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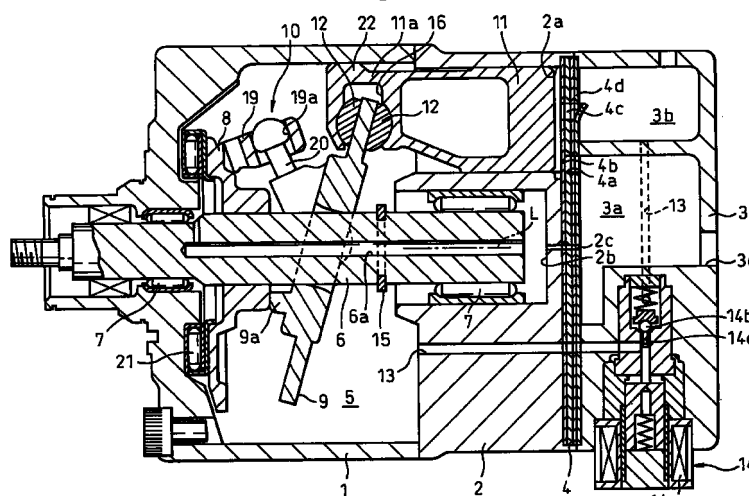
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(54) **Swash plate type compressor**

(57) The single head piston 11 of the present invention includes: a head section 11b engaged in the cylinder bore 2a; a side force pressure receiving wall 11c₁ extending from the lower side of the head section 11b to the neck section 11a; and a guide wall 11c₂ extending

from the upper side of the head section 11b to the neck section 11a, and the neck section 11a is connected with at least the side force pressure receiving wall 11c₁ by the rib lid.

Fig.1



EP 1 039 128 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a swash plate type compressor. More particularly, the present invention relates to a swash plate type compressor for compressing gas when a single head piston, engaged with a swash plate which is rotated together with a drive shaft, via a pair of shoes, is linearly reciprocated in a cylinder bore.

2. Description of the Related Art

[0002] In general, in a swash plate type compressor used for air conditioning in a vehicle, a swash plate is attached to a drive shaft in a crank chamber, and a rotational motion of the swash plate driven by the drive shaft is converted into a reciprocating motion of single head pistons inserted into respective cylinder bores. Refrigerant gas, which has returned to the compressor from an external refrigerating circuit, is sucked from a suction chamber into the cylinder bore according to the linear motion of the single head piston and is compressed in the cylinder bore by the single head piston and then discharged into a discharge chamber. In this swash plate type compressor, the returned refrigerant is directly introduced into the cylinder bore without passing through the crank chamber. Therefore, lubrication of the sliding parts arranged in the crank chamber mainly relies on lubricant supplied into the crank chamber together with blow-by gas.

[0003] Many of the compressors used for this purpose are of the variable capacity type, and the weight must be reduced because they are mounted on vehicles for air conditioning, and further the weight of the single head piston must be reduced as much as possible. The reason is that the controlling property to control the capacity at high speed operation is deteriorated when the mass of the single head piston is large. That is, when the mass of the piston is large, in the case of changing over from the suction stroke to the compression stroke, a high intensity force of inertia of the piston acts in a direction so that an inclination angle of the swash plate is increased. Therefore, irrespective of the adjustment of pressure in the crank chamber, the capacity exceeds a proper value, and capacity control becomes unstable.

[0004] In view of the above circumstances, in order to reduce the weight of the single head piston, there are some proposals in which the single head piston is made hollow. However, in order to make the single head piston hollow, it is necessary to provide a process in which two members are welded. Therefore, the manufacturing cost is inevitably raised.

[0005] On the other hand, according to the piston

disclosed in Japanese Unexamined Patent Publication No. 9-203378, the weight of the piston is reduced in such a manner that a through-hole section, which passes through the piston body in the rotary direction of the swash plate, is formed. However, a sliding face, which is formed by this through-hole section and located on a side close to the drive shaft, includes a redundant region on which a side force does not concentrate. Therefore, the object of reducing the piston weight cannot be sufficiently attained.

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide a single head piston characterized in that the weight is small, the manufacturing is easy and, further, the piston can smoothly slide.

[0007] In a swash plate type compressor of an embodiment of the present invention, both faces of a swash plate, which is tiltably supported by a drive shaft, are interposed between shoes arranged at a neck section of a single head piston, so that a rotary motion of the swash plate is converted into a linear reciprocating motion of the single head piston inserted into a cylinder bore, and a piston stroke is changed by adjusting a difference in the pressures acting on the single head piston. The single head piston includes: a head section engaged in the cylinder bore; a side force pressure receiving wall extending from the lower side of the head section to the neck section; and a guiding wall extending from the upper side of the head section to the neck section, wherein the neck section is connected with at least the side force pressure receiving wall by a rib.

