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# (54) HYDRODYNAMIC BEARING ASSEMBLY AND SPINDLE MOTOR INCLUDING THE SAME

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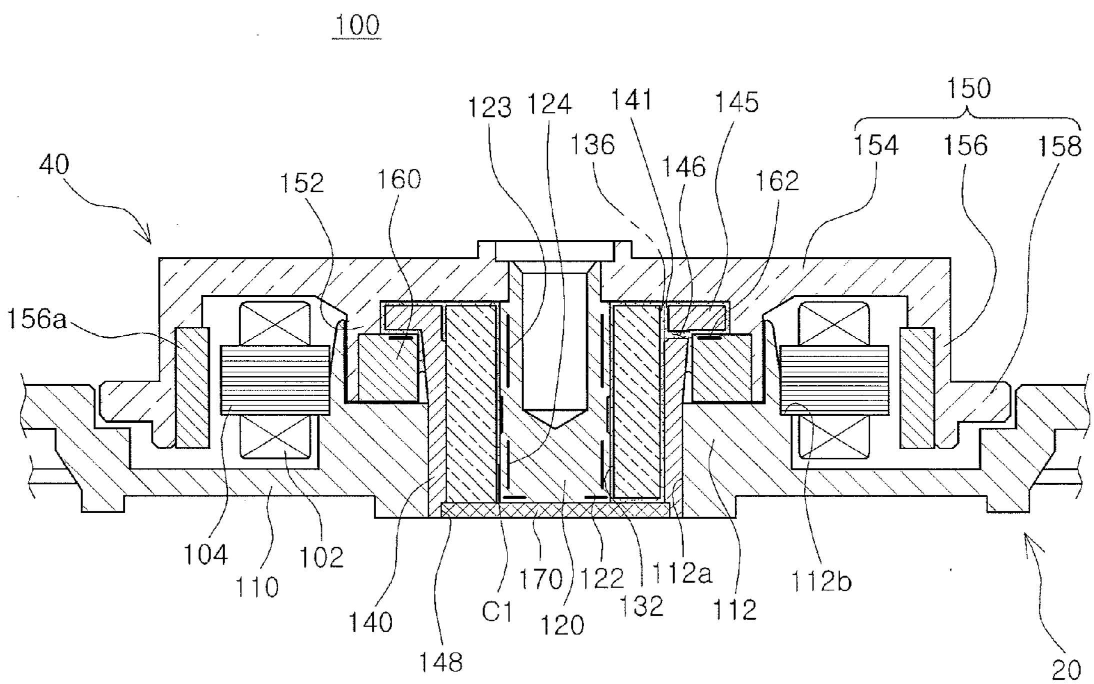
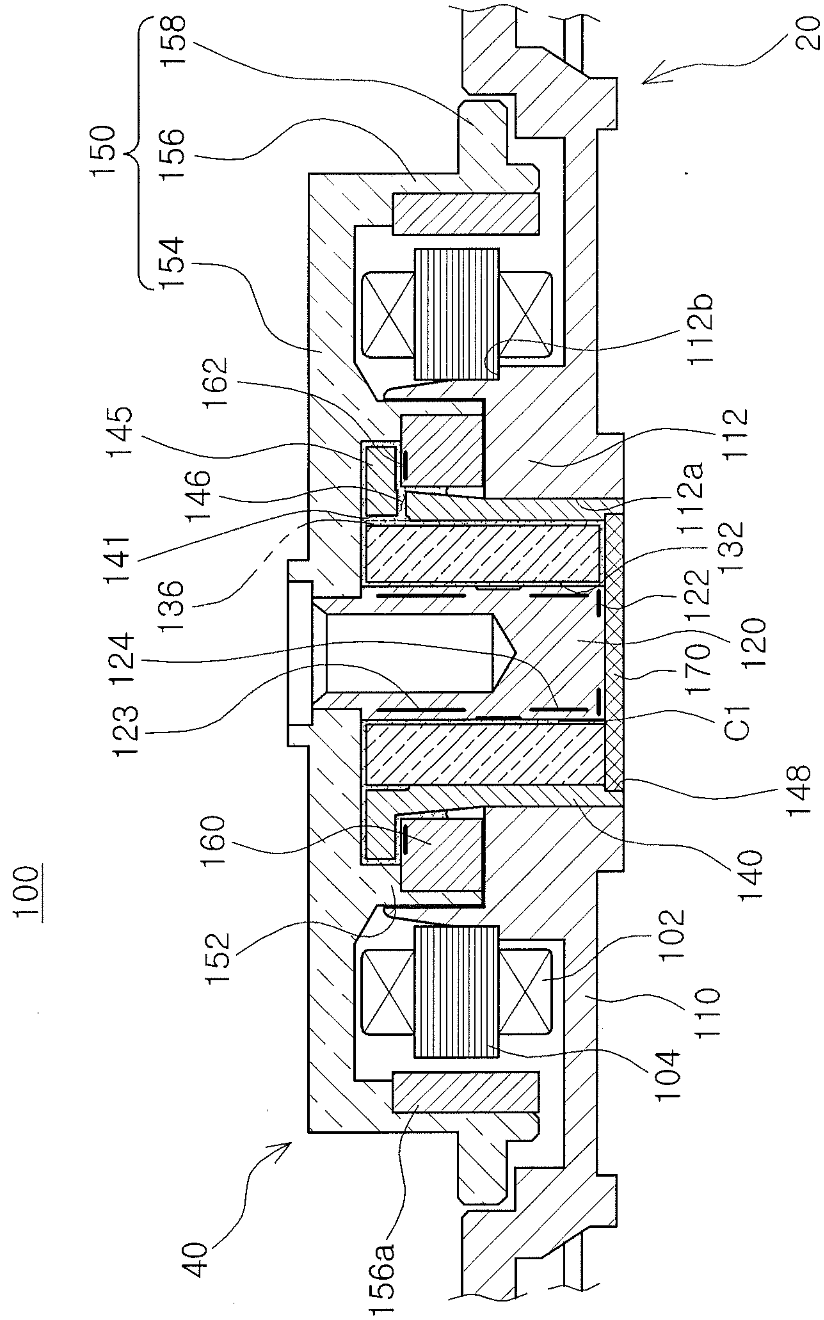
USPC .............. **310/90**; 384/114; 384/107; 384/118

(57) **ABSTRACT**

There are provided a hydrodynamic bearing assembly and a motor including the same. The hydrodynamic bearing assembly includes: a sleeve supporting a shaft and forming a bearing clearance filled with a lubricating fluid; a housing enclosing an outer peripheral surface of the sleeve and including a flange part formed in an upper end portion thereof and extended outwardly; a rotor hub coupled to an upper end portion of the shaft and including an extension wall part extended to be disposed outwardly of the housing; a stopper member fixed to the extension wall part while being disposed under the flange part of the housing, and forming, together with an outer peripheral surface of the housing, a space in which a liquid-vapor interface is formed; and a cover member coupled to a lower end portion of the housing. The sleeve and the housing include first and second circulation holes formed therebetween.





