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(54) METHOD OF MANUFACTURING A BEARING UNIT, AND A MOTOR HAVING LOADED THEREON THE BEARING UNIT

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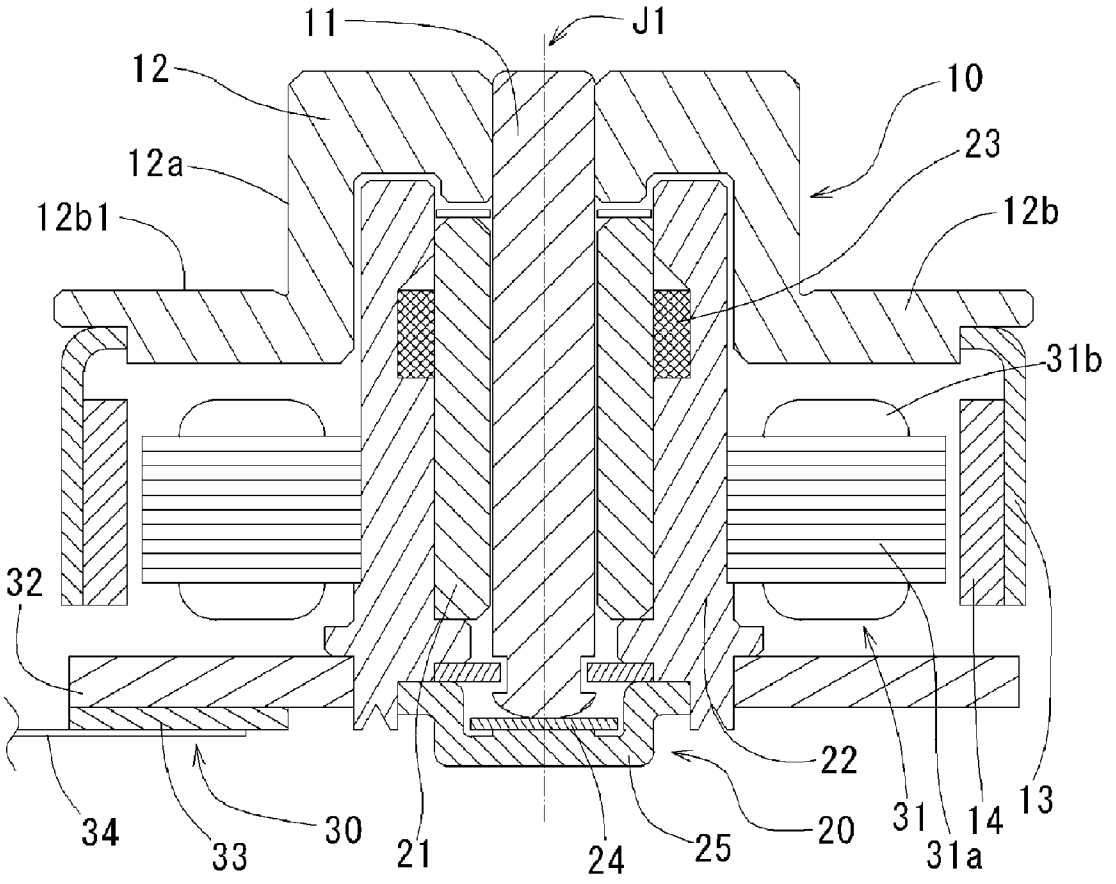
(52) **U.S. Cl.** **29/898.07**

(57) **ABSTRACT**

A bearing unit includes an indent portion arranged on a portion of an inner circumferential surface of a housing to receive an oil supplying component. When inserting the oil supplying component, which is bent into a substantially round shape, a distance between a central axis of the housing and a center point of the inner circumferential surface of the substantially round-shaped oil supplying component is shorter than a radius of the inner circumferential surface of the housing. As a result of this unique arrangement, the inner circumferential surface of the oil supplying component securely makes contact with an outer circumferential surface of a sleeve of the bearing unit.



