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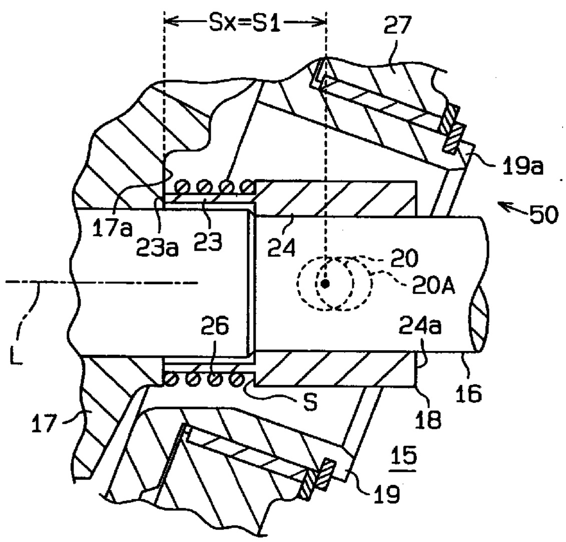
(54) Pivot joint for a swash plate of a variable displacement compressor

(57) A variable displacement compressor the displacement of which depends on the inclination of a drive plate (50). The compressor includes a sleeve (18) fitted on a drive shaft (16). The sleeve (18) supports a pivot joint for supporting the drive plate (50). The maximum inclination of the drive plate (50) depends on the distance (Sx) between the pivot axis of the drive plate (16) and an end that abuts against a limit stop. Therefore changing the sleeve (18) changes the maximum displacement. Changing the sleeve (18) does not alter the balance of the drive plate (50). In compressors having different displacements, all parts are the same except for the sleeve (18), which facilitates mass production.

Fig.2



EP 1 043 500 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a variable displacement compressor, and more particularly, to a compressor in which the maximum displacement is determined by a single part.

[0002] Fig. 5 illustrates a typical variable displacement compressor. A crank chamber 102 and cylinder bores 103 are defined in a compressor housing 101. A drive shaft 104 is supported by the housing 101. A lug plate 105 is fixed to the drive shaft 104. A sleeve 106 is fitted about the drive shaft 104 between the lug plate 105 and the cylinder bores 103. The sleeve 106 slides along the axis L of the drive shaft 104. A drive plate 150 includes a bearing plate 107 and a wobble plate 110. The bearing plate 107 is pivotally supported on the sleeve 106 by pins 108.

[0003] A hinge mechanism 109 causes the bearing plate 107 to rotate integrally with the lug plate 105 and permits the bearing plate 107 to pivot about the pins 108, or to incline relative to the drive shaft 104. The inclination of the bearing plate 107 varies as the sleeve 106 slides on the drive shaft 104.

[0004] Each cylinder bore 103 reciprocally accommodates a piston 111. The pistons 111 are coupled to the wobble plate 110. Rotation of the drive shaft 104 is transmitted to the bearing plate 107 through the lug plate 105 and the hinge mechanism 109. The bearing plate 107 rotates integrally with the drive shaft 104 and relative to the wobble plate 110. Thus, the bearing plate 107 causes the wobble plate 110 to wobble. The wobble motion of the wobble plate 110 causes reciprocation of the pistons 111 when the bearing plate 107 rotates, which compresses gas in the cylinder bores 103.

[0005] The displacement of the compressor of Fig. 5 is adjusted by changing the pressure in the crank chamber 102 with a displacement control valve 112. For example, if the pressure in the crank chamber 102 is decreased, the pressure difference between the crank chamber 102 and the cylinder bores 103 is decreased. The decrease in the pressure difference results a force urging a center portion of the drive plate 150 toward the lug plate 105. Accordingly, the sleeve 106 slides toward the lug plate 105, which increases the inclination of the drive plate 150. A restriction portion A on the bearing plate 107, which is opposite to the hinge mechanism 109 relative to the drive shaft 104, contacts the lug plate 105. The contact between the restriction portion A and the lug plate 105 prevents further inclination of the drive plate 150. In other words, the inclination of the drive plate 150 is maximized when the restriction portion A contacts the lug plate 105. At this time, the compressor displacement is maximized.

[0006] The maximum inclination of the drive plate 150 in the compressor of Fig. 5 is defined by the contact between the bearing plate 107 and the lug plate 105. Thus, to manufacture compressors with drive plates 150 having different maximum inclinations, the thickness T of the restriction portion A of the bearing plate 107 may be altered. Accordingly, compressors having different maximum displacements are manufactured at a relatively low cost by changing the design of the bearing plate 107. Other than the bearing plate 107, the parts are the same in compressors having different maximum displacements.