[0008] In this connection, expressions of the upper and the lower side of the head section are based on the posture of the piston in the cylinder bore located right above the axial center of the drive shaft.

[0009] The present invention may be more fully understood from the description of preferred embodiments of the invention set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In the drawings:

Fig. 1 is a vertical cross-sectional view of a swash plate type compressor of an embodiment of the present invention;

Fig. 2 is a perspective view showing an embodiment of a piston;

Fig. 3 is an enlarged view exaggeratedly showing a primary portion in a state in which the piston located close to the top dead point is inclined;

Fig. 4 is a plan view of the piston shown in Fig. 2;

Fig. 5A is a cross-sectional view taken on line A - A in Fig. 3;

Fig. 5B is a cross-sectional view taken on line B - B

in Fig. 3;

Fig. 6 is a graph showing a relation between a rotary angle of the swash plate and an intensity of the side force acting on the piston;

Fig. 7 is a schematic illustration showing a phase upon which a high intensity of side force concentrates; and

Fig. 8 is a front view showing another embodiment of the piston.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Referring to Figs. 1 and 2, an embodiment of the swash plate type compressor of the present invention will be explained below.

[0012] As shown in Fig. 1, the front housing 1 is joined to a front end face of the cylinder block 2. The rear housing 3 is joined to a rear end face of the cylinder block 2 via the valve plate 4. The front housing 1, cylinder block 2 and rear housing 3 compose housing assembly of the compressor. A suction chamber 3a and a discharge chamber 3b are formed enclosed by the rear housing 3 and the valve plate 4. Refrigerant gas is directly introduced from an external refrigerating circuit (not shown) into the suction chamber 3a via the inlet 3c.

[0013] The valve plate 4 includes a suction port 4a, a suction valve 4b, a discharge port 4c and a discharge valve 4d. The crank chamber 5 is formed enclosed by the front housing 1 and the cylinder block 2. The drive shaft 6 is pivotally supported by the front housing 1 and cylinder block 2 via a pair of bearings 7. The drive shaft 6 penetrates the crank chamber 5. The support hole 2b is formed at the center of the cylinder block 2. A rear end portion of the drive shaft 6 is inserted into the support hole 2b and supported by an inner circumferential face of the support hole 2b via the bearing 7.

[0014] The lug plate 8 is fixed to the drive shaft 6. The swash plate 9 is supported by the drive shaft 6 in the crank chamber 5 in such a manner that it can be slid in the axial direction L and it can be tilted with respect to the drive shaft 6. The swash plate 9 is connected with the lug plate 8 via the hinge mechanism 10. The hinge mechanism 10 is composed of a support arm 19 formed on the lug plate 8 and a pair of guide pins 20 formed on the swash plate 9. The guide pins 20 are slidably inserted into a pair of guide holes 19a formed in the support arm 19. The hinge mechanism 10 rotates the swash plate 9 integrally with the drive shaft 6. At the same time, the hinge mechanism 10 guides the swash plate 9 when the swash plate 9 is moved in the axial direction L and inclined with respect to drive shaft 6.

[0015] A plurality of cylinder bores 2a are formed in the cylinder block 2 round the drive shaft 6 and extend in the axial direction L of the drive shaft 6. The single head piston 11, which will be referred to as a piston hereinafter, is housed in the cylinder bore 2a. The groove 16 is formed at the neck section 11a of the pis-

ton 11, and hemispherical sections of a pair of shoes 12 are relatively slidably engaged with inner wall faces of the groove 16 which are opposed to each other. The swash plate 9 is slidably interposed between the planes of both shoes 12. A rotary motion of the swash plate 9 is converted into a linear reciprocating motion of the piston 11 via the shoes 12. The piston 11 is reciprocated in the cylinder bore 2a in the longitudinal direction. In the suction stroke in which the piston moves from the top dead center to the bottom dead center, refrigerant gas in the suction chamber 3a pushes the suction valve 4b open and flows into the cylinder bore 2a via the suction port 4a. In the compression stroke in which the piston 11 is moved from the bottom dead center to the top dead center, refrigerant gas in the cylinder bore 2a is compressed and pushes the discharge valve 4d open and flows through the discharge port 4c into the discharge chamber 3b.

[0016] The thrust bearing 21 is arranged between the lug plate 8 and the front housing 1. The piston 11 is given a compressive reaction force in accordance with the compression of refrigerant gas. This compressive reaction force is received by the front housing 1 via the piston 11, the swash plate 9, the lug plate 8 and the thrust bearing 21.

[0017] As can be seen in Fig. 2, a rotation restricter 22 is integrally formed in the neck section 11a of the piston 11. Since the diameter of the circumferential face of the rotation restricter 22 is substantially the same as that of the inner circumferential face of the front housing 1, even when the piston 11 is given a torque, the center of which is the axial center, the piston 11 can be prevented from rotating by the contact with the inner circumferential face of the front housing 1.

