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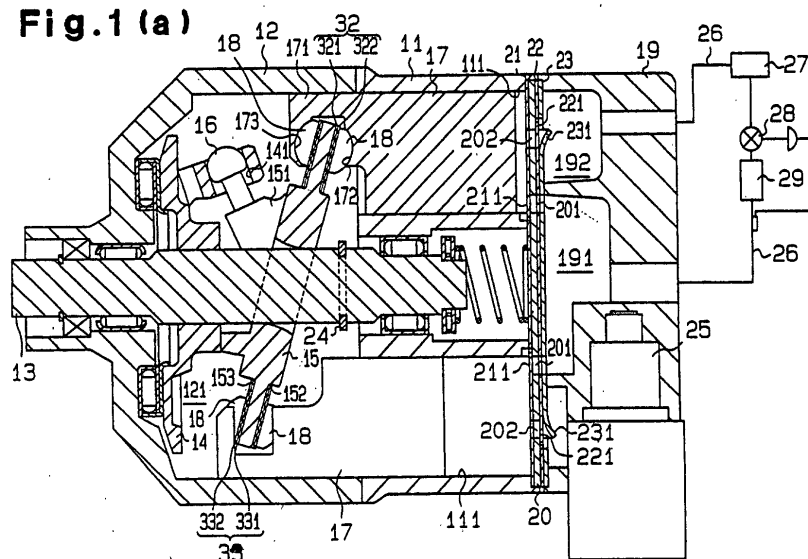
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(54) **SWASH PLATE OF SWASH PLATE TYPE COMPRESSOR**

(57) A swash plate (15) of a swash plate type compressor includes a slide-contact film (32, 33) having a metal layer, which is formed on a slide-contact surface (152, 153), which slide-contacts shoes (18), through sintering, and a resin layer (322, 332), which is formed on

the metal layer. By using the metal layer, which is formed through sintering, the bonding of the resin layer and the metal layer is guaranteed, deficiencies such as cracking of a slide film and seizure are prevented, and the slide-contact characteristic relative to the shoes is improved.

Fig.1 (a)



Description

[TECHNICAL FIELD]

[0001] The present invention relates to a swash plate type compressor, and more particularly, to a swash plate having a surface, which contacts shoes, with a slide-contact film formed thereon in a swash plate type compressor that transmits the rotational force of the swash plate to pistons by means of shoes to reciprocally move the pistons.

[BACKGROUND ART]

[0002] As disclosed in Japanese Laid-Open Patent Publication No. 2-267371, pistons of a swash plate type compressor are reciprocally moved by the rotating action of a swash plate, which rotates integrally with a rotary shaft. Shoes are arranged between the peripheral portion of the swash plate and the pistons. The rotational force of the swash plate is transmitted to the pistons by means of the shoes. The shoes, which are made of a steel material, contact the rotating swash plate. Thus, the slide-contact portion between the shoes and the swash plate may wear out, and seizure may occur between the shoes and the swash plate. The slide-contact characteristic of the swash plate with respect to the shoes must therefore be improved. Japanese Laid-Open Patent Publication No. 2-267371 discloses a swash plate having a metal layer formed on the surface of the swash plate that comes into contact with the shoes. The metal layer is formed by sintering or spraying a copper bearing alloy.

[0003] However, the metal layer, which is formed by spraying the copper bearing alloy, may result in the occurrence of deficiencies, such as cracking of the slide-contact film or seizure. Accordingly, Japanese Laid-Open Patent Publication No. 2-267371 discloses a swash plate having a resin layer, which includes a solid lubricant, formed on the metal layer by spraying copper. Further, the formation of a plating layer on the metal layer has been proposed in the prior art. The resin layer, which is formed by means of spraying, or the plating layer contribute to preventing cracking of the slide-contact film or seizure but do not obtain desirable results from the viewpoint of slide-contact (sliding) characteristic with respect to the shoes.

[DISCLOSURE OF THE INVENTION]

[0004] It is an object of the present invention to provide a swash plate of a swash plate type compressor that prevents the occurrence of deficiencies, such as cracking of the slide-contact film or seizure, while improving the slide-contact characteristic with respect to the shoes.

