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(54) **Scroll compressor with a discharge valve**

(57) A scroll-type compressor is disclosed. The compressor has a fixed scroll (11) and a movable scroll (20). Two scrolls (11, 20) respectively have volute portions (32,34) cooperate to form a variable volume gas pocket. The movable scroll (20) moves along a predetermined orbital path to vary the volume of the pocket. A movable base plate (33) has a discharge port (25) that discharges the gas from the pocket when the volume of the pocket is less than a predetermined volume. A valve unit (26, 29, 30) connects and disconnects the discharge port (25) with the gas passage. The valve has a movable valve body (39) movable between two positions open and close the discharge port (25).

Fig.1A

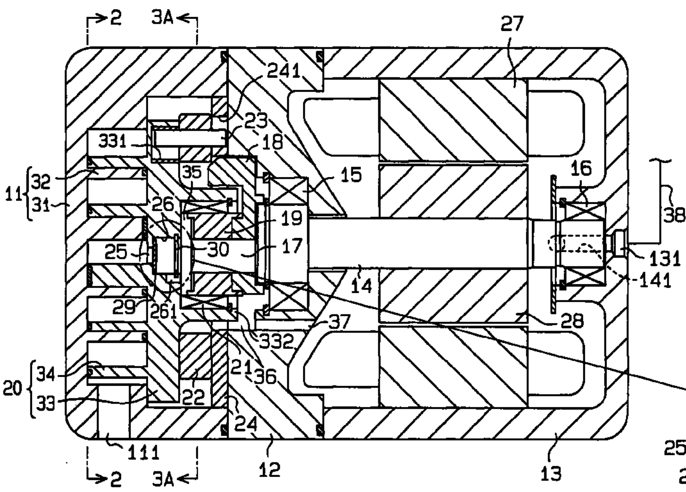
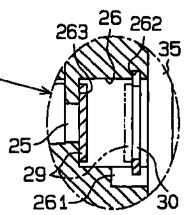


Fig.1B



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Description

[0001] The present invention relates to the discharge structure of a scroll compressor.

[0002] A typical scroll compressor includes a fixed scroll and a movable scroll. The fixed scroll has a fixed base plate and a fixed volute portion, which is formed on the fixed base plate. The movable scroll has a movable base plate and a movable volute portion, which is formed on the movable base plate. The fixed scroll and the movable scroll face each other. The moveable scroll orbits about the axis of a drive shaft of the compressor without rotating about its own axis.

[0003] Pockets are defined between the movable volute portion and the fixed volute portion. As the movable scroll orbits, the pockets moves radially inward while the volume of each pocket decreases. When the volume of each pocket is less than a predetermined volume, the pocket is communicated with a discharge port and pressurized gas is discharged from the discharge port. In Japanese Unexamined Utility Model Publication No. 4-93781, a discharge port is formed in a fixed base plate. In Japanese Unexamined Patent Publications Nos. 2-227583 and 6-264875, a discharge port is formed in a movable base plate.

[0004] If a discharge port is formed in the fixed base plate, a discharge chamber must be located adjacent to the back, or the side opposite to the fixed volute portion, of the fixed base plate. This increases the axial dimension of the compressor.

[0005] If a discharge port is formed in the movable base plate, a discharge chamber need not be adjacent to the back of the fixed base plate. This structure reduces the size of the compressor.

[0006] In the apparatus disclosed in Publication No. 6-264875, the discharge port is opened and closed by a discharge valve flap, which can be flexed. The maximum deflection of the valve flap, or the opening size of the discharge port, is limited by a retainer. The discharge valve flap and the retainer are secured to the movable base plate by a screw. The structure for securing the valve flap and the retainer increases the axial dimension of the compressor.

[0007] In the apparatus disclosed in Publication No. 2-227583, the discharge port, which is formed in the movable base plate, communicates with a discharge gas passage formed in a drive shaft. A float valve type check valve is located in the discharge hole. Compared to a flexible type discharge valve flap, the float valve type check valve occupies less space. However, since the check valve is located in the discharge passage in the drive shaft, the pocket, when at its final stage, is connected to a segment of the discharge passage between the pocket and the inlet to the check valve. When the passage segment is connected to the subsequent pocket, gas in the passage segment is recompressed. The greater the volume of gas that is recompressed, the lower the compressor volumetric efficiency. The compression efficiency is thus relatively low.

[0008] Accordingly, it is an objective of the present invention to provide a compact scroll compressor that improves the compression efficiency.

[0009] To achieve the above objective, an improved scroll-type compressor is disclosed. The compressor has a fixed scroll and a movable scroll. Two scrolls respectively have volute portions cooperate to form a variable volume gas pocket. The movable scroll moves along a predetermined orbital path to vary the volume of the pocket. A movable base plate has a discharge port that discharges the gas from the pocket when the volume of the pocket is less than a predetermined volume. A valve unit connects and disconnects the discharge port with the gas passage. The valve has a movable valve body movable between two positions open and close the discharge port.

[0010] 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.

[0011] 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.

Fig. 1A is a cross-sectional view illustrating a compressor according to a first embodiment of the present invention;

Fig. 1B is an enlarged partial view of Fig. 1A;

Fig. 2 is a cross-sectional view taken along line 2-2 of Fig. 1;

Fig. 3A is a cross-sectional view taken along line 3A-3A of Fig. 1;

Fig. 3B is an enlarged partial view of Fig. 3A;

Fig. 4 is a partial cross-sectional view illustrating a compressor according to second embodiment;

Fig. 5 is a partial cross-sectional view illustrating a compressor according to a third embodiment;

Fig. 6 is a cross-sectional view illustrating a compressor according to a fourth embodiment;

Fig. 7A is a cross-sectional view taken along line 7A-7A of Fig. 6;

Fig. 7B is an enlarged partial view of Fig. 7A;

Fig. 8 is a cross-sectional view taken along line 8-8 of Fig. 6; and

Fig. 9 is a cross-sectional view taken along line 9-9 of Fig. 6.

