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Hatakeyama

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(54) **WORK MACHINE**

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***B24B 23/02*** (2006.01)
***B24B 47/12*** (2006.01)

(52) **U.S. Cl.**
CPC ............ ***B24B 41/04*** (2013.01); ***B24B 23/028*** (2013.01); ***B24B 47/12*** (2013.01)

(58) **Field of Classification Search**
CPC ... B24B 55/052; B24B 55/102; B24B 55/105; B24B 47/12; B24B 23/00; B24B 23/02;
(Continued)

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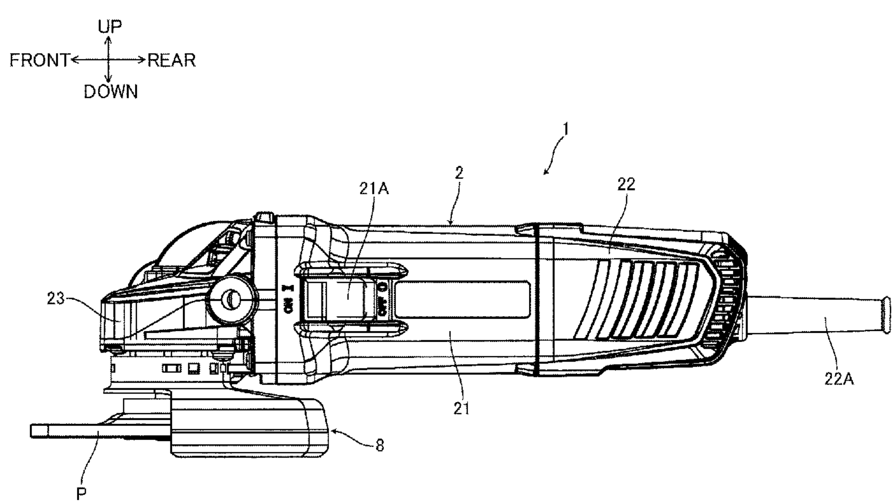
(57) **ABSTRACT**

The work machine includes: a gear housing; a spindle protruding in a first direction from the gear housing; a bearing held by the gear housing and including an inner race and an outer race, the bearing rotatably supporting the spindle; a tip tool attachment portion to which a tip tool is attachable, the tip tool attachment portion being provided at the spindle; a sealing member positioned further in the first direction than the bearing; and a restricting member for restricting the sealing member from moving in the first direction. At least a part of the sealing member is overlapped with the inner race in an axial direction of the spindle. The restricting member is held either by the spindle or by the gear housing.

**14 Claims, 12 Drawing Sheets**



(58) **Field of Classification Search**
CPC ... B24B 23/005; B24B 23/022; B24B 23/024; B24B 23/026; B24B 23/028; B24B 23/03; B24B 23/04; B24B 23/046; B24B 27/00; B24B 27/08; B24B 41/04; B24B 41/047; B24B 45/006; B25F 5/001; B25F 5/02
USPC ....... 451/294, 344, 350, 351, 352, 353, 357, 451/358, 359
See application file for complete search history.

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FIG. 1

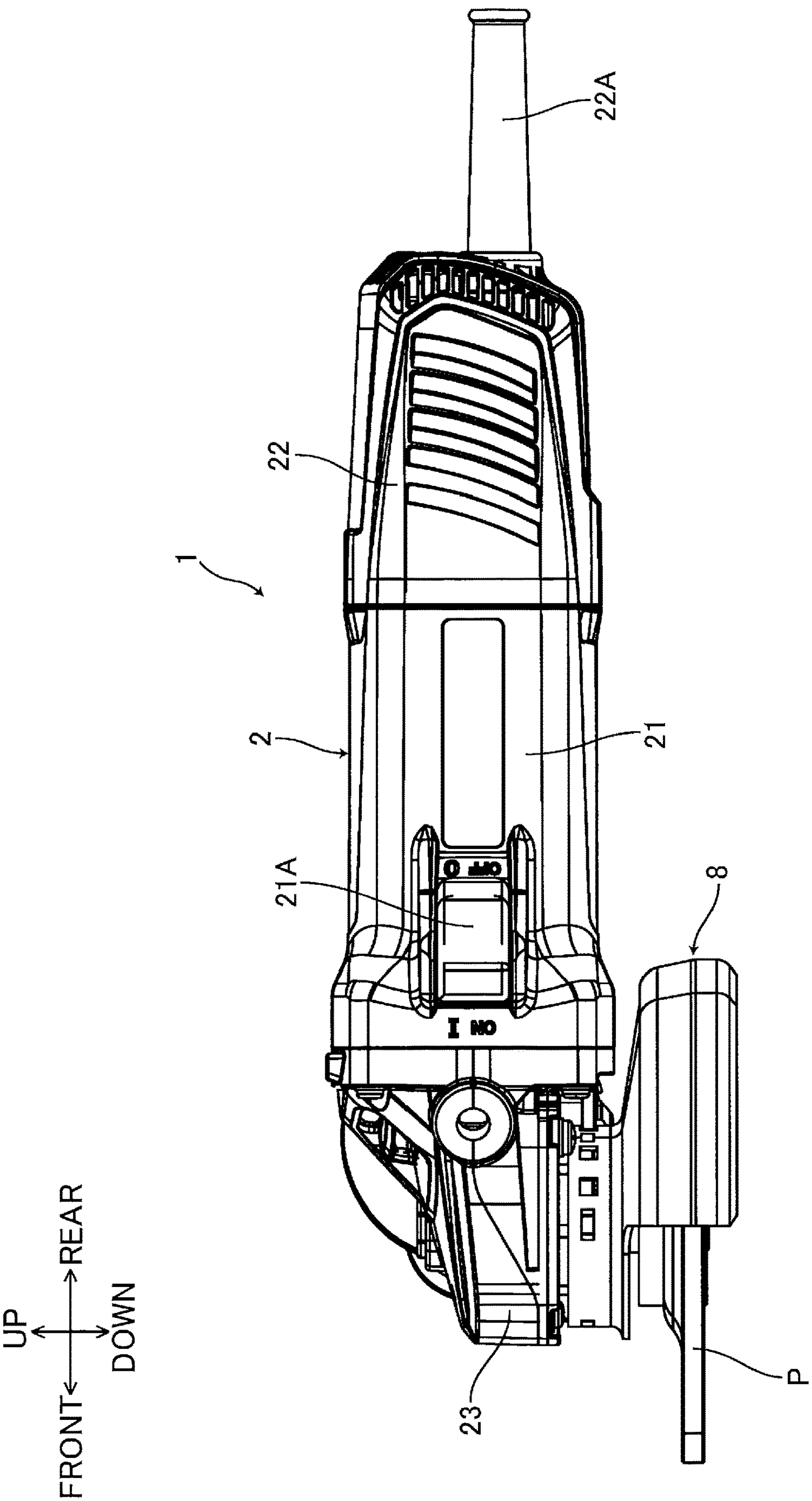


FIG. 2

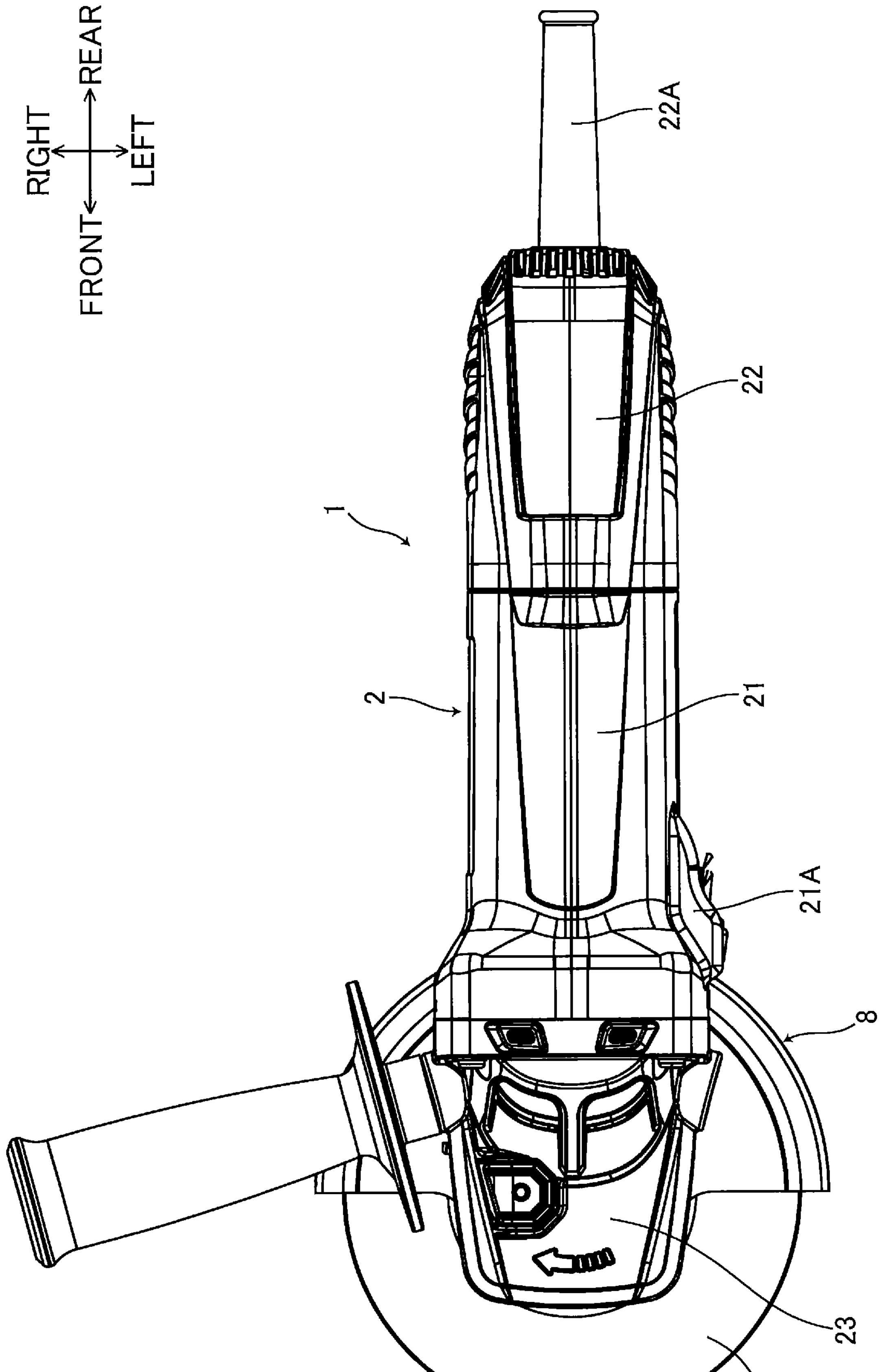
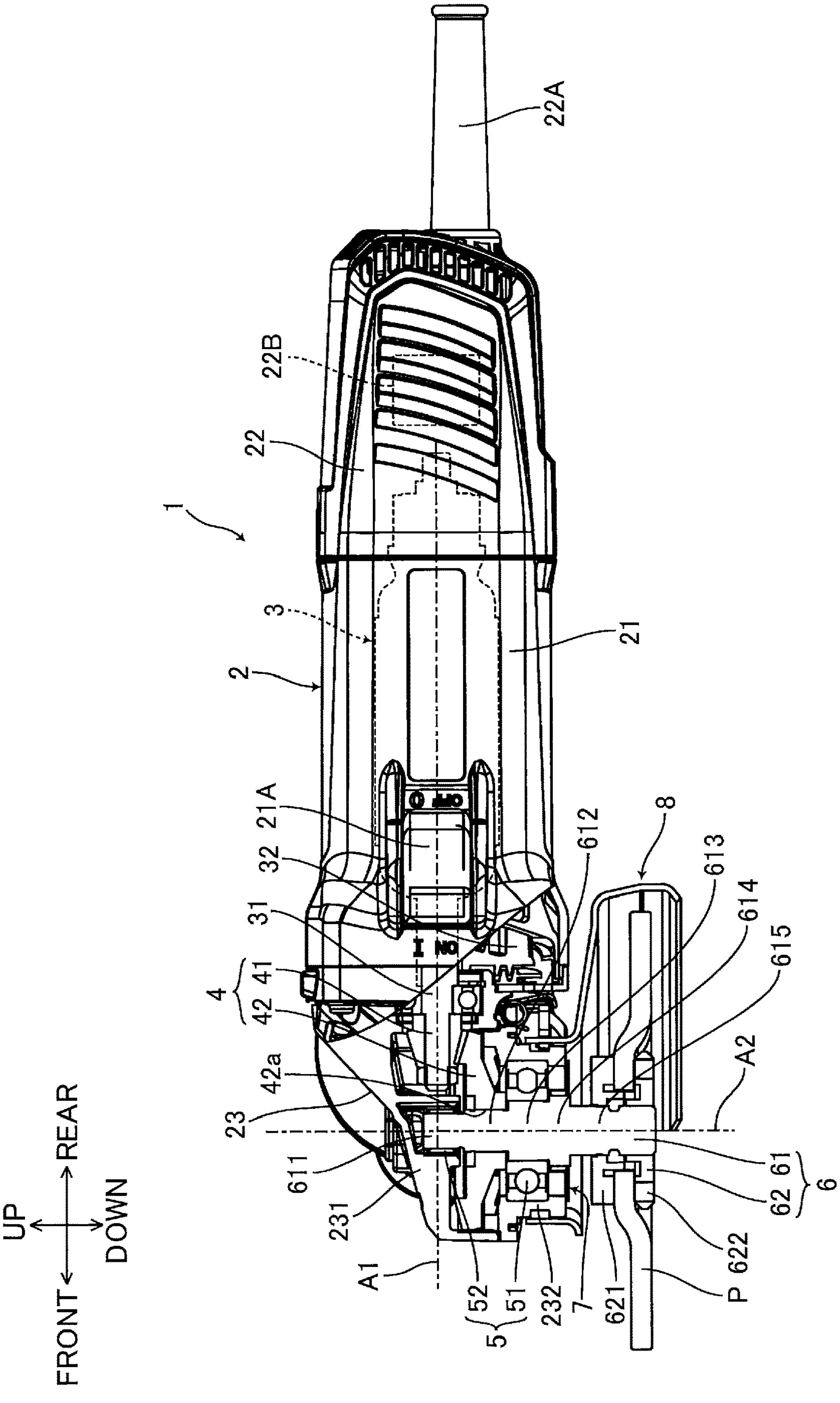


