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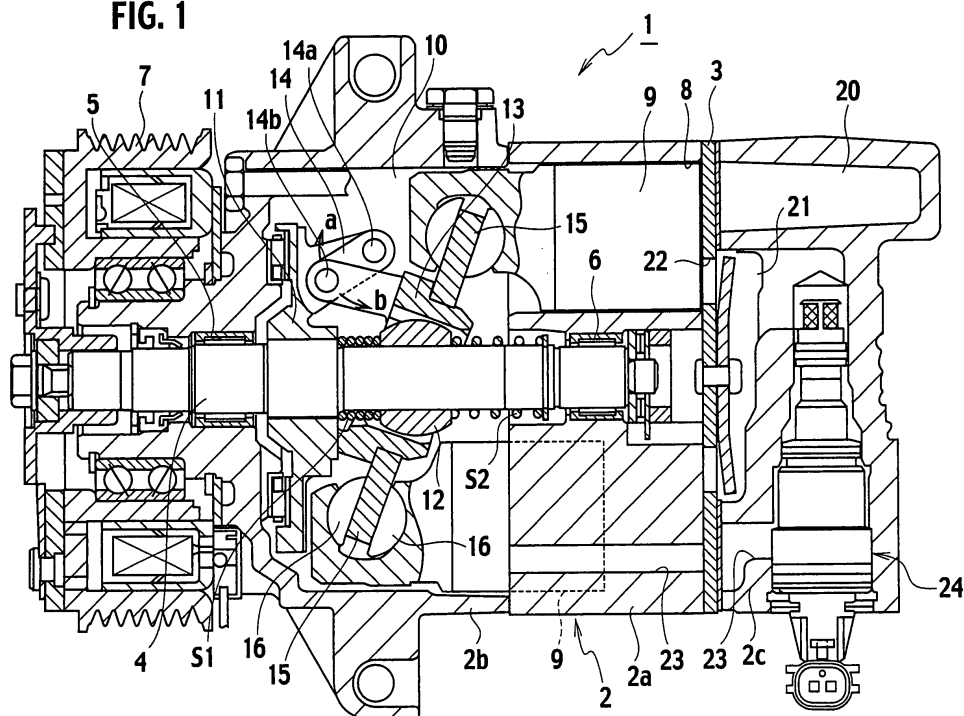
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(54) **Variable capacity compressor**

(57) A variable capacity compressor includes: cylinder bores; a drive shaft; a rotor fixed with the drive shaft; a link for linking the rotor and a journal; a tilting plate capable of changing its tilted angle; and pistons capable of reciprocating within the cylinder bores along with a rotation of the tilting plate. Each reciprocating stroke of the pistons is adjusted according to the tilted angle of the

tilting plate. The link is linked with the rotor via a first pivot and linked with the journal via a second pivot. An arrangement of the first and second pivot is set so that each head clearance of the pistons decreases as a discharge capacity decreases toward its minimum value within a small discharge capacity range. According to the compressor, it can be prevented that the discharge flow amount is cut off abruptly and the tilted angle can be sustained stably.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a variable capacity compressor for varying its discharging capacity of a piston by adjusting a tilted angle of a tilting plate (swash plate, wobble plate).

2. Description of Related Art

[0002] A conventional variable capacity compressor is disclosed in Japanese Patent Application Laid-Open Number 2006-233855.

[0003] As shown in Fig. 5, the variable capacity compressor 100 includes a housing 101. The housing 101 is assembled primarily of a cylinder block 101a, a front head 101b provided at one end of the cylinder block 101a and a rear head 101c provided at another end of the cylinder block 101a via a valve plate 102.

[0004] A drive shaft 103 is provided at the center of the housing 101. Both ends of the drive shaft are rotatably supported by the housing 101 via radial bearings 104 and 105.

[0005] Within the cylinder block 101a, cylinder bores 106 are formed on a circumference with the drive shaft 103 as the center. A piston 107 capable of reciprocating is provided in each of the cylinder bores 106. A crank chamber 108 is provided within the front head 101a, which communicates with the cylinder bores 106. Within the crank chamber 108, provided are a rotor 109 fixed on an outer circumferential surface of the drive shaft 103, a sleeve 110 provided slidably on the outer circumferential surface of the drive shaft 103, a journal 112 provided outside the sleeve 110 and linked with the rotor 109 via a link 111 and a tilting plate 113 fixed on an outer circumferential surface of the journal 112. The pistons 107 are coupled to an outer circumference of the tilting plate 113 via pairs of shoes 114. First and second springs S1 and S2 are provided at both sides of the sleeve 110. The tilting plate 113 will be returned to its initial position due to a balance between elastic forces of the first and second springs S1 and S2 after a shutdown.

[0006] On the drive shaft 103 rotating, the pistons 107 are reciprocated within the cylinder bores 106, respectively, due to the rotor 109, the tilting plate 113 and so on. A reciprocating stroke amount of the pistons 107 is varied due to a tilted angle of the tilting plate 113.

[0007] A suction chamber 120 and a discharge chamber 121 are provided within the rear head 101c.

[0008] The valve plate 102 is interposed between the cylinder head 101a and the rear head 101c. Therefore, the cylinder bores 106 and the chambers 120 and 121 are partitioned by the valve plate 102.

[0009] According to the above-mentioned configuration, the tilting plate 113 swings to reciprocate the pistons

107 on the drive shaft 103 being rotated. Refrigerant is supplied into the cylinder bore 106 from the suction chamber 120 during a suction stroke of the piston 107. The supplied refrigerant is compressed and discharged into the discharge chamber 121 during a compression stroke of the piston 107. The discharged refrigerant is circulated in a refrigerating cycle to be served for air-conditioning or the like and returned to the capacity variable compressor 100.

[0010] A pressure in the crank chamber 108 is made low when thermal load for the refrigerating cycle becomes large during the capacity variable compressor 100 driving. As a result, a balance will be disrupted between a counter-clockwise moment (to move the tilting plate 113 in Fig. 5) due to a crank chamber pressure (a back pressure of the pistons 107) and the elastic force of the first spring S1 and a clockwise moment due to a front pressure of the pistons 107 and the elastic force of the second spring S2. Thereby, the clockwise moment becomes large to increase the tilted angle of the tilting plate 113, so that the link 111 swings in an arrowed direction a in Fig. 5 until the both moments are balanced. (A second pivot 111b is moved in the arrowed direction a from a small capacity state [Fig. 7] to a large capacity state [Fig. 5].) Such swinging of the link 111 makes the tilted angle of the tilting plate 113 large. The reciprocating stroke amount of the pistons 107 turns to be large when the tilted angle of the tilting plate 113 is made large. Thereby, a discharge amount of the refrigerant is made large, so that a cooling performance or the like is enhanced.

