the members of the compressor (10) other than the valve body (342).

22. The refrigerant suction structure according to any one of claims 14 to 17, **characterized in that** the introduction passage (31) has an inlet.(311) for accepting the refrigerant from the suction pressure zone (142), and the inlet (311) of the introduction passage (31) is positioned in an end surface of the rotary valve (35, 36),
wherein the outlets (312, 313) of the introduction passage (31) are positioned in a peripheral surface (211, 212) of the rotary valve (35, 36),
wherein the valve body (71, 72, 74, 75) is fitted into the introduction passage (31) from the inlet (311) of the introduction passage (31), and
wherein, in the case that the switch portion is in the shutoff state, the valve body (71, 72, 74, 75) is arranged in the introduction passage (31) in such a manner as to shut off the outlets (312, 313) of the introduction passage (31) from the portion (142) of the suction pressure zone within the compressor (10) .

23. The refrigerant suction structure according to claim 22, **characterized in that** the introduction passage (31) has an in-shaft passage (31) positioned in the rotary shaft (21), and the in-shaft passage (31) extends in a direction of a rotation axis (210) of the rotary shaft (21),
wherein the outlets (312, 313) of the introduction passage (31) extends through a peripheral surface (211, 212) of the rotary shaft (21) so as to communicate with the in-shaft passage (31),
wherein the valve body (71, 72, 74, 75) is fitted into the in-shaft passage (31) in such a manner as to be slidable in a direction of the rotation axis (210) within the introduction passage (31),
wherein the valve body (71, 72, 74, 75) is moved in the direction of the rotation axis (210) within the in-shaft passage (31), so as to be switched between the communication position and the shutoff position, and
wherein the valve body (71, 72, 74, 75) at the shutoff position shuts off the outlets (312, 313) of the introduction passage (31) with respect to the in-shaft passage (31).

24. The refrigerant suction structure according to any one of claims 14 to 23, **characterized in that** the compressor (10) comprises:

a cylinder block (12) having the cylinder bores (28); and
a rear housing member (14) coupled to the cylinder block (12), and

wherein the rear housing member (14) has in it a suction chamber (142), and the valve body (242) is arranged within the rear housing member (14).

25. An operation control method in a fixed displacement type piston compressor (10), wherein the compressor (10) comprises:

a rotary shaft (21) coupled to an external drive source (26) via a clutch (25);
a plurality of cylinder bores (27, 28) arranged around the rotary shaft (21);
a plurality of pistons (29) defining compression chambers (271, 281) in the cylinder bores (27, 28) by being respectively accommodated in the cylinder bores (27, 28);
a cam body (23) integrated with the rotary shaft (21), the cam body (23) converting a rotation of the rotary shaft (21) into reciprocation of each of the pistons (29);
a suction pressure zone (142);
a rotary valve (35, 36) having an introduction passage (31) for introducing a refrigerant from the suction pressure zone (142) to each of the compression chambers (271, 281); and
a discharge pressure zone (141),

wherein the rotary valves (35, 36) integrally rotate with the rotary shaft (21),
wherein the suction pressure zone has a portion within the compressor (10),
wherein the introduction passage (31) has outlets (312, 313) for feeding out the refrigerant toward each of the compressors (271, 281),
the operation control method being **characterized in by**:

preparing a switch portion capable of being switched between a communication state and a shutoff state, wherein the switch portion in the communication state allows the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31), the switch portion in the shutoff state shuts off the portion (142) of the suction pressure zone within the compres-

sor (10) from the outlets (312, 313) of the introduction passage (31), the switch portion is provided with a valve body (42), a working pressure chamber (412), and a working pressure applying portion (48, 67-68), wherein the valve body is capable being switched between a communication position allowing the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlet (312, 313) of the introduction passage (31), and a shutoff position shutting off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31), wherein the working pressure chamber (412) introduces a working pressure applied to the valve body (42) to arrange the valve body (42) at the communication position, wherein the working pressure applying portion (48, 67-68) applies the working pressure to the working pressure chamber (412), and wherein the working pressure applying portion (48, 67-68) is provided with a switch valve that is switched between a first state; in which the refrigerant in the discharge pressure zone (141) can be fed to the working pressure chamber (412) and a second state, in which the refrigerant in the discharge pressure chamber (141) cannot be fed to the working pressure chamber (412);
setting the clutch (25) to a coupled state after setting the switch valve to the second state, at a time of switching the clutch (25) from the shutoff state to the coupled state; and
switching the switch valve to the first state after setting the clutch (25) to the coupled state.

26. The operation control method according to claim 25, **characterized in that** the clutch (25) is an electromagnetic clutch (25) which, when magnetized, comes to the coupled state coupling the rotary shaft (21) to the external driving source (26), and wherein the operation control method comprises:

gradually increasing an electric current fed to the electromagnetic clutch (25) to magnetize the electromagnetic clutch (25), at a time of switching the electromagnetic clutch (25) from a demagnetized state to a magnetized state; and
switching the switch valve from the second state to the first state after a value of the electric current becomes maximum.

27. An operation control method in a fixed displacement type piston compressor (10), wherein the compressor (10) comprises:

a rotary shaft (21) coupled to an external drive source (26) via a clutch (25);
a plurality of cylinder bores (27, 28) arranged around the rotary shaft (21);
a plurality of pistons (29) defining compression chambers (271, 281) in the cylinder bores (27, 28) by being respectively accommodated in the cylinder bores (27, 28);
a cam body (23) integrated with the rotary shaft (21), the cam body (23) converting a rotation of the rotary shaft (21) into reciprocation of each of the pistons (29);
a suction pressure zone (142);
a rotary valve (35, 36) having an introduction passage (31) for introducing a refrigerant from the suction pressure zone (142) to each of the compression chambers (271, 281), the rotary valve (35, 36) integrally rotating with the rotary shaft (21), the suction pressure zone having a portion (142) within the compressor (10), and the introduction passage (31) having outlets (312, 313) for feeding out the refrigerant toward each of the compression chambers (271, 281),

the operation control method being **characterized by**:

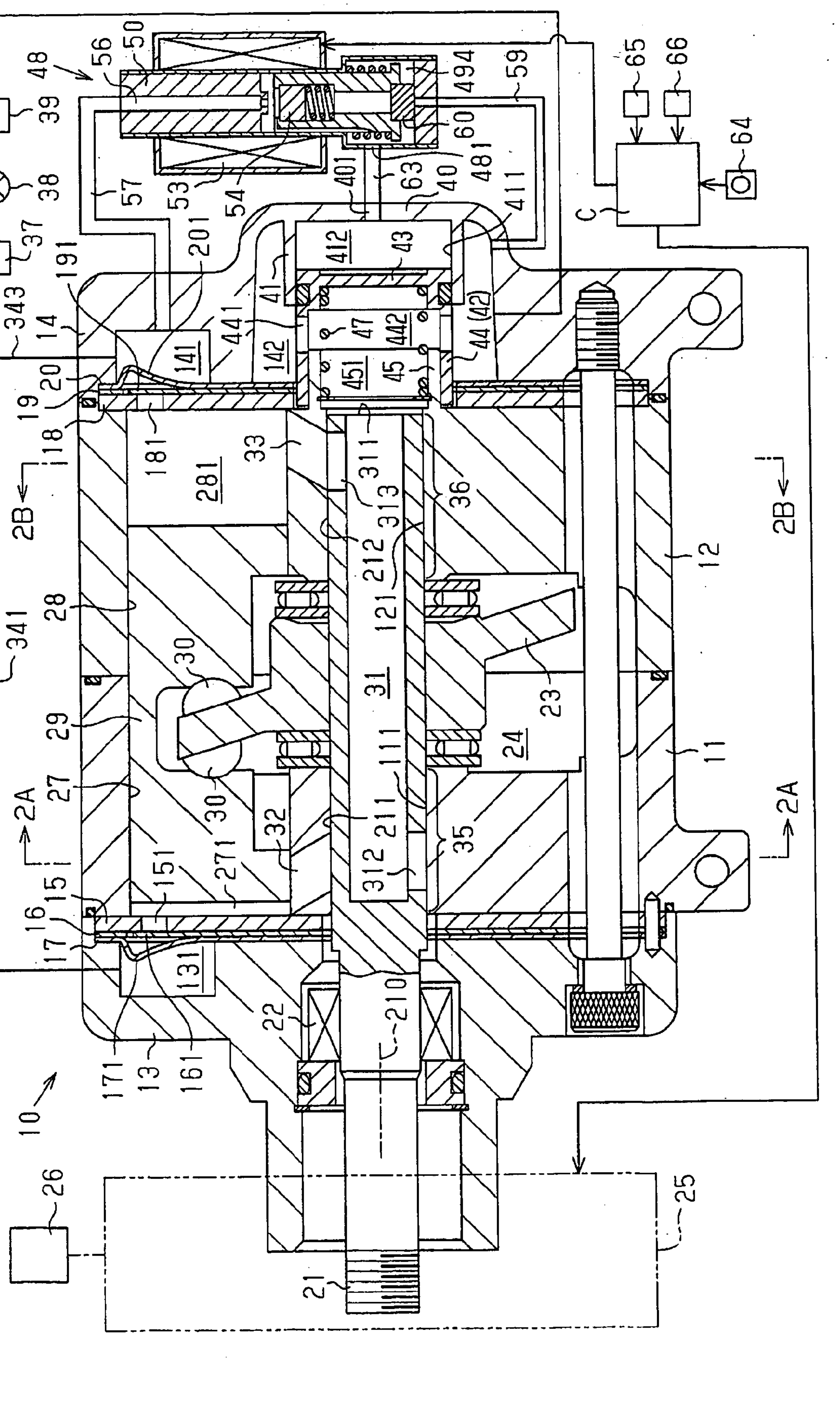
preparing a switch portion capable of being switched between a communication state and a shutoff state, wherein the switch portion in the communication state allows the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31), the switch portion in the shutoff state shuts off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31), the switch portion is provided with a valve body (242) and an electromagnetic driving portion (248), wherein the valve body (242) is capable being switched between a communication position allowing the portion (142) of the suction pressure zone within the compressor (10) to communicate with the outlets (312, 313) of the introduction passage (31), and a shutoff position shutting off the portion (142) of the suction pressure zone within the compressor (10) from the outlets (312, 313) of the introduction passage (31), wherein the electromagnetic driving portion (248) is capable of driving the valve body (242) on the basis of an electromagnetic force, and the electromagnetic driving portion (248) is capable of switching the valve body (242) between a first state, in which the valve body (242) is arranged at the communication position, and a second state, in which the valve body (242) is arranged at the shutoff position;

wherein the operation control method comprises:

setting the clutch (25) to the coupled state after setting the electromagnetic driving portion (248) to the second state, at a time of switching the clutch (25) from the shutoff state to the coupled state; and
setting the electromagnetic driving portion (248) to the first state after setting the clutch (25) to the coupled state.

28. The operation control method according to claim 27, **characterized in that** the clutch (25) is an electromagnetic clutch (25) which, when magnetized, comes to the coupled state coupling the rotary shaft (21) to the external driving source (26), and wherein the operation control method comprises:

gradually increasing an electric current fed to the electromagnetic clutch (25) to magnetize the electromagnetic clutch (25), at a time of switching the electromagnetic clutch (25) from a demagnetized state to a magnetized state; and
demagnetizing the electromagnetic driving portion (248) after a value of the electric current becomes maximum.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44 (42)
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57
59
60
63
64
65
66
C
2A
2B
111
121
131
141
142
151
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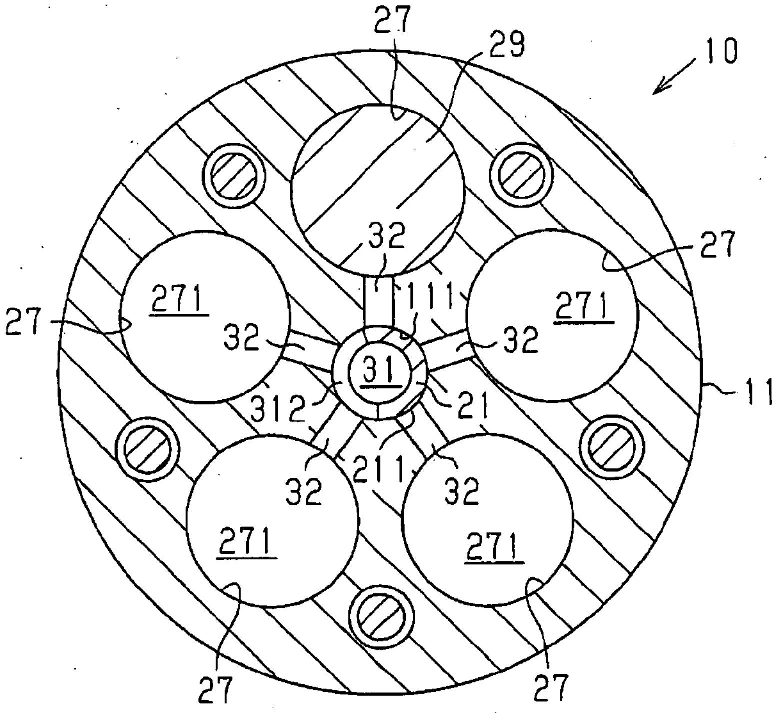
494

Fig.1

Fig.2A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111
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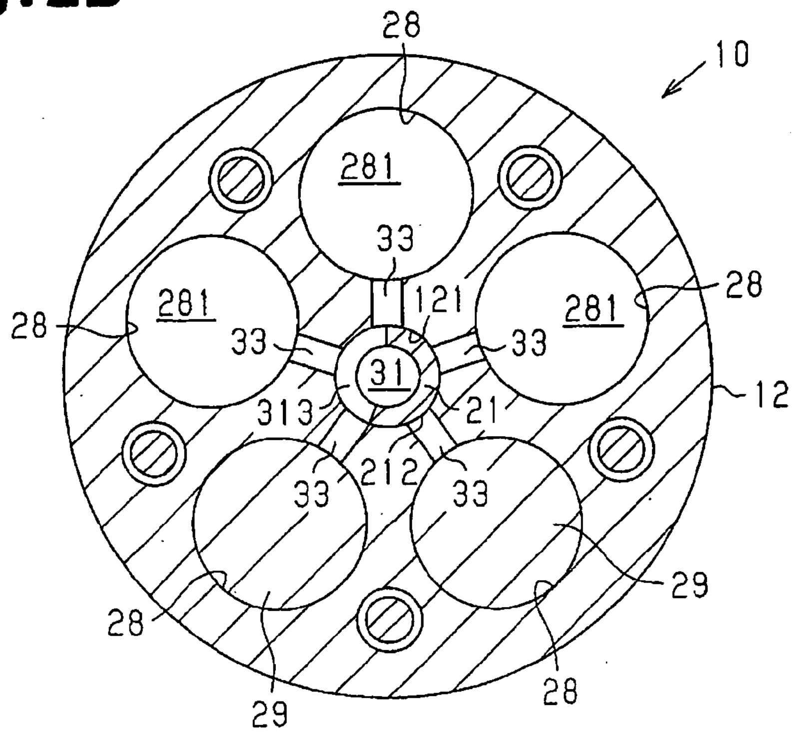
Fig.2B


28
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281
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121
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281
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313
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212
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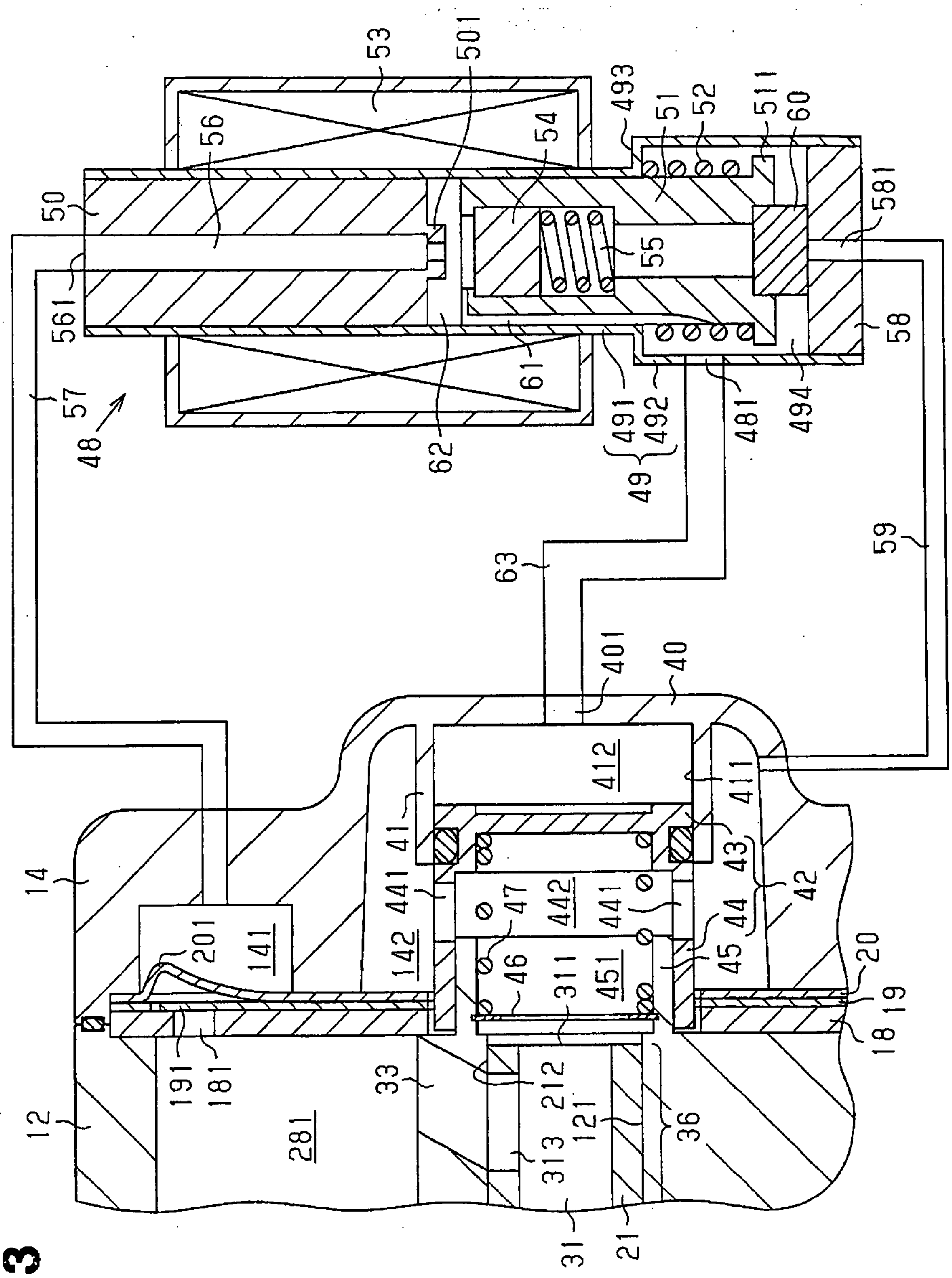