[0018] As can be seen in Fig. 1, a supply passage 13 connects the discharge chamber 3b with the crank chamber 5. The electromagnetic valve 14 is attached to the rear housing 3 and located in the middle of the supply passage 13. When the solenoid 14a of the electromagnetic valve 14 is magnetized, the valve body 14b closes the valve hole 14c. When the solenoid 14a is demagnetized, the valve body 14b opens the valve hole 14c.

[0019] A bleed passage 6a is formed in the drive shaft 6. The inlet of the bleed passage 6a is open to the crank chamber 5, and the outlet of the bleed passage 6a is open to the inside of the support hole 2b. The bleed hole 2c connects the inside of the support hole 2b with the suction chamber 3a.

[0020] When the supply passage 13 is closed by the magnetization of the solenoid 14a, no refrigerant gas at high pressure is supplied from the discharge chamber 3b into the crank chamber 5. Under the above condition, refrigerant gas only flows out from the crank chamber 5 into the suction chamber 3a via the bleed passage 6a and the bleed hole 2c. Therefore, pressure in the crank chamber 5 becomes close to the low pressure in the suction chamber 3a. Due to the foregoing,

pressure in the crank chamber 5 is decreased, and an inclination angle of the swash plate 9 increased to the maximum as shown in Fig. 1. Therefore, the discharge capacity of the compressor becomes the maximum.

[0021] When the supply passage 13 is opened by demagnetization of the solenoid 14a, refrigerant gas of high pressure is supplied from the discharge chamber 3b into the crank case 5, so that the pressure in the crank chamber 5 is increased. In this way, the pressure in the crank chamber 5 is raised, and finally the inclination angle of the swash plate 9 is decreased to the minimum, so that the discharge capacity of the compressor becomes the minimum.

[0022] When the stopper 9a provided on the front face of the swash plate 9 comes into contact with the lug plate 8, the swash plate 9 is restricted so that it cannot be inclined beyond the predetermined maximum angle. On the other hand, when the swash plate 9 comes into contact with the ring 15 attached to the drive shaft 6, the minimum inclination angle of the swash plate 9 is restricted.

[0023] As described above, when the supply passage 13 is closed and opened by the magnetization and demagnetization of the solenoid 14a, pressure in the crank chamber 5 can be adjusted. When pressure in the crank chamber 5 changes, the inclination angle of the swash plate 9 is changed. According to the change in the inclination angle of the swash plate 9, the piston stroke is changed, so that the discharge capacity of the compressor can be adjusted. When control is conducted by a controller not shown, the solenoid 14a of the electromagnetic valve 14 is selectively magnetized and demagnetized according to the information such as a cooling load. That is, the discharge capacity of the compressor is adjusted according to the cooling load.

[0024] Aluminum alloy is used for the cylinder block 2 having the cylinder bore 2a. Aluminum alloy is also used for the piston 11. Preferably, hyper-eutectic aluminum silicon alloy is used for the cylinder block 2 having the cylinder bore 2a and is also used for the piston 11. On an outer circumferential face of the piston 11, there is provided a coat of fluororesin (PTFE) so that the direct contact of the same metal can be avoided and a clearance between the piston 11 and the cylinder bore 2a can be reduced to as small as possible. In order to reduce the weight so as to enhance the capacity control property and also in order to ensure the lubricating property of the piston 11 with respect to the cylinder bore 2a, the piston 11 has the following characteristics.

[0025] The piston 11 shown in Figs. 2, 5A and 5B includes: a head section 11b engaged with the cylinder bore 2a; a side force pressure receiving wall 11c₁ (referred to as a pressure receiving wall hereinafter) extending from the lower side of the head section 11b to the neck section 11a, specifically extending from a position unevenly distributed on the preceding side of the swash plate in the rotary direction to the neck section 11a; and a guide wall 11c₂ extending from the upper

side of the head section 11b to the neck section 11a. The neck section 11a is connected with the pressure receiving wall 11c₁ and the guide wall 11c₂, respectively, by ribs 11d₁, 11d₂. That is, a space formed between the neck section 11a and the head section 11b of the piston 11 is open except for the pressure receiving wall 11c₁, the guide wall 11c₂ and the ribs 11d₁, 11d₂ as shown by the reference numeral 17 in the drawing. In this connection, when the compressor is stopped, the swash plate 9 is transferred to a posture of a smaller capacity by the biasing force of a spring not shown so that the swash plate 9 can prepare for the next starting operation. At this time, the guide wall 11c₂ is linked with the swash plate 9, so that a twist of the piston 11, which advances into the cylinder bore 2a, can be effectively prevented.

[0026] In this case, consideration is given to the side force acting on the piston 11. The piston 11 is given a reaction force (side force) from the inner circumferential face of the cylinder bore 2a which is caused by the compressive reaction force generated in the process of reciprocation and also by the force of inertia.

