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(71) Applicant: **Kabushiki Kaisha Toyota Jidoshokki Kariya-shi, Aichi 448-8671 (JP)**

(72) Inventors:
• **Kimoto, Yoshio**
Kariya-shi Aichi 448-8671 (JP)
• **Kawaguchi, Masahiro**
Kariya-shi Aichi 448-8671 (JP)
• **Ota Masaki**
Kariya-shi Aichi 448-8671 (JP)
• **Hoshino, Nobuaki**
Kariya-shi Aichi 448-8671 (JP)

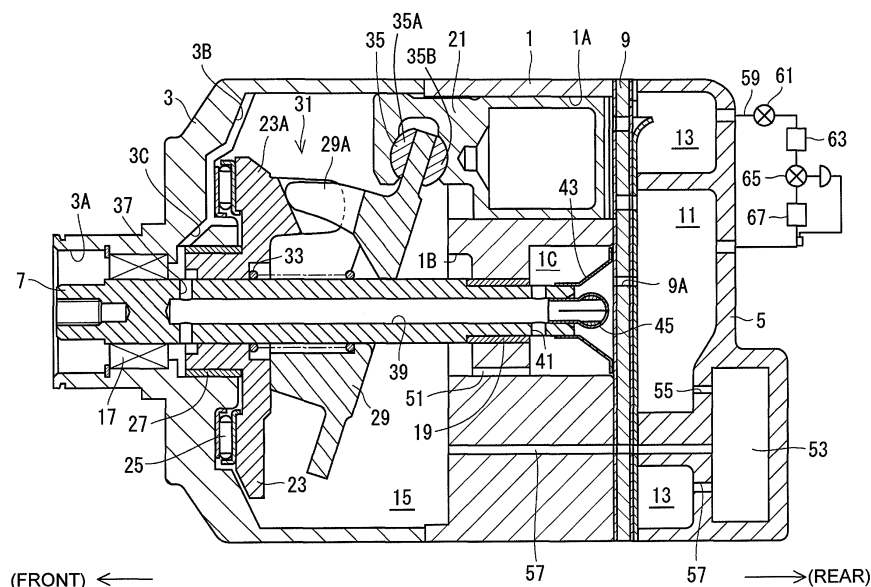
(74) Representative: **TBK-Patent Bavariaring 4-6 80336 München (DE)**

(54) **Swash plate type compressor**

(57) A swash plate type compressor has a housing assembly (1,3,5), a drive shaft (7), a swash plate (29), a piston (21), a motion converter (35), a bleed passage (39), and an oil separator (43). The housing assembly includes a cylinder bore (1A), a suction chamber (11), a discharge chamber (13), and a crank chamber (15). The drive shaft is rotatably supported by the housing assembly, and extends through the crank chamber. The bleed

passage communicates between the crank chamber and the suction chamber. The oil separator is disposed in the housing assembly. The oil separator separates no or less amount of lubricating oil from the refrigerant gas in the increased rotational speed of the drive shaft than that in the decreased rotational speed of the drive shaft. The refrigerant gas passed through the oil separator is introduced into the suction chamber, and the separated lubricating oil is returned to the crank chamber.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a swash plate type compressor.

[0002] A conventional swash plate type compressor is disclosed in Japanese Patent Application Publication No. 10-54350. The swash plate type compressor has a housing assembly including a front housing, a cylinder block, and a rear housing. The housing assembly defines therein a plurality of cylinder bores, a suction chamber, a discharge chamber, and a crank chamber. A drive shaft is rotatably supported by the front housing. One end of the drive shaft extends out of the front housing through the crank chamber. The cylinder block defines therein an accommodation chamber in which the other end of the drive shaft is located. A valve unit is arranged between the cylinder block and the rear housing. The accommodation chamber communicates with the suction chamber through a hole of the valve unit.

[0003] A swash plate is inclinably and slidably supported by the drive shaft in the crank chamber. Each cylinder bore accommodates therein a piston so that the piston is reciprocally slidable therein. A pair of front and rear shoes are disposed between the swash plate and the pistons. Wobbling motion of the swash plate is converted into reciprocating motion of the pistons through the shoes. The discharge chamber is connected to the crank chamber through a supply passage. A displacement control valve is disposed in the supply passage for adjusting the pressure in the crank chamber.

[0004] In this swash plate type compressor, the drive shaft has a bleed passage formed therein for communication between the crank chamber and the suction chamber. The bleed passage has a hole extending radially in the drive shaft, and a passage extending axially in the drive shaft for connecting the hole to the suction chamber.

[0005] In this swash plate type compressor, the drive shaft has at the end thereof in the accommodation chamber a valve. The valve is operable to reduce the opening of the bleed passage in response to an increase of the rotational speed of the drive shaft, and to increase the opening of the bleed passage in response to a decrease of the rotational speed of the drive shaft.

[0006] The swash plate type compressor constitutes a refrigeration circuit with a condenser, an expansion valve, and an evaporator for a vehicle air conditioning system. Refrigerant gas containing lubricating oil is sealed in the refrigeration circuit. The displacement control valve is operable to adjust the pressure in the crank chamber in accordance with the pressure in the suction chamber and the flow rate of refrigerant gas. Thus, the inclination angle of the swash plate with respect to the drive shaft is changed for controlling the displacement of the swash plate type compressor.

[0007] While a vehicle is running at a high speed, the opening of the bleed passage of the swash plate type

compressor is decreased due to the increased rotational speed of the drive shaft. Especially, while the compressor is driven at a high speed and operating with a high displacement, the pressure in the crank chamber is gradually increased thereby to reduce the displacement of the compressor. Thus, the compression load of the compressor may be reduced. While a vehicle is running at a low speed, on the other hand, the opening of the bleed passage is increased due to the decreased rotational speed of the drive shaft. Thus, in accordance with the required refrigeration performance, the pressure in the crank chamber is gradually decreased thereby to increase the displacement of the compressor. Therefore, the compressor can improve the refrigeration performance.

[0008] The swash plate type compressor, especially when the drive shaft is driven to rotate at a high speed, requires improved sliding characteristics between the swash plate and the shoes, and also between the cylinder bores and the pistons. When the drive shaft is driven to rotate at a low speed, it is required that the amount of lubricating oil contained in refrigerant gas discharged into external refrigeration circuit outside the compressor should be decreased, and the compressor should provide a high refrigeration performance.

[0009] The present invention is directed to providing a swash plate type compressor that can provide excellent sliding characteristics when the drive shaft is driven to rotate at a high speed, and provide high refrigeration performance when the drive shaft is driven to rotate at a low speed.

SUMMARY OF THE INVENTION

[0010] In accordance with the present invention, a swash plate type compressor has a housing assembly, a drive shaft, a swash plate, a piston, a motion converter, a bleed passage, and an oil separator. The housing assembly includes a cylinder bore, a suction chamber, a discharge chamber, and a crank chamber. The drive shaft is rotatably supported by the housing assembly, and extends through the crank chamber. The swash plate is supported by the drive shaft in the crank chamber. The piston is accommodated in the cylinder bore so as to be reciprocally slidable therein. The motion converter is disposed between the swash plate and the piston, and converts wobbling motion of the swash plate into reciprocating motion of the piston. The bleed passage communicates between the crank chamber and the suction chamber. The oil separator is disposed in the housing assembly. The oil separator separates no or less amount of lubricating oil from the refrigerant gas in the increased rotational speed of the drive shaft than that in the decreased rotational speed of the drive shaft. The refrigerant gas passed through the oil separator is introduced into the suction chamber, and the separated lubricating oil is returned to the crank chamber.

[0011] Other aspects and advantages of the invention will become apparent from the following description, tak-

en in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a longitudinal cross-sectional view showing a swash plate type compressor according to a first preferred embodiment of the present invention;

Fig. 2 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor of Fig. 1 when the drive shaft is driven to rotate at a low speed;

Fig. 3 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor of Fig.1 when the drive shaft is driven to rotate at a high speed;

Fig. 4 is a perspective view showing a valve of the swash plate type compressor of Fig.1;

Fig. 5 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor according to a second preferred embodiment of the present invention when the drive shaft is driven to rotate at a low speed;

Fig. 6 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor of Fig. 5 when the drive shaft is driven to rotate at a high speed;

Fig. 7 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor according to a third preferred embodiment of the present invention when the drive shaft is driven to rotate at a low speed;

Fig. 8 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor of Fig. 7 when the drive shaft is driven to rotate at a high speed;

Fig. 9 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor according to a fourth preferred embodiment of the present invention when the drive shaft is driven to rotate at a low speed; and

Fig. 10 is a partially enlarged longitudinal cross-sectional view showing the swash plate type compressor of Fig. 9 when the drive shaft is driven to rotate at a high speed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The following will describe a swash plate type compressor according to the first through fourth preferred embodiments of the present invention with reference to Figs. 1 through 10.

[0014] The swash plate type compressor of the first preferred embodiment is a variable displacement type compressor used for a vehicle air conditioning system. Referring to Fig. 1, the compressor has a drive shaft 7 and a housing assembly including a cylinder block 1, a front housing 3, and a rear housing 5. The cylinder block 1 has a plurality of cylinder bores 1A extending parallel to the axis of the drive shaft 7. The left side of the drawing corresponds to the front side of the compressor, and the right side of the drawing corresponds to the rear side of the compressor.

[0015] A suction chamber 11 and a discharge chamber 13 are defined in the rear housing 5 for communication with the cylinder bores 1A through a valve unit 9. A crank chamber 15 is defined by the front housing 3 and the cylinder block 1. The front housing 3 and the cylinder block 1 have shaft holes 3A, 1 B formed therein, respectively. A shaft seal 17 made of a rubber material is arranged between the front housing 3 and the drive shaft 7 in the shaft hole 3A for sealing the drive shaft 7. A plane bearing 19 is arranged in the shaft hole 1 B. An accommodation chamber 1C is defined in the cylinder block 1 at the rear center thereof so as to face the valve unit 9 and for communication with the shaft hole 1 B.

[0016] The drive shaft 7 is rotatably supported by the front housing 3 and the cylinder block 1 in such a manner that the center part thereof extends through the crank chamber 15, and one end thereof extends out of the front housing 3. The drive shaft 7 is connected to a pulley (not shown) and an electromagnetic clutch on which a belt is wound, and driven to rotate by a drive source such as an engine or the like through the belt. Each cylinder bore 1 A accommodates therein a piston 21 so that the piston 21 is reciprocally slidable therein. Each piston 21 defines a compression chamber with the corresponding cylinder bore 1A.