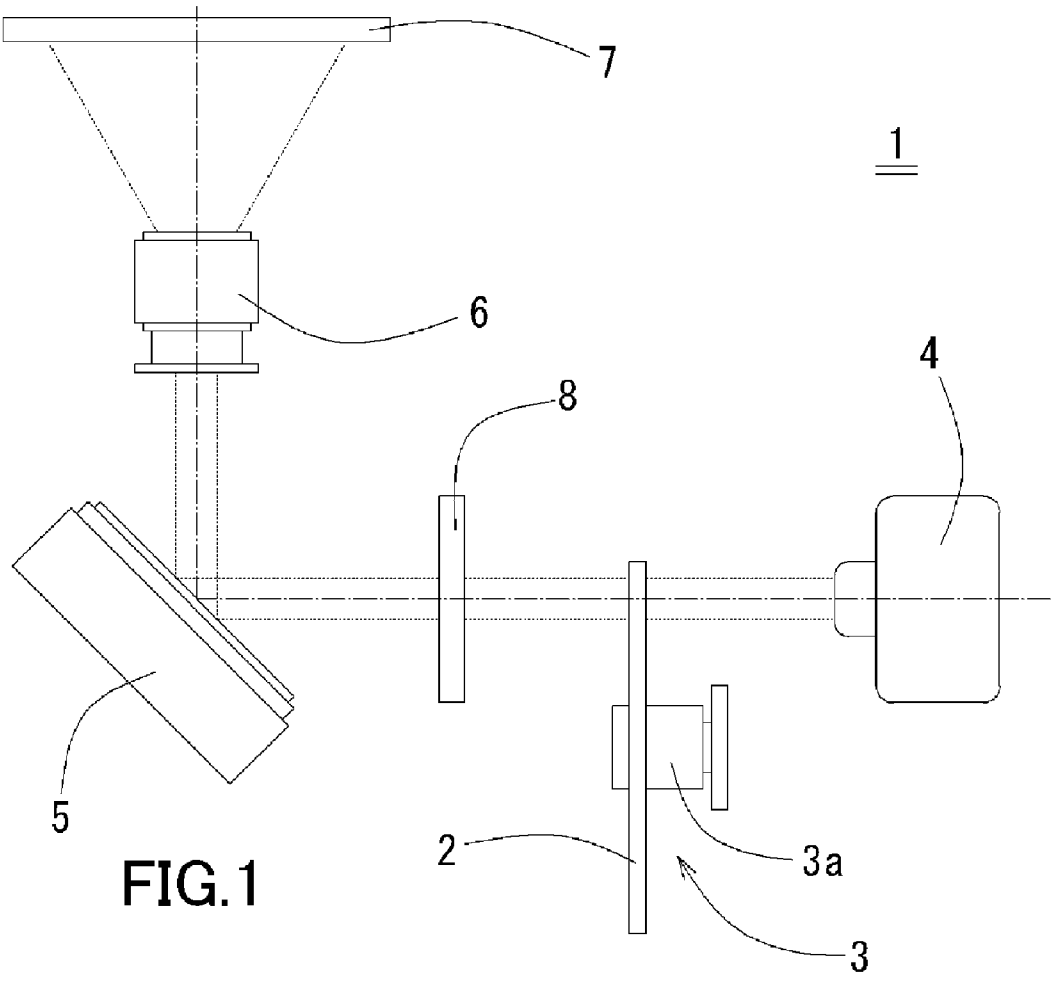


FIG.1

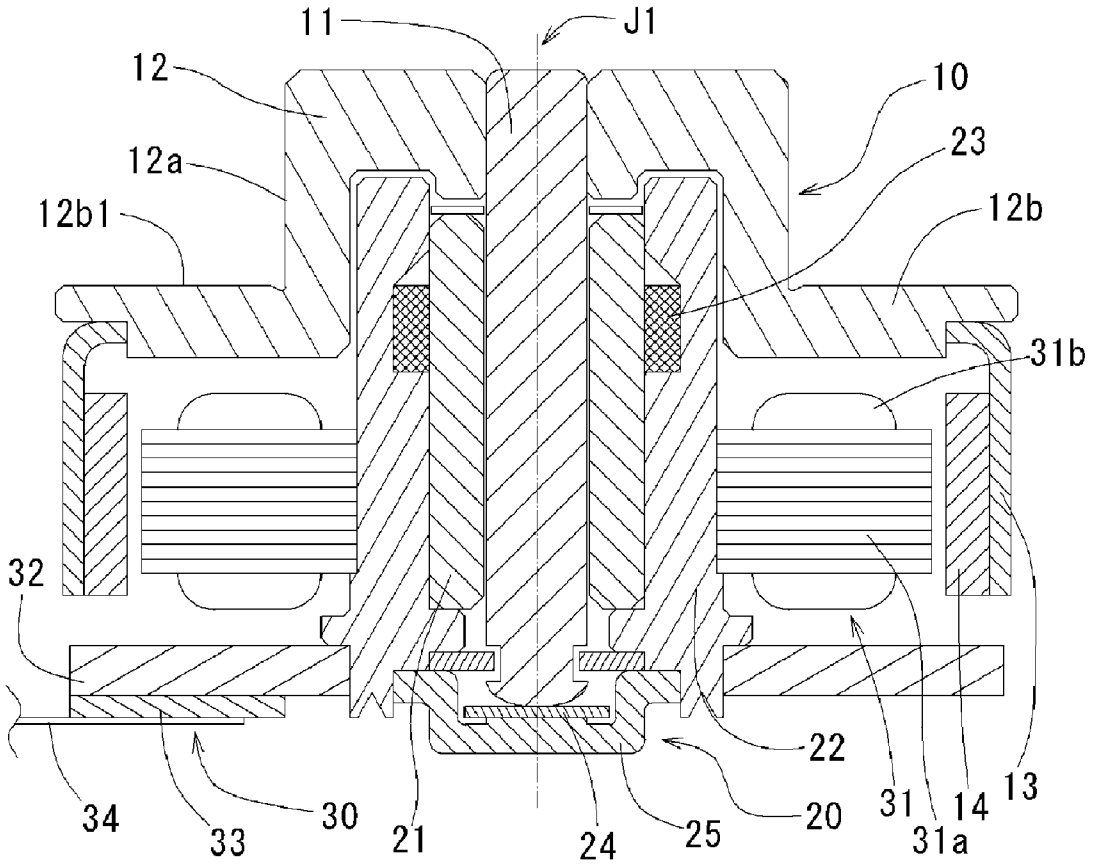

11
J1
12
10
12a
23
12b1
12b
31b
32
22
34
33
30
21
24
25
20
31
14
13
31a

FIG.2

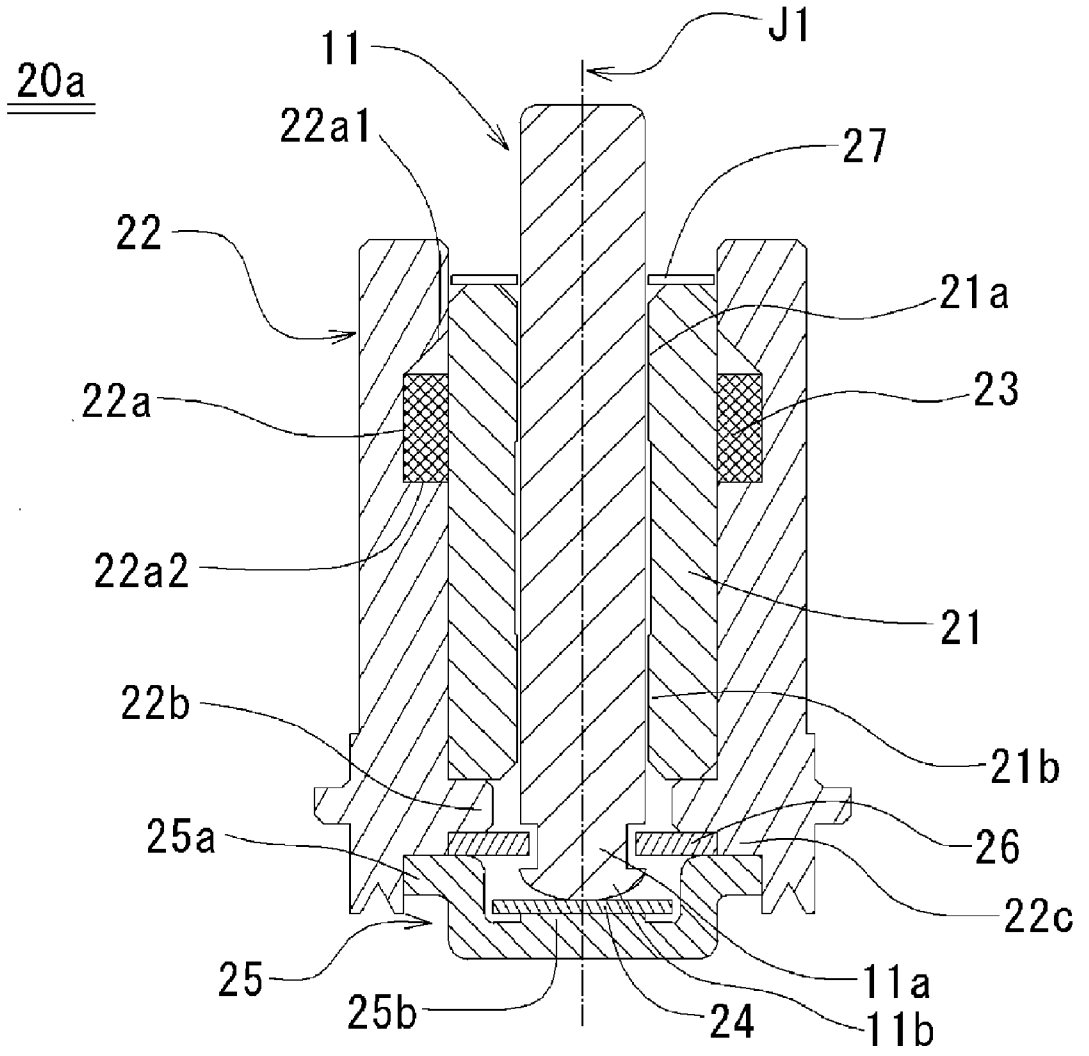

20a
11
J1
22a1
27
22
21a
22a
23
22a2
21
22b
21b
25a
26
22c
25
11a
25b
24
11b

FIG.3

FIG. 4A

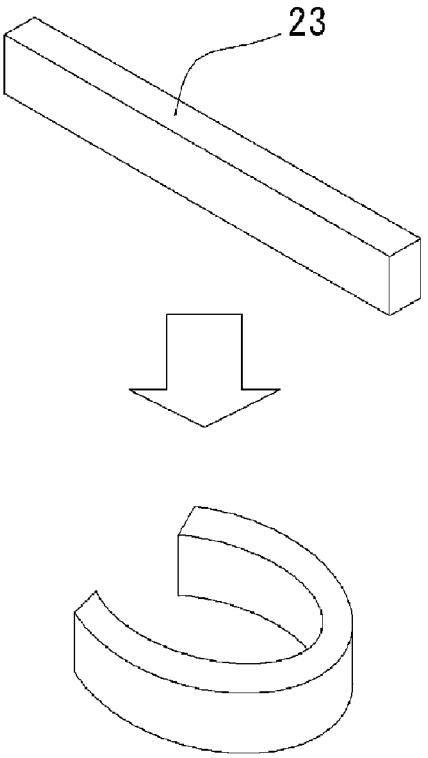


FIG. 4B

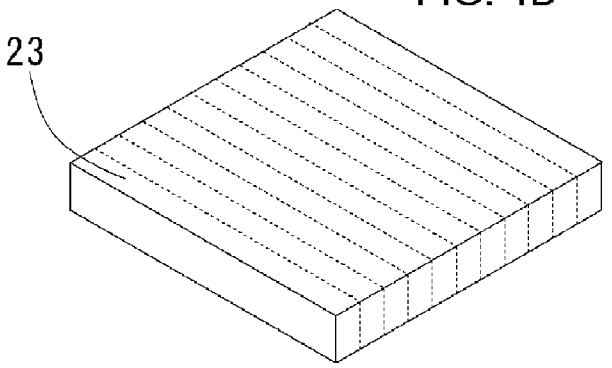
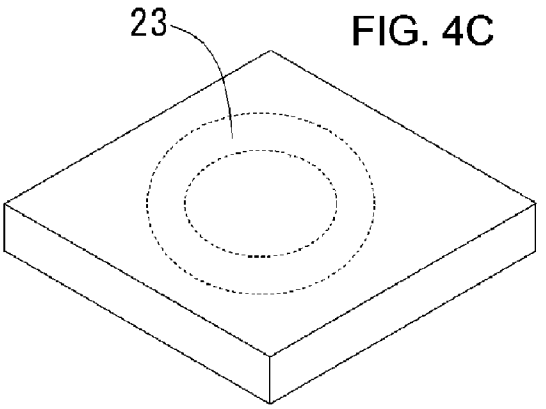


