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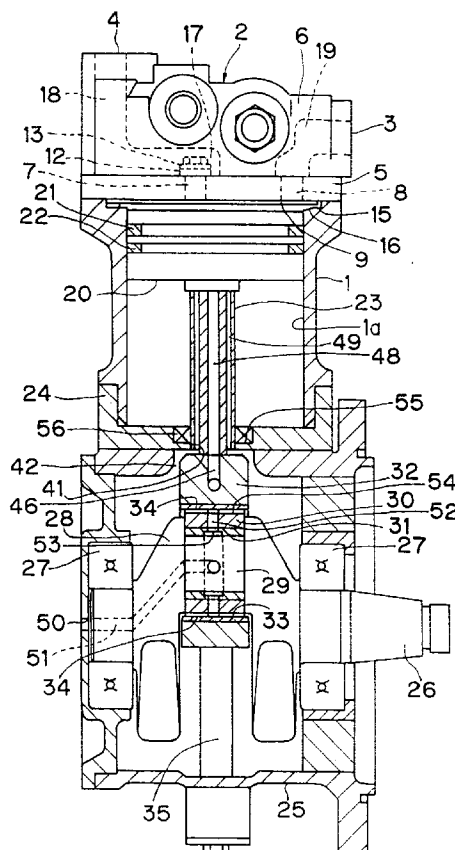
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(54) **Compressor**

(57) In an air compressor of this invention, a piston (20) connects to a crankshaft (26) by means of a cross slider crank mechanism and reciprocates in a cylinder (1). Lubricating oil is supplied to a cooling chamber (60) in the piston by way of oil supply passages (44,45,46,48). Lubricating oil is supplied to the sliding surfaces of the slider (30) and slider frame (32) by way of a crankshaft oil supply passage (51) and a slider oil hole (52). The interior of the cylinder (1) and interior of a crankcase (25) are sealed with an oil seal (56) at the middle section of a piston rod (23). A sliding surface of the slider frame (32) which contacts the slider (30) is chromium plated. The compressor also comprises a suction valve (9) and a discharge valve (12) formed in the cylinder head (2), and additionally a further suction valve (93) and a discharge valve (98) formed in the cylinder base (90) to achieve two suction and discharge strokes per cycle.

FIG.1**EP 0 833 054 A2**

Description

This invention relates to an air compressor which can be mounted in a vehicle.

Medium-sized or large-sized trucks use compressed air as a source for driving various types of control equipment such as brake systems. Currently, reciprocating air compressors are used as a supply source. Such air compressors utilize an ordinary crank mechanism and have piston rings lubricated with lubricating oil inside a cylinder chamber.

The danger of freezing may occur during the winter season inside the air pipes when moisture penetrates into the compressed air. Therefore, separation of the moisture from the air is necessary. In the currently used method to separate the moisture from the air, the moisture is first absorbed into a porous water absorbent from air under high pressure, then the pressure is quickly reduced and the moisture trapped in the absorbent is discharged into the atmosphere. This method has the problem that separation of moisture from the air is poor when lubricating oil mixes in the compressed air.

Other problems are that when lubricating oil mixes in the compressed air, the lubricating oil around the suction and discharge valves is prone to carbonize due to heat. When sludge adheres to the discharge valve, the valve may operate incompletely, so that the compressed air temperature increasingly rises, causing the carbonization to develop yet further.

Therefore it is preferable to prevent penetration of lubricating oil into the compressed air.

A non-lubrication type of compressor is available among common compressor types. In the most commonly used type, ball bearings are used in the crank section, needle bearings are used in the piston and piston pin sections and these bearings are filled with grease and sealed so that lubricating oil cannot enter the cylinder chamber.

However, the bearings of this compressor type are large, making the compressor unsuitable for use in vehicles.

On the other hand, some vacuum pumps utilize a piston rod driven by a cam and has an oil seal at the center section of this piston rod. The structures of this type in actual use have a piston stroke of only 20mm or less, so this type is also unsuitable for use in compressors in medium-sized or large-sized trucks.

The cross slider crank mechanism on the other hand, is also used in some machines. This cross slider crank mechanism is comprised of a reciprocating rod, a slider frame fixedly connected to the rod and supported to be allowed reciprocating motion, a slider supported by the slider frame to be allowed movement perpendicular to the slider frame movement, and a crank shaft connecting the slider to allow rotation. When this structure is attached to the piston, a piston not effected by side thrust is obtained, however there are stricter limits on structure compared to ordinary crank mechanisms, so this type has never been used in a reciprocating compressor and no compressor having an oil seal at the middle section of the piston rod is known to have been made.

In view of the above, it is therefore an object of the present invention to provide a compressor that is compact, capable of being mounted in a vehicle and further has no lubricating oil contamination of the compressed air.

Another object of the present invention is to provide a compressor that maintains the durability of the seal ring (piston ring) and cylinder without lubrication.

A further object of the present invention is to provide a compressor having a lubrication mechanism for a cross slider crank mechanism, and a cooling mechanism for the piston.

A still further object of the present invention is to improve the sliding characteristics of a slider and slider frame in the cross slider crank mechanism.

Still another object of the present invention is to reduce the wear and fatigue on the suction valve guard and the suction valve formed of reed valve in the compressor.

A yet further object of the present invention is to provide a compressor that is compact yet has high performance.

This invention, a compressor having a piston reciprocating in a cylinder by means of a crank mechanism, is characterized in that the crank mechanism is a cross slider crank mechanism. The cross slider crank mechanism is comprised of a piston rod fastened to the piston, a slider frame fixedly connected to the piston rod and supported to be allowed reciprocating motion, a slider mounted in the window hole of the slider frame to be allowed movement perpendicular to the direction of slider frame movement and, a crank shaft connecting the slider to allow rotation.

A cross slider crank mechanism for reciprocating the piston in the cylinder has the following advantages.

(1) The piston rod is rectilinearly moved while generating a simple sine frequency, so there are no higher order harmonic constituents incident to conventional crank mechanisms. Therefore noise can be limited and the durability of the cylinder and the seal ring (piston ring) mounted in the piston is improved.

(2) The rectilinear motion of the piston rod allows easy oil seal at the middle section of the piston rod. The interior of the cylinder and the crank case can therefore easily be sealed and the interior of the cylinder maintained in a non-lubrication state.

(3) The rectilinear motion of the piston rod prevents piston slap from occurring so that durability of the seal ring (piston ring) and the cylinder is improved even in a non-lubrication state.

(4) The rectilinear motion of the piston rod prevents piston slap from occurring so that noise and vibration are limited.

(5) The piston and piston rod have no relative motion so that lubricating oil can easily be supplied to the interior of the piston by way of the interior of the piston rod, allowing easy oil cooling of the piston.

The compressor of this invention is also characterized by the following structure for lubrication of the cross slider crank mechanism and cooling of the piston. The structure is comprised of an oil supply passage formed in a guide rod for supporting the slider frame to allow reciprocating motion and, an oil supply passage formed between the guide rod and a guide rod hole formed in the slider frame and, an oil supply passage formed in the slider frame and, an oil supply passage and oil drain passage formed in the piston rod. Lubricating oil is supplied to a cooling chamber formed in the piston by way of the guide rod oil supply passage, the oil supply passage between the guide rod and the guide rod hole of the slider frame, the slider frame oil supply passage, and the piston rod oil supply passage. The lubricating oil in the cooling chamber drains into the crankcase by way of the oil drain passage of the piston rod.

Preferably, a pair of guide rods are provided. In this structure, the lubricating oil may be supplied from the oil supply passage of one guide rod, through the oil supply passage between the guide rod and the guide rod hole, and the slider frame oil supply passage, to the piston rod oil supply passage and the oil supply passage between the other guide rod and guide rod hole.

The above structure allows oil passages for cooling and lubrication to be formed together to achieve a simplified lubrication and cooling system.

The compressor of this invention is also characterized by the following structure for lubrication of the cross slider crank mechanism. The structure is comprised of an oil supply passage formed in the interior of the crankshaft and an oil hole formed in the slider. Lubricating oil is supplied to the sliding surfaces of the slider and slider frame by way of the crankshaft oil supply passage and the slider oil hole.

