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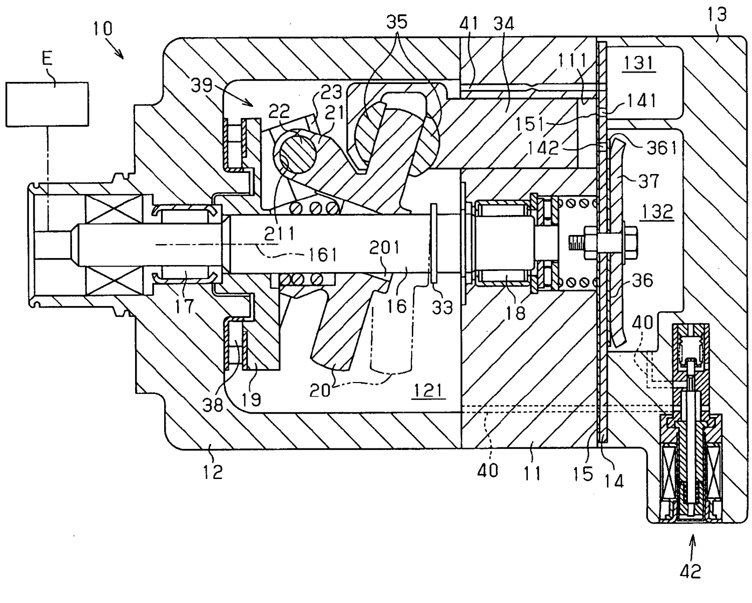
(54) Variable displacement compressor

(57) A variable displacement compressor has a pin for forming a part of connecting mechanism interposed between a cam member and a rotary support. When one of the cam member and the rotary support forms a part of support while the other forms a part of pin guide, the connecting mechanism has a pin supported by the support, a first guide portion and a second guide portion which are provided in the pin guide. The first guide portion has a first guide surface that guides an end face of the first end of the pin, and the second guide portion has a second guide surface that guides an end face of the second end of the pin. When the pin comes in contact with the first or second guide surface, the pin comes in contact with only one of the first and second guide surfaces.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a variable displacement compressor having a cam member which is inclinably connected to a rotary support fixed on a rotary shaft through a connecting mechanism and operable to control its displacement by controlling the pressure in a pressure control chamber having therein the cam member thereby to change the inclination angle of the cam member.

[0002] The Japanese Patent Application Publication No. 10-274154 discloses a connecting mechanism for a swash plate of a variable displacement compressor. In this prior art, the swash plate (cam member) is provided with a pin. The rotor (rotary support) which is rotatable with the rotary shaft is provided with a pair of engaging portions each having a groove. In another example, the rotor is provided with a pin and the swash plate is provided with a pair of engaging portions.

[0003] The connecting mechanism is so arranged that the opposite ends (connecting portions) of the pin are guided in the pair of grooves, respectively. The swash plate is inclinably supported by the spherical bushing which is slidable along the circumferential surface of the rotary shaft. Thus guiding the opposite ends of the pin in the pair of grooves enables the swash plate to incline about the spherical bushing.

[0004] FIG. 6 shows an example of the connecting mechanism in which a pair of pins 2 is provided in an arm member 1A formed as a part of the swash plate 1 and a pair of grooves 4 is formed in engaging portions 3A, 3B formed as a part of the rotor 3. One end of each pin 2 has angled portions 5, 6. This connecting mechanism allows the angled portions 5, 6 to respectively come in contact with an inclined surface 7 and a guide surface 8 which form the groove 4.

[0005] If the angled portions 5 of the pins 2 simultaneously come in contact with the inclined surfaces 7 of the engaging portions 3A, 3B when the pins 2 are inclined, the pins 2 will be held or bound between the pair of engaging portions 3A, 3B (a pair of guide portions) in the axial direction of the pin 2. This badly affects the motion of the pins 2 in the grooves 4, thereby reducing the displacement controllability.

[0006] The present invention is directed to a variable displacement compressor wherein a pin forming a part of the connecting mechanism interposed between a cam member and a rotary support will not be bound between a pair of guide portions in the direction of an axis of the pin.

SUMMARY OF THE INVENTION

[0007] In accordance with an aspect of the present invention, a variable displacement compressor includes a rotary shaft, a cam member which is rotatable with the rotary shaft, a piston which is operable in conjunction with rotation of the rotary shaft through the cam member, and a rotary support fixed on the rotary shaft. The cam member is connected to the rotary support through a connecting mechanism in such a way that inclination angle of the cam member is variable. When one of the cam member and the rotary support forms a part of support while the other of the cam member and the rotary support forms a part of pin guide, the connecting mechanism has a pin supported by the support, a first guide portion and a second guide portion which are provided in the pin guide. The first guide portion guides a first end of the pin in accordance with the variation of the inclination angle of the cam member and the second guide portion guides a second end of the pin in accordance with the variation of the inclination angle of the cam member. The inclination angle of the cam member is varied and displacement of the compressor is varied by controlling pressure in a pressure control chamber having therein the cam member. The variable displacement compressor is characterized in that the first guide portion has a first guide surface that guides an end face of the first end, in that the second guide portion has a second guide surface that guides an end face of the second end, and in that when the pin comes in contact with the first guide surface or the second guide surface, the pin comes in contact with only one of the first guide surface and the second guide surface.

[0008] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] 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 in which:

FIG. 1 is a longitudinal sectional view showing a variable displacement compressor according to a first embodiment of the present invention;

FIG. 2A is a partial plan view of FIG. 1;

FIG. 2B is a partial view showing plane cross section of FIG. 2A;

FIG. 3A is a partially broken plan view showing a state of FIG. 2B wherein a pin is not inclined;

FIG. 3B is a partially broken plan view showing a state of FIG. 2B wherein the pin is inclined;

FIG. 3C is a diagram which is referred to in giving the expression (1);

FIG. 4A is a partially broken plan view showing a state of a variable displacement compressor according to a second embodiment of the present invention wherein a pin is not inclined;

FIG. 4B is a partially broken plan view showing a state of the variable displacement compressor according to the second embodiment of the present invention wherein the pin is inclined;

FIG. 5 is a partial view showing plane cross section of a variable displacement compressor according to a third embodiment of the present invention; and

FIG. 6 is a partially broken plan view showing a prior art variable displacement compressor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The following will describe a first embodiment of a variable displacement compressor according to the present invention with reference to FIGs. 1 through 3C. Referring firstly to FIG. 1, the variable displacement compressor designated by numeral 10 includes a cylinder block 11 and a front housing 12 which is connected to the front end of the cylinder block 11. A rear housing 13 is connected to the rear end of the cylinder block 11 through a valve plate 14 and a suction valve forming plate 15. The cylinder block 11, the front housing 12 and the rear housing 13 cooperate to form a housing of the variable displacement compressor 10.