[0017] A lug plate 23 is fixed to the drive shaft 7 in the crank chamber 15 for rotation therewith and for receiving compression force, and a thrust bearing 25 and a plane bearing 27 are arranged between the lug plate 23 and the front housing 3. A swash plate 29 is mounted on and supported by the drive shaft 7 so as to be tiltable with a variable inclination angle with respect to a plane extending perpendicularly to the axis of the drive shaft 7 in the crank chamber 15. The lug plate 23 has a hinge portion 23A extending toward the swash plate 29. The swash plate 29 has a hinge portion 29A extending toward the lug plate 23. The hinge portions 23A, 29A form a link mechanism 31. A coil spring 33 is arranged between the lug plate 23 and the swash plate 29 for urging the lug plate 23 and the swash plate 29 away from each other.

[0018] A shoe 35 is arranged between the swash plate 29 and each piston 21. The shoe 35 includes a pair of front and rear shoes 35A, 35B. The front shoe 35A is arranged between the front surface of the swash plate 29 and the front seat surface of the piston 21, and the rear shoe 35B is arranged between the rear surface of the swash plate 29 and the rear seat surface of the piston 21. Each of the front and rear shoes 35A, 35B has a substantially hemispherical shape, and serves as a motion converter.

[0019] The drive shaft 7 has a radial hole 37, an axial passage 39, and a discharge hole 41 formed therein. The axial passage 39 extends along the axial direction of the drive shaft 7 to the rear end of the drive shaft 7, the radial hole 37 extends radially from the axial passage 39, and the discharge hole 41 extends radially from the axial passage 39 at a position adjacent to the rear end of the drive shaft 7.

[0020] The radial hole 37 is formed in the drive shaft 7 at a position between the lug plate 23 and the front housing 3 so as to extend across the diameter of the drive shaft 7 from the axis to the outer peripheral surfaces thereof. An oil guide passage 3B is formed in the front housing 3 so as to extend from the outer region of the crank chamber 15 to a space between the front housing 3 and the lug plate 23 in facing relation to the thrust bearing 25. The front housing 3 also has formed therein an oil guide passage 3C connected to the oil guide passage 3B, and extending in facing relation to the plane bearing 27 and the shaft seal 17. The oil guide passage 3C communicates with the radial hole 37 through the shaft seal 17 in the shaft hole 3A. The oil guide passage 3B and the oil guide passage 3C form the oil guide passage of the first preferred embodiment of the present invention.

[0021] Referring to Figs. 2 and 3, the rear end of the drive shaft 7 extends into the accommodation chamber 1C which is in communication with the discharge hole 41. The discharge hole 41 is formed in the drive shaft 7 so as to extend across the diameter of the drive shaft 7 from the axis to the outer peripheral surfaces thereof. An oil separating member 43 is mounted to the rear end of the drive shaft 7, and a valve 45 is inserted into the rear end of the axial passage 39 of the drive shaft 7.

[0022] The oil separating member 43 has a cylindrical portion 43A, a tapered portion 43B, and a flange portion 43C. The cylindrical portion 43A is fitted over the rear end of the drive shaft 7. The tapered portion 43B is formed integrally with the cylindrical portion 43A so as to taper from the valve unit 9 toward the rear end portion of the cylindrical portion 43A. The flange portion 43C is flanged outwardly from the rear end portion of the tapered portion 43B and extends in facing relation to the valve unit 9. The accommodation chamber 1C is partitioned into a first chamber 47 and a second chamber 49 with a clearance therebetween by the oil separating member 43. The first chamber 47 is located outside the cylindrical portion 43A, the tapered portion 43B, and the flange portion 43C, and in indirect communication with the throttle hole 9A. The

second chamber 49 is located inside the cylindrical portion 43A, the tapered portion 43B, and the flange portion 43C, and in direct communication with the throttle hole 9A.

[0023] The front end portion of the valve 45 having a cylindrical shape is inserted into the axial passage 39 of the drive shaft 7, while the rear end portion of the valve 45 has a spherical cap shape. As shown in Fig. 4, the rear end portion of the valve 45 is divided into four segments to the radial direction. The four segments move to radial direction, or move away one another against its own elastic force under the influence of centrifugal force so as to open the valve 45. As shown in Figs. 2 and 3, a weight 45A is fixed on the inner surface of each segment of the valve 45.

[0024] The valve unit 9 has a throttle hole 9A formed therethrough for communication between the second chamber 49 in the accommodation chamber 1C and the suction chamber 11. As shown in Fig. 1, the cylinder block 1 has a return passage 51 formed therein for connecting the first chamber 47 in the accommodation chamber 1C to the inner region of the crank chamber 15 adjacent to the drive shaft 7. With the compressor installed in the vehicle, the return passage 51 connects the lower region of the first chamber 47, as seen in Fig. 1, to the crank chamber 15. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39, the discharge hole 41, the first chamber 47, the second chamber 49 and the throttle hole 9A form the bleed passage of the first preferred embodiment of the present invention. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, and the axial passage 39 form the upstream passage of the first preferred embodiment of the present invention. The accommodation chamber 1C, the oil separating member 43, the return passage 51 and the valve 45 form the oil separator of the first preferred embodiment of the present invention.

[0025] As shown in Fig. 1, the rear housing 5 accommodates therein a displacement control valve 53. The displacement control valve 53 communicates with the suction chamber 11 through a detecting passage 55, and connects the discharge chamber 13 to the crank chamber 15 through the supply passage 57. The displacement control valve 53 is operable to change the opening of the supply passage 57 depending on the detected pressure in the suction chamber 11, thus varying the displacement of the compressor.

[0026] As shown in Fig. 1, the discharge chamber 13 of the compressor is connected to the suction chamber 11 by a tube 59 by way of a check valve 61, a condenser 63, an expansion valve 65, and an evaporator 67. The compressor, the check valve 61, the condenser 63, the expansion valve 65 and the evaporator 67 and the tube 59 form the refrigeration circuit. Refrigerant gas containing lubricating oil is sealed and circulated in the refrigeration circuit.

[0027] In the above-described compressor, the displacement control valve 53 adjusts the pressure in the

crank chamber 15 in accordance with the pressure in the suction chamber 11 and the flow rate of the refrigerant gas. Thus, the inclination angle of the swash plate 29 is changed with respect to the drive shaft 7, with the result that the displacement of the compressor is varied.

[0028] While a vehicle is running at a high speed, the drive shaft 7 is driven to rotate at a high speed, accordingly. The valve 45 is then opened by centrifugal force against its own elastic force, as shown in Fig. 3. Thus, the effective opening of the axial passage 39 of the drive shaft 7 is increased. Therefore, the axial passage 39 is connected to the second chamber 49, so that refrigerant gas in the axial passage 39 is flowed into the suction chamber 11 through the second chamber 49 inside the oil separating member 43 and the throttle hole 9A without separating lubricating oil therefrom. The cross-section of the opening of the valve 45 is set greater than at least one of the cross-sections of the opening of the discharge hole 41 and the opening of a passage formed by a clearance between the flange portion 43C and the valve unit 9 or between the first chamber 47 and the second chamber 49.

[0029] The crank chamber 15 has regions having a relatively large amount of lubricating oil, and having a relatively small amount of lubricating oil. The region having a relatively large amount of lubricating oil includes the outer region of the crank chamber 15, and the region having a relatively small amount of lubricating oil includes the inner region away from the outer surface of the crank chamber 15. In the crank chamber 15, the swash plate 29 is driven to rotate by the drive shaft 7, and lubricating oil is brought to the outer region of the crank chamber 15 due to a centrifugal force. The region having a relatively large amount of lubricating oil further includes the lower region of the crank chamber 15, and the region around the outer surface of the cylinder bore 1A. The region having a relatively large amount of lubricating oil further includes the upper region of the crank chamber 15.

[0030] The outer region of the crank chamber 15 has a relatively large amount of lubricating oil. Lubricating oil in the crank chamber 15 is introduced into the radial hole 37 through the oil guide passage 3B that extends from such outer region of the crank chamber 15 and also through the oil guide passage 3C. Thus, refrigerant gas containing a relatively large amount of lubricating oil is introduced into the suction chamber 11. Therefore, the amount of lubricating oil in the crank chamber 15 is adequate, and the lubricating oil is not subjected excessive agitation by the swash plate 29, so that the lubrication oil is not heated excessively due to the shearing of the swash plate 29, and the viscosity of lubricating oil is not decreased. Therefore, sliding surfaces of the shoes 35 and the swash plate 29 and the like are lubricated properly. Since refrigerant gas from the suction chamber 11 contains a relatively large amount of lubricating oil, the sliding surfaces of the cylinder bores 1A and the pistons 21 are also lubricated properly.

[0031] The amount of lubricating oil in refrigerant gas

discharged out of the compressor into the external refrigeration circuit is increased. However, the refrigeration performance of the compressor is not affected since the pistons 21 are then reciprocating at a high speed.

[0032] Since lubricating oil is introduced into the radial hole 37 through the shaft seal 17, a relatively large amount of lubricating oil is supplied to the shaft seal 17 made of a rubber material, so that the durability of the shaft seal 17 is improved.

[0033] While the vehicle is running at a low speed, the drive shaft 7 is driven to rotate at a low speed, accordingly. As shown in Fig. 2, the valve 45 is closed due to a relatively small centrifugal force against the elastic force of the valve 45. Thus, the effective opening of the axial passage 39 of the drive shaft 7 is decreased. Then, the fluid communication between the axial passage 39 and the second chamber 49 is blocked, so that refrigerant gas in the axial passage 39 is introduced into the first chamber 47 through the discharge hole 41, and then into the second chamber 49. Lubrication oil is separated from refrigerant gas when the refrigerant gas in the first chamber 47 is passed through the clearance between the valve unit 9 and the flange portion 43C or between the first chamber 47 and the second chamber 49. Subsequently, refrigerant gas in the second chamber 49 is introduced into the suction chamber 11 through the throttle hole 9A. Meanwhile, lubricating oil separated from refrigerant gas is retained in the first chamber 47, and then returned to the crank chamber 15 through the return passage 51. The return passage 51 connects the lower region of the first chamber 47 to the region of the crank chamber 15 having the relatively small amount of lubricating oil. Thus, the separated lubricating oil from the refrigerant gas retained in the first chamber 47 is easily returned to the crank chamber 15. In other words, the oil separator separates no or less amount of lubricating oil from the refrigerant gas in the increased rotational speed of the drive shaft 7 than that in the decreased rotational speed of the drive shaft 7, the refrigerant gas passed through the oil separator is introduced into the suction chamber 11, and the separated lubricating oil is returned to the crank chamber 15.