The sealing between the cylinder and the crank case can be performed by providing an oil seal at the middle section of the piston rod. Maintaining a non-lubrication state inside the cylinder prevents lubricating oil from contaminating the compressed air inside the cylinder.

The compressor of this invention is also characterized by the following structure to improve the slidability of the slider and slider frame of the cross slider crank mechanism. The sliding surface of the slider frame which contacts the slider is coated with chromium plating. Preferably, the slider is formed of cast iron.

Preferably, an oil groove is formed on the sliding surface of the slider which contacts the slider frame.

Porous chromium plating is preferably as chromium plating and surface grinding may be performed to improve the smoothness, surface roughness and porosity rate.

The compressor of this invention is further characterized by the following structure in order to reduce wear and fatigue on the suction valve guard and the suction valve formed of reed valve. An inlet valve for opening and closing the inlet hole formed in the cylinder head is formed of a reed valve and has one end secured to the lower surface of the cylinder head. An inlet valve guard is formed on the upper surface of the cylinder and is formed with a tapered surface.

The taper angle of the tapered surface is preferably 1 to 4 degrees.

The compressor of this invention is further characterized by the following structure in order to achieve compactness along with high performance. In a compressor structured such that the piston is able to reciprocate in the cylinder by means of a crank mechanism, during the lowering stroke of the piston air is drawn through the inlet opening formed in the cylinder head into the space in the cylinder facing the upper surface of the piston and, during the rising stroke of the piston, compressed air is discharged from the discharge opening formed in the cylinder head. The structure of this invention is characterized in that, during rising stroke of the piston, the air is drawn through an inlet opening formed separately from the inlet opening formed in the cylinder head into the space in the cylinder facing the lower surface of the piston and, during the lowering stroke of the piston, compressed air is discharged from a discharge opening formed separately from the discharge opening formed in the cylinder head.

Thus, in the above structure, the amount of discharge is large since two suction and discharge strokes are performed in one cycle.

The aforesaid and other objects and features of the present invention will become more apparent from the following detailed description of preferred embodiments, given by way of example only, and the accompanying drawings.

Figure 1 is a front view partly in cross section showing an embodiment of the compressor of this invention.

Figure 2(a) is a right side view partly in cross section showing a portion of the compressor.

Figure 2(b) is a plan view of the slider.

Figure 3 is a plan view partly in cross section showing the crankcase of the compressor.

Figure 4 is a longitudinal cross sectional view showing the piston fastened in the upper end of the piston rod.

Figure 5(a) is a bottom view showing the valve assembly in which the valve is installed.

Figure 5(b) is a longitudinal cross sectional view showing the suction valve for the compressor.

Figure 5(c) is a longitudinal cross sectional view showing the discharge valve installed in the valve assembly.

Figure 6 is a longitudinal cross sectional view showing the status in this invention when the suction valve is in

contact with the suction valve guard.

Figure 7 is a front view partly in cross section showing another embodiment of the compressor of this invention.

Figure 8 is a right side view partly in cross section showing a portion of the compressor.

Figure 9(a) is a transverse cross sectional view showing a portion of the suction valve on the opposite side to the cylinder head in the compressor.

Figure 9(b) is a transverse cross sectional view showing a portion of the discharge valve on the opposite side to the cylinder head in the compressor.

Figure 10 is a longitudinal cross sectional view showing the status in the conventional art when the suction valve is in contact with the suction valve guard.

Figures 1 through 6 show an embodiment of this invention.

In the air compressor of this invention, the piston reciprocates inside the cylinder. A cylinder head 2 is fastened above a cylinder 1. A suction or inlet opening 3 for the air and a discharge opening 4 for the compressed air are formed in the cylinder head 2.

The cylinder head 2 is comprised of a valve assembly 5 and a head body 6. The valve assembly 5 fastened at the upper surface of the cylinder 1 has a roughly flat square shape with installation holes 5a at the four corners. A pair of discharge holes 7 are aligned in parallel to the side near the center of the valve assembly 5. Near the side, four suction or inlet holes 8 are disposed in an arc shape along the same direction as the alignment of the discharge holes 7.

A suction or inlet valve 9 is installed at the lower surface of the valve assembly 5. The suction valve 9 is formed of thin reed valve, in a ring shape. One portion of this valve 9 seals the four suction holes 8. Two discharge holes 7 are formed within the ring shape. A plate 10 is mounted on the base edge of the suction valve 9. A setscrew 11 secures the suction valve 9 to the valve assembly 5.

A discharge valve 12 is mounted at the upper surface of the valve assembly 5. The discharge valve 12 is formed of thin reed valve, in a narrow rectangular shape, and seals the two discharge holes 7. On the upper side of the discharge valve 12, a discharge valve guard 13 is installed which is made from a plate in the same shape as the discharge valve 12 as seen from the top. The discharge valve guard 13 and the discharge valve 12 are secured at both end with bolts 14 to the valve assembly 5. The discharge valve guard 13 is formed in an arch bending upwards. When the discharge valve 12 opens, the discharge valve 12 bends upwards and makes contacts with the lower surface of the discharge valve guard 13 so that the amount of lift is restricted.

On the upper end surface of the cylinder 1, a notch 15 is formed around the entire circumference and opens on the inner circumferential side. The suction valve 9 is positioned in the notch 15. The bottom surface of the notch 15 forms a flat surface at a right angle to the inner circumferential surface of the cylinder 1. When the suction valve 9 opens, the suction valve 9 bends downwards and its tip contacts the bottom of the notch 15 so that the amount of lift is restricted. The bottom of the notch 15 where the suction valve 9 makes contact is formed with a taper on the inner circumferential side and this taper portion comprises a suction valve guard 16. An angle of 1° to 4° is preferable as the angle (oblique angle versus the right angled flat surface to the inner circumferential surface of the cylinder 1) of the taper surface. The taper surface may be formed only for the notch 15 portion at the suction valve guard 16 but may also be formed along the entire circumference of the notch 15.

The interior of the head body 6 attached to the upper surface of the valve assembly 5, has a space 17 which contains the discharge valve 12 and the discharge valve guard 13. A discharge passage 18 is formed from the space 17 to the discharge opening 4, and a suction passage 19 is formed from the suction hole 8 to the suction opening 3.

A piston 20 is inserted inside the cylinder 1. The outer circumferential surface of the piston 20 is formed with two ring grooves in which piston rings 21 and 22 are mounted to act as a seal with the inner wall 1a of the cylinder 1. One end of a piston rod 23 is fastened in the center at the bottom of the piston 20. The piston 20 is structured to reciprocate in the cylinder 1 by means of the cross slider crank mechanism.

The bottom of the cylinder 1 is supported in a bottomed cylinder 24. The bottomed cylinder 24 is attached to the upper surface of a crankcase 25. Besides being made of cast iron, the cylinder 1 can also be made of cast iron sleeve enveloped in aluminum to achieve lighter weight and improve heat transmission.

Inside the crankcase 25, a crankshaft 26 is installed at a right angle with respect to the movement direction (hereafter up/down direction) of the piston 20 and supported to be allowed rotation by bearings 27 at both ends. One end of the crankshaft 26 protrudes outward from the crankcase 25 and is structured to provide rotational drive from a driving source not shown in the drawing.

The crankshaft 26 has a pair of crank arms 28 inside the crankcase 25. A slider 30 is installed to be allowed rotation on a crank pin 29 attached between the pair of crank arms 28. The slider 30 has a square block shape separated above and below as seen in the direction of the crankshaft 26. A bearing metal 31 is attached on the inner circumference of the pin hole formed in the center of the slider 30, and the slider 30 is installed to rotate freely on the crank pin 29.

A slider frame 32 is installed around the slider 30. The slider frame 32 has a horizontally long rectangular frame shape as seen in the direction of the crankshaft 26. A horizontally long, rectangular-shaped window hole 33 has a height equivalent to the slider 30 and a horizontal width longer than that of the slider 30. The slider 30 connected to

the crank pin 29 is installed in the window hole 33 of the slider frame 32 to be allowed sliding movement in a direction perpendicular (hereafter right/left direction) to the movement direction of the piston 20.