[0011] On the other hand, the pressure in the crank chamber 108 is made high when the thermal load for the refrigerating cycle becomes small. As a result, the balance will be disrupted between the counter-clockwise moment due to the crank chamber pressure (the back pressure of the pistons 107) and the elastic force of the first spring S1 and the clockwise moment due to the front pressure of the pistons 107 and the elastic force of the second spring S2. Thereby, the counter-clockwise moment becomes large to decrease the tilted angle of the tilting plate 113, so that the link 111 swings in an arrowed direction b in Fig. 5 until the both moments are balanced. (The second pivot 111b is moved in the arrowed direction b from the large capacity state [Fig. 5] to the small capacity state [Fig. 7].) Such swinging of the link 111 makes the tilted angle of the tilting plate 113 small. The reciprocating stroke amount of the pistons 107 turns to be small when the tilted angle of the tilting plate 113 is made small. Thereby, the discharge amount of the refrigerant is made small, so that the cooling performance or the like is reduced. The capacity variable compressor 100 conserves energy according to the above-mentioned operation.

[0012] In addition, the rotor 109 and the journal 112 are connecting each other with the link 111 as shown in Figs. 6A and 6B in the conventional capacity variable compressor 100. Such a linkage with the link 111 can serve lower frictions than a linkage with an elongate hole and a pin slidable within the elongate hole. Note that the

link 111 is provided in a pair and a first pivot 111a is also provided in a pair as shown in Figs. 6A and 6B. However, they are referred as the "link 111" and the "first pivot 111a" hereinafter.

SUMMARY OF THE INVENTION

[0013] However, with respect to the first pivot 111a (connecting the rotor 109 and the link 111) and the second pivot 111b (connecting the journal 112 and the link 111), the first pivot 111a is arranged near the rotor 109 (on the side of the rotor 109) and the second pivot 111b is arranged near the journal 112 (on the side of the journal 112) in the above-mentioned conventional capacity variable compressor 100. Therefore, with respect to head clearance, there is a tendency indicated by a characteristic line of a conventional example in Fig. 4 at a time when the tilted angle of the tilting plate 113 is small (within a small discharge amount range of the piston 107) as shown in Fig. 7. Then, the head clearance increases as the capacity decreases toward its minimum value. Since stroke becomes small as a matter of course, dead volume ratio to the discharge amount increases drastically. As a result, a discharge flow amount from the cylinder bores 106 is cut off abruptly as a certain tilted angle. Since the small discharge amount range is basically an unstable range due to a small discharge amount, the tilted angle of the tilting plate 113 cannot be sustained stably when the discharge flow amount changes rapidly as mentioned above.

[0014] An object of the present invention is to provide a capacity variable compressor that can restrain a sudden cut-off of the discharge flow amount within the small discharge amount range as much as possible and can sustain the tilted angle of the tilting plate stably.

[0015] An aspect of the present invention is to provide a capacity variable compressor that includes a housing within which a plurality of cylinder bores and a crank chamber communicating with the plurality of cylinder bores are provided; a drive shaft rotatably supported within the housing; a rotor fixed with the drive shaft; a link for linking the rotor and a journal; a tilting plate capable of changing a tilted angle thereof by a movement of the journal; and a plurality of pistons capable of reciprocating within the plurality of cylinder bores, respectively, due to a swinging rotation of the tilting plate. The tilted angle of the tilting plate is changed due to a rotation of the rotor by way of the link. Each reciprocating stroke of the plurality of pistons is adjusted according to the tilted angle of the tilting plate. The link is linked with the rotor via a first pivot and linked with the journal via a second pivot. An arrangement of the first and second pivot is set so that each head clearance of the plurality of pistons decreases as a discharge capacity decreases toward a minimum value thereof within a small discharge capacity range.

[0016] According to the above aspect of the present invention, since the head clearance reduces as the ca-

capacity decreases toward its minimum value within the small discharge capacity range, it can be prevented as much as possible that the discharge flow amount is cut off abruptly and the tilted angle of the tilting plate can be sustained stably.

[0017] It is preferable that a ratio of a head clearance B at the top dead center of the piston to a stroke A of the piston shall be defined as a stroke ratio B/A, and the arrangement of the first and second pivot is set so that the stroke rate B/A is made constant or decreases as the discharge capacity decreases within the small discharge capacity range.

[0018] According to this, since the stroke rate is made constant or decreases as the capacity decreases within the small discharge capacity range of the pistons, it can be prevented firmly that the discharge flow amount is cut off abruptly and the tilted angle of the tilting plate can be sustained stably.

[0019] It is also preferable that the link is configured so that the first pivot is arranged nearer to the journal than the second pivot and the second pivot is arranged nearer to the rotor than the first pivot.

[0020] According to this, since the head clearance reduces as the capacity decreases toward its minimum value within the small discharge capacity range, it can be prevented as much as possible that the discharge flow amount is cut off abruptly and the tilted angle of the tilting plate can be sustained stably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 is an overall cross-sectional view of a variable capacity compressor according to an embodiment of the present invention;

Fig. 2A is a plan view of a linkage in the variable capacity compressor according to the embodiment of the present invention;

Fig. 2B is a side view of the linkage in the variable capacity compressor according to the embodiment of the present invention;

Fig. 3A is an explanatory diagram showing a stroke ratio under a mid capacity setting;

Fig. 3B is an explanatory diagram showing a stroke ratio under a small capacity setting;

Fig. 4 is a characteristic line chart showing relations between a discharge capacity and a head clearance in the variable capacity compressor according to the embodiment of the present invention;

Fig. 5 is an overall cross-sectional view of a conventional variable capacity compressor;

Fig. 6A is a plan view of a linkage in the conventional variable capacity compressor;

Fig. 6B is a side view of the linkage in the conventional variable capacity compressor; and

Fig. 7 is a cross-sectional view of primary elements when a stroke is zero.

