

SPECIFICATION

TITLE OF THE INVENTION

Apparatus and Method for Manufacturing Fluid Bearing

BACKGROUND OF THE INVENTION

5 The present invention relates to an apparatus and method for manufacturing a fluid bearing having a shaft, a sleeve, and a dynamic pressure-generating groove formed on the inner peripheral surface of a bearing of the sleeve which is used in, for example, disk drive devices, rotary
10 head cylinders etc.

 In recent years, with the development of bearing-applied equipments having high performance, equipments using fluid bearings are increasingly adopted. As shown in Fig. 5, in this type of fluid bearing, a shaft 4 is
15 rotatably inserted into a sleeve 3 having a dynamic pressure-generating groove 3A formed on the inner peripheral surface thereof, and lubricating oil is applied to the gap between the shaft 4 and the sleeve 3. A pressure is generated owing to the pumping action of the
20 dynamic pressure-generating groove 3A caused by the rotation of the bearing 4 or that of the sleeve 3, with the result that the bearing 4 or the sleeve 3 rotates without contact being made therebetween and with high accuracy.

 An example of a conventional apparatus for
25 manufacturing this type of groove-equipped fluid bearing is

described below with reference to Figs. 6A and 6B. As a conventional method for processing a dynamic pressure-generating groove 13A on the inner peripheral surface of a sleeve 13 made of a comparatively soft metal, a method for plastically processing the dynamic pressure-generating groove 13A by using hard balls is known. As an apparatus for carrying out the method, an apparatus as shown in Figs. 6A and 6B is known. A guide ring 18 is fixed to the leading end 16A of a guide shaft 16. The guide ring 18 has a plurality of guide holes 18A, 18B, 18C, and 18D formed thereon such that the guide holes 18A and 18B and guide holes 18C and 18D are symmetrical and radially arranged with respect to the center axis of the guide ring 18, respectively. Hard balls 17A, 17B, 17C, and 17D are inserted into the guide holes 18A, 18B, 18C, and 18D or pressed thereinto, respectively. The diameter of the leading end 16A is so selected that the sum of the diameter of the leading end 16A, that of the ball 17A, and that of the ball 17B is slightly larger than the inner diameter (d) of the sleeve 13.

The operation of the conventional apparatus for manufacturing the fluid bearing is described below. Referring to Figs. 6A and 6B, when a rotational speed (W) and a feeding speed (V) are applied to the guide shaft 16 or the guide ring 18 with respect to the sleeve 13, the

dynamic pressure-generating groove 13A is formed by plastic processing comprising the motion of the balls 17A, 17B, 17C, and 17D. In processing the herringbone-shaped dynamic pressure-generating groove 13A as shown in Fig. 5, when the
5 balls 17A, 17B, 17C, and 17D have fed to approximately the center of the sleeve 13, the rotational direction of the guide shaft 16 is switched to the direction opposite to the rotational direction (W) without changing the feeding speed (V) of the guide shaft 16.

10 The above-described construction has, however, the following problem: Fluid bearings of this type having a smaller diameter are increasingly manufactured in recent years. But if the inner diameter of the sleeve is equal to or less than 2mm, the diameter of the leading end 16A
15 inevitably becomes as small as 1mm or less, with the result that the guide shaft 16 may be broken during plastic processing.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention
20 is to provide an apparatus and a method for manufacturing fluid bearing capable of preventing a guide shaft from being broken during plastic processing even though a diameter of a leading end of the guide shaft becomes as small as, for example, 1mm or less.

In accomplishing these and other aspects, according to one aspect of the present invention, there is provided an apparatus, for manufacturing fluid bearing of dynamic pressure type, by being inserted into a bore of a sleeve and processing an inner peripheral surface of the bore to form a dynamic pressure-generating groove, comprising:

a guide shaft for coaxially inserting into the bore of the sleeve while being rotated and fed axially, the shaft having a first guide hole in a vicinity of a front end thereof; and

a plurality of balls held radially into the first guide hole of the shaft, the balls being harder than the sleeve and bringing into contact with each other, and a diameter of a circumscribed circle about the balls being set to be larger than an inner diameter of the bore of the sleeve.

According to another aspect of the present invention, there is provided a method for manufacturing fluid bearing of dynamic pressure type, by using an apparatus for manufacturing fluid bearing of dynamic pressure type comprising: a guide shaft for coaxially inserting into a bore of a sleeve while being rotated and fed axially, the shaft having a first guide hole in a vicinity of a front end thereof; and a plurality of balls

held radially into the first guide hole of the shaft, the balls being harder than the sleeve and bringing into contact with each other, and a diameter of a circumscribed circle about the balls being set to be larger than an inner diameter of the bore of the sleeve, the method comprising steps of:

- holding the sleeve on a base;
- inserting the guide shaft into the bore of the sleeve;
- rotating and feeding the guide shaft into the bore of the sleeve in a rotating direction and a feeding direction to process an inner peripheral surface of the bore to form a dynamic pressure-generating groove; and
- removing the guide shaft from the bore of the sleeve; and
- removing the sleeve from the base.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Figs. 1A and 1B are sectional views showing a part of an apparatus for manufacturing a fluid bearing according to a first embodiment of the present invention;