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156
158
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112b
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141
136
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132
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C1
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124
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152
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110
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FIG. 1

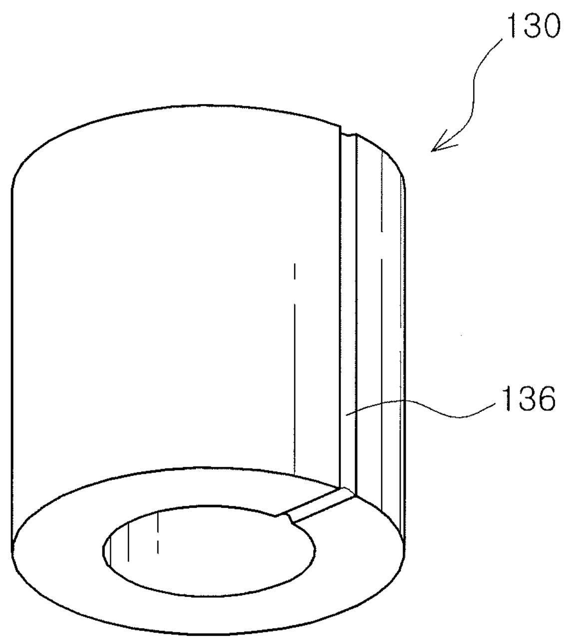



FIG. 2A

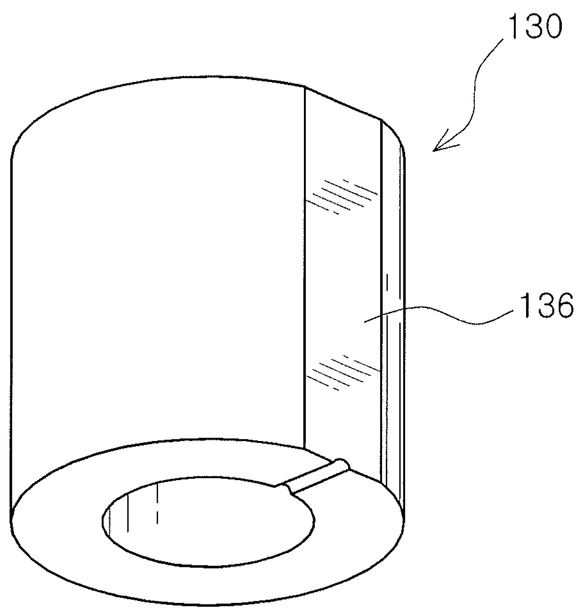



FIG. 2B

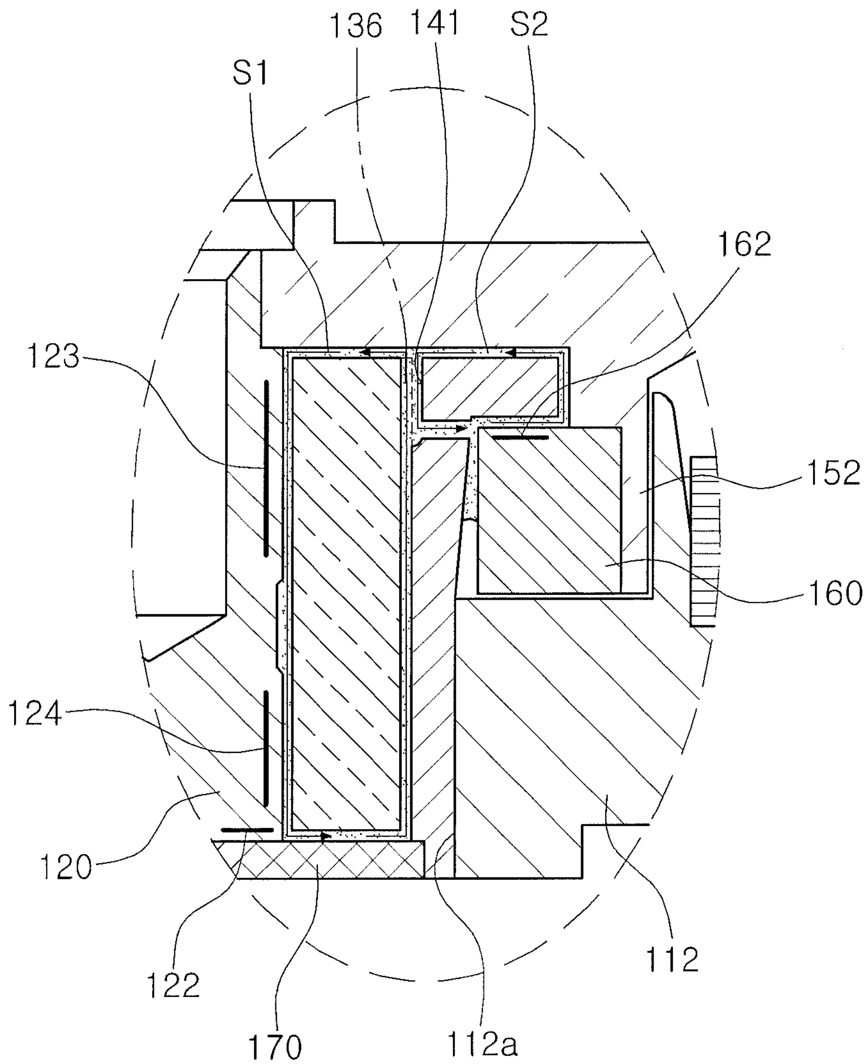
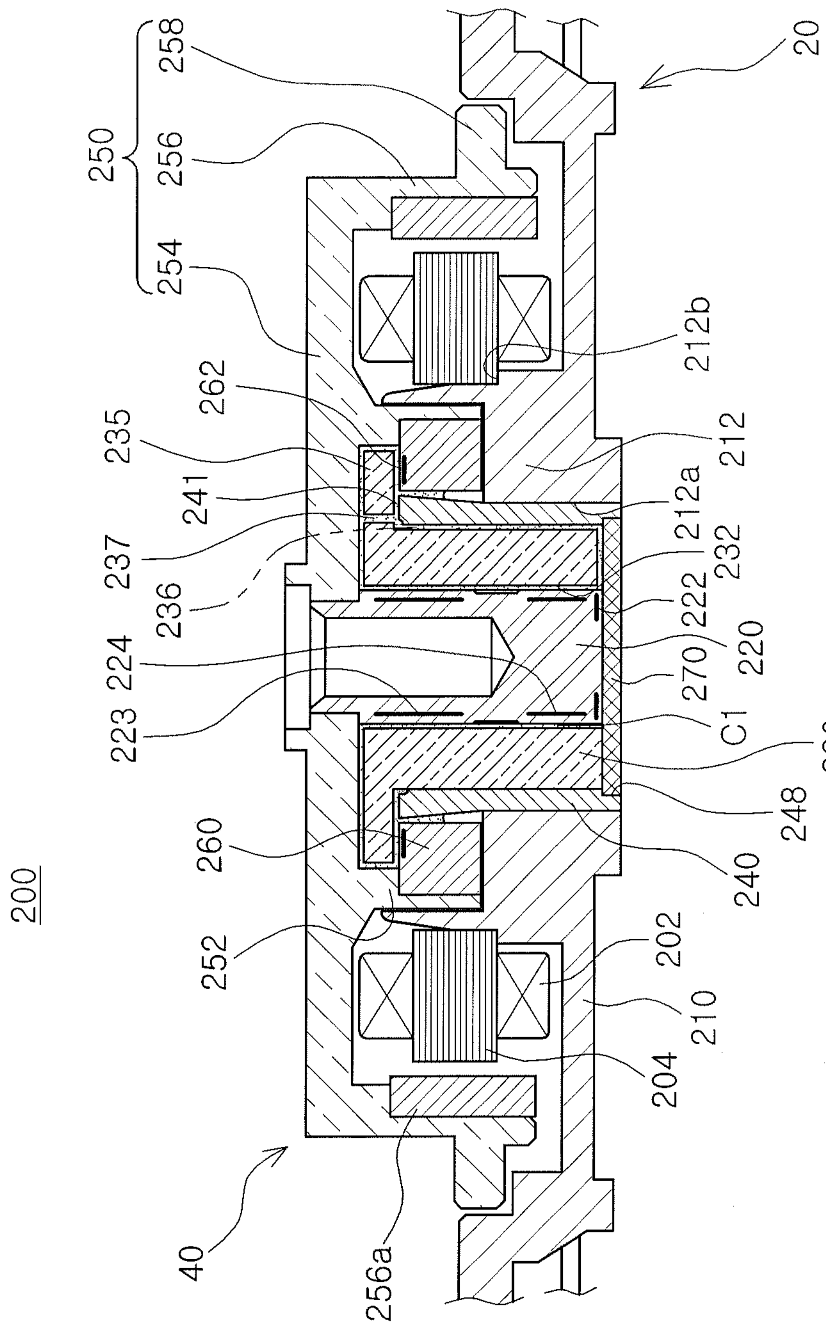