[0027] To explain in more detail, as shown in Figs. 3 and 4, when the piston 11 is located at a position close to the top dead point, the compressive reaction force acting on the piston 11 becomes the maximum. This compressive reaction force and the force of inertia of the piston 11 act on the swash plate 9. The piston 11 softens a high intensity reaction force F_s according to resultant force F_0 of the compressive reaction force and force of inertia from the swash plate 9 which is inclined with respect to a face perpendicular to the axis L of the drive shaft 6. According to the inclination angle of the swash plate 9, this reaction force F_s can be resolved into a component force f_1 which is directed in the moving direction of the piston 11 and a component force f_2 which is directed in the direction of axial center L of the drive shaft 6. As can be seen in Fig. 4, the component force f_3 is generated by rotation R of the swash plate 9 in the same manner. These component forces f_2 and f_3 tilt the piston 11 with respect to the axial center of the cylinder bore 2a. The pressure receiving wall 11c₁ unevenly distributed on the preceding side of the swash plate 9 in the rotary direction R receives a high intensity reaction force (side force) F_a from the inner circumferential face of a portion close to the opening of the cylinder bore 2a according to the component forces f_2 and f_3 .

[0028] A position at which side force F_a acts on the piston 11 is changed by the movement of the piston 11. The circumstances will be explained in detail below.

[0029] Fig. 6 is a graph showing a relation between a rotary angle of the swash plate 9, that is, a moving position of the piston 11, and an intensity of the side force F_a acting on the piston 11. On this graph, a rotary angle of the swash plate 9 is set at 0° when the piston 11 is located at the top dead point. Side force F_a successively acts on the overall circumference in the same direction as the direction of rotation R of the drive shaft

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[0030] Fig. 7 is a schematic illustration for explaining a phase upon which a high intensity portion of side force F_a concentrates. Fig. 7 is a view of the piston 11 taken from a side on which the rotary direction R of the drive shaft 6 is clockwise. In this view, the piston 11 is viewed from the side of the neck section 11a. Virtual straight line M, which passes through the axial center L of the drive shaft 6 and the axial center of the piston 11, is drawn, and this virtual straight line M crosses the circumferential face of the piston 11 at cross points P1 and P2. Cross point P1, which is distant from axial center L of the drive shaft 6, is set at the 12 o'clock position.

[0031] From the point in time at which the piston 11 is located at the top dead center to the point in time at which the swash plate 9 is rotated by 90° in the direction of arrow R, compressed refrigerant gas remaining in the cylinder bore 2a expands again in accordance with the movement of the piston 11 from the top dead center to the bottom dead center. After the completion of the expansion, refrigerant gas starts to be sucked into the cylinder bore 2a. Under the above condition, no compressive reaction force acts on the swash plate 9, and force F_0 acting on the swash plate 9 is mainly a force of inertia of the piston 11. Accordingly, even in this state, the piston 11 receives reaction force F_s , which is mainly based on the force of inertia, from the swash plate 9. However, force F_0 acting on the swash plate 9 actually becomes 0 under the above conditions. Therefore, side force F_a hardly acts on the piston 11.

[0032] While the swash plate 9 rotates from 0° to 90° , side force F_a becomes negative. This means that the direction of each force described above is reversed.

[0033] When the swash plate 9 is further rotated by 90° in the direction of arrow R and the piston 11 comes to the bottom dead position, the side force acts at the 12 o'clock position, however, the intensity of the side force is much lower than that of the side force in the case shown in Fig. 3.

[0034] Side force F_a acting on the piston 11 becomes maximum at the end of the compression stroke in which the rotary angle of the swash plate 9 is directed from 270° to 360° . This highest side force F_a is received in range T' of 4 to 6 o'clock as shown in Fig. 6. Consequently, the range of pressure receiving circumferential face T may be a circumferential face from 4 to 6 o'clock, however, when consideration is given to enhancement of the mechanical strength, the range of pressure receiving circumferential face T is extended to a circumferential face from 3 to 7 o'clock. However, as long as the mechanical strength allows, it is preferable that the range of pressure receiving circumferential face T is made to come close to the aforementioned circumferential face T'.

[0035] To sum up, when pressure receiving circumferential face T is reinforced by the necessary minimum wall thickness so as to enhance the mechanical strength, the aforementioned pressure receiving wall

11c₁ can be obtained. On this pressure receiving wall 11c₁, when the redundant wall thickness portion is removed to the utmost, a crescent-shaped thickness portion, which is substantially inclined, can be formed, that is, the ultimate reduction in the weight can be attained. Further, the inner face of the pressure receiving wall 11c₁ is inclined in the same direction as the flowing direction Q of drops of lubricant which spread from the sliding contact interface between the swash plate 9 and the shoes 12 and are affected by a centrifugal force. Therefore, the cylinder bore 2a can be more smoothly lubricated.