[0011] A rotary shaft 16 is rotatably supported by the front housing 12 and the cylinder block 11 through radial bearings 17, 18, respectively. The front housing 12 and the cylinder block 11 cooperate to form a pressure control chamber 121. The rotary shaft 16 extends out of the pressure control chamber 121 and is connected to a vehicle engine E that serves as an external drive source for receiving therefrom a driving force.

[0012] A rotary support 19 is fixedly mounted on the rotary shaft 18, and a swash plate 20 that serves as a cam member is supported by the rotary shaft 16 in such a way that it is slidable in the direction of the axis 161 of the rotary shaft 16 and also inclinable relative to the axis 161. The rotary shaft 16 is inserted through a hole 201 formed at the center of the swash plate 20 in such a way that the swash plate 20 is slidable along the outer circumferential surface of the rotary shaft 16 through the peripheral wall of the hole 201.

[0013] Referring to FIG. 2A, the swash plate 20 has a support arm 21 formed integrally therewith on the side opposite to the rotary support 19. As shown in FIG. 2B, the support arm 21 has a hole 211 extending in the direction perpendicular to the axis 161 of the rotary shaft 16 and a pin 22 is press-fitted in the hole 211. The pin 22 has a mid portion 221 which is held and supported by the support arm 21. The swash plate 20 and the support arm 21 cooperate to form a support for the pin 22.

[0014] The pin 22 has guided portions 25, 26 which are formed integral with and on the opposite sides of the mid portion 221, as shown in FIG. 2B. The guided portions 25, 26 correspond to first and second ends of the present invention, respectively.

[0015] As shown in FIG. 3A, the guided portion 25 has a cylindrical surface 251, a conical surface 252 and an end face 253 which are formed in continuity with each other in this order. The cylindrical surface 251 and the conical surface 252 serve as a circumferential surface of the present invention. The boundary between the conical surface 252 and the end face 253 which is designated by numeral 254 is formed by an angled portion in the form of an obtuse angle. The boundary between the conical surface 252 and the cylindrical surface 251 which is designated by numeral 255 is also formed by an angled portion in the form of an obtuse angle. The guided portion 26 has a cylindrical surface 261, a conical surface 262 and an end face 263 which are formed in continuity with each other in this order. The cylindrical surface 261 and the conical surface 262 serve as a circumferential surface of the present invention. The boundary between the conical surface 262 and the end face 263 which is designated by numeral 264 is also formed by an angled portion in the form of an obtuse angle. The boundary between the conical surface 262 and the cylindrical surface 261 which is designated by numeral 265 is also formed by an angled portion in the form of an obtuse angle.

[0016] As shown in FIG. 2A, the rotary support 19 has a pair of guide arms 23, 24 formed integrally therewith on the side opposite to the swash plate 20. The guide arms 23, 24 serve as first and second guide portions of the present invention, respectively. The guide arm 23 has a first guide wall 27, a second guide wall 28 and a third guide wall 29 and the guide arm 24 has a fourth guide wall 30, a fifth guide wall 31 and a sixth guide wall 32.

[0017] As shown in FIG. 2B, the first guide wall 27 has a guide plane 271 serving as a third guide surface which is allowed to come in contact with a part of the cylindrical surface 251 adjacent to the swash plate 20. The second guide wall 28 has a guide plane 281 serving as a fourth guide surface which is allowed to come in contact with a part of the cylindrical surface 251 adjacent to the rotary support 19. The third guide wall 29 has a guide plane 291 serving as a first guide surface which is allowed to come in contact with the end face 253. The guide planes 271, 281, 291 are formed so as to guide the pin 22 in the direction that is perpendicular to an axis 222 of the pin 22 and also in a direction that is inclined from the axis 161 of the rotary shaft 16. The third guide wall 29 performs the function of restricting the movement in the direction of the axis 222 of the pin 22.

[0018] The fourth guide wall 30 has a guide plane 301 serving as a fifth guide surface which is allowed to come in contact with a part of the cylindrical surface 261 adjacent to the swash plate 20. The fifth guide wall 31 has a guide plane 311 serving as a sixth guide surface which is allowed to come in contact with a part of the cylindrical surface 261 adjacent to the rotary support 19. The sixth guide wall 32 has a guide plane 321 serving as a second guide surface which is allowed to come in contact with the end face 263. The guide planes 301, 311, 321 are formed so as to guide the pin 22 in the direction that is the perpendicular to the axis 222 of the pin 22 and also in the direction that is inclined from the axis 161 of the rotary shaft 16. The sixth guide wall 32 performs the function of restricting the movement in the direction of the axis 222 of the pin 22.

[0019] The guide arm 23 guides the guided portion 25 and the guide arm 24 guides the guided portion 26. The rotary support 19 and the guide arms 23, 24 form a pin guide. The guide planes 271, 301 are flush with each other in a plane and the guide planes 281, 311 are flush with each other in a plane which is different from the plane for the guide planes 271, 301. The guide planes 271, 301 are in parallel with the guide planes 281, 311 and the guide plane 291 is in parallel with the guide plane 321. The guide plane 291 is perpendicular to the guide planes 271, 281, and the guide plane 321 is perpendicular to the guide planes 301, 311.

[0020] FIG. 3A shows a state of the pin 22 where the cylindrical surface 251 of the guided portion 25 is in contact with the guide plane 281 and the cylindrical surface 261 of the guided portion 26 is in contact with the guide plane 311. In the following description, the state of the pin 22 as shown in FIG. 3A will be referred to as a non-inclination state of the pin. The state where the cylindrical surface 251 is in contact with the guide plane 271 and the cylindrical surface 261 is in contact with the guide plane 301 will be also referred to as a non-inclination state of the pin.

[0021] The spacing W between the guide planes 271, 281 is set larger than the diameter d of a circle for the cylindrical surface 251. In the state of FIG. 3A, there is a clearance C11 between the guide plane 271 and the cylindrical surface 251. Similarly, the spacing W between the guide planes 301, 311 is set larger than the diameter d of a circle for the cylindrical surface 261. In the state of FIG. 3A, there is a clearance C12 between the guide plane 301 and the cylindrical surface 261. Since the clearances C11 and C12 have the same dimension, the clearances C11, C12 and their dimension will be designated by reference symbol C1 in the following description. The clearance C1 refers to the clearance which is formed between the guide arms 23, 24 and the pin 22 as measured in the direction perpendicular to the axis 222 of the pin 22.

[0022] In the state of FIG. 3A, there exists a clearance C2 between the end face 263 of the guided portion 26 and the guide plane 321 of the sixth guide wall 32. When the end face 263 is in contact with the guide plane 321, a clearance C2 is formed between the end face 253 of the guided portion 25 and the guide plane 291. In the following description, the dimension of the clearance C2 is designated by reference symbol C2. The clearance C2 refers to the clearance between the guide arms 23, 24 and the pin 22 as measured in the direction of the axis 222 of the pin 22.

[0023] FIG. 3B shows a state where the pin 22 is inclined and the boundary 255 of the pin 22 is in contact with the guide plane 271 and the boundary 265 of the pin 22 is in contact with the guide plane 311. Reference symbol L1 in FIG. 3B denotes the length of the pin 22 in the direction of its axis 222 between a contact point 255P between the boundary 255 and the guide plane 271 and a contact point 265P between the boundary 265 and the guide plane 311.