[0005] A first perspective of the present invention provides a swash plate of a swash plate type compressor

that transmits the rotating force of the swash plate, which rotates integrally with a rotary shaft, to a piston by means of a shoe to reciprocally move the piston. The swash plate rotates while contact occurs between the shoe and a slide-contact surface. The swash plate includes a slide-contact film having a metal layer, which is formed on the slide-contact surface of the swash plate through sintering, and a resin layer or a plating layer, which is formed on the metal layer.

[0006] A second perspective of the present invention provides a swash plate type compressor including a rotary shaft, a swash plate rotated integrally with the rotary shaft, a shoe that contacts a slide-contact surface of the swash plate when the swash plate rotates, and a piston connected to swash plate by means of the shoe. The swash plate includes a slide-contact film having a metal layer, which is formed on the slide-contact surface of the swash plate through sintering, and a resin layer or a plating layer, which is formed on the metal layer.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0007]

Fig. 1(a) is a cross-sectional side view of a swash plate type compressor according to an embodiment of the present invention, and Fig. 1(b) is an enlarged cross-sectional view showing the main portion of the compressor of Fig. 1(a).

Fig. 2(a) is a front view showing a swash plate having a surface on which a metal layer is partially formed, and Fig. 2(b) is a front view showing the swash plate with a resin layer formed on the surface of the metal layer.

Fig. 3 is a side view showing an apparatus for forming the metal layer.

[BEST MODE OF CARRYING OUT THE INVENTION]

[0008] A variable displacement compressor according to an embodiment of the present invention will now be discussed with reference to Figs. 1 to 3.

[0009] Fig. 1(a) shows the internal structure of the variable displacement compressor. The variable displacement compressor includes a front housing 12, which defines a control pressure chamber 121, and a cylinder block 11. A rotary shaft 13 is supported in the housings 11, 12. The rotary shaft 13 is rotated by drive force, which is transmitted from an external drive source (e.g., vehicle engine). A circular rotary support 14 is secured to the rotary shaft 13 to support a circular swash plate 15 so that the swash plate 15 is slidable and inclinable in the axial direction of the rotary shaft 13.

[0010] A support body 151 is formed integrally with the swash plate 15, which is made of a steel material. Guide pins 16 are attached to the support body 151. The

guide pins 16 are slidably fitted in guide holes 141, which are formed in the rotary support 14. The swash plate 15 is inclinable in the axial direction of the rotary shaft 13 and integrally rotatable with the rotary shaft 13 by the cooperation between the guide holes 141 and the guide pins 16. The inclination of the swash plate 15 is guided by the slide-guide relationship between the guide holes 141 and the guide pins 16, and the slide support function of the rotary shaft 13.

[0011] The inclination angle of the swash plate 15 is changed by controlling the pressure of the control pressure chamber 121. As the pressure in the control pressure chamber 121 increases, the inclination angle of the swash plate 15 decreases. As the pressure in the control pressure chamber 121 decreases, the inclination angle of the swash plate 15 increases. Refrigerant flows from the control pressure chamber 121 via a pressure releasing passage, which is not shown, to a suction chamber 191, which is formed in a rear housing 19. Further, refrigerant is supplied from a discharge chamber 192, which is formed in the rear housing 19, to the control pressure chamber 121 via a pressure supply passage, which is not shown.

[0012] A displacement control valve 25 is arranged in the pressure supply passage. The flow rate of the refrigerant supplied from the discharge chamber 192 to the control pressure chamber 121 is controlled by the displacement control valve 25. When the flow rate of the refrigerant supplied from the discharge chamber 192 to the control pressure chamber 121 increases, the pressure in the control pressure chamber 121 increases. When the flow rate of the refrigerant supplied from the discharge chamber 192 to the control pressure chamber 121 decreases, the pressure in the control pressure chamber 121 decreases. Accordingly, the inclination angle of the swash plate 15 is controlled by the displacement control valve 25.

[0013] The maximum inclination angle of the swash plate 15 is determined by the contact between the swash plate 15 and the rotary support 14. The minimum inclination angle of the swash plate 15 is determined by the contact between a snap ring 24 on the rotary shaft 13 and the swash plate 15.