FIG. 3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212b
212
212a
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C1
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248
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202
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204
200
40
256a

FIG. 4

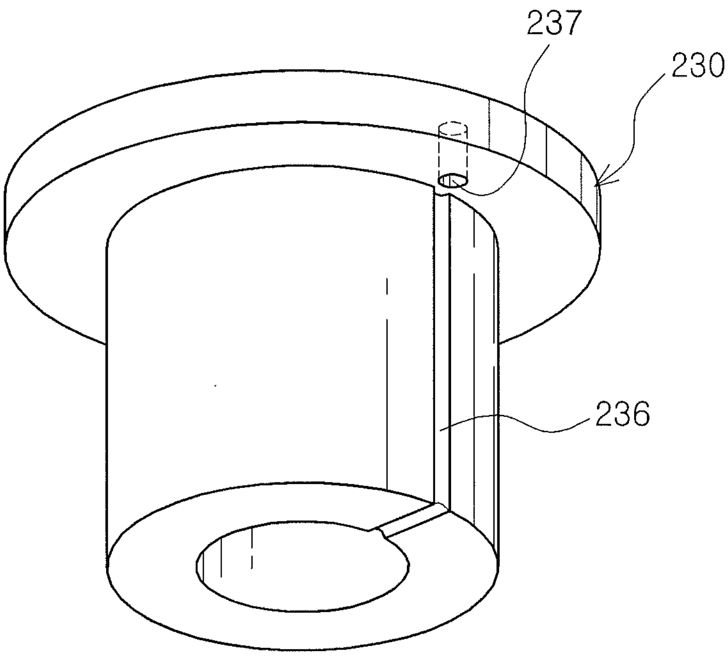



FIG. 5A

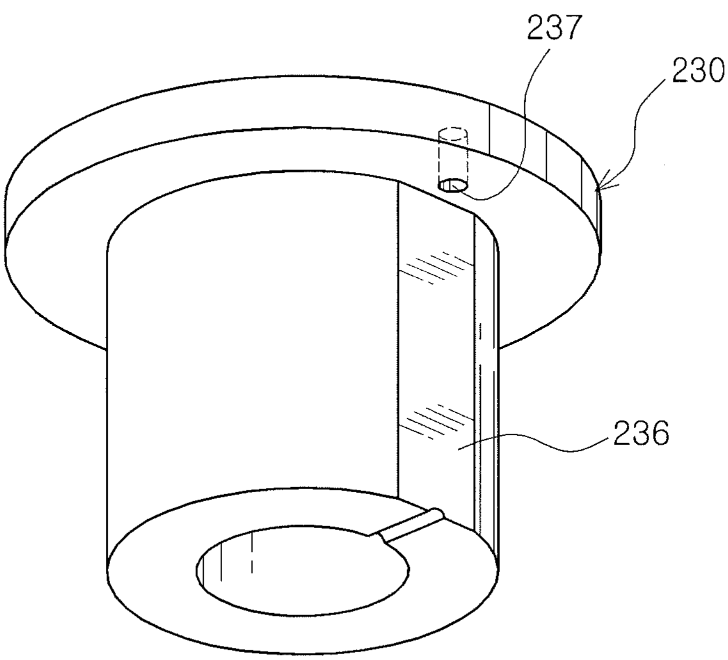
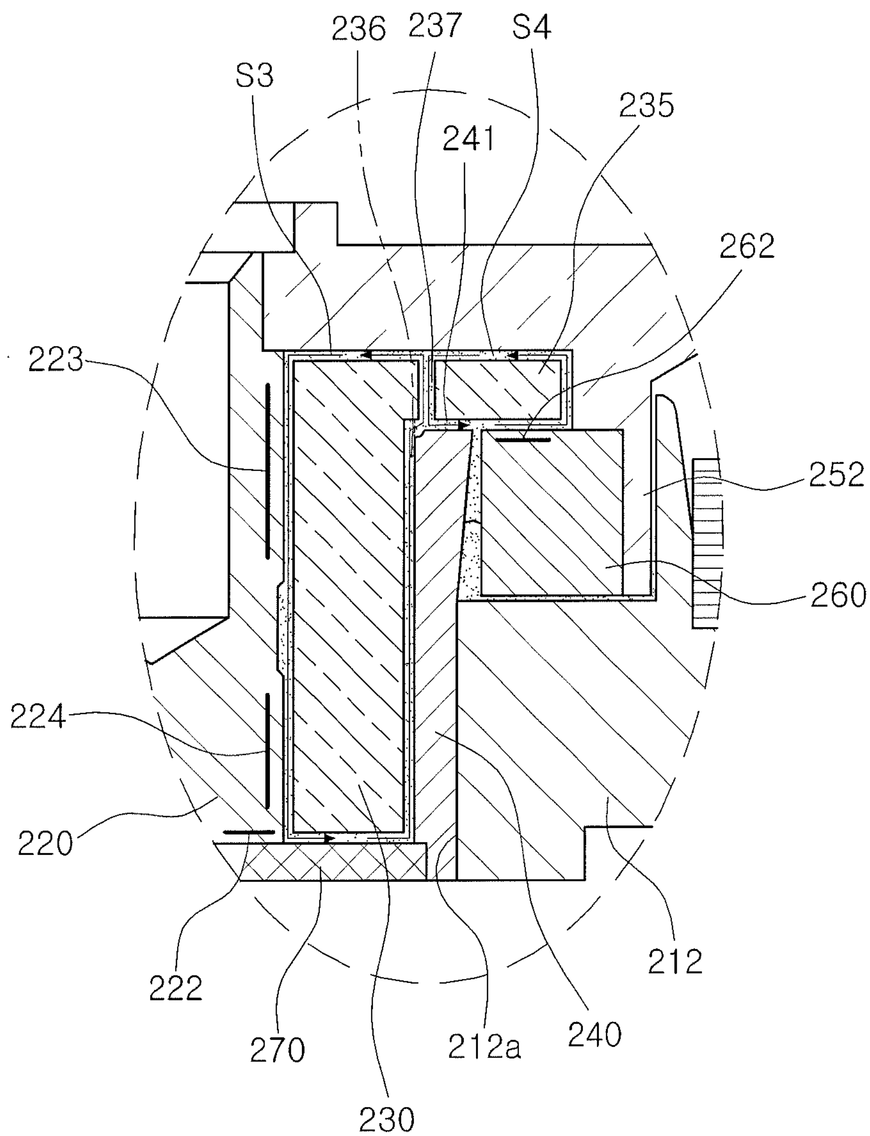



FIG. 5B


236
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S4
S3
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270
212a
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FIG. 6

# HYDRODYNAMIC BEARING ASSEMBLY AND SPINDLE MOTOR INCLUDING THE SAME

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority of Korean Patent Application No. 10-2011-0141671 filed on Dec. 23, 2011, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a hydrodynamic bearing assembly and a spindle motor including the same.

[0004] 2. Description of the Related Art

[0005] A small spindle motor used in a hard disk drive (HDD) is generally provided with a hydrodynamic bearing assembly, and a bearing clearance between a shaft and a sleeve of the hydrodynamic bearing assembly is filled with lubricating fluid such as oil. The oil filling the bearing clearance generates hydrodynamic pressure while being compressed, thereby rotatably supporting the shaft.

[0006] That is, the hydrodynamic bearing assembly generally generates dynamic pressure through spiral shaped grooves in an axial direction and herringbone shaped grooves in a circumferential direction, thereby promoting stability of rotational driving of the spindle motor.

[0007] Meanwhile, in accordance with an increase in capacity of the hard disk drive, it is necessary to reduce vibrations generated during the driving of the spindle motor. That is, in order to allow the hard disk drive to be driven without an error due to the vibrations generated during the driving of the spindle motor, the demand for improvement in performance of the hydrodynamic bearing assembly provided in the spindle motor has increased.