FIG. 4C



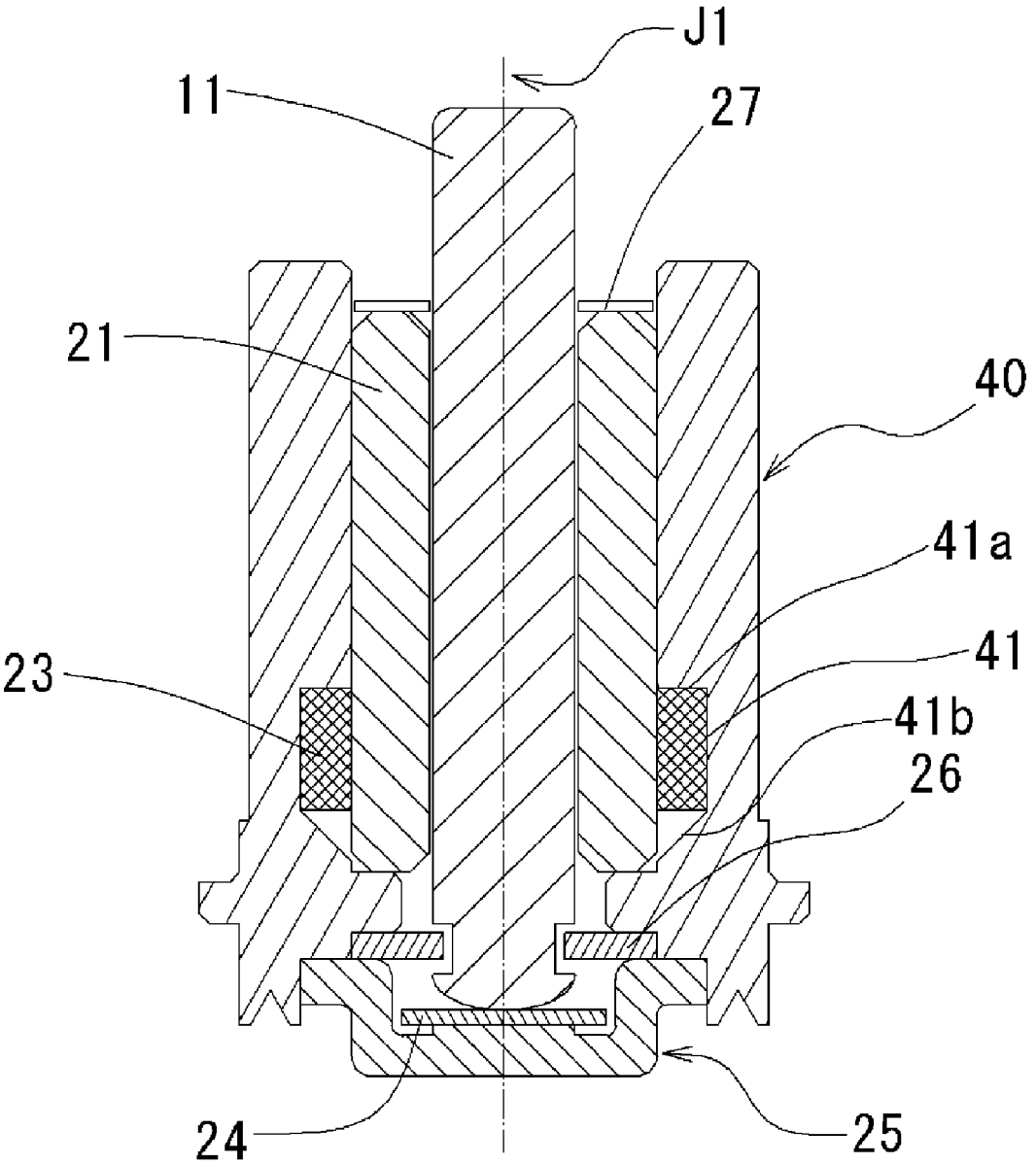


FIG.5

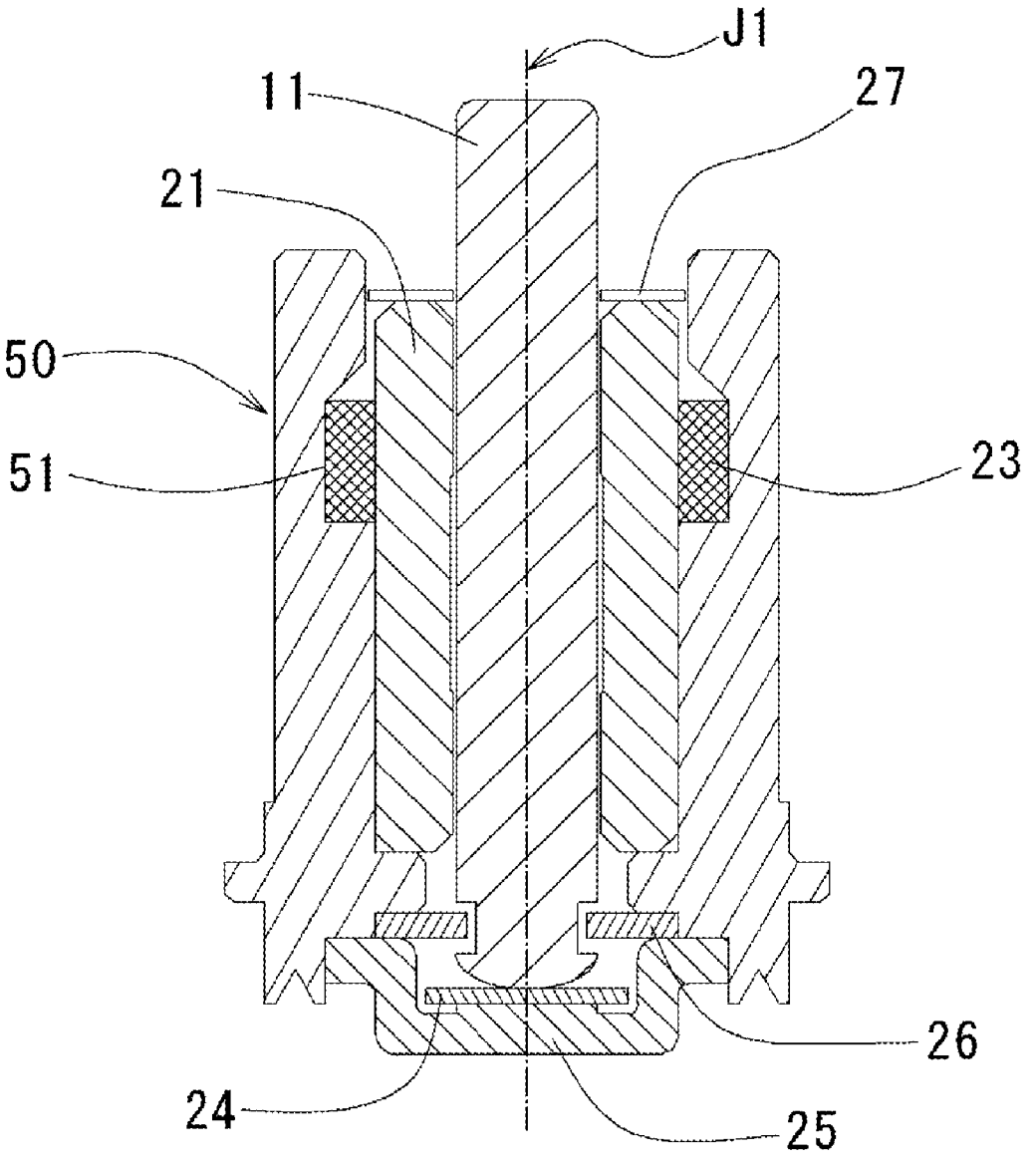


FIG.6

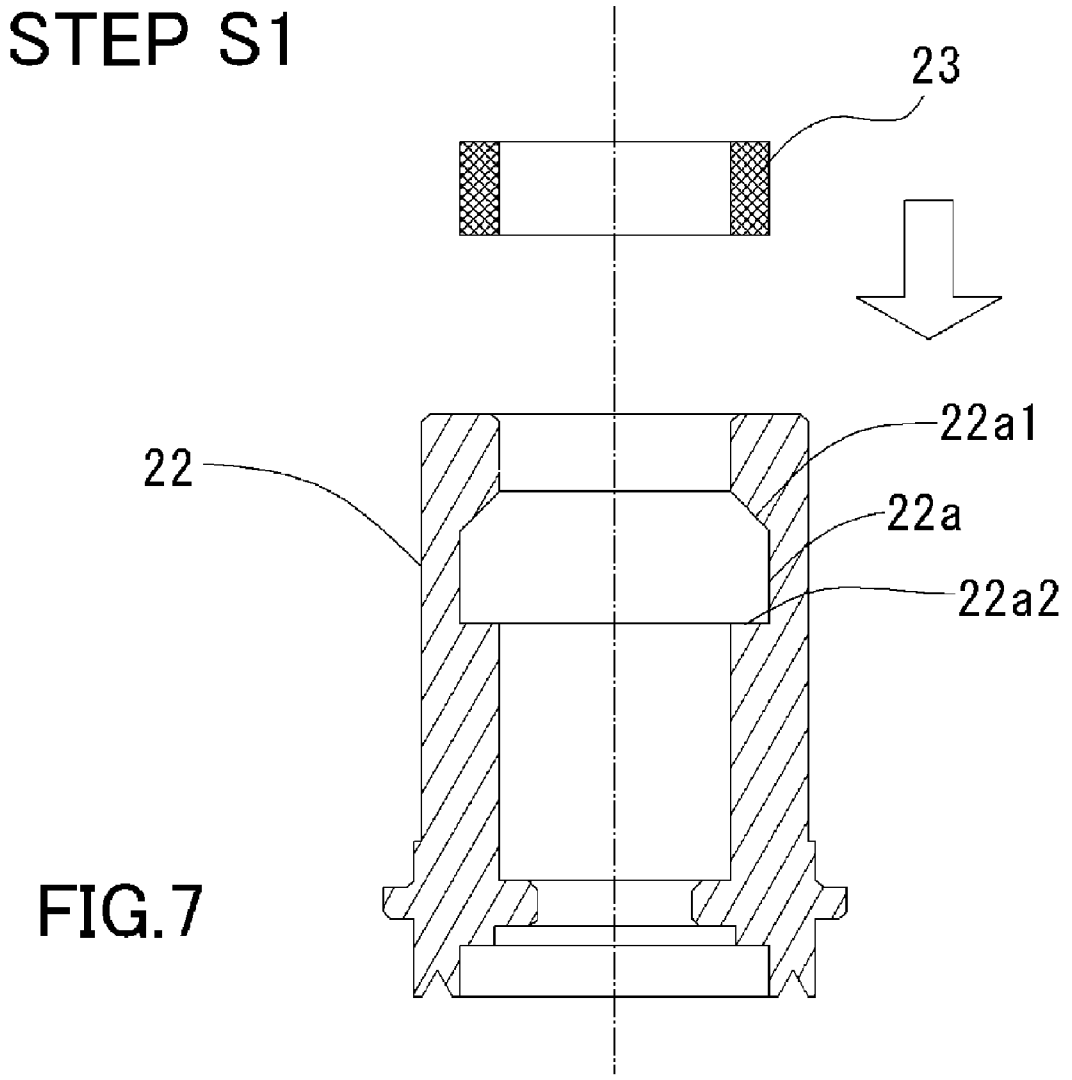


FIG.7

STEP S2

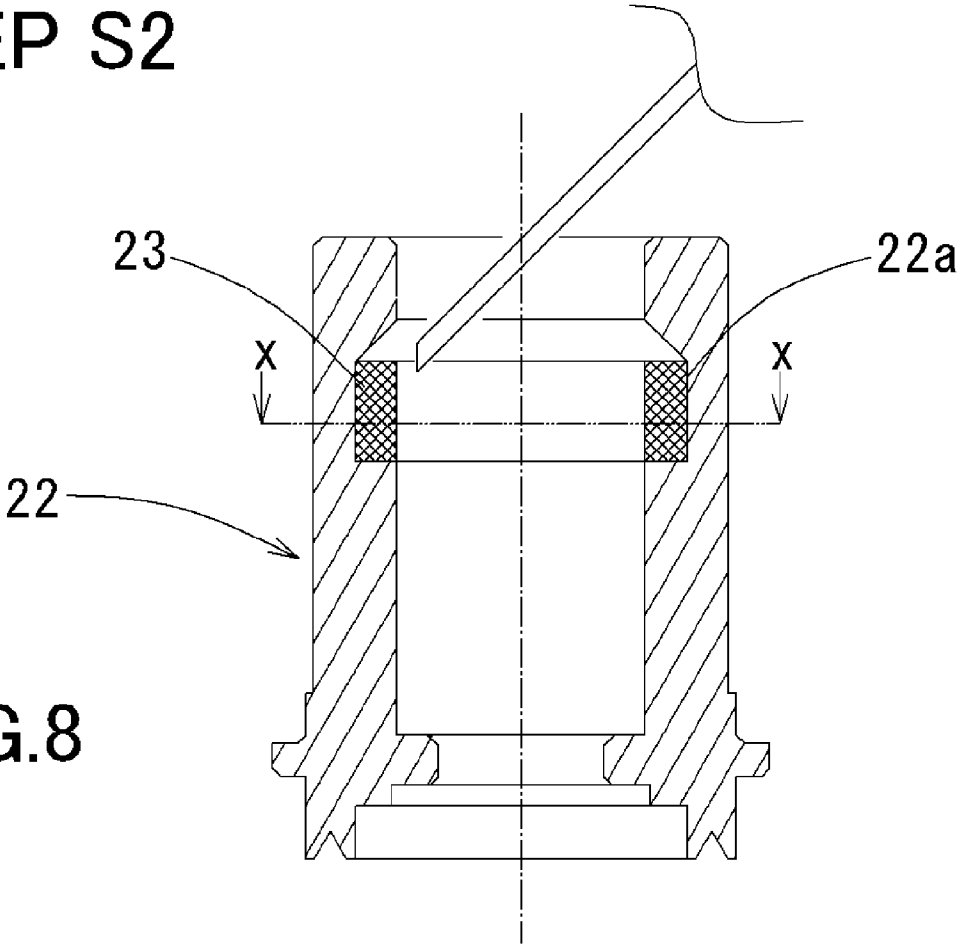


FIG.8

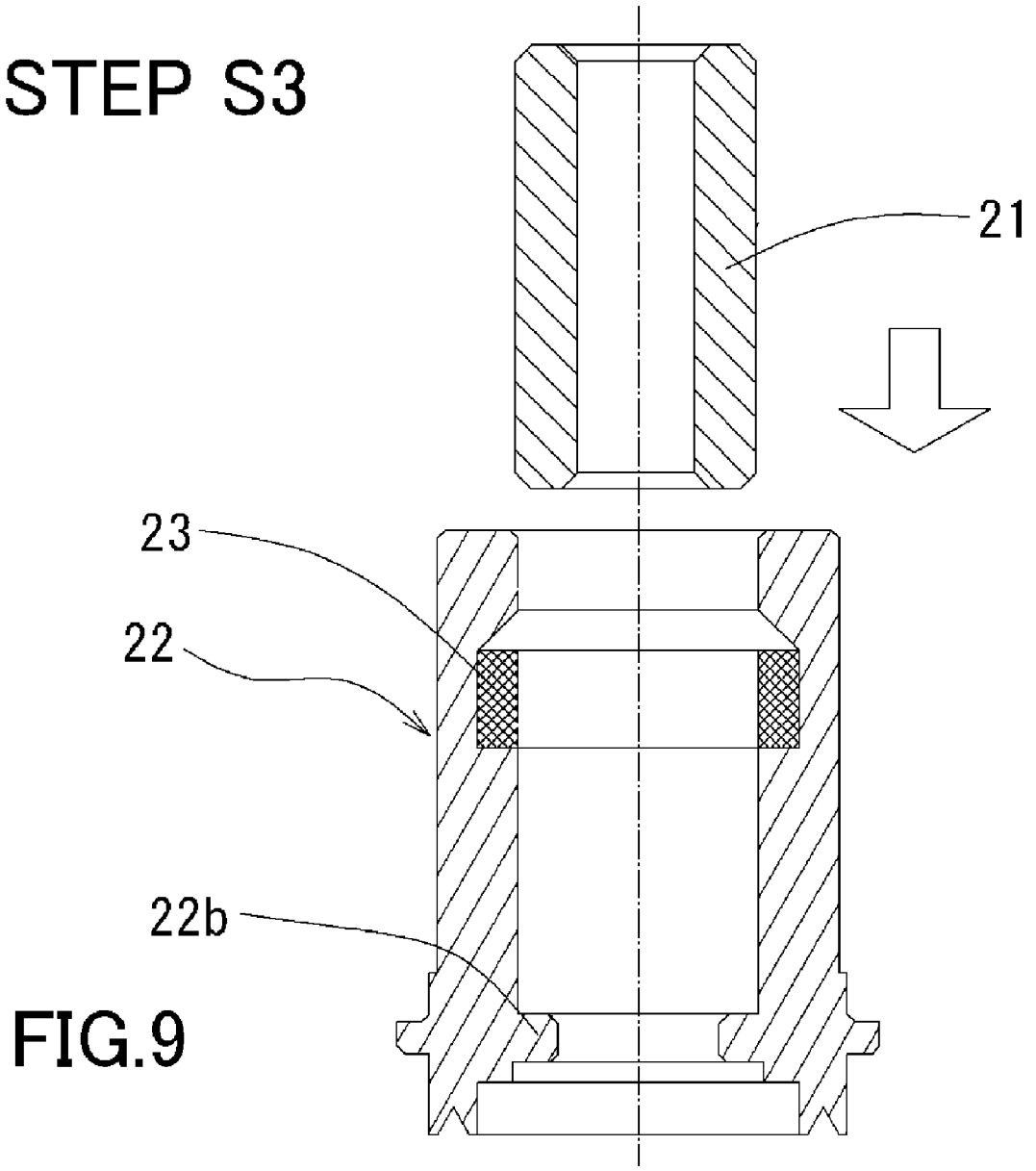


FIG.9

STEP S4

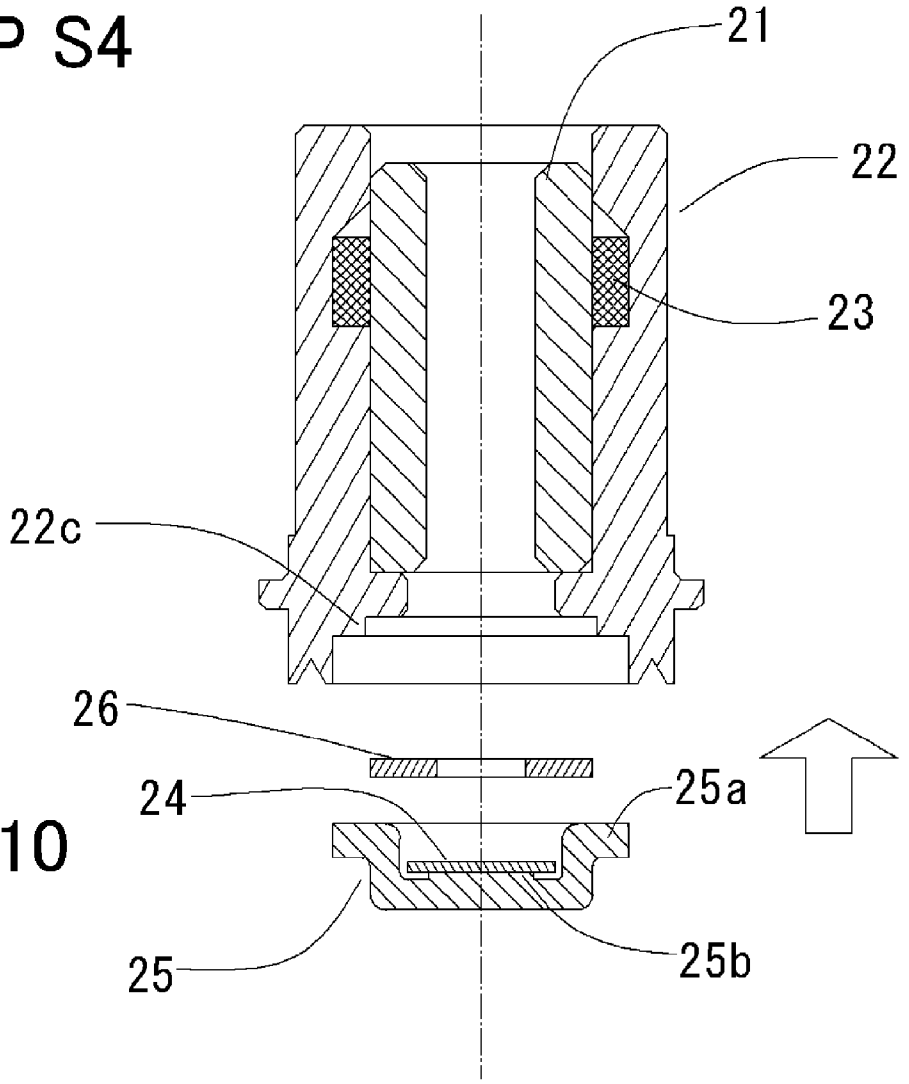


FIG.10

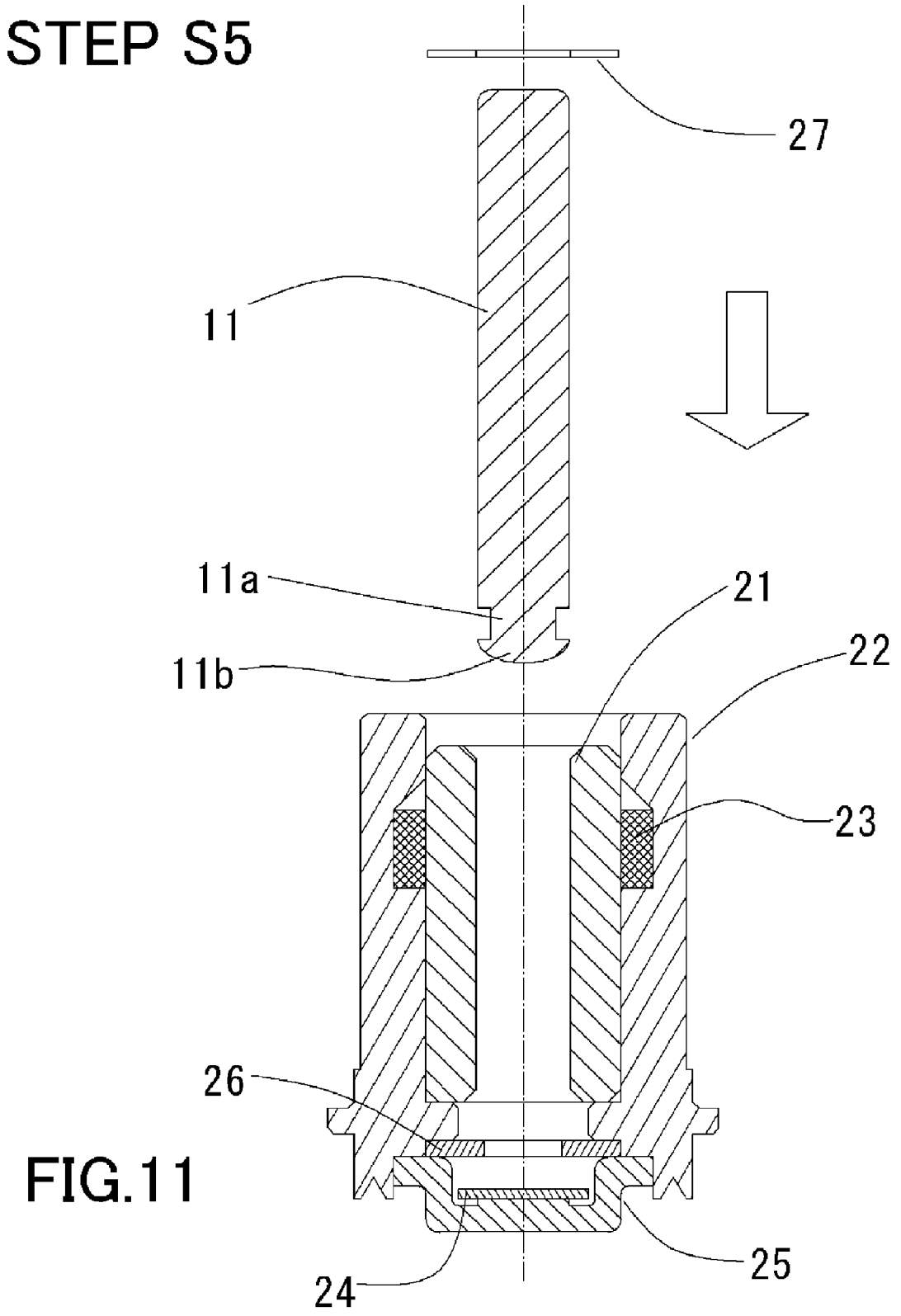


FIG.11

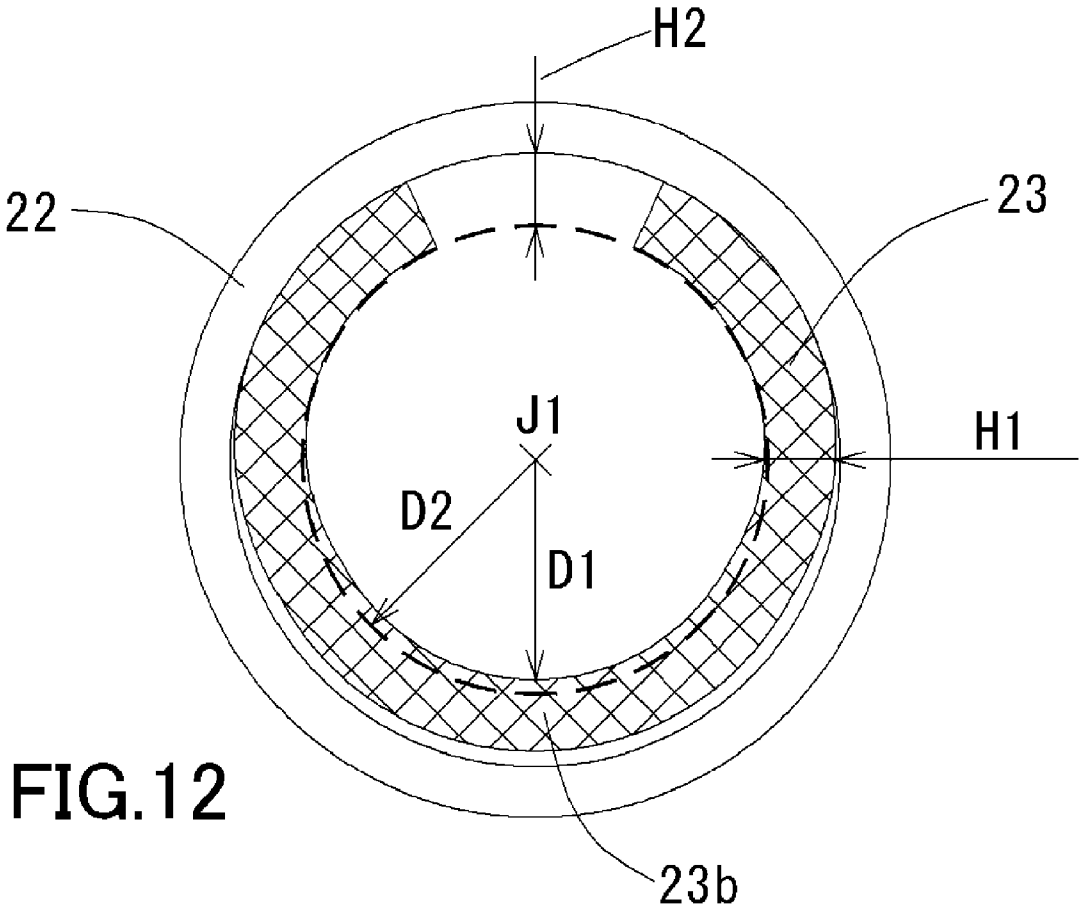


FIG.12

METHOD OF MANUFACTURING A BEARING UNIT, AND A MOTOR HAVING LOADED THEREON THE BEARING UNIT

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method of manufacturing a bearing unit having a long operating life, and to a motor including such a bearing unit.

[0003] 2. Description of the Related Art

[0004] An operating life of a bearing unit is an important element determining a length of an operating life of a motor having therein the bearing unit. Therefore, when oil runs out (e.g., by evaporation) of a bearing made of a sintered material impregnated with oil, the bearing unit will no longer operate. Thus, conventionally, a component for supplying oil has been used in order to extend the operating life of the bearing unit.

[0005] A long operating life is required for a motor used for a projector device (e.g., front-projection television, or rear-projection television) having applied therein DLP (Digital Light Processing) technology. Also, since the aforementioned projector device is sometimes operated continuously for a long period of time, the temperature inside the projector device may increase, thereby evaporating the oil impregnated in the bearing. Also, even when the aforementioned component for supplying oil is used, a secure contact has to be made between the component and the bearing in order for the component to supply oil to the bearing in an appropriate manner. If a secure connection is not made, the operating life of the bearing unit will not be extended, and thus the motor having therein such a bearing unit will not have a long operating life.

SUMMARY OF THE INVENTION