[0007] However, the bearing plate 107 contacts the lug plate 105 at the restriction portion A, which is radially spaced from the axis L of the drive shaft 104. Therefore, a change of the thickness T of the bearing plate 107 at the restriction portion A unbalances the weight about the axis L, which destabilizes the rotation of members including the drive shaft 104, the bearing plate 107 and the lug plate 105. Accordingly, the reciprocation of the pistons 111 and the inclination of the drive plate 150 are hindered.

[0008] To solve this problem, the weight imbalance about the drive shaft 104 may be computed for each maximum compressor displacement and a counterweight corresponding to the result of the computation may be attached to or removed from the bearing plate 107. However, the computation and the use of a counterweight is troublesome and increase costs.

SUMMARY OF THE INVENTION

[0009] Accordingly, it is an objective of the present invention to provide a variable displacement compressor the maximum displacement of which is changed at a low cost, while maintaining stable rotation of rotating members.

[0010] To achieve the foregoing and other objectives and in accordance with the purpose of the present invention, a variable displacement compressor is provided. The compressor includes a housing having a cylinder bore, a drive shaft supported in the housing, a drive plate supported on the drive shaft, a piston connected to the drive plate, a sleeve fitted on the drive shaft, and a first stopper. The drive plate is driven by the drive shaft. The piston is moved reciprocally in the cylinder bore. The drive plate pivots about a pivot joint and inclines with respect to the drive shaft to change the stroke of the piston and to control the displacement of the compressor. The sleeve slides axially on the drive shaft and supports the pivot joint. Also, the sleeve has a first end. The first stopper stops the sleeve from sliding on the drive shaft when the first end abuts against the first stopper. The first stopper determines the maximum inclination of the drive plate.

[0011] The present invention may also be embodied as a method of setting the maximum displacement of a compressor during the assembly of the compressor. The method includes selecting one of a plurality of different sleeves and installing the sleeve on a drive shaft of the compressor. A certain dimension of the sleeve determines the maximum displacement of the compressor in which it is installed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings.

Fig. 1 is a cross-sectional view illustrating a variable displacement compressor;
Fig. 2 is a partial enlarged cross-sectional view of the compressor shown in Fig. 1;
Fig. 3 is a cross-sectional view illustrating another variable displacement compressor;
Fig. 4 is a partial enlarged cross-sectional view of the compressor shown in Fig. 3; and
Fig. 5 is a cross-sectional view illustrating a prior art variable displacement compressor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] A variable displacement compressor according to one embodiment of the present invention will now be described. The compressor is used in a vehicle air conditioner. The left end of the compressor in Fig. 1 is defined as the front of the compressor, and the right end is defined as the rear of the compressor. As shown in Figs. 1 and 3, a front housing member 11 is secured to the front end face of a cylinder block 12. A rear housing member 13 is secured to the rear end face of the cylinder block 12, and a valve plate 14 is located between the rear housing member 13 and the rear end face of the cylinder block 12. The front housing member 11, the cylinder block 12 and the rear housing member 13 form the compressor housing.

[0014] A crank chamber 15 is defined by the front housing member 11 and the cylinder block 12. A drive shaft 16 extends through the crank chamber 15 and is supported by the front housing member 11 and the cylinder block 12. The drive shaft 16 is rotated by an external drive source such as a vehicle engine.

[0015] A lug plate 17 is fixed to the drive shaft 16 in the crank chamber 15. An annular front stopper 17a is formed on the rear face of the lug plate 17 about the drive shaft 16. The surface of the front stopper 17a is perpendicular to the axis L of the drive shaft 16. The lug plate 17 has a supporting arm 21 projecting toward the cylinder block 12. The supporting arm 21 has an elongate hole 21a.

[0016] A drive plate 50 is located on the drive shaft 16 behind the lug plate 17. The drive plate 50 includes a bearing plate 19 and a wobble plate 27. The bearing plate 19 rotates integrally with the drive shaft 16. The bearing plate 19 rotates relative to the wobble plate 27. A cylindrical sleeve 18 is fitted about the drive shaft 16 between the lug plate 17 and the cylinder block 12. The sleeve 18 slides along the axis L. The bearing plate 19 includes a boss 19a. The boss 19a and the sleeve 18 each have through holes. A pair of pins 20 (only one is shown) are fitted in the through holes. The pins 20 are located on a line that is perpendicular to the axis L of the drive shaft 16. The pins 20 form a pivot joint to pivotally couple the bearing plate 19 to the sleeve 18. A guide rod 28 is located in the crank chamber 15. The guide rod 28 supports the wobble plate 27 and prevents the wobble plate 27 from rotating.