[0008] In order to improve the performance of the hydrodynamic bearing assembly, there is a need to increase an interval (that is, bearing span length) between the herringbone shaped grooves to move the center of rotation upwardly, thereby promoting stability of the driving of the spindle motor.

[0009] In addition, the spindle motor has been used in a portable electronic device, such that the demand for reduction in power consumption has increased.

[0010] The development of a structure capable of reducing power consumption while promoting stability of driving of a motor as described above has been urgently demanded.

[0011] In Related Art Documents described below, Related Art Document 1 fails to disclose that two circulations of a fluid are formed, and Related Art Document 2 discloses a spindle motor in which a housing is not provided.

### Related Art Document

[0012] (Patent Document 1) Japanese Patent Laid-open Publication No. 2006-022831

[0013] (Patent Document 2) Japanese Patent Laid-open Publication No. 2004-270820

## SUMMARY OF THE INVENTION

[0014] An aspect of the present invention provides a hydrodynamic bearing assembly capable of preventing generation of negative pressure and excessive floating of a rotor and easily discharging air bubbles, and a spindle motor including the same.

[0015] According to an aspect of the present invention, there is provided a hydrodynamic bearing assembly including: a sleeve supporting a shaft such that an upper end portion of the shaft is protruded upwardly in an axial direction, and forming a bearing clearance filled with a lubricating fluid; a housing provided to enclose an outer peripheral surface of the sleeve and including a flange part formed in an upper end portion thereof and extended outwardly; a rotor hub coupled to the upper end portion of the shaft and including an extension wall part extended to be disposed outwardly of the housing; a stopper member fixed to the extension wall part of the rotor hub while being disposed under the flange part of the housing, and forming, together with an outer peripheral surface of the housing, a space in which a liquid-vapor interface is formed; and a cover member coupled to a lower end portion of the housing, wherein the sleeve and the housing include a first circulation hole formed therebetween in order to connect upper and lower portions of the sleeve to each other, and a second circulation hole formed therebetween in order to connect the first circulation hole and a space formed by the stopper member and the outer peripheral surface of the housing to each other.

[0016] The sleeve and an inner surface of a portion of the housing in which the flange part is provided may form an annular space therebetween.

[0017] A first thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure may be formed in at least one of a lower surface of the shaft and an upper surface of the cover member.

[0018] A second thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure may be formed in at least one of a lower surface of the flange part and an upper surface of the stopper member.

[0019] At the time of rotational driving of the shaft, a first circulation in which the lubricating fluid moves from a lower portion of the first circulation hole toward an upper portion thereof and a second circulation in which the lubricating fluid moves from the first circulation hole toward a bearing clearance formed by the flange part and the stopper member may be formed.

[0020] The shaft may include upper and lower radial dynamic pressure generating grooves formed in an outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof, and the lubricating fluid may move from the upper radial dynamic pressure generating groove toward the lower radial dynamic pressure generating groove.

[0021] The housing may be integrally provided with the cover member.

[0022] The shaft may be integrally provided with the rotor hub.

[0023] The first circulation hole may be provided as a communication groove formed in at least one of the outer peripheral surface of the sleeve and an inner peripheral surface of the housing.

[0024] According to another aspect of the present invention, there is provided a hydrodynamic bearing assembly including: a sleeve supporting a shaft such that an upper end portion of the shaft is protruded upwardly in an axial direction, forming a bearing clearance filled with a lubricating fluid, and including a flange part formed in an upper end portion thereof and extended outwardly; a housing provided to enclose an outer peripheral surface of the sleeve while allowing an upper end surface thereof to be spaced apart from a lower surface of the flange part of the sleeve by a predetermined interval; a rotor hub coupled to the upper end portion of the shaft and including an extension wall part extended to be disposed outwardly of the sleeve and the housing; a stopper member fixed to the extension wall part of the rotor hub while being disposed under the flange part of the sleeve and forming, together with an outer peripheral surface of the housing, a space in which a liquid-vapor interface is formed; and a cover member coupled to a lower end portion of the housing, wherein the sleeve and the housing includes a third circulation hole formed therebetween in order to connect a lower portion of the sleeve and the upper end surface of the housing to each other and a fourth circulation hole formed therebetween in order to connect the third circulation hole and an upper portion of the sleeve to each other.

**[0025]** A third thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure may be formed in at least one of a lower surface of the shaft and an upper surface of the cover member.

**[0026]** A fourth thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure may be formed in at least one of a lower surface of the flange part and an upper surface of the stopper member.

**[0027]** At the time of rotational driving of the shaft, a third circulation in which the lubricating fluid moves from lower portions of the third and fourth circulation holes toward upper portions thereof and a fourth circulation in which the lubricating fluid moves from the third circulation hole toward a bearing clearance formed by the flange part and the stopper member may be formed.

**[0028]** The shaft may include upper and lower radial dynamic pressure generating grooves formed in an outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof, and the lubricating fluid may move from the upper radial dynamic pressure generating groove toward the lower radial dynamic pressure generating groove.

**[0029]** The third circulation hole may be provided as a communication groove formed in at least one of the outer peripheral surface of the sleeve and an inner peripheral surface of the housing.

**[0030]** The fourth circulation hole may penetrate through the flange part so as to connect the third circulation hole and the upper portion of the sleeve to each other.

**[0031]** According to another aspect of the present invention, there is provided a spindle motor including: the hydrodynamic bearing assembly as described above; and a stator coupled to an outside of the housing and including a core having a coil wound therearound in order to generate rotational driving force.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0032]** The above and other aspects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

**[0033]** FIG. **1** is a schematic cross-sectional view showing a spindle motor according to an embodiment of the present invention;

**[0034]** FIGS. **2**A and **2**B are perspective views showing a sleeve according to an embodiment of the present invention;

**[0035]** FIG. **3** is a view describing an operation of a spindle motor according to an embodiment of the present invention;

**[0036]** FIG. **4** is a cross-sectional view schematically showing a spindle motor according to another embodiment of the present invention;

**[0037]** FIGS. **5**A and **5**B are perspective views showing a sleeve according to another embodiment of the present invention; and

**[0038]** FIG. **6** is a view describing an operation of a spindle motor according another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

**[0039]** Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. However, it should be noted that the spirit of the present invention is not limited to the embodiments set forth herein and those skilled in the art and understanding the present invention can easily accomplish retrogressive inventions or other embodiments included in the spirit of the present invention by the addition, modification, and removal of components within the same spirit, but those are construed as being included in the spirit of the present invention.

**[0040]** Further, when it is determined that the detailed description of the known art related to the present invention may obscure the gist of the present invention, the detailed description thereof will be omitted.

**[0041]** FIG. **1** is a schematic cross-sectional view showing a spindle motor according to an embodiment of the present invention; FIGS. **2**A and **2**B are perspective views showing a sleeve according to the embodiment of the present invention; and FIG. **3** is a view describing an operation of the spindle motor according to the embodiment of the present invention.

**[0042]** Referring to FIGS. **1** through **3**, a spindle motor **100** according to this embodiment of the present invention may include a base member **110**, a shaft **120**, a sleeve **130**, a housing **140**, a rotor hub **150**, a stopper member **160**, and a cover member **170**.

**[0043]** The spindle motor **100** may be a motor used in a hard disk drive driving a recoding disk.

**[0044]** Here, terms with respect to directions will be defined. As viewed in FIG. **1**, an axial direction refers to a vertical direction, that is, a direction from a lower portion of the shaft **120** toward an upper portion thereof or a direction from the upper portion of the shaft **120** toward the lower portion thereof, and a radial direction refers to a horizontal direction, that is, a direction from an outer peripheral surface of the rotor hub **150** toward the shaft **120** or from the shaft **120** toward the outer peripheral surface of the rotor hub **150**.

**[0045]** In addition, a circumferential direction refers to a rotation direction along an outer peripheral surface of the rotor hub **150** or the shaft **120**.