[0024] Reference symbol L21 in FIGs. 3A, 3B denotes the length corresponding to the diameter of a circle made by the boundary 254. In other words, the length L21 corresponds to the maximum distance between any two points on the boundary 254 which is allowed to come in contact with the guide plane 291. In the case of FIG. 3B, the distance between the two contact points 254P, 254Q on the boundary 254 corresponds to the length L21. Reference symbol L22 in FIGs. 3A, 3B denotes the length corresponding to the diameter of a circle made by the boundary 264. In other words, the length L22 corresponds to the maximum distance between any two points on the boundary 264 which is allowed to come in contact with the guide plane 321. In the case of FIG. 3B, the distance between the two contact points 264P, 264Q on the boundary 264 corresponds to the length L22. Since the lengths L21 and L22 have the same dimension, the lengths L21, L22 will be designated by reference symbol L2 in the following description.

[0025] The clearances C1, C2 and the lengths L1, L2 are set so as to satisfy the relation of the expression (1).

$$C2 > C1 \cdot L2 / L1 \qquad (1)$$

The expression (1) can be formulated as explained below while having reference to a figure F shown in FIGs. 3B and 3C.

[0026] The line segment 255S of the figure F shown in FIG. 3C represents the line segment of the end face 253 of FIG. 3B which has been displaced in parallel so that the contact point 254P is moved to the contact point 255Q in FIG. 3B. The line segment 265S of the figure F shown in FIG. 3C represents the line segment of the end face 263 of FIG. 3B which has been displaced in parallel so that the contact point 264Q is moved to the contact point 265P in FIG. 3B. The line segment S3 of the figure F shown in FiGs. 3B and 3C represents the line segment between the contact points 254Q and 264P which have been moved by the parallel displacement, the length of which is L1. The line segment S4 of the figure F shown in FIGs. 3B and 3C represents the line segment between the contact points 254P and 264Q which have been moved by the parallel displacement, the length of which is L1. The line segment 291 S shown in FIGs. 3B and 3C represents the line segment of the guide plane 291 which has been displaced in parallel so that the guide plane 291 comes in contact with the contact point 254P which has been moved by the parallel displacement. The line segment 321S shown in FIGs. 3B and 3C represents the line segment of the guide plane 321 which has been displaced in parallel so that the guide plane 321 comes in contact with the contact point 264P which has been moved by the parallel displacement. The line segment S1 shown in FIGs. 3B and 3C represents the line segment which extends parallel to the guide planes 271, 301 and one end of which passes through the contact point 254Q which has been moved by the parallel displacement. The line segment S2 shown in FIGs. 3B and 3C represents the line segment which extends parallel to the guide planes 281, 311 and one end of which passes through the contact point 264Q which has been moved by the parallel displacement. As is apparent from FIG. 3C, the line segments S1, S2, 291 S and 321 S define a rectangle.

[0027] The line segments 255S, 291S, S1c (the line segment S1c being a part of the line segment S1) form a triangle Δ1. The line segments 265S, 321S, S2c (the line segment S2c being a part of the line segment S2) form a triangle Δ2. The triangles Δ1 and Δ2 are congruent figures. Similarly, the line segments S1, S3, 321 Sc (the line segment 321 Sc being a part of the line segment 321S) form a triangle Δ3. The line segments S2, S4, 291Sc (the line segment 291 Sc being a part of the line segment 291 S) form a triangle Δ4. The triangles Δ3 and Δ4 are congruent figures. Therefore, the line segment S1c and the line segment S2c have substantially the same length (hereinafter designated by reference symbol C2e), and the line segment 321Sc and the line segment 291 Sc have also substantially the same length (hereinafter designated by reference symbol C1e). Further, the triangles Δ1, Δ2 and the triangles Δ3, Δ4 are similar figures.

[0028] The lengths C1e, C2e may be considered as the dimensions of the clearances C1, C2, respectively. The inclination angle of the pin 22 (or the inclination angle of the axis 222 relative to the guide planes 271, 281, 301, 311) which is designated by reference symbol θ in FIG. 3B corresponds to an angle made between the line segments S1, S3, and also to an angle made between the line segments S2, S4, as shown in FIG. 3C. In addition, the inclination angle θ corresponds to an angle made between the line segments 291S, 255S, and also to an angle made between the line segments 321S, 265S. Therefore, the inclination angle θ whose unit is radian may be approximately represented by two ways of the expressions (2), (3).

$$\theta \approx C1 / L1 \qquad (2)$$

$$\theta \approx C2 / L2 \qquad (3)$$

The expression (4) is given by the expressions (2), (3).

$$\theta \approx C1 / L1 \approx C2 / L2 \qquad (4)$$

In the state of FIG. 3B, in order to prevent the contact of the boundary 254 with the guide plane 291 from occurring at the same time as the contact of the boundary 264 with the guide plane 321, the value for C2/L2 of the expression (4) needs to be greater than that for C1/L1 of the same expression. That is, if the expression (1) is satisfied, the contact of the boundary 254 with the guide plane 291 does not occur at the same time as the contact of the boundary 264 with the guide plane 321.

[0029] The imaginary plane 321 H shown in FIG. 3B is parallel to the guide plane 321 and, if the guide plane 321 is positioned in the imaginary plane 321 H, the point 264P will be in contact with the guide plane 321. In such a state, the pin 22 will be simultaneously in contact with both guide planes 321, 291. If the expression (1) is satisfied, however, the guide plane 321 is not positioned in the imaginary plane 321 H. In the case where the pin 22 is inclined and the point 264P is in contact with the guide plane 321, as shown in FIG. 3B, the point 254P does not come in contact with the guide plane 291 if the expression (1) is satisfied. In the case where the pin 22 is inclined, the boundary 255 is in contact with the guide plane 281 and the boundary 265 is in contact with the guide plane 301, the contact of the boundary 254 with the guide plane 291 does not occur at the same time as the contact of the boundary 264 with the guide plane 321 if the expression (1) is satisfied.

[0030] The torque of the rotary support 19 which is rotatable with the rotary shaft 16 is transmitted to the swash plate 20 through the engagement between the guide plane 291 of the third guide wall 29 of the guide arm 23 and the end face 253 of the guided portion 25 of the pin 22, so that the swash plate 20 is rotated integrally with the rotary shaft 16.

[0031] The guide arms 23, 24, the pin 22 and the support arm 21 cooperate to form a connecting mechanism 39 for connecting the swash plate 20 to the rotary support 19 in such a way that the inclination angle of the swash plate 20 is varied and also that the torque is transmitted from the rotary shaft 16 to the swash plate 20.