[0006] In order to overcome the problems described above, preferred embodiments of the present invention provide a method of manufacturing a bearing unit in which a bearing and an oil supplying component are properly arranged with respect to each other. The bearing unit manufactured by a method according to a preferred embodiment of the present invention achieves a long and stable operating life. The preferred embodiments of the present invention also provide a motor including therein the bearing unit manufactured in accordance with the aforementioned method.

[0007] According to a preferred embodiment of the present invention, an oil supplying component makes contact with an outer circumferential surface of the sleeve so as to supply oil to the sleeve in an adequate manner. To be more specific, a distance between a central axis and a most curved portion of the oil supplying component, which is roundly bent to have a "c" shape, is designed to be shorter than a radius of an inner circumferential surface of a housing of the bearing unit such that the oil supplying component is operable to supply the oil effectively.

[0008] Other features, elements, steps, processes, characteristics and advantages of the present invention will become more apparent from the following description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a diagram schematically showing a projector device.

[0010] FIG. **2** is a schematic cross sectional view of a motor according to a preferred embodiment of the present invention.

[0011] FIG. **3** is a schematic cross sectional view of a bearing unit according to a preferred embodiment of the present invention.

[0012] FIGS. **4**A to **4**C are schematic cross sectional views of oil supplying members according to various preferred embodiments of the present invention.

[0013] FIG. **5** is a schematic cross sectional view of a bearing unit according to yet another preferred embodiment of the present invention.

[0014] FIG. **6** is a schematic diagram showing a step of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0015] FIG. **7** is a schematic diagram showing a step S**1** of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0016] FIG. **8** is a schematic diagram showing a step S**2** of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0017] FIG. **9** is a schematic diagram showing a step S**3** of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0018] FIG. **10** is a schematic diagram showing a step S**4** of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0019] FIG. **11** is a schematic diagram showing a step S**5** of a method for manufacturing the bearing unit according to a preferred embodiment of the present invention.