[0017] The bearing plate 19 is coupled to the lug plate 17 by a connecting pin 22. Specifically, the pin 22 is fitted into the elongate hole 21a. The connecting pin 22, the supporting arm 21 and the elongate hole 21a form a hinge mechanism. The hinge mechanism causes the bearing plate 19 to rotate integrally with the lug plate 17 and permits the bearing plate 19 to pivot about the pin 20 relative to the drive shaft 16. The inclination of the bearing plate 19 varies as the sleeve 18 slides on the drive shaft 16.

[0018] The sleeve 18 includes a small diameter portion 23 and a large diameter portion 24, which are integral with each other. A step S is defined between the small diameter portion 23 and the large diameter portion 24. The front end face 23a of the small diameter portion 23 defines the maximum inclination of the bearing plate 19 of the drive plate 50. The rear end face 24a of the large diameter portion 24 defines the minimum inclination of the bearing plate 19. A rear stopper 25, which is, for example, a snap ring, is fitted about the drive shaft 16 between the sleeve 18 and the cylinder block 12. A spring 26 extends between the step S and the lug plate 17. The spring 26 urges the sleeve 18 toward the rear stopper 25.

[0019] Cylinder bores 29 are formed in the cylinder block 12. Each cylinder bore 29 reciprocally accommodates a piston 30. Each piston 30 is connected to the peripheral portion of the wobble plate 27 of the drive plate 50 by a rod 31.

[0020] Rotation of the drive shaft 16 is transmitted to the bearing plate 19 of the drive plate 50 by the lug plate 17 and the hinge mechanism 21, 22. The lug plate 17 and the hinge mechanism 21, 22 convert rotation of the drive shaft 16 into rotating and wobbling motion of the bearing plate 19. Since the bearing plate 19 rotates relative to the wobble plate 27, only the wobbling motion of the bearing plate 19 is transmitted to the wobble plate 27. Force is transmitted from the wobble plate 27 to the pistons 30 through the rods 31, which reciprocate each piston 30 between the top dead center and the bottom dead center.

[0021] A suction chamber 32 and a discharge chamber 33 are defined in the rear housing member 13. When moved from the top dead center to the bottom dead center, each piston 30 draws refrigerant gas from the suction chamber 32 to the associated cylinder bore 29 via a suction port 34 and a suction valve flap 35, which are formed in the valve plate 14. Refrigerant gas in each cylinder bore 29 is compressed to reach a predetermined pressure as the associated piston 30 is moved from the bottom dead center to the top dead center and is discharged to the discharge chamber 33 via a discharge port 36 and a discharge valve flap 37, which are formed in the valve plate 14.

[0022] The discharge chamber 33 is connected to the crank chamber 15 by a pressurizing passage 38. The crank chamber 39 is connected to the suction chamber 32 by a bleeding passage 39. The bleeding passage 39 is regulated by a displacement control valve 40.

[0023] The control valve 40 opens or closes the bleeding passage 39 to adjust the flow rate of refrigerant gas from the crank chamber 15 to the suction chamber 32. Compressed refrigerant gas in the discharge chamber 33 is conducted to the crank chamber 15 by the pressurizing passage 38. The pressure in the crank chamber 15 is altered by changing the amount of refrigerant gas introduced to and released from the crank chamber 15.

[0024] For example, when the pressure in the crank chamber 15 is increased, the pressure difference between the crank chamber 15 and the cylinder bores 29 is also increased. The increased pressure difference applies a force directed toward the cylinder block 12 to the radial center of the drive plate 50, which causes the sleeve 18 to slide on the drive shaft 16 toward the cylinder block 12. Accordingly, the drive plate 50 is pivoted counterclockwise (from the viewpoint of Fig. 1) about the pins 20 and the inclination of the drive plate 50 is decreased. If the sleeve 18 slides toward the cylinder block 12, the rear end face 24a contacts the rear stopper 25, which defines the minimum inclination of the drive plate 50.