[0014] A plurality of cylinder bores 111 (only two shown in Fig. 1(a)) are arranged about the rotary shaft 13 in the cylinder block 11. A piston 17 is retained in each cylinder bore 111. A holding portion 171 is formed in one end of the piston 17. A pair of opposed spherical recess portions 172, 173 are formed in the holding portion 171. As shown in Fig. 1(b), semispherical shoes 18 are held in the recess portions 172, 173 not to be spilled therefrom.

[0015] The rotating action of the swash plate 15, which rotates integrally with the rotary shaft 13, is converted to the forward and rearward reciprocating action of the piston 17 by the semispherical shoes 18 to move the piston 17 forward and rearward in the cylinder bore 111. The pair of shoes 18 are made of a steel material

and slidably contact slide-contact surfaces 30, 31 of the swash plate 15.

[0016] The reciprocating movement of the pistons 17 (movement from the right to the left, as viewed in Fig. 1 (a)) causes the refrigerant in the suction chamber 191 to open suction valves 211, which are formed in a valve formation plate 21, and flow into the cylinder bores 111 through suction ports 201, which are formed in a valve plate 20. The reciprocating movement of the pistons 17 (movement from the left to the right, as viewed in Fig. 1 (a)) causes the refrigerant that entered the cylinder bores 111 to open discharge valves 221, which are formed in a valve formation plate 22, and flow into the discharge chamber 192 through discharge ports 202, which are formed in the valve plate 20. The discharge valves 221 contact retainers 231, which are formed on a retainer formation plate 23, so that its opened degree is restricted.

[0017] The discharge chamber 192 and the suction chamber 191 are connected to each other by an external refrigerant circuit 26. The refrigerant sent to the external refrigerant circuit 26 from the discharge chamber 192 flows through a condenser 27, an expansion valve 28, and an evaporator 29 and returns to the suction chamber 191.

[0018] As shown in Figs. 1(a) and 1(b), slide-contact films 32, 33 are formed on a front surface 152 and a rear surface 153 of the peripheral portion of the swash plate 15. The slide-contact film 32 has a double-layer structure comprising a metal layer 321, which is formed, through sintering, on the front surface (slide-contact surface) 152 that has a slide-contact section corresponding with the shoes 18, and a resin layer 322, which is formed on the metal layer 321. The slide-contact film 33 has a double-layer structure comprising a metal layer 331, which is formed, through sintering, on the rear surface (slide-contact surface) 153 that has a slide-contact section corresponding with the shoes 18, and a resin layer 332, which is formed on the metal layer 331.

[0019] The metal layers 321, 331 respectively formed on the front surface 152 and the rear surface 153, which originally are the surfaces of substrate of the swash plate 15, are formed from a copper material. The resin layer 322 is made of a material obtained by dispersing a solid lubricant in resin. In the present embodiment, molybdenum disulfide and graphite are used as the solid lubricant, and thermosetting polyamide imide is used as the resin.

[0020] The metal layers 321, 331 are formed using the apparatus shown in Fig. 3. The swash plate 15 is attached to a rotary holding mechanism 35, which is rotated by a motor 34 in the direction of arrow Q1. Fine copper particles are deposited on the front surface 152 of the peripheral portion of the swash plate 15, which is attached to the rotary holding mechanism 35, to form a layer that is greater than or equal to a predetermined thickness.

[0021] In Fig. 2(a), S1 denotes the layer of fine parti-

cles deposited on the front surface 152. A roller 37, which is attached to an output shaft 361 of the motor 36, is moved reciprocally in directions of arrow Q2 (vertical direction) by a space maintaining mechanism 38. The roller 37 has the form of a truncated cone. The roller 37 is arranged so that its rotating axis extends through the swash plate 15 near the center P of the swash plate 15 and the minimum space between the conical surface of the roller 37 and the front surface 152 of the swash plate 15 is equal to the predetermined thickness. The motors 34, 36 are synchronously rotated, and the roller 37 rolls along the front surface 152 of the swash plate 15 in the circumferential direction of the swash plate 15 without being relatively displaced. That is, the layer of copper particles on the front surface 152 is pressed by the roller 37 so that it has the predetermined thickness. The layer of copper particles having the predetermined thickness is sintered in an oxygen-free state to form the metal layer 321. The thickness adjustment by the roller 37 and the sintering treatment is also performed on the rear surface 153 of the swash plate 15 to form the metal layer 331.