FIG. 3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A2
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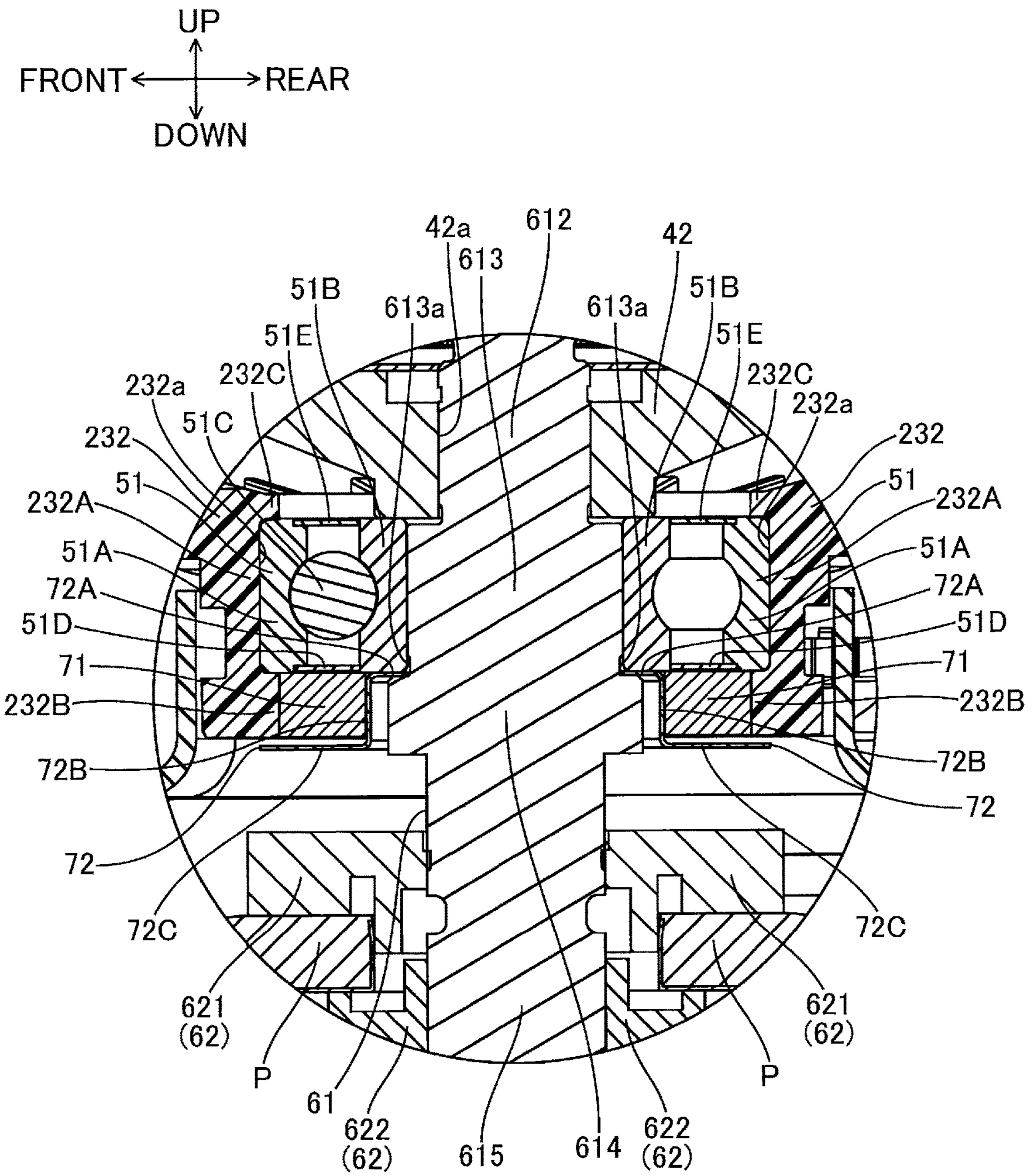
FIG. 4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51D
71
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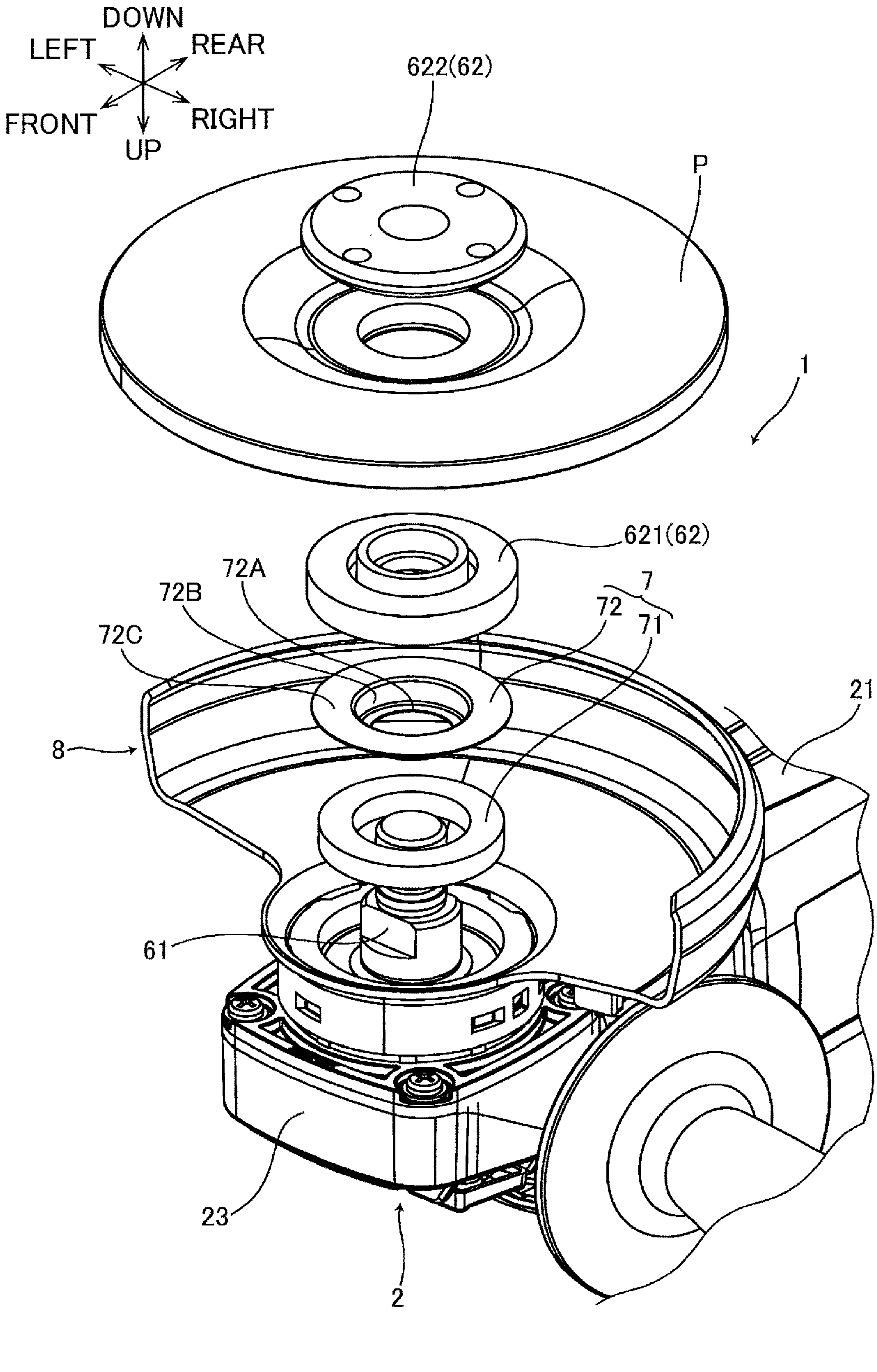
FIG. 5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622(62)
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FIG. 6A