[0034] Thus, the amount of lubricating oil in refrigerant gas discharged out of the compressor and into the external refrigeration circuit is decreased, so that the compressor can provide high refrigeration performance.

[0035] The amount of lubricating oil in the crank chamber 15 is increased during the low-speed operation of the compressor. However, the swash plate 29 agitates lubricating oil only at a low speed, so that the viscosity of lubricating oil is hardly decreased, and lubrication oil is hardly heated. Therefore, the sliding surfaces are lubricated properly.

[0036] The compressor according to the first preferred embodiment of the present invention can provide excellent sliding characteristics when the drive shaft 7 is driven to rotate at a high speed, and high refrigeration performance when the drive shaft 7 is driven to rotate at a low

speed.

[0037] The swash plate type compressor according to the second preferred embodiment of the present invention shown in Figs. 5 and 6 differs from the compressor according to the first preferred embodiment in terms of the structure of the valve and the oil separating member.

[0038] The drive shaft 7 has a discharge hole 73 formed therein so as to extend in the radial direction thereof for connecting the axial passage 39 to the first chamber 47. The drive shaft 7 also has a valve hole 7A and a guide hole 7B formed therein behind the discharge hole 73 so as to extend in the radial direction thereof and in parallel with the discharge hole 73 for connecting with the axial passage 39. The valve hole 7A has a larger diameter than the guide hole 7B, and the valve hole 7A and the guide hole 7B are formed coaxially. A valve body 69A and a connecting bar 69B are received slidably in the valve hole 7A and the guide hole 7B, respectively. The valve body 69A is movable into the axial passage 39 so as to close the axial passage 39. One end of the connecting bar 69B is fixed to the valve body 69A, and the other end of the connecting bar 69B is fixed to a spring seat 69C disposed in the accommodation chamber 1C. A spring 69D is disposed between the outer peripheral surface of the drive shaft 7 and the spring seat 69C for urging the valve body 69A in the direction that closes the axial passage 39. The valve body 69A, the connecting bar 69B, the spring seat 69C and the spring 69D form a valve 69. The valve body 69A serves also as a weight.

[0039] An oil separating member 71 has a cylindrical portion 71A and a flange portion 71 B. The cylindrical portion 71 A is fitted over the rear end of the drive shaft 7. The flange portion 71 B is formed integrally with the cylindrical portion 71 A and flanged outwardly from the rear end of the cylindrical portion 71 A in facing relation to the valve unit 9. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39, the discharge hole 73, the first chamber 47, the second chamber 49, and the throttle hole 9A form the bleed passage of the second preferred embodiment of the present invention. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, and the axial passage 39 form the upstream passage of the second preferred embodiment of the present invention. The accommodation chamber 1C, the oil separating member 71, the return passage 51 and the valve 69 form the oil separator of the second preferred embodiment of the present invention. The rest of the structure of the second preferred embodiment of the present invention are substantially the same as the first preferred embodiment.

[0040] When the drive shaft 7 is driven to rotate at a high speed, the valve 69 is moved due to a relatively large centrifugal force so that the valve body 69A is moved away from the axis of the drive shaft 7 against the urging force of the spring 69D. As a result, the effective opening of the axial passage 39 is increased by the valve body 69A, as shown in Fig. 6. Thus, refrigerant gas in the crank chamber 15 containing a relatively large

amount of the lubricating oil is introduced into the second chamber 49 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37 and the axial passage 39. Refrigerant gas in the second chamber 49 is drawn into the suction chamber 11 through the throttle hole 9A. The cross-section of the opening of the axial passage 39 is set greater than at least one of the cross-sections of the opening of the discharge hole 73 and the opening of a passage formed by a clearance between the flange portion 71 B and the valve unit 9, or between the first chamber 47 and the second chamber 49.

[0041] When the drive shaft 7 is driven to rotate at a low speed, on the other hand, the valve 69 is moved due to a relatively small centrifugal force so that the valve body 69A is moved toward the axis of the drive shaft 7 by the urging force of the spring 69D, as shown in Fig. 5. Thus, the effective opening of the axial passage 39 is decreased by the valve body 69A. Therefore, refrigerant gas in the crank chamber 15 containing a relatively large amount of lubricating oil is introduced into the first chamber 47 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39 and the discharge hole 73. Then, lubricating oil is separated from refrigerant gas when refrigerant gas in the first chamber 47 is flowed into the second chamber 49. Subsequently, refrigerant gas in the second chamber 49 is flowed into the suction chamber 11 through the throttle hole 9A. Meanwhile, lubricating oil retained in the first chamber 47 separated from refrigerant gas is returned to the crank chamber 15 through the return passage 51.

[0042] As is obvious from the foregoing, the compressor according to the second preferred embodiment of the present invention can provide the same advantageous effects as the first preferred embodiment.

[0043] The swash plate type compressor according to the third preferred embodiment of the present invention differs from the compressors according to the first and second preferred embodiments in terms of the structure of the valve and the oil separating member.

[0044] The drive shaft 7 has a discharge hole 79 formed therein so as to extend in the radial direction for connecting the axial passage 39 to the first chamber 47. The drive shaft 7 also has a valve hole 7C and a guide hole 7D formed coaxially therein behind the discharge hole 79 so as to extend in the radial direction thereof and in parallel with the discharge hole 79, and connect to the axial passage 39. The valve hole 7C and the guide hole 7D are in communication with the axial passage 39 and the second chamber 49, respectively. The valve hole 7C has a larger diameter than the guide hole 7D. A connecting bar 75B is slidably inserted through the valve hole 7C and the guide hole 7D. A valve body 75A is disposed in the accommodation chamber 1C or movably disposed on the outer end of the valve hole 7C. One end of the connecting bar 75B is fixed to the valve body 75A, and the other end of the connecting bar 75B is fixed to a spring seat 75C disposed in the accommodation chamber 1C. A spring 75D is disposed between the outer peripheral

surface of the drive shaft 7 and the spring seat 75C for urging the valve body 75A against the outer peripheral surface of the drive shaft 7 thereby to close the valve hole 7C. The valve body 75A, the connecting bar 75B, the spring seat 75C and the spring 75D form a valve 75. The valve body 75A serves also as a weight. The valve body 75A is made of a material having a larger specific gravity than the materials of the connecting bar 75B and the spring seat 75C. The rear end of the axial passage 39 is closed by a plug 78.

[0045] An oil separating member 77 has a cylindrical portion 77A, a tapered portion 77B, and a flange portion 77C. The cylindrical portion 77A is fitted over the rear end of the drive shaft 7. The tapered portion 77B is formed integrally with the cylindrical portion 77A so as to taper from the valve unit 9 toward the end of the cylindrical portion 77A. The flange portion 77C is flanged outwardly from the rear end of the tapered portion 77B and extends in facing relation to the valve unit 9. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39, the discharge hole 79, the first chamber 47, the valve hole 7C, the second chamber 49 and the throttle hole 9A form the bleed passage of the third preferred embodiment of the present invention. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, and the axial passage 39 form the upstream passage of the third preferred embodiment of the present invention. The accommodation chamber 1C, the oil separating member 77, the return passage 51 and the valve 75 form the oil separator of the third preferred embodiment of the present invention. The rest of the structure of the third preferred embodiment of the present invention is substantially the same as the first preferred embodiment of the present invention.

[0046] When the drive shaft 7 is driven to rotate at a high speed, the valve 75 is moved due to a relatively large centrifugal force so that the valve body 75A is moved away from the axis of the drive shaft 7 against the urging force of the spring 75D. Accordingly, the valve hole 7C is opened by the valve body 75A. Refrigerant gas in the crank chamber 15 containing a relatively large amount of lubricating oil is introduced into the second chamber 49 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39 and the valve hole 7C. Refrigerant gas thus introduced in the second chamber 49 is then flowed into the suction chamber 11 through the throttle hole 9A.

[0047] When the drive shaft 7 is driven to rotate at a low speed, the valve 75 is moved due to a relatively small centrifugal force so that the valve body 75A is moved toward the axis of the drive shaft 7 by the urging force of the spring 75D. Accordingly, the opening of the valve hole 7C is closed by the valve body 75A, as shown in Fig. 7. Thus, refrigerant gas in the crank chamber 15 containing a relatively large amount of lubricating oil is introduced into the first chamber 47 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39 and the discharge hole 79. Lu-

bricating oil is separated from refrigerant gas when the refrigerant gas in the first chamber 47 is introduced into the second chamber 49. Subsequently, refrigerant gas is drawn into the suction chamber 11 through the throttle hole 9A. Meanwhile, lubricating oil retained in the first chamber 47 separated from the refrigerant gas is returned to the crank chamber 15 through the return passage 51.

[0048] Therefore, the compressor according to the third preferred embodiment of the present invention can provide the same advantageous effects as the first and second preferred embodiments of the present invention.

[0049] The swash plate type compressor according to the fourth preferred embodiment of the present invention differs from the compressors according to the first through third preferred embodiments of the present invention in terms of the structure of the valve, the oil separating member, and the axial passage.

[0050] Referring to Figs. 9 and 10, an assembly 80 includes a valve 81 and an oil separating member 82. The valve 81 is formed integrally with an oil separating member 82, and fitted on the rear end of the drive shaft 7. The assembly 80 has a first valve hole 7E and a second valve hole 7F formed coaxially therein in the radial direction of the assembly 80 with the same diameter. A valve seat 7G is formed at the end of the first valve hole 7E. The valve 81 includes a second valve body 81A slidably received in the second valve hole 7F. According to the fourth preferred embodiment of the present invention, the first valve hole 7E and the valve seat 7G form a discharge hole 83. The valve 81 further includes a first valve body 81C and a connecting bar 81B. One end of the connecting bar 81B is fixed to the first valve body 81C, and the other end of the connecting bar 81B is fixed to the second valve body 81A, as shown in Fig. 9. A spring seat 81D is formed between the first valve hole 7E and the second valve hole 7F with a diameter that is smaller than that of the first valve hole 7E and the second valve hole 7F. A spring 81E is disposed between the first valve body 81C and the spring seat 81D for urging the first valve body 81C in the direction that disengages from the valve seat 7G for opening the discharge hole 83, and the second valve body 81A in the direction that closes the axial passage 39. The second valve body 81A, the connecting bar 81B, the first valve body 81C, the spring seat 81D, and the spring 81E form the valve 81. The second valve body 81A serves also as a weight.