[0022] Then, a fluid resin coating, which includes a solid lubricant, is applied to the surface of the metal layers 321, 331. In Fig. 2(b), S2 denotes a coating film of the resin coating. After drying the coating film S2, the coating film S2 is baked and hardened at 200°C to 300°C to form the resin layers 322, 332.

[0023] The variable displacement compressor has the advantages described below.

(1) Layers of copper metal particles are formed on the front and rear surfaces 152, 153 of the swash plate 15, and the layers are sintered to form intended surface with fine pits and lands in the surfaces of the metal layers 321, 331. The fluid resin coating, which includes a solid lubricant, enters the pits of the surface. Accordingly, the contact area of the metal layers 321, 331 relative to the resin coating of the sintered surface is greater than the contact area of a surface that does not have the pits and lands relative to the resin coating. That is, the bonding capacity of the resin coating relative to the surface of the metal layers 321, 331 is high. The state of the pits and lands in the surface of the metal layers 321, 331 is affected by the particle diameter of the metal particles. However, the sintered surface of the metal layers 321, 331, in which the particle diameter of the metal particles is optimally set, has a pit and land state that is preferable as a bonding subject surface of resin.

Accordingly, the bonding of the resin layers 322, 332 to the metal layers 321, 331, which are formed through sintering, is guaranteed. This obtains the slide-contact films 32, 33, which have superior slide-contact characteristic with respect to the shoes 18.

(2) The layer thickness of the metal layers 321, 331

is set at about 60μm to 70μm. The layer thickness is obtained by adjusting the thickness of the copper particle layers, which are formed on the front and rear surfaces 152, 153, to the desired layer thickness of the metal layers 321, 331. The thickness of the copper particle layers is set by adjusting the position of the rollers 37 relative to the front and rear surfaces 152, 153 of the swash plate 15. Such adjustment of the position of roller 37 is simple. Accordingly, the desired layer thickness of the metal layers 321, 333 is easily obtained.

(3) Since the metal layers 321, 331 have the desired layer thickness subsequent to sintering, the metal layers 321, 331 do not have to be ground to obtain the desired thickness. The elimination of the grinding process of the metal layers 321, 331 facilitates the procedure for forming the slide-contact films 32, 33.

(4) Even when the sintered surfaces of the metal layers 321, 331 are ground, the bonding capacity of the resin coatings relative to the ground surface is high. This is because fine pores are formed in the metal layers 321, 331, and fine pits are produced in the ground surface when grinding the surfaces of the metal layers 321, 331. The fluid resin coating, which includes a solid lubricant, enters the fine pits and increases the contact area of the ground surfaces of the metal layers 321, 331 relative to the resin coating.

(5) In comparison with a metal layer formed through spraying, the thickness of the resin layer is uniform when applied on the sintered metal layers 321, 331. A metal layer, which is formed through spraying, has relatively large pores. When such large pores are exposed from the surface of the metal layer, the thickness of the coating layer of the resin coating is not uniform, and the formation of a slide-contact film having a uniform coating thickness becomes difficult.

(6) The swash plate 15 and the shoes 18 are both made of steel materials. Thus, if the shoes 18 were to come into direct slide-contact with the front and rear surfaces 152, 153, seizure would occur at an early stage. The same type of materials is an inadequate combination from the viewpoint of seizure when they come into contact with each other. Even if the shoes 18 come into direct contact with the metal layers 321, 331, since the metal layers 321, 331 are made of a copper material, which differs from the material of the shoes 18, seizure is prevented from occurring at an early stage.

(7) A mixture of solid lubricant and resin is effective for improving the slide-contact characteristic of a

slide-contact film, which includes a metal layer. Particularly, the mixture of molybdenum disulfide, graphite, and polyamide imide is extremely effective for improving the contact characteristic of the slide-contact films 32, 33.

(8) The front and rear surfaces 152, 153 of the swash plate 15 are flat and are thus preferable for uniformly depositing the layers of metal particles with the desired thickness.

[0024] The present invention may be embodied in the following forms without departing from the scope of the present invention.

[0025] The resin layers may be altered to plating layers. The same effects as advantage (1) in the above embodiment guarantees the bonding of the metal layers 321, 331, which are formed through sintering, with the plating layers. For example, a nickel plating or a cobalt plating may be given as the types of plating, and electroplating, chemical plating, or electroless plating may be given as the types of plating processes. In this case, if a composite plating, which disperses a solid lubricant in the plating, is formed, the slide-contact characteristic between a swash plate and shoes is further improved.

