(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 961 030 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.12.1999 Bulletin 1999/48

(51) Int. Cl.^{6}: **F04B 27/10**

(21) Application number: **99109149.7**

(22) Date of filing: **08.05.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **28.05.1998 JP 14743998**

(71) Applicant:
Kabushiki Kaisha Toyoda Jidoshokki Seisakusho
Aichi-ken 448-8671 (JP)

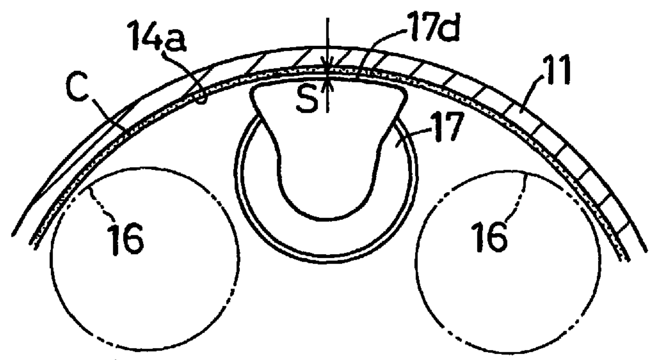
(72) Inventors:
- **Sugiura, Manabu**
  c/o Kabushiki Kaisha Toyoda
  Kariya-shi Aichi-ken, 448-8671 (JP)
- **Hamaoka, Takahiro**
  Kabushiki Kaisha Toyoda
  Kariya-shi Aichi-ken, 448-8671 (JP)

(74) Representative:
Hoeger, Stellrecht & Partner
Uhlandstrasse 14 c
70182 Stuttgart (DE)

(54) Lubrication for pistons in the crankcase of a swash plate type compressor

(57) A swash plate type compressor includes a plurality of single-headed pistons. Each of the pistons has an interference surface at the rear for inhibiting rotation. The interference surfaces are brought into contact with a lubricant film which is formed on an inner peripheral wall of a crank chamber. Thus, by simply forming the lubricant film, the pistons can be efficiently inhibited from being damaged or seizured at the interference surfaces.

FIG. 3



EP 0 961 030 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a swash plate type compressor. More particularly, it relates to an improvement in the construction for preventing the pistons from rotating about their own axes.

Description of the Related Art

[0002] A swash plate type compressor, which is used mainly for an air-conditioning of a vehicle, is constructed in the following manner. For instance, a housing, which covers an inner end surface of a cylinder block, forms a crank chamber. In the crank chamber, a swash plate, which is mounted on a driving shaft, works cooperatively with single-headed pistons by way of shoes. Moreover, there is a variable capacity type compressor in the swash plate type compressors. Such a variable capacity type compressor is provided with a swash plate which is inclinable about the axis of the driving shaft. Thus, when the pressure varies in the crank chamber, the pressure variation results in the balance between the pressures working on the opposite ends of the pistons. Then, the pressure balance controls the variation of the inclination angle of the swash plate, i.e., the strokes of the pistons.

[0003] Such a swash plate type compressor is also used for an air-conditioning of a vehicle. Accordingly, in the swash plate type compressor, it is a main stream that the housing, the cylinder block, the swash plate and the pistons are made of aluminum alloys because of the insatiable light-weight requirement. Hence, anti-wear and anti-seizure measures have been investigated for the sliding surfaces between the swash plate and the shoes, and for the sliding surfaces between the pistons and the bores which are forced to be under the severe sliding conditions. For example, it has been known that a fluororesin film is formed an the sliding surface of the piston, and that a solid lubricant film is formed on the sliding surfaces of the swash plate.

[0004] Whilst, the single-headed pistons undergo the linear reciprocating movement which is transformed from the rotary movement of the swash plate by way of the shoes, and simultaneously receive an angular moment which results from the frictional force produced between themselves and the shoes. Namely, the pistons undergo the rotation. Accordingly, the pistons are brought into contact with the inner peripheral wall of the crank chamber at their interference surfaces which are disposed at their rears for inhibiting the rotation. Consequently, the pistons are inhibited from autorotating (or turning).