**[0046]** Further, a hydrodynamic bearing assembly according to the embodiment of the present invention may include members related to a principle of a bearing utilizing dynamic pressure of a fluid, that is, members other than the base member **110**. That is, the hydrodynamic bearing assembly may include the shaft **120**, the sleeve **130**, the housing **140**, the rotor hub **150**, the stopper member **160**, and the cover member **170**.

**[0047]** The base member **110**, which is a fixed member, may form a stator **20**. Here, the stator **20**, referring to all fixed members except for rotating members, may include the base member **110**, the sleeve **130**, the housing **140**, and the like.

[0048] In addition, the base member **110** may include an installation part **112** having the housing **140** insertedly installed therein. The installation part **112** may be protruded upwardly in the axial direction and include an installation hole **112***a* formed therein so that the housing **140** may be insertedly installed therein.

[0049] In addition, the installation part **112** may include a seat surface **112***b* formed on an outer peripheral surface thereof so that a stator core **104** having a coil **102** wound therearound may be seated thereon. That is, the stator core **104** may be fixed to the outer peripheral surface of the installation part **112** by an adhesive in a state in which it is seated on the seat surface **112***b*.

[0050] However, the stator core **104** may also be installed on the outer peripheral surface of the installation part **112** in a press-fitting scheme without using the adhesive. That is, a scheme of installing the stator core **104** is not limited to the use of the adhesive.

[0051] The shaft **120**, which is a rotating member, may form a rotor **40**. Here, the rotor **40** refers to a member rotatably supported by the stator **20** to thereby rotate.

[0052] Meanwhile, the shaft **120** may be rotatably supported by the sleeve **130**. In addition, as shown in FIG. **1**, the shaft **120** may include a first thrust dynamic pressure generating groove **122** formed in a lower surface thereof in order to generate thrust hydrodynamic pressure at the time of rotation thereof.

[0053] Meanwhile, the first thrust dynamic pressure generating groove **122** is not limited to being formed in the lower surface of the shaft **120**, but may also be formed in an upper surface of the cover member **170** disposed to face the lower surface of the shaft **120**.

[0054] As described above, the first thrust dynamic pressure generating groove **122** is formed in the lower surface of the shaft **120** or the upper surface of the cover member **170** disposed to face the lower surface of the shaft **120**, such that a length of the first thrust dynamic pressure generating groove **122** in the radial direction is reduced, whereby power consumption may be further reduced.

[0055] Meanwhile, the first thrust dynamic pressure generating groove **122** may have a herringbone shape or a spiral shape. However, the first dynamic pressure generating groove **122** is not limited to having the above-mentioned shape, but may have any shape as long as it can generate hydrodynamic pressure at the time of the rotation of the shaft **120**.

[0056] Meanwhile, the shaft **120** may include upper and lower radial dynamic pressure generating grooves **123** and **124** formed in an outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof. In addition, the upper and lower radial dynamic pressure generating grooves **123** and **124** may be disposed to be spaced apart from each other by a predetermined interval and have a herringbone or spiral shape.

[0057] In addition, at the time of the rotational driving of the shaft **120**, a lubricating fluid may move from the upper radial dynamic pressure generating groove **123** toward the lower radial dynamic pressure generating groove **124**. That is, the spindle motor **100** according to the present embodiment may have a down pumping structure.

[0058] The sleeve **130**, which is a fixed member forming the stator **20** together with the housing **140** and the base member **110**, may rotatably support the shaft **120** and form a bearing clearance C**1** filled with the lubricating fluid. The sleeve **130** may be formed by sintering a Cu—Fe-based alloy powder or a SUS-based powder.

[0059] Meanwhile, the sleeve **130** may be inserted into the installation part **112** of the base member **110** in a state in which it is fixed in the housing **140**, such that it may be fixedly installed indirectly to the base member **110**. That is, an outer peripheral surface of the housing **140** may be adhered to an inner peripheral surface of the installation part **112** by an adhesive.

[0060] Further, the sleeve **130** may include a shaft hole **132** formed therein, such that the shaft **120** is inserted thereinto. Further, in the case in which the shaft **120** is insertedly disposed in the shaft hole **132** of the sleeve **130**, an inner peripheral surface of the sleeve **130** and the outer peripheral surface of the shaft **120** may be spaced apart from each other by a predetermined interval to thereby form the bearing clearance C**1** therebetween.

[0061] Here, the bearing clearance C**1** will be described in more detail. As described above, the sleeve **130** forms the bearing clearance C**1** filled with the lubricating fluid. This bearing clearance C**1** indicates a clearance formed by the shaft **120** and the sleeve **130**, a clearance formed by an upper end portion of the sleeve **130** and the rotor hub **150**, a clearance formed by a flange part **145** of the housing **140** and the rotor hub **150**, a clearance formed by the housing **140** and the stopper member **160**, and a clearance formed by the cover member **170** and the lower surface of the shaft **120**.

[0062] In addition, the spindle motor **100** according to the present embodiment may have a structure in which the entire bearing clearance C**1** is filled with the lubricating fluid. This structure may be called a full-fill structure.

[0063] Meanwhile, the sleeve **130** may include upper and lower radial dynamic pressure generating grooves formed in the inner peripheral surface thereof in order to generate hydrodynamic pressure at the time of the rotational driving of the shaft **120**. In addition, the upper and lower radial dynamic pressure generating grooves may be disposed to be spaced apart from each other by a predetermined interval and have a herringbone or spiral shape.

[0064] Further, the sleeve **130** and the housing **140** to be described below may include a first circulation hole **136** formed therebetween in order to connect upper and lower portions of the sleeve **130** to each other. The first circulation hole **136** may be provided as a communication groove formed in at least one of an outer peripheral surface of the sleeve **130** and an inner peripheral surface of the housing **140**.

[0065] In the case in which the first circulation hole **136** is formed along the outer peripheral surface of the sleeve **130** and has a groove shape in which it allows the upper and lower portions of the sleeve **130** to communicate with each other, the first circulation hole **136** may include a groove formed in a horizontal direction (the radial direction based on FIG. **1**) in a bottom surface of the sleeve **130** and a groove formed in a vertical direction (the axial direction based on FIG. **1**) in a side of the sleeve **130** in a state in which it is in communication with the groove formed in the bottom surface of the sleeve **130**. In addition, the groove may be formed in the horizontal direction (the radial direction based on FIG. **1**) in the bottom surface of the sleeve **130**, and the groove may be formed in the side of the sleeve **130** by cutting a portion of the side of the sleeve **130** in the vertical direction (the axial direction based on FIG. **1**) in a state in which it is in communication with the groove formed in the bottom surface of the sleeve **130**. Since the outer peripheral surface of the sleeve

**130** and the inner peripheral surface of the housing **140** have a circular shape, when the outer peripheral surface of the sleeve **130** is cut vertically (in the axial direction based on FIG. **1**), a space between the sleeve **130** and the housing **140** is naturally formed, such that the first circulation hole **136** may be provided.

**[0066]** Further, in the case in which a circulation hole is formed along the inner peripheral surface of the housing **140**, the circulation hole may be formed in the same method as that of forming the circulation hole in the outer peripheral surface of the sleeve **130**. However, the case in which the circulation hole is formed along the inner peripheral surface of the housing **140** is slightly different from the case in which the circulation hole is formed in the outer peripheral surface of the sleeve **130**, in that a groove in communication with the circulation groove formed in the inner peripheral surface of the housing **140** may be formed along an upper surface of the cover member **170** since a lower surface of the sleeve **130** may partially contact the cover member **170**.

**[0067]** The housing **140** may be coupled to the outer peripheral surface of the sleeve **130** while enclosing the sleeve **130**. More specifically, the sleeve **130** may be inserted into the inner peripheral surface of the housing **140** and be coupled thereto by press-fitting or bonding.

**[0068]** The housing **140** may be coupled to the outer peripheral surface of the sleeve **130** containing oil to thereby prevent the oil from being leaked.

**[0069]** In addition, an inner surface of a portion of the housing **140** in which the flange part **145** is provided may be spaced apart from the sleeve **130** by a predetermined interval to form an annular space **141**. The space **141** may be provided by allowing the inner peripheral surface of the housing **140** or the outer peripheral surface of the sleeve **130** to be stepped.