[0051] The axial passage 39 of the fourth embodiment includes a front passage 39A formed in the drive shaft 7 and a rear passage 39B formed in the assembly 80 for fluid communication with each other. The rear passage 39B is formed in such a manner that the effective diameter of the rear passage 39B is variable. The first valve hole 7E and the second valve hole 7F are connected to the rear passage 39B, respectively. The valve 81 is arranged at a position adjacent to the rear end of the rear passage 39B. The second valve body 81A is movable into the rear passage 39B so as to close the rear passage

39B.

[0052] The oil separating member 82 of the assembly 80 has a base portion 82A, a tapered portion 82B, and a flange portion 82C. The tapered portion 82B is formed so as to taper from the valve unit 9 toward the rear end of the base portion 82A. The flange portion 82C is flanged outwardly from the rear end of the tapered portion 82B and extends in facing relation to the valve unit 9. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39, the discharge hole 83, the first chamber 47, the second chamber 49, and the throttle hole 9A form the bleed passage of the fourth preferred embodiment of the present invention. The oil guide passage 3B, the oil guide passage 3C, the radial hole 37, and the axial passage 39 form the upstream passage of the fourth preferred embodiment of the present invention. The accommodation chamber 1C, the oil separating member 82, the return passage 51, and the valve 81 form the oil separator of the fourth preferred embodiment of the present invention. The rest of the structure of the fourth preferred embodiment of the present invention is substantially the same as the first preferred embodiment of the present invention.

[0053] According to the compressor of the fourth preferred embodiment of the present invention, when the drive shaft 7 is driven to rotate at a high speed, the valve 81 is moved due to a relatively large centrifugal force so that the first valve body 81C is moved toward the axis of the drive shaft 7 against the urging force of the spring 81 E. This causes the opening of the discharge hole 83 to be decreased, but the opening of the rear passage 39B to be increased. When the first valve body 81C is in direct contact with the valve seat 7G, the discharge hole 83 is closed, but the cross-section of the opening of the rear passage 39B becomes maximum. Refrigerant gas in the crank chamber 15 containing a relatively large amount of lubricating oil is introduced into the second chamber 49 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37, and the axial passage 39. Then, refrigerant gas in the second chamber 49 is drawn into the suction chamber 11 through the throttle hole 9A.

[0054] When the drive shaft 7 is driven to rotate at a low speed, the valve 81 is moved due to a decreased centrifugal force so that the first valve body 81C is moved away from the axis of the drive shaft 7 by the urging force of the spring 81 E, as shown in Fig. 9. Thus, the cross-section of the opening of the discharge hole 83 is increased. When the second valve body 81 A is in direct contact with the spring seat 81 D, the rear passage 39B is closed, and the effective opening of the discharge hole 83 becomes the maximum. Thus, refrigerant gas in the crank chamber 15 containing a relatively large amount of lubricating oil is introduced into the first chamber 47 through the oil guide passage 3B, the oil guide passage 3C, the radial hole 37, the axial passage 39, and the discharge hole 83. Lubricating oil is separated from refrigerant gas when the refrigerant gas in the first chamber

47 is introduced into the second chamber 49. Subsequently, refrigerant gas in the second chamber 49 is drawn into the suction chamber 11 through the throttle hole 9A. Meanwhile, lubricating oil separated from refrigerant gas is returned to the crank chamber 15 through the return passage 51.

[0055] Therefore, the compressor according to the fourth preferred embodiment of the present invention can provide the same advantageous effects as the first preferred embodiment of the present invention. According to the compressor of the fourth preferred embodiment, the assembly 80 is formed in such a manner that the valve 81 is formed integrally with the oil separating member 82. In assembling the compressor, the assembly 80 is previously made, and then the assembly 80 is only press-fitted over the rear end of the drive shaft 7, which contribute to decreasing the processes of assembling the compressor.

[0056] The present invention is not limited to the above-described first through fourth embodiments, but may be modified into the various alternative embodiments as follows.

[0057] The link mechanism 31 is not limited to that of the above-described embodiments. Alternatively, any one of various types of link mechanisms is applicable.

[0058] According to the above-described embodiments, the upstream passage is in communication with the outer region of the crank chamber 15. Alternatively the upstream passage may in communication with either region of the crank chamber 15 having a relatively large amount of lubricating oil.

[0059] The return passage 51 is not limited to that of the above-described embodiments. Alternatively, the return passage 51 may decline from the accommodation chamber 1C to the crank chamber 15.

[0060] The valve is not limited to that of the above-described embodiments. Alternatively, any one of the various types of valves operated in accordance with the rotational speed of the drive shaft 7 is applicable. For example, the valve may be a solenoid valve. The solenoid valve is an electromechanical valve whose state is varied in accordance with signals outputted from a rotational speed sensor or an acceleration sensor. The rotational speed sensor detects rotational speed, and the acceleration sensor detects centrifugal force.

[0061] The swash plate type compressor of the present invention is not limited to the variable displacement swash plate type compressor in which an inclination angle of the swash plate is variable, but it is applicable to a fixed displacement swash plate type compressor in which an inclination angle of the swash plate is not variable.

[0062] The swash plate type compressor of the present invention can be used for a vehicle air conditioner.

[0063] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the

appended claims.

[0064] A swash plate type compressor has a housing assembly, a drive shaft, a swash plate, a piston, a motion converter, a bleed passage, and an oil separator. The housing assembly includes a cylinder bore, a suction chamber, a discharge chamber, and a crank chamber. The drive shaft is rotatably supported by the housing assembly, and extends through the crank chamber. The bleed passage communicates between the crank chamber and the suction chamber. The oil separator is disposed in the housing assembly. The oil separator separates no or less amount of lubricating oil from the refrigerant gas in the increased rotational speed of the drive shaft than that in the decreased rotational speed of the drive shaft. The refrigerant gas passed through the oil separator is introduced into the suction chamber, and the separated lubricating oil is returned to the crank chamber.

Claims

1. A swash plate type compressor comprising:

a housing assembly including a cylinder bore (1A), a suction chamber (11), a discharge chamber (13), and a crank chamber (15);
 a drive shaft (7) rotatably supported by the housing assembly (1A, 11, 13, 15), the drive shaft (7) extending through the crank chamber (15);
 a swash plate (29) supported by the drive shaft (7) in the crank chamber (15);
 a piston (21) accommodated in the cylinder bore (1A) so as to be reciprocally slidable therein;
 a motion converter (35, 35A, 35B) disposed between the swash plate (29) and the piston (21), the motion converter (35, 35A, 35B) converting wobbling motion of the swash plate (29) into reciprocating motion of the piston (21); and
 a bleed passage (3B, 3C, 37, 39, 41, 73, 79, 83, 47, 7C, 49, 9A) for communicating between the crank chamber (15) and the suction chamber (11),
characterized in that an oil separator (1 C, 43, 71, 77, 82, 51, 45, 69, 75, 81) is disposed in the housing assembly (1A, 11, 13, 15), and the oil separator (1 C, 43, 71, 77, 82, 51, 45, 69, 75, 81) separates no or less amount of lubricating oil from the refrigerant gas in the increased rotational speed of the drive shaft (7) than that in the decreased rotational speed of the drive shaft (7), the refrigerant gas passed through the oil separator (1 C, 43, 71, 77, 82, 51, 45, 69, 75, 81) is introduced into the suction chamber (11), and the separated lubricating oil is returned to the crank chamber (15).

2. The swash plate type compressor according to claim 1, **characterized in that** the bleed passage (3B, 3C,

37, 39, 41, 73, 79, 83, 47, 7C, 49, 9A) includes an upstream passage (3B, 3C, 37, 39) in communication with a region containing a relatively large amount of lubricating oil in the crank chamber (15), and the oil separator (1 C, 43, 71, 77, 82, 51, 45, 69, 75, 81) separates lubricating oil from refrigerant gas in the upstream passage (3B, 3C, 37, 39).

3. The swash plate type compressor according to claim 2, **characterized in that** the housing assembly (1A, 11, 13, 15) further having a valve unit (9) having a throttle hole (9A) which is connected to the suction chamber (11), the oil separator (1 C, 43, 71, 77, 82, 51, 45, 69, 75, 81) has an accommodation chamber (1 C) being in communication with the suction chamber (11) through the throttle hole (9A) wherein one end of the drive shaft (7) is located, an oil separating member (43, 71, 77, 82) disposed in the accommodation chamber (1C) wherein the oil separating member (43, 71, 77, 82) partitions into the first chamber (47) in indirect communication with the throttle hole (9A) and a second chamber (49) in direct communication with the throttle hole (9A) with a clearance therebetween so as to separate lubricating oil from refrigerant gas by introducing the refrigerant gas from the first chamber (47) to the second chamber (49) through the clearance, and the separated lubricating oil is retained in the first chamber (47), a return passage (51) for connecting the first chamber (47) to the crank chamber (15), and a valve (45, 69, 75, 81) for connecting the upstream passage (3B, 3C, 37, 39) to the second chamber (49) due to the increased rotational speed of the drive shaft (7) and disconnecting the upstream passage (3B, 3C, 37, 39) to the second chamber (49) due to the decreased rotational speed of the drive shaft (7), and the bleed passage (3B, 3C, 37, 39, 41, 73, 79, 83, 47, 7C, 49, 9A) has a discharge hole (41, 73, 79, 83) for communicating with the upstream passage (3B, 3C, 37, 39) and the first chamber (47).

4. The swash plate type compressor according to claim 3, **characterized in that** the valve (45, 69, 75, 81) has an opening for passing through the refrigerant gas, wherein the cross-section of the opening of the valve (45, 69, 75, 81) is larger than either the cross section of the clearance or the cross-section of the discharge hole (41, 73, 79, 83).