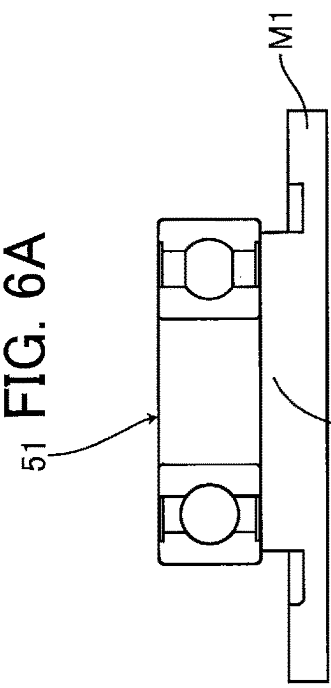


FIG. 6B

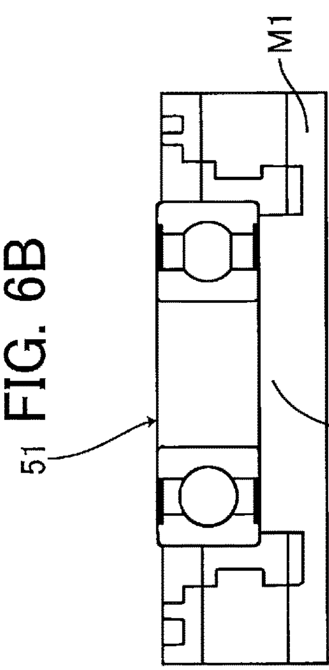


FIG. 6C

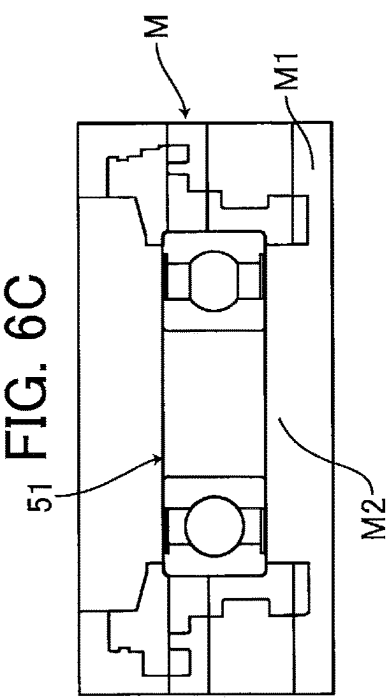


FIG. 6D

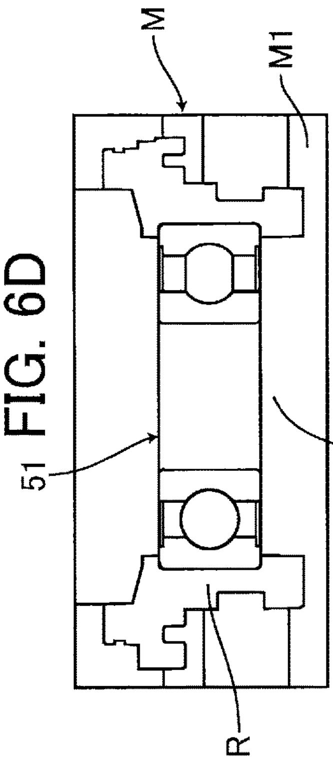


FIG. 6E

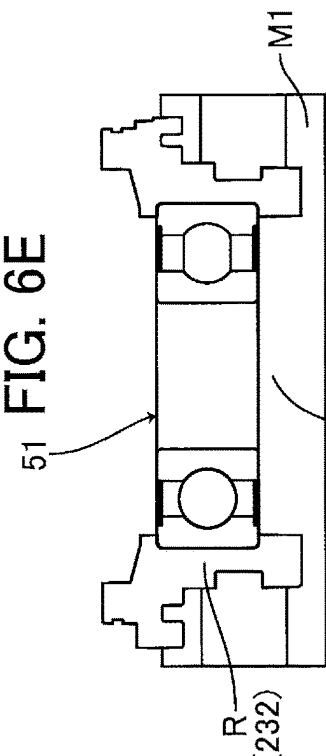


FIG. 6F

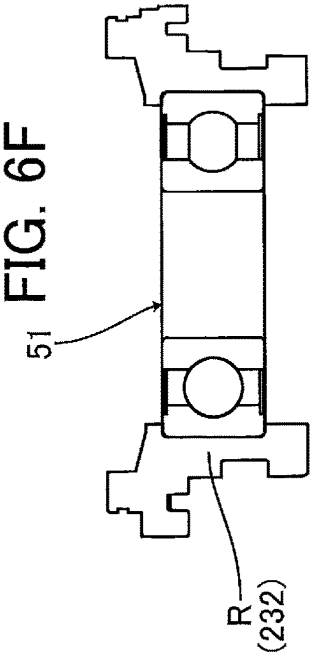

FIG. 7

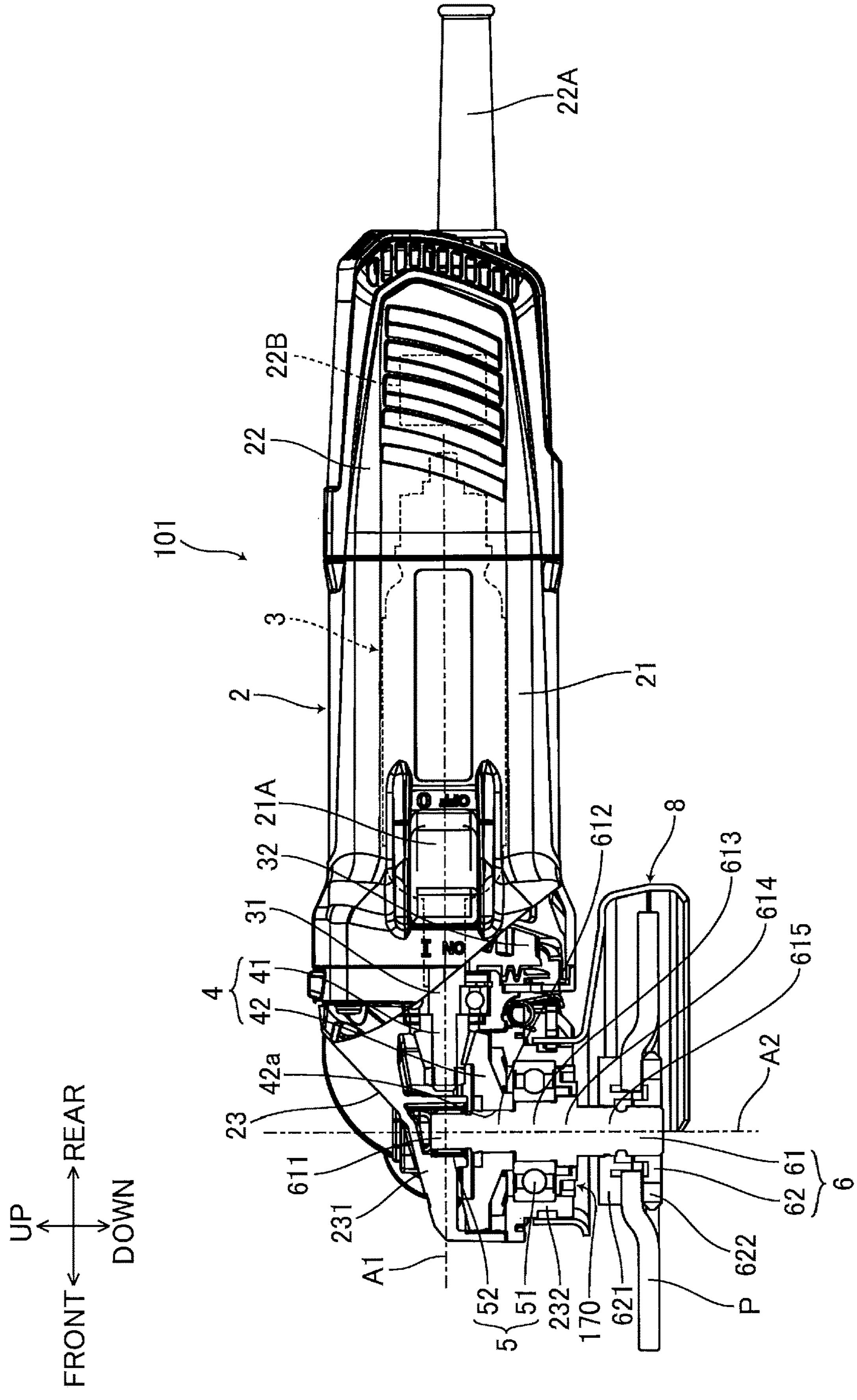
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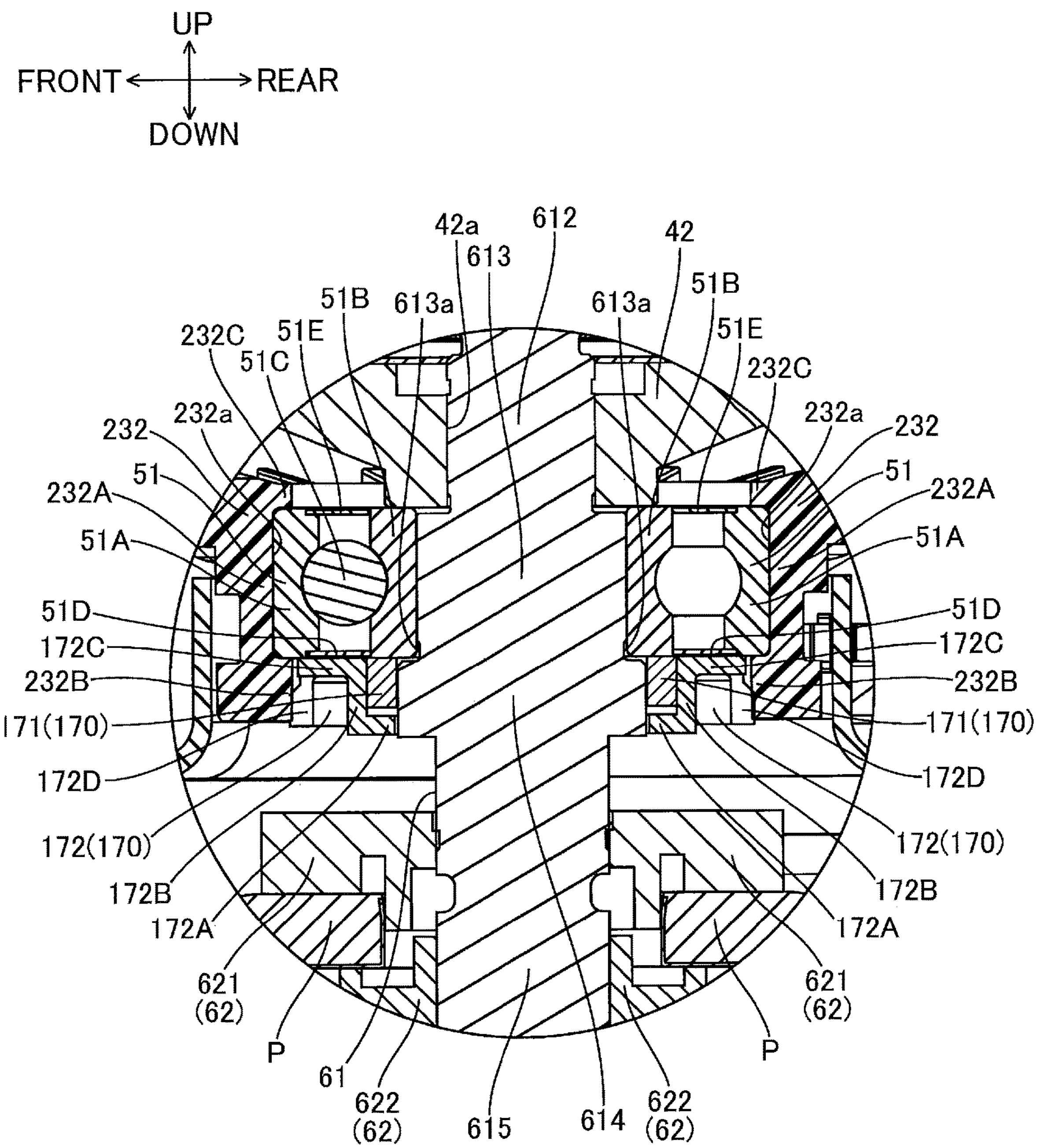
FIG. 8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172C
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232B
232B
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172D
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172B
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FIG. 9