[0012] A first embodiment according to a first embodiment of the present invention will be described with reference to Figs. 1 to 3.

[0013] As shown in Fig. 1, a center housing 12 is secured to a fixed scroll 11. A motor housing 13 is secured to the center housing 12. A rotary shaft 14 is supported by the center housing 12 and the motor housing 13 through radial bearings 15, 16. An eccentric shaft 17 is integrally formed with the rotary shaft 14.

[0014] A counter weight 18 and a bushing 19 are supported by the eccentric shaft 17. A movable scroll 20 is supported by the bushing 19 through a needle bearing 21 and rotates relative to the bushing 19. The movable scroll 20 faces the fixed scroll 11. The needle bearing 21 is accommodated in a cylindrical portion 332, which is formed on the back surface of a movable base plate 33. As shown in Fig. 2, a fixed base plate 31, a fixed volute portion 32, the movable base plate 33 and a movable volute portion 34 define pockets S0 and S1, which are closed spaces.

[0015] As the eccentric shaft 17 rotates, the movable scroll 20 orbits about the axis of the rotary shaft 14. Centrifugal force created by the orbital movement of the movable scroll 20 is cancelled by the counter weight 18. The eccentric shaft 17 rotates integrally with the rotary shaft 14. The bushing 19, the needle bearing 21, which is located between the eccentric shaft 17 and the cylindrical portion 332 of the movable scroll 20, and the eccentric shaft 17 form an orbiting mechanism.

[0016] A ring 22 is located between the movable base plate 33 and the center housing 12. Cylindrical stopper pins 23, the number of which is more than two, are extended through and secured to the ring 22. In this embodiment, the number of the pins 23 is four. An annular pressure receiving plate 24 is located between the center housing 12 and the ring 22. As shown in Fig. 3A, the plate 24 has holes 241, the number of which corresponds to the number of the pins 23. The holes 241 are arranged circumferentially. Also, the movable base plate 33 has circumferentially arranged holes 331, the number of which corresponds to the number of the pins 23. The holes 241, 331 are arranged in aligned pairs at equal angular intervals. The ends of each pin 23 are inserted into the corresponding pair of the holes 241, 331.

[0017] A stator 27 is fixed to the inner surface of the motor housing 13. A rotor 28 is supported by the rotary shaft 14. The stator 27 and the rotor 28 form a motor. When a current is supplied to the stator 27, the rotor 28 and the rotary shaft 14 are integrally rotated.

[0018] As the eccentric shaft 17, which is formed integrally with the rotary shaft 14, rotates, the movable scroll 20 orbits. Accordingly, refrigerant gas is drawn from an inlet 111 and flows to the space between the fixed base plate 31 and the movable base plate 33 from the peripheral portions of the scrolls 11, 20. As the movable scroll 20 orbits, the surface of each stopper pin 23 slides along the inner walls of the corresponding pair of the holes 331, 241. The diameter D of the holes 331, 241, the diameter d of each pin 23 and the orbit radius r of the bushing 19 satisfy the following equation:

$$D=d+r$$

[0019] Accordingly, the orbit radius of the movable scroll 20 is r, and the ring 22 orbits at half the orbit radius r of the movable scroll 20.

[0020] The ring 22 receives a force that urges it to rotate about its axis. However, each stopper pin 23 contacts the inner surface of the corresponding hole 241, which prevents the ring 22 from rotating. The movable scroll 20 receives a force that urges the movable scroll 20 to rotate about the axis of the bushing 19. However, the inner wall of each hole 331 contacts the corresponding pin 23 on the ring 22, which does not rotate. The movable scroll 20 is therefore not rotated. That is, the movable scroll 20 and the ring 22 do not rotate about their own axes but orbit along predetermined paths.

[0021] As the movable scroll 20 orbits, each of the closed pockets S1, S0 moves toward the inner ends 321, 341 of the volute portions 32, 34 of the scrolls 11, 20. As it moves, the volume of each pocket S1, S0 decreases. At the final stage, the volume of the pocket S0 is zero.

[0022] A discharge port 25 is formed in the movable base plate 33. The discharge port 25 opens to the pocket S0, when the pocket S0 is at the final stage. An accommodation recess 26 is formed in a side of the movable base plate 33 that faces the eccentric shaft 17. The recess 26 is connected to the discharge port 25. A movable disk-shaped valve body 29 is accommodated in the recess 26. An annular groove 262 is formed in the wail of the recess 26. A snap ring 30 is fitted in the groove 262. As shown in Fig. 3A, gas passages 261 are formed in the wail of the recess 26.

[0023] The valve body 29 is moved between a closed position and an open position. When at the closed position, which is illustrated by solid lines in Fig. 1B. the valve body 29 contacts a step defined by the discharge port 25 and the recess 26, or the bottom 263 of the recess 26, to close the discharge port 25. When at the open position, which is illustrated by a broken line, the valve body 29 contacts the snap ring 30, which defines the open position of the valve body 29.

[0024] As the volume of each pocket S1, S0 decreases, the refrigerant gas in the pocket S1, S0 is compressed. The gas is then discharged to the interior space 35 of the cylindrical portion 332 from the pocket S0 through the discharge port 25 and the gas passage 261. The interior space 35 is communicated with a cylindrical space 36 outside the cylindrical portion 332 through the space in the needle bearing 21. The cylindrical space 36 is communicated with the interior of the motor housing 13 through a passage 37. Refrigerant gas in the motor housing 13 is discharged to the external refrigerant circuit 38 through a passage 141 formed in the rotary shaft 14 and an outlet 131 formed on the motor housing 13.

[0025] The recess 26, which accommodates the valve body 29, and the discharge port 25 are formed in the movable base plate 33. The passage from the final stage of the pocket S0 to the valve body 29 is substantially formed by the discharge port 25. The volume of gas that is recompressed is equal to the volume of the discharge port 25, which is relatively small. The amount of gas that is compressed again is less than that of prior art compressors. The compressor volumetric efficiency is improved accordingly, which improves the compression efficiency.