5. The swash plate type compressor according to claim 3 or 4, **characterized in that** the return passage (51) is in communication with a region containing a relatively small amount of lubricating oil in the crank chamber (15).

6. The swash plate type compressor according to any one of claims 3 through 5, **characterized in that** the return passage (51) connects the lower region of the

first chamber (47) to the crank chamber (15) with the compressor installed in a vehicle.

7. The swash plate type compressor according to any one of claims 3 through 6, **characterized in that** the valve (45, 69, 75, 81) is operated by centrifugal force. 5
8. The swash plate type compressor according to claim 7, **characterized in that** the valve (45) is fixed to the rear end of the drive shaft (7), and formed with a cylindrical shape having a spherical cap shaped end which is divided into plural segments to the radial direction, wherein the plural segments move to the radial direction by the centrifugal force against its own elastic force so as to open the valve (45). 10
9. The swash plate type compressor according to claim 7, **characterized in that** the drive shaft (7) includes a valve hole (7A) and a guide hole (7B) formed in parallel with the discharge hole (73) so as to extend in the radial direction of the drive shaft (7) and connect to the upstream passage (3B, 3C, 37, 39), and the valve (69) includes a valve body (69A) received slidably in the valve hole (7A) and being movable into the upstream passage (3B, 3C, 37, 39) so as to close the upstream passage (3B, 3C, 37, 39), a connecting bar (69B) received in the guide hole (7B) and one end of which is fixed to the valve body (69A), a spring seat (69C) fixed to the other end of the connecting bar (69A), and a spring (69D) disposed between the outer peripheral surface of the drive shaft (7) and the spring seat (69C) for urging the valve body (69A) in the direction that closes the upstream passage (3B, 3C, 37, 39). 20 25 30
10. The swash plate type compressor according to claim 7, **characterized in that** the drive shaft (7) includes a valve hole (7C) formed in the bleed passage (3B, 3C, 37, 39, 79, 47, 7C, 49, 9A) for communicating with the upstream passage (3B, 3C, 37, 39) and the second chamber (49), and a guide hole (7D) formed coaxially with the valve hole (7C) in parallel with the discharge hole (79) so as to extend in the radial direction of the drive shaft (7), and having a smaller cross-section than the valve hole (7C), and the valve (75) includes a valve body (75A) movably disposed on the outer end of the valve hole (7C) so as to close the valve hole (7C), a connecting bar (75B) slidably inserted through the guide hole (7D) and the valve hole (7C) and one end of which is fixed to the valve body (75A), a spring seat (75C) fixed to the other end of the connecting bar (75B), and a spring (75D) disposed between the outer peripheral surface of the drive shaft (7) and the spring seat (75C) for urging the valve body (75A) against the outer peripheral surface of the drive shaft (7) to close the valve hole (7C). 35 40 45 50 55

11. The swash plate type compressor according to claim 7, **characterized in that** an assembly (80) is fitted on the rear end of the drive shaft (7), and includes a rear passage (39B) formed through the assembly (80) to form a part of the upstream passage (3B, 3C, 37, 39, 39A, 39B), a first valve hole (7E) and a second valve hole (7F) extending in the radial direction of the assembly (80) and connected to the rear passage (39B) respectively, a valve seat (7G) formed at the end of the first valve hole (7E) and forming the discharge hole (7E) with the first valve hole (7E), and the valve (81) having: 5 10

a first valve body (81 C);
 a second valve body (81A) slidably received in the second valve hole (7F), the second valve body (81A) being movable into the rear passage (39B) so as to close the upstream passage (3B, 3C, 37, 39, 39A, 39B);
 a connecting bar (81 B) one end of which is fixed to the first valve body (81 C), and the other end of which is fixed to the second valve body (81A);
 a spring seat (81 D) disposed between the first valve hole (7E) and the second valve hole (81A);
 and
 a spring (81 E) disposed between the first valve body (81 C) and the spring seat (81 D) for urging the first valve body (81 C) in the direction that disengages from the valve seat (7G) for opening the discharge hole (7E, 7G), and the second valve body (81A) in the direction that closes the upstream passage (3B, 3C, 37, 39). 15 20 25 30

12. The swash plate type compressor according to any one of claims 2 through 11, **characterized in that** the swash plate (29) is supported so as to be tiltable, a lug plate (23) is fixed to the drive shaft (7) for rotation therewith, and the upstream passage (3B, 3C, 37, 39) includes an oil guide passage (3B, 3C) extending from the outer region of the crank chamber (15) to a space between the housing assembly (1A, 11, 13, 15) and the lug plate (23). 35 40

13. The swash plate type compressor according to claim 12, **characterized in that** the shaft seal (17) is arranged between the housing assembly (1A, 11, 13, 15) and the drive shaft (7) for sealing the drive shaft (7), and the upstream passage (3B, 3C, 37, 39) communicates with the shaft seal (17) adjacent to the oil guide passage (3B, 3C). 45 50 55