A porous chromium plating 34 covers the sliding surface of the slider frame 32 which contacts the slider 30, namely the upper and lower surfaces forming the window hole 33 of the slider frame 32. Preferably, surface grinding is performed after coating the surface with the chromium plating 34 in order to improve the smoothness, surface roughness and porosity rate. The slider 30 is formed of cast iron material such as gray cast iron.

The slide frame 32 is supported by a pair of guide rods 35 and 36 to be allowed reciprocating motion upwards and downwards inside the crankcase 25. The pair of guide rods 35 and 36 extend upwards and downwards inside the crankcase 25 and are fastened to the crankcase 25. The pair of guide rods 35 and 36 pass through respective guide rod holes 37, 38 extending upwards and downwards at both ends of the horizontal direction of the slider frame 32. Bushings 39 and 40 are mounted respectively at the upper and lower ends of the pair of guide rod holes 37, 38 in the slider frame 32. These bushings 39 and 40 support the guide rods 35 and 36 to allow sliding movement.

The piston rod 23 attached to the bottom of the piston 20 and extending downward is inserted from the lower end of the cylinder 1 into holes 41 and 42 formed at the bottom of the bottomed cylinder 24 and the upper edge of the crankcase 25. The piston rod 23 is secured to the center of the upper surface of the slider frame 32 inside the crankcase 25.

The lubrication of the cross slider crank mechanism and the cooling of the piston is explained next.

An oil supply passage 44 is formed in the guide rod 35. The oil supply passage 44 is comprised of a linear oil passage formed longitudinally along the guide rod 35, an inlet passage stretching radially from the upper edge of the linear oil passage to the outer circumference of the guide rod 35, and an outlet passage stretching radially from the lower edge of the linear oil passage to the outer circumference of the guide rod 35. The inlet passage of the oil supply passage 44 of the guide rod 35 connects to an oil supply passage having an oil supply opening 43 on the exterior of the upper part of the crankcase 25. The crankcase 25 oil supply passage comprises an annular oil passage formed around the guide rod 35 and communicated the inlet opening of the oil supply passage 44 of the guide rod 35 as well as an oil passage extending from the annular oil passage to the oil supply opening 43.

In the slider frame 32, the inner diameter of the guide rod holes 37 and 38 between the upper and lower bushings 39 and 40 is formed larger than the outer diameter of the guide rods 35 and 36. Gaps are present between the guide rod holes 37, 38 and the guide rods 35, 36. At the side of the piston rod 23, the lower end portions of the upper bushings 39 and 40 are notched and connect to the above mentioned gaps. Oil supply passages 45 and 47 are formed by these notches and gaps. The oil supply passage 45 between the guide rod 35 and the guide rod hole 37 at the side of the guide rod 35 connects to the oil supply passage 44 on the inside of the guide rod 35.

At the upper part of the window hole 33 of the slider frame 32, is formed an oil supply passage 46. The oil supply passage 46 is comprised of; a straight oil passage extending on the left and right between the pair of guide rod holes 37, 38 as well as a straight oil passage having an opening at the upper surface of the slider frame 32 and extending upwards from the center of the said straight oil passage. The oil supply passage 46 connects to the oil supply passages 45 and 47 between the guide rod holes 37, 38 and guide rods 35, 36.

An oil supply passage 48 is formed to extend longitudinally in the center of the interior of the piston rod 23. The oil supply passage 48 connects to the oil supply passage 46 of the slider frame 32.

The interior of the piston 20 has a cooling chamber 60. The cooling chamber 60 is formed on the bottom of the piston 20 with a concave section 61 which is sealed by means of a plug 62. The plug 62 has a flange 64 on the outer circumference of a cylindrical body 63. The flange 64 is placed in a notch 65 formed near the concave section 61 at the bottom of the piston 20 and is secured to the body of the piston 20 by means of a bolt 66.

The cylindrical body 63 of the plug 62 is disposed inside the cooling chamber 60. The plug 62 has a large concavity 67 and a small concavity 68 in a concentric position on the bottom at the side of the piston rod 23. The piston rod 23 has an outer tube 23b on the outer side of a rod 23a. The upper end of the outer tube 23b is in a position pulled downwards slightly more than the upper end of the rod 23a. The upper end of the rod 23a of the piston rod 23 is inserted into the small concavity 68. A bolt 69 screws into screw holes formed in the upper part of the rod 23a and the plug 62, to secure the plug 62 and the piston rod 23.

Inside the bolt 69, is formed an oil supply passage 71. The oil supply passage 71 is comprised of a linear oil passage formed longitudinally in the bolt 69 and connected to the oil supply passage 48 of the piston rod 23; and linear oil passages extending radially inside the head of the bolt 69 exposed within the cooling chamber 60 and having a plurality of discharge openings 70 in the exterior circumference of the head of the bolt 69.

The top of the outer tube 23b of the piston rod 23 is inserted and fixed into the large concavity 67 of the plug 62. The piston rod 23 is formed with an oil drain passage 72 in the gap between the outer circumference of the rod 23a and the inner circumference of the outer tube 23b. The lower end of the outer tube 23b is at a position slightly higher than the upper surface of the slider frame 32. The lubricating oil flows from the opening at the lower end of the oil drain passage 72 into the crankcase 25. An oil drain passage 73 is formed radially at the lower section of the cylindrical body 63 of the plug 62. The oil drain passage 73 connects to the upper end opening of the oil drain passage 72 of the piston

rod 23.

An oil supply passage 51 is formed in the interior of the crankshaft 26. The oil supply passage 51 extends from one end of the crankshaft 26, through the crank arm 28, to the center of the crankpin 29, and also extends radially to the outer circumference of the crankpin 29.

Oil holes 52 are formed in the slider 30. The oil holes 52 are formed through the upper and lower sliding surfaces contacting the slider frame 32. Oil grooves 54 are formed respectively in each of the upper and lower sliding surfaces of the slider 30 which contacts the slider frame 32. As seen from the surface, the oil groove 54 has the shape of the letter "I" with a horizontal bar through the middle and faces an opening of the oil hole 52 in the center.

An oil supply passage 53 is formed in the bearing metal 31 to connect the oil supply passage 51 of the crankshaft 26 with the oil hole 52 of the slider 30. The oil supply passage 53 is comprised of an annular groove formed in the inner circumference of the bearing metal 31 and connected to the oil supply passage 51 of the crankshaft 26; and an oil hole from the bottom of the annular groove connecting to the oil hole 52 of the slider 30.

As mentioned above, the lubrication and cooling passages are formed within the cross slider crank mechanism.

However, the inside of the cylinder 1 is maintained in a non-lubrication state. In other words, an oil seal 56 is mounted in an annular concavity 55 formed in the bottom interior surface around the hole 41 of the bottomed cylinder 24 below the cylinder 1. The inner circumference of the oil seal 56 makes contact with the outer circumference of the piston rod 23 to provide sealing so that lubricating oil from the crankcase 25 does not penetrate into the cylinder 1. Therefore, the piston rings 21 and 22 slide against the cylinder wall 1a in a non-lubrication state.

The function of the invention is described next. When the crankshaft 26 is driven by a driving source not shown in the drawing, the slider 30 mounted on the crankpin 29, moves in a circular path around the crankshaft 26. This circular movement of the slider 30 moves it within the window hole 33 of the slider frame 32, and the slider frame 32 moves upward and downward (in direction of piston 20 movement) along with the slider 30.

When the slider frame 32 performs the up and down movement described previously, the piston 20 inside the cylinder 1 reciprocates by means of the piston rod 23 connected to the slider frame 32.

The suction valve 9 opens when the piston 20 lowers. In other words, the suction valve 9 bends downward, and its tip contacts the suction valve guard 16 formed on the upper surface of the cylinder 1. As shown in Fig. 6, when this occurs, the suction valve 9 contacts the tapered surface of the suction valve guard 16 so that only a surface contact between the suction valve 9 and the suction valve guard 16 occurs, which reduces wear and fatigue of the suction valve 9 and the suction valve guard 16.

As shown in Fig. 13, when the suction valve guard has no tapered surface and is formed with a right angled flat surface to the inner circumferential surface of the cylinder, the suction valve 9 contacts the inner edge of the suction valve guard in a line contact, which causes more wear and fatigue on the suction valve and suction valve guard.