[0025] When the pressure in the crank chamber 15 is decreased, the pressure difference between the crank chamber 15 and the cylinder bores 29 is also decreased. The effect of the reduced difference is a force directed toward the lug plate 17 at the radial center of the drive plate 50, which causes the sleeve 18 to slide on the drive shaft 16 toward the lug plate 17. Accordingly, the drive plate 50 is pivoted clockwise about the pins 20 and the inclination of the drive plate 50 is increased. If the sleeve 18 slides toward the lug plate 17, the front end face 23a contacts the front stopper 17a on the lug plate 17, which defines the maximum inclination of the drive plate 50.

[0026] In this manner, the inclination of the drive plate 50 is altered by changing the pressure difference between the crank chamber 15 and the cylinder bores 29. As a result, the stroke of the pistons 30 is altered and the compressor displacement is varied. When the drive plate 50 is at the minimum inclination position, as illustrated by broken lines in Fig. 1, the compressor displacement is minimized. When the drive plate 50 is at the maximum inclination, as illustrated by solid lines in Fig. 1, the compressor displacement is maximized.

[0027] When the external drive source stops the compressor, that is, when the drive shaft 16 is stopped, the pressures in the chambers of the compressor become equal. At this time, the sleeve 18 is moved to an initial position by the force of the spring 26, where the sleeve 18 contacts the rear stopper 25. As result, the inclination of the drive plate 50 is minimized. When the compressor is started again, the displacement of the compressor is minimized, which minimizes the torque. The shock caused by starting the compressor is thus reduced.

[0028] The distance between the front end face 23a and the pivot axis (the axis of the pins 20) of the drive plate 50 is designated as Sx. As shown in Fig. 2, the dimension Sx of the compressor shown in Fig. 1 is S1. The dimension Sx determines the maximum inclination of the drive plate 50. That is, since the position of the rear stopper 25 is fixed, when Sx increases, the sliding range of the sleeve 18 decreases, which decreases the maximum inclination of the drive plate 50. When Sx decreases, the sliding range of the sleeve 18 increases, which increases the maximum inclination of the drive plate 50.

[0029] Figs. 3 and 4 illustrate a compressor that has a smaller maximum displacement than the compressor of Figs. 1 and 2. In the compressor shown in Figs. 3 and 4, the length of the small diameter portion 23 of the sleeve 18 along the axis L is longer than that of the compressor shown in Figs. 1 and 2. The dimension Sx between the axis of the pins 20 and the front end face 23a is a distance S2, which is longer than the distance S1 (S2>S1). The parts other than the sleeve 18 are the same as that of the compressor shown in Figs. 1 and 2. That is, the maximum displacement of the compressors of Figs. 1 to 4 can be altered by changing the sleeve 18, or by adjusting the dimension Sx. Parts other than the sleeve 18 are common to both compressors and therefore can be mass-produced, which reduces costs.

[0030] The common parts are assembled on the same assembly line. When installing the sleeve 18, sleeves 18 having different dimensions Sx (S1 and S2) are prepared. One of the two sleeves 18 is selected according to the desired maximum displacement and installed in each compressor.

[0031] As described above, the maximum displacement of compressors can be changed simply changing the dimension Sx between the end face 23a of the small diameter portion 23 and the axis of the pins 20. The sleeve 18 is cylindrical and is supported on the drive shaft 16. Therefore, when changing the dimension Sx, the length of the sleeve 18 is uniformly changed about the entire circumference. Thus, changing the dimension Sx does not unbalance the lug plate 17, the bearing plate 19 and the wobble plate 27. The smooth reciprocation of the pistons 30 and the smooth tilting of the drive plate 50 are not hindered. In other words, the balance of the rotating members need not be adjusted when changing the dimension Sx. This simplifies the manufacture of compressors having different maximum displacements.

[0032] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. More particularly, the present invention may be modified as described below.

[0033] In the illustrated embodiment, the length of the small diameter portion 23 along the axis L is changed to vary the dimension Sx between the pivot axis of the drive plate 50 (the axis of the pins 20) and the front end face 23a. Instead, the position of the pins 20 may be changed as shown by 20A in Fig. 2. If the pin position is changed, the length of the large diameter portion 24 along the axis L must be adjusted to maintain the minimum compressor displacement.

[0034] The compressor shown in Figs. 1 and 2 and the compressor shown in Figs. 3 and 4 may be assembled in different lines. This eliminates the necessity for selecting from sleeves 18 having different lengths.