FIG. 1

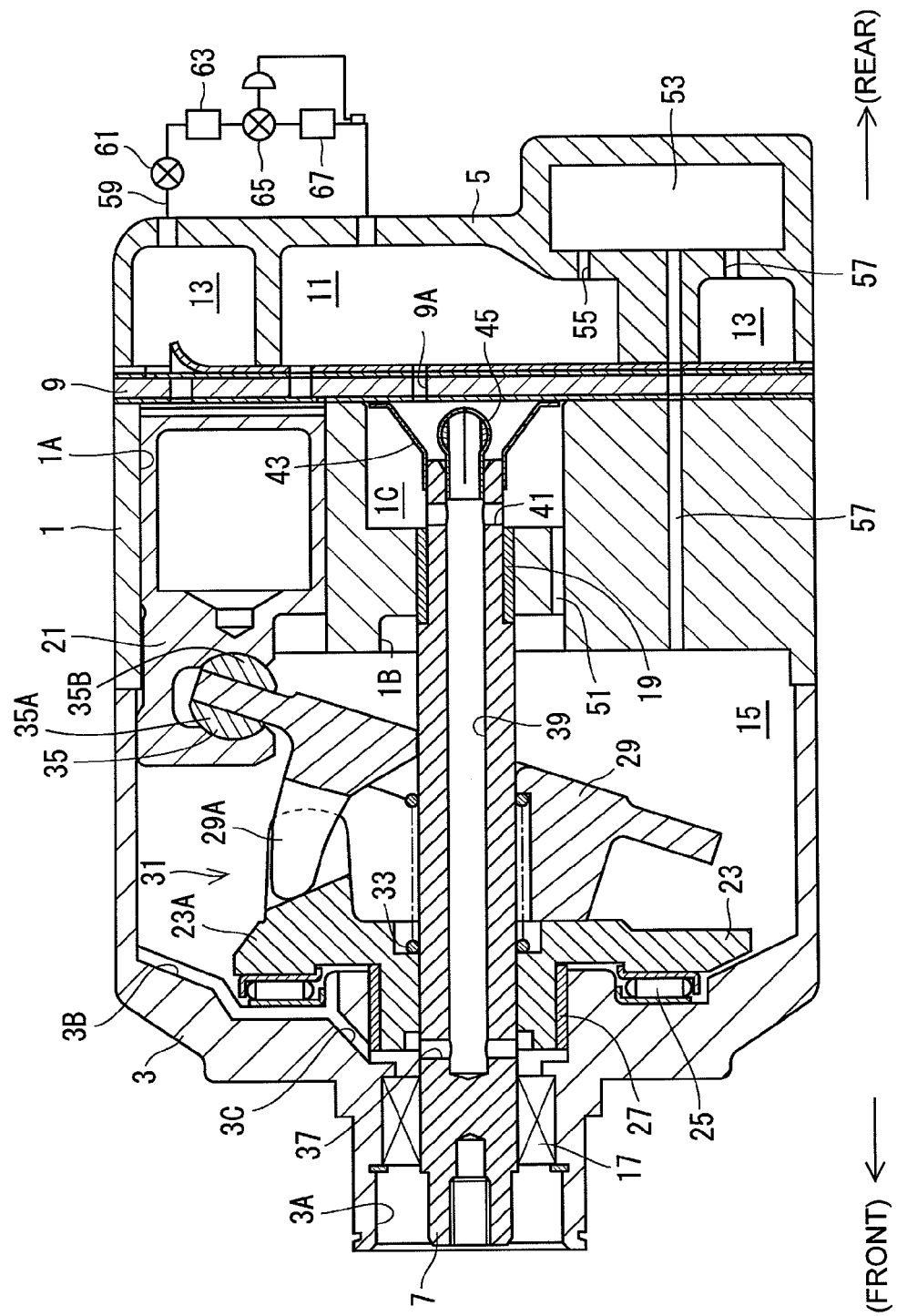


FIG. 2

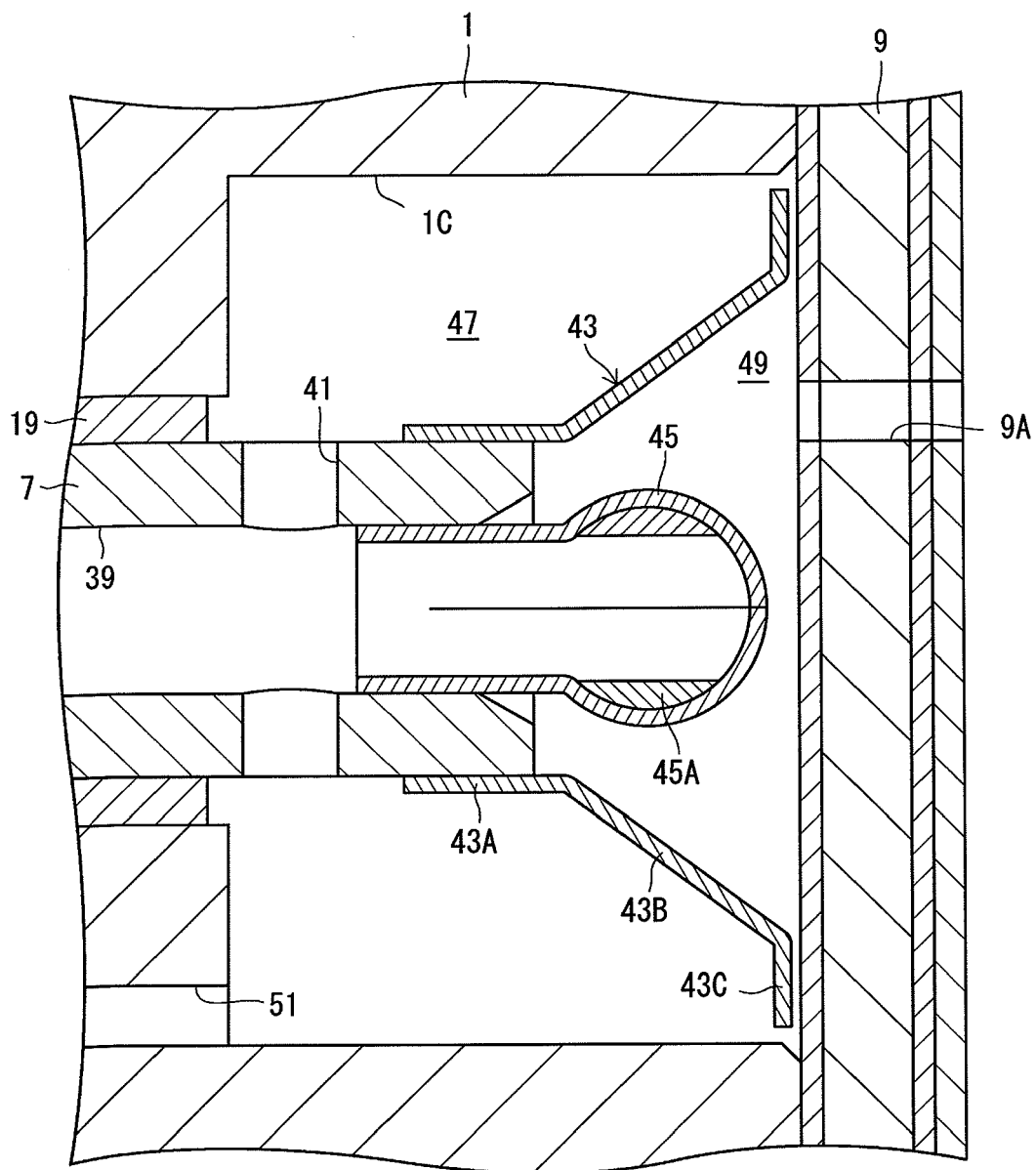


FIG. 3

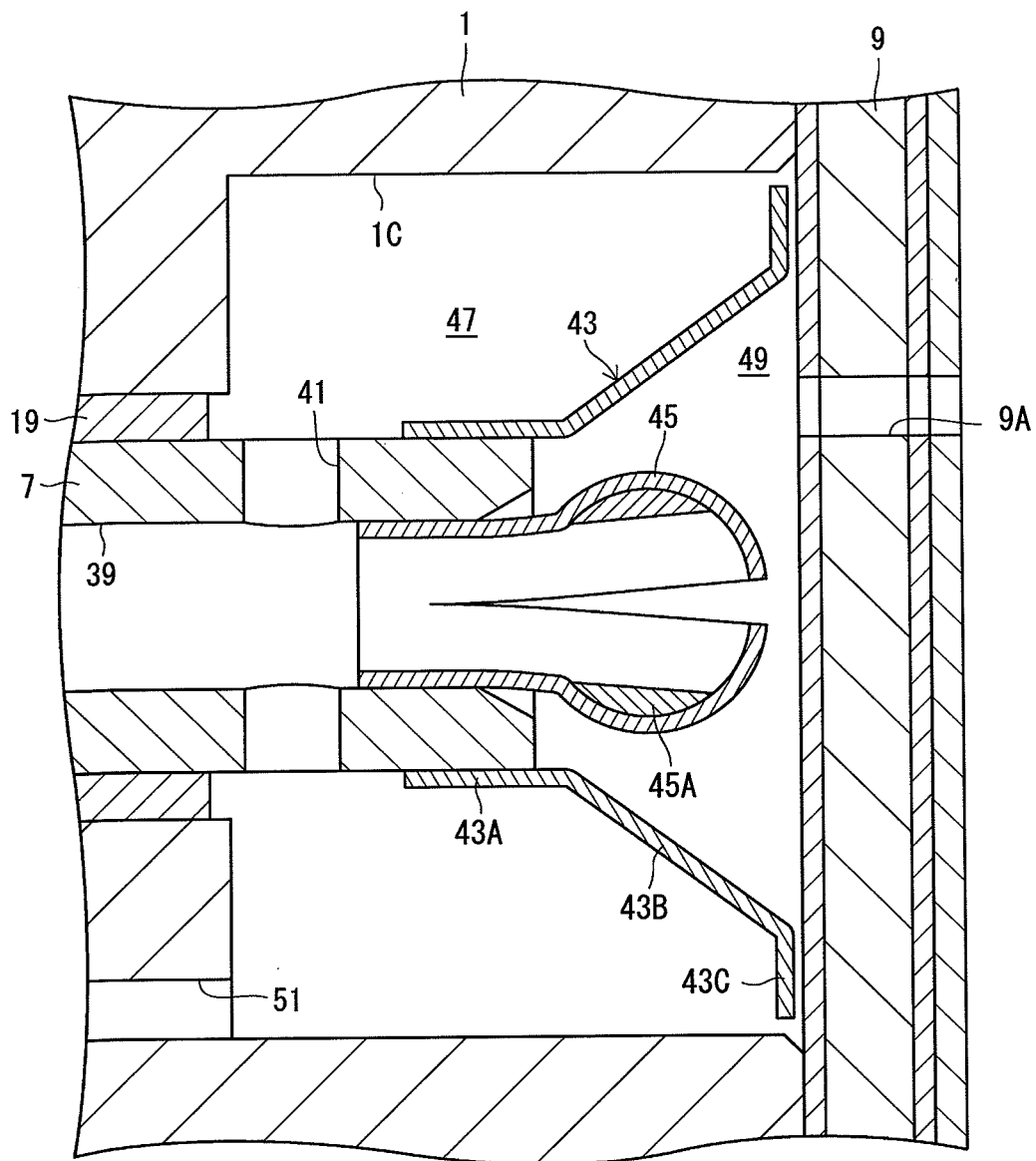


FIG. 4

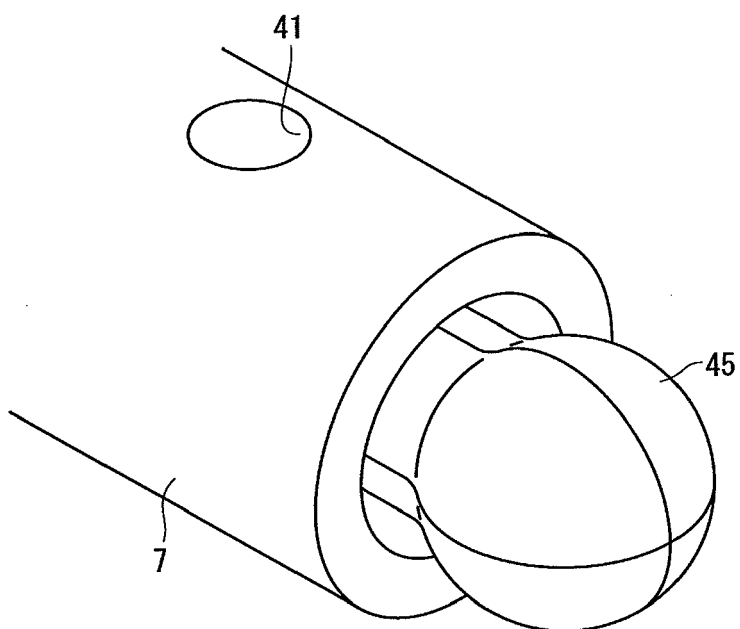