DETAILED DESCRIPTION OF THE EMBODIMENT

[0022] Hereinafter, one embodiment according to the present invention will be explained with reference to drawings.

[0023] As shown in Fig. 1, a variable capacity compressor 1 includes a housing 2. The housing 2 is configured to be assembled of a cylinder block 2a, a front head 2b provided at one end of the cylinder block 2a and a rear head 2c provided at another end of the cylinder block 2a via a valve plate 3.

[0024] A drive shaft 4 penetrating an after-mentioned crank chamber 10 is provided within the cylinder block 2a and the front head 2b. Both ends of the drive shaft 4 are rotatably supported by the cylinder block 2a and the front head 2b via radial bearings 5 and 6. One end of the drive shaft 4 is projected outward from the front head 2b and a pulley 7 is fixed on the projected end to receive engine rotation. The drive shaft 4 is configured to rotate by receiving a drive force from the pulley 7 fixed on its one end.

[0025] Cylinder bores 8 are formed within the cylinder block 2a. The cylinder bores 8 are formed at even intervals on a circumference with the drive shaft 4 as the center. A piston 9 capable of reciprocating is provided in each of the cylinder bores 8.

[0026] The crank chamber 10 is provided within the front head 2b, which communicates with the cylinder bores 8. Within the crank chamber 10, provided are a rotor 11 fixed on an outer circumferential surface of the drive shaft 4, a sleeve 12 provided slidably on the outer circumferential surface of the drive shaft 4, a journal 13 provided outside the sleeve 12, a link 14 connecting the journal 13 and the rotor 11, a tilting plate 15 fixed on an outer circumferential surface of the journal 13 and rear ends of the pistons 9, each coupled to an outer circumference of the tilting plate 15 via a pair of shoes 16.

[0027] An outer circumferential surface of the sleeve 12 is formed almost spherical to smoothly guide a transition of the tilted angle of the tilting plate 13. First and second springs S1 and S2 are provided at both sides of the sleeve 12. The tilting plate 15 will be returned to its initial position due to a balance between elastic forces of the first and second springs S1 and S2 after a shutdown. A linkage with the link 14 will be explained later in detail.

[0028] On the drive shaft 4 rotating, its rotation is transmitted to the tilting plate 15 by the rotor 11, the link 14 and the journal 13 to reciprocate the pistons 9 within the cylinder bores 8. In addition, each stroke of the pistons 9 is varied due to the tilted angle of the tilting plate 15 to change a discharge amount of refrigerant. Mechanism for adjusting the tilted angle of the tilting plate 15 will be explained later.

[0029] A suction chamber 20 and a discharge chamber 21 for refrigerant gas are provided within the rear head 2c. The suction chamber 20 is connected to an outlet of an evaporator in a refrigerating cycle. The discharge chamber 21 is connected to an inlet of a condenser in

the refrigerating cycle. In addition, the cylinder bores 8 and the chambers 20 and 21 are partitioned by the valve plate 3. Discharge holes 22 are provided on the valve plate 3 within partitioning areas between the bores 8 and the discharge chamber 21. A discharge valve is provided at each of the discharge holes 22. Suction holes (not shown) are provided on the valve plate 3 within partitioning areas between the bores 8 and the suction chamber 20. A suction valve (not shown) is provided at each of the suction holes.

[0030] Further, an extraction path (not shown) is provided between the crank chamber 10 and the suction chamber 20, which is always opened. An intake path 23 is provided between the crank chamber 10 and the discharge chamber 21. A pressure control valve 24 is provided on the intake path 23. The pressure control valve 24 is configured to control a pressure within the crank chamber 10 by adjusting its valve opening.

[0031] Next, the linkage with the link 14 will be explained. As shown in Figs. 1, 2A and 2B, the link 14 is connected with the rotor 11 via the first pivot 14a and connected with the journal 13 via the second pivot 14b. The first pivot 14a is arranged near the journal 13 (on the side of the journal 13) and the second pivot is arranged near the rotor 11 (on the side of the rotor 11). Namely, the link 14 is linked with the arrangement of the first and second pivot 14a and 14b being reversed as compared with the above-mentioned conventional example. According to the linkage, head clearance decreases as the capacity (tilted angle) decreases toward its minimum value within a small discharge amount range of the pistons 9 (equal-to or less-than 40% capacity, equal-to or less-than 8 degrees tilting plate angle) as shown by a characteristic line of the present invention in Fig. 4.

[0032] A ratio of a head clearance B at the top dead center (TDC) of the piston 9 to a stroke A of the piston 9 shall be defined as a stroke ratio B/A, as shown in Fig. 3. In the present embodiment, with respect to a decreasing tendency of the head clearance, the arrangement of the first and second pivots 14a and 14b is set so that the stroke rate is made constant or decreases as the capacity decreases within the small discharge capacity range of the piston 9.

[0033] In the above configuration, on the drive shaft 4 rotating, the tilting plate 15 rotates due to the rotational force of the drive shaft 4. Then, the pistons 9 reciprocate within the cylinder bores 8. During the suction stroke of the pistons 9 (stroke from TDC to BDC), the suction holes (not shown) are opened due to a pressure reduction within the cylinder bores 8. As a result, the refrigerant gas is supplied from the suction chamber 20 to cylinder bores 8.

[0034] During the compression stroke of the pistons 9 (stroke from BDC to TDC), the suction holes (not shown) are closed and the refrigerant gas within the cylinder bores 8 is compressed adiabatically by the pistons 9. The compressed refrigerant gas with high-temperature and high-pressure is discharged from the discharge holes 22 to the discharge chamber 21. The discharged refrigerant

gas with high-temperature and high-pressure is discharged from the capacity variable compressor 1 via the outlet port (not shown). The discharged refrigerant gas is circulated in the refrigerating cycle to be served for air-conditioning or the like and returned to the capacity variable compressor 1 again.