[0005] In the pistons and the housing which are made of aluminum alloys, however, there naturally arises a fear for the wear and the seizure at the portions which are relatively brought into contact with each other. Accordingly, the countermeasures have been tried in which a variety of surface treatments are carried out onto the interference surfaces of the pistons. However, there have been already formed the films, such as the fluororesin films, on the sliding surfaces of the pistons which slide in the bores. If the processing of the interference surfaces of the pistons is carried out in addition to the formation of the films, it is an extra burden which is not negligible in view of the productivity since the multi-cylinder compressor has a plurality of the pistons.

SUMMARY OF THE INVENTION

[0006] It is therefore an object of the present invention to improve the durability of a compressor by providing a very simple process which keeps the rotation inhibiting construction of the piston from being damaged.

[0007] A first aspect of the present invention can carry out the object, and is a swash plate type compressor, comprising:

- a cylinder block supporting a driving shaft at a center thereof and having a plurality of bores disposed so as to surround the driving shaft;
- a housing connected to the cylinder block and forming a crank chamber therein;
- a swash plate rotating together with the driving shaft;
- a plurality of single-headed pistons moving linearly in the bores cooperatively with the swash plate, each of the pistons having an interference surface disposed at a rear thereof for inhibiting rotation; and
- a lubricant film formed on an inner peripheral wall of the crank chamber to be brought into contact with the interference surfaces of the pistons.

[0008] In the swash plate type compressor, the lubricant film is formed on the inner peripheral surface of the crank chamber, and exhibits good lubricant performance. Accordingly, the lubricant film inhibits the interference surfaces of the pistons, which are brought into contact with it in a non-lubricating manner, from being seizured. In this instance, the lubricant film is very advantageous over the case where the respective interference surfaces of the pistons are subjected to a certain surface treatment, because the multi-cylinder compressor usually uses the pistons in a large quantity of from 5 to 7. Moreover, the lubricant film produces an extra effect of sound-shielding the crank chamber additionally.

[0009] In a second aspect of the present invention, the lubricant film includes a solid lubricant.

[0010] When the lubricant film includes the solid lubricant, such as molybdenum disulfide, as a film constituent element as aforementioned, it produces the advantages more effectively.

[0011] In a third aspect of the present invention, the lubricant film is formed by a transfer method.

[0012] When the lubricant film is formed as aforementioned, such an arrangement is advantageous not only in view of saving the film material but also in view of controlling the film thickness.

[0013] In a fourth aspect of the present invention, an area of the inner peripheral wall of the crank chamber, which faces the interference surface of one of said pistons, is dented at a middle in a peripheral direction of the crank chamber so that an oil groove, which extends in an axial direction of the crank chamber, is formed.

[0014] In the swash plate type compressor, a lubricating oil is usually dissipated by the centrifugal force which results from the rotation of the swash plate. When the area of the inner peripheral wall is dented as aforementioned, the lubricating oil flows into the oil groove by way of a space which is formed between the inner peripheral wall and the interference surface of one of the pistons which is free from the contact with the inner peripheral wall. At the same time, the lubricating oil flows into the oil groove in the axial direction. The dissipated lubricating oil is thus stored altogether in the oil groove. As a result, the lubrication can be provided securely at the portions where the constituent members are brought into contact with each other and slid mutually.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] A more complete appreciation of the present invention and many of its advantages will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings and detailed specification, all of which forms a part of the disclosure:

- Fig. 1 is a cross-sectional view of a swash plate type compressor according to a preferred embodiment of the present invention;
- Fig. 2 is a front view of a single-headed piston which is used in the compressor;
- Fig. 3 is a partial cross-sectional view for illustrating an interference surface of the piston and an inner peripheral wall of a crank chamber;
- Fig. 4 is a diagram for illustrating a transfer apparatus which is used for applying a lubricant film on the inner peripheral wall of the crank chamber;
- Fig. 5 is a partial cross-sectional view for illustrating another preferred embodiment which concerns the inner peripheral wall of the crank chamber; and
- Fig. 6 is an enlarged explanatory diagram of a major portion of the inner peripheral wall of the crank chamber.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Having generally described the present invention, a further understanding can be obtained by reference to the specific preferred embodiments which are provided herein for the purpose of illustration only and not intended to limit the scope of the appended claims.