FIG. 5

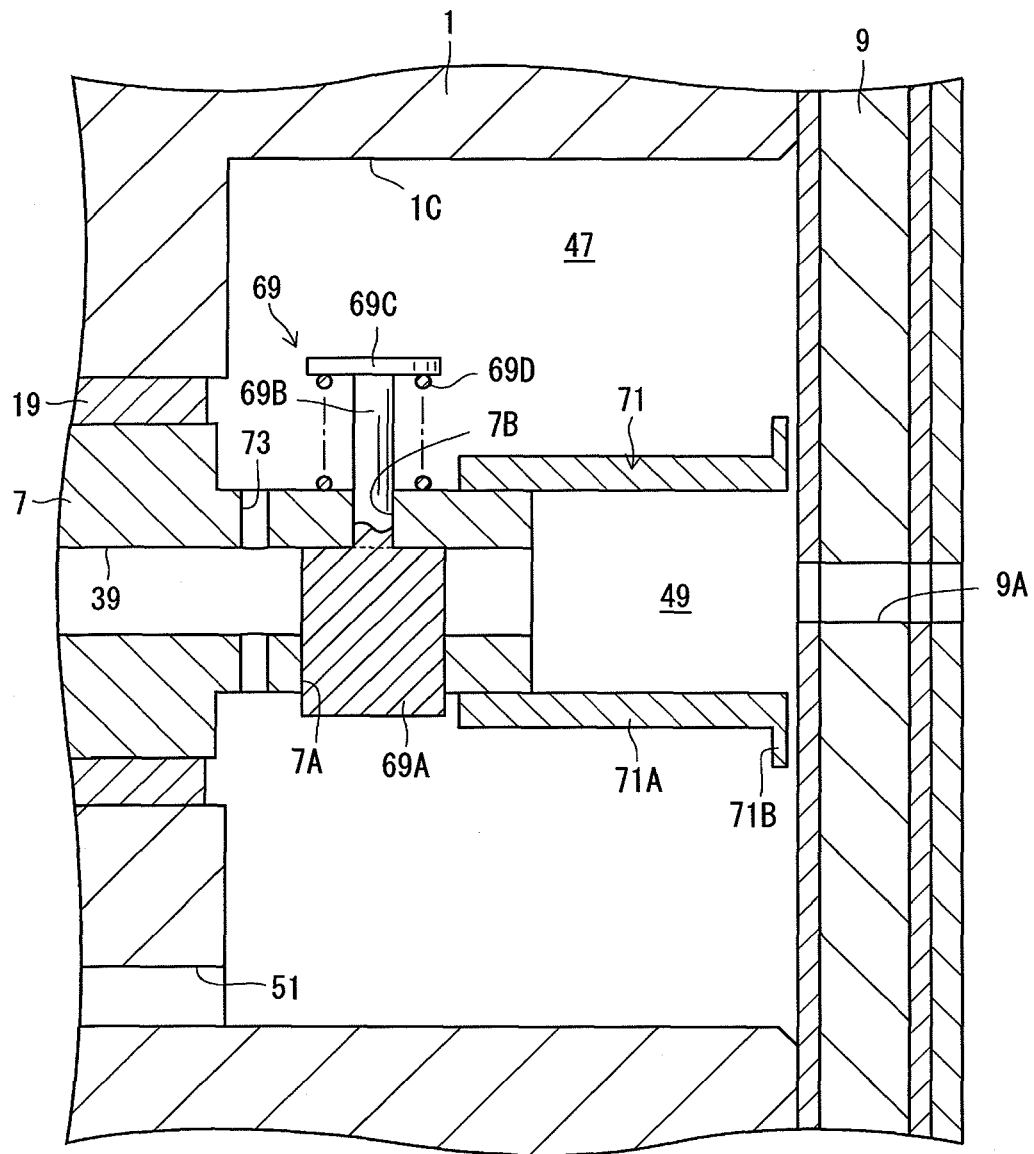


FIG. 6

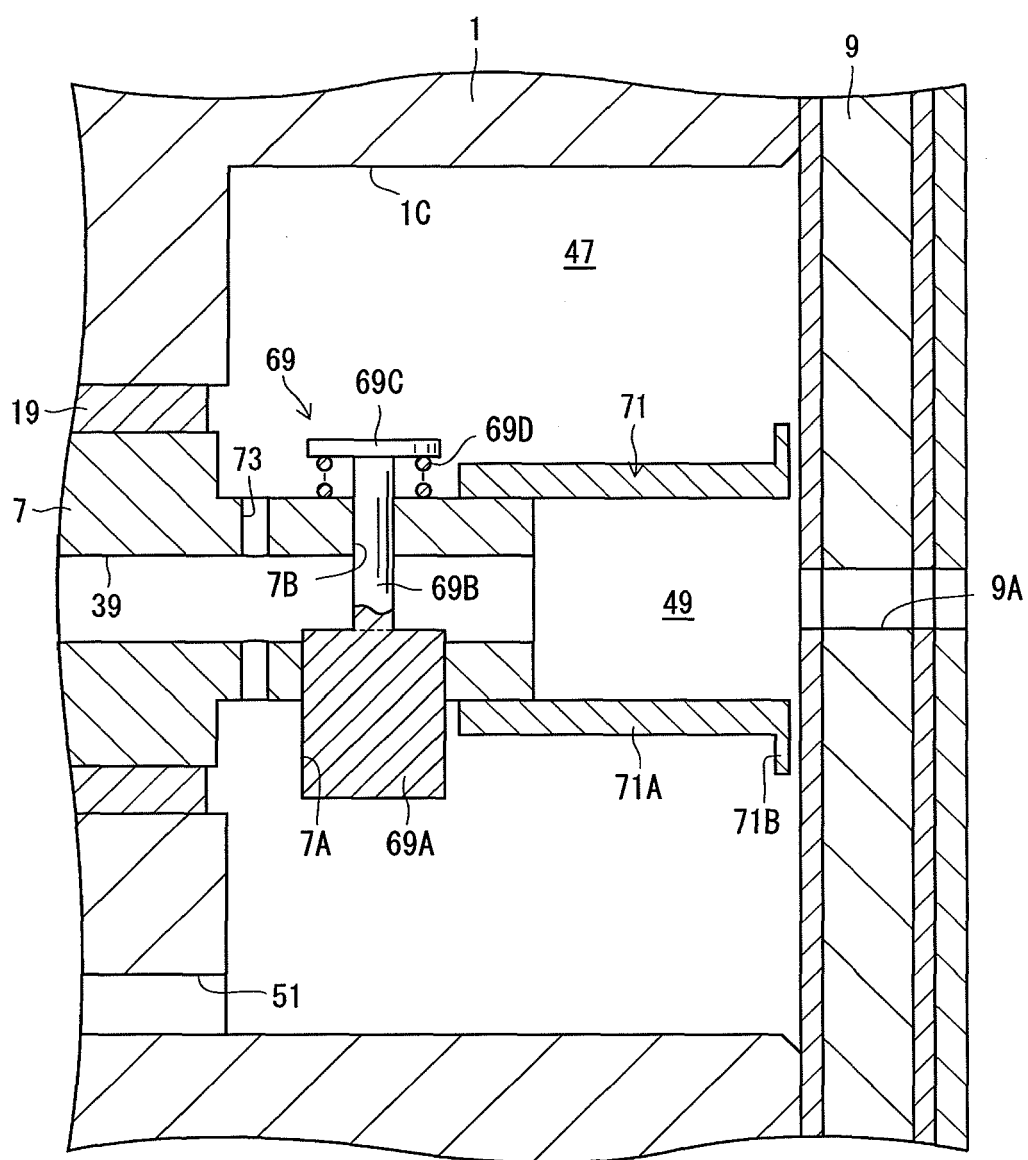


FIG. 7

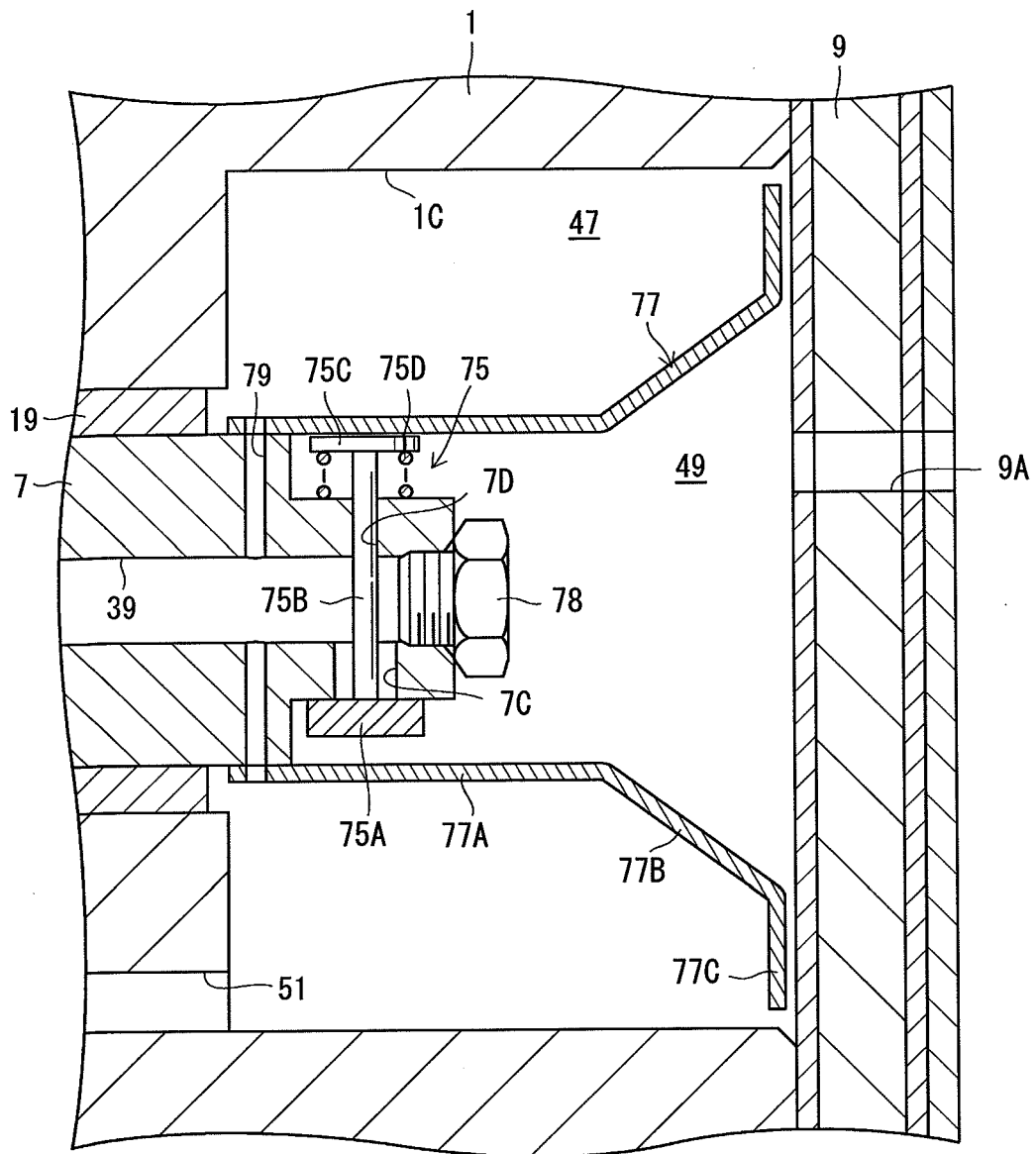


FIG. 8

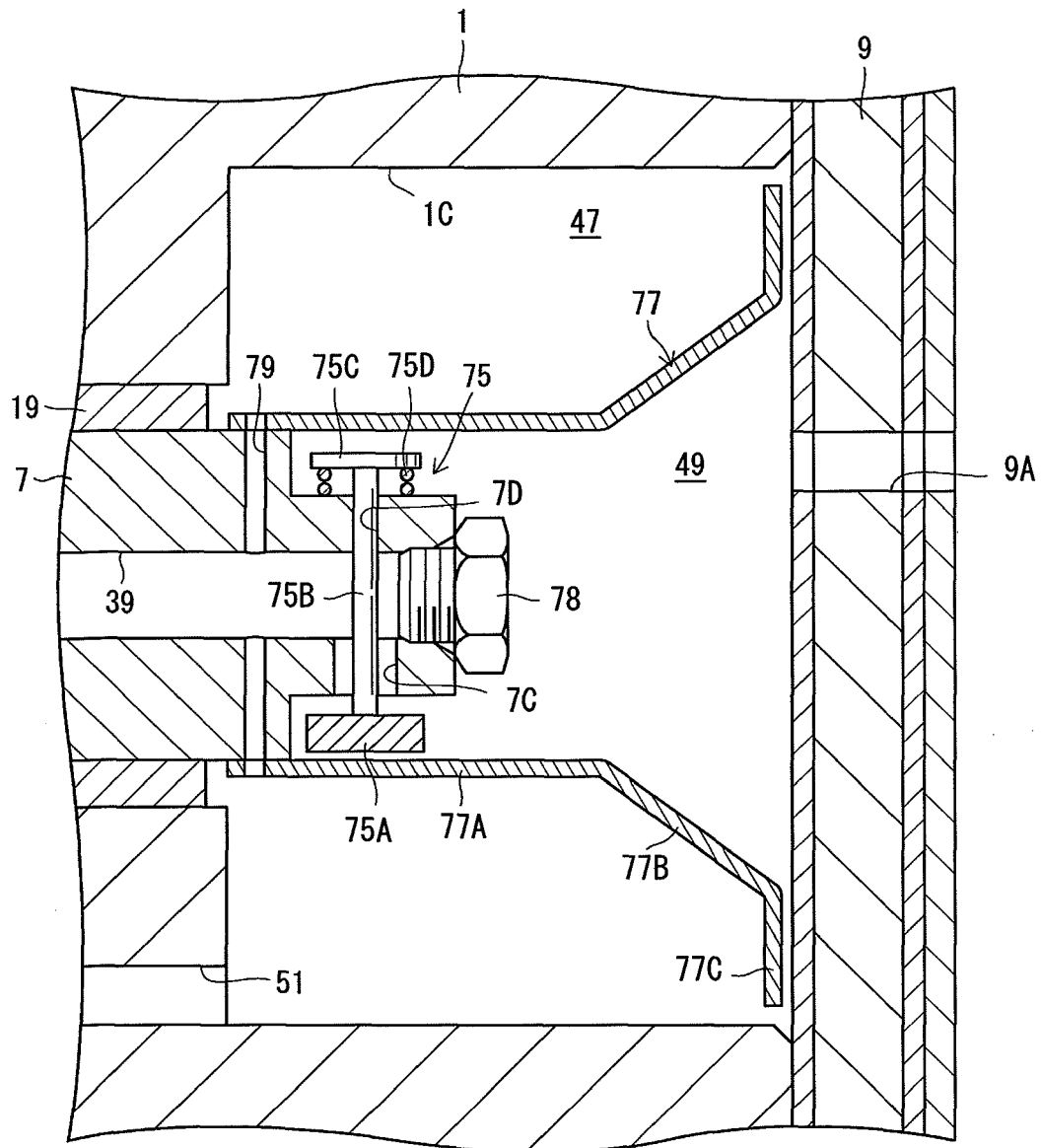