**[0070]** The housing **140** may include the flange part **145** extended to be disposed over the stopper member **160**. In addition, the flange part **145** may serve to limit excessive floating of the rotor hub **150**.

**[0071]** Further, the housing **140** may include a second circulation hole **146** connecting the first circulation hole **136** provided in the sleeve **130** to a space formed by the stopper member **160** and the outer peripheral surface of the housing **140**.

**[0072]** More specifically, the housing **140** may include the second circulation hole **146** formed under the flange part **145** and connected to the first circulation hole **136**.

**[0073]** In addition, the first circulation hole **136** may be formed along the outer peripheral surface of the sleeve **130** or the inner peripheral surface of the housing **140** to thereby be connected to the second circulation hold **146**. That is, the first circulation hole **136** may be connected to the space formed by the stopper member **160** and the outer peripheral surface of the housing **140** by the second circulation hole **146** while connecting the bearing clearance C**1** formed by the shaft **120** and the cover member **170** and the bearing clearance C**1** formed by the sleeve **130** and the rotor hub **150** to each other. Therefore, the first and second circulation holes **136** and **146** may connect three bearing clearances C**1** to each other.

**[0074]** The rotor hub **150**, which is a rotating member forming the rotor **40** together with the shaft **120**, may be coupled to the upper end portion of the shaft **120** and include an extension wall part **152** extended to be disposed outwardly of the sleeve **130**.

**[0075]** Meanwhile, the rotor hub **150** may include a rotor hub body **154** provided with an mounting hole **154*a*** into which the upper end portion of the shaft **120** is inserted, a magnet mounting part **156** extended downwardly from an edge of the rotor hub body **154** in the axial direction, and a disk seat part **158** extended from a distal end of the magnet mounting part **156** in the outer radial direction.

**[0076]** In addition, the magnet mounting part **156** may have a driving magnet **156*a*** installed on an inner surface thereof, wherein the driving magnet **156*a*** is disposed to face a front end of the stator core **104** having the coil **102** wound therearound.

**[0077]** Meanwhile, the driving magnet **156*a*** may have an annular ring shape and be a permanent magnet generating magnetic force having a predetermined strength by alternately magnetizing an N pole and an S pole in a circumferential direction.

**[0078]** Here, rotational driving of the rotor hub **150** will be briefly described. When power is supplied to the coil **102** wound around the stator core **104**, driving force capable of rotating the rotor hub **150** is generated by electromagnetic interaction between the driving magnet **156*a*** and the stator core **104** having the coil **102** wound therearound.

**[0079]** Therefore, the rotor hub **150** may be rotated. In addition, the shaft **120** on which the rotor hub **150** is fixedly installed may be rotated together with the rotor hub **150** by the rotation of the rotor hub **150**.

**[0080]** In addition, the extension wall part **152** may be extended downwardly from a lower surface of the rotor hub body **154** in the axial direction and be stepped such that the stopper member **160** may be installed thereto.

**[0081]** Meanwhile, the rotor hub **150** may be integrally provided with the shaft **120**.

**[0082]** The stopper member **160** may be fixed to the extension wall part **152** of the rotor hub **152** and form, together with the outer peripheral surface of the housing **140**, a space in which a liquid-vapor interface is formed.

**[0083]** In addition, an inner peripheral surface of the stopper member **160** and the outer peripheral surface of the housing **140** disposed to face the inner peripheral surface of the stopper member **160** may be inclined so that an interface between the lubricating fluid and air may be formed.

**[0084]** Further, in the case in which the stopper member **160** is installed on the extension wall part **152**, the flange part **145** of the housing **140** may be disposed over the stopper member **160** so as to face the stopper member **160**. Therefore, when an external impact is applied thereto, the stopper member **160** is supported by the extension wall part **152**, whereby excessive floating of the rotor hub **150** and the shaft **120** may be suppressed.

**[0085]** In addition, a second thrust dynamic pressure generating groove **162** for generating thrust hydrodynamic pressure may be formed in at least one of an upper surface of the stopper member **160** and a lower surface of the flange part **145**.

**[0086]** Therefore, the second thrust dynamic pressure generating groove **162** generates thrust hydrodynamic pressure at the time of the rotation of the shaft **120**, whereby the rotation of the rotor hub **150** may be more stably supported.

**[0087]** In addition, the lubricating fluid may move along the flange part **145** and the first and second circulation holes **136** and **146** by the second thrust dynamic pressure generating groove **162**.

**[0088]** The housing **140** may include a mounting groove **148** formed in a lower end portion thereof so that the cover member **170** may be installed therein.

[0089] The cover member **170**, which is a fixed member forming the stator **20** together with the base member **110**, the sleeve **130**, and the housing **140**, may be installed on the lower end portion of the housing **140** to thereby serve to prevent the lubricating fluid filling the bearing clearance C**1** from being leaked to the lower end portion of the housing **140**.

[0090] Meanwhile, the cover member **170** may be bonded to the mounting groove **148** of the housing **140** by an adhesive and/or welding.

[0091] Meanwhile, the cover member **170** may be integrally provided with the housing **140**.

[0092] Here, a movement path of the lubricating fluid will be described.

[0093] First, as shown in FIG. **3**, at the time of the rotational driving of the shaft **120**, a first circulation S**1** in which the lubricating fluid moves from a lower portion of the first circulation hole **136** toward an upper portion thereof and a second circulation S**2** in which the lubricating fluid moves from the first circulation hole **136** toward the bearing clearance C**1** formed by the flange part **145** and the stopper member **160**, that is, the second circulation hole **146** may be formed.

[0094] That is, a movement path of the first circulation S**1** is as follows.

[0095] First, the lubricating fluid moves from the upper radial dynamic pressure generating groove **123** to the lower radial dynamic pressure generating groove **124**, moves from the lower portion of the first circulation hole **136** toward the upper portion thereof, and then moves in the inner radial direction in the bearing clearance C**1** formed by the rotor hub **150** and the upper surface of the sleeve **130**.

[0096] In addition, a movement path of the second circulation S**2** is as follows. The lubricating fluid moves from the second thrust dynamic pressure generating groove **162** to the bearing clearance C**1** formed by the flange part **145** and the extension wall part **152** by the second thrust dynamic pressure generating groove **162**, moves in the inner radial direction in the bearing clearance C**1** formed by the rotor hub **150** and the upper surface of the housing **140**, and then moves from the upper portion of the first circulation hole **136** to the second circulation hole **146**.

[0097] As described above, since the second circulation S**2** is formed, generation of negative pressure and an abnormal increase in pressure may be suppressed. That is, the second circulation S**2** is formed in an area having a possibility that pressure may become unstable, whereby the generation of the negative pressure and the abnormal increase in pressure may be reduced.

[0098] In addition, air bubbles generated at the time of the rotational driving of the shaft **120** may be more easily discharged to the outside by the second circulation S**2**. That is, the air bubbles moving from the lower portion of the first circulation hole **136** to the upper portion thereof may move to a space in which the liquid-vapor interface is formed, by the second circulation S**2** through the second circulation hole **146**.

[0099] Therefore, the air bubbles may be easily discharged.

[0100] As described above, the stopper member **160** is installed on the extension wall part **152**, such that a bearing span length is increased, whereby rotational characteristics may be improved and power consumption may be reduced.

[0101] Here, the bearing span length indicates a distance between a region in which maximum dynamic pressure is generated while the lubricating fluid is pumped by the upper radial dynamic pressure generating groove **123** and a region in which maximum dynamic pressure is generated while the lubricating fluid is pumped by the lower radial dynamic pressure generating groove **124**.

[0102] That is, the stopper member **160** is installed on the extension wall part **152**, such that a distance between the upper and lower radial dynamic pressure generating grooves **123** and **124** is increased, whereby the bearing span length may be increased.

[0103] Therefore, the rotational characteristics may be improved and the power consumption may be reduced.