[0032] As the center in the radial direction of the swash plate 20 is moved toward the rotary support 19, the inclination angle of the swash plate 20 is increased and the maximum inclination angle of the swash plate 20 is regulated by the contact of the swash plate 20 with the rotary support 19. The minimum inclination angle of the swash plate 20 is regulated by the contact of the swash plate

20 with a circlip 33 (shown in FIG. 1) mounted on the rotary shaft 16. Referring to FIG. 1, the maximum inclination angle of the swash plate 20 is indicated by solid line and the minimum inclination angle thereof by chain double-dashed line. It is so arranged that the minimum inclination angle of the swash plate 20 is set larger than 0°.

[0033] As shown in FIG. 1, the cylinder block 11 has formed therethrough a plurality of cylinder bores 111 (only one cylinder bore 111 being shown) and a piston 34 is disposed in each cylinder bore 111. The rotary motion of the swash plate 20 is converted into the reciprocating motion of each piston 34 through its corresponding pair of shoes 35 which is engaged with the swash plate 20, and the piston 34 reciprocates in its corresponding cylinder bore 111, accordingly. That is, the piston 34 is operable in conjunction with the rotation of the rotary shaft 16 through the swash plate 20 which is rotated with the rotary shaft 16.

[0034] The rear housing 13 has formed therein a suction chamber 131 and a discharge chamber 132. The valve plate 14 has formed therethrough a plurality of suction ports 141 (only one suction port 141 being shown). Each of the valve plate 14 and the suction valve forming plate 15 has formed therethrough a plurality of discharge ports 142 (only one discharge port 142 being shown for each). The suction valve forming plate 15 has formed thereon a plurality of suction valves 151. A discharge valve forming plate 36 is joined to the valve plate 14 and has formed thereon a plurality of discharge valves 361. During the suction stroke of the piston 34 (or leftward movement of the piston 34 in FIG. 1), the suction valve 151 is opened and refrigerant gas in the suction chamber 131 is drawn into the corresponding cylinder bore 111. During the discharge stroke of the piston 34 (or rightward movement of the piston 34 in FIG. 1), the refrigerant gas compressed in the cylinder bore 111 pushes open the discharge valve 361 and is discharged into the discharge chamber 132. The opening of the discharge valve 361 is regulated by a retainer 37.

[0035] The discharge chamber 132 and the suction chamber 131 are connected by an external refrigerant circuit (not shown), so that refrigerant discharged from the discharge chamber 132 to the external refrigerant circuit returns to the suction chamber 131. As shown in FIG. 2A, the rotary shaft 16 is rotated in the arrow direction Q. When the swash plate 20 is divided into two halves by an imaginary plane H which extends in the axis 161 of the rotary shaft 16 in perpendicular relation to the axis 222 of the pin 22, one half of the swash plate 20 is located in the region S for the suction stroke and the other half in the region D for the discharge stroke. As seen along the direction of the axis 161 of the rotary shaft 16, the pistons 34 located in the region S are in the suction stroke and the pistons 34 located in the region D are in the discharge stroke. The guided portion 25 of the pin 22 is located in the region S and the guided portion 26 of the pin 22 is located in the region D.

[0036] As shown in FIG. 1, a thrust bearing 38 is interposed between the rotary support 19 and the front housing 12 for receiving the compressive reaction force which is applied from the refrigerant gas in the cylinder bores 111 to the rotary support 19 through the pistons 34, the shoes 35, the swash plate 20 and the connecting mechanism 39.

[0037] The discharge chamber 132 and the pressure control chamber 121 are connected by a supply passage 40, and the pressure control chamber 121 and the suction chamber 131 are connected by a bleed passage 41. Part of the refrigerant gas in the discharge chamber 132 is supplied into the pressure control chamber 121 through the supply passage 40 and then flown into the suction chamber 131 through the bleed passage 41.

[0038] An electromagnetically-operated displacement control valve 42 is located in the supply passage 40. The amount of refrigerant supplied from the discharge chamber 132 to the pressure control chamber 121 through the supply passage 40 is varied in accordance with the opening of the displacement control valve 42. Since the refrigerant in the pressure control chamber 121 is flown into the suction chamber 131 through the bleed passage 41, the pressure in the pressure control chamber 121 is changed in accordance with the amount of refrigerant supplied from the discharge chamber 132 to the pressure control chamber 121 through the supply passage 40. As the supply of refrigerant increases, the pressure in the pressure control chamber 121 rises. As the supply of refrigerant decreases, the pressure in the pressure control chamber 121 falls. By so controlling the pressure in the pressure control chamber 121, the inclination angle of the swash plate 20 is varied and the displacement of the compressor 10 is varied, accordingly.

[0039] While the swash plate 20 varies its inclination angle, the guided portion 25 is moved along the guide planes 271, 281, 291 and the guided portion 26 along the guide planes 301, 311, 321.

[0040] The first embodiment has the following advantageous effects.

[0041] In the case where the pin 22 is simultaneously in contact with both guide planes 271, 311 or the pin 22 is simultaneously in contact with both guide planes 281, 301, the pin 22 will not come in contact simultaneously with both guide planes 291, 321. In such a structure, the pin 22 will not be bound between the paired guide arms 23, 24 in the direction of the axis 222 of the pin 22. Therefore, the pin 22 is smoothly movable along the guide planes 271, 281, 291, 301, 311, 321.

[0042] The following will describe a second embodiment according to the present invention with reference to FIGs. 4A and 4B. The same reference numerals or symbols of the first embodiment are used for the same parts or elements in the second embodiment. The guide arm 23 has a pair of guide planes 43 between the guide planes 271, 281 and the guide plane 291, respectively. The guide arm 24 also has a pair of guide planes 44 between the guide planes 301, 311 and the guide plane

321, respectively. The torque of the rotary support 19 which is rotatable with the rotary shaft 16 is transmitted to the swash plate 20 through the engagement between one of the guide planes 43 and the conical surface 252 of the guided portion 25, so that the swash plate 20 is rotated with the rotary shaft 16.

[0043] In the state of FIG. 4B wherein the pin 22 is inclined, the point 255P on the boundary 255 is in contact with the guide plane 271 and the point 265P on the boundary 265 is in contact with the guide plane 311. In addition, the point 254Q on the boundary 254 is in contact with the guide plane 43.

[0044] With the clearance between the guide plane 44 and the conical surface 262 designated by reference symbol C2 in the state of FIG. 4A wherein the pin 22 is not inclined, the pin 22 will not come in contact simultaneously with both guide planes 43, 44 if the expression (1) is satisfied.

[0045] The following will describe a third embodiment according to the present invention with reference to FIG. 5. The same reference numerals or symbols of the first embodiment are used for the same parts or elements in the third embodiment. The swash plate 20 has a pair of guide arms 23C, 24C which are formed integrally therewith. The rotary support 19C is formed with an integral support arm 21C. The pin 22 is supported by the support arm 21C. The guide arm 23C has the first guide wall 27, the second guide wall 28 and the third guide wall 29. The guide arm 24C has the fourth guide wall 30, the fifth guide wall 31 and the sixth guide wall 32.