When the wear and fatigue on the suction valve 9 and suction valve guard 16 are small, not only is the durability of these two parts improved but the increase in dead volume is slight so that the drop in performance (a drop in discharge amount) is correspondingly small.

When the suction valve 9 opens, air is suctioned from the suction opening 3 of the cylinder head 2 into the cylinder 1 by means of the suction holes 8. This air is then compressed by the upward movement of the piston 20.

When the air is compressed by the rise of the piston 20, the discharge valve 20 opens at the specified compression position. In other words, the discharge valve 12 bends upward and makes contact with the discharge valve guard 13.

When the discharge valve 12 opens, the compressed air is discharged from the discharge opening 4 of the cylinder head 2 by way of the discharge holes 7.

In the above process, the sliding portion of each member in the crankcase 25 is lubricated but the oil seal 56 maintains the cylinder 1 in a non-lubrication state so that contamination of the compressed air with lubricating oil is prevented.

The rotation of the crankshaft 26 moves the piston rod 23. The piston rod 23 is rectilinearly moved due to the cross slider crank mechanism so that there are no higher order harmonic constituents incident to conventional crank mechanisms. Emission of noise is therefore limited and the durability of the piston rings 21 and 22 and the cylinder 1 is increased. Further, piston slap does not occur, so the durability of the piston rings 21 and 22 and the cylinder 1 can be maintained even in the non-lubrication state. Further, piston slap does not occur, so noise and vibration are limited. The piston 20 and piston rod 23 have no relative motion so that lubricating oil can easily be supplied to the interior of the piston 20 by way of the interior of the piston rod 23 allowing easy oil cooling of the piston 20.

The lubrication of the cross slider crank mechanism and the cooling of the piston are described next.

The lubricating oil supplied to the compressor from the oil supply opening 43 of the crankcase 25 passes one after another; the oil supply passage 44 inside the guide rod 35, and the oil supply passage 45 between the guide rod 35 and the guide rod hole 37, and the lubricating oil while lubricating the sliding portions around the guide rod 35 and the bushing 39, flows into the oil supply passage 46 of the slider frame 32.

The lubricating oil that flowed into the oil supply passage 46 of the slider frame 32 branches off along the way, into the other guide rod 36 side, and into the piston rod 23 side. The lubricating oil that flowed into the other guide rod 36

flows into the oil supply passage 47 between the guide rod 36 and the guide rod hole 38, and after lubricating the sliding portions around the guide rod 36 and the bushing 40, drops from the top and bottom edges into the crankcase 25.

The lubricating oil that flowed into the piston rod 23 side, flows into the oil supply passage 48 of the piston rod 23, and flows in the oil supply passage 71 of the bolt 69, and is discharged into the cooling chamber 60 of the piston 20 from the discharge openings 70 of the head section of the bolt 69 to cool the inner side of the piston 20. The lubricating oil that cooled the piston 20 flows from the oil drain passage 73 of the plug 62 through the oil drain passage 72 of the piston rod 23 and drains into the crankcase 25 from the opening at the lower end.

Therefore, the above arrangement allows the cooling and oil passages to be formed together, thus achieving a simplified lubrication and cooling system.

The lubricating oil supplied from the oil supply opening 50 on the side of the crankcase 25 to the oil supply passage 51 of the crankshaft 26, reaches the crankpin 29 by way of the interior of the crankshaft 26. A portion of the lubricating oil is supplied to the sliding surfaces of the crankpin 29 and the bearing metal 31 by means of the oil supply passage 53 of the bearing metal 31. The other portion flows into the oil groove 54 of the slider 30 by way of the oil hole 52 of the slider 30 and the oil supply passage 53 of the bearing metal 31, and is supplied to the sliding surfaces of the slider 30 and the slider frame 32.

The slider frame 32 is covered with a chromium plating 34 on the sliding surface contacting the slider 30 and the slider 30 is formed of cast iron material so that the sliding characteristics of the slider 30 and the slider frame 32 in other words, the resistance to wear and resistance to scuffing are good.

The results of the durability tests performed on the compressor are described next.

(1) Piston rings 21 and 22

Material : Resin mixture of polyimide,
polytetrafluoroethylene, carbon fiber and graphite

Joint Configuration : Stepped joint

(2) Cylinder 1

Material : Gray cast iron
Inner circumference surface roughness : Mirror finish 0.8 μ m

(3) Material of slider frame 32

AC4C (Si 6.5 to 7.5 % by wt., Indispensable impurities 1.7 to 11.9 % by wt., remainder A1)

(4) Surface treatment of the slider frame 32 sliding surface, material of the slider 30 and the test results are shown in Table 1.

Table 1

Surface treatment of slider frame sliding surface	Slider Material	Pass/Fail
Tuframe process	LBC2	X
No treatment	LBC2	X
Chromium Plating	FC25	O
Tuframe Process	FC25	X

O : No scuffing, little wear

X : Scuffing present, much wear

LBC2 : Cu 82 to 86 % by wt., Sn 9 to 11 % by wt., Pb 4 to 6 % by wt., Remainder indispensable impurity

FC25 : T.C 3.2 to 3.3% by wt., Si 1.5 to 2.1 % by wt., Mn 0.7 to 0.9% by wt., P < 0.2 % by wt., S < 0.1 % by wt., Remainder Fe

(5) Operating conditions

Engine speed : 3,000 rpm

Test hours : 100 hours

(6) Results of the durability test performed under the above conditions, as shown in Table 1, confirmed that superior resistance to wear and superior resistance to scuffing are obtained when the sliding surface of the slider frame 32 are coated with a chromium plating and the material of the slider 30 is cast iron.

Figures 7 through 9 show another embodiment of this invention. The compressor of the first embodiment has one suction opening and one discharge opening but the compressor of the second embodiment has two suction openings and two discharge openings. The compressor of the second embodiment is compact yet has high performance.

The points differing from the compressor of the first embodiment are described next. Explanation of sections identical to the first embodiment is omitted here.

The bottom of the cylinder 1 is supported in a cylinder base 90. The cylinder base 90 is attached to the upper surface of the crankcase 25.

The compressor has suction and discharge mechanisms formed on the cylinder head 2 side and also on the opposite side of the cylinder head 2.

The outside of the cylinder base 90 has a square shape on the outside circumference. A valve assembly 91 of the suction valve and a valve assembly 92 of the discharge valve are fastened at the outer side of the lower portion of the bottomed cylinder 90. Each of the valve assemblies 91 and 92 are installed at opposite sides on the outer circumferential surface of the cylinder base 90.

The valve assembly 91 having a suction valve is formed in a flat plate. Two suction holes or inlets 93 are formed aligned horizontally and a suction valve 94 is disposed on the inner surface. The suction valve 94 is formed of thin reed valve in a narrow rectangular shape and seals the two suction holes 93. The suction valve 94 is fastened to the valve assembly 91 at both ends with bolts 95.

A concavity 96 is formed on the outer side of the lower portion of the cylinder base 90. The suction valve 94 is installed in the concavity 96. At the bottom of the cylinder base 90 two suction passages 97 are formed from the cylinder 1 to the bottom surface of the concavity 96. The opening for the suction passage 97 in the bottom surface of the concavity 96 is disposed facing the suction hole 93. When the suction valve 94 is open, the suction valve 94 bends inward and makes contact with the bottom (comprises the suction valve guard) of the concavity 96, which limits the amount of lift.

The valve assembly 92 having the discharge valve is formed in a flat plate. Two discharge holes or outlets are formed aligned horizontally and an discharge valve 99 is disposed on the outer surface. The discharge valve 99 is formed of thin reed valve in a narrow rectangular shape and seals the two discharge holes 98. A discharge valve guard 100 is installed at the outer side of the discharge valve 99 and is comprised of a plate of the same shape as the discharge valve 99 as seen from the outer side. Both ends of the discharge valve 99 and the discharge valve guard 100 are secured to the valve assembly 92 with a bolt 101. The discharge valve guard 100 has an arch shape bending outwards. When the discharge valve 99 opens, the discharge valve 99 bends outwards and makes contact with the inner surface of the discharge valve guard 100 to limit the amount of lift. At the bottom of the cylinder base 90, two discharge valve passages 102 are formed connecting the discharge hole 98 of the valve assembly 92 and the interior of the cylinder 1.