[0020] FIG. **12** is a diagram showing a cross sectional view along line x-x in FIG. **8**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] Hereinafter, preferred embodiments of the present invention will be described with reference to the drawings. Note that reference numerals, figure numbers, and supplementary explanations are provided for assisting the reader in finding corresponding components in the description of the preferred embodiments below to facilitate the understanding of the present invention. It is understood that these expressions are in no way intended to limit the scope of the invention.

Structure of the DLP Projector Device

[0022] FIG. **1** is a schematic diagram showing an entire structure of a display unit according to a preferred embodiment of the present invention. The display unit is a projector device **1** having applied therein DLP technology.

[0023] The projector device **1** includes a color wheel assembly **3** in which a disc shaped color wheel **2** is attached to a rotor portion of a motor **3***a*, a light source **4** emitting an optical light toward the color wheel **2**, a digital micro mirror

device **5** (hereinafter, referred to as DMD **5**) reflecting the optical light passing through the color wheel **2**, and a projection optical system **6** projecting the optical light from the DMD **5** to a predetermined screen **7**.

[**0024**] The color wheel **2** has, for example, three equal amount of areas each representing a color (e.g., red (R), green (G), and blue (B)) and each having a filter allowing an optical light to pass therethrough. The color wheel **2** rotates, due to the motor **3***a*, at about 7200 rpm to about 14000 rpm. The DMD **5** provides in a two dimensional manner a plurality of micro reflection mirrors whose tilt can be adjusted. Once the optical light passes through the color wheel **2**, the optical light having a predetermined frequency is transmitted in accordance with the frequency to predetermined