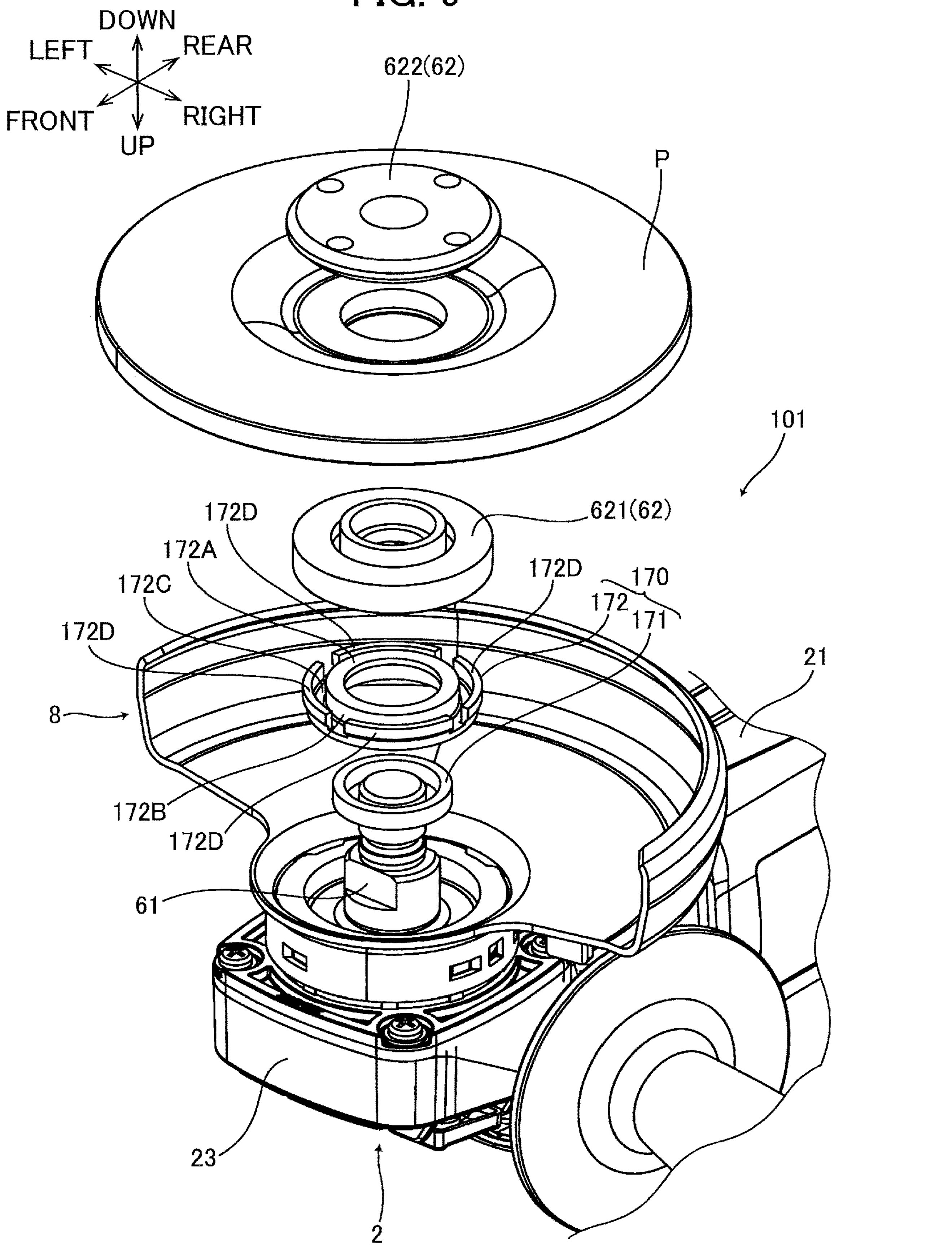
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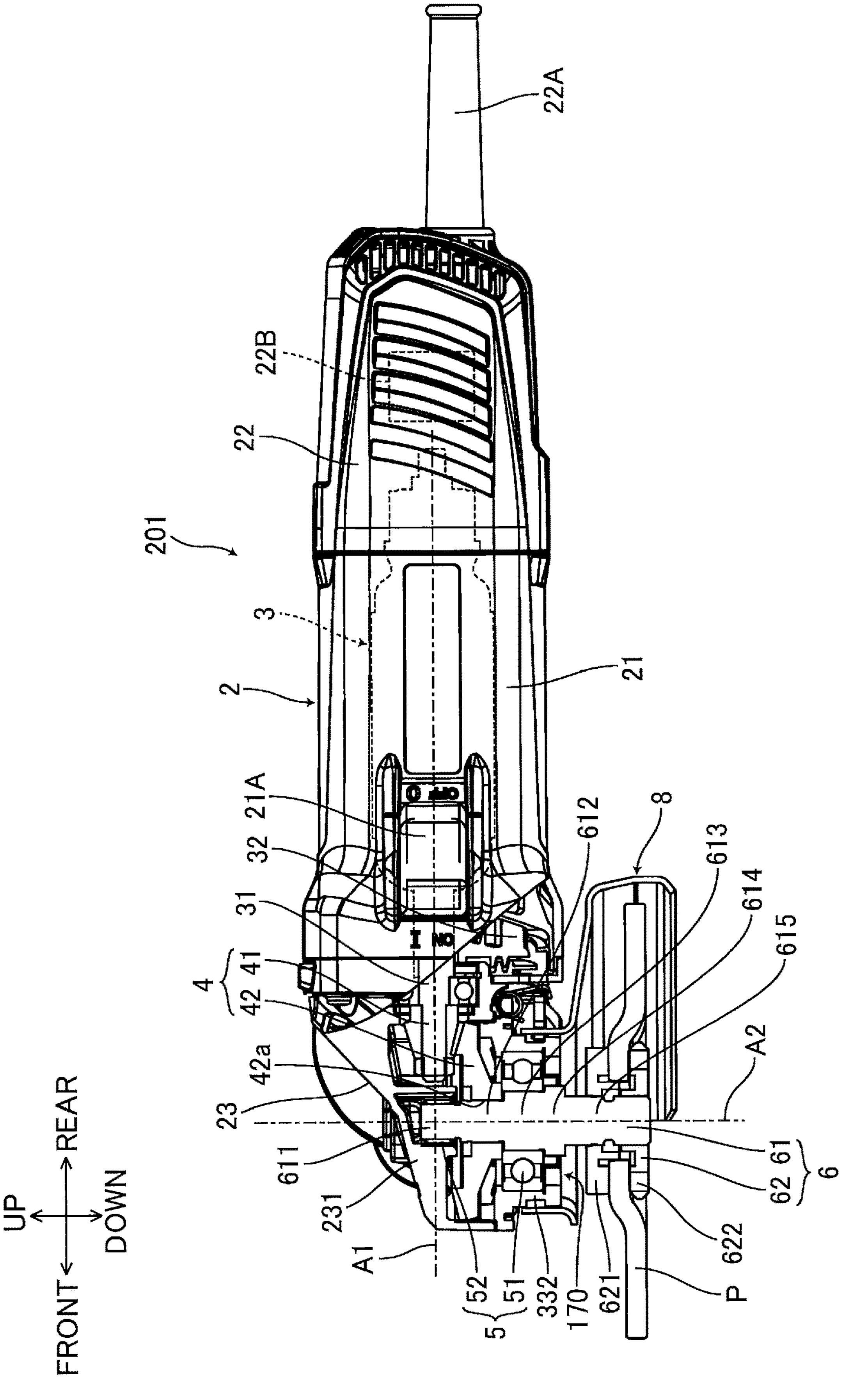
FIG. 10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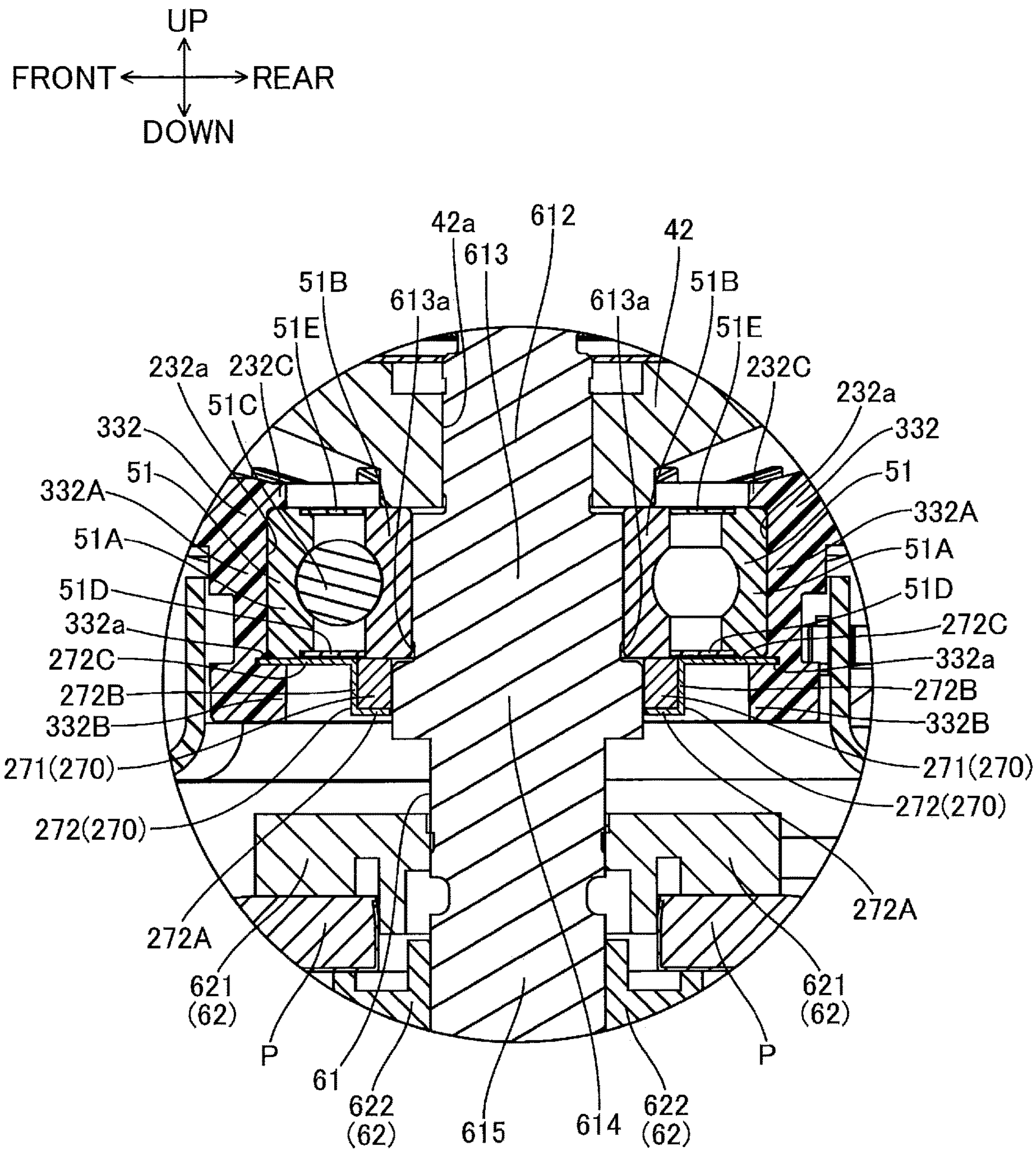
# FIG. 11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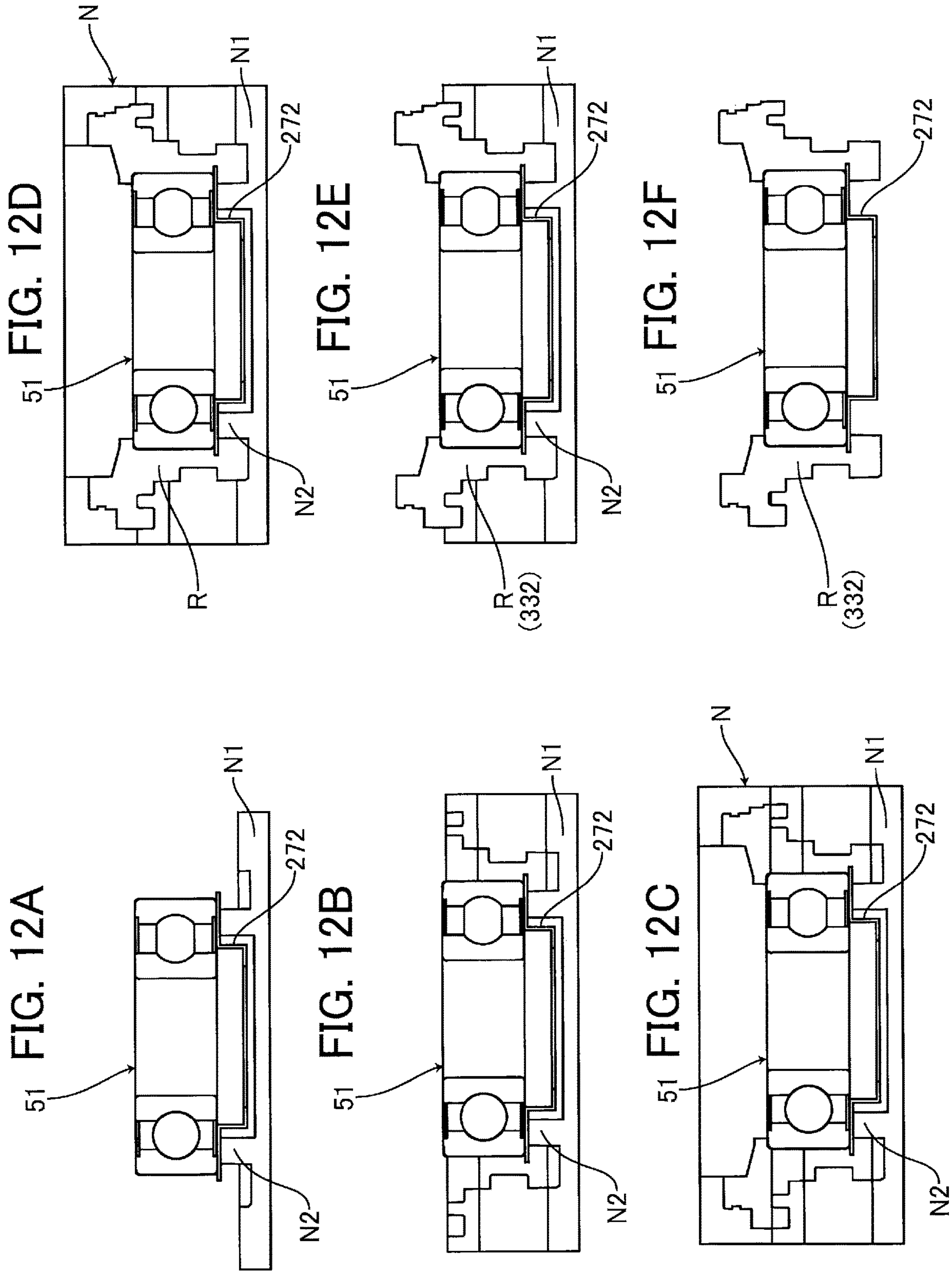


FIG. 12A

FIG. 12B

FIG. 12C

FIG. 12D

FIG. 12E

FIG. 12F

# WORK MACHINE

## TECHNICAL FIELD

The present invention relates to a work machine.

## BACKGROUND ART

There have conventionally been widely used work machines that perform machining work such as grinding or cutting. Patent literature 1 discloses, as an example of the work machines, an electric grinder including a motor, a bevel gear configured to rotate by rotation of the motor, a spindle extending downward from the bevel gear and configured to rotate together with the bevel gear, a tip tool attachment portion provided at the lower portion of the spindle, and a gear cover rotatably supporting the bevel gear and the spindle.

In the above-described electric grinder, the motor is driven in a state where the tip tool such as a grinding stone is attached to the tip tool attachment portion, so that the bevel gear, the spindle, the tip tool attachment portion, and the tip tool are integrally rotated to perform machining work such as grinding by the rotating tip tool. The spindle of the electric grinder is rotatably supported by two bearings; one bearing is positioned at the inner upper portion of the gear cover and the other bearing is positioned at the inner lower portion of the gear cover. The lower portion of the spindle protrudes downward from the lower portion of the gear cover.

## CITATION LIST

### Patent Literature

PTL1: Japanese Patent Application Publication No. 2011-167812

## SUMMARY OF INVENTION

### Technical Problem

In the above-described electric grinder, machining work such as grinding is performed by the tip tool attached to the tip tool attachment portion provided at the lower portion of the spindle. Accordingly, the work portion subject to machining work such as grinding is performed is close to the lower portion of the gear case. Hence, powder dust generated by the machining work such as grinding may enter the bearing provided at the lower portion of the gear case. Further, entry of such powder dust into the bearing may hinder the spindle from smoothly rotating, which may degrade workability.

In view of the foregoing, it is an object of the present invention to provide a work machine that can favorably maintain workability by suppressing powder dust generated by machining work from entering the bearing rotatably supporting the spindle.

### Solution to Problem

In order to attain the above and other objects, the present invention provides a work machine including: a gear housing; a spindle protruding in a first direction from the gear housing; a bearing held by the gear housing and including an inner race and an outer race, the bearing rotatably supporting the spindle; a tip tool attachment portion to which a tip tool



is attachable, the tip tool attachment portion being provided at the spindle; a sealing member positioned further in the first direction than the bearing; and a restricting member for restricting the sealing member from moving in the first direction. At least a part of the sealing member is overlapped with the inner race in a radial direction of the spindle. The restricting member is held either by the spindle or by the gear housing.