[0026] In addition to molybdenum disulfide and graphite, which are discussed above, tungsten disulfide, boron nitride, antimony oxide, indium, tin, and so forth may be used as the solid lubricant.

[0027] A double-layer structure including a first metal layer, which has a relative small particle diameter, and a second metal layer, which has a relatively large particle diameter, may be formed, and a resin layer may be formed on the second metal layer to form a slide-contact film. The fine pits and lands in the surface of the second metal layer increase the bonding capacity of a resin layer. The metal layers of such double-layer structure is obtained by depositing metal particles having a relatively small particle diameter on the peripheral surface of the swash plate to a predetermined thickness to form a first deposit layer, then depositing metal particles having a relatively large particle diameter on the first deposit layer to a predetermined thickness to form a second deposit layer, and then sintering the first and second deposit layers. The sintering simultaneously forms two metal layers.

[0028] An aluminum material may be formed for the metal layers.

[0029] When forming the metal layers of the double-layer structure with aluminum that includes silicon, it is preferred that the silicon content of the first metal layer, which is formed on the surface of the swash plate, be small and that the silicon content of the second metal layer, to which a resin layer is applied, be large. When the silicon content is small, the bonding strength of the first metal layer with respect to the surface of the swash plate is large. When the silicon content is increased, the contact characteristic of the second metal layer, to which

the resin layer is applied, is improved.

[0030] The present invention may be applied to a swash plate made of an aluminum material to reduce weight.

[0031] The present invention may be applied to a swash plate of a fixed displacement swash plate type compressor.

10 Claims

1. A swash plate (15) of a swash plate type compressor that transmits the rotating force of the swash plate, which rotates integrally with a rotary shaft (13), to a piston (17) by means of a shoe (18) to reciprocally move the piston, wherein the swash plate rotates while slide-contact occurs between the shoe and a slide-contact surface (152, 153), the swash plate comprising:

a slide-contact film including a metal layer (321, 331), which is formed on the slide-contact surface of the swash plate through sintering, and a resin layer (322, 332) or a plating layer, which is formed on the metal layer.

2. The swash plate according to claim 1, wherein the metal layer is made of a copper material or an aluminum material.

3. The swash plate according to claim 1 or 2, wherein the resin layer or the plating layer includes a solid lubricant.

4. The swash plate according to any one of claims 1 to 3, wherein the metal layer has a surface that is not ground, and the resin layer or the plating layer is formed on the surface.

5. The swash plate according to any one of claims 1 to 4, wherein the swash plate is made of a steel material.

6. A swash plate type compressor including:

a rotary shaft (13);
a swash plate (15) rotated integrally with the rotary shaft;
a shoe (18) that slidably contacts a slide-contact surface of the swash plate (15) when the swash plate rotates; and
a piston (17) connected to swash plate by means of the shoe, the swash plate comprising:

a slide-contact film including a metal layer (321, 331), which is formed on the slide-contact surface of the swash plate through sintering, and a resin layer (322, 332) or a

plating layer, which is formed on the metal layer.

7. The swash plate type compressor according to claim 6, wherein the metal layer is made of a copper material or an aluminum material. 5
8. The swash plate type compressor according to claim 6 or 7, wherein the resin layer or the plating layer includes a solid lubricant. 10

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Fig. 1 (a)