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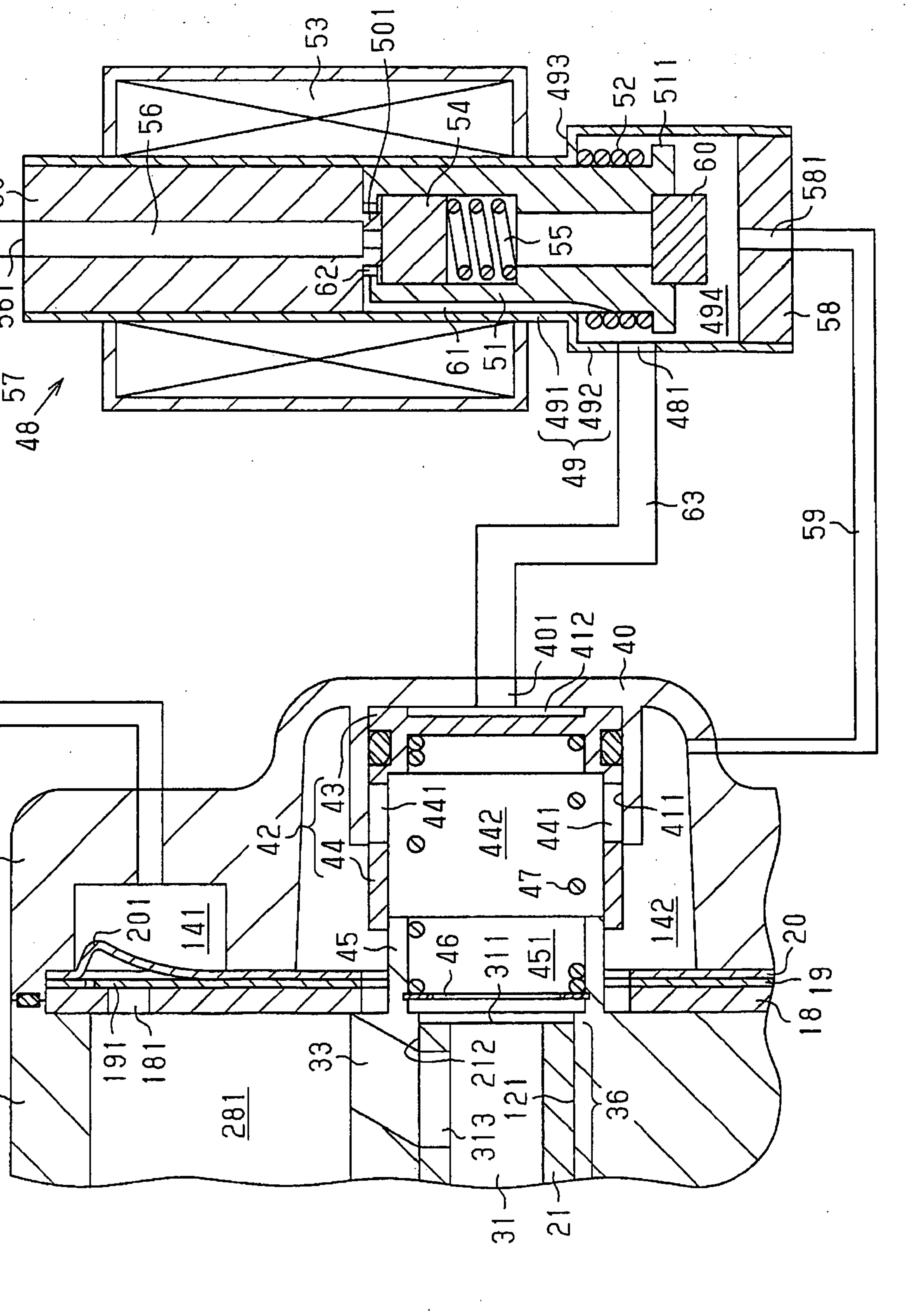
Fig. 3


53
501
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581
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561
494
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492
481
49
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Fig. 4

Fig.5

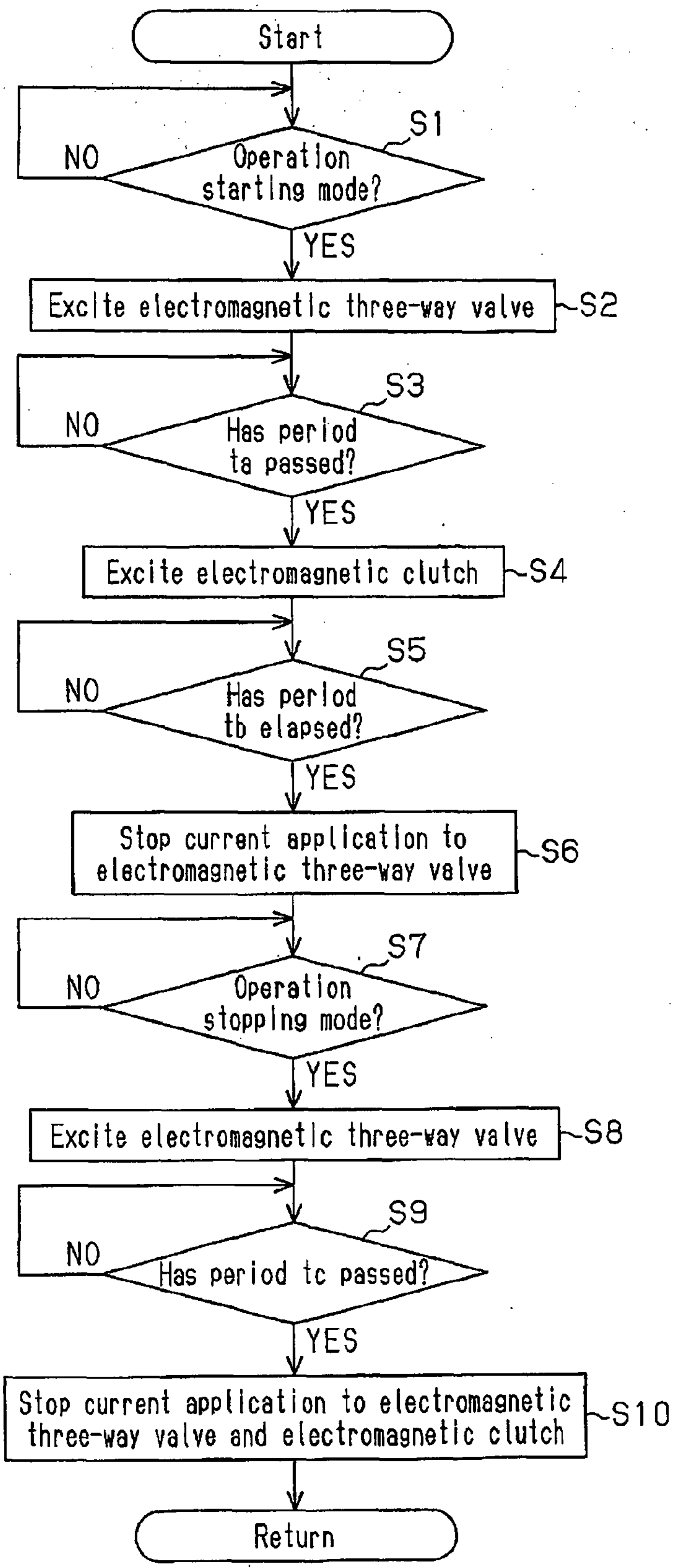

Start
S1
NO
Operation starting mode?
YES
Excite electromagnetic three-way valve
S2
S3
NO
Has period ta passed?
YES
Excite electromagnetic clutch
S4
S5
NO
Has period tb elapsed?
YES
Stop current application to electromagnetic three-way valve
S6
S7
NO
Operation stopping mode?
YES
Excite electromagnetic three-way valve
S8
S9
NO
Has period tc passed?
YES
Stop current application to electromagnetic three-way valve and electromagnetic clutch
S10
Return

Fig.6

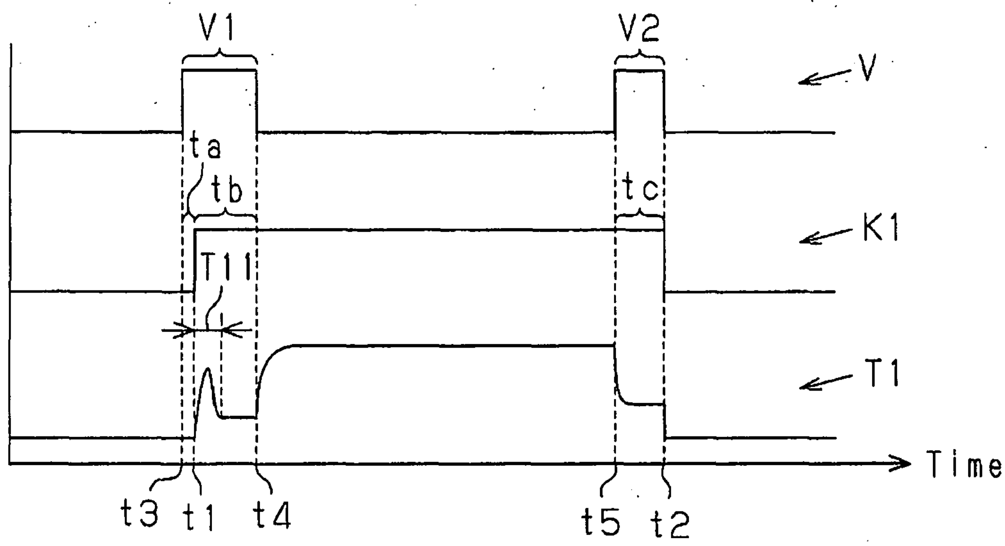
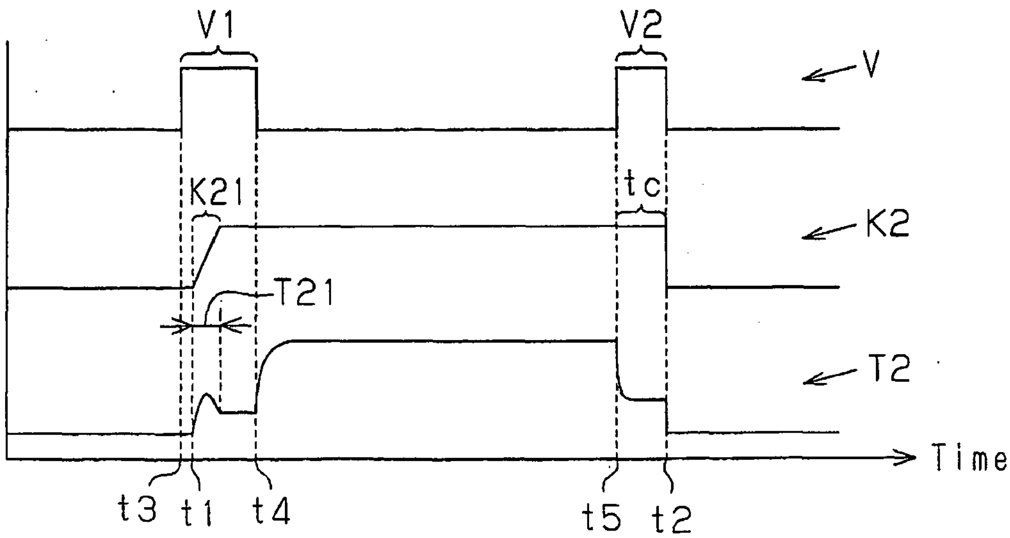
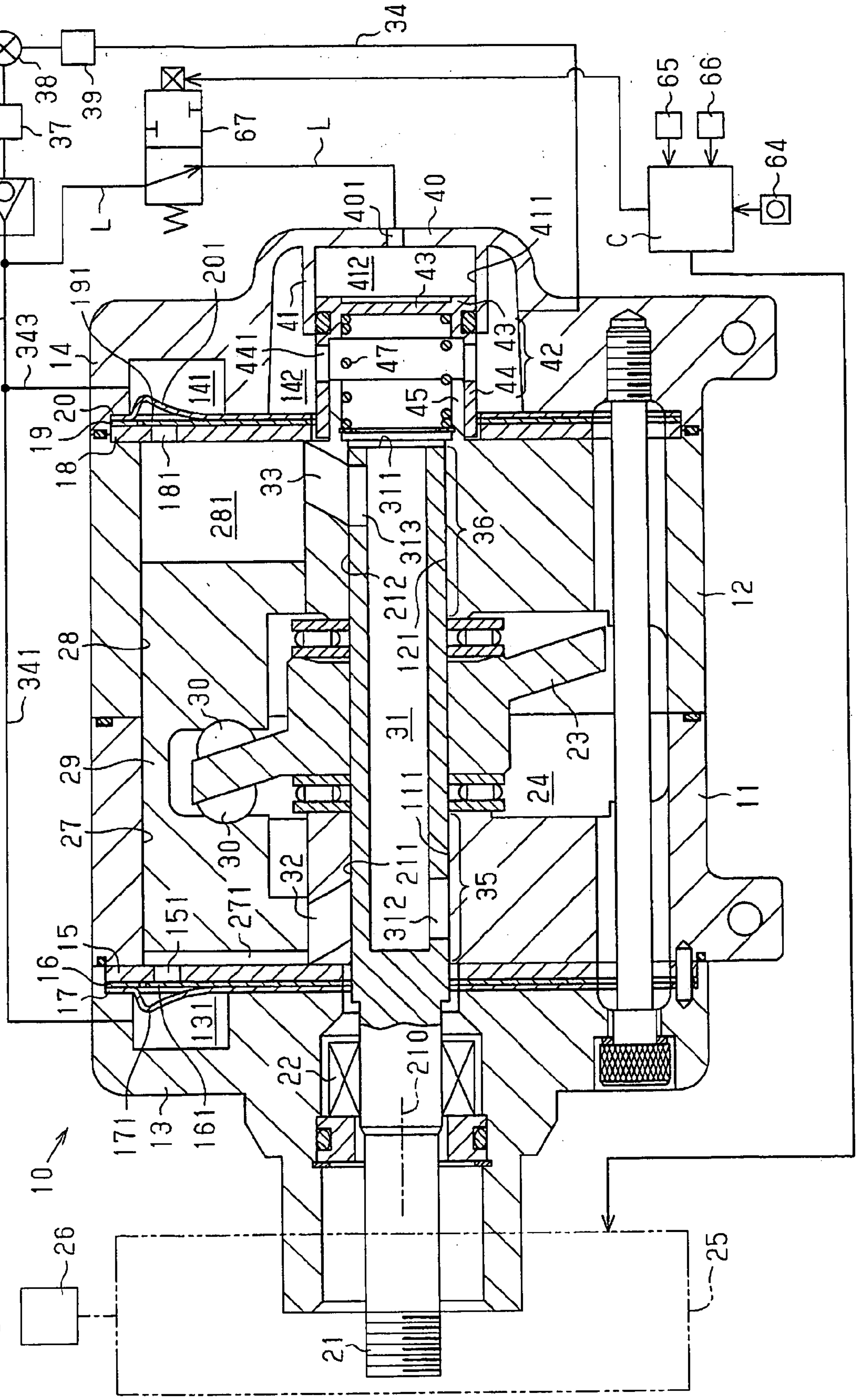