[0035] A pressure in the crank chamber 10 is made low when thermal load for the refrigerating cycle becomes large during the capacity variable compressor 1 driving. As a result, a balance will be disrupted between a counter-clockwise moment (to move the tilting plate 15 in Fig. 1) due to the crank chamber pressure (a back pressure of the pistons 9) and the elastic force of the first spring S1 and a clockwise moment due to a front pressure of the pistons 9 and the elastic force of the second spring S2. Thereby, the clockwise moment becomes large to increase the tilted angle of the tilting plate 15, so that the link 14 swings in an arrowed direction a in Figs. 1 and 2B until the both moments are balanced. (The second pivot 14b is moved in the arrowed direction a from the small capacity state toward the large capacity state [Fig. 1]. In Fig. 1, the second pivot 14b is already moved to the limit of the arrowed direction a.) Such swinging of the link 14 makes the tilted angle of the tilting plate 15 large. The reciprocating stroke amount of the pistons 9 is made large when the tilted angle of the tilting plate 15 is made large. Thereby, a discharge amount of the refrigerant is made large, so that a cooling performance or the like is enhanced.

[0036] On the other hand, the pressure in the crank chamber 10 is made high when the thermal load for the refrigerating cycle becomes small. As a result, the balance will be disrupted between the counter-clockwise moment due to the crank chamber pressure (the back pressure of the pistons 9) and the elastic force of the first spring S1 and the clockwise moment due to the front pressure of the pistons 9 and the elastic force of the second spring S2. Thereby, the counter-clockwise moment becomes large to decrease the tilted angle of the tilting plate 15, so that the link 14 swings in an arrowed direction b in Figs. 1 and 2B until the both moments are balanced. (The second pivot 14b is moved in the arrowed direction b from the large capacity state [Fig. 1] toward the small capacity state.) Such swinging of the link 14 makes the tilted angle of the tilting plate 15 small. The reciprocating stroke amount of the pistons 9 turns to be small when the tilted angle of the tilting plate 15 is made small. Thereby, the discharge amount of the refrigerant is made small, so that the cooling performance or the like is reduced. The capacity variable compressor 1 conserves energy according to the above-mentioned operation.

[0037] Next, explained will be an operation within the small discharge amount range of the pistons 9. Within the small discharge amount range of the pistons 9, the head clearance is made smaller as the capacity (tilted angle) decreases toward its minimum value. Therefore, it can be prevented firmly that the discharge flow amount is cut off abruptly and the tilted angle of the tilting plate

15 can be sustained stably.

[0038] In the present embodiment, since the arrangement of the first and second pivots 14a and 14b is set so that the stroke rate is made constant or decreases as the capacity decreases within the small discharge capacity range of the piston 9, it can be prevented firmly that the discharge flow amount is cut off abruptly and the tilted angle of the tilting plate 15 can be sustained stably. Specifically, the stroke rate is hardly influenced even if the head clearance B is somewhat large within a mid discharge capacity range as shown in Fig. 3A because the stroke A is large. However, the stroke rate is greatly influenced by alteration of the head clearance B within the small discharge capacity range as shown in Fig. 3B because the stroke A is small. Therefore, within the small discharge capacity range, the refrigerant discharge may be cut off abruptly if the stroke rate became large. However, since the stroke rate is set not more than a certain value in the present embodiment, it can be prevented firmly that the discharge flow amount is cut off abruptly.

Claims

1. A variable capacity compressor (1) comprising:

a housing (2) within which a plurality of cylinder bores (8) and a crank chamber (10) communicating with the plurality of cylinder bores (8) are provided;
a drive shaft (4) rotatably supported within the housing (2);
a rotor (11) fixed with the drive shaft (4);
a link (14) for linking the rotor (11) and a journal (13);
a tilting plate (15) capable of changing a tilted angle thereof by a movement of the journal (13); and
a plurality of pistons (9) capable of reciprocating within the plurality of cylinder bores (8), respectively, due to a swinging rotation of the tilting plate (15);

wherein

the tilted angle of the tilting plate (15) is changed due to a rotation of the rotor (11) by way of the link (14), each reciprocating stroke of the plurality of pistons (9) is adjusted according to the tilted angle of the tilting plate (15),

the link (14) is linked with the rotor (11) via a first pivot (14a) and linked with the journal (13) via a second pivot (14b), and

an arrangement of the first and second pivot (14a, 14b) is set so that each head clearance of the plurality of pistons (9) decreases as a discharge capacity decreases toward a minimum value thereof within a small discharge capacity range.

2. The compressor (1) according to claim 1, wherein a ratio of a head clearance B at the top dead center of the piston (9) to a stroke A of the piston (9) shall be defined as a stroke ratio B/A, and the arrangement of the first and second pivot (14a, 14b) is set so that the stroke rate B/A is made constant or decreases as the discharge capacity decreases within the small discharge capacity range. 5
3. The compressor (1) according to claim 1 or 2, wherein the link (14) is configured so that the first pivot (14a) is arranged nearer to the journal (13) than the second pivot (14b) and the second pivot (14b) is arranged nearer to the rotor (11) than the first pivot (14a). 10 15