With the above configuration, the restricting member held either by the spindle or by the gear housing restricts the sealing member from moving in the first direction at a position where the sealing member is overlapped with the inner race of the bearing in the radial direction, thereby attaining favorable sealability. As a result, entry of powder dust generated in machining work into the bearing can be suitably suppressed, and accordingly, workability can be favorably maintained.

In the above configuration, it is preferable that the gear housing includes a bearing holding portion molded integrally with the bearing.

In the above configuration, it is preferable that the bearing holding portion includes: a cylindrical supporting member extending in the first direction and supporting an outer circumferential surface of the outer race; and a protruding portion positioned further in the first direction than the outer race, the protruding portion protruding inward in the radial direction of the spindle from the cylindrical supporting member to restrict the bearing from moving in the first direction.

In the above configuration, it is preferable: that an inward end of the protruding portion in the radial direction is positioned further inward in the radial direction than the outer circumferential surface of the outer race and further outward in the radial direction than an inner circumferential surface of the outer race; and that the sealing member is provided between the protruding portion and the spindle in the radial direction.

According to another aspect, the present invention provides a work machine including: a gear housing; a spindle protruding in a first direction from the gear housing; a bearing held by the gear housing and including an inner race and an outer race, the bearing rotatably supporting the spindle; a tip tool attachment portion to which a tip tool is attachable, the tip tool attachment portion being provided at the spindle; a sealing member positioned further in the first direction than the bearing; and a restricting member for restricting the sealing member from moving in the first direction. The gear housing includes a bearing holding portion molded integrally with the bearing and holding the bearing. The bearing holding portion includes: a cylindrical supporting member extending in the first direction and supporting an outer circumferential surface of the outer race; and a protruding portion positioned further in the first direction than the outer race, the protruding portion protruding inward in a radial direction of the spindle from the cylindrical supporting member to restrict the bearing from moving in the first direction. An inward end of the protruding portion in the radial direction is positioned further inward in the radial direction than the outer circumferential surface of the outer race and further outward in the radial direction than an inner circumferential surface of the outer race. The sealing member is provided between the protruding portion and the spindle. At least a part of the sealing member is overlapped with the inner race in the axial direction. The restricting member is held either by the spindle or by the bearing holding portion.

Typically, effect of reduction in production cost of the work machine is obtained when the bearing holding portion molded integrally with the bearing is employed. However, in such a configuration, the inward end in the radial direction of the protruding portion restricting the bearing from moving in the first direction (i.e., the position at which movement in the first direction of the bearing is restricted) needs to be positioned further outward in the radial direction than the inner circumferential surface of the outer race because of the molding process used for the bearing holding portion. Further, although the sealing member exhibits proper sealability at a position overlapping with the inner race in the axial direction, it is difficult to fix the position of the sealing member at the above-described suitable position in a configuration where the inward end in the radial direction of the protruding portion needs to be positioned further outward in the radial direction than the inner circumferential surface of the outer race. However, with the above configuration according to the present invention, the sealing member is restricted from moving in the first direction at the overlapping position in the axial direction with the inner race of the bearing by virtue of the restricting member held either by the spindle or by the bearing holding portion. Hence, the position of the sealing member can be fixed at the overlapping position in the axial direction with the inner race of the bearing despite the configuration where the bearing holding portion molded integrally with the bearing is employed, and therefore, reduction in production cost and suitable sealability can be realized. As a result, entry of powder dust generated in machining work into the bearing can be suitably suppressed, and accordingly, workability can be favorably maintained.

In the above configuration, it is preferable that the restricting member is positioned between the spindle and the protruding portion in the radial direction.

With this configuration, the restricting member is positioned in the space between the spindle and the protruding portion which space needs to be sealed. Hence, the restricting member also functions as a dust proof member. Accordingly, entry of powder dust generated in machining work into the bearing can be further suitably suppressed, and workability can be further favorably maintained.

In the above configuration, it is preferable that the restricting member is fixed to an outer circumferential surface of the spindle and rotates together with the spindle.

In the above configuration, it is preferable: that the restricting member includes: an annular portion fixed to the spindle; a cylindrical portion extending in the first direction from an outer circumferential edge in the radial direction of the annular portion; and a flange portion extending outward in the radial direction from an outer circumferential surface of an end portion in the first direction of the cylindrical portion; and that the restricting member is positioned outward of the cylindrical portion in the radial direction.

In the above configuration, it is preferable that the restricting member is fixed to the bearing holding portion.

With this configuration, because the restricting member does not rotate, friction is unlikely to be generated between the restricting member and the sealing member whose position is fixed by the restricting member. Accordingly, early wearing of the sealing member can be suppressed.

In the above configuration, it is preferable: that the restricting member includes: an annular portion positioned outward of the spindle in the radial direction; a cylindrical portion extending in a second direction from an outer circumferential edge in the radial direction of the annular portion, the second direction being opposite to the first direction; and a flange portion fixed to the bearing holding portion, the flange portion extending outward in the radial direction from an outer circumferential surface of an end portion in the second direction of the cylindrical portion; and that the sealing member is positioned between the spindle and the cylindrical portion.

With this configuration, the dimension in the radial direction of the sealing member overlapped with the inner race in the axial direction can be reduced. Hence, friction can be further suppressed from being generated between the restricting member and the sealing member, thereby further suppressing early wearing of the sealing member.

In the above configuration, it is preferable that the restricting member is fixed to the bearing holding portion by press-fitting.

In the above configuration, it is preferable that the restricting member is fixed to the bearing holding portion by molding the bearing holding portion integrally with the restricting member.

## Advantageous Effects of Invention

The present invention can provide a work machine that can favorably maintain workability by suppressing powder dust generated by machining work from entering the bearing rotatably supporting the spindle.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view illustrating the external appearance of a disc grinder according to a first embodiment of the present invention.

FIG. **2** is a plan view illustrating the external appearance of the disc grinder according to the first embodiment of the present invention.

FIG. **3** is a partial vertical cross-sectional view illustrating the internal structure of the disc grinder according to the first embodiment of the present invention.

FIG. **4** is an enlarged partial cross-sectional view illustrating a bearing holding portion, a first bearing, an output shaft portion, and a dust proof portion in the disc grinder according to the first embodiment of the present invention.

FIG. **5** is an exploded perspective view illustrating the dust proof portion, a tip tool attachment portion, and a tip tool to be attached to the tip tool attachment portion in the disc grinder according to the first embodiment of the present invention.

FIGS. **6**A-**6**F are views for describing a process of integral molding of the bearing holding portion with the first bearing in the disc grinder according to the first embodiment of the present invention, in which: FIG. **6**A illustrates a state where the first bearing has been fixed to a mold member used for molding the lower end part of the bearing holding portion; FIG. **6**B illustrates a state where another mold member used for molding the center portion in the up-down direction of the bearing holding portion has been assembled to the mold member used for molding the lower end part of the bearing holding portion; FIG. **6**C illustrates a state where a mold used for molding the bearing holding portion has been completed; FIG. **6**D illustrates a state where a liquid resin has been poured in the internal space of the completed mold; FIG. **6**E illustrates a state where the resin has been solidified and a mold member used for molding the upper part of the bearing holding portion has been removed; and FIG. **6**F illustrates a state where the bearing holding portion having the first bearing held thereon has been molded.

FIG. **7** is a partial vertical cross-sectional view illustrating the internal structure of a disc grinder according to a second embodiment of the present invention.

FIG. **8** is an enlarged partial cross-sectional view illustrating a bearing holding portion, a first bearing, an output shaft portion, and a dust proof portion in the disc grinder according to the second embodiment of the present invention.

FIG. **9** is an exploded perspective view illustrating the dust proof portion, a tip tool attachment portion, and a tip tool to be attached to the tip tool attachment portion in the disc grinder according to the second embodiment of the present invention.

FIG. **10** is a partial vertical cross-sectional view illustrating the internal structure of a disc grinder according to a third embodiment of the present invention.

FIG. **11** is an enlarged partial cross-sectional view illustrating a bearing holding portion, a first bearing, an output shaft portion, and a dust proof portion in the disc grinder according to the third embodiment of the present invention.

FIGS. **12**A-**12**F are views for describing a process of integral molding of the bearing holding portion with both the first bearing and a restricting member in the disc grinder according to the third embodiment of the present invention, in which FIG. **12**A illustrates a state where the restricting member and the first bearing have been fixed to a mold member used for molding the lower end part of the bearing holding portion; FIG. **12**B illustrates a state where another mold member used for molding the center portion in the up-down direction of the bearing holding portion has been assembled to the mold member used for molding the lower end part of the bearing holding portion; FIG. **12**C illustrates a state where a mold used for molding the bearing holding portion has been completed; FIG. **12**D illustrates a state where a liquid resin has been poured in the internal space of the completed mold; FIG. **12**E illustrates a state where the resin has been solidified and a mold member used for molding the upper part of the bearing holding portion has been removed; and FIG. **12**F illustrates a state where the bearing holding portion holding on which both the first bearing and the restricting member have been held has been molded.

## DESCRIPTION OF EMBODIMENTS

### 1. Description of First Embodiment

Hereinafter, a disc grinder **1** as an example of a work machine according to a first embodiment of the present invention will be described with reference to FIGS. **1** through **6**. The disc grinder **1** is an electric work machine used for performing grinding work and cutting work on a workpiece using a tip tool P formed in a disc like shape, such as a grinding stone.

In the following description, "front", "rear", "up", and "down" indicated in the drawings will be defined as the frontward direction, rearward direction, upward direction, and downward direction, respectively. Further, "right" and "left" when viewing the disc grinder **1** from the rear thereof will be defined as the rightward direction and leftward direction, respectively.

#### 1-1. Outline of Overall Structure of Disc Grinder 1 According to First Embodiment

As illustrated in FIGS. **1** through **3**, the disc grinder **1** includes a housing **2**, a motor **3**, a power transmission portion **4**, an output shaft supporting portion **5**, an output shaft portion **6** to which the tip tool P such as a grinding stone is attachable, a dust proof portion **7**, and a wheel guard **8**.

As illustrated in FIGS. **1** and **2**, the housing **2** constitutes the outer shell of the disc grinder **1**. The housing **2** includes a motor housing **21**, a tail housing **22**, and a gear housing **23**.

The motor housing **21** is made of resin or metal and has a tubular shape extending in the front-rear direction. The motor housing **21** accommodates therein the motor **3**. The front portion of the left side surface of the motor housing **21** is provided with a slidable drive switch **21**A. The drive switch **21**A is manually operable for controlling start and stop of the motor **3**.

The tail housing **22** is made of resin or metal and has a generally polygonal tubular shape extending rearward from the rear end portion of the motor housing **21**. A power supply cord portion **22**A extends rearward from the rear end portion of the tail housing **22**. The power supply cord portion **22**A can be connected to an AC power supply (not illustrated), such as a commercial AC power supply. As illustrated in FIG. **3**, the tail housing **22** accommodates therein a switch mechanism **22**B.

The switch mechanism **22**B is a switch configured to be switched between an ON state and an OFF state in response to an operation to the drive switch **21**A. The switch mechanism **22**B electrically connects the motor **3** to the power supply cord **22**A in the ON state, and shuts off electrical connection between the motor **3** and the power supply cord portion **22**A in the OFF state. The switch mechanism **22**B is brought into the ON state in response to an ON operation (a frontward slide operation) to the drive switch **21**A, and is brought into the OFF state in response to an OFF operation (a rearward slide operation) to the drive switch **21**A. When the ON operation to the drive switch **21**A is performed in a state where the power supply cord portion **22**A is connected to an AC power supply, the switch mechanism **22**B enters the ON state to cause electric power to be supplied from the AC power supply to the motor **3** through the switch mechanism **22**B and the power supply cord portion **22**A, so that the motor **3** is driven.

As illustrated in FIG. **3**, the gear housing **23** protrudes frontward from the front end portion of the motor housing **21**. The gear housing **23** includes a gear cover **231** and a bearing holding portion **232**. The gear housing **23** accommodates therein the power transmission portion **4**, the output shaft supporting portion **5**, and the upper portion of the output shaft portion **6**.

The gear cover **231** constitutes the upper portion of the gear housing **23** and is made of metal such as aluminum. The bearing holding portion **232** constitutes the lower portion of the gear housing **23** and is fixed to the lower portion of the gear cover **231** by a bolt, etc. Details of the bearing holding portion **232** will be described later.

The motor **3** is an AC motor with brush and includes a rotation shaft **31**, a rotor (not illustrated), and a stator (not illustrated). As illustrated in FIG. **3**, the rotation shaft **31** extends in the front-rear direction and is rotatably supported by the motor housing **21**. The rotation shaft **31** is rotatable about a first rotation axis A**1** extending in the front-rear direction. A fan **32** for generating cooling air inside the housing **2** is fixed to the front portion of the rotation shaft **31**. The fan **32** is rotatable coaxially and together with the rotation shaft **31**.