Preferably, a cooling passage is formed in the interior of the cylinder base 90 to provide cooling for the suction passage 97 and the discharge passage 102.

The function of the invention is described next. When the crankshaft 26 is driven by a driving source not shown in the drawing, the slider 30 mounted on the crankpin 29, moves in a circular path around the crankshaft 26. This circular movement of the slider 30 moves it within the window hole 33 of the slider frame 32, and the slider frame 32 moves upward and downward (in direction of piston 20 movement) along with the slider 30.

When the slider frame 32 performs the up and down movement described above, the piston 20 inside the cylinder 1 reciprocates by means of the piston rod 23 connected to the slider frame 32.

The suction valve 9 opens when the piston 20 lowers. In other words, the suction valve 9 bends downward, and its tip contacts the suction valve guard 16 formed on the upper surface of the cylinder 1.

The suction valve 9 opens and air is suctioned into the cylinder 1 from the suction opening 3 and through the suction hole 8. This air is then compressed by the rising of the piston 20.

When the piston 20 rises and the air is compressed, the discharge valve 12 opens at the specified compression position. In other words, the discharge valve 12 bends upward and makes contact with the discharge valve guard 13.

When the discharge valve 12 opens, the compressed air is discharged by way of the discharge hole 7 from the discharge opening 4 in cylinder head 2.

On the other hand, in the rising stroke of the piston 20, the suction valve 94 installed at a position on the opposite side to the cylinder head 2 opens when the piston 20 rises. In other words, the suction valve 94 bends inwards and makes contact with the bottom of the concavity 96 (suction valve guard) on the outer side of the bottomed cylinder 90.

The suction valve 94 opens and air is suctioned into the cylinder 1 from a suction opening 103 on the opposite side to the cylinder head 2 and by way of the suction hole 93 and suction passage 97.

Then, in the lowering stroke of the piston 20, the discharge valve 99 installed at a position on the opposite side to the cylinder head 2 opens at the specified compression position when the piston 20 lowers. In other words, the discharge valve 99 bends outward and makes contact with the discharge valve guard 100.

When the discharge valve 99 opens, the compressed air is discharged from the discharge opening 104 on the opposite side to the cylinder head 2 by way of the discharge passage 102 and discharge hole 98.

Thus, as described above, a large amount of discharge can be obtained since two suction and discharge strokes are performed in one cycle.

Although the present invention has been described with reference to the preferred embodiments, it is apparent that the present invention is not limited to the aforesaid preferred embodiments, but various modification can be attained without departing from its scope as defined by the claims.

Claims

1. A compressor having a piston (20) reciprocable in a cylinder (1) by means of a cross slider crank mechanism,

wherein said cross slider mechanism is comprised of a piston rod (23) connected to said piston (20), a slider frame (32) connected to said piston rod (23) and supported to be allowed reciprocating motion, a slider (30) mounted in a window hole (33) of said slider frame (32) to be allowed movement perpendicular to said slider frame movement, and a crank shaft (26) connected to said slider (30) to allow rotation of said slider, and wherein said compressor comprises an oil supply passage (44) formed in a guide rod (35) supporting said slider frame (32) to allow reciprocating motion, an oil supply passage (45) formed between a guide rod hole (37) formed in said slider frame (32) and said guide rod (35), an oil supply passage (46) formed in said slider frame (32), and an oil supply passage (48) and oil drain passage (72) formed in said piston rod (23), in which lubricating oil is supplied from said oil supply passage (44) of said guide rod (35) to a cooling chamber (60) formed in said piston (20) by way of said oil supply passage (45) between said guide rod hole (37) of said slider frame (32) and said guide rod (35) said oil supply passage (46) in said slider frame, and said oil supply passage (48) in said piston rod, and lubricating oil in said cooling chamber (60) drains into a crankcase (25) by way of said oil drain passage (72) in said piston rod (23).
2. A compressor as claimed in claim 1, wherein a pair of said guide rods (35,36) are provided, and lubricating oil from the oil supply passage (44) of one of said guide rods (35) is supplied by way of the oil supply passage (45) between said one guide rod (35) and guide rod hole (37), and said oil supply passage (46) in said slider frame (32), to said oil supply passage (48) in said piston rod (23), and to the oil supply passage (47) between the other guide rod (36) and guide rod hole (38).
3. A compressor as claimed in claim 1 or 2, wherein the interior of said crankshaft (26), is formed with an oil supply passage (51), said slider (30) is formed with an oil hole (52), and lubricating oil is supplied to the sliding surfaces of said slider (30) and said slider frame (32) by way of said oil supply passage (51) of said crankshaft (26) and said slider oil hole (52).
4. A compressor having a piston (20) reciprocable in a cylinder (1) by means of a cross slider crank mechanism,

wherein said cross slider crank mechanism is comprised of a piston rod (23) connected to said piston (20), a slider frame (32) connected to said piston rod (23) and supported to be allowed reciprocating motion, a slider (30) mounted in a window hole (33) of said slider frame (32) to be allowed movement perpendicular to said slider frame movement, and a crank shaft (26) connected to said slider (30) to allow rotation of said slider, and wherein the interior of said crankshaft (26) is formed with an oil supply passage (51), said slider (30) is formed with an oil hole (52), and lubricating oil is supplied to the sliding surfaces of said slider (30) and said slider frame (32) by way of said oil supply passage (51) of said crankshaft (26) and said slider oil hole (52).
5. A compressor as claimed in any one of claims 1 to 4, wherein the interior of said cylinder (1) and interior of said crankcase are sealed with an oil seal (56) provided at the middle section of said piston rod (23).
6. A compressor having a piston (20) reciprocable in a cylinder (1) by means of a cross slider crank mechanism,

wherein said cross slider crank mechanism is comprised of a piston rod (23) connected to said piston (20), a slider frame (32) connected to said piston rod (23) and supported to be allowed reciprocating motion, a slider

(30) mounted in a window hole (33) of said slider frame (32) to be allowed movement perpendicular to said slider frame movement, and a crank shaft (26) connected to said slider (30) to allow rotation of said slider, and wherein a sliding surface of said slider frame (32) which contacts said slider (30) is covered with a chromium plating (34).

- 5 7. A compressor as claimed in claim 6, wherein said slider (30) is made of cast iron.
8. A compressor as claimed in claim 6 or claim 7, wherein an oil groove (54) is formed on a sliding surface of said slider (30) which contacts said slider frame (32).
- 10 9. A compressor as claimed in claim 6, 7 or 8, wherein said chromium plating is a porous chromium plating and the smoothness, surface roughness and porosity rate are improved by surface grinding.
- 15 10. A compressor having a piston (20) reciprocable in a cylinder (1) by means of a cross slider crank mechanism, wherein an inlet valve (9) for opening and closing inlet holes (8) formed in a cylinder head (2) is formed of thin reed valve, one end of said inlet valve (8) is secured to a lower surface of said cylinder head (2), an inlet valve guard (16) is formed on an upper surface of said cylinder (1), and said inlet valve guard (16) is formed with a tapered surface.
- 20 11. A compressor as claimed in claim 10, wherein the taper angle of said tapered surface is one to four degrees.
12. A compressor as claimed in claim 10 or 11, wherein a discharge valve (12) for opening and closing discharge holes (7) formed in said cylinder head (2) is formed of thin reed valve, and disposed in the space inside said cylinder head (2) and secured at both ends, and a discharge valve guard (13) is installed above said discharge valve (12).
- 25 13. A compressor having a piston (20) reciprocable in a cylinder (1) by means of a cross slider crank mechanism, wherein, in use, in a lowering stroke of said piston (20), air is drawn through an inlet opening (8) formed in a cylinder head (2) into a space in said cylinder (1) facing an upper surface of said piston (20), and in a rising stroke of said piston (20), compressed air is discharged from a discharge opening (7) formed in said cylinder head (2), and in the rising stroke of said piston (20), air is drawn through an inlet opening (93) formed separately from said inlet opening (8) formed in said cylinder head (2) into a space in said cylinder (1) facing a lower surface of said piston (20), and in the lowering stroke of said piston (20), compressed air is discharged from a discharge opening (98) formed separately from said discharge opening (7) formed in said cylinder head (2).
- 30
- 35
- 40
- 45
- 50
- 55