[0046] The rotary support 19C and the support arm 21C cooperate to form the support for supporting the pin 22. The swash plate 20 and the guide arms 23C, 24C cooperate to form the pin guide. The guide arms 23C, 24C, the pin 22 and the support arm 21C cooperate to form the connecting mechanism 39C for connecting the swash plate 20 to the rotary support 19C in such a way that the inclination angle of the swash plate 20 is varied and also that the torque is transmitted from the rotary shaft 16 to the swash plate 20.

[0047] As in the first and second embodiments, the pin 22 in the third embodiment will not be bound between the guide arms 23C, 24C in the direction of the axis 222 of the pin 22 if the expression (1) is satisfied.

[0048] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

Claims

1. A variable displacement compressor (10) comprising:

   a rotary shaft (16);
   a cam member (20) which is rotatable with the rotary shaft (16);
   a piston (34) which is operable in conjunction with rotation of the rotary shaft (16) through the cam member (20); and
   a rotary support (19, 19C) fixed on the rotary shaft (16);
   wherein the cam member (20) is connected to the rotary support (19, 19C) through a connecting mechanism (39, 39C) in such a way that inclination angle of the cam member (20) is variable,
   wherein when one of the cam member (20) and the rotary support (19, 19C) forms a part of support (19, 19C, 20, 21, 21C) while the other of the cam member (20) and the rotary support (19, 19C) forms a part of pin guide (19, 19C, 20, 23, 23C, 24, 24C), the connecting mechanism (39, 39C) has a pin (22) supported by the support (19, 19C, 20, 21, 21C), a first guide portion (23, 23C) and a second guide portion (24, 24C) which are provided in the pin guide (19, 19C, 20, 23, 23C, 24, 24C),
   wherein the first guide portion (23, 23C) guides a first end (25) of the pin (22) in accordance with the variation of the inclination angle of the cam member (20) and the second guide portion (24, 24C) guides a second end (26) of the pin (22) in accordance with the variation of the inclination angle of the cam member (20), and
   wherein the inclination angle of the cam member (20) is varied and displacement of the compressor (10) is varied by controlling pressure in a pressure control chamber (121) having therein the cam member (20),
   characterized in that
   the first guide portion (23, 23C) has a first guide surface (291) that guides an end face (253) of the first end (25),
   in that the second guide portion (24, 24C) has a second guide surface (321) that guides an end face (263)of the second end (26), and
   in that when the pin (22) comes in contact with the first guide surface (291) or the second guide surface (321), the pin (22) comes in contact with only one of the first guide surface (291) and the second guide surface (321).

2. The variable displacement compressor (10) according to claim 1, wherein the first end (25) has a circumferential surface (251, 252), wherein the first guide portion (23, 23C) has a third guide surface (271) that guides a part of the circumferential surface (251, 252) of the first end (25) adjacent to the support (19, 19C, 20, 21, 21C), and a fourth guide surface (281) that guides a part of the circumferential surface (251, 252) of the first end (25) adjacent to the pin guide (19, 19C, 20, 23, 23C, 24, 24C), wherein the second end (26) has a circumferential surface (261,

262), wherein the second guide portion (24, 24C) has a fifth guide surface (301) that guides a part of the circumferential surface (261, 262) of the second end (26) adjacent to the support (19, 19C, 20, 21, 21 C), and a sixth guide surface (311) that guides a part of the circumferential surface (261, 262) of the second end (26) adjacent to the pin guide (19, 19C, 20, 23, 23C, 24, 24C), wherein the pin (22) is allowed to simultaneously come in contact with the third guide surface (271) and the sixth guide surface (311), and wherein the pin (22) is allowed to simultaneously come in contact with the fourth guide surface (281) and the fifth guide surface (301).

3. The variable displacement compressor (10) according to claim 2, wherein the expression (1) is satisfied:

$$C2 > C1 \cdot L2 / L1 \qquad (1)$$

where L1 is length in the direction of an axis (222) of the pin (22) between a point (255P, 255Q) of the first end (25) which is allowed to come in contact with the third guide surface (271) or the fourth guide surface (281) and a point (265Q, 265P) of the second end (26) which is allowed to come in contact with the fifth guide surface (301) or the sixth guide surface (311), L2 is length corresponding to maximum distance in the direction perpendicular to the axis (222) of the pin (22) between any two points (254P, 254Q) on the first end (25) which is allowed to come in contact with the first guide surface (291) and besides L2 is length corresponding to maximum distance in the direction perpendicular to the axis (222) of the pin (22) between any two points (264Q, 264P) on the second end (26) which is allowed to come in contact with the second guide surface (321), C1 is dimension of clearance between the third guide surface (271) or the fourth guide surface (281) and the circumferential surface (251, 252) of the first end (25) in a non-inclination state of the pin (22) and besides C1 is dimension of clearance between the fifth guide surface (301) or the sixth guide surface (311) and the circumferential surface (261, 262) of the second end (26) in the non-inclination state of the pin (22), and C2 is dimension of clearance between the first guide surface (291) and the end face (253) of the first end (25) in the non-inclination state of the pin (22), or dimension of clearance between the second guide surface (321) and the end face (263) of the second end (26) in the non-inclination state of the pin (22).

4. The variable displacement compressor (10) according to claim 2 or 3, wherein the circumferential surface (251, 252) of the first end (25) has a conical surface (252) formed in continuity with the end face (253) of the first end (25) and a cylindrical surface (251) formed in continuity with the conical surface (252), and wherein the circumferential surface (261, 262) of the second end (26) has a conical surface (262) formed in continuity with the end face (263) of the second end (26) and a cylindrical surface (261) formed in continuity with the conical surface (262).