V1
V2
V
ta
tb
tc
K1
T11
T1
Time
t3
t1
t4
t5
t2

Fig.7


V1
V2
V
K21
tc
K2
T21
T2
Time
t3
t1
t4
t5
t2


34
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L
W
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343
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401
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441
142
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66
64
C
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19
18
181
281
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311
313
36
212
121
28
341
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31
23
12
29
24
27
111
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211
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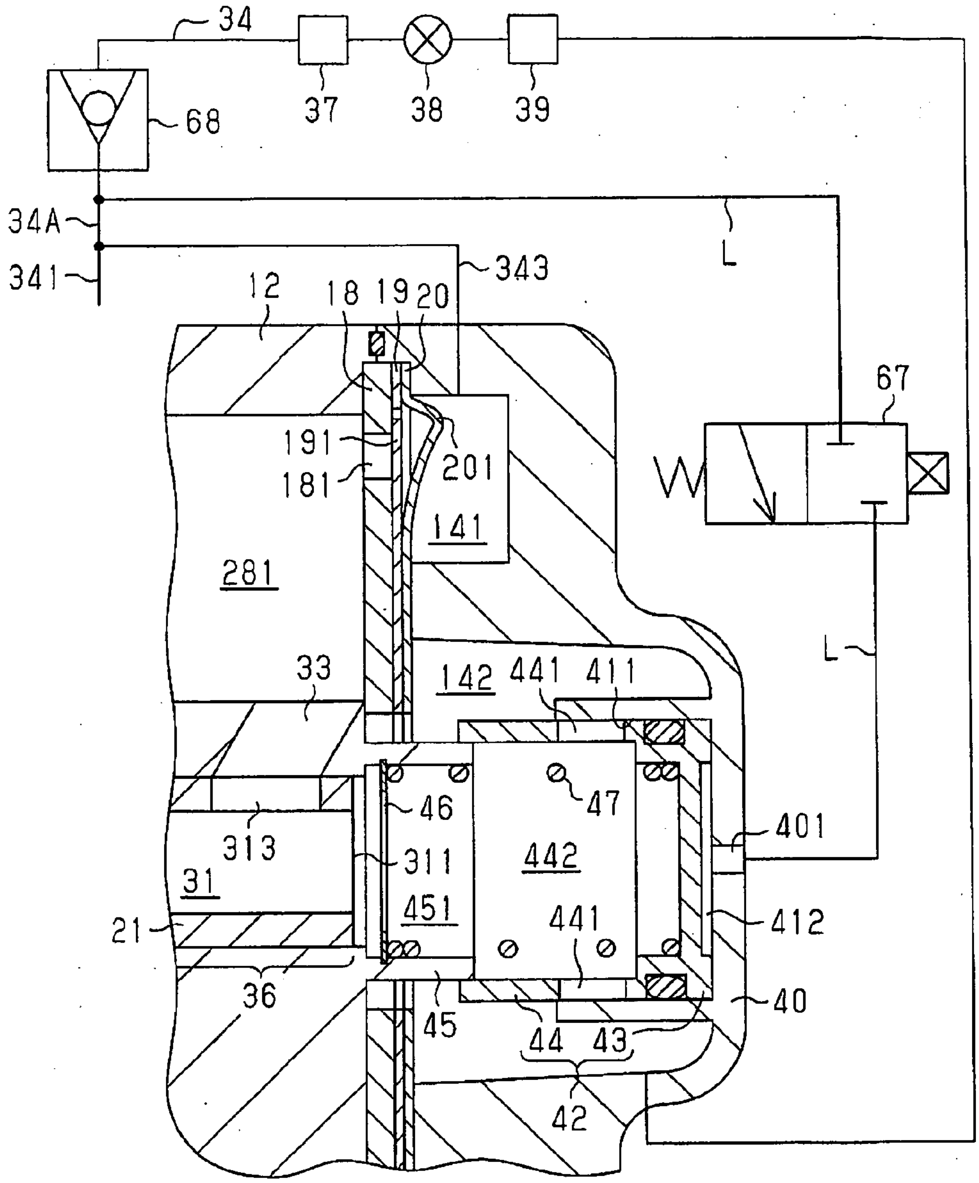
Fig.8

Fig.9A


34
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34A
341
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L
12
18
19
20
67
191
181
201
141
281
W
L
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142
441
411
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42

Fig.9B

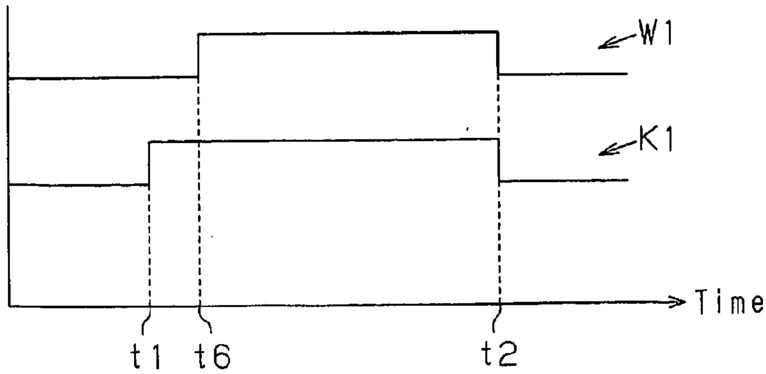
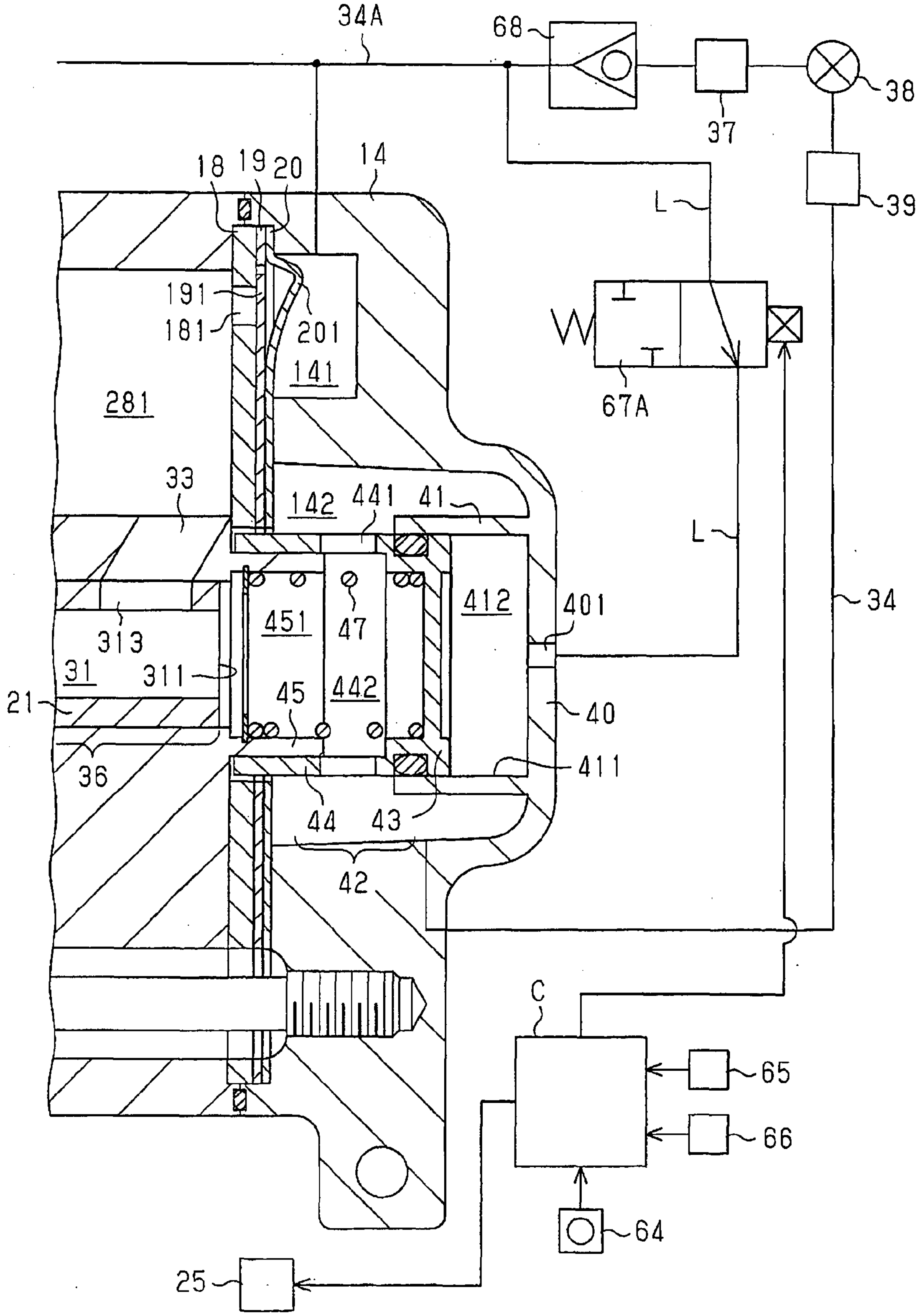

W1
K1
Time
t1
t6
t2

Fig.10


34A
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441
41
L
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451
47
412
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442
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40
36
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43
411
42
C
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Fig.11A