[0035] The number of compressors that have different maximum displacement is not limited to two. Three or more compressors having different maximum displacement may be manufactured.

[0036] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0037] A variable displacement compressor the displacement of which depends on the inclination of a drive plate (50). The compressor includes a sleeve (18) fitted on a drive shaft (16). The sleeve (18) supports a pivot joint for supporting the drive plate (50). The maximum inclination of the drive plate (50) depends on the distance (Sx) between the pivot axis of the drive plate (16) and an end that abuts against a limit stop. Therefore changing the sleeve (18) changes the maximum displacement. Changing the sleeve (18) does not alter the balance of the drive plate (50). In compressors having different displacements, all parts are the same except for the sleeve (18), which facilitates mass production.

Claims

1. A variable displacement compressor wherein a drive plate (50) is supported on a drive shaft (16) so that the drive plate (50) pivots about a pivot joint and inclines with respect to the drive shaft (16) in a housing (11, 12, 13), wherein pistons (30) connected to the drive plate (50) are moved reciprocally in cylinder bores (29), wherein the inclination of the drive plate controls the displacement of the compressor, the compressor being characterized by:

   a sleeve (18) fitted on the drive shaft (16), wherein the sleeve (18) slides axially on the drive shaft (16), and the sleeve (18) supports the pivot joint, the sleeve (18) having a first end (23a); and
   a first stopper(17a) for stopping the sleeve (18) from sliding on the drive shaft when the first end (23a) abuts against the first stopper, wherein the first stopper determines the maximum inclination of the drive plate (50).

2. The compressor according to claim 1 further comprising a lug plate (17) fixed to the drive shaft (16), the first stopper (17a) being formed on the lug plate (17).

3. The compressor according to claim 2, wherein the drive plate (50) includes a bearing plate (19), which is driven by the lug plate (17), and a wobble plate (27), which is fitted to the bearing plate (19), wherein the bearing plate (19) rotates relative to the wobble plate(27), and wherein each piston (30) is connected to the wobble plate(27).

4. The compressor according to any one of claims 1 to 3, wherein the maximum inclination of the drive plate (50) depends on the distance (Sx) between the pivot axis of the pivot joint and the first end (23a).

5. The compressor according to claims any one of claims 1 to 4, wherein the sleeve (18) includes a second end (24a) opposite to the first end (23a), wherein a second stopper (25) is attached to the drive shaft (16), the second stopper (25) being opposite to the first stopper (17a) with respect to the drive plate (50), and wherein the second stopper (25) stops the sleeve (18) from sliding on the drive shaft (16) when the second end (24a) abuts the second stopper (25), such that the second stopper (25) determines the minimum inclination of the drive plate (50).

6. The compressor according to claim 5, wherein the sleeve (18) includes:

   a small diameter portion (23) on which the first end (23a) is formed;
   a large diameter portion (24) on which the second end (24a) is formed; and
   a stepped portion (S) between the small diameter portion (23) and the large diameter portion(24); wherein a spring (26) is positioned between the lug plate (17) and the stepped portion (S) to urge the sleeve (18) toward against the second stopper (25).

7. The compressor according to claim 6, wherein the maximum inclination of the drive plate (50) depends on the axial length of the small diameter portion (23).

8. The compressor according to claim 4, wherein the maximum inclination of the drive plate (50) depends on the axial position of the axis of the pivot joint on the sleeve (18).

9. The compressor according to claim 8, wherein the pivot joint includes a pin (20), and wherein the maximum inclination of the drive plate (50) depends on the axial position of the axis of the pin (20) on the sleeve (18).

10. The compressor according to claim 3 further comprising

a hinge mechanism (21,22) coupling the bearing plate (19) to the lug plate (17), wherein the hinge mechanism (21,22) drives the bearing plate (19) and permits the bearing plate (19) to incline with respect to the axis of the drive shaft (16).

11. A method of setting the maximum displacement of a compressor during the assembly of the compressor, the method comprising selecting one of a plurality of different sleeves (18) and installing the sleeve (18) on a drive shaft (16) of the compressor, wherein a certain dimension of the sleeve (18) determines the maximum displacement of the compressor in which it is installed.