[0026] The snap ring 30, which is fitted in the wall of the recess 26, prevents the valve body 29 from being disengaged from the recess 26 and defines the open position of the valve body 29. When fitted in the groove 262, the snap ring 30 is simply contracted. The installation of the snap ring 30 is relatively easy. The snap ring 30 is thus an ideal means for defining the open position of the valve body 29.

[0027] The final stage pocket S0 is located in the center of the movable base plate 33, and the discharge port 25, which communicates with the pocket S0, lies within a circular area corresponding to the area surrounded by the cylindrical portion 332 of the bearing 21, when viewed toward an axial direction of the drive shaft. To decrease the volume of the final stage pocket S0 to zero, the discharge port 25 is preferably located in the vicinity of the axis of the eccentric shaft 17. Thus, the area corresponding to the area surrounded by the cylindrical portion 332, which includes the axis of the eccentric shaft 17, is optimal for the location of the discharge port 25. Therefore, the area selected based on the position of the bearing 21 is optimal for the location of the recess 26 and the valve body 29.

[0028] When discharged from the discharge port 25 to the space 35, refrigerant gas passes through the motor housing 13. The temperature of the refrigerant gas is lower than the temperature of the motor, which includes the stator 27 and the rotor 28. Thus, the refrigerant gas cools the motor. The gas passage that extends from the discharge port 25 to the motor housing 13 is simple compared to that of a motorized scroll compressor in which a discharge port is formed in a fixed base plate and a gas passage is formed between the discharge port and a motor housing.

[0029] A second embodiment of the present invention will now be described with reference to Fig. 4. To avoid a redundant description, like or same reference numerals are given to those components that are the same as the corresponding components of the first embodiment.

[0030] The compressor of the second embodiment has a valve body 39. The valve body 39 includes openings 391, through which gas passes. The openings 391 are radially displaced from the discharge port 25. When the valve body 39 contacts the bottom 263 of the recess 26, the openings 391 are shut.

[0031] The embodiment of Fig. 4 has the same advantages as the embodiment of Figs. 1 to 3B. The openings 391 reduce the weight of the valve body 39, which improves the response of the valve body 39.

[0032] A third embodiment will now be described with reference to Fig. 5.

[0033] As shown in Fig. 5, a projection 171 is integrally formed with the distal end of the eccentric shaft 17. The diameter of the projection 171 is smaller than the diameter of the recess 26. The end surface 172 of the projection 171 is located in the recess 26. The valve body 29 is moved between a closed position, which is illustrated by a solid line, and an open position, which is illustrated by a broken line. At the closed position, the valve body 29 contacts the bottom 263 of the recess 26. At the open position, the valve body 29 contacts the end surface 172 of the projection 171.

[0034] The projection 171 is easily formed on the eccentric shaft 17 and eliminates the necessity for the groove 262 and the snap ring 30

[0035] A fourth embodiment will now be described with reference to Figs. 6 to 9.

[0036] As shown in Fig. 6, a fixed scroll 40 is secured to the center housing 12. A front cover 41 is secured to the fixed scroll 40. A movable scroll 42 is located between the front cover 41 and the fixed scroll 40. The movable scroll 42 has a movable volute portion 43. A cylindrical portion 421 is formed on the movable scroll 42 at the same side as the volute portion 43. The bushing 19 is inserted into the cylindrical portion 421. The needle bearing 21 is located between the bushing 19 and the cylindrical portion 421. That is, the movable scroll 42 is supported by the bushing 19 through the cylindrical portion 421 and the needle bearing 21 to rotate relative to the bushing 19. The fixed base plate 44, the fixed volute portion 45, the movable base plate 46 and the movable volute portion 43 define pockets S_0, S_1, S_2 as shown in Figs. 7A and 8.

[0037] The movable scroll 42 orbits as the eccentric shaft 17 rotates.

[0038] Cylindrical stopper pins 47, the number of which is four in this embodiment, are fixed to the front side of the movable base plate 46. A pressure receiving plate 48 is located between the front cover 41 and the movable base plate 46. As shown in Fig. 9, holes 49, the number of which corresponds to the number of the pins 47, are formed in the pressure receiving plate 48 and the front cover 41. The holes 49 are arranged circumferentially. The holes 49 are arranged at equal angular intervals. The ends of the pins 47 are inserted into the corresponding holes 49.

[0039] As the eccentric shaft 17 rotates, the movable scroll 42 orbits. Accordingly, refrigerant gas is drawn from an inlet 401 formed in the fixed scroll 40 and flows to the space between the fixed base plate 44 and the movable base plate 46 from the peripheral portions of the scrolls 40, 42. As the movable scroll 42 orbits, the surface of each stopper pin 47 slides along the inner wall of the corresponding hole 49. As in the first embodiment of Figs. 1 to 3B, the diameter D of each hole 49, the diameter d of each pin 47 and the orbit radius r of the bushing 19 satisfy the following equation:

$$D=d+2r$$

[0040] Accordingly, the orbit radius of the movable scroll 42 is r.

[0041] Since each pin 47, which is fixed to the movable base plate 46, contacts the wall of the corresponding hole 49, the movable scroll 42 does not rotate about the axis of the bushing 19. Instead, the movable scroll 42 orbits.

[0042] A discharge port 50 is formed in the movable base plate 46. As shown in Figs. 7A and 7B, an accommodation recess 26 is formed in the movable base plate 46. The recess 26 is located within an area circled by the cylindrical portion 421 adjacent to the recess 26. Also, the valve body 29 and the snap ring 30 are located in the area circled by the cylindrical portion 421. The recess 26 is connected to the discharge port 50. As the movable scroll 42 orbits, the pockets S2, S1, S0 move toward the inner ends of the volute portions 45, 43 of the scrolls 40, 42. The volume of each pocket S2, S1, S0 decreases as it moves. Compressed gas is discharged to the space 35 from the final stage pocket S0 through the discharge port 50.