reflection mirrors via a focusing lens **8**. Then, the optical light will be reflected to the projection optical system **6** or to a predetermined position in accordance with the tilt of each reflection mirror. Then, only the optical light that enters the projection optical system **6** will be projected onto the screen **7**. At this point, in accordance with an external signal, the tilt of each reflection mirror is adjusted with respect to the rotation of the color wheel **2**. By this, the projector device **1** projects an image (e.g., R image, G image, and/or B image) in accordance with the external signal, thereby projecting a color moving image on the screen **7**.

Structure of the Motor

[**0025**] Next, the entire structure of the motor provided with the color wheel assembly **3** will be described with reference to FIG. **2**. FIG. **2** is a schematic cross sectional view of the motor according to a preferred embodiment of the present invention.

[**0026**] According to FIG. **2**, the motor includes a rotor portion **10** which rotates about a central axis J**1**, a bearing portion **20** which supports the rotor portion **10** such that the rotor can freely rotate, and a stator portion **30** which retains the bearing portion **20**.

[**0027**] The rotor portion **10** includes a shaft **11** which rotates about the same axis as the central axis J**1**, a rotor hub **12** which has attached thereto the color wheel **2** (not shown in FIG. **2**) and which is affixed on a top portion of the shaft **11**, a substantially cylindrically shaped yoke **13** which is made of a magnetic material and is affixed to the rotor hub **12**, and a rotor magnet **14** which is affixed to the yoke **13**.

[**0028**] The rotor hub **12** is made of a non magnetic material (e.g., aluminum). Also, the rotor hub **12** has a substantially cylindrical shape having an opening at a bottom portion thereof. An extension portion **12***b*, which extends in a radially outward direction, is provided at a bottom portion of a cylinder portion **12***a*. An attaching portion **12***b***1** is provided on a top surface of the extension portion **12***b*. The color wheel **2** is to be attached to the attaching portion **12***b***1**.