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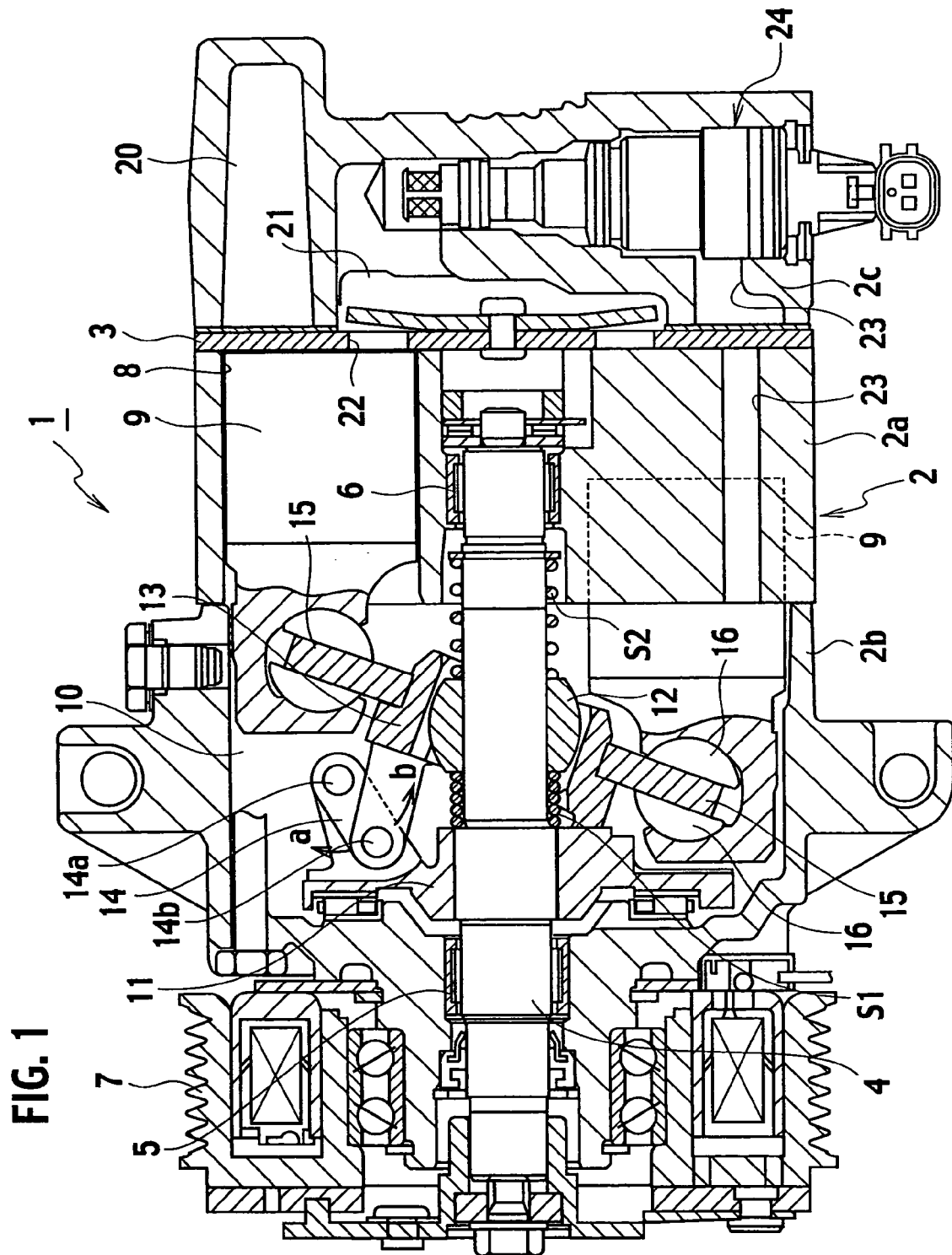