[0104] In addition, since force pulling the rotor hub **150** toward the base member **110** by magnetic force is not required through the first and second thrust dynamic pressure generating grooves **122** and **162**, in other words, a double thrust structure, a pulling plate need not to be installed, whereby manufacturing costs may be reduced.

[0105] Further, since the force pulling the rotor hub **150** toward the base member **110**, that is, pulling force is not required, loss of power for generating the puling force is reduced, whereby the power consumption may be reduced.

[0106] In addition, since the upper and lower portions of the sleeve **130** and the outer peripheral surface of the housing **140** may be connected to each other through the first and second circulation holes **136** and **146**, the generation of the negative pressure and the abnormal increase in pressure may be prevented.

[0107] Further, the air bubbles may be easily discharged through the first and second circulation holes **136** and **146**.

[0108] Hereinafter, a spindle motor according to another embodiment of the present invention will be described with reference to the accompanying drawings. However, a detailed description of the same components as the above-mentioned components will be omitted and be replaced by the above-mentioned description.

[0109] FIG. **4** is a cross-sectional view schematically showing a spindle motor according to another embodiment of the present invention; FIGS. **5**A and **5**B are perspective views showing a sleeve according to another embodiment of the present invention; and FIG. **6** is a view describing an operation of the spindle motor according another embodiment of the present invention.

[0110] Referring to FIGS. **4** through **6**, a spindle motor **200** according to another embodiment of the present invention may include a base member **210**, a shaft **220**, a sleeve **230**, a housing **240**, a rotor hub **250**, a stopper member **260**, and a cover member **270**.

[0111] Meanwhile, the base member **210**, the shaft **220**, the rotor hub **250**, the stopper member **260**, and the cover member **270** provided in the spindle motor **200** according to this embodiment of the present invention are substantially identical to the base member **110**, the shaft **120**, the rotor hub **150**, the stopper member **160**, and the cover member **170** provided in the spindle motor **100** according to the foregoing embodiment of the present invention. Therefore, a detailed description thereof will be omitted and be replaced by the above-mentioned description.

[0112] The sleeve **230** may form a bearing clearance C**1** filled with a lubricating fluid.

[0113] Meanwhile, the sleeve **230** may be inserted into an installation part **212** of the base member **210** in a state in which it is fixed in the housing **240**, such that it may be fixed to the base member **210**. That is, an outer peripheral surface of the housing **240** may be adhered to an inner peripheral surface of the installation part **212** by an adhesive.

**[0114]** Further, the sleeve **230** may include a shaft hole **232** formed therein, such that the shaft **220** is inserted thereinto. Further, in the case in which the shaft **220** is insertedly disposed in the shaft hole **232** of the sleeve **230**, an inner peripheral surface of the sleeve **230** and the outer peripheral surface of the shaft **220** may be spaced apart from each other by a predetermined interval to thereby form the bearing clearance C**1** therebetween.

**[0115]** In addition, the sleeve **230** may include a flange part **235** formed in an upper end portion thereof to be extended outwardly. Further, the housing **240** may be provided to enclose an outer peripheral surface of the sleeve **230** while an upper end surface thereof may be disposed to be spaced apart from a lower surface of the flange part **235** of the sleeve **230** by a predetermined interval. That is, the housing **240** may be provided to enclose the outer peripheral surface of the sleeve **230** except for the flange part **235** of the sleeve **230** and a portion under the flange part **235**. Therefore, the upper end portion of the housing **240** and the lower surface of the flange part **235** may be spaced apart from each other by a predetermined interval to thereby form a space **241**.

**[0116]** Here, the bearing clearance C**1** will be described in more detail. As described above, the sleeve **230** forms the bearing clearance C**1** filled with the lubricating fluid. This bearing clearance C**1** indicates a clearance formed by the shaft **220** and the sleeve **230**, a clearance formed by an upper end portion of the sleeve **230** and the rotor hub **250**, a clearance formed by the sleeve **230** and the stopper member **260**, a clearance formed by the cover member **270** and the sleeve **230**, a clearance formed by the housing **240** and the sleeve **230** or the stopper member **260**, and a clearance formed by the cover member **270** and the lower surface of the shaft **220**.

**[0117]** In addition, the spindle motor **200** according to the present embodiment may have a structure in which the entire bearing clearance C**1** is filled with the lubricating fluid. This structure may be called a full-fill structure.

**[0118]** Meanwhile, the shaft **220** may include upper and lower radial dynamic pressure generating grooves **223** and **224** formed in the outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof. In addition, the upper and lower radial dynamic pressure generating grooves **223** and **224** may be spaced apart from each other by a predetermined interval and have a herringbone or spiral shape.

**[0119]** In addition, at the time of the rotational driving of the shaft **220**, the lubricating fluid may move from the upper radial dynamic pressure generating groove **223** toward the lower radial dynamic pressure generating groove **224**. That is, the spindle motor **200** according to the present embodiment may have a down pumping structure.

**[0120]** Meanwhile, the sleeve **230** may include the flange part **235** extended so as to be disposed over the stopper member **260**. In addition, the flange part **235** may serve to limit excessive floating of the rotor hub **250** and the shaft **220**.

**[0121]** Further, the sleeve **230** and the housing **240** may include a third circulation hole **236** formed therebetween in order to connect a lower portion of the sleeve **230** and an upper end surface of the housing **240** to each other and a fourth circulation hole **237** formed therebetween in order to connect the third circulation hole **236** and an upper portion of the sleeve **230** to each other.

**[0122]** In addition, as described above, since the upper end portion of the housing **240** and the lower surface of the flange part **235** are spaced apart from each other by a predetermined interval to thereby form the space **241**, the third and fourth circulation holes **236** and **237** may be connected to a space formed by the stopper member **260** and the outer peripheral surface of the sleeve **230** through the space **241**.

**[0123]** Therefore, the space **241** and the third and fourth circulation holes **236** and **237** may connect three bearing clearances C**1** to each other.

**[0124]** Here, a movement path of the lubricating fluid will be described.

**[0125]** First, at the time of the rotational driving of the shaft **220**, a third circulation S**3** in which the lubricating fluid moves from lower portions of the third and fourth circulation holes **236** and **237** toward upper portions thereof and a fourth circulation S**4** in which the lubricating fluid moves from the third and fourth circulation holes **236** and **237** toward the bearing clearance C**1** formed by the flange part **235** and the stopper member **260** may be formed.

**[0126]** That is, a movement path of the third circulation S**3** is as follows.

**[0127]** First, the lubricating fluid moves from the upper radial dynamic pressure generating groove **223** to the lower radial dynamic pressure generating groove **224**, moves from the lower portion of the sleeve **230** toward the upper portion thereof by the third and fourth circulation holes **236** and **237**, and then moves in the inner radial direction in the bearing clearance C**1** formed by the rotor hub **250** and the upper surface of the sleeve **230**.

**[0128]** In addition, a movement path of the fourth circulation S**4** is as follows. The lubricating fluid moves from the second thrust dynamic pressure generating groove **262** to the bearing clearance C**1** formed by the flange part **235** and the extension wall part **252** by the second thrust dynamic pressure generating groove **262**, moves in the inner radial direction in the bearing clearance C**1** formed by the rotor hub **250** and the upper surface of the sleeve **230**, and then moves from the upper portion of the fourth circulation hole **237** to the space **241**.

**[0129]** As described above, since the fourth circulation S**4** is formed, generation of negative pressure may be suppressed. That is, the fourth circulation S**4** is formed in a region in which the negative pressure is generated, whereby the generation of the negative pressure may be reduced.

**[0130]** In addition, air bubbles generated at the time of the rotational driving of the shaft **220** may be more easily discharged to the outside by the fourth circulation S**4**. That is, air bubbles moving from the lower portion of the third circulation hole **236** to the upper portion thereof may move to a space in which a liquid-vapor interface is formed through the spaced space **241**.