The rotor is fixed to the rotation shaft **31** so as to be rotatable coaxially and together with the rotation shaft **31**.

The rotor includes a plurality of rotor coils. The stator includes a plurality of driving coils and a plurality of braking coils.

The power transmission portion **4** is a mechanism configured to transmit rotation of the motor **3** to the output shaft portion **6**. The power transmission portion **4** is accommodated in the gear cover **231** of the gear housing **23**. As illustrated in FIG. **3**, the power transmission portion **4** includes a pinion gear **41** and a bevel gear **42**.

The pinion gear **41** extends in the front-rear direction and is fixed to the front end portion of the rotation shaft **31**. The pinion gear **41** is rotatable coaxially and together with the rotation shaft **31**. When the motor **3** is driven, the pinion gear **41** rotates about the first rotation axis A1 together with the rotation shaft **31**.

The bevel gear **42** has an approximate disc shape and is in meshing engagement with the pinion gear **41**. A through-hole **42***a* is formed at the center portion in a plan view of the bevel gear **42**. The through-hole **42***a* penetrates the bevel gear **42** in the up-down direction.

The output shaft supporting portion **5** rotatably supports the output shaft portion **6** such that the output shaft portion **6** is rotatable about a second rotation axis A2. As illustrated in FIG. **3**, the output shaft supporting portion **5** includes a first bearing **51** and a second bearing **52**. The first bearing **51** is a ball bearing held by the bearing holding portion **232**. The first bearing **51** includes an outer race **51**A and an inner race **51**B, which have each an annular shape in a plan view. The first bearing **51** rotatably supports the output shaft portion **6** at the center portion in the up-down direction of the output shaft portion **6**. The second bearing **52** is a needle bearing and is provided in the inner upper portion of the gear cover **231**. The second bearing **52** rotatably supports the output shaft portion **6** at the upper end portion of the output shaft portion **6**. Details of the first bearing **51** will be described later.

The output shaft portion **6** performs machining work such as grinding by rotating in a state where the tip tool P is attached to the output shaft portion **6**. As illustrated in FIG. **3**, the output shaft portion **6** includes a spindle **61** and a tip tool attachment portion **62**.

The spindle **61** is a shaft extending in the up-down direction and having a generally solid cylindrical shape. The upper end portion of the spindle **61** is accommodated in the gear housing **23**, while the lower end portion of the spindle **61** protrudes downward from the gear housing **23**. The spindle **61** is supported by the first bearing **51** and the second bearing **52** so as to be rotatable about the second rotation axis A2. The upper portion of the spindle **61** is press-fitted through the through-hole **42***a* of the bevel gear **42**. Hence, the output shaft portion **6** and the bevel gear **42** are fixed to each other. When the pinion gear **41** rotates, the spindle **61** and the bevel gear **42** rotate together about the second rotation axis A2 extending in a direction approximately orthogonal to the first rotation axis A1 (in the present embodiment, the second rotation axis A2 extends in the up-down direction). Details of the spindle **61** will be described later. The downward direction is an example of the "first direction" in the present invention. The upward direction is an example of the "second direction" in the present invention. The lower end portion of the spindle **61** is an example of the "first end portion" in the present invention. The upper end portion of the spindle **61** is an example of the "second end portion" in the present invention.

The tip tool attachment portion **62** is a portion to which the tip tool P is attached. The tip tool attachment portion **62** includes a washer **621** and a nut **622**. The washer **621** is a member for holding the tip tool P in cooperation with the nut **622**. The washer **621** has a generally annular shape in a plan view and is fixed to the lower portion of the spindle **61**. The nut **622** has a generally annular shape in a plan view and is threadingly engageable with a male thread portion formed on the lower end portion of the spindle **61**.

For example, a grinding stone, a bevel wire brush, a non-woven fabric brush, a diamond wheel, and the like are available as the tip tool P. Examples of the grinding stone include a resinoid flexible grindstone, a flexible grindstone, a resinoid grindstone, and a sanding disc. In a case where the grinding stone is employed as the tip tool P, surface grinding, curved surface grinding, and the like to metal, synthetic resin, marble, concrete, and other workpieces can be performed by suitably selecting kinds of material and abrasive grain of the grinding stone.

Attachment of the tip tool P to the tip tool attachment portion **62** can be performed by bringing the upper surface of the tip tool P into contact with the bottom surface of the washer **621** while inserting the annular tube portion of the washer **621** through the through-hole formed in the center portion in a plan view of the tip tool P, and then threadingly engaging the nut **622** with the male thread portion formed in the lower end portion of the spindle **61**. On the other hand, detachment of the tip tool P from the tip tool attachment portion **62** can be performed by releasing the threaded engagement of the nut **622** with the male thread portion of the spindle **61**.

The dust proof portion **7** is a dust proof mechanism for suppressing powder dust generated in machining work (such as grinding) using the tip tool P from entering the internal space of the first bearing **51** and the like. The dust proof portion **7** is provided below the first bearing **51** and between the inner surface of the bearing holding portion **232** and the spindle **61**. Details of the dust proof portion **7** will be described later.

The wheel guard **8** is provided at the lower end portion of the gear housing **23**. The wheel guard **8** is configured to cover the rear portion of the tip tool P in a state where the tip tool P is attached to the tip tool attachment portion **62**.

## 1-2. Operations of Disc Grinder 1

Next, operations of the disc grinder **1** will be described. When a user performs the ON operation to the drive switch **21**A of the motor housing **21** in a state where the tip tool P is attached to the tip tool attachment portion **62** and the power supply cord portion **22**A is connected to an AC power supply, the switch mechanism **22**B comes into the ON state to cause electric power to be supplied from the AC power supply to the motor **3**. Upon supply of electric power to the motor **3**, the motor **3** is driven and thus the rotation shaft **31** and the pinion gear **41** rotate together about the first rotation axis A1.

By the rotation of the pinion gear **41**, rotation of the motor **3** is transmitted to the bevel gear **42** that is in meshing engagement with the pinion gear **41**, so that the bevel gear **42**, the spindle **61**, the tip tool attachment portion **62**, and the tip tool P attached to the tip tool attachment portion **62** rotate together about the second rotation axis A2. This rotating tip tool P enables machining work such as grinding.

## 1-3. Detailed Explanations of Bearing Holding Portion 232, First Bearing 51, Spindle 61, and Dust Proof Portion 7

Next, the bearing holding portion **232**, the first bearing **51**, the spindle **61**, and the dust proof portion **7** will be described in detail with reference to FIGS. **3** through **6**.

<1-3-1. Details of Bearing Holding Portion **232**>

The bearing holding portion **232** is made of resin. As illustrated in FIG. **4**, the bearing holding portion **232** includes a cylindrical supporting portion **232**A, a first annular protruding portion **232**B, and a second annular protruding portion **232**C. Further, the bearing holding portion **232** is formed with an annular recessed portion **232***a*.

The cylindrical supporting portion **232**A has a generally hollow cylindrical shape extending in the up-down direction. The cylindrical supporting portion **232**A is positioned outward of the first bearing **51** in the radial direction of the spindle **61**. The inner circumferential surface of the cylindrical supporting portion **232**A is in contact with the outer circumferential surface of the outer race **51**A of the first bearing **51**, and thus the cylindrical supporting portion **232**A supports the outer circumferential surface of the outer race **51**A. The dimension in the up-down direction of the cylindrical supporting portion **232**A is greater than the dimension in the up-down direction of the outer race **51**A. The upper end of the cylindrical supporting portion **232**A is positioned upper than the upper end of the outer race **51**A, and the lower end of the cylindrical supporting portion **232**A is positioned lower than the lower end of the outer race **51**A. Note that, in the following description, the radial direction of the spindle **61** will be simply referred to as the "radial direction".

The first annular protruding portion **232**B protrudes inward in the radial direction from the portion of the cylindrical supporting portion **232**A which is lower than the outer race **51**A. The first annular protruding portion **232**B has an annular shape in a bottom view. The upper surface of the first annular protruding portion **232**B is in contact with the lower surface of the outer race **51**A, and thus the first annular protruding portion **232**B supports the lower surface of the outer race **51**A. The inward end in the radial direction of the first annular protruding portion **232**B is positioned further inward in the radial direction than the outer circumferential surface of the outer race **51**A and further outward in the radial direction than the inner circumferential surface of the outer race **51**A. The first annular protruding portion **232**B is an example of the "protruding portion" in the present invention.

The second annular protruding portion **232**C protrudes inward in the radial direction from the portion of the cylindrical supporting portion **232**A which is upper than the outer race **51**A. The second annular protruding portion **232**C has an annular shape in a plan view. The lower surface of the second annular protruding portion **232**C is in contact with the upper surface of the outer race **51**A, and thus the second annular protruding portion **232**C supports the upper surface of the outer race **51**A. The inward end in the radial direction of the second annular protruding portion **232**C is positioned further inward in the radial direction than the outer circumferential surface of the outer race **51**A and further outward in the radial direction than the inner circumferential surface of the outer race **51**A.

The annular recessed portion **232***a* is a recessed portion defined by the inner circumferential surface of the cylindrical supporting portion **232**A, the upper surface of the first annular protruding portion **232**B, and the lower surface of the second annular protruding portion **232**C. The annular recessed portion **232***a* has an annular shape in a plan view. The dimension in the up-down direction of the annular recessed portion **232***a* is equal to the dimension in the up-down direction of the outer race **51**A.

<1-3-2. Details of First Bearing **51**>

As illustrated in FIG. **4**, in addition to the above-described outer race **51**A and inner race **51**B, the first bearing **51** includes a plurality of balls **51**C, a first annular sealing member **51**D, and a second annular sealing member **51**E. The balls **51**C are interposed between the outer race **51**A and the inner race **51**B. The first annular sealing member **51**D has an annular shape in a plan view. The first annular sealing member **51**D seals the lower end of a hollow cylindrical space defined between the inner circumferential surface of the outer race **51**A and the outer circumferential surface of the inner race **51**B. The second annular sealing member **51**E has an annular shape in a plan view. The second annular sealing member **51**E seals the upper end of the hollow cylindrical space. In the following description, the hollow cylindrical space defined between the inner circumferential surface of the outer race **51**A and the outer circumferential surface of the inner race **51**B will be simply referred to as the "internal space of the first bearing **51**".

The first bearing **51** is held by the bearing holding portion **232** in a state where the outer circumferential portion of the outer race **51**A is accommodated in the annular recessed portion **232***a* of the bearing holding portion **232**. Specifically, the outer race **51**A is fixed to (held by) the gear housing **23** by molding the bearing holding portion **232** integrally with the outer race **51**A. Further, the upper surface of the inner circumferential portion of the inner race **51**B is in contact with the lower surface of the bevel gear **42**.

Integral molding of the bearing holding portion **232** with the first bearing **51** will be described with reference to FIGS. **6**A through **6**F. A predetermined mold M illustrated in FIGS. **6**A through **6**F is used for molding the bearing holding portion **232** integrally with the first bearing **51**. The mold M is constituted by a plurality of mold members including a mold member M**1** used for molding the lower end part of the bearing holding portion **232**. The mold M can be assembled from the plurality of mold members, and can be disassembled into the plurality of mold members.

For molding the bearing holding portion **232** integrally with the first bearing **51**, firstly, the first bearing **51** is placed on the upper surface of a solid cylindrical portion M**2** of the mold member M**1** as illustrated in FIG. **6**A, and then the first bearing **51** is fixed to the mold member M**1** by a prescribed method. Note that the diameter of the solid cylindrical portion M**2** is smaller than the diameter of the first bearing **51**, and the position in the radial direction of the outer circumferential surface of the solid cylindrical portion M**2** is coincident with the position in the radial direction of the inner circumferential surface of the first annular protruding portion **232**B.

Thereafter, as illustrated in FIGS. **6**B and **6**C, the remaining mold members used for molding the remaining part of the bearing holding portion **232** which is positioned upper than the lower end part of the bearing holding portion **232** are assembled to the mold member M**1** to complete the mold M. In this state, as illustrated in FIG. **6**D, liquid resin R heated to a high temperature is poured into the space defined in the mold M through a hole (not illustrated) formed in the mold M. After the resin R is solidified, the mold M is removed from the solidified resin R while being disassembled as illustrated in FIG. **6**E. As a result, as illustrated in FIG. **6**F, the bearing holding portion **232** having the first bearing **51** held thereon is molded. In this way, the bearing holding portion **232** is molded integrally with the first bearing **51**.

<1-3-3. Details of Spindle **61**>

As illustrated in FIGS. **3** and **4**, the spindle **61** includes a first solid cylindrical portion **611**, a second solid cylindrical portion **612**, a third solid cylindrical portion **613**, a fourth solid cylindrical portion **614**, and a fifth solid cylindrical portion **615**.

As illustrated in FIG. **3**, the first solid cylindrical portion **611** constitutes the upper end portion of the spindle **61**, and has a solid cylindrical shape extending in the up-down direction. The first solid cylindrical portion **611** is press-fitted in the second bearing **52**.