FIG. 9

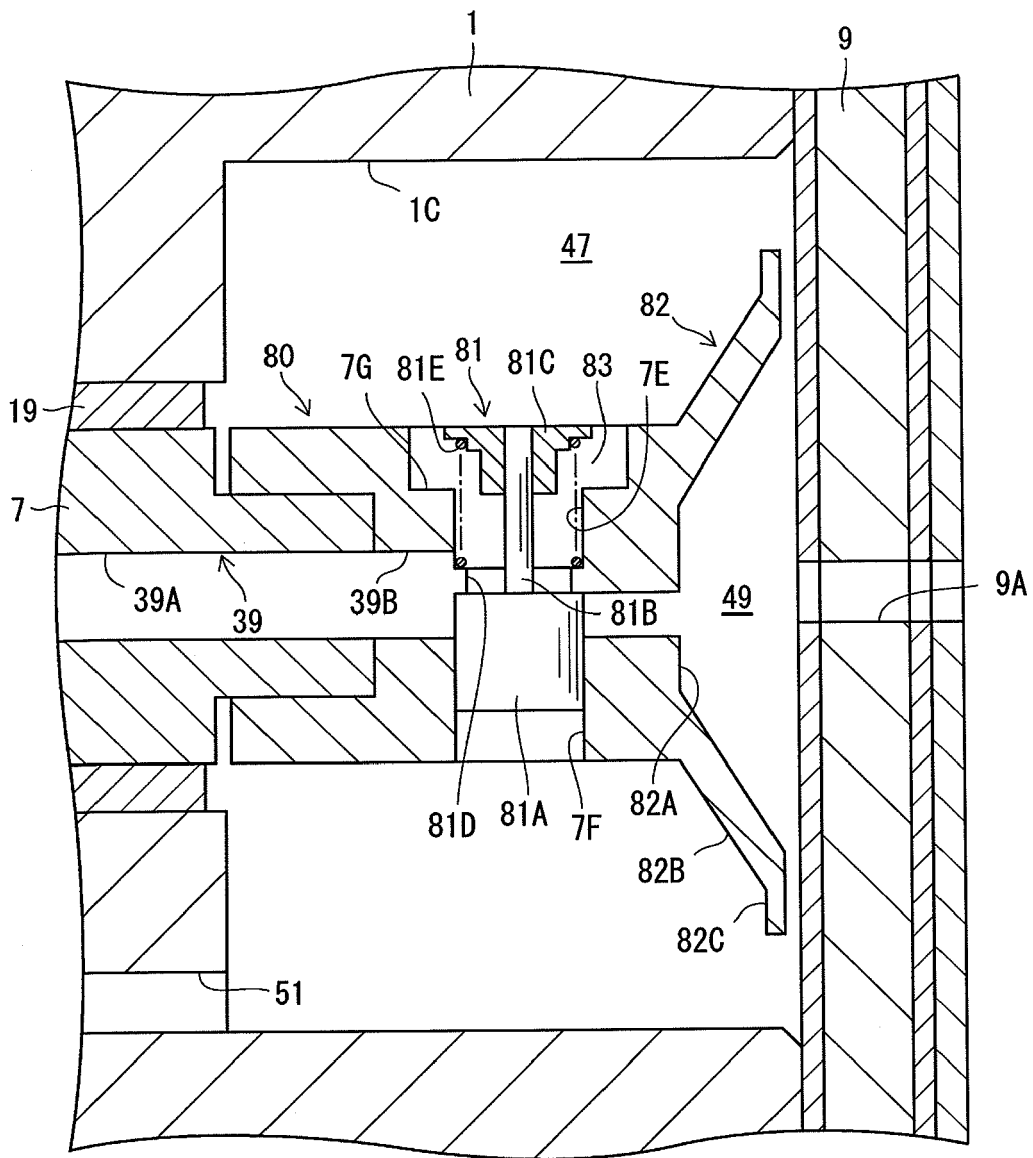
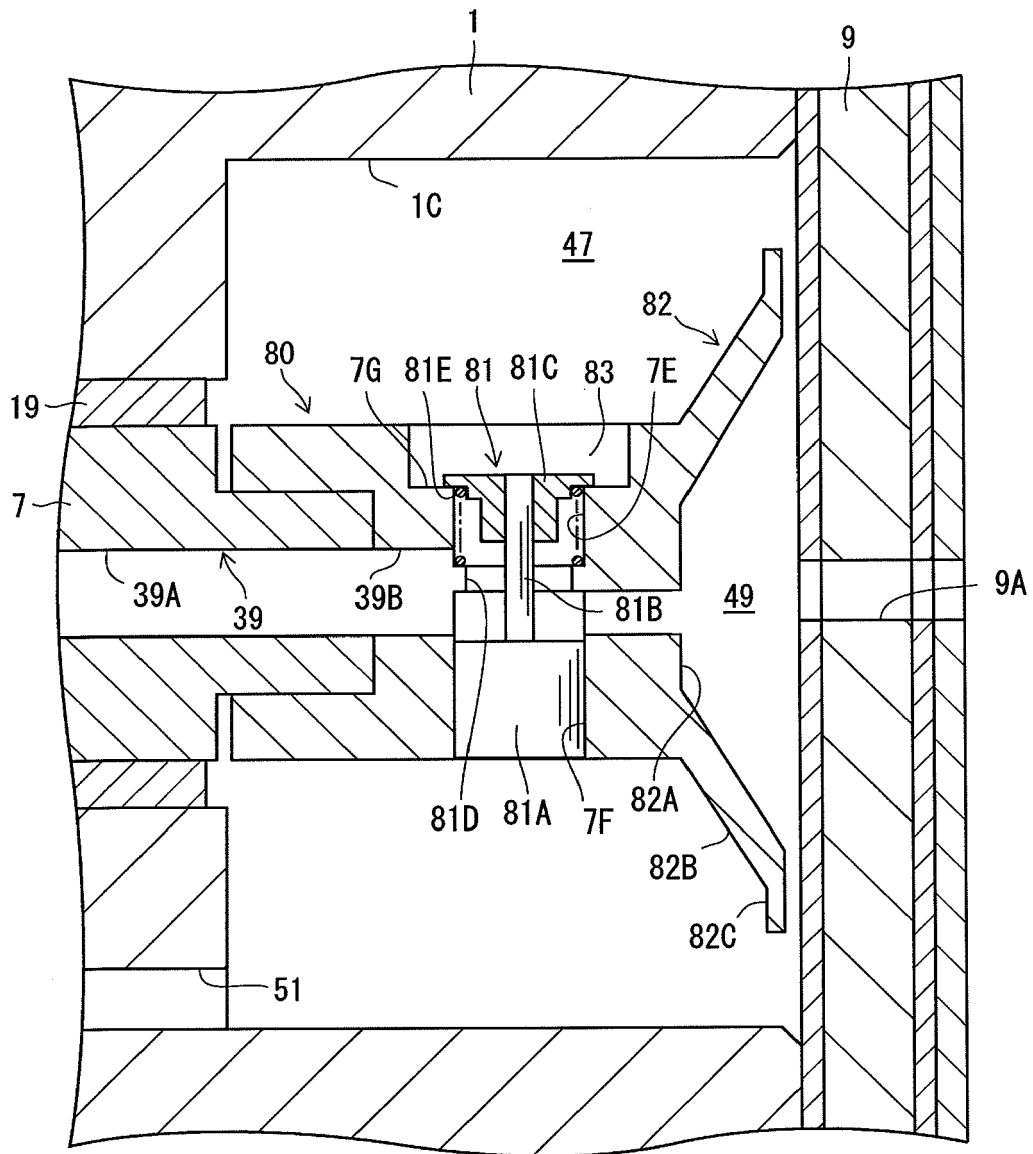


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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