[0036] In the above embodiment, the neck section 11a of the piston 11 is connected with the pressure receiving wall 11c₁ and the guide wall 11c₂ by the ribs 11d₁, 11d₂. However, as shown by the piston 11A in Fig. 8, when consideration is given to the mechanical strength, it is possible to put the piston 11A into practical use in which the neck section 11a of the piston 11 is connected with only the lower rib 11d₁. According to this piston, the weight can be further reduced. Depending upon the type of refrigerant gas and the selection of the pressure condition of the compressor, it is possible to attach a piston ring for adjusting a quantity of blow-by gas to the head section of the piston and also it is possible to form oil grooves for enhancing the sliding property of the piston. Further, in the case of an embodiment in which the rotary direction of the swash plate 9 is inverted, of course, the aforementioned circumferential face T' is transferred to the range of 6 to 8 o'clock.

[0037] As the detail are described above, in the piston used for the compressor of the present invention, a space formed between the neck section and the head section is open except for the side force pressure receiving wall, the guide wall and the ribs. Therefore, the ultimate reduction in weight can be attained. On the other hand, drops of lubricant which have spread from the sliding interface between the swash plate and the shoes are effectively supplied into the cylinder bore via this open space. Therefore, smooth sliding of the piston can be positively guaranteed. In the case where the aforementioned pressure receiving wall is formed and is unevenly distributed and inclined onto the preceding side of the swash plate in the rotary direction, drops of lubricant, which have spread from the sliding interface between the swash plate and the shoes, are influenced by a centrifugal force and made to flow. These drops of lubricant can be appropriately guided on the inner face of the pressure receiving wall inclined in the same direction as the flowing direction of the drops of lubricant. Therefore, a sufficient quantity of lubricant can be supplied.

[0038] While the invention has been described by reference to specific embodiments chosen for purposes of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

Claims

1. A swash plate type compressor in which both faces of a swash plate, which is tiltably supported by a drive shaft, are interposed between shoes arranged at a neck section of a single head piston, so that a rotary motion of the swash plate is converted into a linear reciprocating motion of the single head piston inserted into a cylinder bore, a piston stroke is changed by adjusting a difference in pressure acting on the single head piston, the single head piston including: a head section engaged in the cylinder bore; a side force pressure receiving wall extending from the lower side of the head section to the neck section; and a guiding wall extending from the upper side of the head section to the neck section, wherein the neck section is connected with at least the side force pressure receiving wall by a rib.
2. A swash plate type compressor according to claim 1, wherein the side force pressure receiving wall is arranged and unevenly distributed and inclined onto the preceding side in the rotary direction of the swash plate.