Preferred Embodiment

[0017] A preferred embodiment of the present invention will be hereinafter described with reference to the drawings. Fig. 1 is a cross-sectional view of a variable capacity swash plate type compressor. Fig. 2 is a front view of a single-headed piston of the compressor. Fig. 3 is a side view for illustrating an interference surface which is formed in the piston to inhibit the piston from autorotating. As illustrated in Fig. 1, a cylinder block 10 is covered by a front housing 11 at the front end, and is covered by a rear housing 13 at the rear end by way of a valve plate 12. The cylinder block 10, the front housing 11, the valve plate 12 and the rear housing 13 are fastened by through bolts. The cylinder block 10 and the front housing 11 form a crank chamber 14. In the crank chamber 14, a driving shaft 15 is accommodated so that it extends in an axial direction of the crank chamber 14. The driving shat 15 is supported rotatably by radial bearings. The cylinder block 10 is provided with a plurality of bores 16 around the driving shaft 15. A plurality of pistons 17 are disposed in the bores 16 so as to be able to reciprocate.

[0018] In the crank chamber 14, a rotor 20 is connected with the driving shaft 15 so that it synchronously rotates together with the driving shaft 15. Between the rotor 20 and the front housing 11, a thrust bearing is disposed. A swash plate 18 is mounted on the driving shaft 15 behind the rotor 20. Between the rotor 20 and the swash plate 18, a pressing spring 21 is interposed so that the swash plate 18 is always urged toward the rear.

[0019] In the swash plate 18, a sliding surface 18a is formed on the opposite sides, and is disposed on the outer peripheral side. The sliding surfaces 18a contact with shoes 19, 19. The shoes 19, 19 are engaged with semi-sphere-shaped seats 17c, 17c which are formed in the pistons 17. Between the swash plate 18 and the rotor 20, a hinge mechanism "K", which operates relatively with respect to the swash plate 18, is disposed. The swash plate 18 is fitted with the driving shaft 15 by way of a dogleg-shaped through hole 18b. Thus, while keeping the position of the top dead center of the pistons 17 stationary, the swash plate 18 is arranged so that the inclination angle is variable.

[0020] In this preferred embodiment, the cylinder block 10, the front housing 11 (hereinafter simply referred to as a "housing') and the pistons 17 are made by using an aluminum-based metal, for example, a supereutectic aluminum-silicon alloy. As illustrated in

Fig. 2, the piston 17 includes a sliding surface 17a and a dent 17b. The sliding surface 17a is disposed at the head of the piston 17, has a predetermined fitting length, and is fitted into one of the bores 16. The dent 17b is disposed at the rear of the piston 17, and sits astride the swash plate 18. On the rear-surface side of the dent 17b, an interference surface 17d is formed so as to inhibit the piston 17 from autorotating. As illustrated in Fig. 3, the interference surface 17d has a large radius of curvature, and is disposed so as to face an inner peripheral wall 14a of the crank chamber 14 (specifically, a surface of a lubricant film "C" later described) while providing a clearance "S" between itself and the inner peripheral wall 14a.

[0021] A major feature of the present invention, a surface treatment of the housing 11, will be hereinafter described. As mentioned earlier, the crank chamber 14 is formed in the housing 11, A lubricant film "C" is formed on the inner peripheral wall 14a of the housing 11. The lubricant film "C" is made by coating a film material "C" on the inner peripheral wall 14a and thereafter by heating and curing it thereon. The film material "C" is composed of molybdenum disulfide, graphite and an uncured thermosetting resin. The molybdenum disulfide and the graphite are selected as solid lubricants. The uncured thermosetting resin is selected as a binder, and can be polyamide, etc. As for the film material, it is possible to use a low-friction resin or mixtures of the low-friction resin and a solid lubricant, hard metallic particles or ceramic particles. The coating can be carried out by a simple spraying method. However, in view of the adhesion strength and the film-thickness control, the coating can preferably be carried out by a printing technique (or a roller-transfer method) as hereinafter described.