The second solid cylindrical portion **612** is a solid cylindrical portion continuous with and extending downward from the lower end of the first solid cylindrical portion **611**. The second solid cylindrical portion **612** is press-fitted in the through-hole **42***a* of the bevel gear **42**. The diameter of the second solid cylindrical portion **612** is greater than the diameter of the first solid cylindrical portion **611**.

The third solid cylindrical portion **613** is a solid cylindrical portion continuous with and extending downward from the lower end of the second solid cylindrical portion **612**. The third solid cylindrical portion **613** is press-fitted in the inner race **51**B of the first bearing **51**. The diameter of the third solid cylindrical portion **613** is greater than the diameter of the second solid cylindrical portion **612**. The upper end of the third solid cylindrical portion **613** is positioned slightly lower than the upper end of the inner race **51**B, and the lower end of the third solid cylindrical portion **613** is positioned slightly lower than the lower end of the inner race **51**B.

Further, the entire outer circumferential surface of the lower end portion of the third solid cylindrical portion **613** is slightly recessed inward in the radial direction to form an annular recessed portion **613***a* having an annular shape in a plan view. The upper end of the annular recessed portion **613***a* is positioned upper than the lower end of the inner race **51**B, and the lower end of the annular recessed portion **613***a* is positioned lower than the lower end of the inner race **51**B. In the present embodiment, the lower end of the annular recessed portion **613***a* is in alignment with the lower end of the third solid cylindrical portion **613**.

The fourth solid cylindrical portion **614** is a solid cylindrical portion continuous with and extending downward from the lower end of the third solid cylindrical portion **613**. The fourth solid cylindrical portion **614** has a predetermined dimension in the up-down direction. The diameter of the fourth solid cylindrical portion **614** is greater than the diameter of the third solid cylindrical portion **613**. The outer circumferential surface of the fourth solid cylindrical portion **614** is positioned further outward in the radial direction than the inner circumferential surface of the inner race **51**B and further inward in the radial direction than the outer circumferential surface of the inner race **51**B. The upper end of the fourth solid cylindrical portion **614** is positioned slightly lower than the lower end of the inner race **51**B, and thus the upper surface of the outer circumferential portion of the fourth solid cylindrical portion **614** is slightly spaced apart from the lower surface of the inner circumferential portion of the inner race **51**B.

The fifth solid cylindrical portion **615** constitutes the lower portion of the spindle **61**. The fifth solid cylindrical portion **615** is continuous with and extends downward from the lower end of the fourth solid cylindrical portion **614**, and protrudes downward from the gear housing **23**. Note that the washer **621** of the tip tool attachment portion **62** described above is fixed to the fifth solid cylindrical portion **615**.

<1-3-4. Details of Dust Proof Portion 7>

As illustrated in FIGS. **4** and **5**, the dust proof portion **7** includes a dust proof sealing member **71** and a restricting member **72**.

The dust proof sealing member **71** is a sealing member for suppressing powder dust generated in machining work such as grinding from entering the internal space (that is, the hollow cylindrical space) of the first bearing **51**. The dust proof sealing member **71** is an example of the "sealing member" in the present invention.

The dust proof sealing member **71** has an annular shape in a plan view, and is positioned between the spindle **61** and the first annular protruding portion **232**B of the bearing holding portion **232**. Specifically, the dust proof sealing member **71** is positioned further inward in the radial direction than the first annular protruding portion **232**B and further outward in the radial direction than the spindle **61** (more specifically, the fourth solid cylindrical portion **614**) and a cylindrical portion **72**B described later. In the present embodiment, a felt impregnated with lubricating oil is employed as the dust proof sealing member **71**.

The dimension in the radial direction (the widthwise direction) of the dust proof sealing member **71** is greater than the dimension in the radial direction (the widthwise direction) of the hollow cylindrical space of the first bearing **51**. The outer circumferential surface of the dust proof sealing member **71** is positioned further inward in the radial direction than the outer circumferential surface of the outer race **51**A and further outward in the radial direction than the inner circumferential surface of the outer race **51**A. The inner circumferential surface of the dust proof sealing member **71** is positioned further inward in the radial direction than the outer circumferential surface of the inner race **51**B and further outward in the radial direction than the inner circumferential surface of the inner race **51**B. That is, at least a part of the dust proof sealing member **71** is overlapped with the inner race **51**B in the axial direction. In other words, at least a part of the dust proof sealing member **71** is overlapped with the inner race **51**B as viewed in the up-down direction (in the axial direction). More specifically, the inward end portion in the radial direction of the dust proof sealing member **71** is overlapped with the inner race **51**B in the axial direction.

Further, the outer circumferential surface of the dust proof sealing member **71** is in contact with the inward end of the first annular protruding portion **232**B (that is, the inner circumferential surface of the first annular protruding portion **232**B). In other words, the entire hollow cylindrical space of the first bearing **51** is overlapped with the dust proof sealing member **71** in the axial direction. Stated differently, the entirety of the hollow cylindrical space is overlapped with the dust proof sealing member **71** as viewed in the up-down direction.

The dimension in the up-down direction of the dust proof sealing member **71** is equal to the dimension in the up-down direction of the first annular protruding portion **232**B. The upper end of the dust proof sealing member **71** is in alignment with the upper end of the first annular protruding portion **232**B, and the lower end of the dust proof sealing member **71** is in alignment with the lower end of the first annular protruding portion **232**B. Further, the upper surface of the dust proof sealing member **71** is in contact with the lower surface of the inward end portion in the radial direction of the outer race **51**A, the lower surface of the first annular sealing member **51**D, and the lower surface of the outward end portion in the radial direction of the inner race **51**B. That is, the contact portion between the outer race **51**A and the first annular sealing member **51**D and the contact portion between the inner race **51**B and the first annular sealing member **51**D, which contact portions could be a pathway of entry of powder dust generated in machining work such as grinding into the internal space of the first bearing **51** (into the hollow cylindrical space), are covered by the dust proof sealing member **71**.

The restricting member **72** is made of metal and holds the dust proof sealing member **71** in cooperation with the first annular protruding portion **232**B. The restricting member **72** is a member for restricting the dust proof sealing member **71** from moving downward. The restricting member **72** is positioned between the first annular protruding portion **232**B and the spindle **61**. As illustrated in FIGS. **4** and **5**, the restricting member **72** includes an annular portion **72**A, the cylindrical portion **72**B, and a flange portion **72**C

The annular portion **72**A constitutes the inward portion in the radial direction of the restricting member **72**, and has an annular shape in a plan view. The inner circumferential edge portion of the annular portion **72**A is nipped and held by the lower surface of the inner race **51**B of the first bearing **51** and the upper surface of the fourth solid cylindrical portion **614** of the spindle **61**. Hence, the annular portion **72**A is fixed to the spindle **61** and the inner race **51**B. That is, the restricting member **72** is fixed to the outer circumferential surface of the spindle **61**.

The outward end in the radial direction of the annular portion **72**A is positioned further inward in the radial direction than the outer circumferential surface of the inner race **51**B and further outward in the radial direction than the inner circumferential surface of the inner race **51**B. The inward end in the radial direction of the annular portion **72**A is positioned further inward in the radial direction than the inner circumferential surface of the inner race **51**B and is in contact with the annular recessed portion **613***a* of the third solid cylindrical portion **613**. Further, the upper surface of the annular portion **72**A is in contact with the lower surface of the inner race **51**B.

The cylindrical portion **72**B has a hollow cylindrical shape and extends downward from the outer circumferential edge in the radial direction of the annular portion **72**A. The cylindrical portion **72**B is positioned further inward in the radial direction than the dust proof sealing member **71**. The lower end of the cylindrical portion **72**B is positioned lower than the lower end of the dust proof sealing member **71**. Further, the outer circumferential surface of the cylindrical portion **72**B is in contact with the inner circumferential surface of the dust proof sealing member **71**, and the cylindrical portion **72**B and the first annular protruding portion **232**B nip and hold the dust proof sealing member **71** therebetween in cooperation with each other with the dust proof sealing member **71** compressively deformed slightly in the radial direction. The lower end portion of the cylindrical portion **72**B is an example of the "end portion in the first direction of the cylindrical portion" in the present invention.

The flange portion **72**C extends outward in the radial direction from the outer circumferential surface of the lower end portion of the cylindrical portion **72**B, and has an annular shape in a plan view. The flange portion **72**C is positioned below the dust proof sealing member **71** with a slight gap formed between the flange portion **72**C and the dust proof sealing member **71**.

Further, the outward end in the radial direction of the flange portion **72**C is positioned further outward in the radial direction than the outer circumferential surface of the dust proof sealing member **71**, so that the flange portion **72**C covers the lower surface of the dust proof sealing member **71**. That is, the entire dust proof sealing member **71** is overlapped with the flange portion **72**C in the axial direction. In other words, the entirety of the dust proof sealing member **71** is overlapped with the flange portion **72**C as viewed in the up-down direction. With such a structure of the flange portion **72**C, if the dust proof sealing member **71** moves downward, the dust proof sealing member **71** comes into contact with the upper surface of the flange portion **72**C, so that further downward movement of the dust proof sealing member **71** is restricted. Accordingly, the dust proof sealing member **71** is suppressed from slipping and falling off from the disc grinder **1**.

### 1-4. Functions and Effects of Disc Grinder 1

The disc grinder **1** according to the first embodiment described above includes: the gear housing **23**; the spindle **61** extending downward, the lower end portion of the spindle **61** protruding from the gear housing **23**, the upper end portion of the spindle **61** being accommodated in the gear housing **23**; the first bearing **51** held by the gear housing **23** and including the inner race **51**B and the outer race **51**A, the first bearing **51** rotatably supporting the spindle **61**; the tip tool attachment portion **62** provided at the lower end portion of the spindle **61** and to which the tip tool P is attachable; the dust proof sealing member **71** positioned below the first bearing **51**; and the restricting member **72** for restricting the dust proof sealing member **71** from moving downward. Further, the gear housing **23** includes the bearing holding portion **232** molded integrally with the first bearing **51** and holding the first bearing **51**. Further, the bearing holding portion **232** includes: the cylindrical supporting portion **232**A extending downward and supporting the outer circumferential surface of the outer race **51**A; and the first annular protruding portion **232**B positioned below the outer race **51**A and protruding inward in the radial direction of the spindle **61** from the cylindrical supporting portion **232**A to restrict downward movement of the first bearing **51**. Further, the inward end in the radial direction of the first annular protruding portion **232**B (that is, the inner circumferential surface of the first annular protruding portion **232**B) is positioned further inward in the radial direction than the outer circumferential surface of the outer race **51**A and further outward in the radial direction than the inner circumferential surface of the outer race **51**A. The dust proof sealing member **71** is positioned between the spindle **61** and the first annular protruding portion **232**B. At least a part of the dust proof sealing member **71** is overlapped with the inner race **51**B in the axial direction, and the restricting member **72** is held by the spindle **61**.

In the disc grinder **1** constructed as described above, the restricting member **72** held by the spindle **61** restricts the dust proof sealing member **71** from moving downward at the overlapping position in the axial direction between the dust proof sealing member **71** and the inner race **51**B of the first bearing **51**. With this arrangement, despite the configuration where the bearing holding portion **232** molded integrally with the first bearing **51** is employed, the position of the dust proof sealing member **71** can be fixed at the overlapping position in the axial direction between the dust proof sealing member **71** and the inner race **51**B of the first bearing **51**, thereby reducing production cost and attaining favorable sealability. As a result, entry of powder dust generated in machining work into the first bearing **51** can be suitably suppressed, and accordingly, workability can be favorably maintained.

Specifically, effect of reduction in production cost of the disc grinder **1** is obtained when the bearing holding portion **232** molded integrally with the first bearing **51** is employed. However, in a configuration where the bearing holding portion **232** molded integrally with the first bearing **51** is employed like the present embodiment, the inward end in the radial direction of the first annular protruding portion **232**B (i.e., the position at which downward movement of the first bearing **51** is restricted) needs to be positioned further outward in the radial direction than the inner circumferential surface of the outer race **51**A because the above-described molding process is used for molding the bearing holding portion **232** integrally with the first bearing **51**. If the first annular protruding portion **232**B were designed to protrude such that its inward end in the radial direction (i.e., the position at which downward movement of the first bearing **51** is restricted) is positioned further inward in the radial direction than the inner circumferential surface of the outer race **51**A, the solid cylindrical portion M**2** of the mold member M**1** would have to be designed to such a small size that the outer circumferential surface of the solid cylindrical portion M**2** is positioned further inward in the radial direction than the inner circumferential surface of the outer race **51**A, use of the mold member M**1** including the solid cylindrical portion M**2** designed to have such a small size would cause liquid resin R heated to a high temperature to melt the first annular sealing member **51**D of the first bearing **51** and then to enter the internal space of the first bearing **51**, and after solidification of the entered resin R, relative rotation between the outer race **51**A and the inner race **51**B would become impossible.