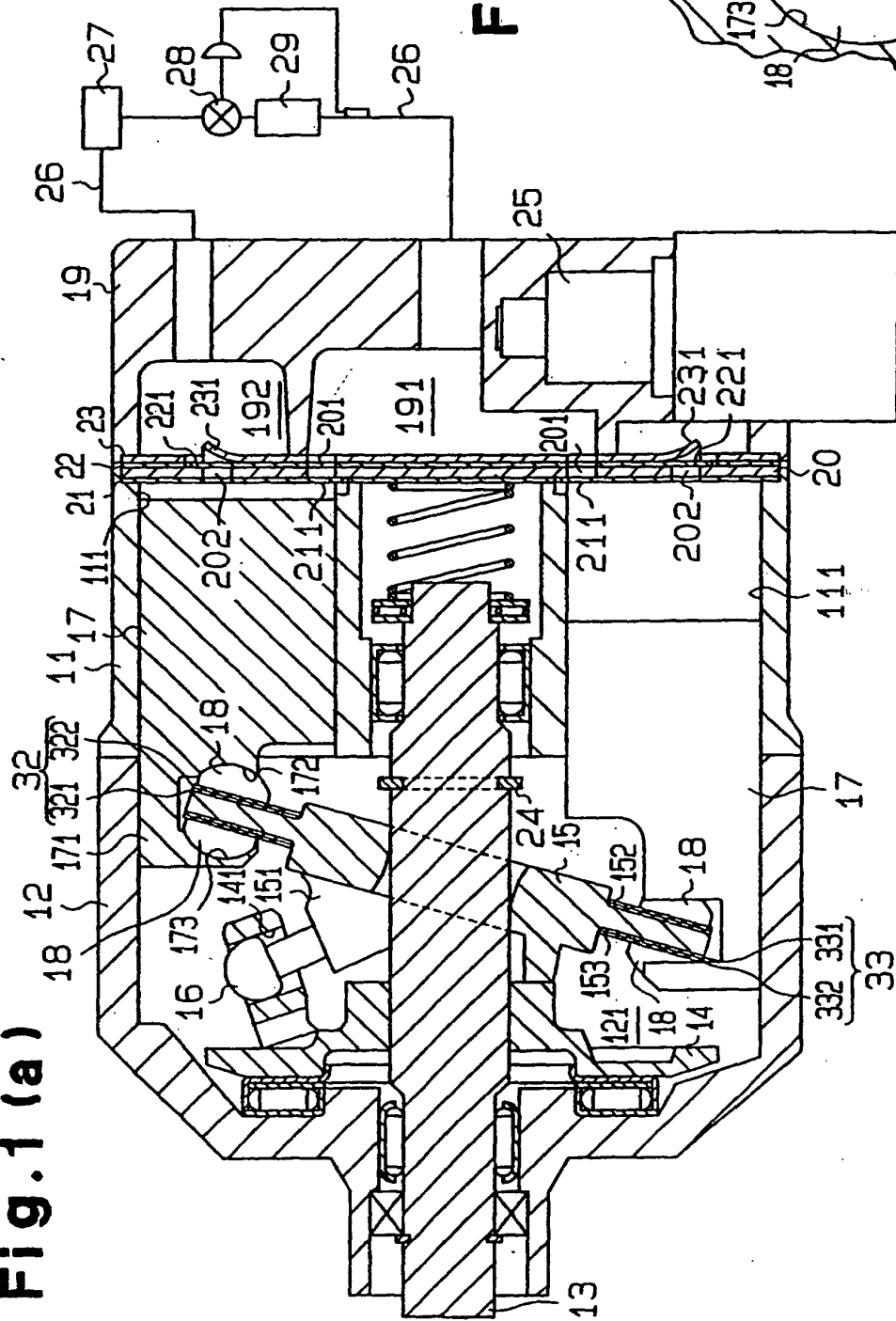


Fig. 1 (b)

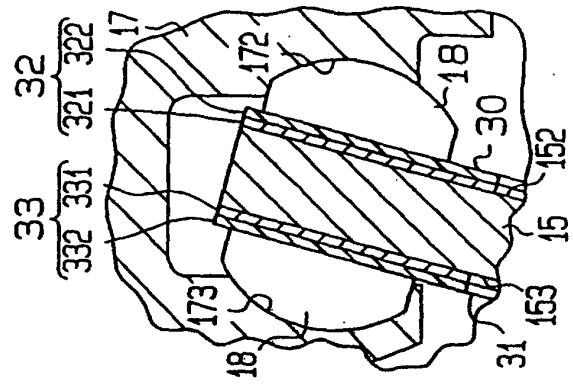


Fig.2 (a)