[0022] Fig. 4 is a diagram for illustrating a transfer apparatus. As illustrated in the drawing, the transfer apparatus includes a transfer roller 51, a comma-shaped roller 52 and a scraper 53. The transfer roller 51 is disposed rotatably in the direction of the arrow of the drawing. The comma-shaped roller 52 is disposed above the transfer roller 51 so that a predetermined clearance is provided between itself and the transfer roller 51, and is adapted for controlling a film thickness. The scraper 53 is disposed away from the comma-shaped roller 52 on the rear side thereof in the rotary direction of the transfer roller 51. These constituent members have an axial length which is applicable to the stroke of the interference surfaces 17d of the pistons 17. Moreover, 54 designates a dispenser which is adapted for supplying the film material "C" to a space between the comma-shaped roller 52 and the scraper 53.

[0023] Whilst, a housing workpiece 11w is detachably mounted to a driving means (not shown) which rotates in the direction opposite to the rotary direction of the transfer roller 51 at a speed which is synchronous to the speed of the transfer roller 51. Moreover, the driving means can advance and retract in the axial direction, and can move in the directions of the arrows "A" and "B" of Fig. 4.

[0024] Thus, the housing workpiece 11w, mounted to the driving means, is first moved in the axial direction. Accordingly, the transfer roller 51 is introduced into the crank chamber 14 up to a predetermined position. Then, the housing workpiece 11w is moved in the direction of the arrow "A" of Fig. 4. Consequently, the inner peripheral wall 14a of the crank chamber 14 contacts with the transfer roller 51 as illustrated in the drawing. Whilst, the film material "C" is supplied between the comma-shaped roller 52 and the scraper 53 by the dispenser 54.

[0025] As a result, the film material "C" is transferred as the transfer roller 51 rotates, and is then adjusted to a predetermined film thickness by the comma-shaped roller 52. Thereafter, the film material "C" is applied (or transferred) to the inner peripheral wall 14a of the crank chamber 14 of the housing workpiece 11w. When the application is finished, the housing workpiece 11w is moved in the direction of the arrow "B" of Fig. 4 simultaneously with the interruption of the supply of the film material "C". Then, the housing workpiece 11w is retracted in the axial direction. Consequently, the transfer roller 51 is gotten out of the crank chamber 14 relatively. After the housing workpiece 11w is dismounted from the driving means, it is subjected to the subsequent drying and burning processes. Thus, a lubricant film "C" is formed on the inner peripheral wall 14a of the crank chamber 14, and is closely adhered thereon. If required, the lubricant film "C" is wounded so that the dimensional accuracy is adjusted. The thickness of the lubricant film "C" can preferably fall in the range of from 5 to 200 µm, further preferably from 20 to 70 µm.

[0026] The lubricant film "C" is thus formed on the inner peripheral wall 14a of the crank chamber 14, and is composed of the solid lubricants which are good in the wear resistance and the seizure resistance. Accordingly, even when the pistons 17 autorotates (or turns), the interference surfaces 17d contact smoothly with the lubricant film "C". As a result, it is possible to inhibit the pistons 17 from turning.

Modified Version of Preferred Embodiment

[0027] Fig. 5 and Fig. 6 illustrate a modified version of the preferred embodiment. In the modified version, the areas of the inner peripheral wall 14a of the crank chamber 14, which face the interference surfaces 17d of the pistons 17, are dented at their middles in a peripheral direction of the crank chamber 14. Consequently, there are formed oil grooves 14b which extend in an axial direction of the crank chamber 14. The oil grooves 14b can be formed by an as-cast surface which appears when the housing 11 is formed by casting. The configuration of the oil grooves 14b can be varied as the specific occasion may demand.