FIG.1

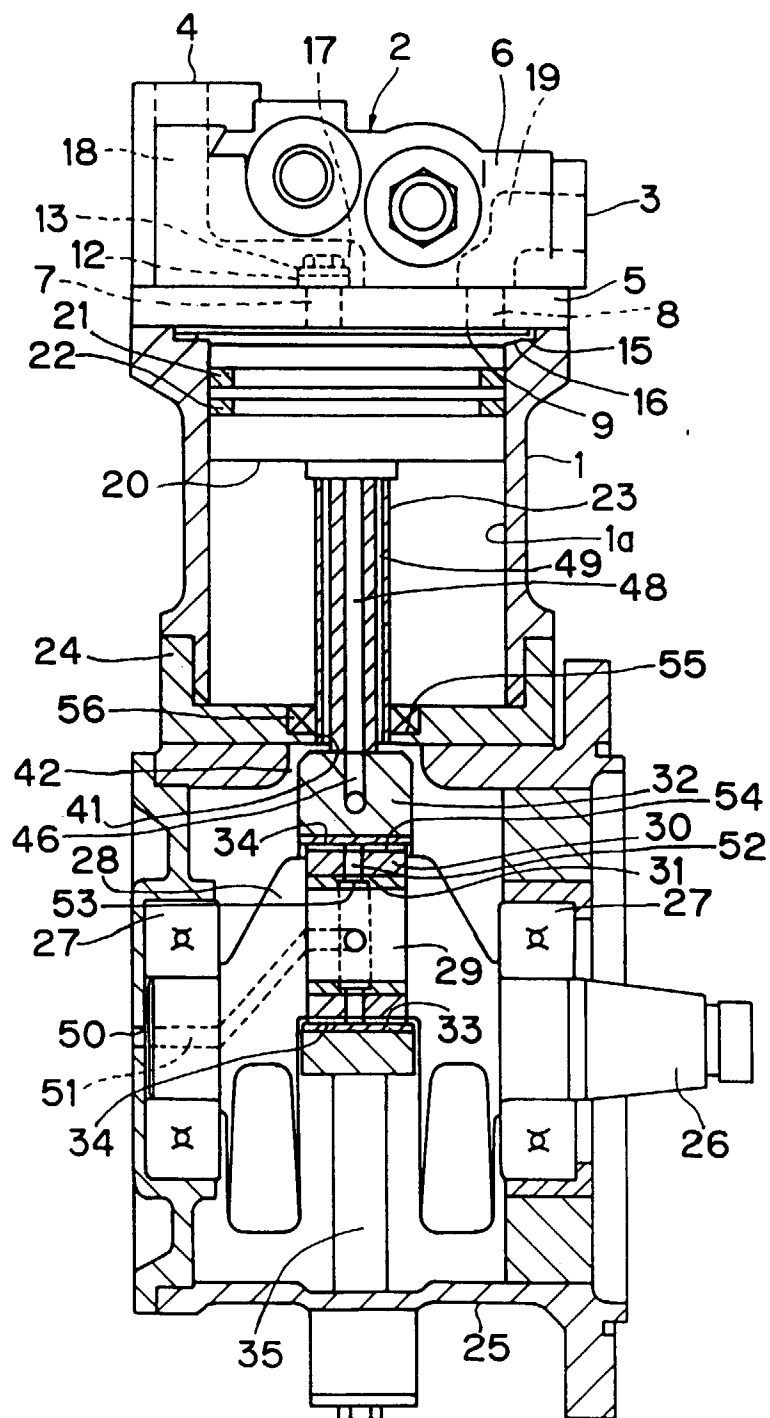


FIG.2 (a)

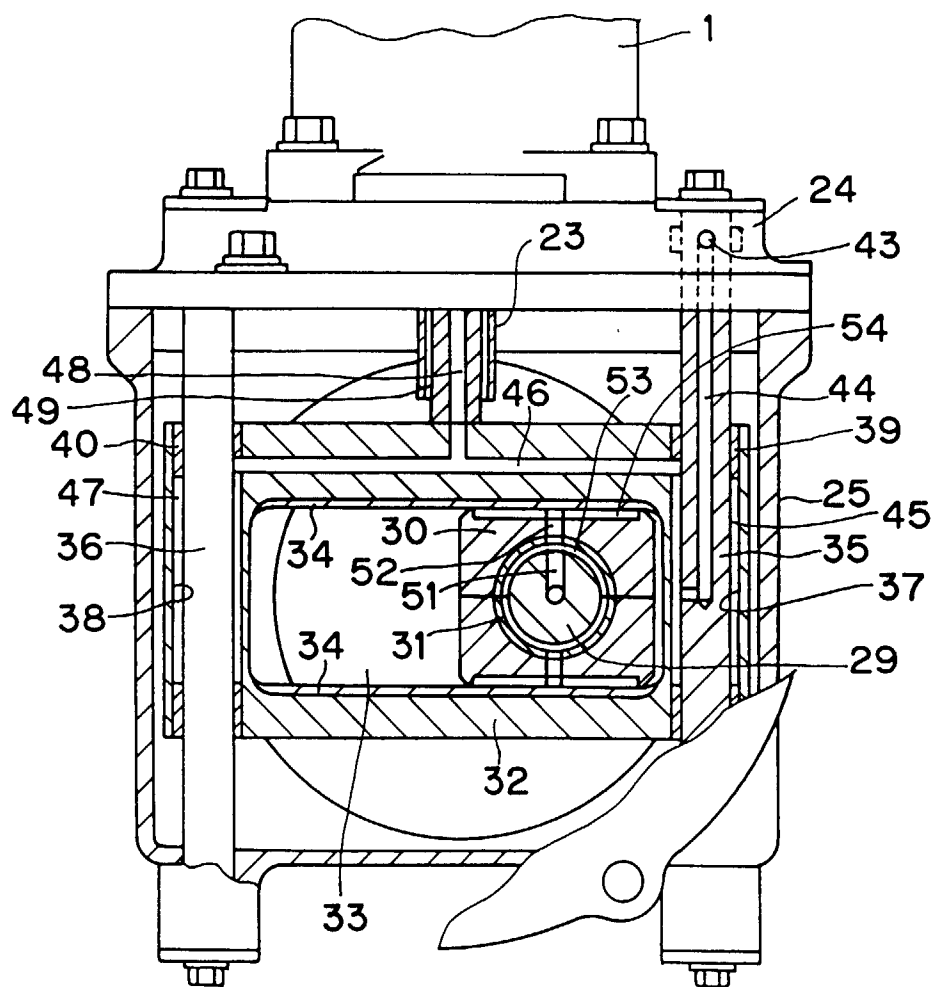


FIG.2(b)