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Fig.1

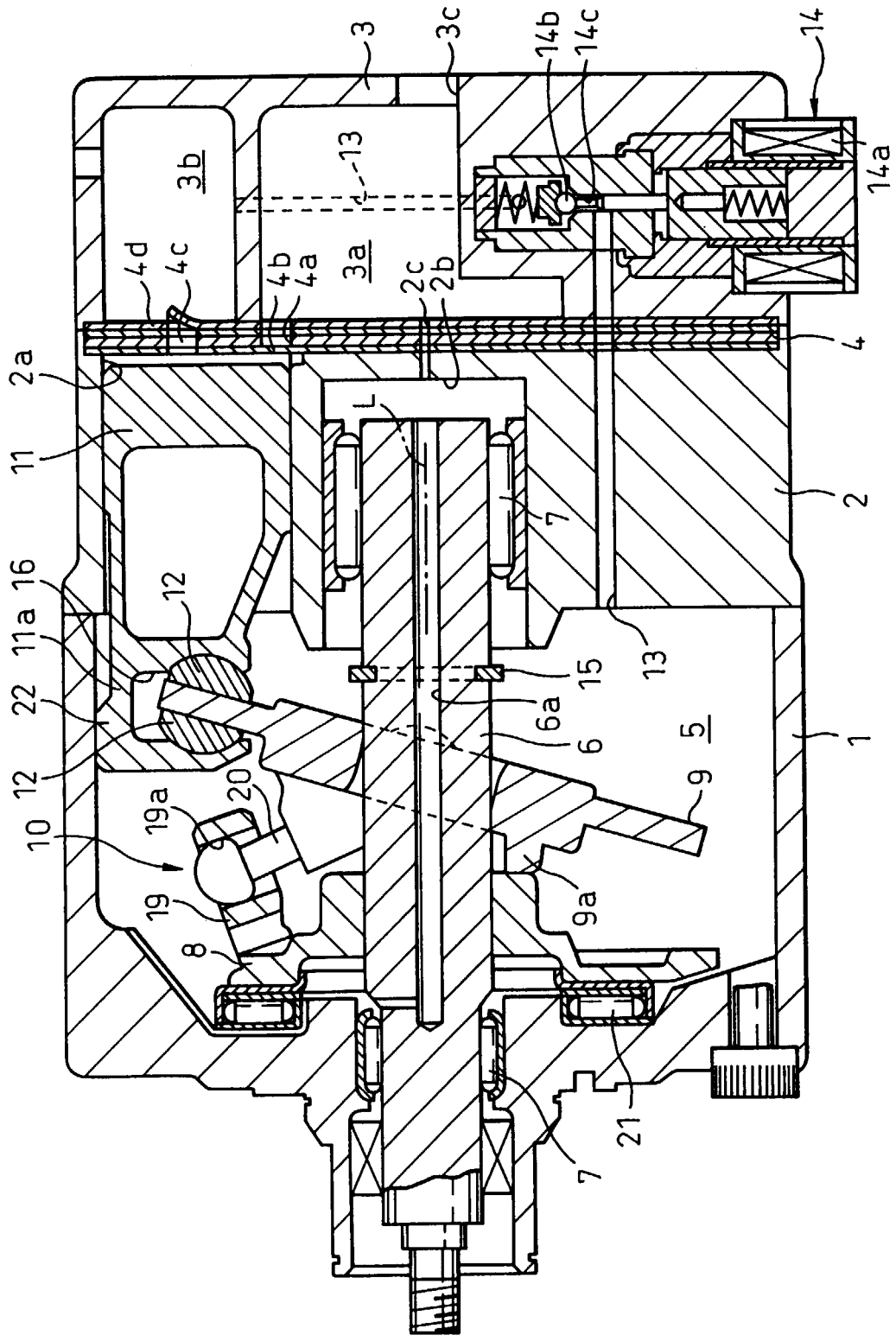


Fig.2

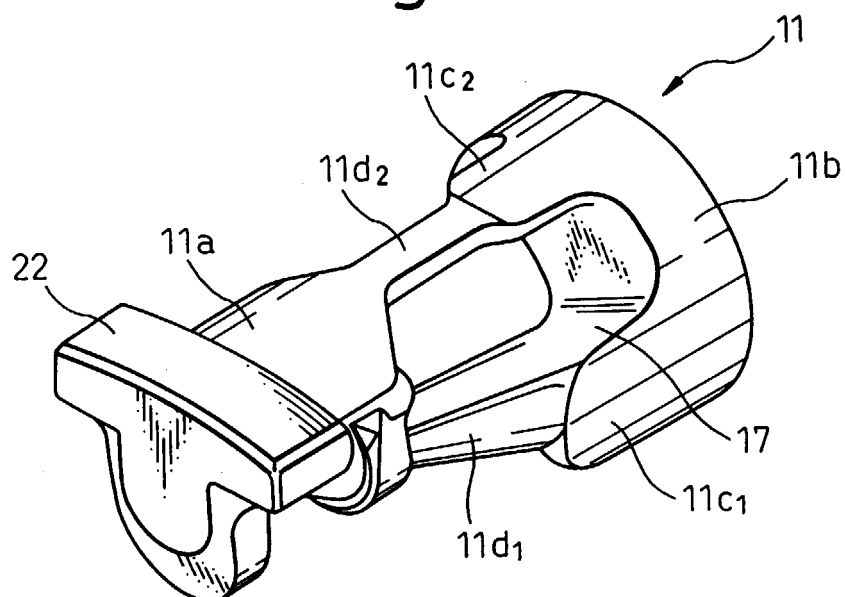