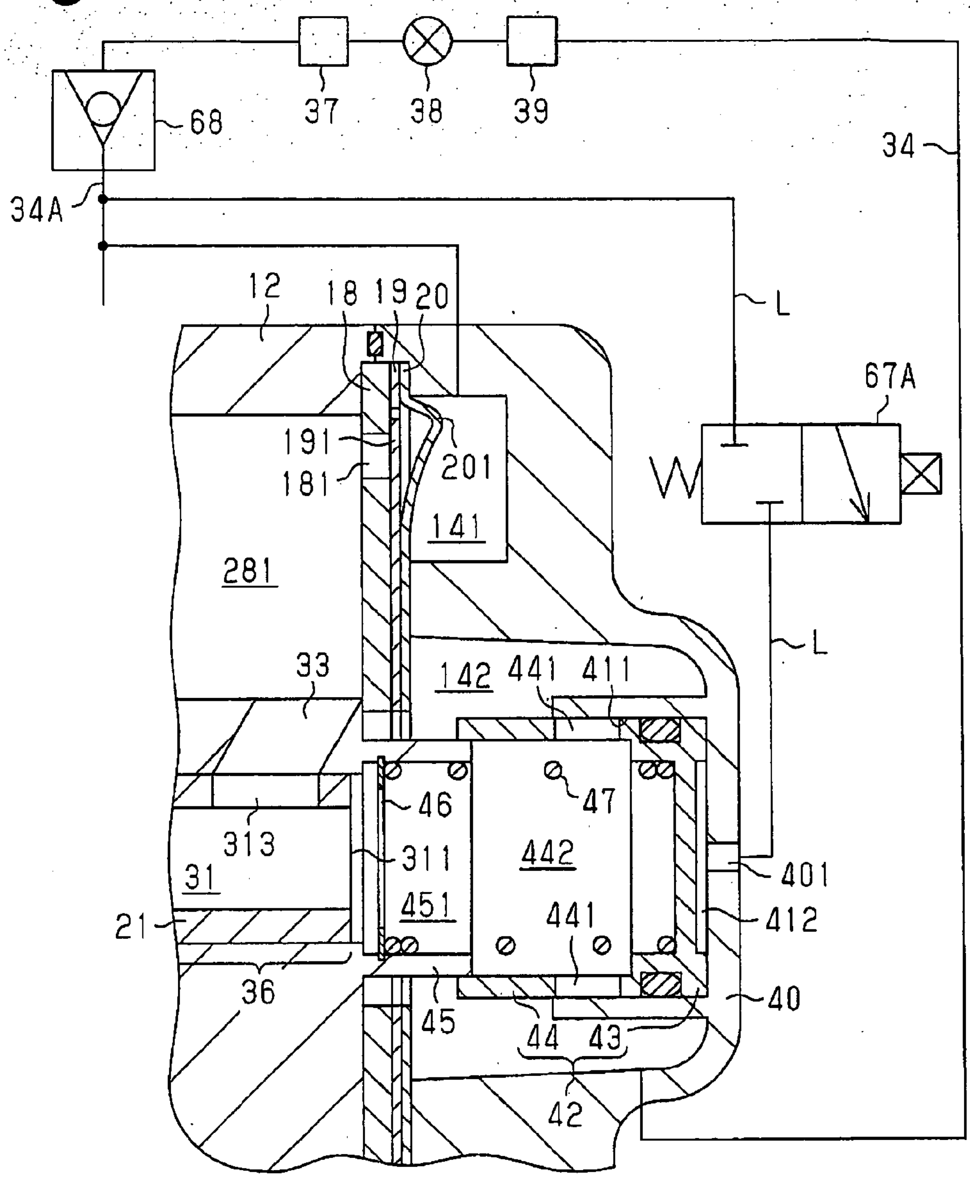


Fig.11B

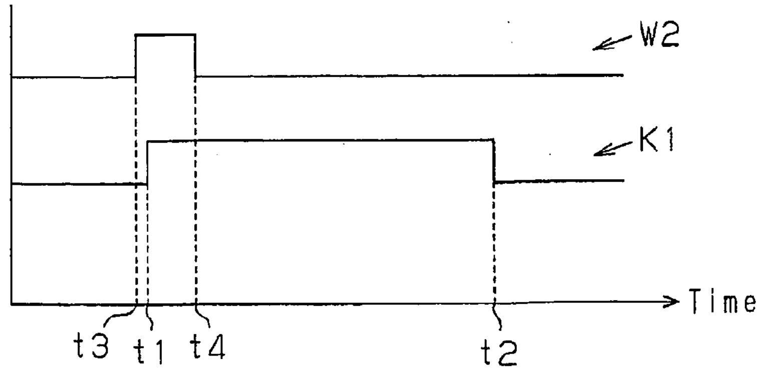


Fig.12A

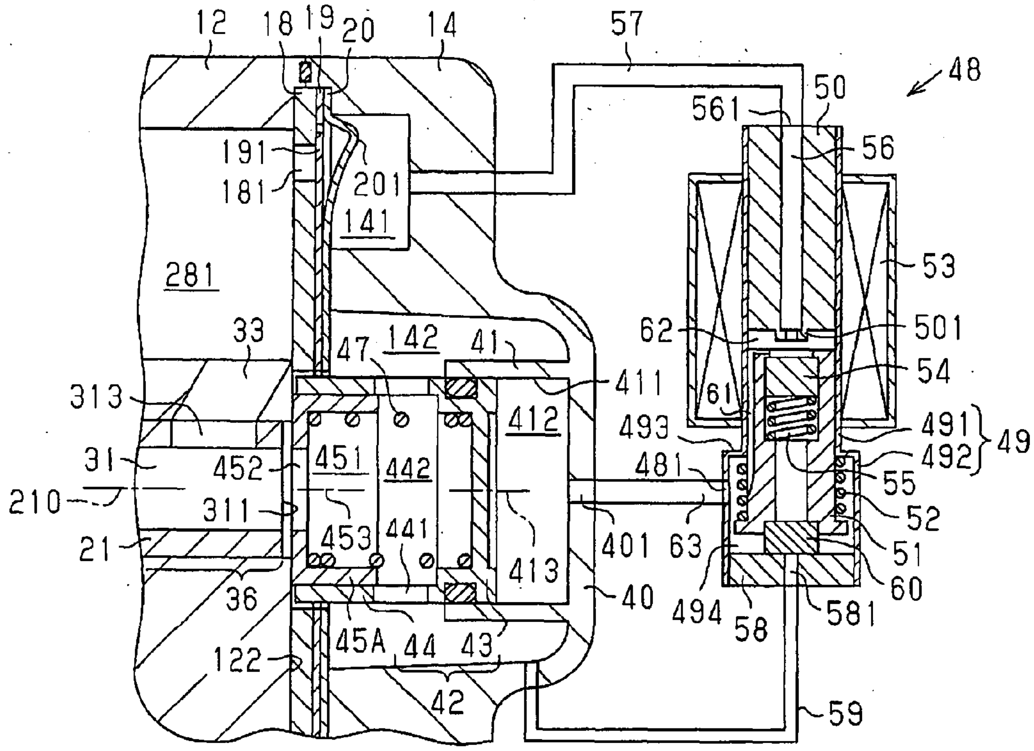


Fig.12B

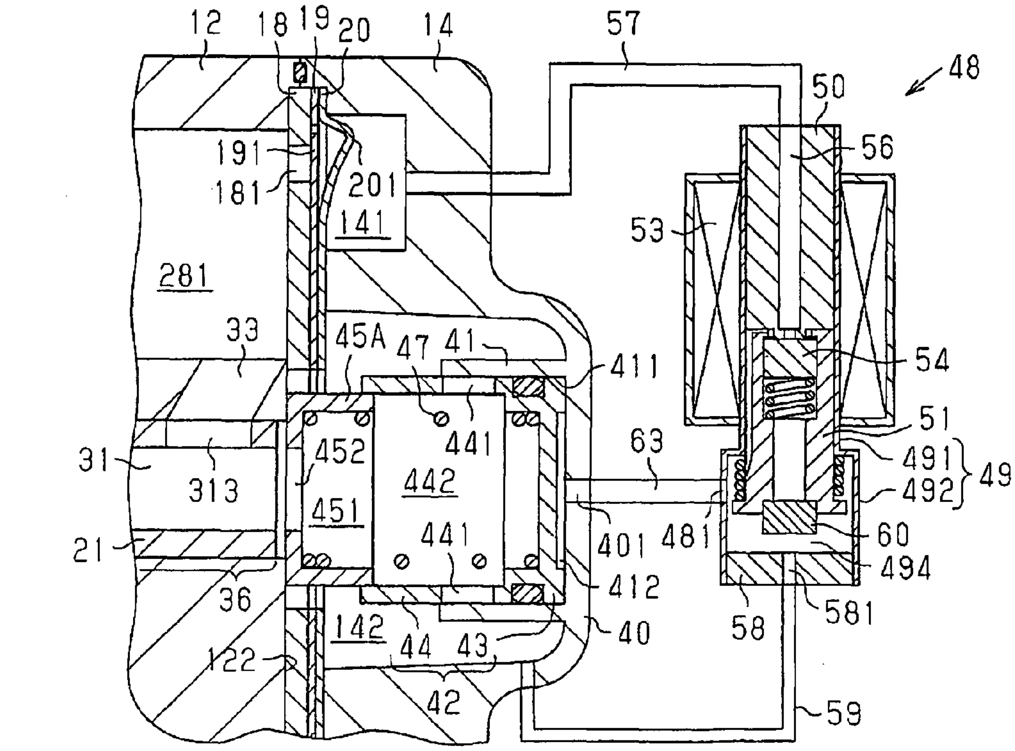
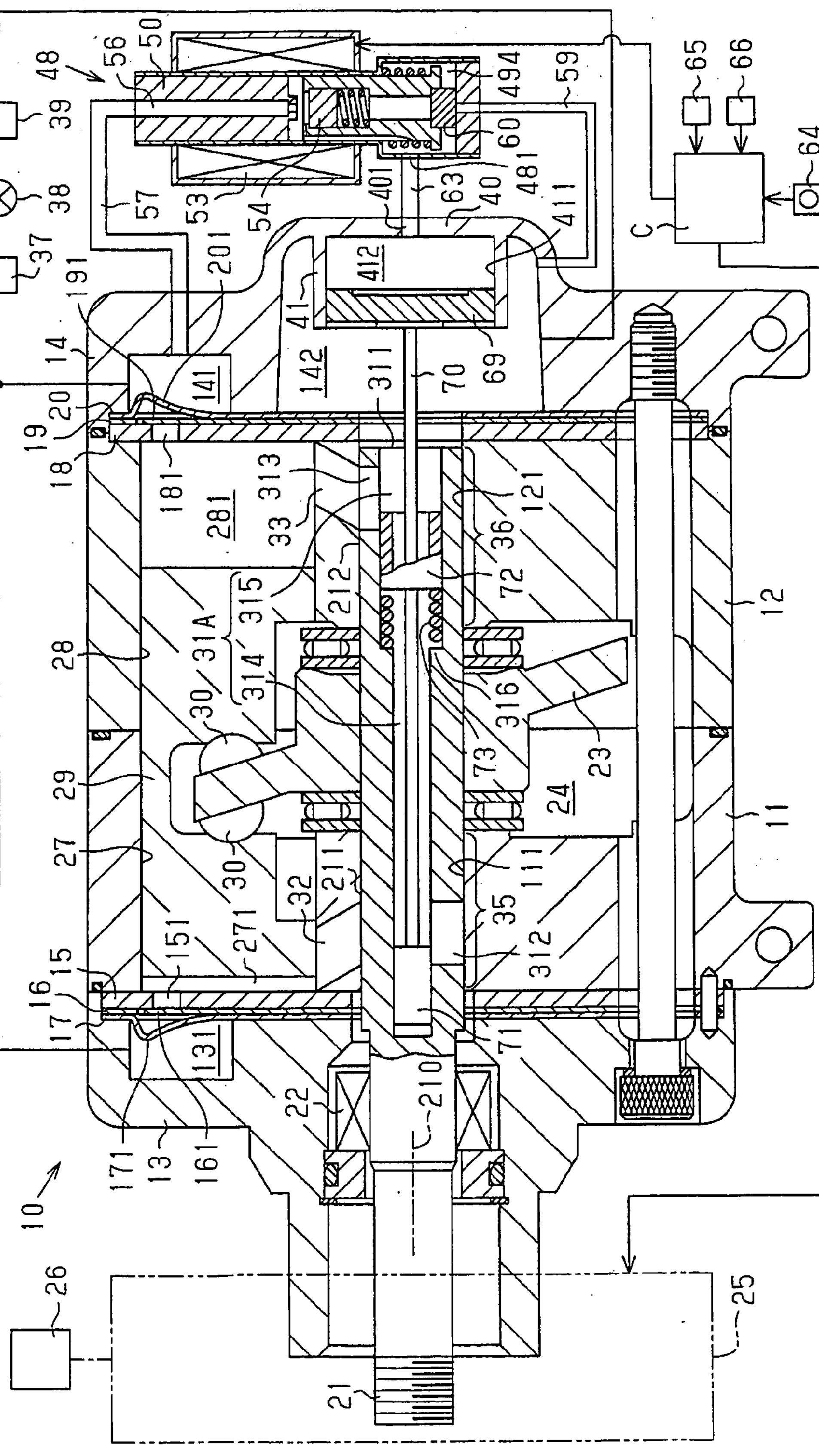


Fig.13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C

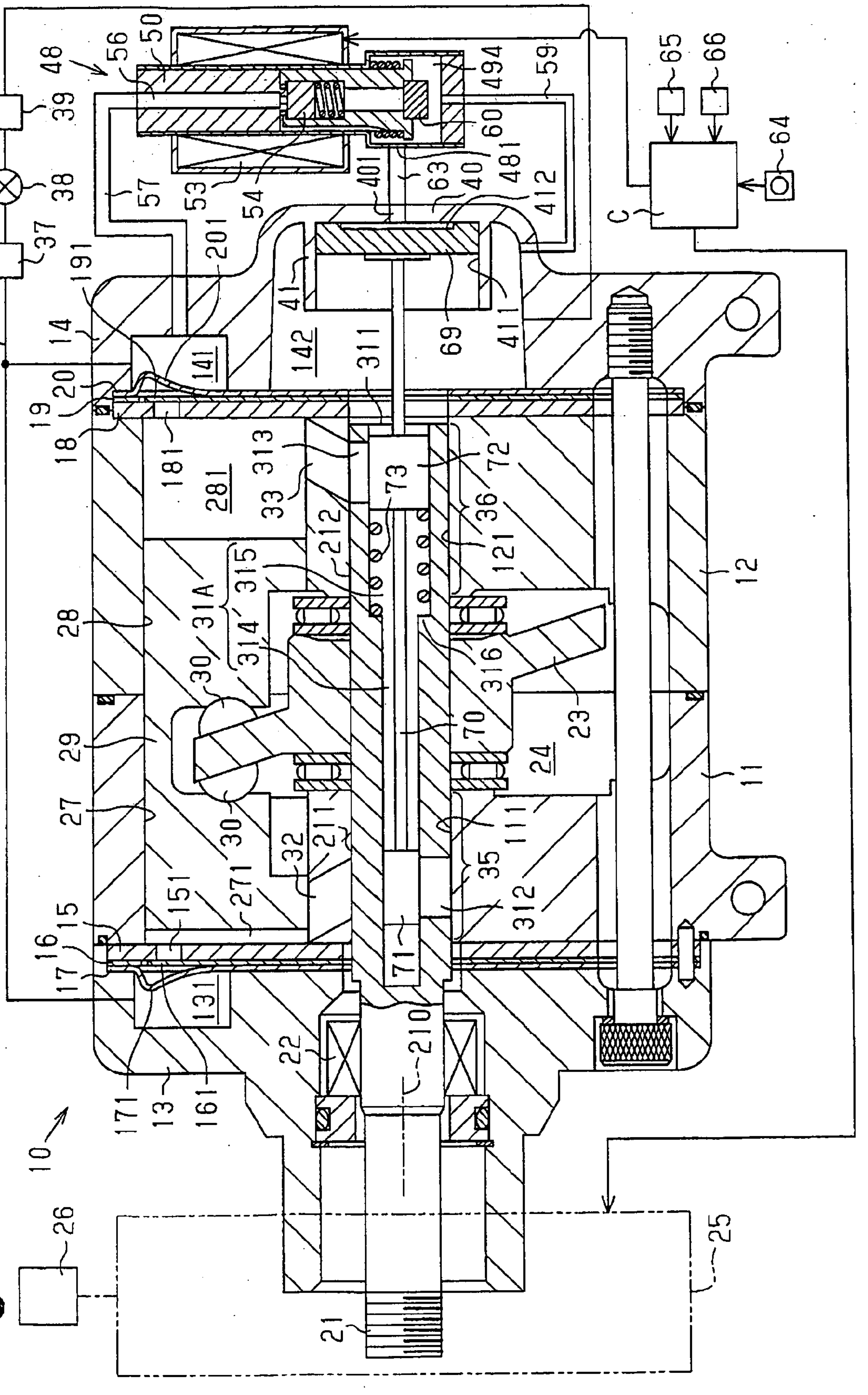
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Fig.14