[0028] When an angular moment acts onto the piston

17 in the direction of the arrow of Fig. 6 during the operation of the compressor, the lubricating oil 18 flows in the direction of the arrow "Q" of the drawing into the oil groove 14b by way of a space which is formed between the inner peripheral wall 14a (specifically, the surface of the lubricant film "C") and the interference surface 17d of the piston 17 which is free from the contact with the inner peripheral wall 14a. The lubricating oil is usually dissipated by the centrifugal force which results from the rotation of the swash plate 18. At the same time, the lubricating oil flows into the oil groove 14b in an axial direction of the crank chamber 14. The dissipated lubricating oil is thus stored altogether in the oil groove 14b. The oil storage function of the oil grooves 14b provides the lubrication securely at the portions where the inner peripheral wall 14a of the crank chamber 14 and the interference surfaces 17d of the pistons 17 are substantially brought into contact with each other and slid mutually.

[0029] Having now fully described the present invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit or scope of the present invention as set forth herein including the appended claims.

Claims

1. A swash plate type compressor, comprising:

   a cylinder block supporting a driving shaft at a center thereof and having a plurality of bores disposed so as to surround the driving shaft;
   a housing connected to the cylinder block and forming a crank chamber therein;
   a swash plate rotating together with the driving shaft;
   a plurality of single-headed pistons moving linearly in the bores cooperatively with the swash plate, each of the pistons having an interference surface disposed at a rear thereof for inhibiting rotation; and
   a lubricant film formed on an inner peripheral wall of the crank chamber to be brought into contact with the interference surfaces of the pistons.

2. The swash plate type compressor according to Claim 1, wherein said lubricant film includes a solid lubricant.

3. The swash plate type compressor according to Claim 2, wherein said solid lubricant is molybdenum disulfide.

4. The swash plate type compressor according to Claim 2, wherein said solid lubricant is a mixture of molybdenum disulfide and at least one member selected from the group consisting of fluororesin, tungsten disulfide and graphite.

5. The swash plate type compressor according to Claim 1, wherein said lubricant film is formed by a transfer method.

6. The swash plate type compressor according to Claim 1, wherein an area of the inner peripheral wall of the crank chamber, which faces the interference surface of one of said pistons, is dented in a peripheral direction of the crank chamber so that an oil groove, which extends in an axial direction of the crank chamber, is formed.

7. The swash plate type compressor according to Claim 1, wherein said lubricant film has a thickness falling in the range of from 5 to 200 μm.