Fig.3

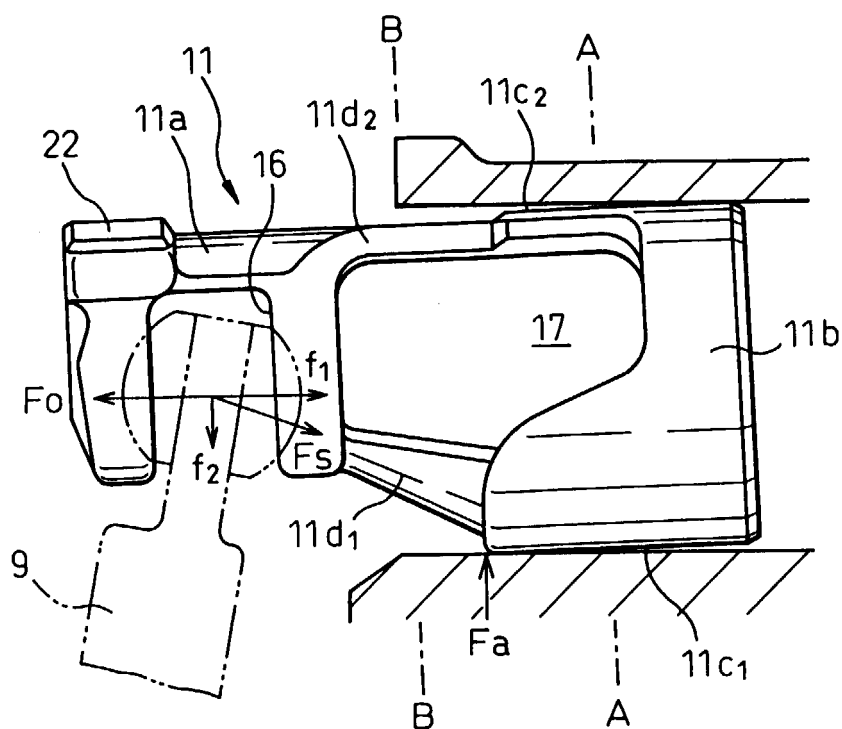


Fig. 4

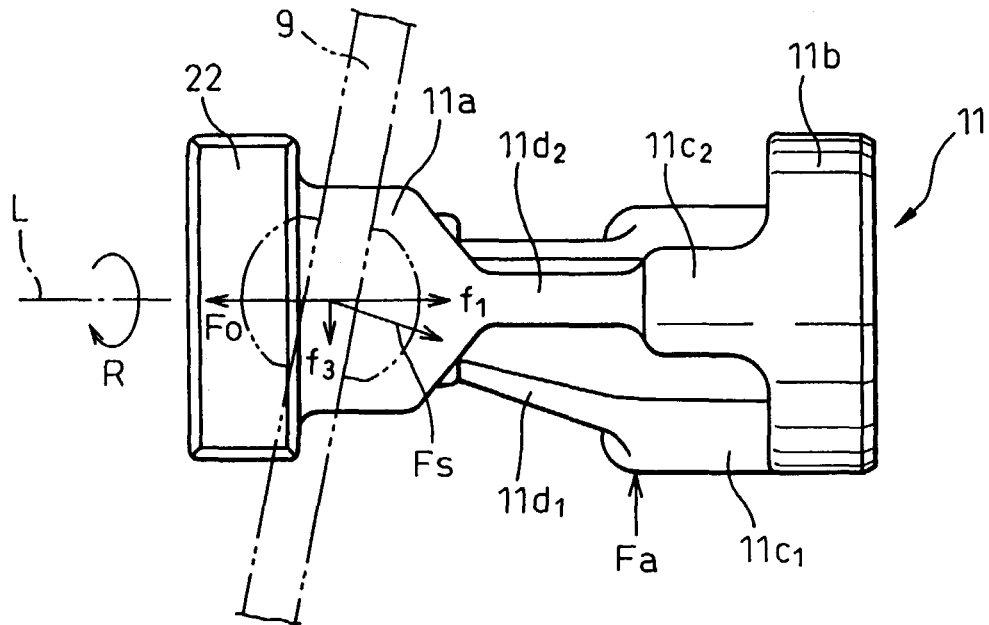


Fig. 5A

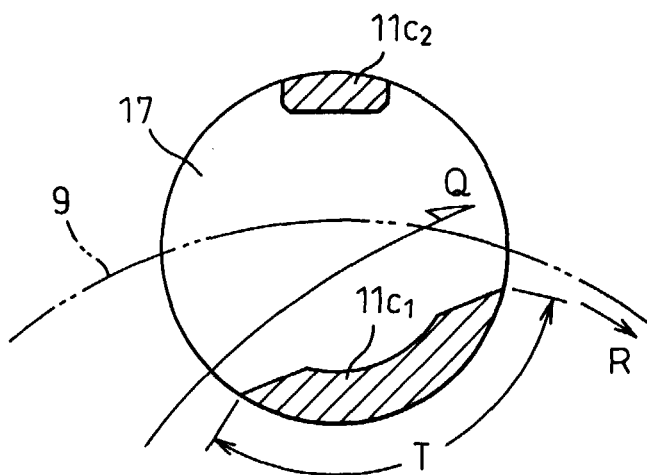


Fig. 5B