FIG. 2A

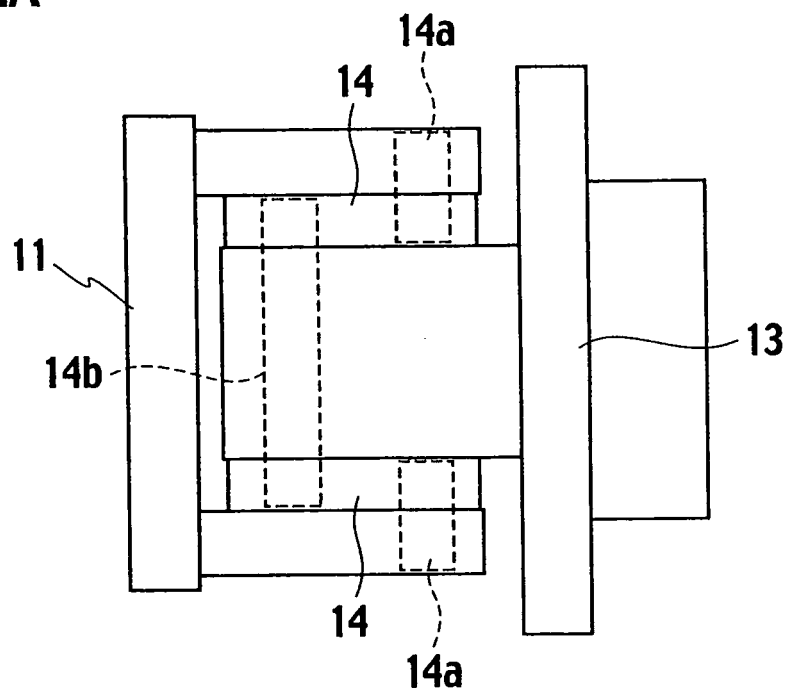


FIG. 2B

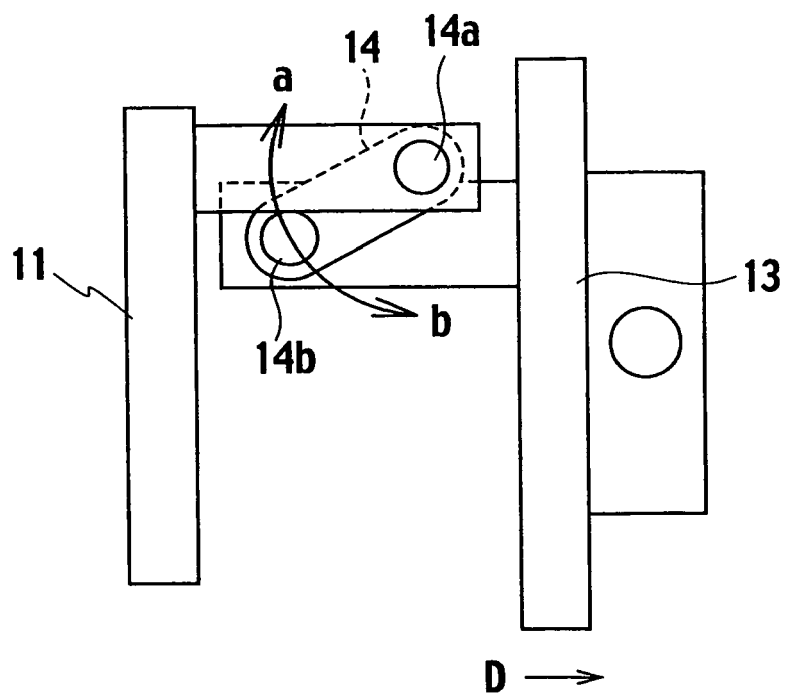


FIG. 3A