Fig.1

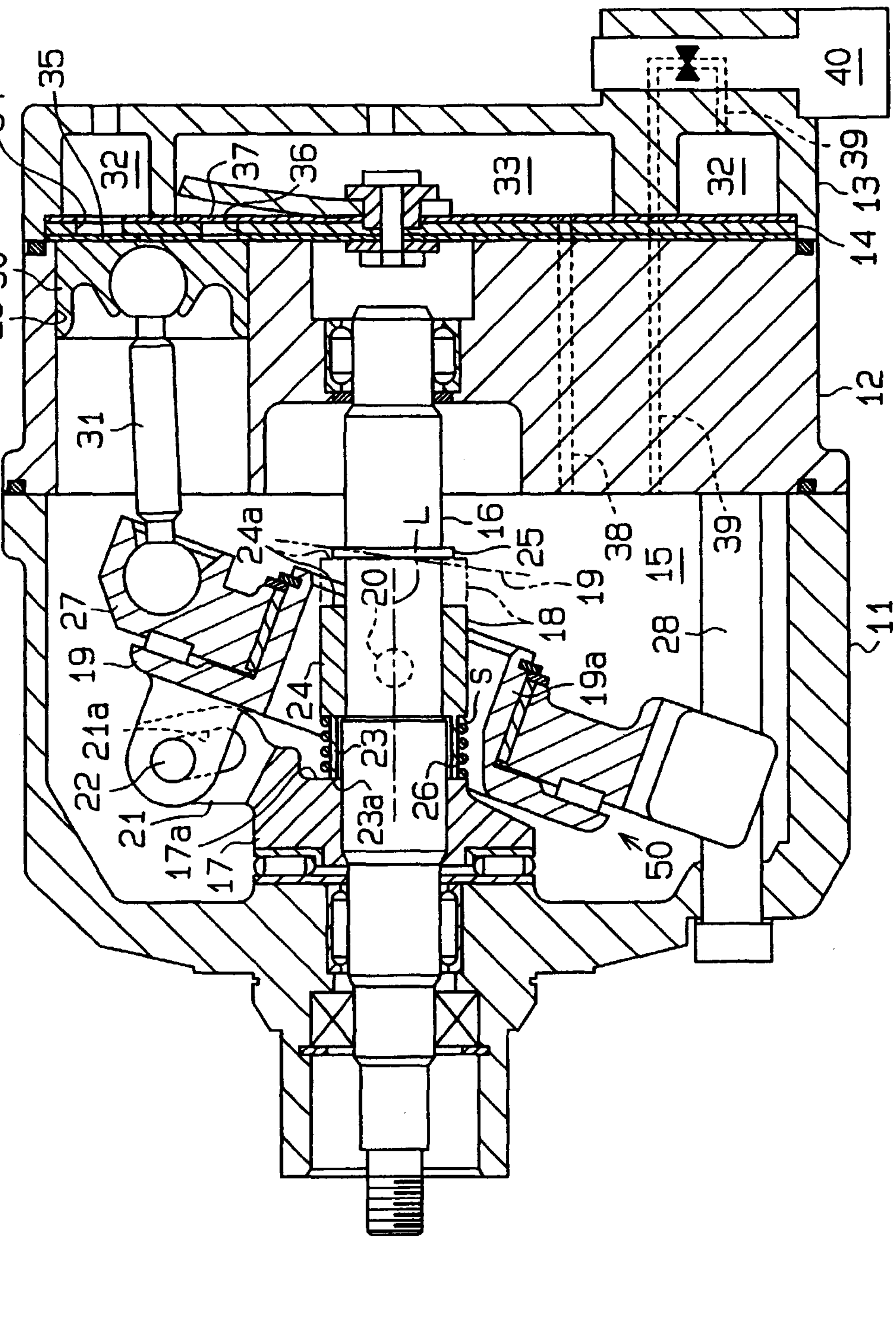

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Fig.2

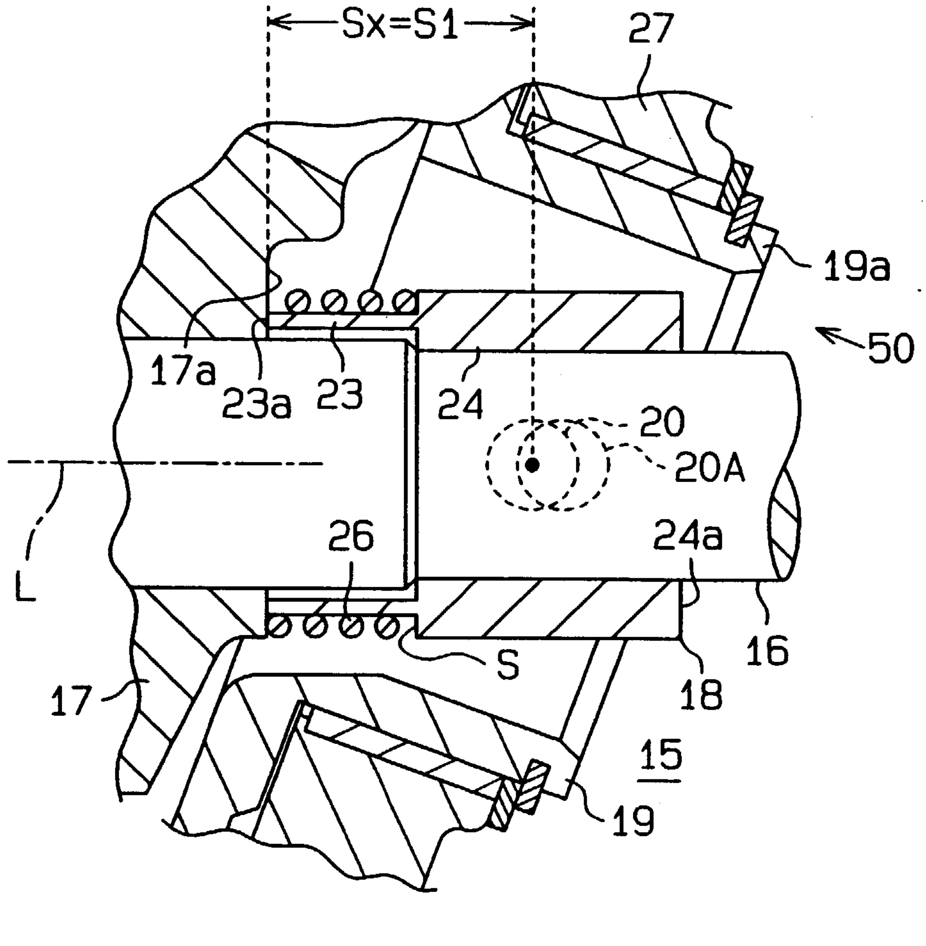