**[0131]** Therefore, the air bubbles may be easily discharged.

**[0132]** As described above, the stopper member **260** is installed on the extension wall part **252**, such that a bearing span length is increased, whereby rotational characteristics may be improved and power consumption may be reduced.

**[0133]** Here, the bearing span length indicates a distance between a region in which maximum dynamic pressure is generated while the lubricating fluid is pumped by the upper radial dynamic pressure generating groove **223** and a region in which maximum dynamic pressure is generated while the lubricating fluid is pumped by the lower dynamic pressure generating groove **224**.

[0134] That is, the stopper member **260** is installed on the extension wall part **252**, such that a distance between the upper and lower radial dynamic pressure generating grooves **223** and **224** is increased, whereby the bearing span length may be increased.

[0135] Therefore, the rotational characteristics may be improved and the power consumption may be reduced.

[0136] In addition, since force pulling the rotor hub **250** toward the base member **210** by magnetic force is not required through the first and second thrust dynamic pressure generating grooves **222** and **262**, that is, a double thrust structure, the pulling plate need not to be installed, whereby manufacturing costs may be reduced.

[0137] Further, since the force pulling the rotor hub **250** toward the base member **210**, that is, pulling force is not required, loss of power for generating the puling force is reduced, whereby the power consumption may be reduced.

[0138] In addition, since the upper and lower portions of the sleeve **230** and the outer peripheral surface of the sleeve **230** may be connected to each other through the third and fourth circulation holes **236** and **237** and the space **241**, the generation of the negative pressure and the abnormal increase in pressure may be prevented.

[0139] Further, the air bubbles may be easily discharged through the third and fourth circulation holes **236** and **237** and the space **241** as described above.

[0140] As set forth above, according to the embodiments of the present invention, the generation of the negative pressure and the excessive floating of the rotor maybe reduced through the circulation hole connecting to the upper and lower portions of the sleeve to each other and connected to the spaced formed by the stopper member and the outer peripheral surface of the sleeve.

[0141] That is, since the circulation hole is connected to the space formed by the stopper member and the outer peripheral surface of the sleeve, pressure in the upper and lower portions of the sleeve connected to each other by the circulation hole may be controlled by atmospheric pressure. Therefore, the generation of the negative pressure may be reduced, and the excessive floating of the rotor due to the abnormal increase in pressure may be prevented.

[0142] In addition, the air bubbles generated during the rotational driving of the shaft may be easily discharged by the second circulation.

[0143] Further, the stopper member may not be installed on the shaft, such that the bearing span length may be increased, whereby the rotational characteristics may be improved and the power consumption may be reduced.

[0144] Furthermore, the power consumption may be further reduced through the first and second thrust dynamic pressure bearings.

[0145] While the present invention has been shown and described in connection with the embodiments, it will be apparent to those skilled in the art that modifications and variations can be made without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

**1**. A hydrodynamic bearing assembly comprising:

a sleeve supporting a shaft such that an upper end portion of the shaft is protruded upwardly in an axial direction, and forming a bearing clearance filled with a lubricating fluid;

a housing provided to enclose an outer peripheral surface of the sleeve and including a flange part formed in an upper end portion thereof and extended outwardly;

a rotor hub coupled to the upper end portion of the shaft and including an extension wall part extended to be disposed outwardly of the housing;

a stopper member fixed to the extension wall part of the rotor hub while being disposed under the flange part of the housing, and forming, together with an outer peripheral surface of the housing, a space in which a liquid-vapor interface is formed; and

a cover member coupled to a lower end portion of the housing,

wherein the sleeve and the housing include a first circulation hole formed therebetween in order to connect upper and lower portions of the sleeve to each other, and a second circulation hole formed therebetween in order to connect the first circulation hole and a space formed by the stopper member and the outer peripheral surface of the housing to each other.

**2**. The hydrodynamic bearing assembly of claim **1**, wherein the sleeve and an inner surface of a portion of the housing in which the flange part is provided form an annular space therebetween.

**3**. The hydrodynamic bearing assembly of claim **1**, wherein a first thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure is formed in at least one of a lower surface of the shaft and an upper surface of the cover member.

**4**. The hydrodynamic bearing assembly of claim **1**, wherein a second thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure is formed in at least one of a lower surface of the flange part and an upper surface of the stopper member.

**5**. The hydrodynamic bearing assembly of claim **1**, wherein, at the time of rotational driving of the shaft, a first circulation in which the lubricating fluid moves from a lower portion of the first circulation hole toward an upper portion thereof and a second circulation in which the lubricating fluid moves from the first circulation hole toward a bearing clearance formed by the flange part and the stopper member are formed.

**6**. The hydrodynamic bearing assembly of claim **1**, wherein the shaft includes upper and lower radial dynamic pressure generating grooves formed in an outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof, and

the lubricating fluid moves from the upper radial dynamic pressure generating groove toward the lower radial dynamic pressure generating groove.

**7**. The hydrodynamic bearing assembly of claim **1**, wherein the housing is integrally provided with the cover member.

**8**. The hydrodynamic bearing assembly of claim **1**, wherein the shaft is integrally provided with the rotor hub.

**9**. The hydrodynamic bearing assembly of claim **1**, wherein the first circulation hole is provided as a communication groove formed in at least one of the outer peripheral surface of the sleeve and an inner peripheral surface of the housing.

**10**. A hydrodynamic bearing assembly comprising:

a sleeve supporting a shaft such that an upper end portion of the shaft is protruded upwardly in an axial direction, forming a bearing clearance filled with a lubricating fluid, and including a flange part formed in an upper end portion thereof and extended outwardly;

a housing provided to enclose an outer peripheral surface of the sleeve while allowing an upper end surface thereof to be spaced apart from a lower surface of the flange part of the sleeve by a predetermined interval;

a rotor hub coupled to the upper end portion of the shaft and including an extension wall part extended to be disposed outwardly of the sleeve and the housing;

a stopper member fixed to the extension wall part of the rotor hub while being disposed under the flange part of the sleeve and forming, together with an outer peripheral surface of the housing, a space in which a liquid-vapor interface is formed; and

a cover member coupled to a lower end portion of the housing,

wherein the sleeve and the housing includes a third circulation hole formed therebetween in order to connect a lower portion of the sleeve and the upper end surface of the housing to each other and a fourth circulation hole formed therebetween in order to connect the third circulation hole and an upper portion of the sleeve to each other.

**11**. The hydrodynamic bearing assembly of claim **10**, wherein a third thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure is formed in at least one of a lower surface of the shaft and an upper surface of the cover member.

**12**. The hydrodynamic bearing assembly of claim **10**, wherein a fourth thrust dynamic pressure generating groove for generating thrust hydrodynamic pressure is formed in at least one of a lower surface of the flange part and an upper surface of the stopper member.

**13**. The hydrodynamic bearing assembly of claim **10**, wherein, at the time of rotational driving of the shaft, a third circulation in which the lubricating fluid moves from lower portions of the third and fourth circulation holes toward upper portions thereof and a fourth circulation in which the lubricating fluid moves from the third circulation hole toward a bearing clearance formed by the flange part and the stopper member are formed.

**14**. The hydrodynamic bearing assembly of claim **10**, wherein the shaft includes upper and lower radial dynamic pressure generating grooves formed in an outer peripheral surface thereof in order to generate hydrodynamic pressure at the time of rotational driving thereof, and

the lubricating fluid moves from the upper radial dynamic pressure generating groove toward the lower radial dynamic pressure generating groove.

**15**. The hydrodynamic bearing assembly of claim **10**, wherein the third circulation hole is provided as a communication groove formed in at least one of the outer peripheral surface of the sleeve and an inner peripheral surface of the housing.

**16**. The hydrodynamic bearing assembly of claim **10**, wherein the fourth circulation hole penetrates through the flange part so as to connect the third circulation hole and the upper portion of the sleeve to each other.

**17**. A spindle motor comprising:

the hydrodynamic bearing assembly of claim **1**; and

a stator coupled to an outside of the housing and including a core having a coil wound therearound in order to generate rotational driving force.

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