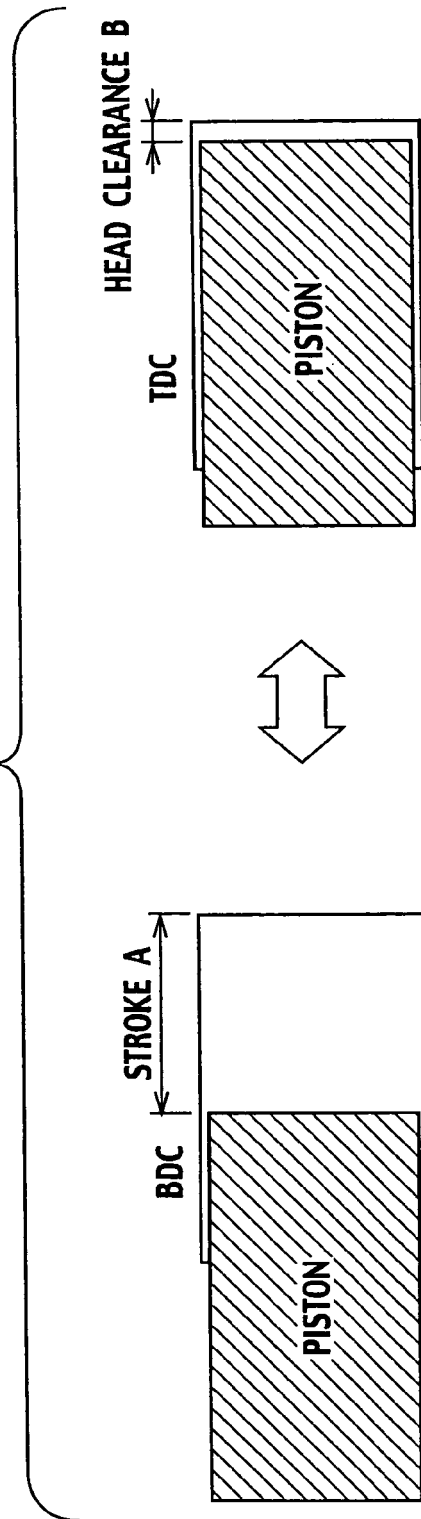


FIG. 3B

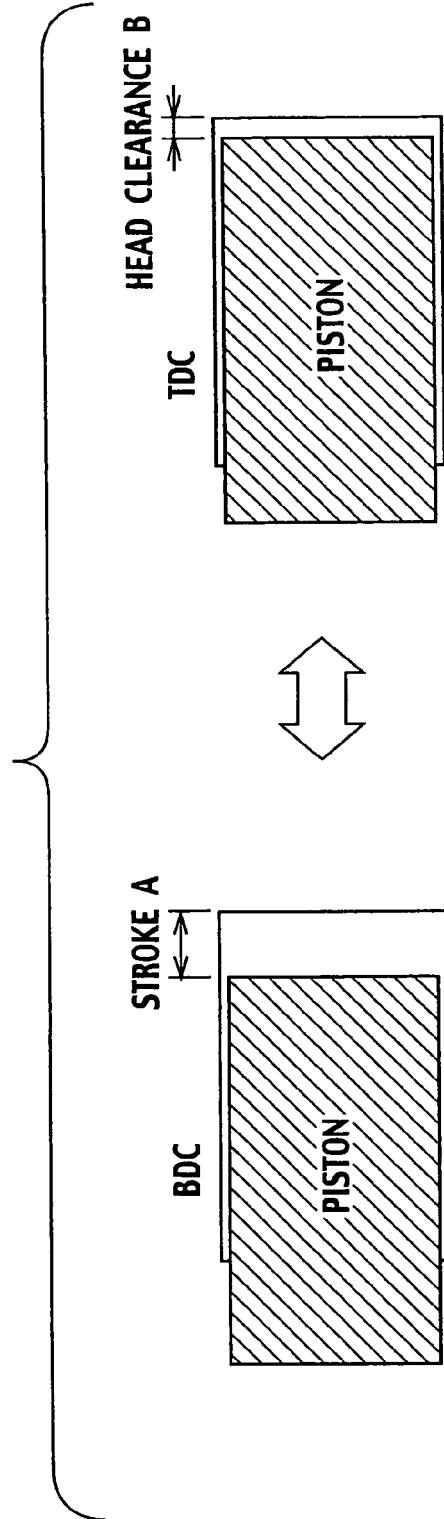
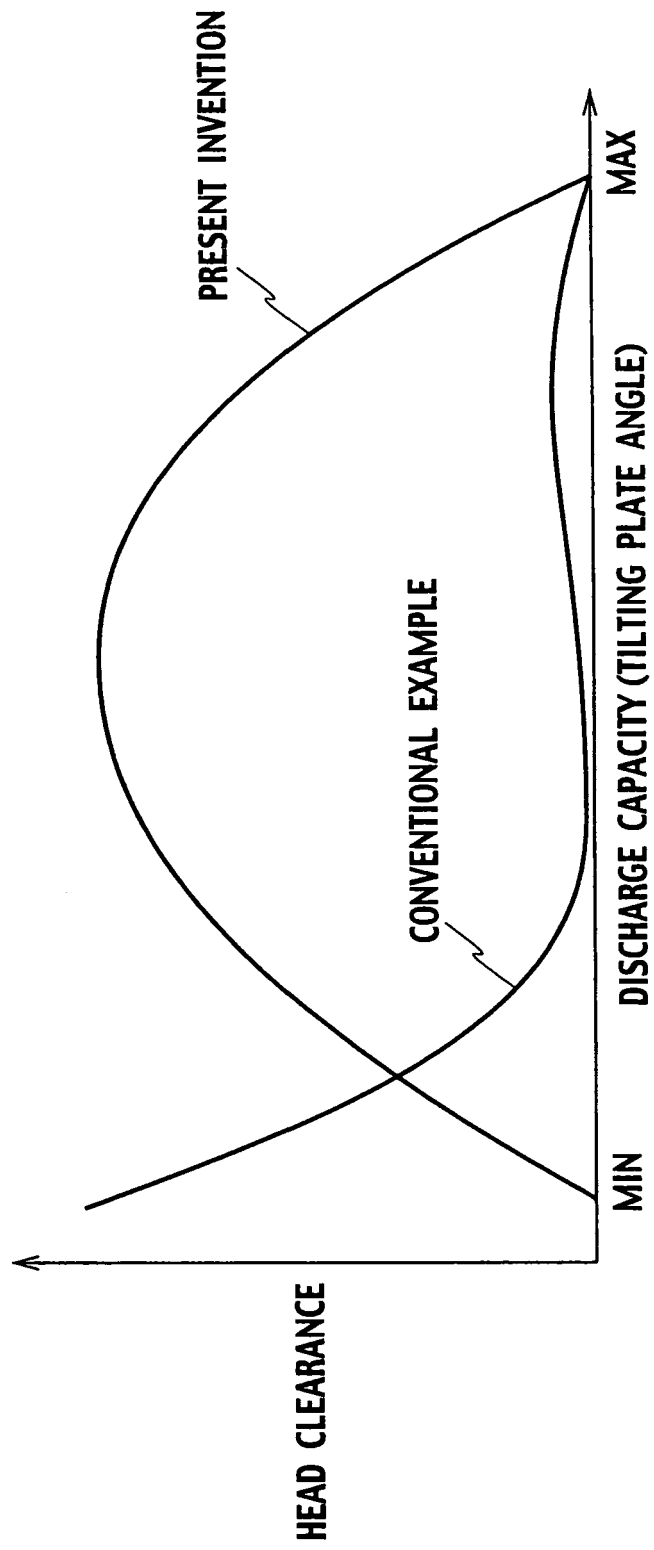