Figs. 2A and 2B are sectional views showing a part of an apparatus for manufacturing a fluid bearing according to a second embodiment of the present invention;

Fig. 2C is a sectional view showing a part of an apparatus for manufacturing a fluid bearing according to a third embodiment of the present invention;

Fig. 3 is a sectional view showing the whole apparatus of the first embodiment;

Fig. 4 is a sectional view showing an apparatus for manufacturing a fluid bearing according to a fourth embodiment of the present invention;

Fig. 5 is a sectional view showing a fluid bearing formed by a conventional apparatus and the embodiments of the present invention;

Figs. 6A and 6B are sectional views showing a part of a conventional apparatus for manufacturing a fluid bearing; and

Fig. 7 is a flowchart showing a method for manufacturing a fluid bearing according to the first embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

An apparatus for manufacturing a fluid bearing according to a first embodiment of the present invention is described below with reference to Figs. 1A and 1B. Referring to Figs. 1A and 1B, reference numeral 1 denotes a
5 guide shaft made of cemented carbide. At least one guide hole 1A arranged radially and passing through the center axis of the guide shaft 1 is formed in the vicinity of the leading end thereof. Hard balls 2A and 2B harder than a sleeve 3 to be processed are inserted into the guide hole
10 1A or pressed thereinto, with the balls 2A and 2B in contact with each other. The guide shaft 1 has an operation means for applying thereto a rotational speed in a rotational direction (W) and a feeding speed in an axial direction (V) shown in Fig. 3. Reference numeral 3 denotes
15 the sleeve made of copper alloy or aluminum alloy etc. and the diameter of a circumscribed circle about the balls 2A and 2B is so selected that the diameter is larger than the inner diameter (D) of the bore 3C of the sleeve 3 by 10 - 100 microns. The balls 2A and 2B are made of steel or
20 sapphire which is harder than the sleeve 3. That is, it is necessary for the ball to have such a hardness that a desired dynamic pressure-generating groove can be formed on the inner peripheral surface of the bore of the sleeve.

In Fig. 3, reference numeral 6 denotes a base
25 serving as a chuck for holding the sleeve 3, 8 a guide bar,

9 a moving body for holding and moving the guide shaft 1 in the feeding direction (V) while guided by the guide bar 8, 10 a first motor for rotating the guide shaft 1 in the rotational direction (W), 11 a second motor for back and forth feeding the moving body together with the guide shaft 1 by engaging a pinion gear 19 of a rotating shaft of the second motor 11 with a rack of the moving body 9, 12 a bearing, and 20 a coupling for connecting the first motor 10 to the guide shaft 1.

10 . The operation of the apparatus for manufacturing a fluid bearing having the above-described construction is described below with reference to Figs. 1A, 1B, 3, and 7. First, at step S1, the sleeve 3 having the bore 3C to be processed is held by the base 6. At step S2, the guide shaft 1 having the balls 2A and 2B in the hole 1A is fed into the bore 3C of the sleeve 3 by driving of the second motor 11. At step S3, the guide shaft 1 is rotated in the rotational direction (W) by the first motor 10 and fed in the feeding direction (V) by the second motor 11. That is, 20 in the sleeve 3, a speed is applied to the guide shaft 1 in the feeding direction (V) and the rotational direction (W), with the result that the balls 2A and 2B are fed into the bore 3C of the sleeve 3 and closely contact to the inner peripheral surface 3B of the bore 3C of the sleeve 3. In 25 this manner, the dynamic pressure-generating groove 3A is

formed on the inner peripheral surface 3B of the bore 3C by plastic processing. At this time, the guide shaft 1 has a high strength in processing even though the outer diameter of the guide shaft 1 is very small, and thus, the processing can be accomplished without damage. As one example, the inner diameter of the bore is (0.8mm - 10 microns) and the outer diameter of the ball is 0.4mm. As another example, the inner diameter of the bore is (0.6mm - 10 microns) and the outer diameter of the ball is 0.3mm while the feeding speed is 2-3cm/second when the feeding speed is 1cm/second by using the apparatus in Figs. 6A and 6B. That is, the feeding speed can be faster than the conventional apparatus. At step S4, after the processing for forming the dynamic pressure-generating groove 3B is completed, the guide shaft 1 is removed from the bore 3C of the sleeve 3A by reverse driving of the second motor 11 and then the sleeve 3 is removed from the base 6 at step S5.

According to the first embodiment, since the leading end of the guide shaft which is provided in the conventional apparatus is unnecessary, the accuracy of the dynamic pressure-generating groove 3B can be improved by increasing only the accuracy of the outer diameters of the two balls 2A and 2B. In the conventional apparatus, it is necessary to increase the accuracy of the leading end of the guide shaft and the outer diameters of the balls and

then it is difficult to improve the accuracy of the dynamic pressure-generating groove.