5. The variable displacement compressor (10) according to claim 2 or 4, wherein the expression (1) is satisfied:

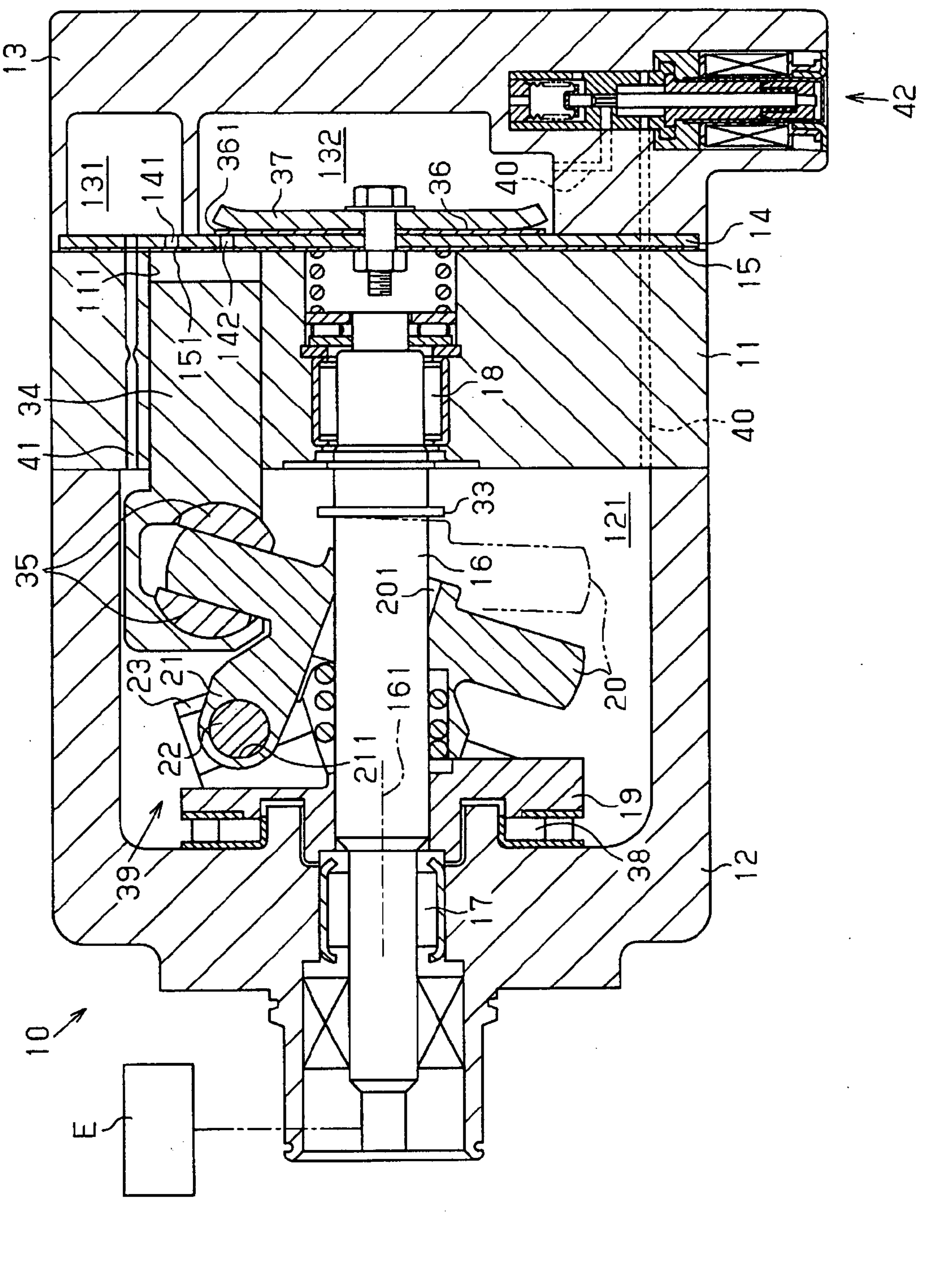
$$C2 > C1 \cdot L2 / L1 \qquad (1)$$

where L1 is length in the direction of an axis (222) of the pin (22) between a point (255P, 255Q) of the first end (25) which is allowed to come in contact with the third guide surface (271) or the fourth guide surface (281) and a point (265Q, 265P) of the second end (26) which is allowed to come in contact with the fifth guide surface (301) or the sixth guide surface (311), L2 is length corresponding to maximum distance in the direction perpendicular to the axis (222) of the pin (22) between any two points (254P, 254Q) on the first end (25) which is allowed to come in contact with the first guide surface (291) and besides L2 is length corresponding to maximum distance in the direction perpendicular to the axis (222) of the pin (22) between any two points (264Q, 264P) on the second end (26) which is allowed to come in contact with the second guide surface (321), C1 is dimension of clearance in the direction perpendicular to the axis (222) of the pin (22), and C2 is dimension of clearance in the direction of the axis (222) of the pin (22).

6. The variable displacement compressor (10) according to any one of claims 1 through 5, wherein the cam member (20) forms a part of the support (20, 21) and the rotary support (19) forms a part of the pin guide (19, 23, 24).

7. The variable displacement compressor (10) according to any one of claims 1 through 5, wherein the cam member (20) forms a part of the pin guide (20, 23C, 24C) and the rotary support (19C) forms a part of the support (19C, 21C).

FIG. 1


13
131
141
361
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132
36
40
42
14
15
111
151
142
11
34
41
18
40
33
121
35
16
201
20
23
21
161
22
211
19
39
38
12
17
10
E