[**0029**] The yoke **13** is affixed to a lower portion of an outer circumferential edge of the extension portion **12***b* by a desired fixing process (e.g., caulking). Also, the rotor magnet **14** is affixed by an adhesive, for example, to an inner circumferential surface of the yoke **13**.

[**0030**] The bearing portion **20** includes a sleeve **21** which is made of a sintered material for rotatably supporting the shaft **11**, a housing **22** which retains the sleeve **21**, an oil supplying component **23** which is retained between the sleeve **21** and the housing **22** for supplying oil to the sleeve **21**, a thrust plate **24** which is made of a resin material having superior abrasion resistance and rotatably supports a bottom portion of the shaft **11**, and a substantially cup shaped lid portion **25** which retains the thrust plate **24**.

[**0031**] The stator portion **30** includes a stator **31** which is affixed on an outer circumferential portion of the housing **22**, a mounting board **32** which is affixed on a bottom surface of the housing **22**, a circuit board **33** which is affixed on a bottom surface of the mounting board **32** for controlling rotation of the rotor portion **10**, and a cable **34** which connects the stator portion **30** with an external power source (not shown in FIG. **2**). Note that the cable **34** may be a Flexible Flat Cable (FFC) or a Flexible Printed Circuit (FPC).

[**0032**] The stator **31** includes a stator core **31***a* which is formed by laminating a plurality of thin magnetic plates, and a coil **31***b* coiling around the stator core **31***a*. An end of the coil **31***b* is electrically soldered to the circuit board **33**.

[**0033**] An electric current coming from the external power source is conducted through the cable **34** to the stator **31** and generates a magnetic field around the stator **31**. Due to an interaction between the generated magnetic field and the rotor magnet **14**, the rotor portion **10** gains a rotary force.

Detailed Structure and Manufacturing Method of the Bearing Unit

1) Detailed Structure of the Bearing Unit

[**0034**] Next, a detailed structure and a manufacturing method of the bearing unit **20***a* according to a preferred embodiment of the present invention will be described with reference to FIGS. **3** through **12**. FIG. **3** shows a bearing unit **20***a*. FIG. **4**A shows the oil supplying component **23**. FIG. **4**B shows an element prior to being formed into the oil supplying component **23**. According to FIG. **4**B, the oil supplying component **23** has a stick shape. FIG. **4**C also shows an element prior to being formed into the oil supplying component **23**. According to FIG. **4**C, the oil supplying component **23** has a ring shape. Note that the bearing unit **20***a* includes the bearing portion **20** having inserted therein the shaft **11**.

[**0035**] According to FIG. **3**, the ring shaped indent portion **22***a* which expands in a radial direction is provided on an upper portion of an inner circumferential surface of the housing **22**. A top surface **22***a* l of the indent portion **22***a* forms an inclined surface wherein the surface extends in a radially upward and inward direction generating a tapered surface. Also, a bottom surface **22***a***2** of the indent portion **22***a* defines, with respect to the central axis J**1**, a substantially perpendicular surface. Also, a ring shaped protruding portion **22***b* is formed on a lower portion of an inner circumferential surface of the housing **22** which determines the axial position of the sleeve **21**.

[**0036**] An upper side bearing **21***a* and a lower side bearing **21***b* are respectively provided on an upper portion and a lower portion on an inner circumferential surface of the sleeve **21**. The upper side bearing **21***a* and the lower side bearing **21***b* have a slightly smaller diameter than the rest of the inner circumferential surface of the sleeve **21** so as to

rotatably support the outer circumferential surface of the shaft **11**. Also, the outer circumferential surface of the sleeve **21** makes contact with the inner circumferential surface of the housing **22** above and below the indent portion **22***a*. Also, the oil supplying component **23** is located in a space generated between the indent portion **22***a* and the outer circumferential surface of the sleeve **21**. Also, a leveled portion **22***c* is provided below the protruding portion **22***b*. Also, a ring shaped plate **26** is provided below the protruding portion **22***b*. Further, the lid portion **25** is affixed to a portion of a bottom surface of the leveled portion **22***c* by a desired fixing process (e.g., caulking). At a top end of the lid portion **25**, an upper end extension portion **25***a* is arranged which extends in a radially outward direction. The plate **26** is secured between the upper end extension portion **25***a* and the bottom surface of the protruding portion **22***b*. Also, an oval shaped elevated portion **25***b* is provided on an upward end surface of the lid portion **25**. The thrust plate **24** is located on a top surface of the elevated portion **25***b*.

[**0037**] The shaft **11** which will be inserted in the sleeve **21** has a substantially cylindrical shape. At a lower portion of the shaft **11**, a reduced circumference portion **11***a* is provided having a reduced circumference than the rest of the shaft **11**. Further, a bottom end portion **11***b* of the shaft **11** has a substantially circular arc shape. A tip portion at the end of the arc shape slides on the thrust plate **24**, and is rotatably supported in the axial direction.

[**0038**] Also, an inner circumferential surface of the plate **26** is located closer to the central axis J**1** than the inner circumferential surface of the protruding portion **22***b*. Also, the inner circumferential surface of the plate **26** is located radially inwardly from the outer circumferential surface of the shaft **11**, and radially outwardly from the outer circumferential surface of the reduced circumference portion **11***a*. The protruding portion **22***b* and the plate **26** define a mechanism to prevent the shaft **11** from coming out of the bearing unit.

[**0039**] At a top surface of the sleeve **21**, a washer **27** is provided so that the oil which travels along the shaft **11** in an upward direction will be directed back to the sleeve **21**.

[**0040**] According to FIG. **4**A, the oil supplying component **23** whose axial position is determined by a position of the bottom surface **22***a***2** is a component made of a textile material (e.g., felt) which has been soaked with oil. According to FIG. **4**B, the oil supplying component **23** is formed by cutting a strip of the textile material into a plurality of substantially quadrangular prism shaped bars. If the oil supplying component **23** is formed as shown in FIG. **4**C in which a ring shaped component is cut out of the strip of the textile material, the rest of the strip will go to waste. That is, by forming the oil supplying component **23** having the substantially quadrangular prism shaped bars as shown in FIG. **4**A, the material will be used efficiently. Also, since the textile material for the oil supplying component **23** is a flexible material, the bar shaped oil supplying component **23** can be roundly bent so as to form a "c" shape as shown in FIG. **4**A.

[**0041**] Hereinafter, another preferred embodiment of the bearing unit will be described with reference to FIGS. **5** and **6**. Note that in FIGS. **5** and **6**, elements similar to those shown in FIG. **3** are denoted by similar reference numerals, and description thereof is omitted. Also, a housing shown in FIG. **5** will be denoted as housing **40**, and that shown in FIG. **6** will be denoted as housing **50**.

[**0042**] According to FIG. **5**, the oil supplying component **23** is located axially lower than as shown in FIG. **3**. When the oil supplying component **23** is located as shown in FIG. **5**, a shape of the indent portion **41** of the housing **40** is such that a top surface of the indent portion **41** is substantially perpendicular with respect to the central axis J**1**, and a bottom surface of the indent portion **41** forms an inclined surface **41***b* wherein the bottom surface extends in a radially downward and inward direction generating a tapered surface.

[**0043**] According to FIG. **6**, the outer circumferential surface of the sleeve **21** makes contact with a lower portion of the inner circumferential surface of the housing **50** below the indent portion **51**. Note that when the oil supplying component **23** is provided as shown in FIG. **5**, the outer circumferential surface of the sleeve **21** makes contact with the inner circumferential surface of the housing **40** above the indent portion **41**.

2) Manufacturing Method of the Bearing Unit **20***a*

[**0044**] Next, a manufacturing method of the bearing unit **20***a* will be described with reference to FIGS. **7** through **12**. FIGS. **7** through **11** each show a schematic diagram illustrating a manufacturing step of the bearing unit **20***a*. FIG. **12** is a diagram showing a cross sectional view of what is shown in FIG. **8** as viewed from a line x-x.

[**0045**] First, the oil supplying component **23** is inserted through an opening in the top surface **22***a***1** (see step S**1** in FIG. **7**). The oil supplying component **23** is roundly bent prior to being inserted. Due to the inclined surface formed at the top surface **22***a***1**, the roundly bent oil supplying component **23** will be allowed to be restored within the indent portion **22***a*. The aforementioned step S**1** allows the oil supplying component **23** to be easily fixed at a predetermined axial position, thereby increasing an efficiency of the manufacturing process.

[**0046**] Next, after the oil supplying component **23** is inserted into the indent portion **22***a*, oil is provided to the oil supplying component **23** (see step S**2** in FIG. **8**). Now, if the oil supplying component **23** is already soaked with oil prior to being inserted into the indent portion **22***a*, the oil maybe spilled before insertion. An oil supplying component **23** not having an adequate amount of oil may shorten the operating life of the bearing unit. Therefore, it is important to insert the oil supplying component **23** which is not soaked with oil into the indent portion **22***a* in order to prevent the aforementioned problem. The oil supplying component **23** can be ring shaped, for example.