[0043] A discharge passage 51 is formed in the rotary shaft 14. The discharge passage 51 extends from the distal end of the eccentric shaft 17 to a point in the rotary shaft 14. The passage 51 then opens to the surface of the rotary shaft 14. The gas discharged to the space 35 flows to the motor housing 13 through the discharge passage 51.

[0044] The eccentric shaft 17, the bushing 19 and the needle bearing 21 constitute an orbiting mechanism and permit the movable scroll 42 to orbit. The orbiting mechanism, the rotary shaft 14 and the volute portion 43 are located on the same side of the movable base plate 46. The fixed base plate 44 surrounds the cylindrical portion 421 and the eccentric shaft 17. In a prior art compressor, in which an orbiting mechanism and a rotary shaft are located in a movable base plate 46, the fixed scroll 40 is arranged at the location corresponding to the vicinity of the front cover 41 of Fig 6 of this invention. Therefore, a space for the discharge chamber is necessarily further forward than the front cover 41 (the left end is forward as viewed in Fig 6). The embodiment of Figs. 6 to 9 thus further reduces the axial dimension of the compressor.

[0045] The structure of the compressor of Figs. 6 to 9, in which the valve body 29 is accommodated in the recess 26 of the movable base plate 46, further reduces the length of the scroll compressor and improves the compression efficiency.

[0046] 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 and equivalence of the appended claims.

[0047] A scroll-type compressor is disclosed. The compressor has a fixed scroll (11) and a movable scroll (20). Two scrolls (11, 20) respectively have volute portions (32,34) cooperate to form a variable volume gas pocket. The movable scroll (20) moves along a predetermined orbital path to vary the volume of the pocket. A movable base plate (33) has a discharge port (25) that discharges the gas from the pocket when the volume of the pocket is less than a predetermined volume. A valve unit (26, 29, 30) connects and disconnects the discharge port (25) with the gas passage. The valve has a movable valve body (39) movable between two positions open and close the discharge port (25).

Claims

1. A scroll-type compressor having a fixed scroll (11) and a movable scroll (20), the fixed scroll (11) including a fixed base plate (31) and a fixed volute portion (32), which extends from the fixed base plate (31), the movable scroll (20) including a movable base plate (33) and a movable volute portion (34) extending from the movable base plate (33), wherein the two volute portions (32)(34) cooperate to form a variable volume gas pocket, the movable scroll (20) moves along a predetermined orbital path to vary the volume of the pocket and the movable base plate (33) includes a discharge port (25) for discharging the gas from the pocket when the volume of the pocket is less than a predetermined volume, whereby gas is discharged through a predetermined gas passage, **the scroll-type compressor being characterized by** a valve (26, 29, 30) for selectively connecting and disconnecting the discharge port with the gas passage, the valve including a movable valve body (39) movable between a first position and a second position by a gas flow, wherein the valve body (39) opens the discharge port (25) in the first position and closes the discharge port in the second position.

2. The scroll-type compressor as set forth in Claim 1, **characterized in that** the valve includes an accommodating chamber (26) formed in the movable base plate (33), the valve body (29; 39) accommodated in the accommodating chamber (26), and the compressor further includes a retainer (30; 171) for preventing the valve body (29; 39) from escaping from the chamber (26) and for determining the first posi-

tion of the valve body (29; 39).

3. The scroll-type compressor as set forth in Claim 2, **characterized in** that the retainer includes a snap ring (30) fitted in the accommodating chamber (26).

4. The scroll-type compressor as set forth in Claim 2, **characterized in that** the retainer includes a projection (131) extending into the chamber (26) from a side opposite to the movable base plate (33).

5. The scroll-type compressor as set forth in any one of preceding claims, **characterized in that** the valve body (39) has a plurality of gas passage holes (391) radially offset from the discharge port.

6. The scroll-type compressor as set forth in any one of preceding claims **characterized by** an orbit mechanism (17, 19, 21) that drives the movable scroll (20) to orbit on a predetermined circular path.

7. The scroll-type compressor as set forth in Claim 1, **characterized by** a drive shaft (14), an eccentric shaft (17) integrally rotatable with the drive shaft (14), a bearing (21) located between the eccentric shaft (17) and the movable scroll (20) and a cylindrical holder (332) projecting from the movable base plate (33), wherein the bearing (21) surrounds a first area, and wherein the valve (26, 29, 30) is located in a second area axially adjacent to the first area in respect with the drive shaft (14) and surrounded by an axial extension of the first area.

8. The scroll-type compressor as set forth in any one of the preceding claims, **characterized by** a motor (27, 28) for driving the drive shaft (14), wherein the gas flowing in the gas passage cools the motor (27, 28).