FIG. 4



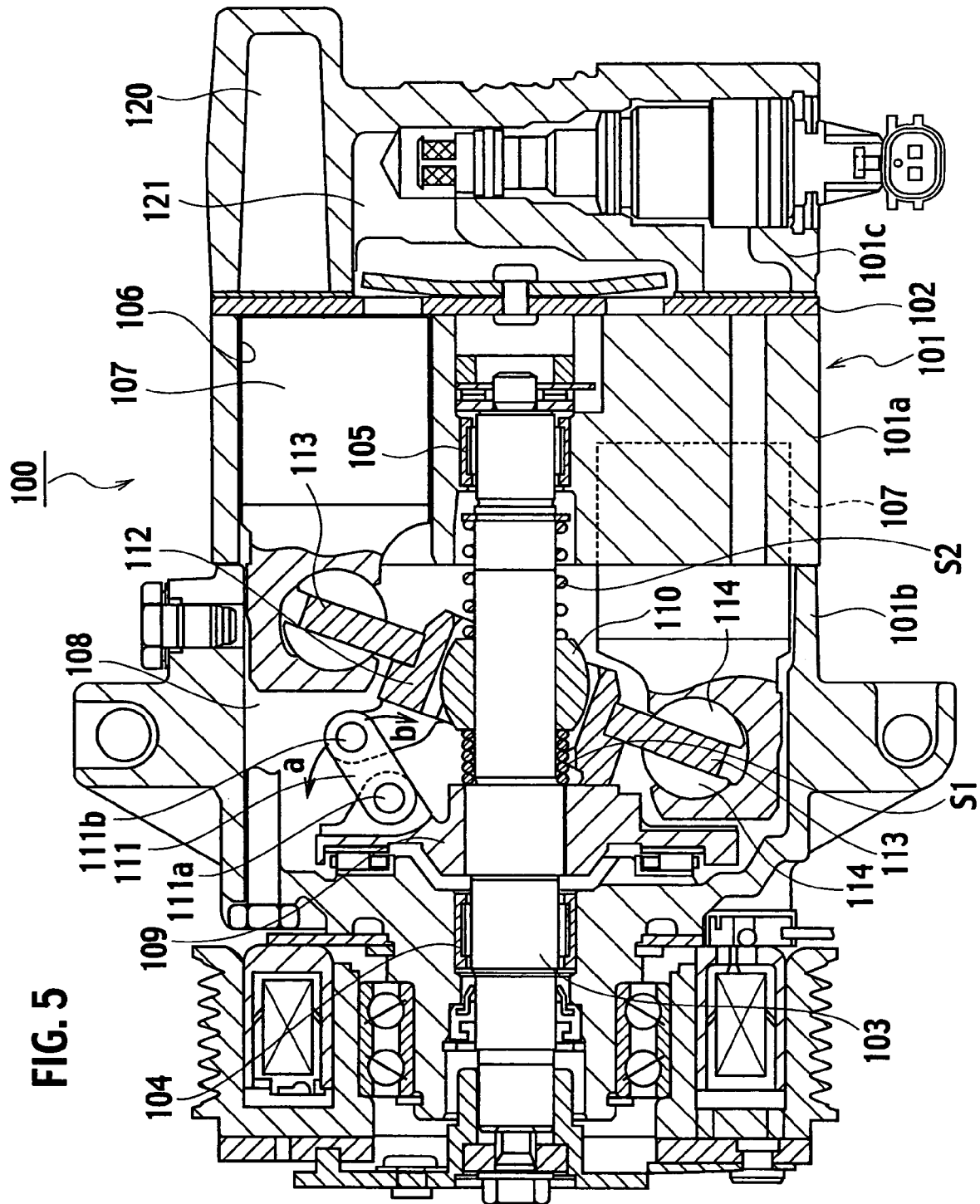


FIG. 6A

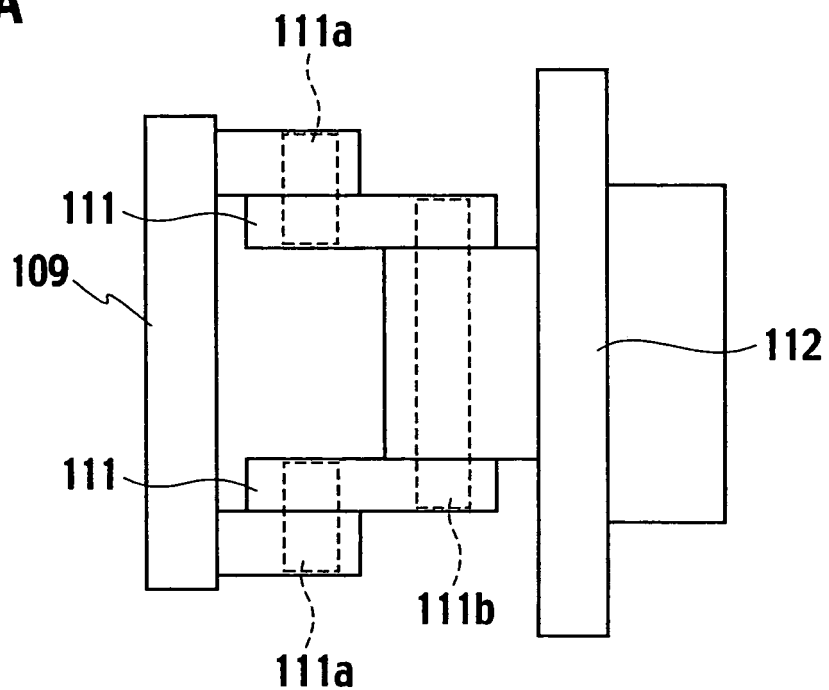


FIG. 6B

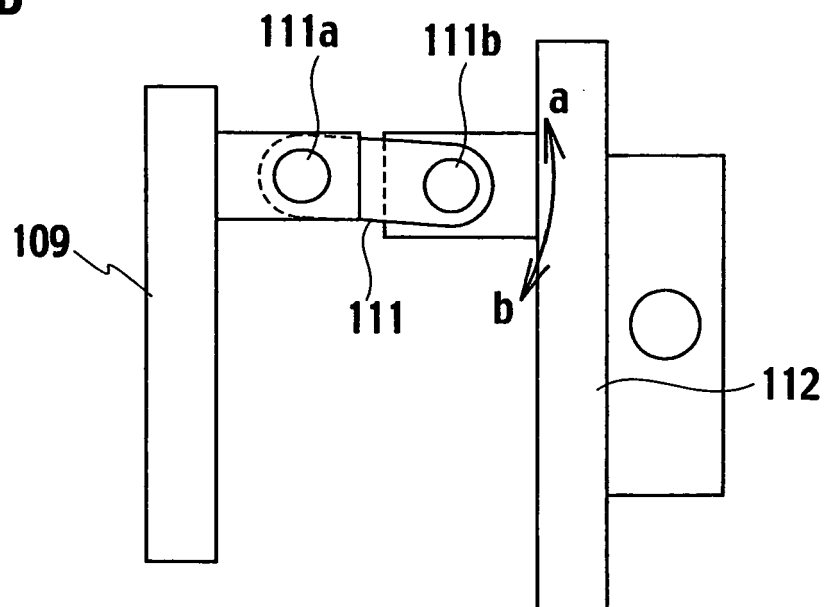
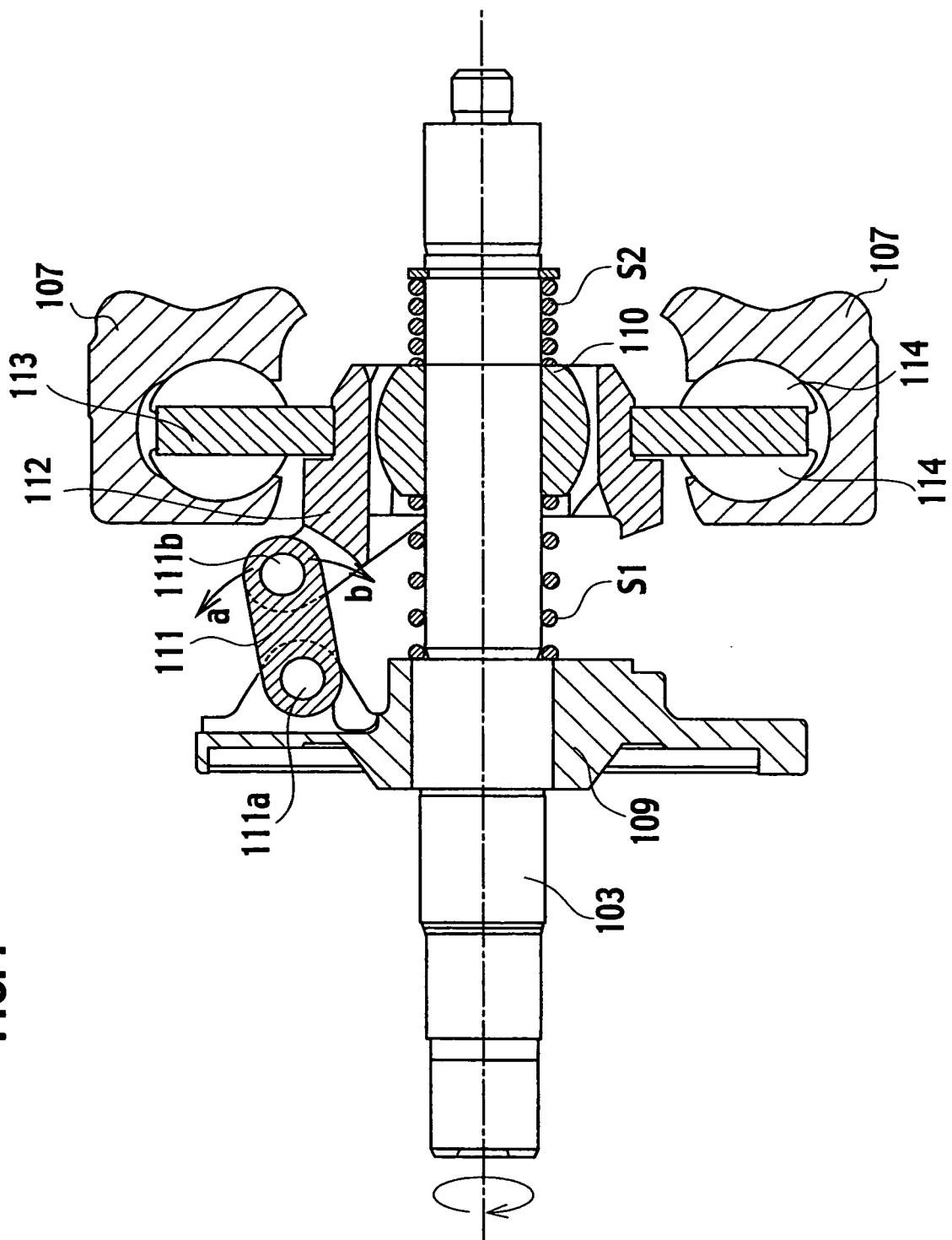


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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