[**0047**] According to FIG. **12**, D**1** which is a line connecting the central axis J**1** and a center portion **23***b* having the highest curvature in the roundly bent oil supplying component **23** is designed to be shorter than D**2** which is a radius connecting the central axis J**1** and a given point of an imaginary circle of the oil supplying component **23**. As a result, a point on an inner circumferential surface of the oil supplying component **23** corresponding to the center portion **23***b* makes contact with the outer circumferential surface of the sleeve **21**. Also, since D**1** is designed to be shorter than D**2**, H which is a radial thickness of the oil supplying component **23** preferably equals H**2** which is a radial depth of the indent portion **22***a*.

[**0048**] Also, once the oil supplying component **23** is placed inside the indent portion **22***a*, a large restoring force will be applied on both ends of the roundly bent oil supplying component **23** while the smallest restoring force will

be applied to the center portion **23***b*. Hereinafter, a restoring force is a force acting upon the roundly bent oil supplying component **23**, which is originally straight, so as to undo the bent shape. Due to the large restoring force, the inner circumferential surface of the center portion **23***b* will be positioned closer to the central axis J**1** than the inner circumferential surface of the housing **22**.

[**0049**] Here, if H**1**, the thickness of the oil supplying component **23**, is greater than the H**2**, the radial depth of the indent portion **22***a*, the oil supplying component **23** will extend out of the indent portion **22***a* and may be damaged when being inserted therein. Also, if H**1** is smaller than H**2**, D**1** may become greater than the D**2**, and therefore the oil will not be supplied in an adequate manner since the inner circumferential surface of the oil supplying component **23** and the outer circumferential surface of the sleeve **21** will not make contact with each other. Note that as long as H**1** and H**2** are designed to have an equal dimension, the dimensional tolerance will be varied only slightly.

[**0050**] Next, the sleeve **21** is inserted into and affixed in the housing **22** (see step S**3** in FIG. **9**). The sleeve **21** is inserted into the housing **22** by press fitting. Since the sleeve **21** is inserted into the housing **22** by press fitting, the inner circumferential surface of the housing **22** and the outer circumferential surface of the sleeve **21** make contact with each other such that the inner circumferential surface of the oil supplying component **23** and the outer circumferential surface of the sleeve **21** fittingly make contact with each other. An axial position of the sleeve **21** is determined in accordance with a position of a top surface of the protruding portion **22***b*, and therefore, the axial position of the sleeve **21** is accurately determined.

[**0051**] Next, the plate **26**, the thrust plate **24**, and the lid portion **25** are affixed at the bottom portion of the housing (see step S**4** in FIG. **10**). In step S**4**, the plate **26** is provided on a bottom surface of the protruding portion **22***b*. Then, the thrust plate **24** is placed on the top surface of the elevated portion **25***b*. Then the lid portion **25** is affixed to the housing **22** by a desired fixing process (e.g., caulking).

[**0052**] Finally, the shaft **11** is inserted into the sleeve **21** (see step S**5** in FIG. **11**). The axial position of the shaft **11** is determined when the bottom end portion **11***b* of the shaft **11** makes contact with the top surface of the thrust plate **24**. An inner circumferential edge of the plate **26** is elastically deformed so as to allow the bottom end portion **11***b* to pass therethrough. Then the shape of the inner circumferential edge of the plate **26** which is deformed when allowing the bottom end portion **11***b* to pass therethrough is restored. As a result, a mechanism to prevent the shaft from coming off the bearing unit is provided.

[**0053**] The manufacturing method of the bearing unit as described above can be applied to the bearing unit as shown in FIGS. **5** and **6**. Note, however, that according to FIG. **5**, the bottom surface **41***b* of the indent portion **41** is the tapered surface, and therefore, the oil supplying component **23** for the bearing unit as shown in FIG. **5** is inserted through a bottom portion of the bearing unit.

[**0054**] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A manufacturing method of a bearing unit, the bearing unit comprising:

a shaft;

a sleeve made of a sintered material impregnated with oil, and having a substantially cylindrical shape and an inner circumferential surface arranged to rotatably support the shaft;

a housing having an inner circumferential surface arranged to radially surround and support the sleeve, wherein the housing includes at the inner circumferential surface a ring shaped indent portion extending in a radially outward direction; and

an oil supplying component retained in the indent portion and making contact with an outer circumferential surface of the sleeve so as to supply oil to the sleeve; wherein

the manufacturing method of the bearing unit comprises the steps of:

a) inserting the oil supplying component into the indent portion such that at least a portion of an inner circumferential surface of the oil supplying component is located closer to a central axis of the housing than an inner circumferential surface of the housing is to the central axis;

b) inserting the sleeve into the housing; and

c) inserting the shaft into the sleeve.

2. The manufacturing method of the bearing unit according to claim 1, wherein the oil supplying component is made of a flexible material, and the oil supplying component is bent into a substantially round shape in step a) in order to be inserted into the indent portion.

3. The manufacturing method of the bearing unit according to claim 1, wherein the oil supplying component is made of a textile material.

4. The manufacturing method of the bearing unit according to claim 1, wherein at least one of a top surface and a bottom surface formed in a space between the inner circumferential surface of the housing and an inner circumferential surface of the indent portion includes an inclined surface extending in an axial direction.

5. The manufacturing method of the bearing unit according to claim 2, further comprising soaking the oil supplying component with the oil after the step a).

6. The manufacturing method of the bearing unit according to claim 2, wherein a center point along the inner circumferential surface of the substantially round-shaped oil supplying component is located closer to the central axis than the inner circumferential surface of the housing is to the central axis.

7. The manufacturing method of the bearing unit according to claim 2, wherein a depth of the indent portion in a radial direction is substantially identical to a thickness of the oil supplying component.

8. The manufacturing method of the bearing unit according to claim 2, wherein a gap is provided between an outer circumferential surface of the oil supplying component and the inner circumferential surface of the indent portion in the step a).

9. The manufacturing method of the bearing unit according to claim 2, wherein a first end of the oil supplying

component does not contact a second end of the oil supplying component when the oil supplying component is arranged in the indent portion.

10. A motor having attached therein the bearing unit manufactured in accordance with claim 1, the motor comprising:

a rotor portion affixed to one end of the shaft and having a rotor magnet; and

a stator portion affixed to an outer circumferential surface of the housing and arranged to oppose the rotor magnet.

11. The motor according to claim 10, wherein the rotor portion includes a color wheel mounted thereto.

12. A manufacturing method of a bearing unit, the bearing unit comprising:

a shaft;

a sleeve made of a sintered material impregnated with oil, and having a substantially cylindrical shape and an inner circumferential surface arranged to rotatably support the shaft;

a housing having an inner circumferential surface arranged to radially surround and support the sleeve, wherein the housing includes at the inner circumferential surface a ring shaped indent portion extending in a radially outward direction; and

an oil supplying component retained in the indent portion and making contact with an outer circumferential surface of the sleeve so as to supply oil to the sleeve; wherein

the manufacturing method of the bearing unit comprises the steps of:

inserting the oil supplying component into the indent portion;

inserting the sleeve into the housing such that at least one radius from a central axis of the housing to an inner circumferential of the oil supplying component is shorter than a radius from the central axis to an outer circumferential surface of the sleeve; and

inserting the shaft into the sleeve.

13. A motor having attached therein the bearing unit manufactured in accordance with claim 12, the motor comprising a rotor portion affixed to a first end of the shaft and having a rotor magnet, and a stator portion affixed on an outer circumferential surface of the housing and opposing the rotor magnet.

14. The motor according to claim 13, wherein the rotor portion includes a color wheel attached thereto.

15. A display unit comprising:

a motor according to claim 10;

a color wheel assembly including a rotary color wheel driven by the motor, the color wheel including color filters arranged to project and display a color picture image;

a digital micro mirror device arranged to reflect a light transmitted through the color wheel by movable mirrors;

a projection optical system arranged to project the light reflected from the digital micro mirror device onto a screen; and

a case arranged to house the color wheel assembly, the light source, the digital micro mirror device, and the projection optical system.

16. A display unit comprising:

a motor according to claim 13;

a color wheel assembly including a rotary color wheel driven by the motor, the color wheel including color filters arranged to project and display a color picture image;

a digital micro mirror device arranged to reflect a light transmitted through the color wheel by movable mirrors;

a projection optical system arranged to project the light reflected from the digital micro mirror device onto a screen; and

a case arranged to house the color wheel assembly, the light source, the digital micro mirror device, and the projection optical system.

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