Fig. 3

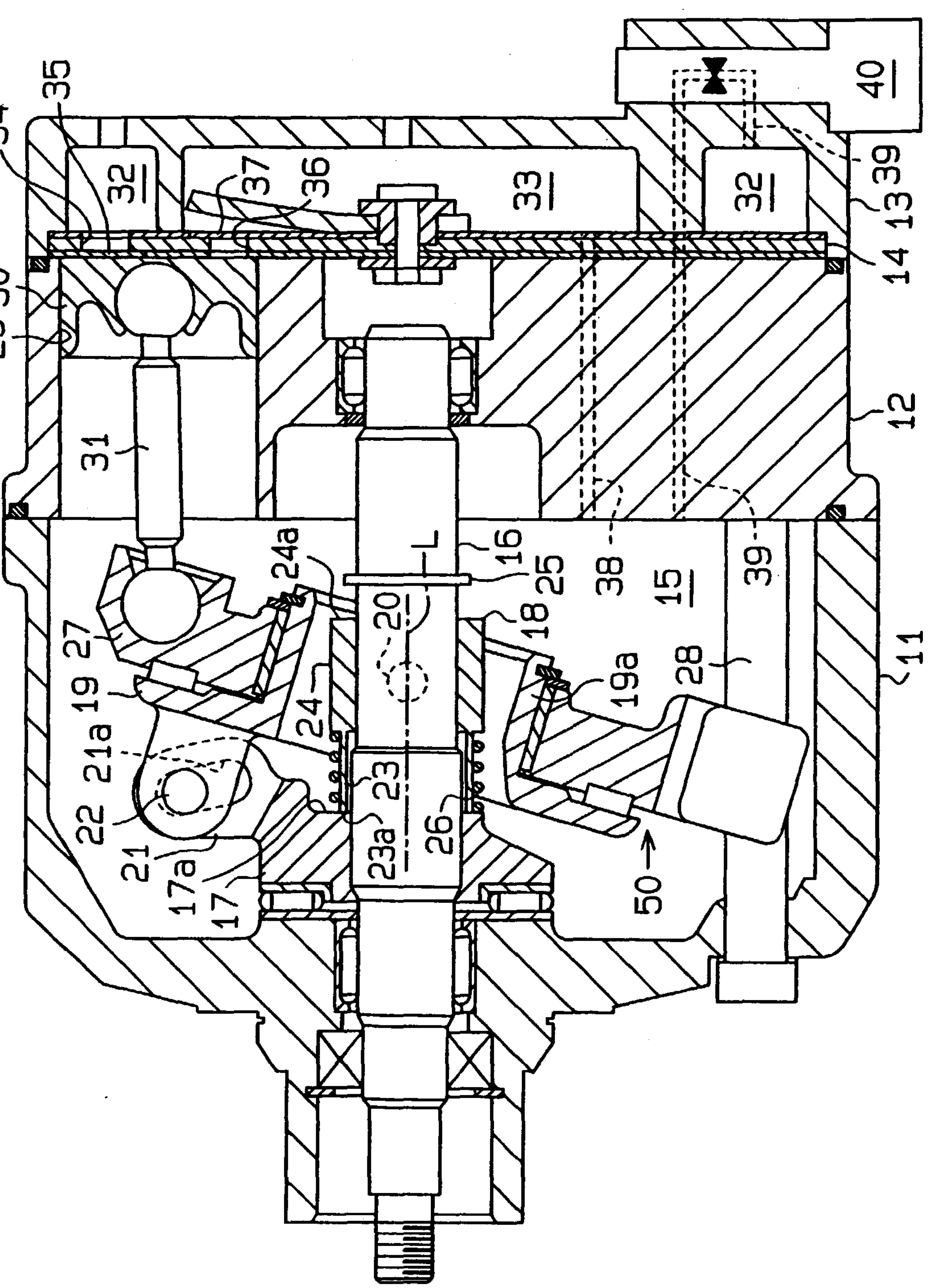
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Fig.4