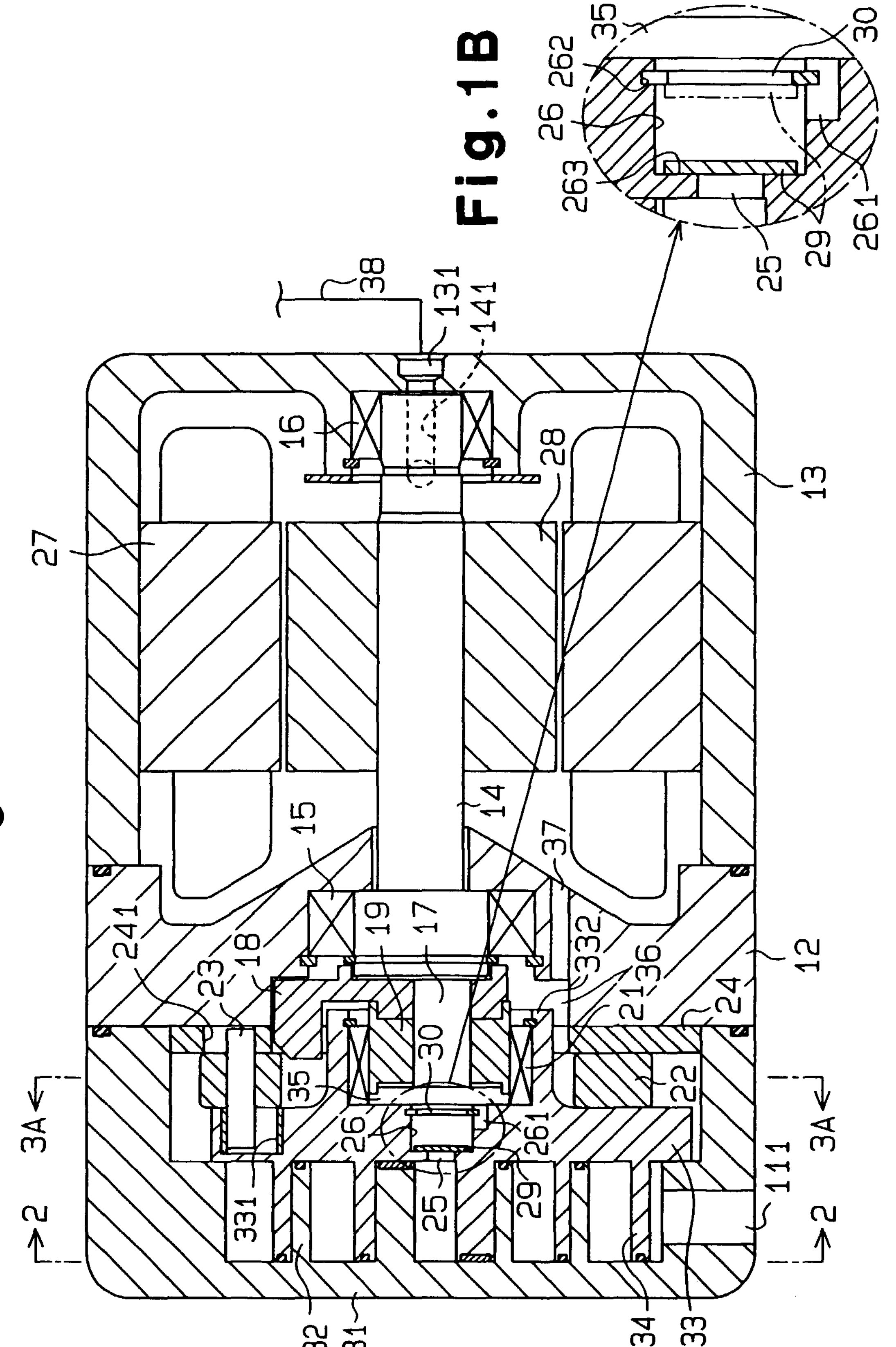
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Fig.1A