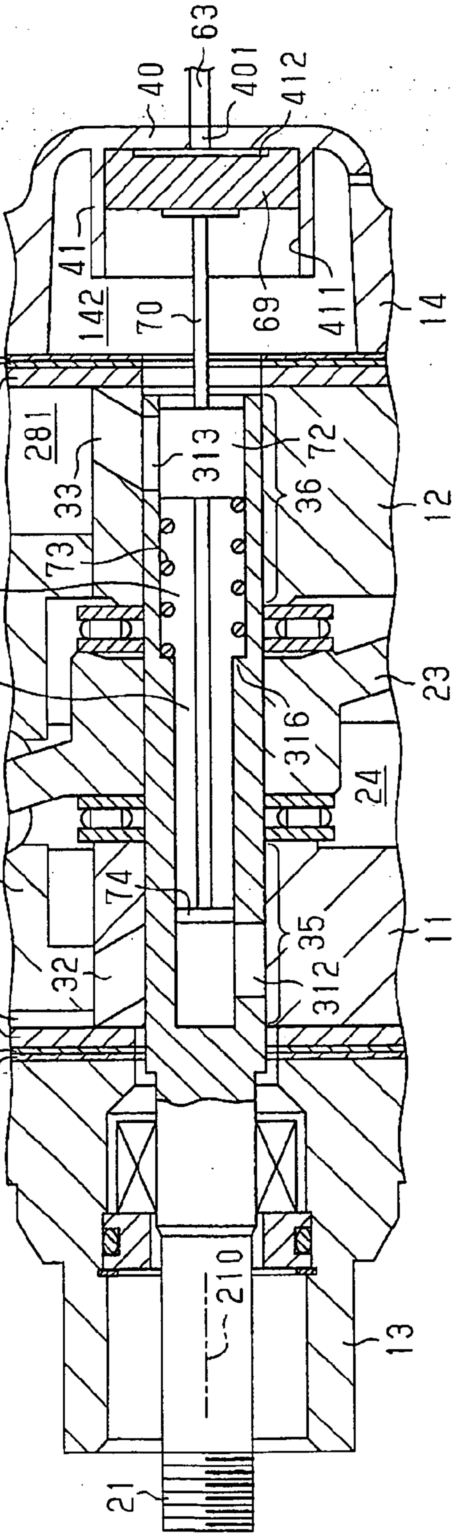

Fig.15A

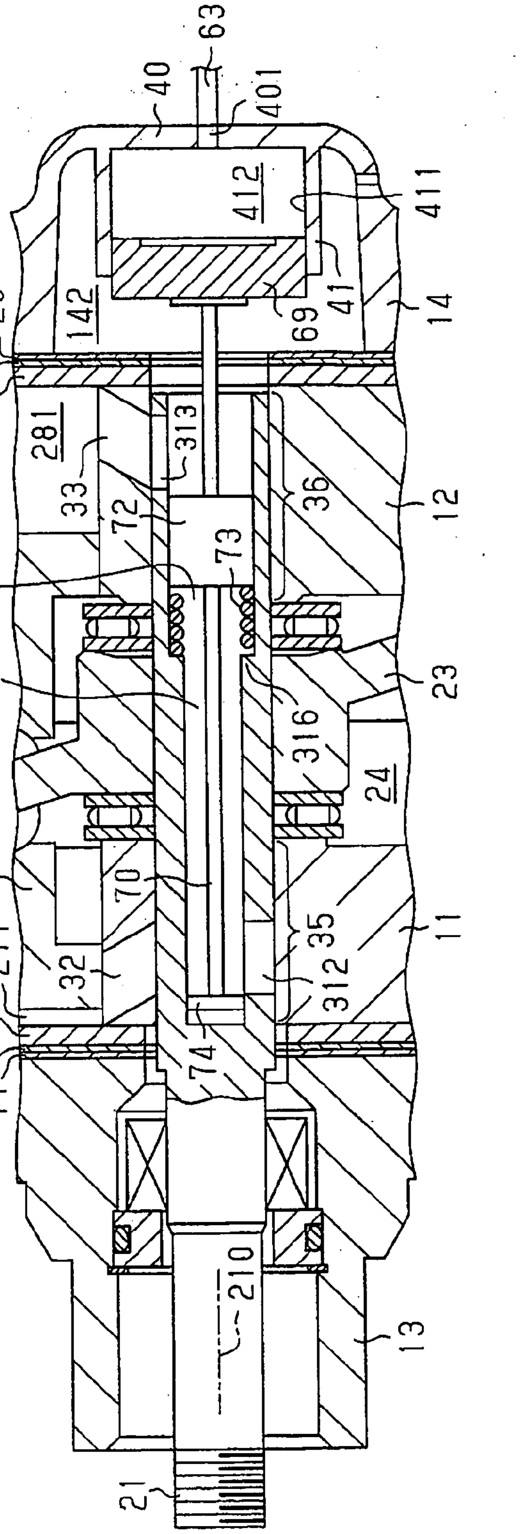

Fig.15B

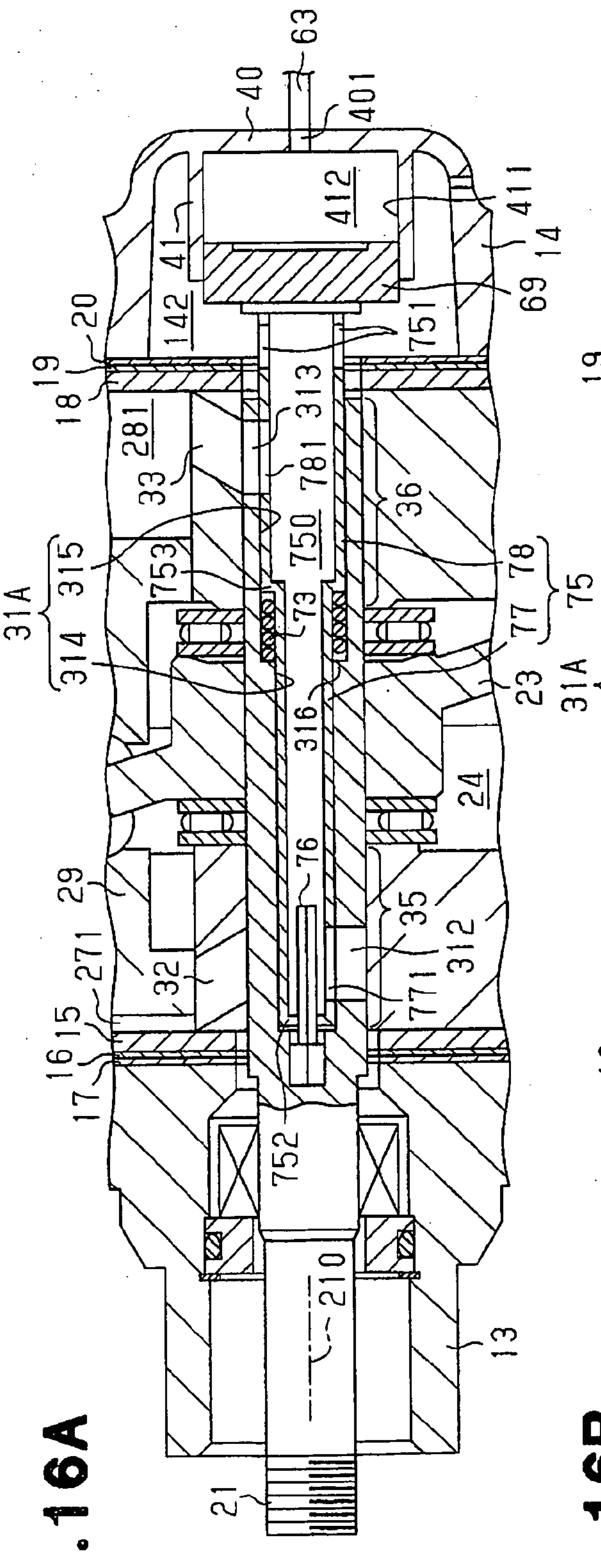

Fig.16A

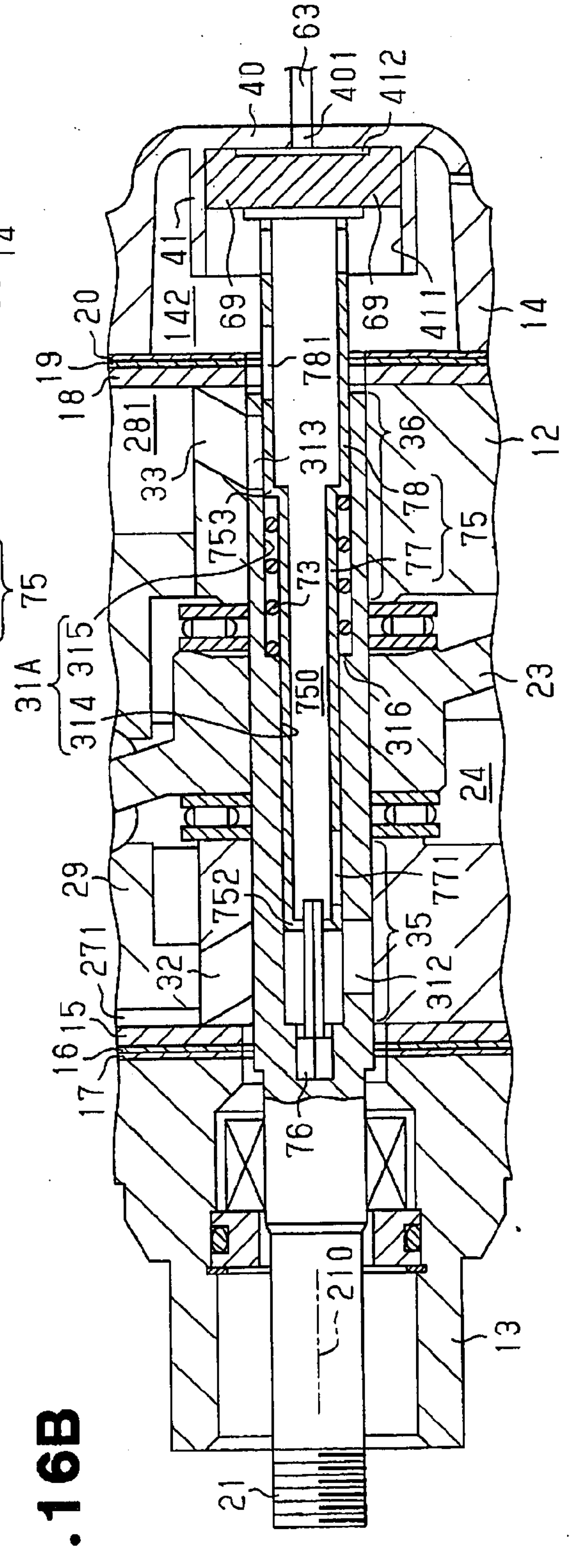

Fig.16B

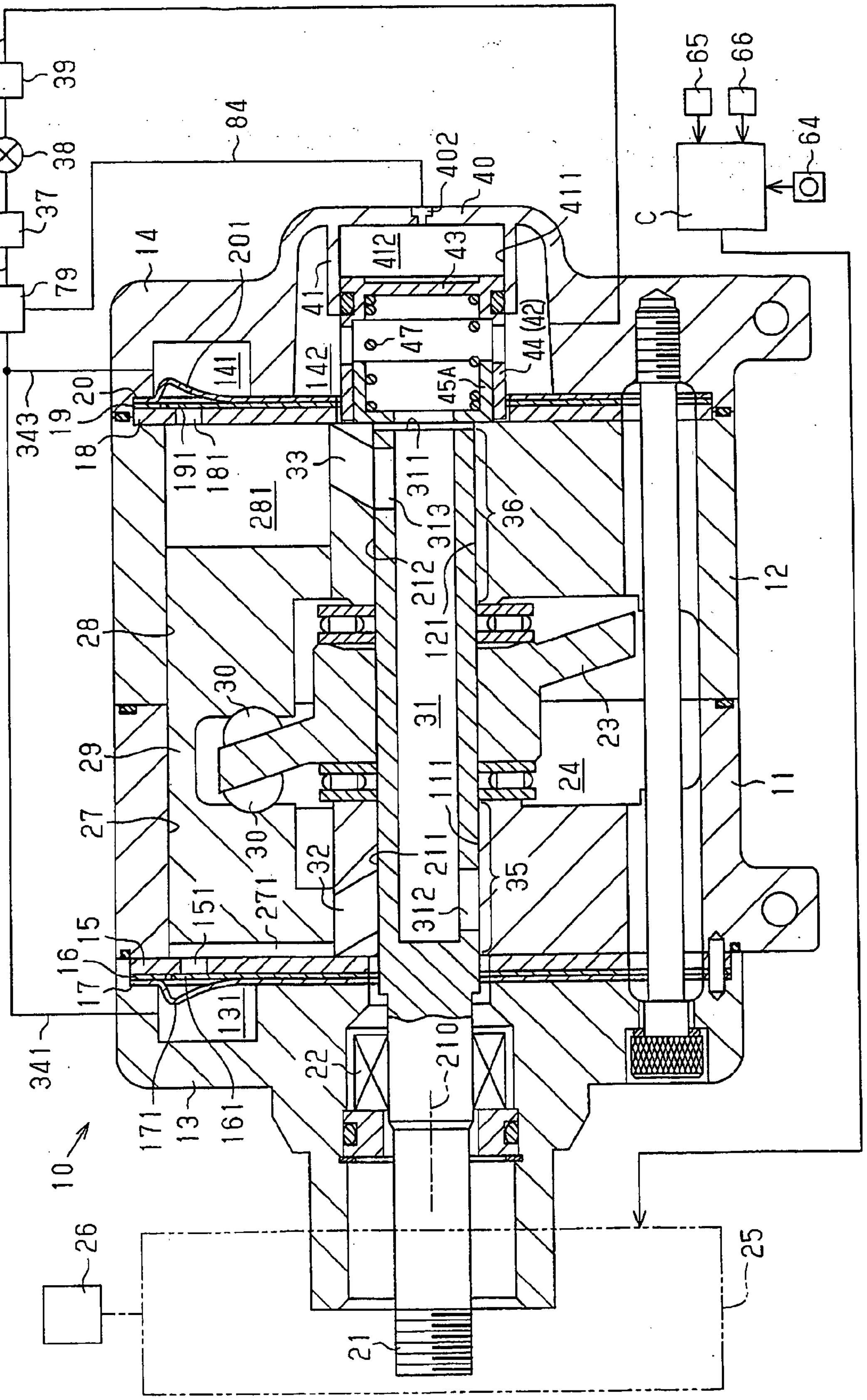
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Fig.17

Fig.18A

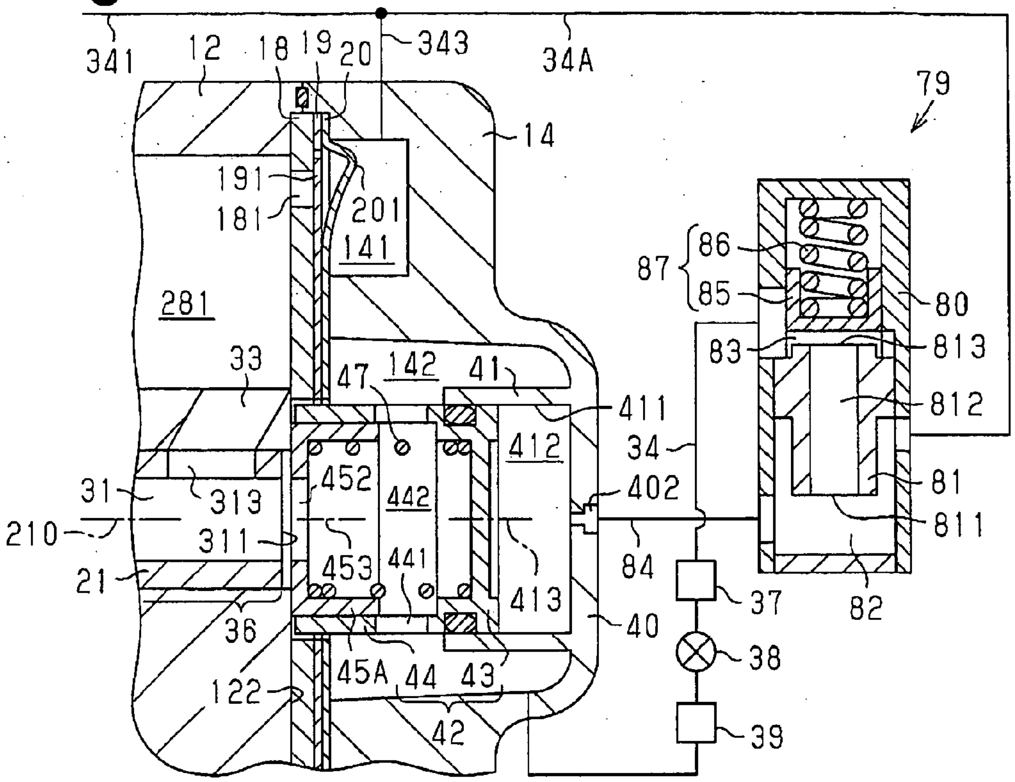


Fig.18B

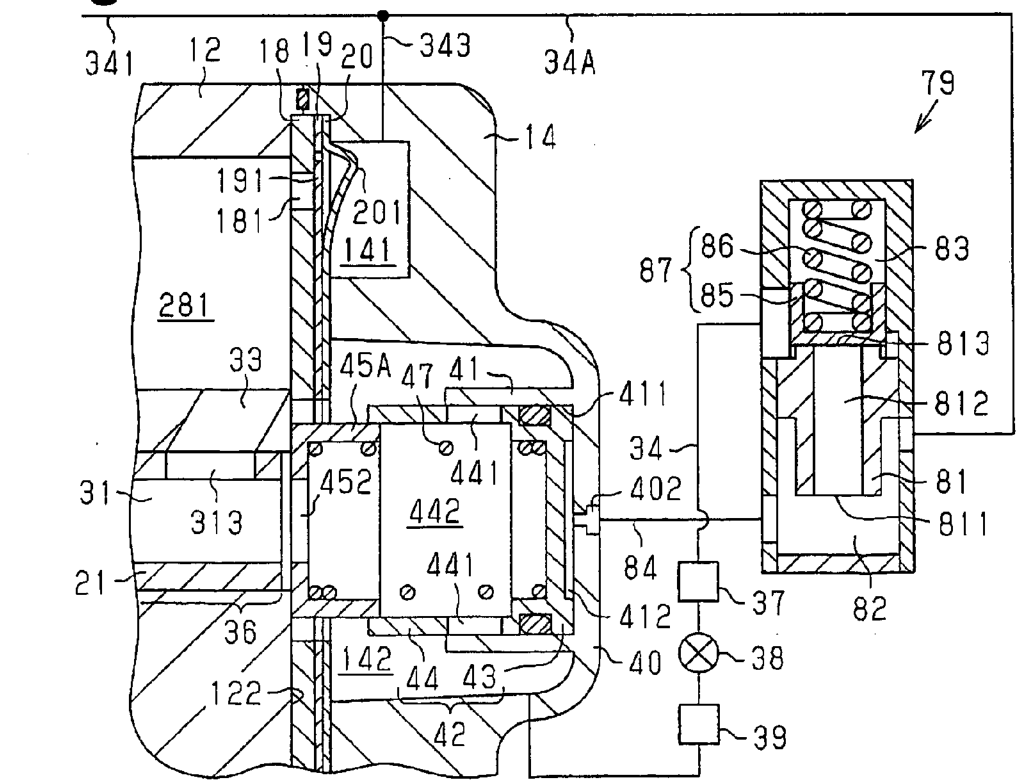


Fig.19A

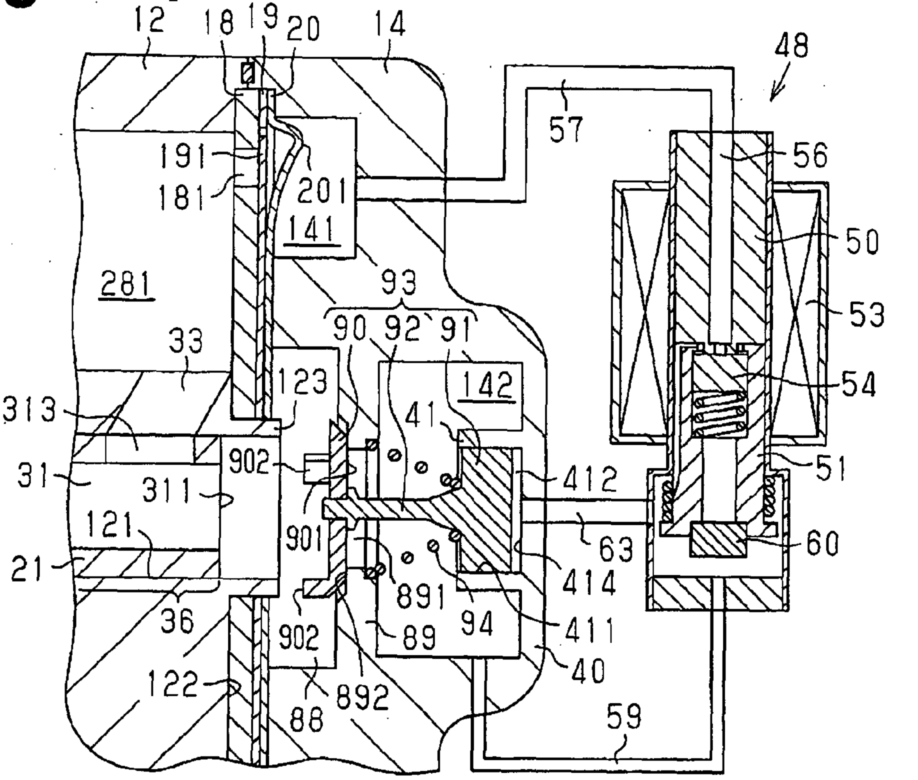
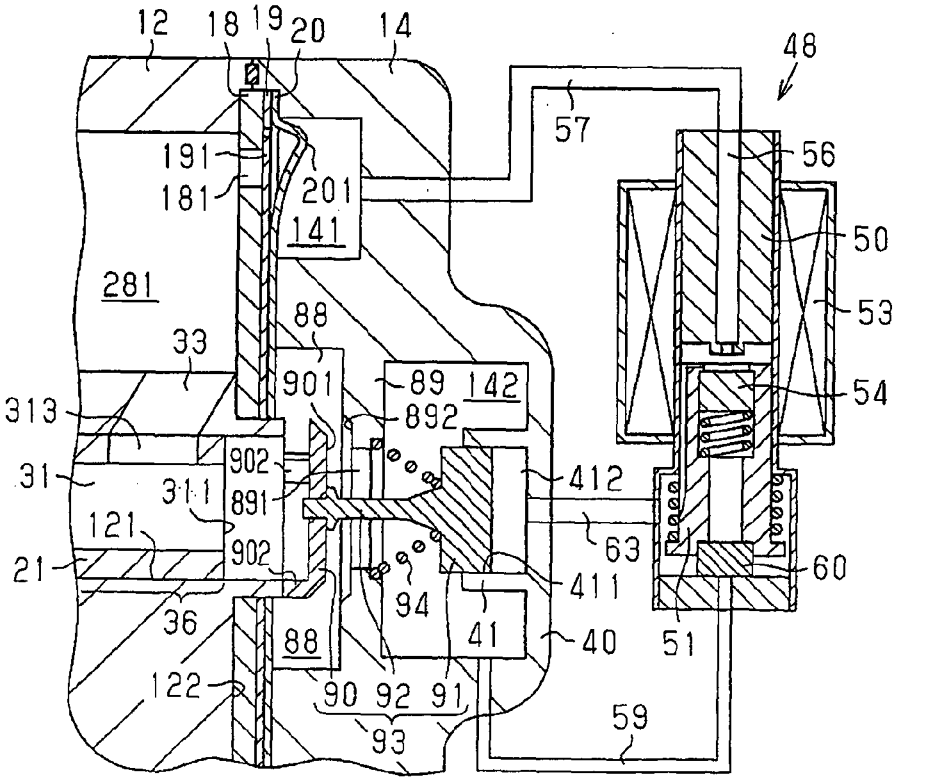
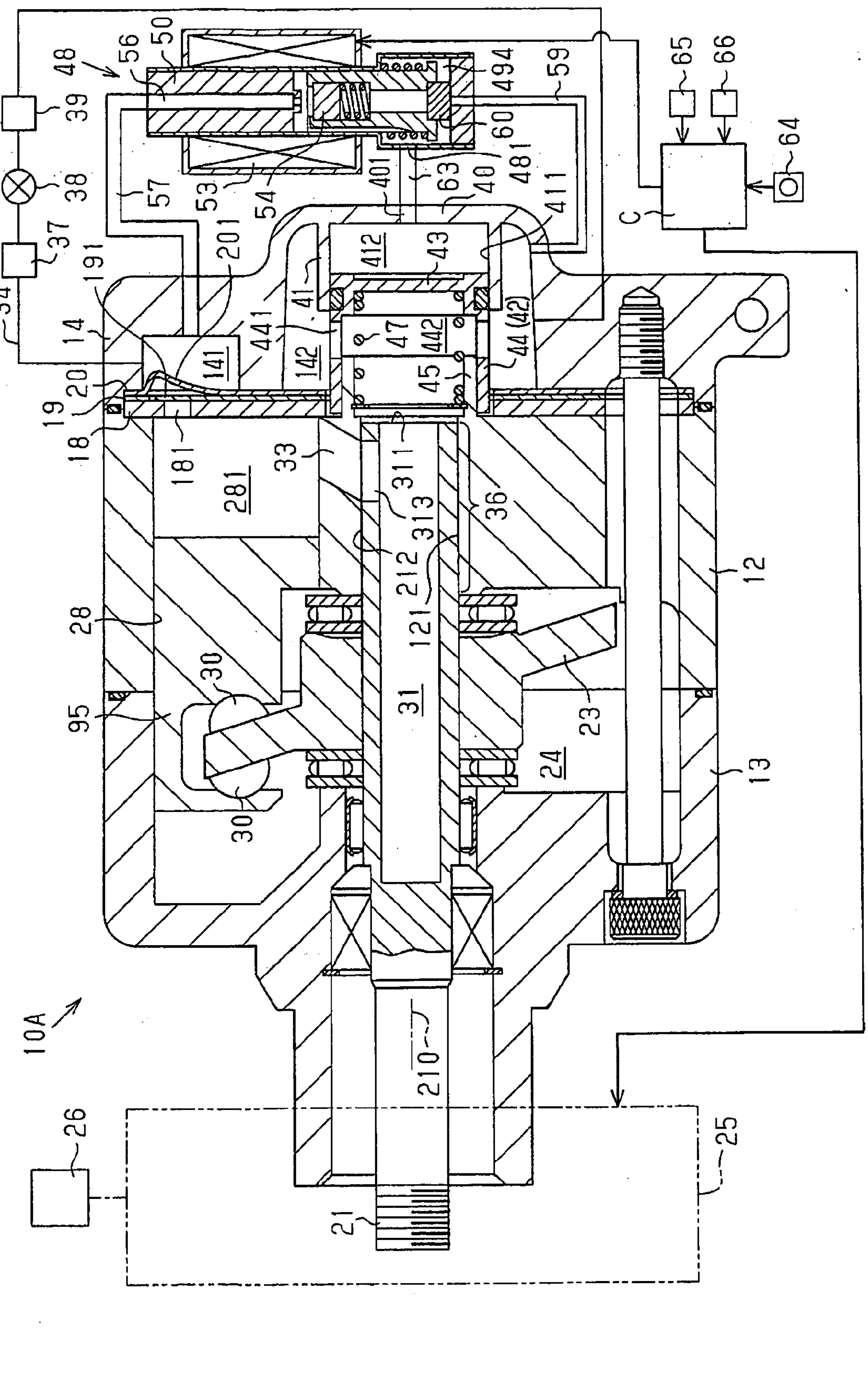