FIG. 2A

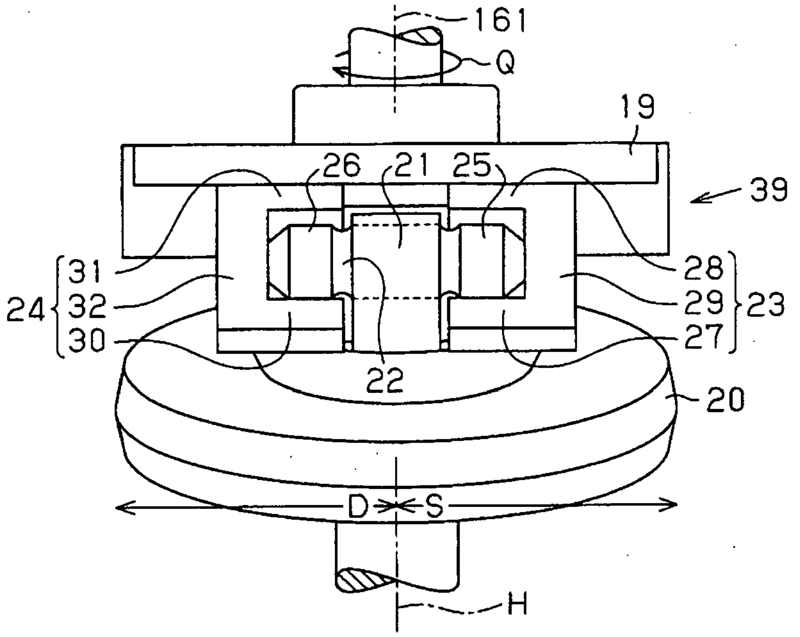

161
Q
19
39
26
21
25
31
32
30
24
28
29
27
23
22
20
D
S
H

FIG. 2B

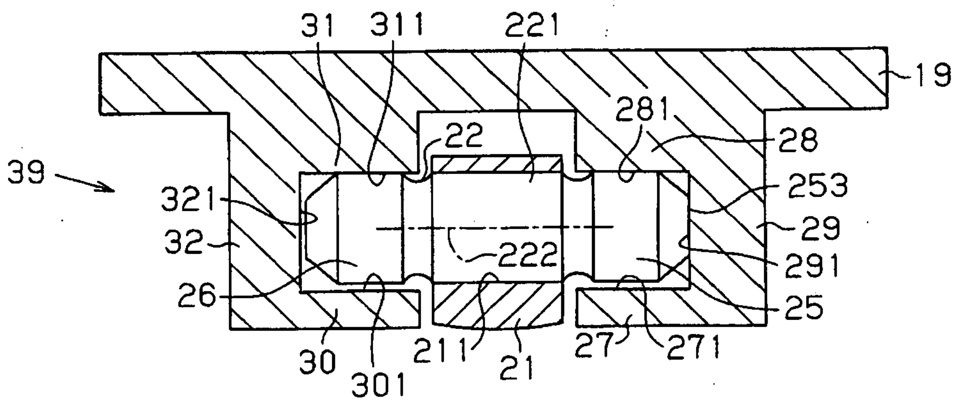

31
311
221
19
281
28
22
39
321
253
32
29
222
291
26
25
30
301
211
21
27
271

FIG. 3A

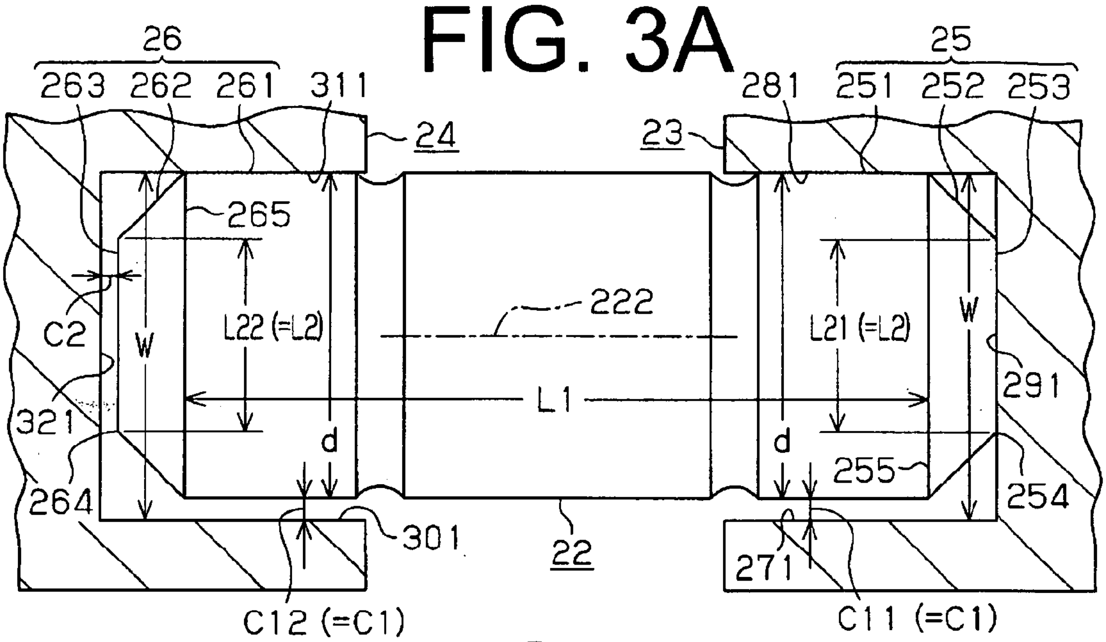


FIG. 3B

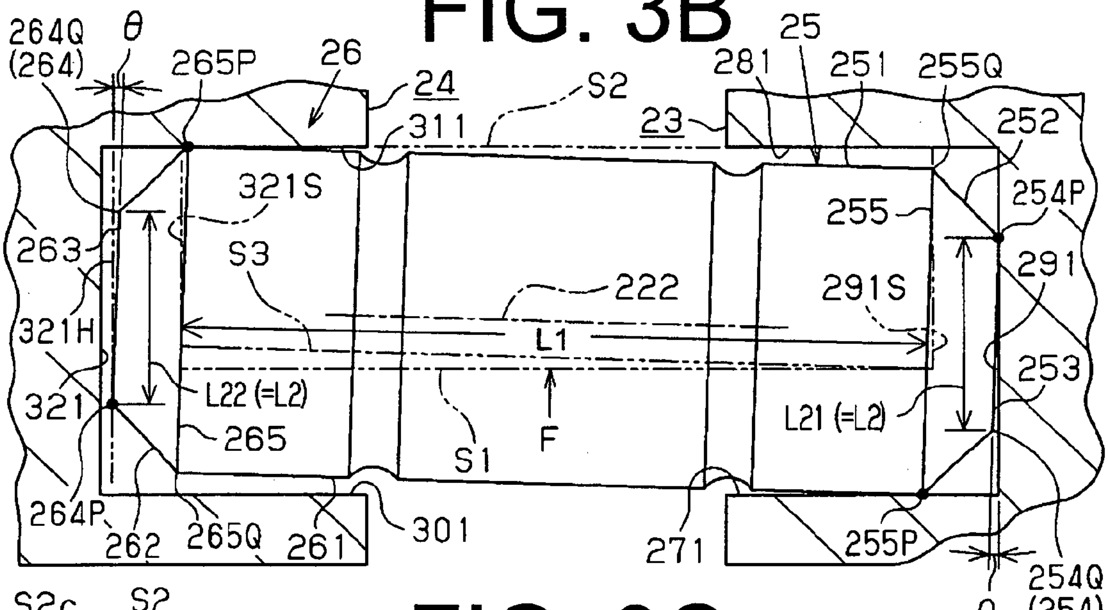


FIG. 3C

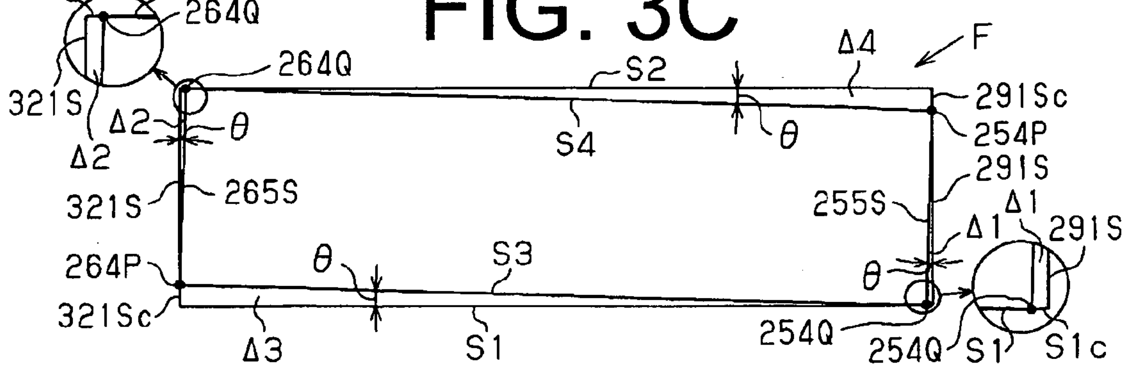


FIG. 4A

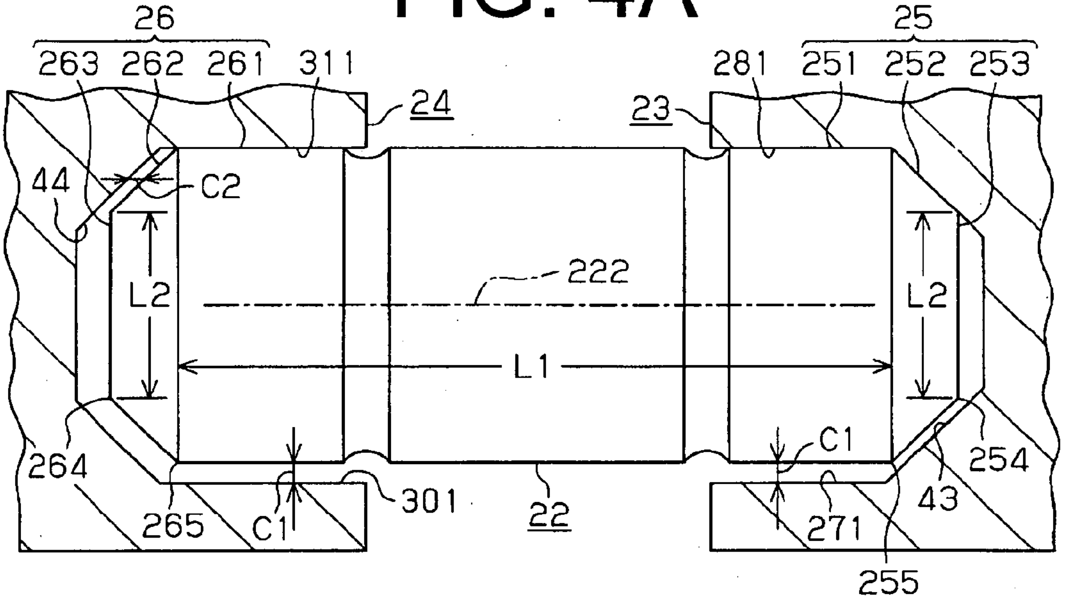

26
25