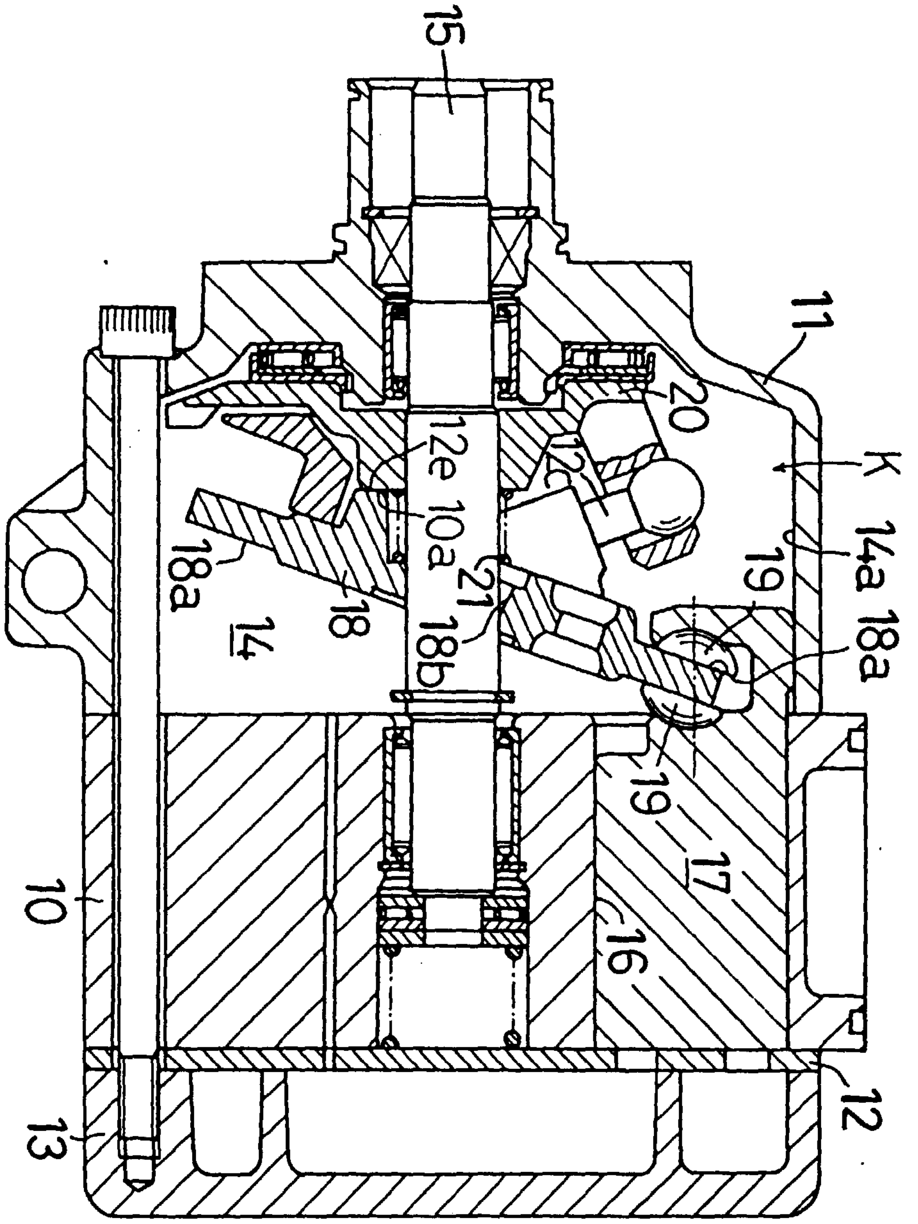


FIG. 1

FIG. 2

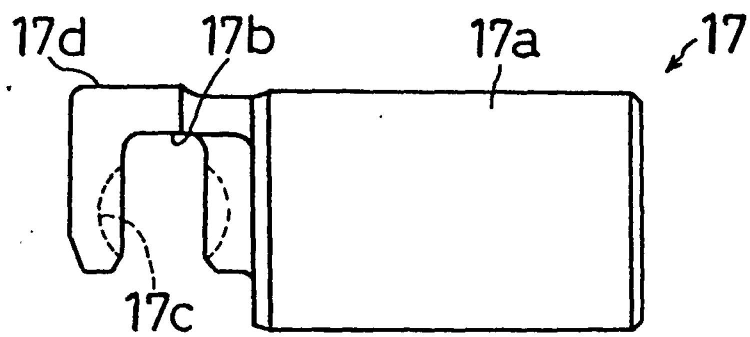


FIG. 3