Fig.19B

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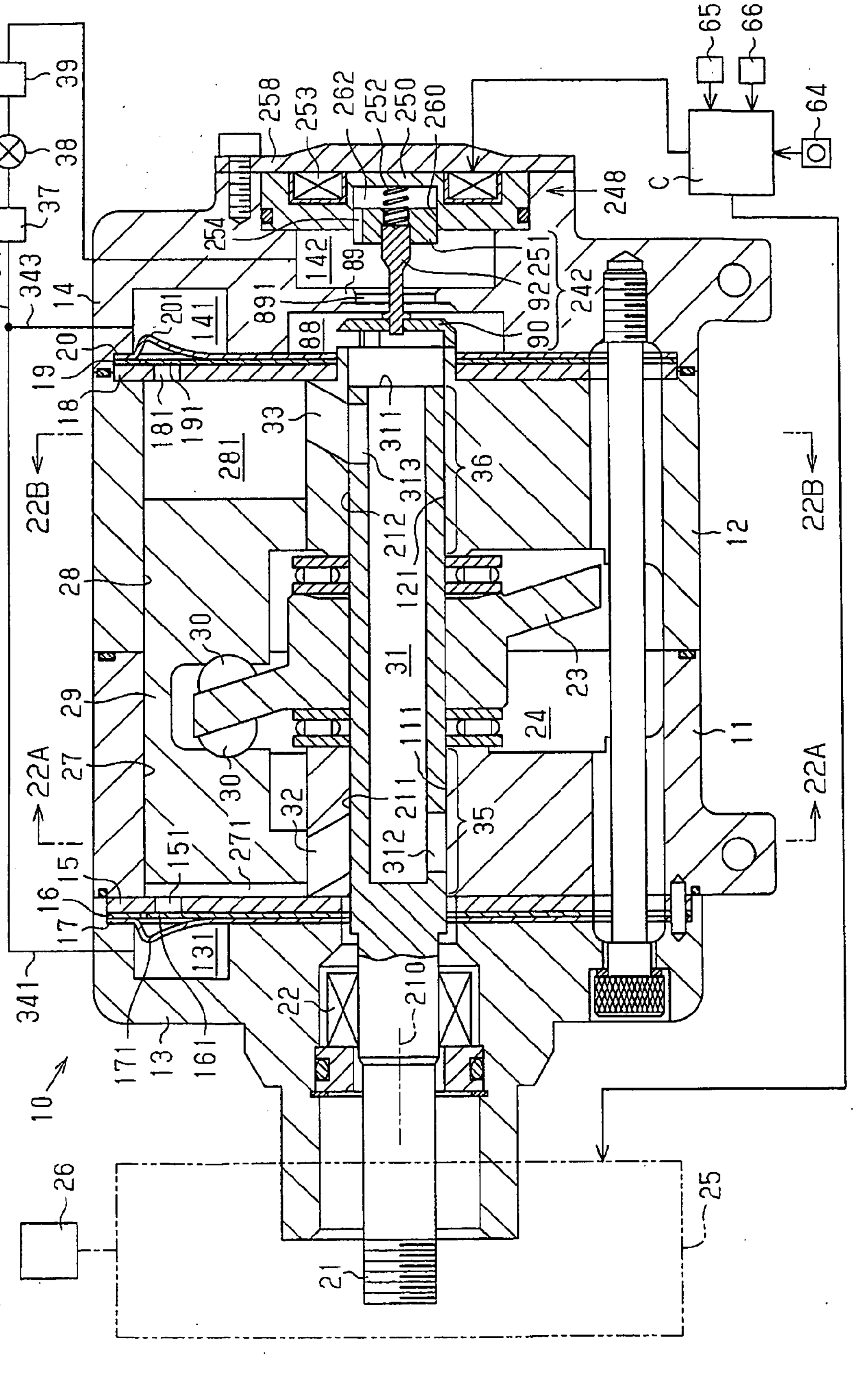
142
C

Fig.20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343
891
C
22A
22B

Fig.21

Fig.22A

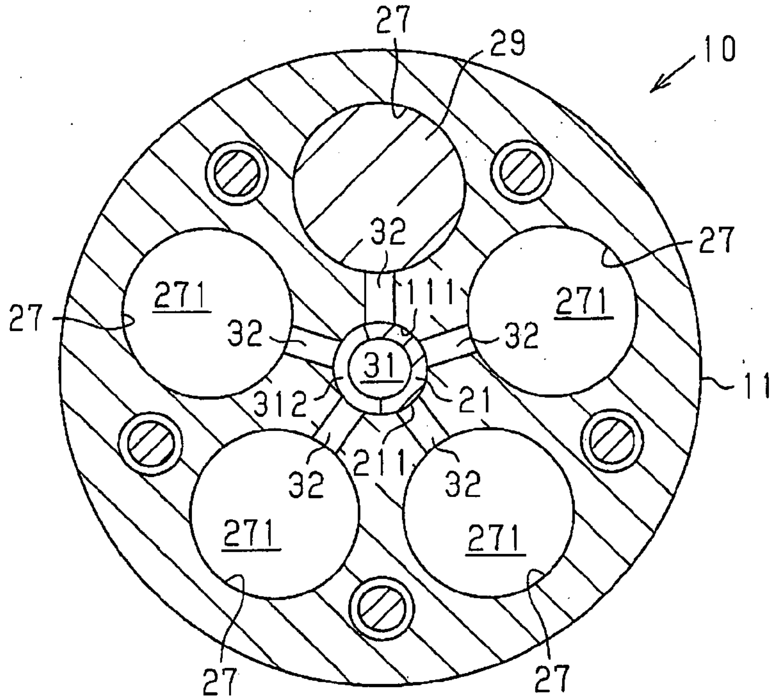


Fig.22B

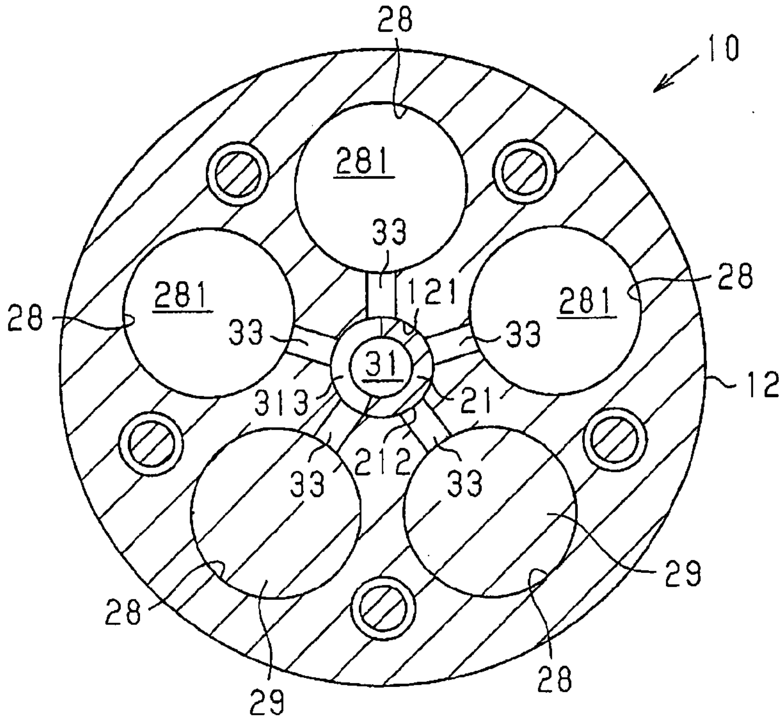
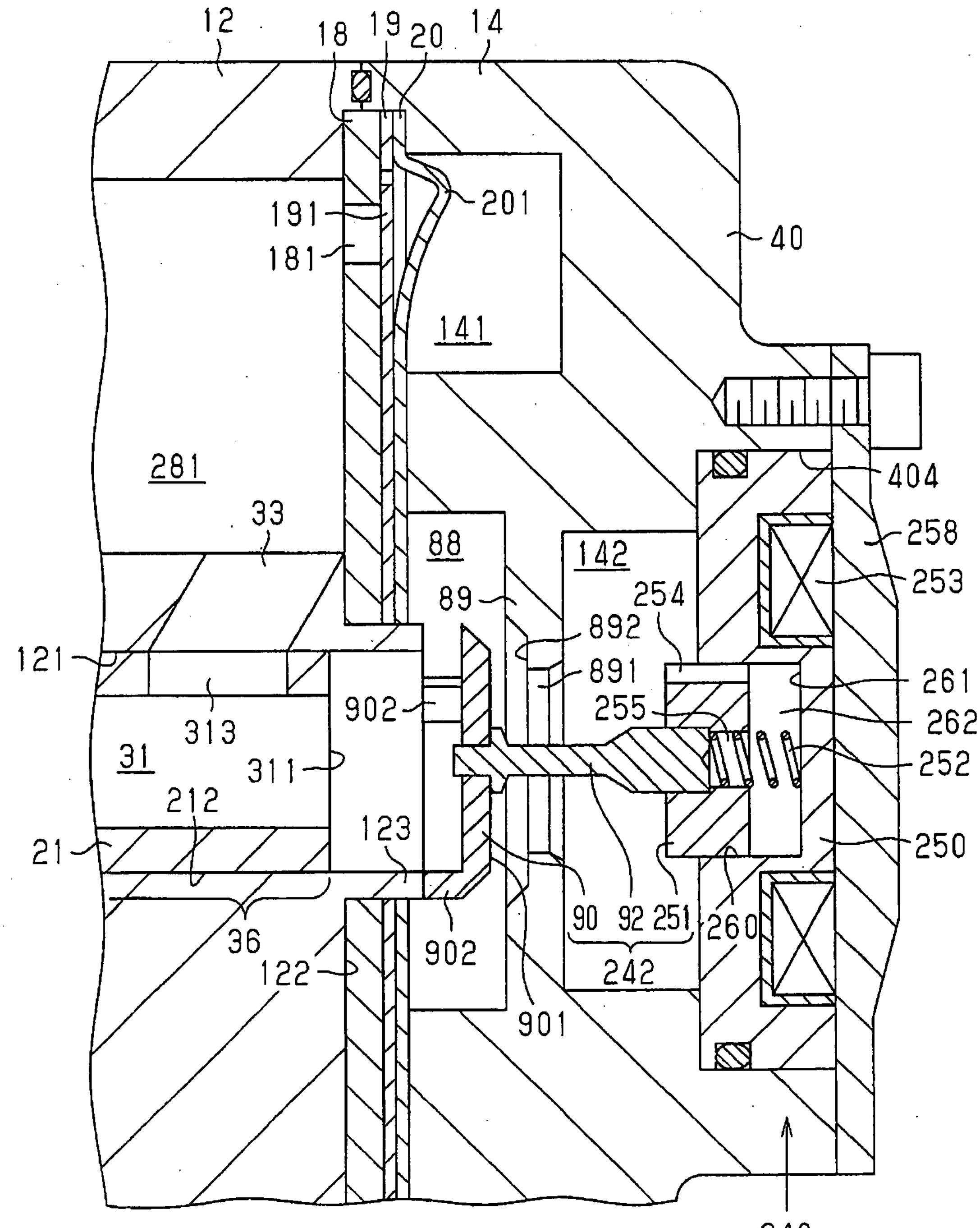


Fig.23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141
281
404
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142
258
253
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254
121
892
891
261
262
902
255
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212
123
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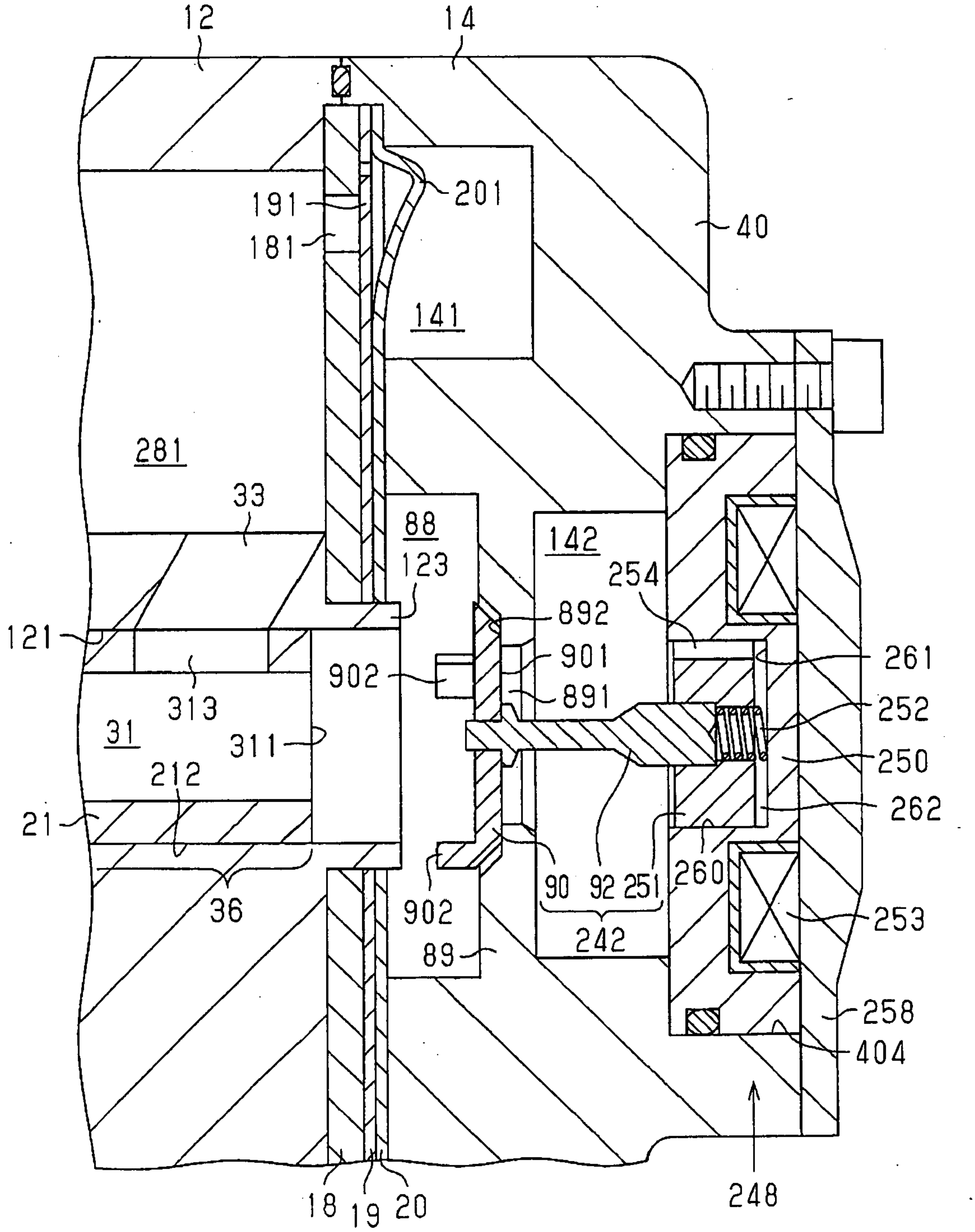
250
90
92
251
260
36
902
122
242
901
248

Fig.24


12
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123
142
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892
121
902
901
261
313
891
252
31
311
250
212
21
262
90
92
251
260
36
902
242
253
89
258
404
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Fig.25