263 262 261 311
281 251 252 253
24
23
44
C2
222
L2
L2
L1
C1
264
254
43
265
C1
301
22
271
255

FIG. 4B

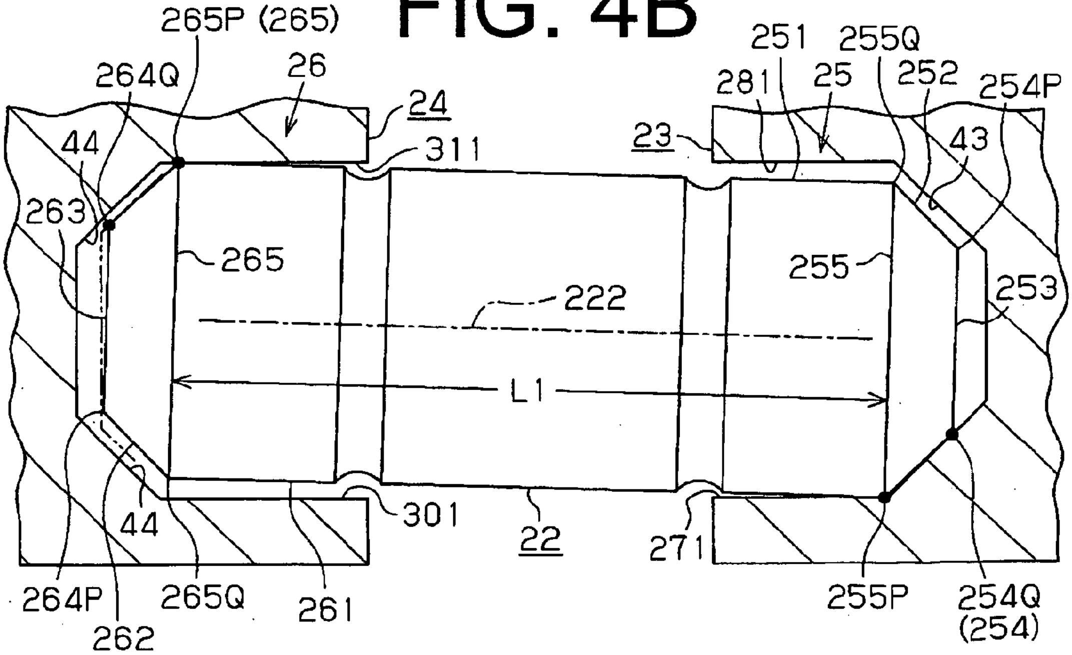

265P (265)
264Q
26
251 255Q
281
25
252
254P
24
23
44
311
43
263
265
255
222
253
L1
44
301
22
271
264P
262
265Q
261
255P
254Q
(254)

FIG. 5

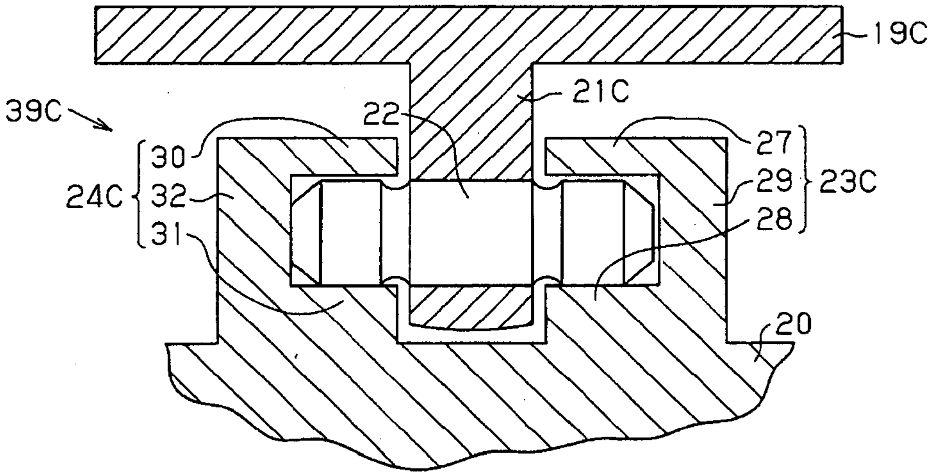
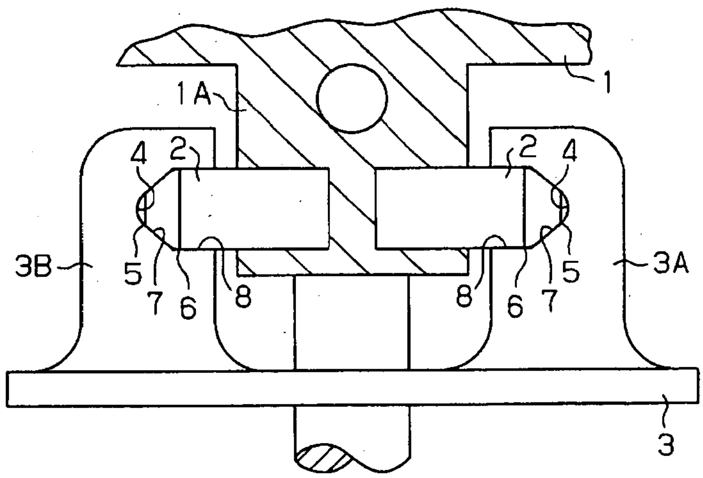


FIG. 6 (PRIOR ART)



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 10274154 A **[0002]**