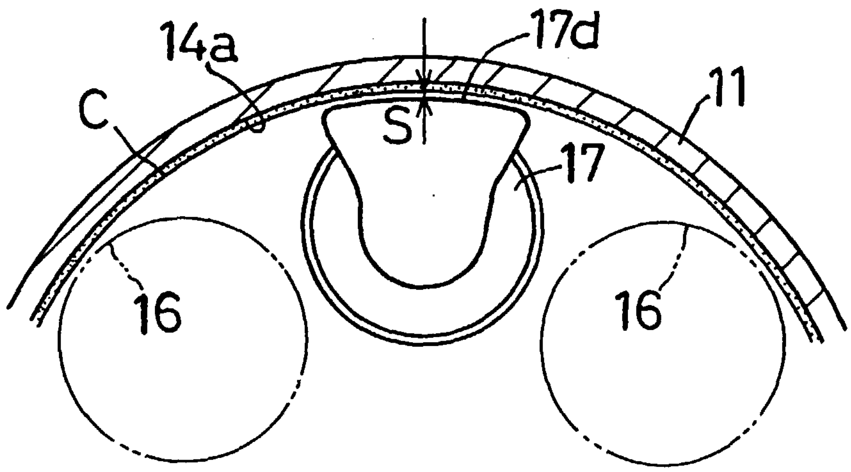


FIG. 4

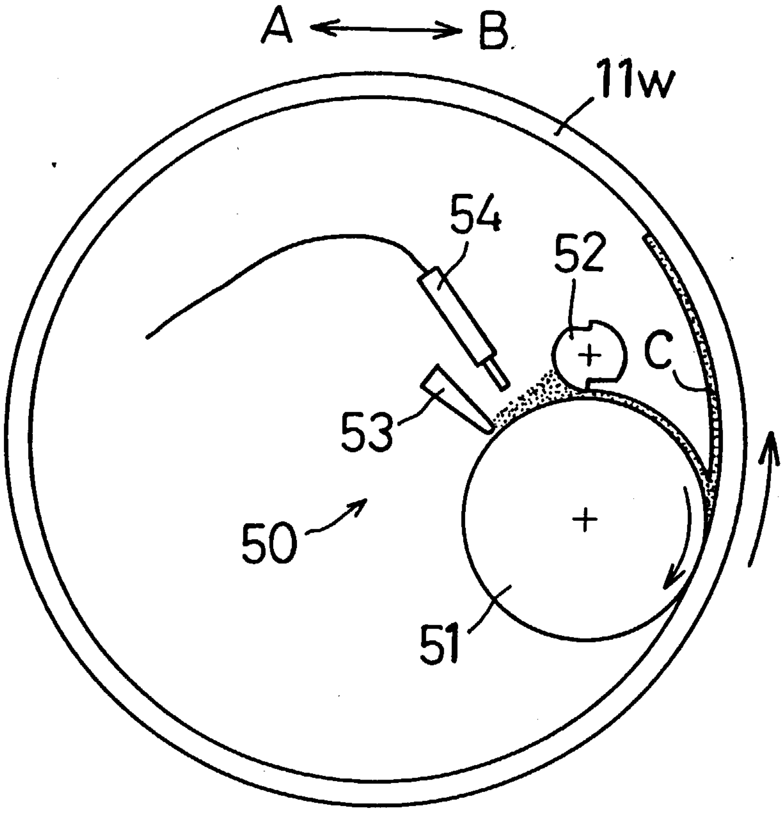


FIG. 5

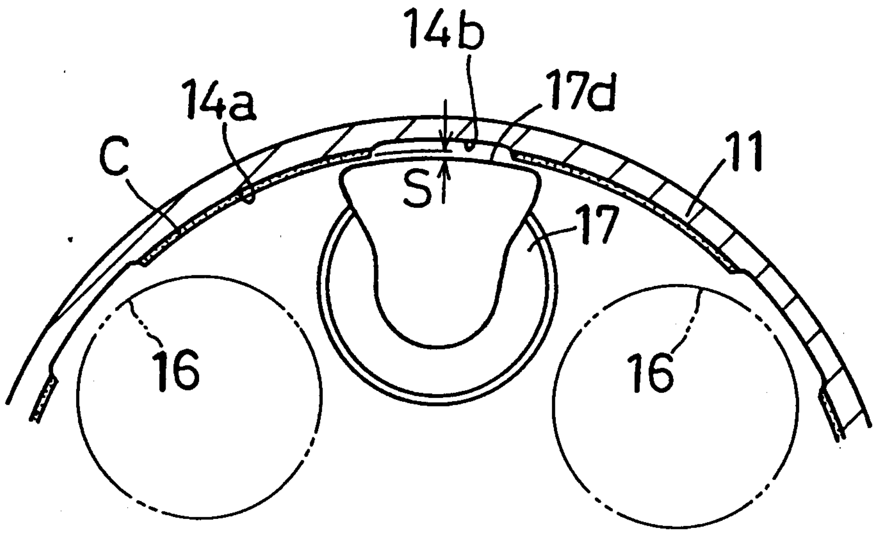


FIG. 6