Fig.1B

Fig.2

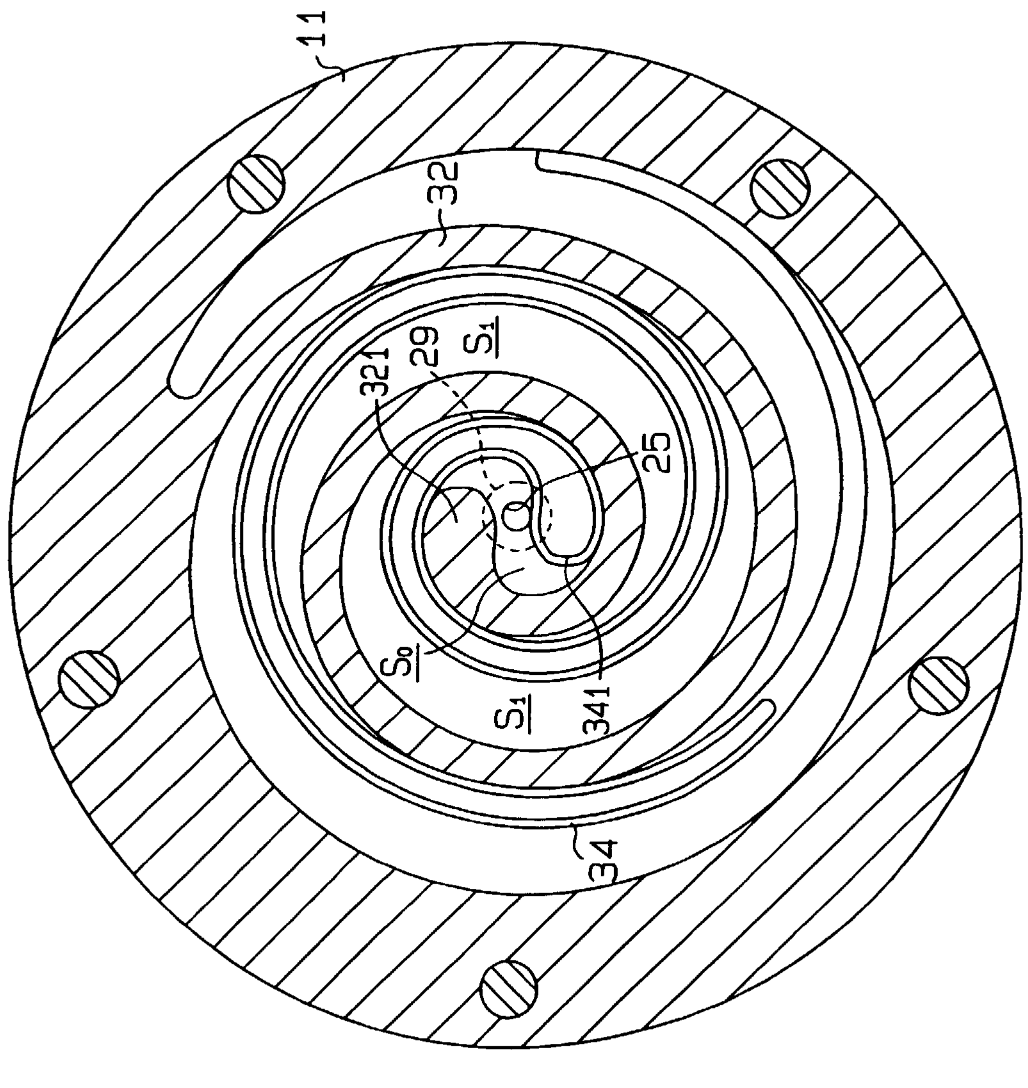

Fig.3A

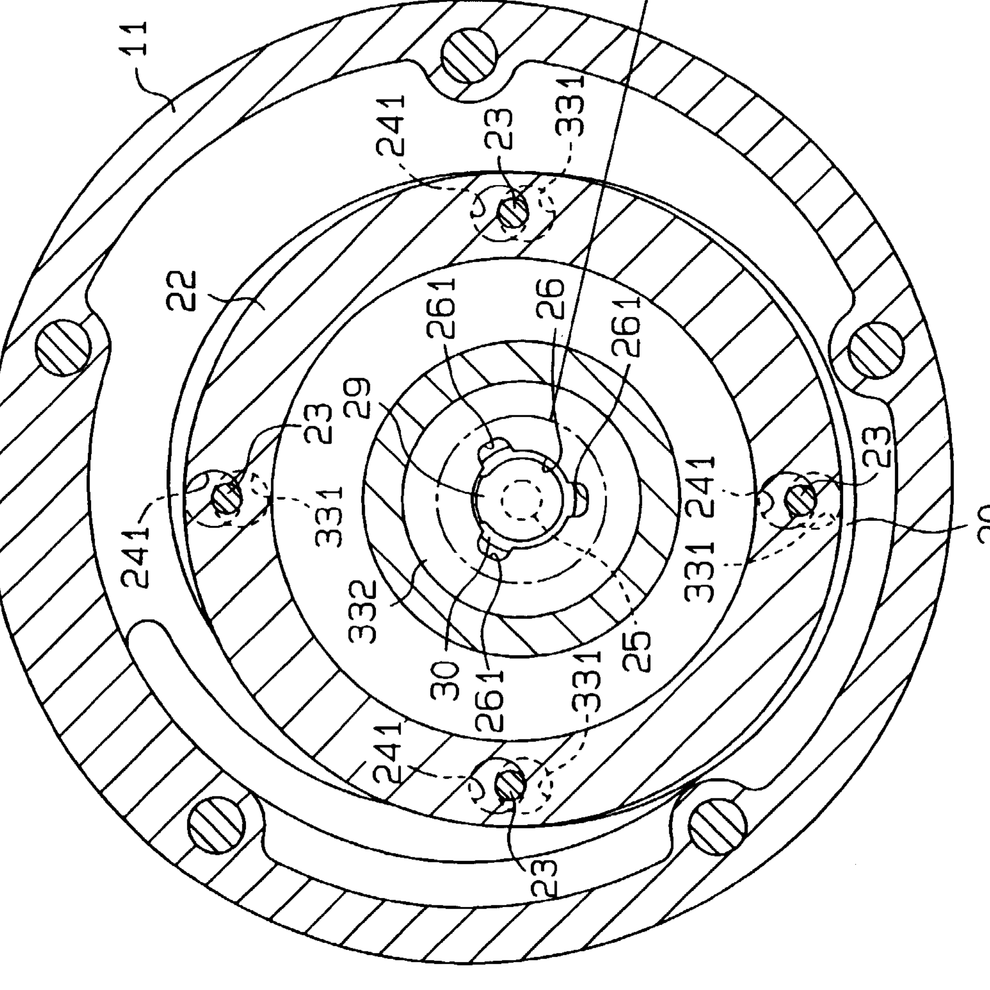
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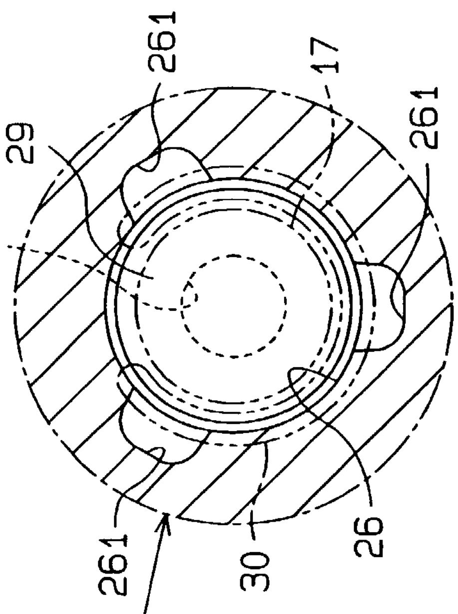
Fig.3B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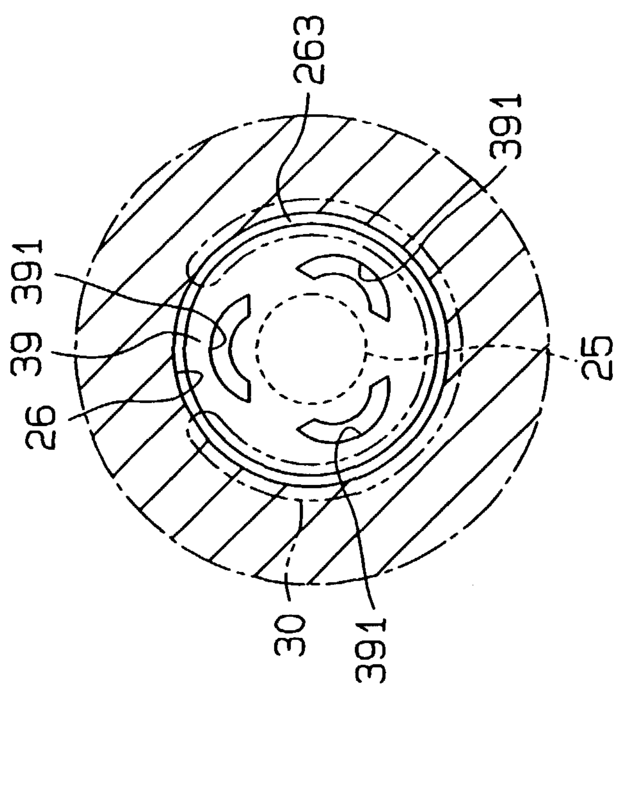