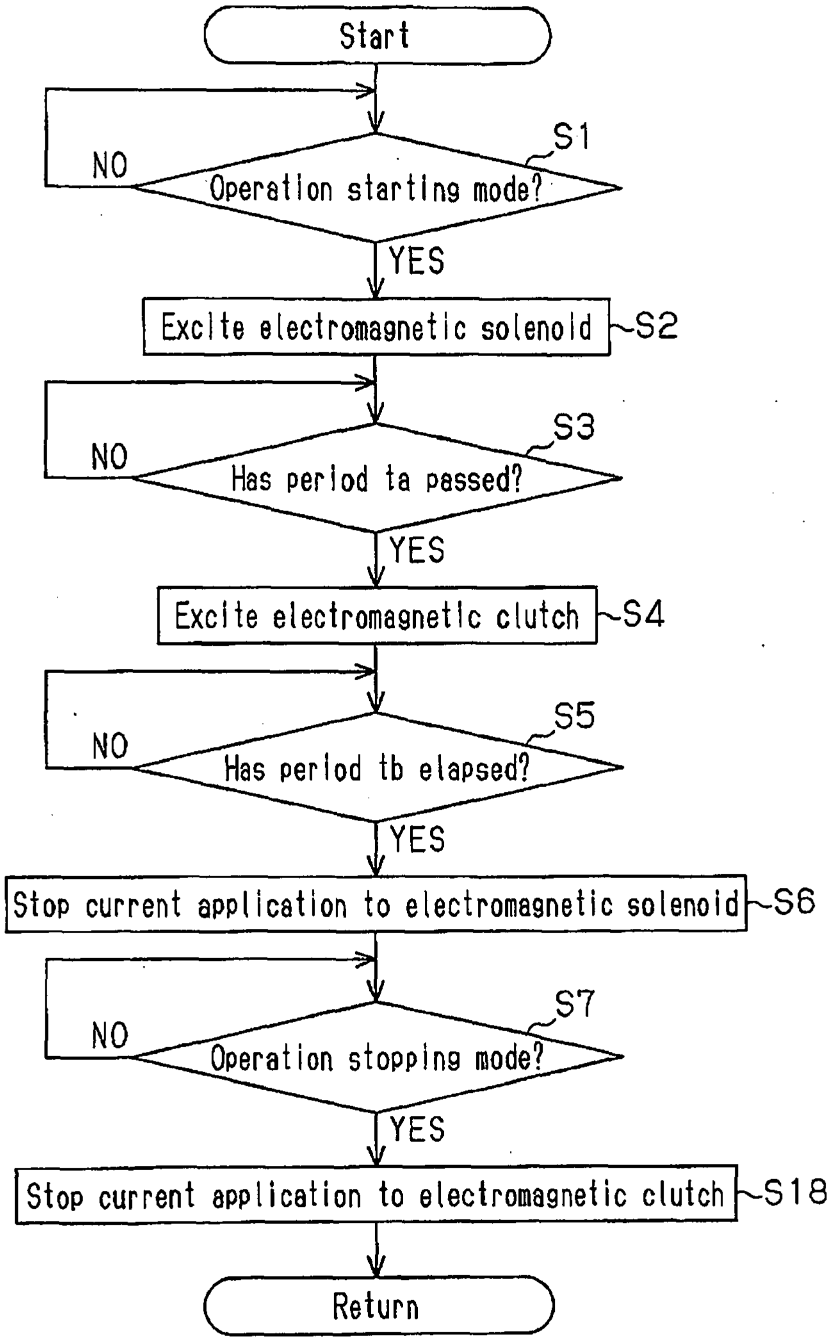

Start
NO
S1
Operation starting mode?
YES
Excite electromagnetic solenoid
S2
NO
S3
Has period ta passed?
YES
Excite electromagnetic clutch
S4
NO
S5
Has period tb elapsed?
YES
Stop current application to electromagnetic solenoid
S6
NO
S7
Operation stopping mode?
YES
Stop current application to electromagnetic clutch
S18
Return

Fig.26

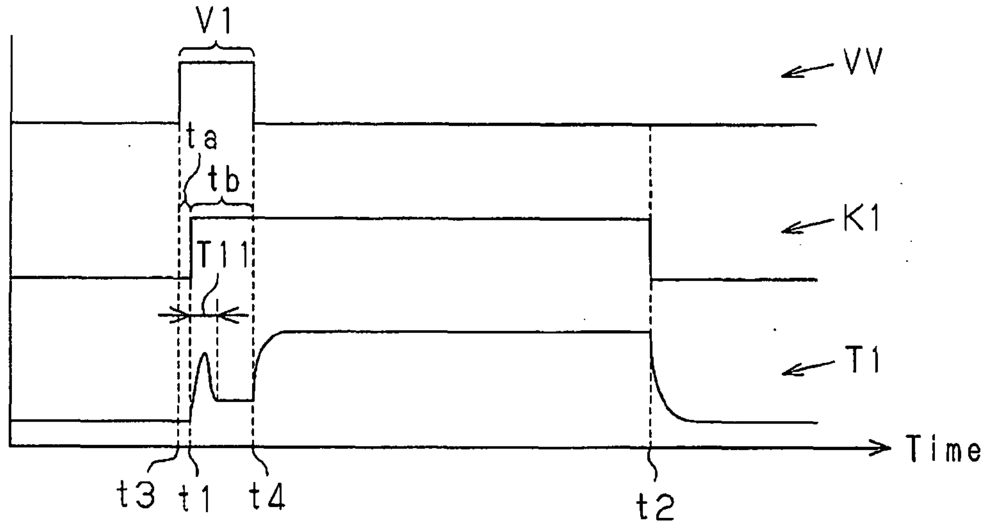

V1
VV
ta
tb
K1
T11
T1
Time
t3
t1
t4
t2

Fig.27

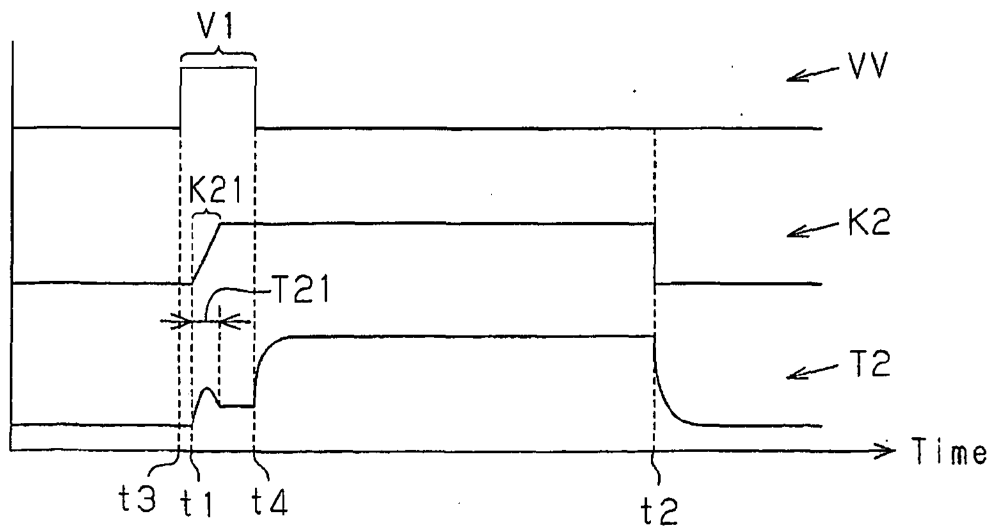

V1
VV
K21
K2
T21
T2
Time
t3
t1
t4
t2

Fig.28A

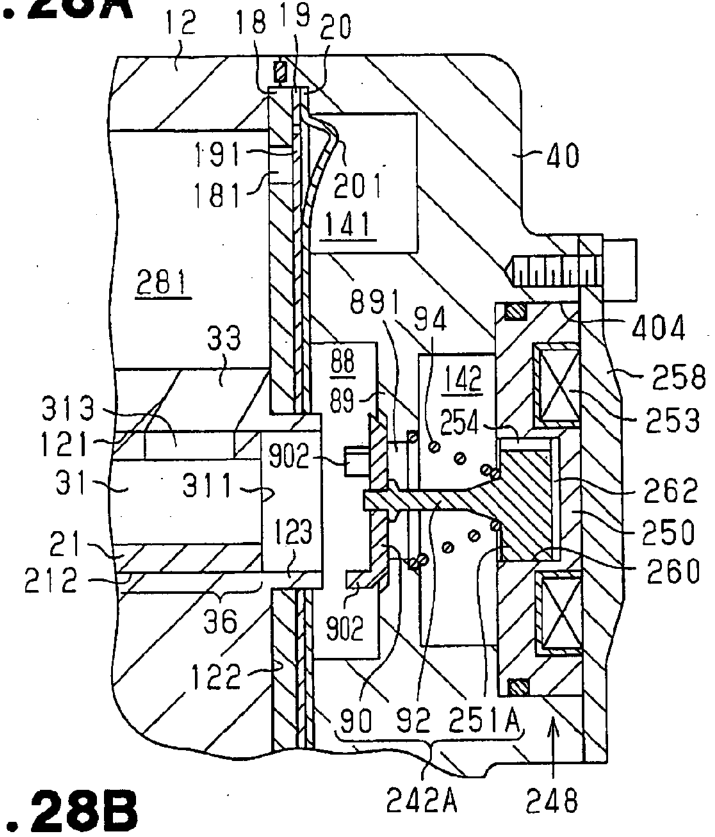


Fig.28B

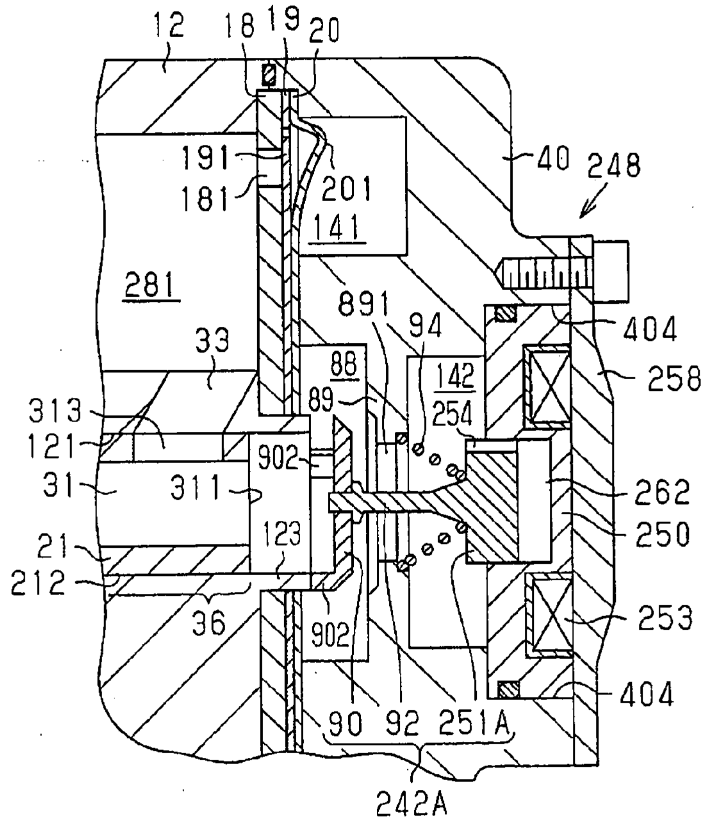


Fig.29A

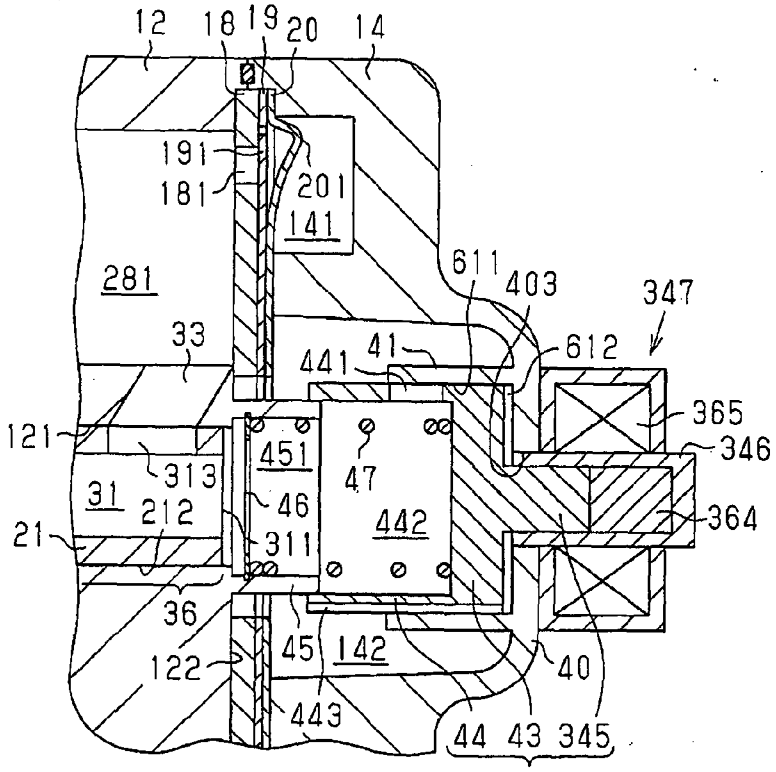


Fig.29B

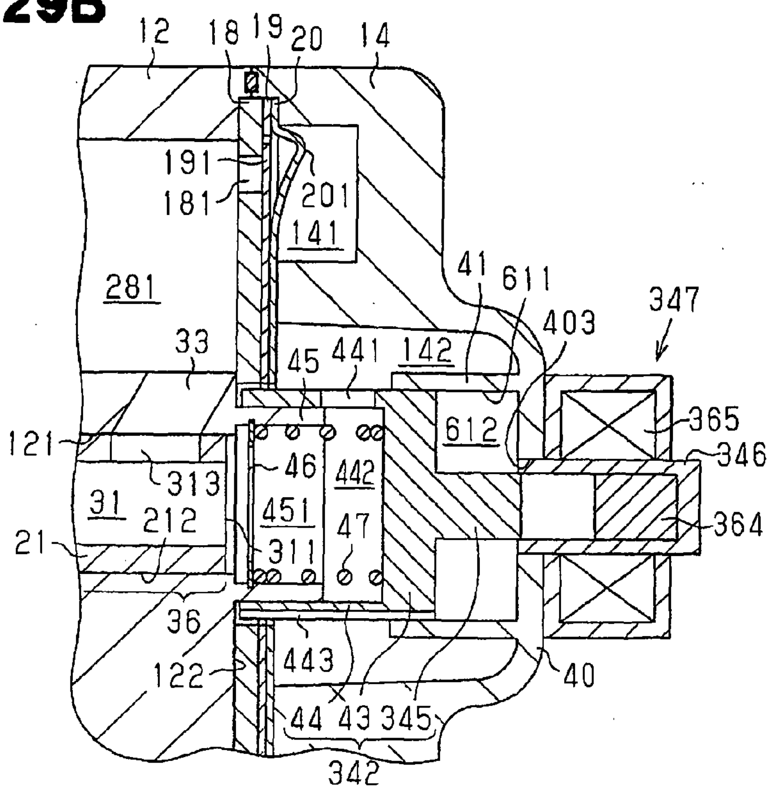


Fig.30A

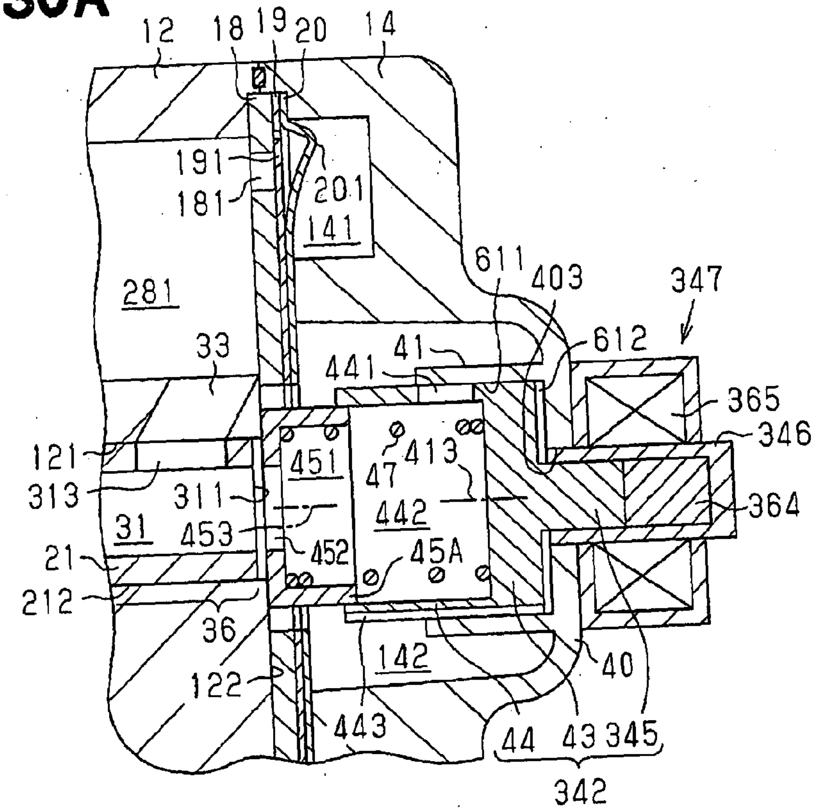
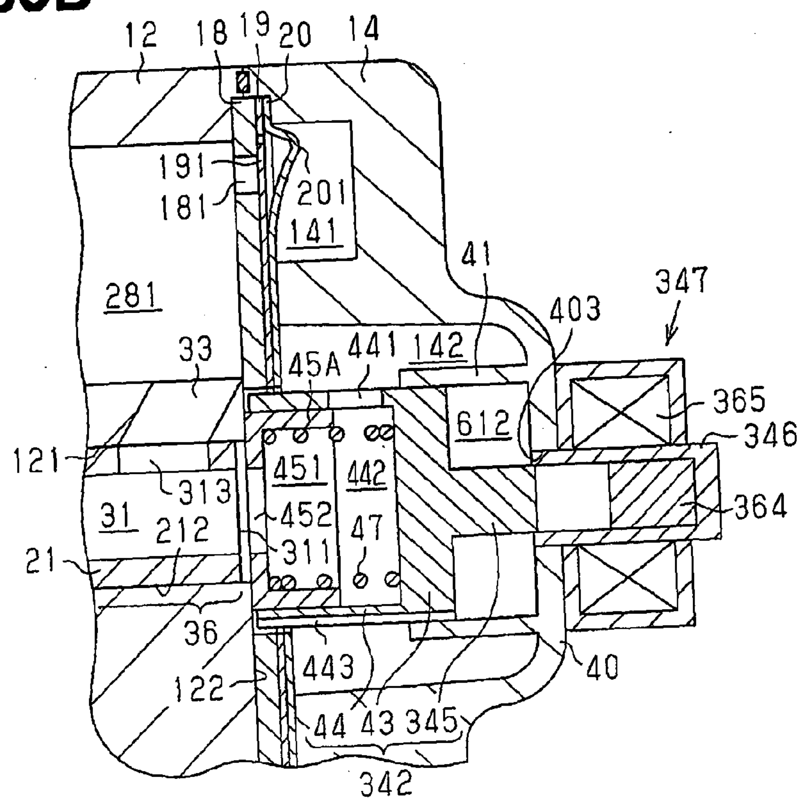