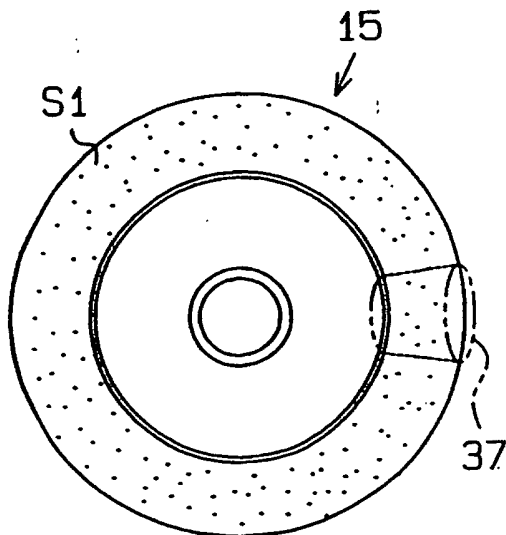


Fig.2 (b)

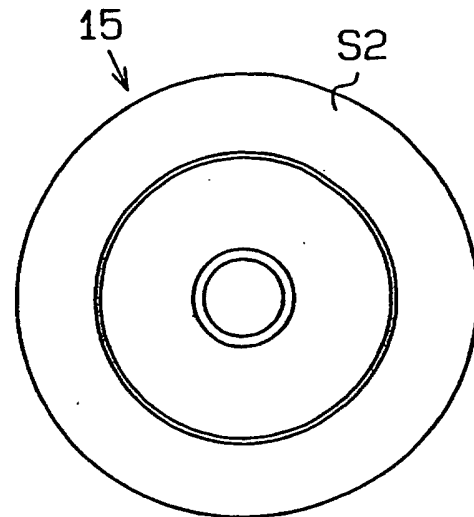
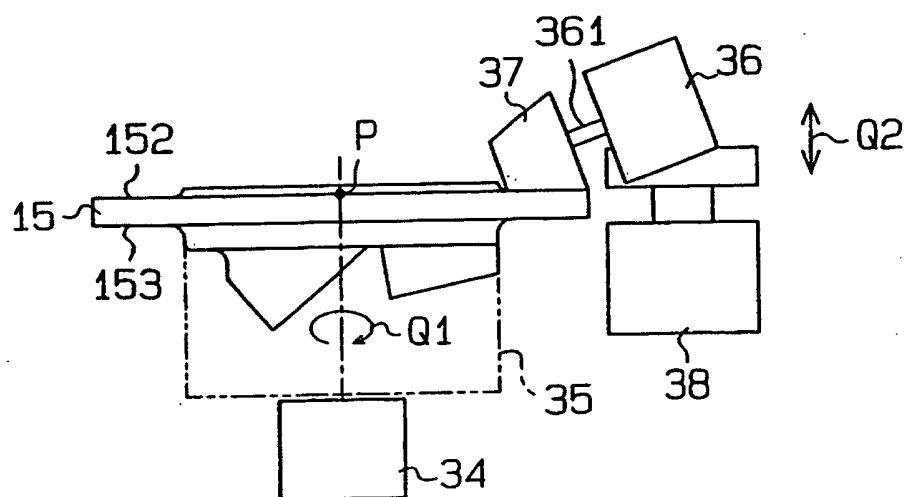


Fig.3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/08651

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁷ F04B27/08, F04B27/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁷ F04B27/08-27/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2002
Kokai Jitsuyo Shinan Koho 1971-2002 Jitsuyo Shinan Toroku Koho 1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-205442 A (Toyoda Automatic Loom Works, Ltd.), 04 August, 1998 (04.08.98), Full text; Figs. 1, 2 & EP 911517 A3	1-8
Y	EP 926340 A1 (Toyoda Automatic Loom Works, Ltd.), 30 June, 1999 (30.06.99), Full text; Figs. 1 to 6 & JP 11-193780 A & US 6189434 A	1-8
Y	WO 98/36173 A1 (Toyoda Automatic Loom Works, Ltd.), 20 August, 1998 (20.08.98), Full text; Figs. 1 to 5 (Family: none)	1-8
A	JP 63-40943 B2 (Toyoda Automatic Loom Works, Ltd.), 15 August, 1988 (15.08.88), Full text; Figs. 1 to 6 (Family: none)	1-8
A	EP 1010771 A1 (Taiyo Kogyo Co., Ltd.), 21 June, 2000 (21.06.00), Full text; Figs. 1 to 3 & JP 2000-179453 A	1-8

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search
15 January, 2002 (15.01.02)

Date of mailing of the international search report
29 January, 2002 (29.01.02)

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