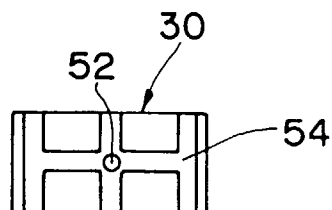


FIG. 3

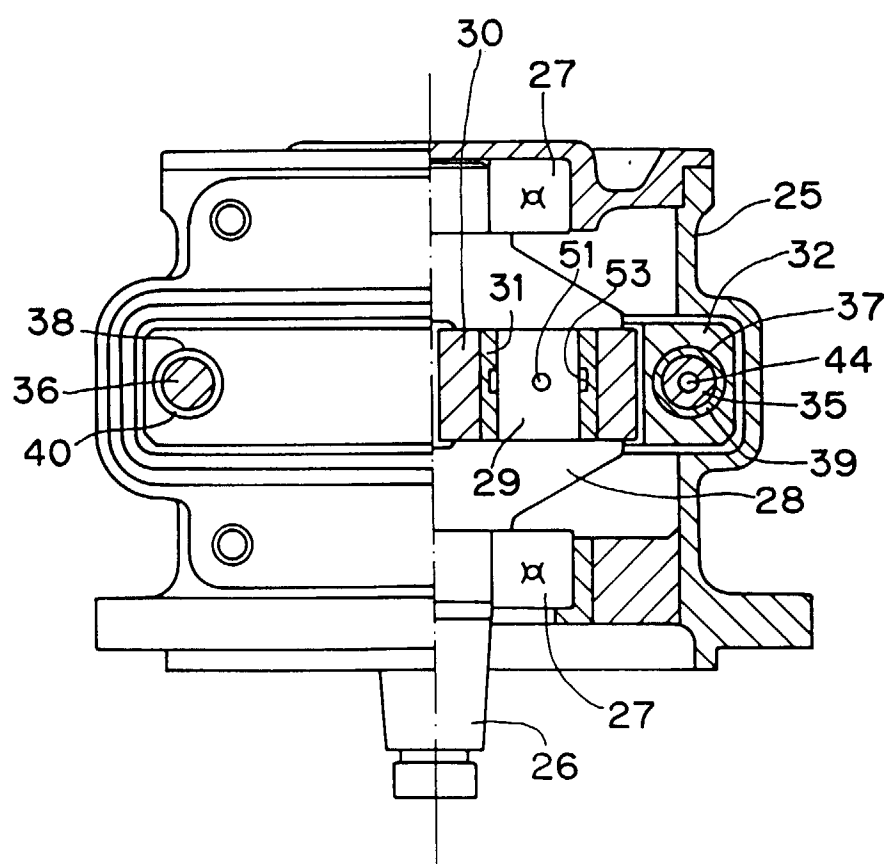


FIG.4

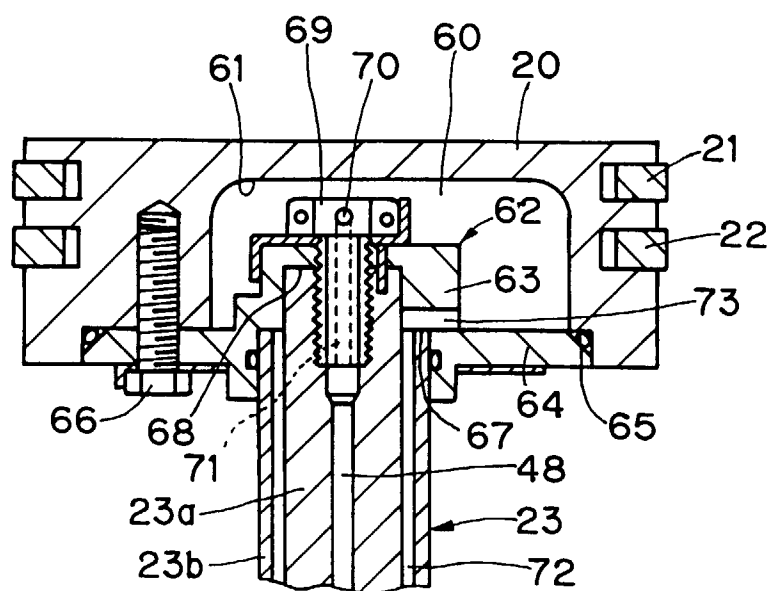


FIG. 5(a)

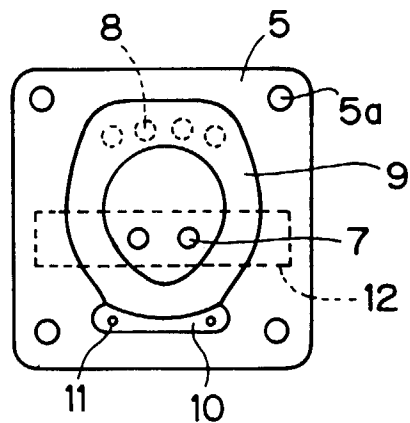


FIG. 5(b)

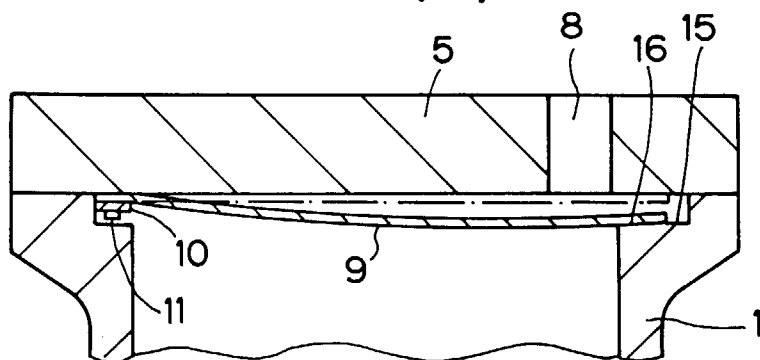


FIG. 5(c)