Fig.30B



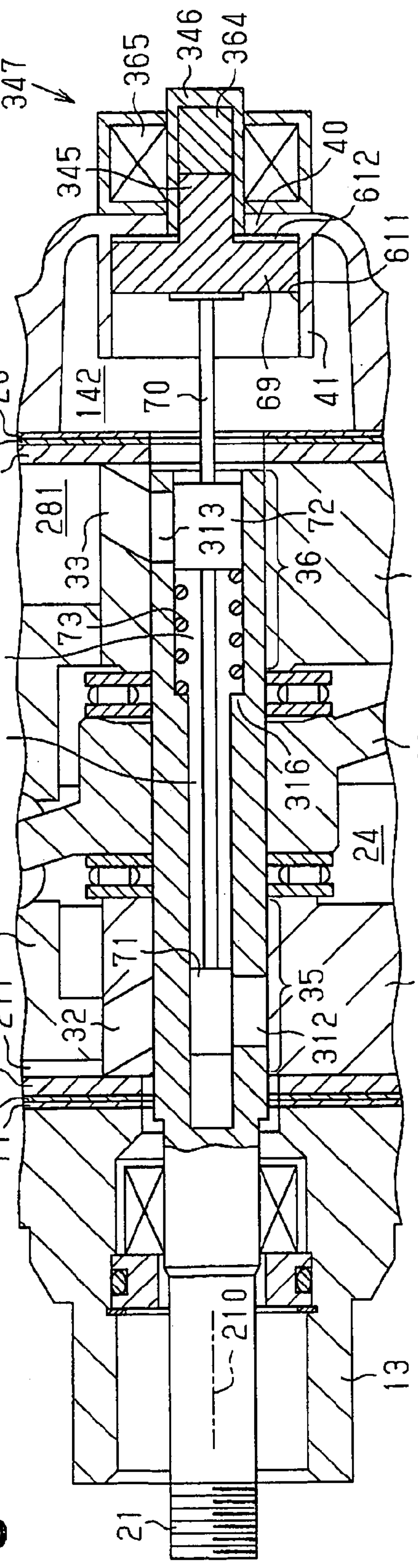


Fig. 31A

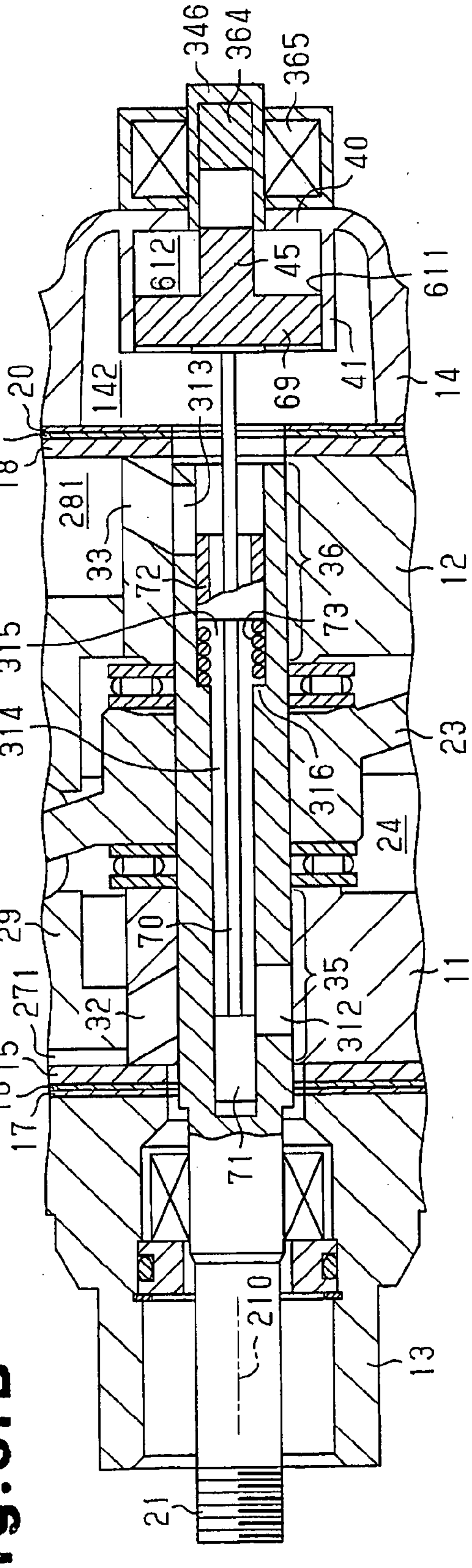


Fig. 31B

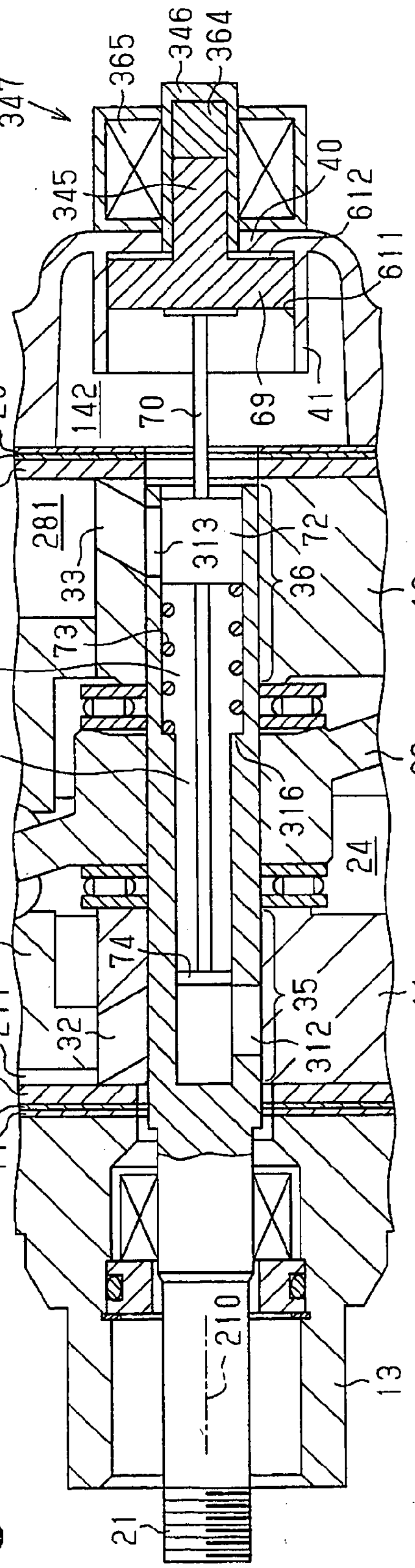


Fig. 32A

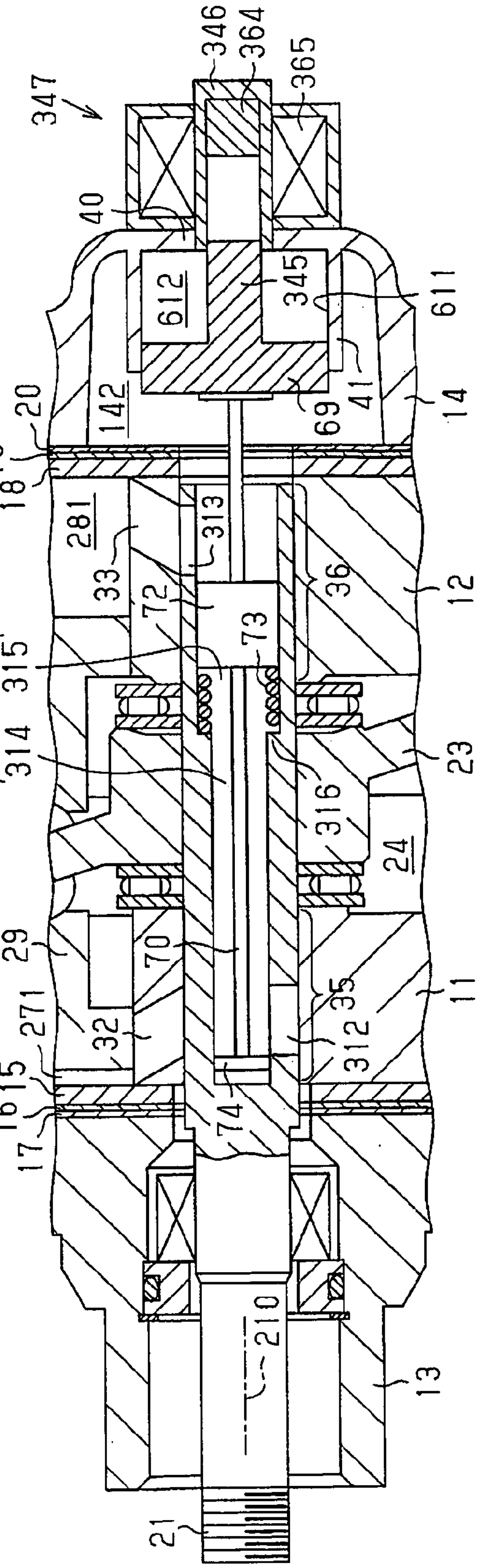


Fig. 32B

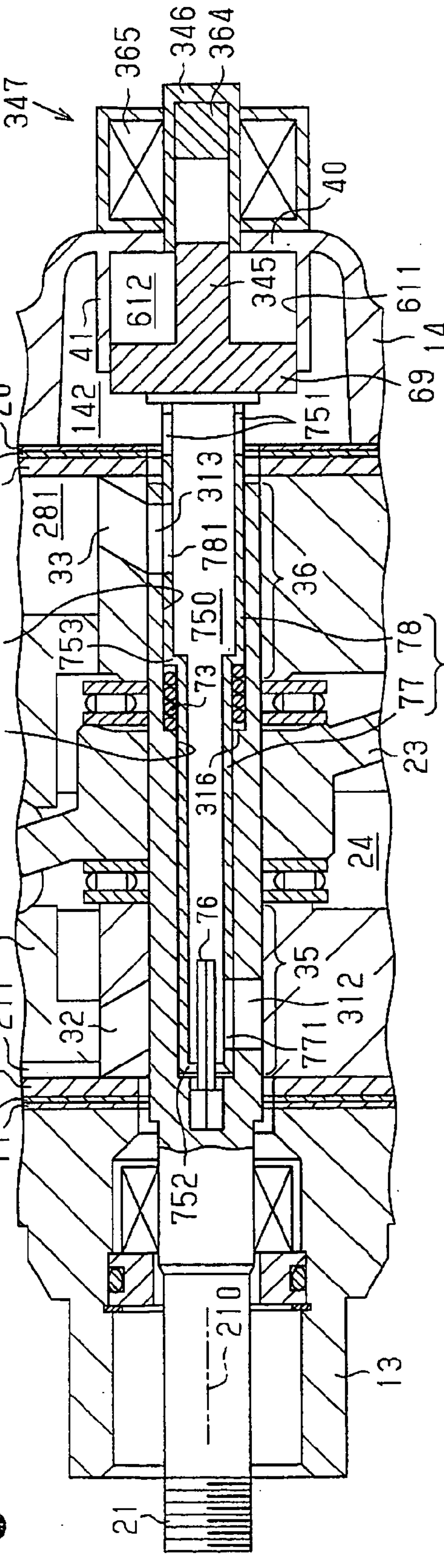


Fig.33A

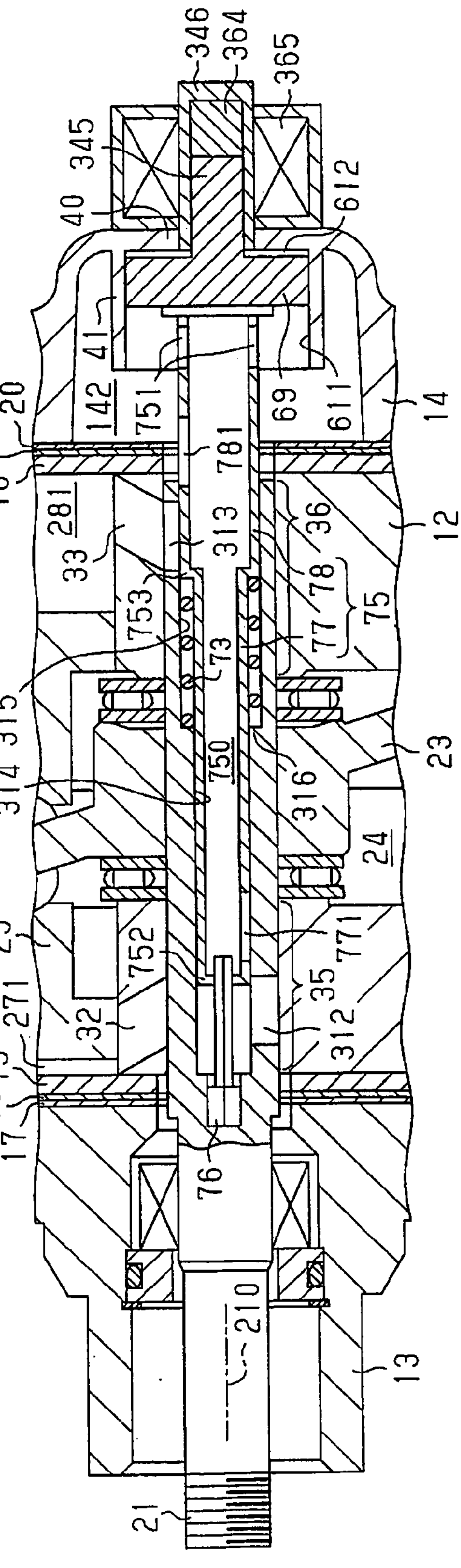
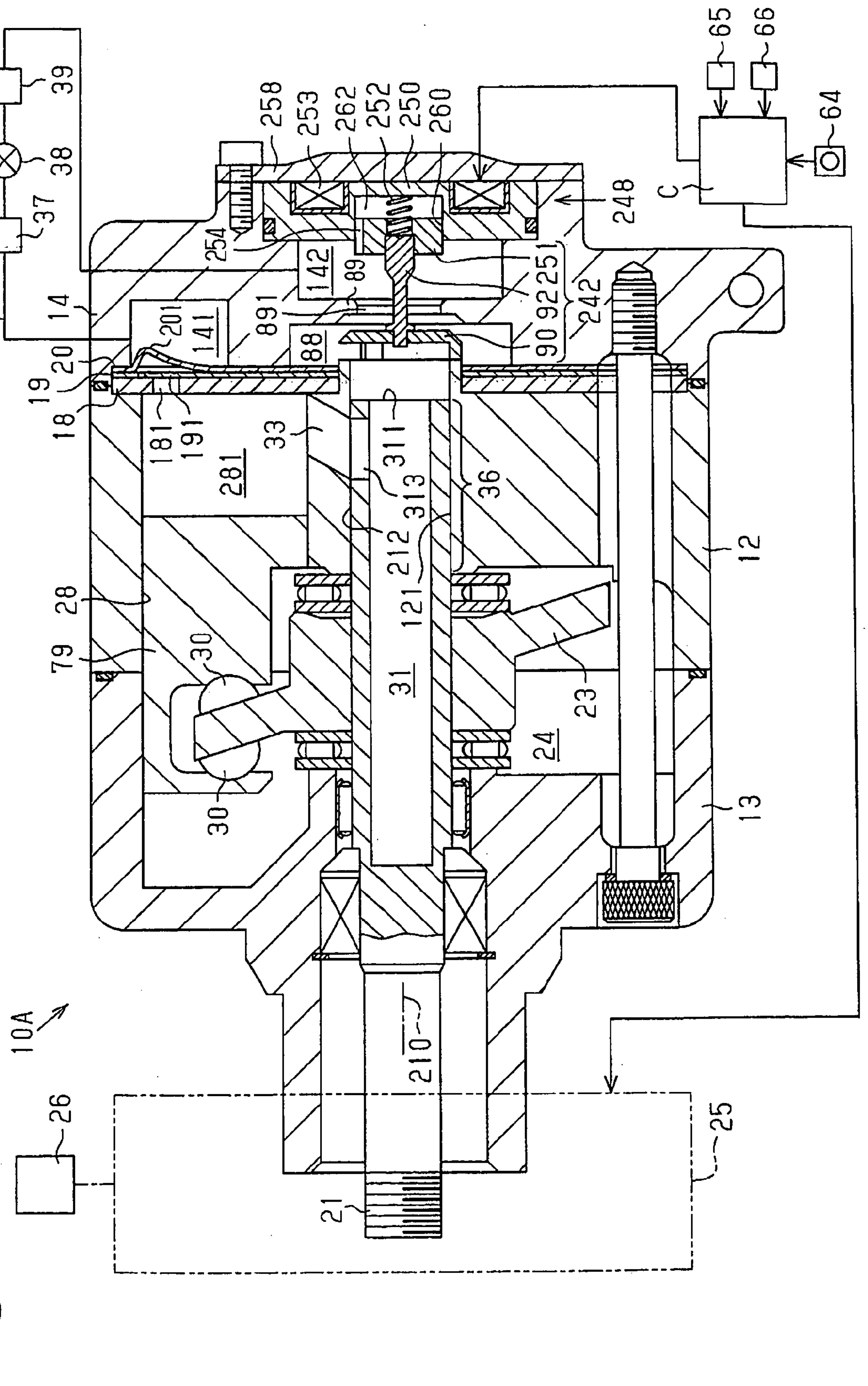


Fig.33B

Fig.34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REFERENCES CITED IN THE DESCRIPTION

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