Fig.4

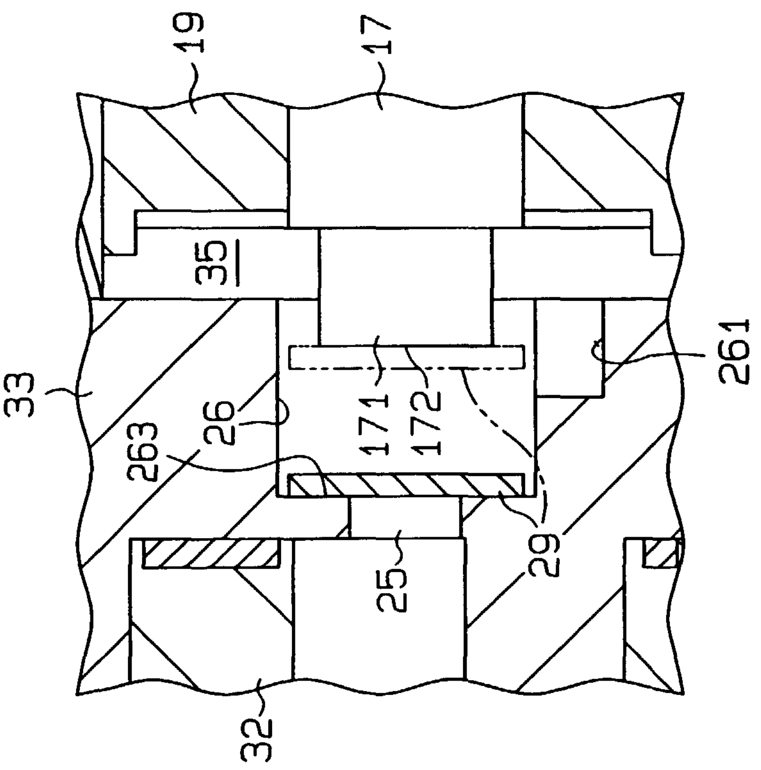

Fig.5

Fig. 6

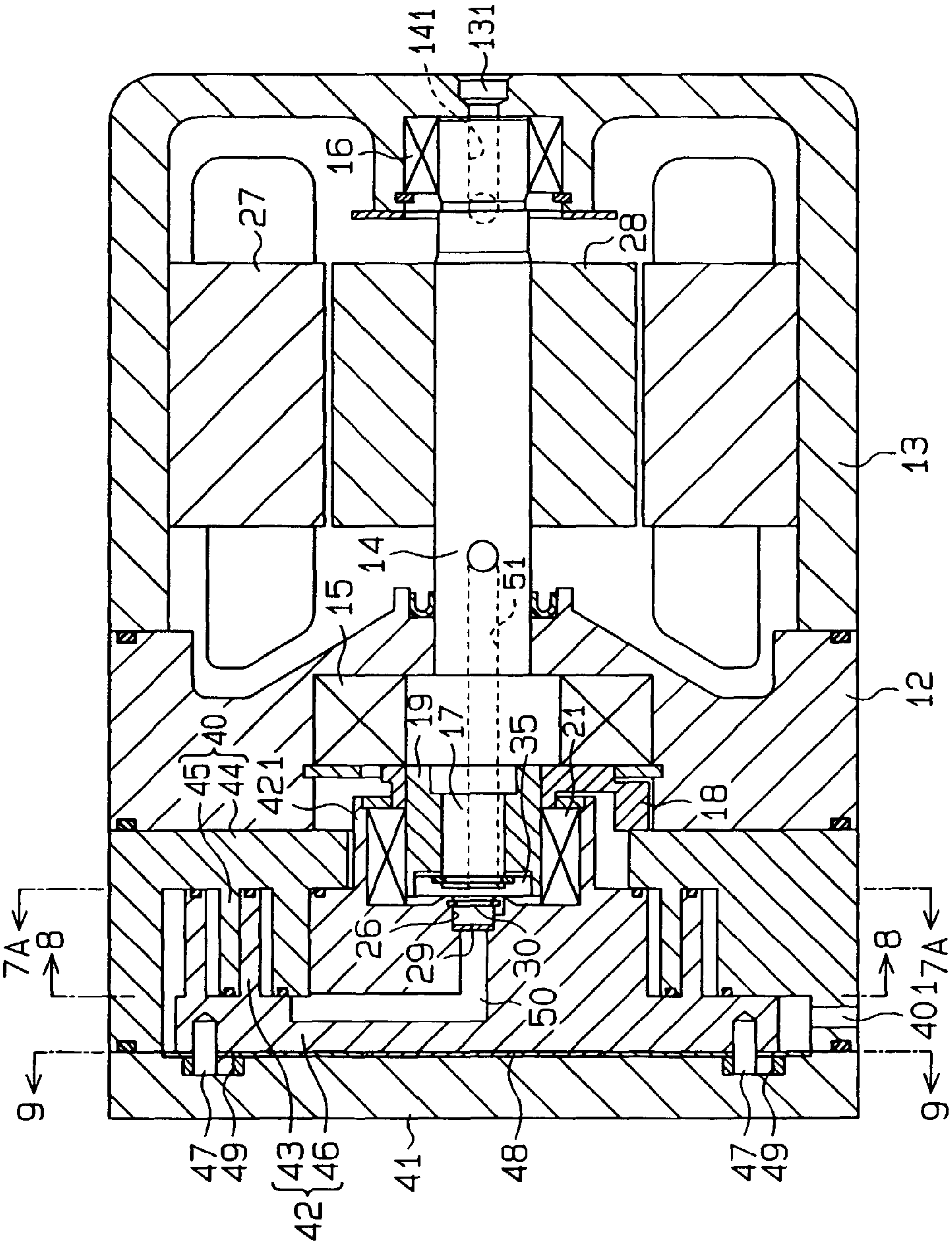
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Fig.7A