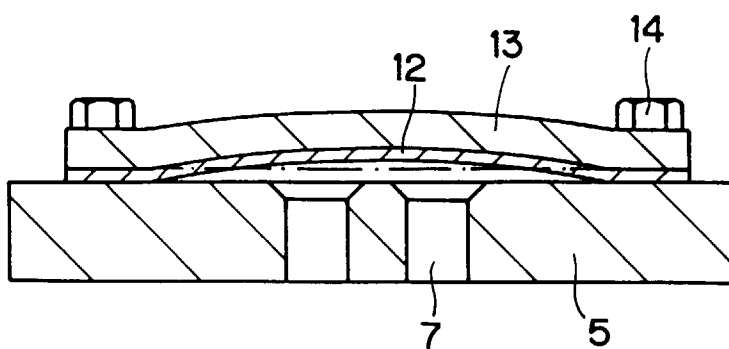


FIG.10

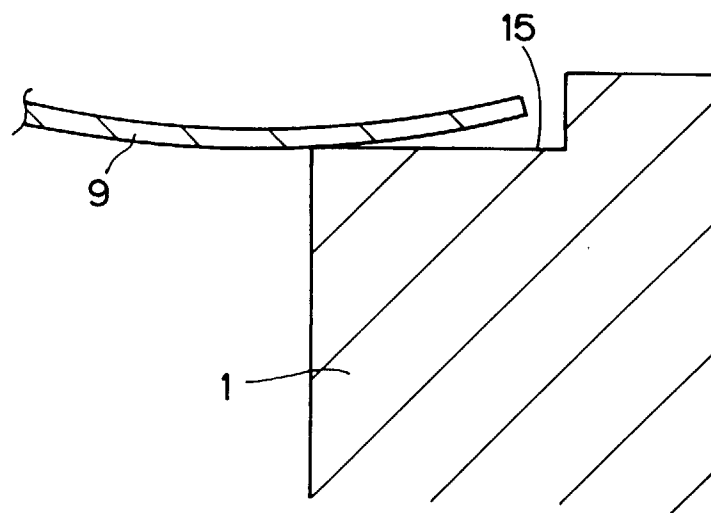


FIG.6

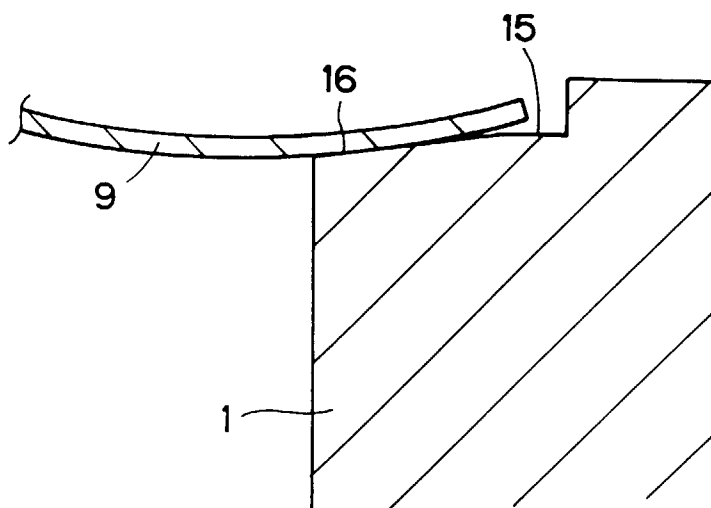


FIG.7

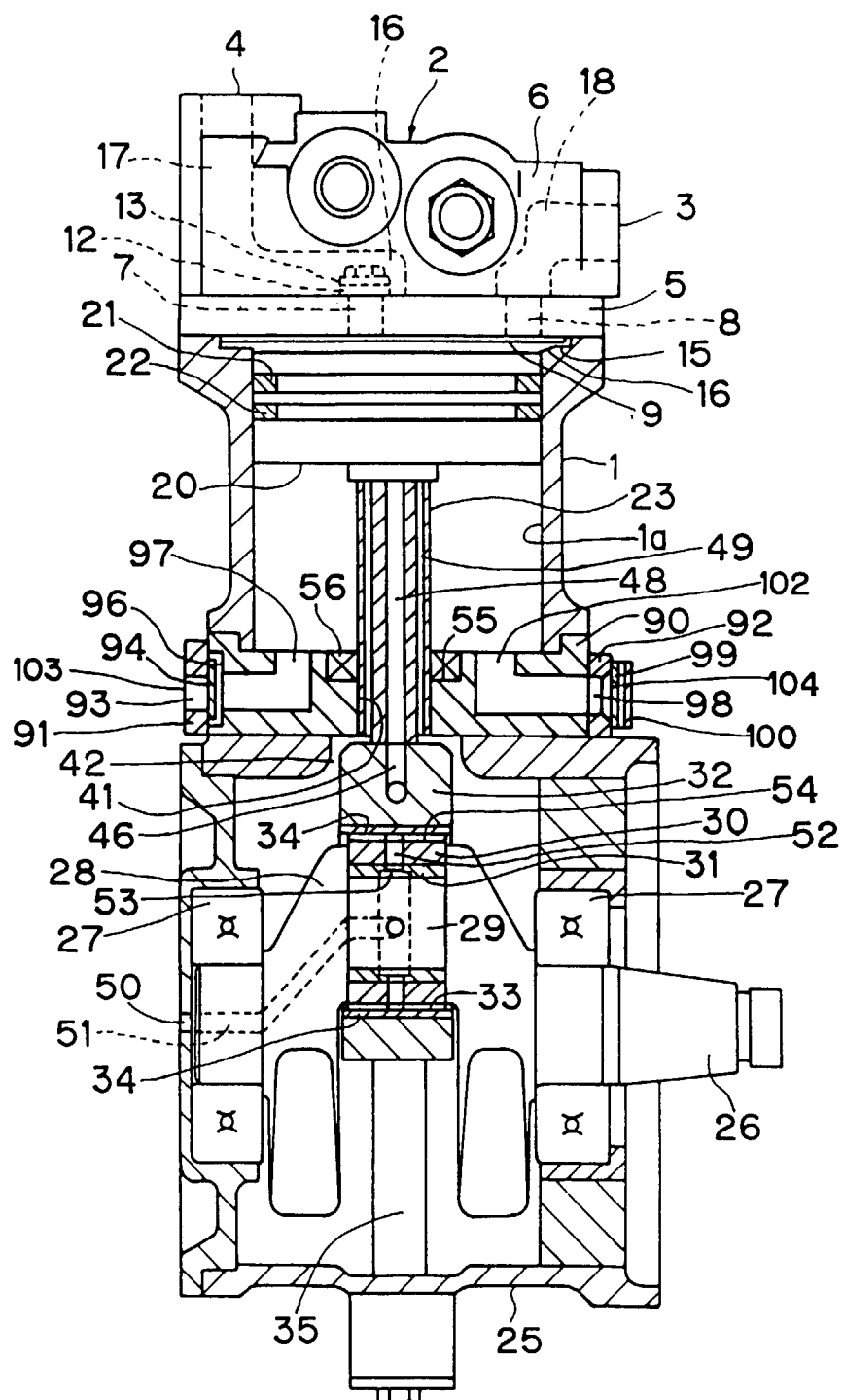


FIG.8

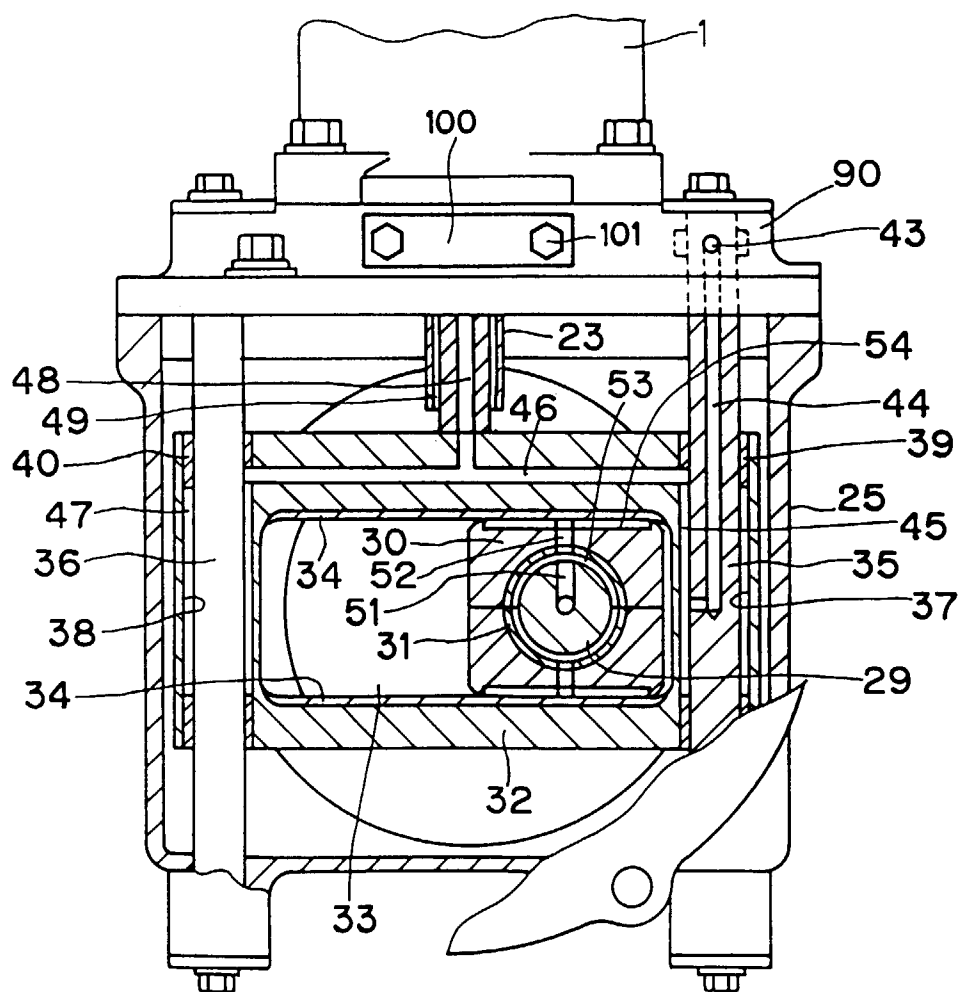


FIG. 9(a)

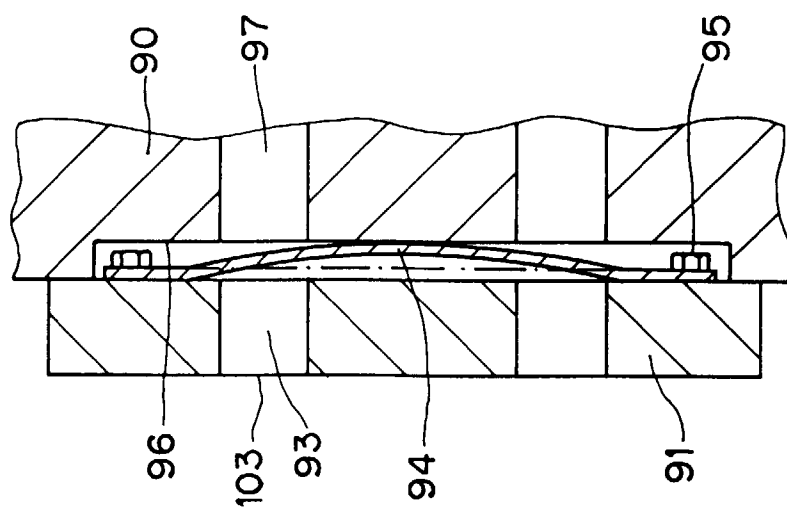


FIG. 9(b)