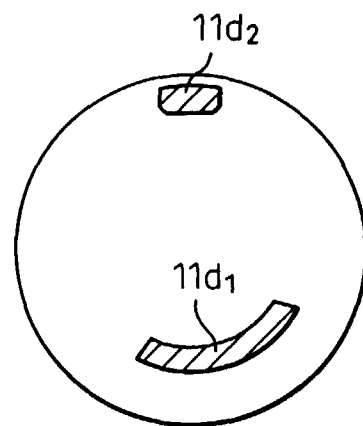


Fig. 6

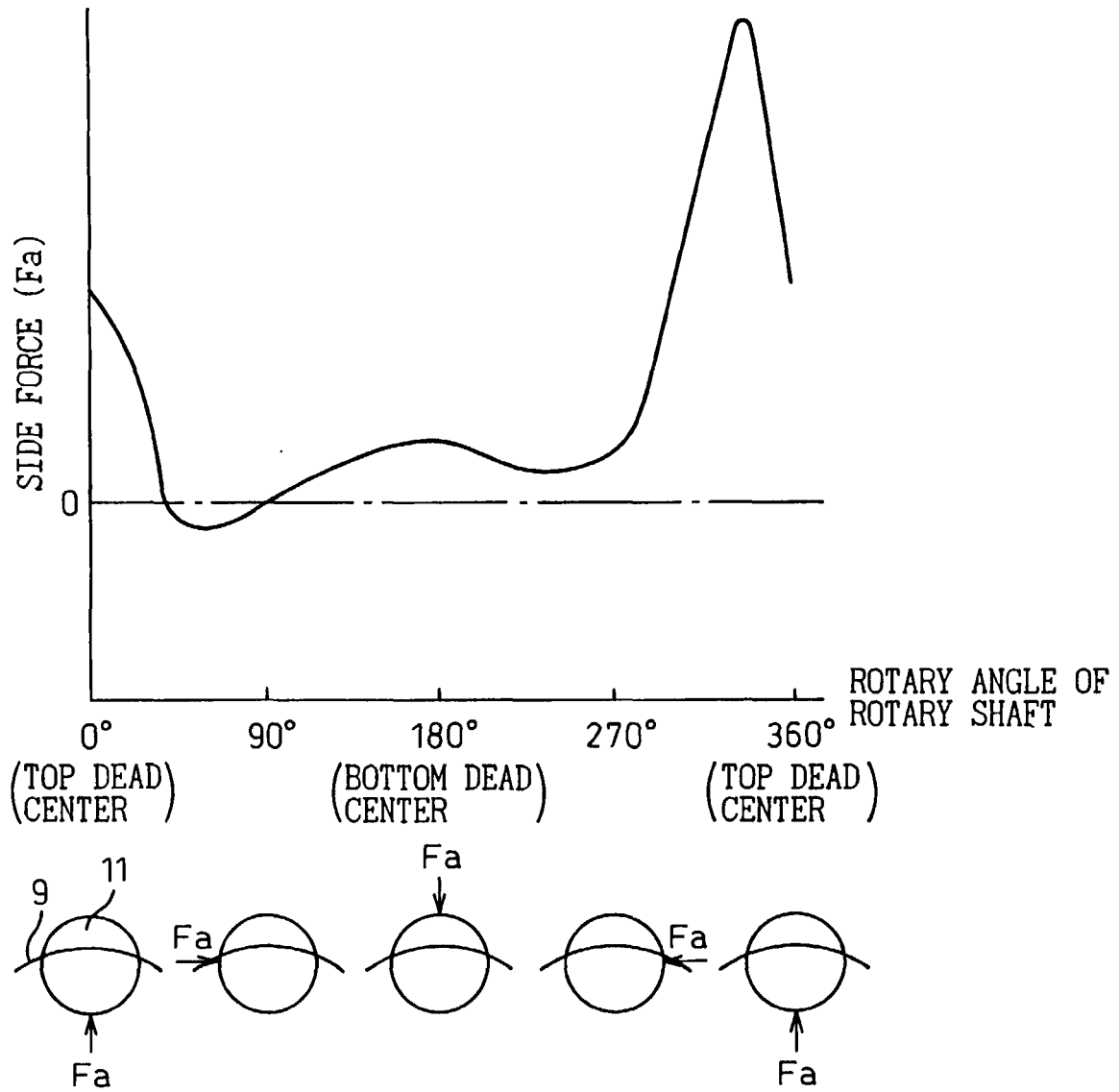


Fig. 7

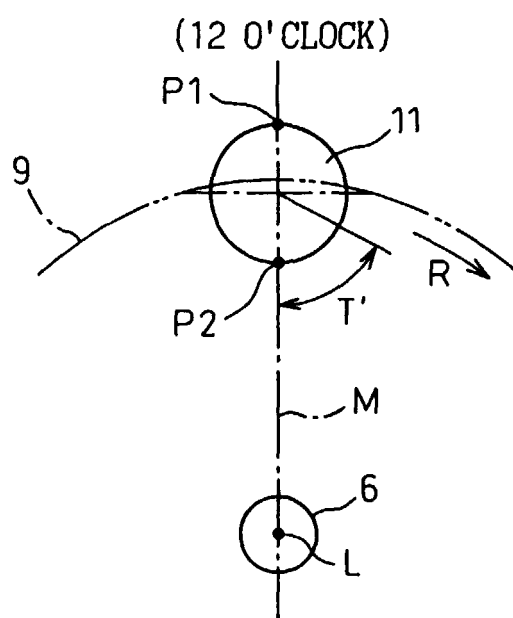


Fig. 8