Fig.7B

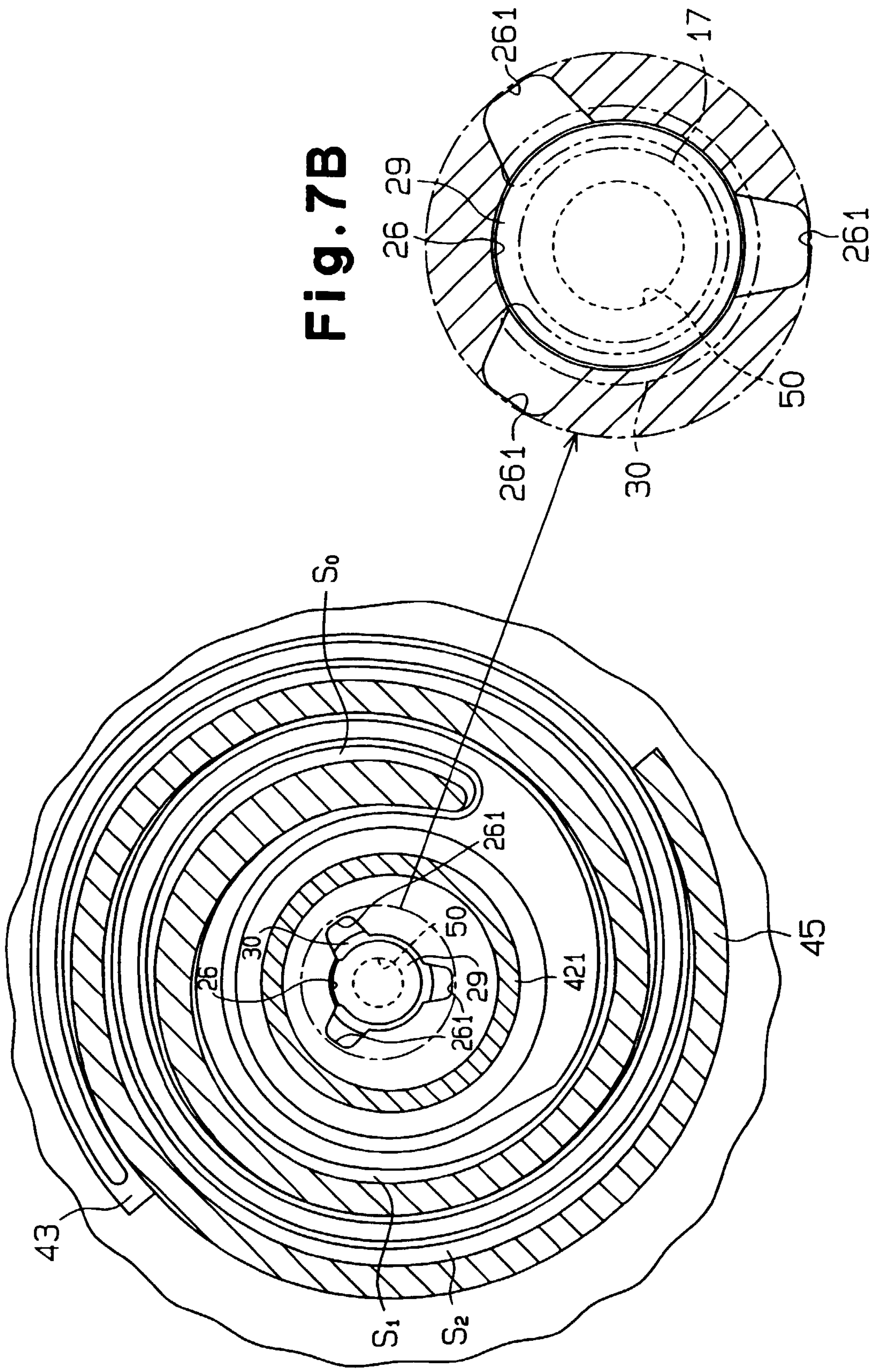

Fig.8

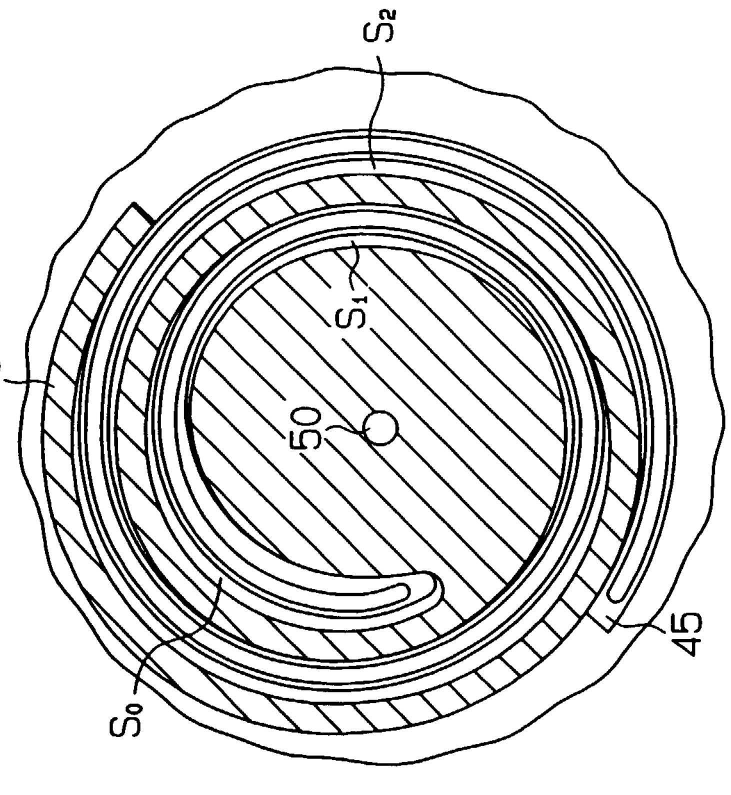

Fig.9