Figs. 2A and 2B are sectional views showing an apparatus for manufacturing a fluid bearing according to a second embodiment of the present invention. Reference numeral 4 denotes a guide shaft. Three balls 2C, and 2D or more balls are inserted into a guide hole 4A or pressed thereinto, with the balls 2C, 2D, and 2E in contact with each other. In the second embodiment, the steel balls 2C, 2D, and 2E each having a diameter of 0.4mm may be used.

Because the number of balls to be used in the second embodiment are more than that of those to be used in the first embodiment, the diameters of the balls to be used in the second embodiment can be smaller than the diameters of those to be used in the first embodiment.

Fig. 2C shows a third embodiment of the present invention wherein five balls 2C, 2D, 2E, 2F, and 2G are inserted into guide holes 4B of the guide shaft 4 or pressed thereinto, with the balls 2C, 2D, 2E, 2F, and 2G in contact with each other. According to the third embodiment, the balls are arranged in the guide hole of the guide shaft in two radial directions perpendicular to each other and thus the arrangement of the balls are in balance as compared with the first and second embodiments.

Fig. 4 shows a fourth embodiment of the present invention. The guide shaft 4 has two guide holes 1A and 1B. The guide hole 1A holds two balls 2J and 2K and guide hole 1B holds two balls 2H and 2I in the similar manner to
5 the above embodiments. The outer diameter of each of the balls 2H and 2I are larger than that of each of the balls 2J and 2K. The outer diameter D1 of the portion of the guide shaft 4 where the guide hole 1A is formed is smaller than that D2 of the portion of the guide shaft 4 where the
10 guide hole 1B is formed. In the fourth embodiment, at the same time, two dynamic pressure-generating grooves can be formed at the bores of the sleeve 3 with different inner diameters.

In the embodiments, the outer diameters of the
15 balls held in one guide hole can be the same as or be different from each other.

As described above, according to the embodiments of the present invention, the guide shaft having a small diameter and yet a high strength can be constructed and
20 thus, the apparatus provides a fluid bearing having a small diameter.

As described above, according to the present invention, the dynamic pressure-generating groove can be formed on the inner peripheral surface of the bore of the
25 sleeve having a small inner diameter by inserting a

plurality of balls into the guide hole formed on the guide shaft, with the balls in contact with each other and then feeding the guide shaft axially and rotating it.

Although the present invention has been fully
5 described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the
10 scope of the present invention as defined by the appended claims unless they depart therefrom.



This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

- 13 -

WHAT IS CLAIMED IS:

1. An apparatus, for manufacturing fluid bearing of dynamic pressure type, by being inserted into a bore (3C) of a sleeve (3) and processing an inner peripheral surface (3B) of the bore to form a dynamic pressure-generating groove (3A), comprising:

a guide shaft (1,4) for coaxially inserting into the bore of the sleeve while being rotated and fed axially, the shaft having a first guide hole (1A,4A) in a vicinity of a front end thereof; and

a plurality of balls (2A,2B,2C,2D,2E,2G, 2H,2I,2J,2K) held radially into the first guide hole of the shaft, the balls being harder than the sleeve and bringing into contact with each other, and a diameter of a circumscribed circle about the balls being set to be larger than an inner diameter of the bore of the sleeve.

2. The apparatus as claimed in claim 1, wherein the diameter of the circumscribed circle about the balls is set to be larger than the inner diameter of the sleeve by 10-100 microns.

3. The apparatus as claimed in claim 1, wherein the sleeve is made of copper alloy or aluminum alloy and each ball is made of steel or sapphire.

4. The apparatus as claimed in claim 1, wherein the balls are pressed into the first guide hole of the shaft.



This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

- 14 -

5. The apparatus as claimed in claim 1, wherein the guide shaft (1) further has a second guide hole (1B) apart from the first guide hole (1A), the second guide hole radially holding a plurality of the balls (2H,2I) which are
5 harder than the sleeve and bring into contact with each other, a diameter of a circumscribed circle about the balls being set to be larger than an inner diameter of the bore of the sleeve.

6. The apparatus as claimed in claim 1, wherein
10 the balls are arranged in the first guide hole of the guide shaft in two radial directions perpendicular to each other.

7. A method for manufacturing fluid bearing of dynamic pressure type, by using an apparatus for manufacturing fluid bearing of dynamic pressure type comprising: a guide shaft (1,4) for coaxially inserting
15 into a bore (3C) of a sleeve (3) while being rotated and fed axially, the shaft having a first guide hole (1A,4A) in a vicinity of a front end thereof; and a plurality of balls (2A,2B,2C,2D,2E,2G,2H,2I,2J,2K) held radially into the
20 first guide hole of the shaft, the balls being harder than the sleeve and bringing into contact with each other, and a diameter of a circumscribed circle about the balls being set to be larger than an inner diameter of the bore of the sleeve, the method comprising steps of:

25 holding the sleeve on a base (6);



This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

- 15 -

inserting the guide shaft into the bore of the sleeve;

rotating and feeding the guide shaft into the bore of the sleeve in a rotating direction and a feeding
5 direction to process an inner peripheral surface (3B) of the bore to form a dynamic pressure-generating groove (3A); and

removing the guide shaft from the bore of the sleeve; and

10 removing the sleeve from the base.