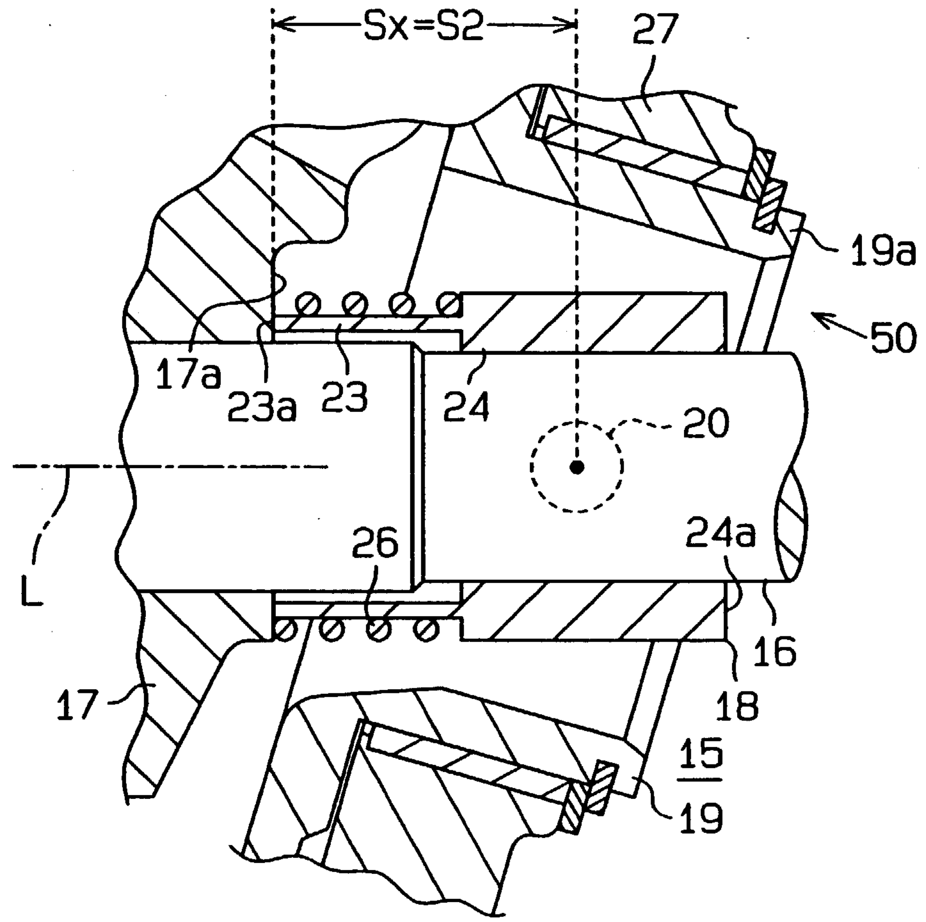

Fig.5