Further, although the dust proof sealing member **71** exhibits proper sealability at a position overlapping with the inner race **51**B in the axial direction, it is difficult to fix the position of the dust proof sealing member **71** at the above-described suitable position in a configuration where the inward end in the radial direction of the first annular protruding portion **232**B needs to be positioned further outward in the radial direction than the inner circumferential surface of the outer race **51**A.

However, according to the present embodiment, the position of the dust proof sealing member **71** can be fixed at the overlapping position with the inner race **51**B of the first bearing **51** in the axial direction by virtue of the restricting member **72** held by the spindle **61** despite the configuration where the bearing holding portion **232** molded integrally with the first bearing **51** is employed, and hence, reduction in production cost and suitable sealability can be realized.

Further, the restricting member **72** of the disc grinder **1** is positioned between the spindle **61** and the first annular protruding portion **232**B in the radial direction. That is, the restricting member **72** is positioned in the space between the spindle **61** and the first annular protruding portion **232**B which needs to be sealed. Hence, the restricting member **72** also functions as a dust proof member (sealing member). Accordingly, entry of powder dust generated in machining work such as grinding into the first bearing **51** can be further suitably suppressed, and workability can be further favorably maintained.

Further, in the disc grinder **1**, the restricting member **72** which is fixed to the spindle **61** rotates together with the spindle **61** when the spindle **61** rotates. Hence, frictional heat is generated between the outer circumferential surface of the cylindrical portion **72**B and the inner circumferential surface of the dust proof sealing member **71** by rotation of the spindle **61**. However, since in the disc grinder **1** the inner circumferential surface of the dust proof sealing member **71** is positioned further inward in the radial direction than the outer circumferential surface of the inner race **51**B, the relative circumferential velocity between the inner circumferential surface of the dust proof sealing member **71** and the outer circumferential surface of the cylindrical portion **72**B can be made low in comparison with a structure where the inner circumferential surface of the dust proof sealing member **71** is positioned further outward in the radial direction than the outer circumferential surface of the inner race **51**B, and accordingly, generated frictional heat can be lowered. Accordingly, early wearing and degradation of the dust proof sealing member **71** due to frictional heat can be suppressed, thereby maintaining suitable sealability for a long duration.

Further, in the disc grinder **1**, a slight gap is formed between the flange portion **72**C of the restricting member **72** and the dust proof sealing member **71**. Therefore, frictional heat can be suppressed from being generated between the flange portion **72**C and the dust proof sealing member **71** when the restricting member **72** rotates together with the spindle **61**. As a result, early wearing and degradation of the dust proof sealing member **71** due to frictional heat can be further suppressed.

Further, in the disc grinder **1**, a pathway of entry of powder dust generated in machining work such as grinding into the first bearing **51** can be elongated because of the above-described slight gap defined between the flange portion **72**C and the dust proof sealing member **71**. Hence, entry of powder dust into the first bearing **51** can be further suitably suppressed.

## 2. Description of Disc Grinder **101** According to Second Embodiment

A disc grinder **101** as an example of a work machine according to a second embodiment of the present invention will be described with reference to FIGS. **7** through **9**. The disc grinder **101** has the same basic structure as the disc grinder **1** according to the first embodiment, and therefore, different structures from the first embodiment will be mainly described. Further, the same members, portions, and components in the disc grinder **101** as those in the disc grinder **1** will be designated by the same reference numerals to avoid duplicating description.

The disc grinder **101** is different from the disc grinder **1** in that the disc grinder **101** includes a dust proof portion **170** instead of the dust proof portion **7**.

### 2-1. Details of Dust Proof Portion **170**

As illustrated in FIGS. **7** and **8**, the dust proof portion **170** includes a dust proof sealing member **171** and a restricting member **172**.

The dust proof sealing member **171** has an annular shape in a plan view, and is positioned between the spindle **61** and the first annular protruding portion **232**B of the bearing holding portion **232**. Specifically, the dust proof sealing member **171** is positioned inward of the first annular protruding portion **232**B in the radial direction and outward of the fourth solid cylindrical portion **614** of the spindle **61** in the radial direction. The dust proof sealing member **171** according to this embodiment is a felt impregnated with lubricating oil, as in the dust proof sealing member **71**. The dust proof sealing member **171** is an example of the "sealing member" in the present invention.

The dimension in the radial direction of the dust proof sealing member **171** is smaller than the dimension in the radial direction of the dust proof sealing member **71** of the disc grinder **1**. Specifically, the dimension in the radial direction of the dust proof sealing member **171** is smaller than the dimension in the radial direction of the outer race

51A, the dimension in the radial direction of the inner race 51B, and the dimension in the radial direction of the hollow cylindrical space. Further, the dimension in the up-down direction of the dust proof sealing member **171** is smaller than the dimension in the radial direction of the dust proof sealing member **71** of the disc grinder **1**.

The outer circumferential surface of the dust proof sealing member **171** is positioned further inward in the radial direction than the inner circumferential surface of the outer race **51**A and further outward in the radial direction than the outer circumferential surface of the inner race **51**B. The inner circumferential surface of the dust proof sealing member **171** is positioned further inward in the radial direction than the outer circumferential surface of the inner race **51**B and further outward in the radial direction than the inner circumferential surface of the inner race **51**B. That is, at least a part of the dust proof sealing member **171** is overlapped with the inner race **51**B in the axial direction. In other words, at least a part of the dust proof sealing member **171** is overlapped with the inner race **51**B as viewed in the up-down direction. More specifically, the portion other than the outward end portion in the radial direction of the dust proof sealing member **171** is overlapped with the inner race **51**B in the axial direction. Further, the inner circumferential surface of the dust proof sealing member **171** is in contact with the outer circumferential surface of the fourth solid cylindrical portion **614** of the spindle **61**.

The dimension in the up-down direction of the dust proof sealing member **171** is smaller than the dimension in the up-down direction the dust proof sealing member **71**, and also is smaller than the dimension in the up-down direction of the first annular protruding portion **232**B. The upper end of the dust proof sealing member **171** is in alignment with the upper end of the first annular protruding portion **232**B, and the lower end of the dust proof sealing member **171** is positioned upper than the lower end of the first annular protruding portion **232**B. Further, the upper surface of the dust proof sealing member **171** is in contact with the inward portion in the radial direction of the first annular sealing member **51**D of the first bearing **51** and the lower surface of the outward end portion in the radial direction of the inner race **51**B that is continuous with that inward portion of the first annular sealing member **51**D. That is, the contact portion between the inner race **51**B and the first annular sealing member **51**D, which contact portion could be a pathway of entry of powder dust into the internal space (the hollow cylindrical space) of the first bearing **51**, is covered by the dust proof sealing member **171**.

The restricting member **172** is made of metal and holds the dust proof sealing member **171** in cooperation with the fourth solid cylindrical portion **614** of the spindle **61**. The restricting member **172** is a member for restricting downward movement of the dust proof sealing member **171**. As illustrated in FIGS. **8** and **9**, the restricting member **172** has an annular shape as a whole in a plan view, and is press-fitted in the first annular protruding portion **232**B of the bearing holding portion **232**. Specifically, the restricting member **172** is fitted in a space that has an annular shape in a plan view and is defined by the inner circumferential surface of the first annular protruding portion **232**B of the bearing holding portion **232**, the lower surface of the first bearing **51**, and the outer circumferential surface of the spindle **61**. Hence, the restricting member **172** is positioned between the first annular protruding portion **232**B and the spindle **61** and is fixed to (held by) the bearing holding portion **232**. The restricting member **172** includes an annular portion **172**A, a cylindrical portion **172**B, a flange portion **172**C, and a plurality of protruding wall portions **172**D.

The annular portion **172**A constitutes the inward portion in the radial direction of the restricting member **172**, and has an annular shape in a plan view. The annular portion **172**A is positioned outward of the spindle **61** in the radial direction with a slight gap formed between the inward edge portion of the annular portion **172**A and the fourth solid cylindrical portion **614** of the spindle **61**.

The outward end in the radial direction of the annular portion **172**A is positioned further outward in the radial direction than the outer circumferential surface of the inner race **51**B and further inward in the radial direction than the inner circumferential surface of the outer race **51**A. The inward end in the radial direction of the annular portion **172**A is positioned further outward in the radial direction than the inner circumferential surface of the inner race **51**B and further inward in the radial direction than the outer circumferential surface of the inner race **51**B. Further, the upper surface of the annular portion **172**A faces the lower surface of the dust proof sealing member **171** in the up-down direction, and a slight gap is formed between the upper surface of the annular portion **172**A and the lower surface of the dust proof sealing member **171**. Hence, if the dust proof sealing member **171** moves downward, the dust proof sealing member **171** comes into contact with the upper surface of the annular portion **172**A, so that further downward movement of the dust proof sealing member **171** is restricted. Accordingly, the dust proof sealing member **171** can be suppressed from slipping and falling off from the disc grinder **101**.

The cylindrical portion **172**B has a hollow cylindrical shape and extends upward from the outer circumferential edge in the radial direction of the annular portion **172**A. The cylindrical portion **172**B is positioned further outward in the radial direction than the dust proof sealing member **171**, and the upper surface of the cylindrical portion **172**B is in contact with the lower surface of the first annular sealing member **51**D of the first bearing **51**. Further, the cylindrical portion **172**B is in contact with the outer circumferential surface of the dust proof sealing member **171** to nip and hold the dust proof sealing member **171** in cooperation with the fourth solid cylindrical portion **614** with the dust proof sealing member **171** compressively deformed slightly in the radial direction.

The flange portion **172**C extends outward in the radial direction from the outer circumferential surface of the upper end portion of the cylindrical portion **172**B, and has an annular shape in a plan view. The flange portion **172**C is positioned below the first bearing **51**. The upper surface of the flange portion **172**C is in contact with the lower surface of the inward portion in the radial direction of the outer race **51**A and the lower surface of the first annular sealing member **51**D. That is, the contact portion between the outer race **51**A and the first annular sealing member **51**D, which contact portion could be a pathway of entry of powder dust into the internal space (the hollow cylindrical space) of the first bearing **51**, is covered by the flange portion **172**C.

Further, the outward end in the radial direction of the flange portion **172**C is positioned further outward in the radial direction than the inner circumferential surface of the outer race **51**A and further inward in the radial direction than the inner circumferential surface of the first annular protruding portion **232**B. A slight gap is formed between the outward end in the radial direction of the flange portion **172**C and the inner circumferential surface of the first annular protruding portion **232**B.

As illustrated in FIG. **9**, each protruding wall portion **172**D protrudes downward from the lower surface of the outward circumferential edge portion of the flange portion **172**C, and the protruding wall portions **172**D have the same shape as each other. The protruding wall portions **172**D are arranged at equal intervals in the circumferential direction of the spindle **61** with a predetermined gap formed between every two neighboring protruding wall portions **172**D. Further, as illustrated in FIG. **8**, the protruding wall portions **172**D are bent inward in the radial direction in a state where the restricting member **172** is fitted in the bearing holding portion **232**. Accordingly, the outer circumferential surface of each protruding wall portion **172**D is in pressure contact with the inner circumferential surface of the first annular protruding portion **232**B, whereby the restricting member **172** is fixed to the first annular protruding portion **232**B.

2-2. Functions and Effects of Disc Grinder **101**

In the above-described disc grinder **101** according to the second embodiment, the restricting member **172** held by the bearing holding portion **232** restricts downward movement of the dust proof sealing member **171** at a position where the dust proof sealing member **171** is overlapped with the inner race **51**B of the first bearing **51** in the axial direction. Hence, despite the configuration where the bearing holding portion **232** molded integrally with the first bearing **51** is employed, the position of the dust proof sealing member **171** can be fixed at the overlapping position with the inner race **51**B of the first bearing **51** in the axial direction, thereby reducing production cost and providing suitable sealability. Accordingly, entry of powder dust generated by machining work into the first bearing **51** can be suitably suppressed, thereby favorably maintaining workability.

Further, the restricting member **172** of the disc grinder **101** is fixed to the bearing holding portion **232**. Therefore, unlike the disc grinder **1** according to the first embodiment, the restricting member **172** is not rotated by rotation of the spindle **61**. Hence, friction can be suppressed from being generated between the restricting member **172** and the dust proof sealing member **171** whose position is fixed by the restricting member **172**, and accordingly, early wearing and degradation of the dust proof sealing member **171** due to frictional heat can be suppressed.

Further, the dimension in the up-down direction of the dust proof sealing member **171** in the disc grinder **101** is smaller than the dimension in the up-down direction of the dust proof sealing member **71** in the disc grinder **1**. Hence, the contact area between the dust proof sealing member **171** and the spindle **61** in the disc grinder **101** is smaller than the contact area between the dust proof sealing member **71** and the cylindrical portion **72**B of the restricting member **72** in the disc grinder **1**. Therefore, although rotation of the spindle **61** causes frictional heat to be generated between the fourth solid cylindrical portion **614** of the spindle **61** and the dust proof sealing member **171** in the disc grinder **101**, the frictional heat generated in the disc grinder **101** can be low in comparison with the frictional heat generated between the dust proof sealing member **71** and the cylindrical portion **72**B of the restricting member **72** in the disc grinder **1**.

Further, in the disc grinder **101**, a slight gap is formed between the dust proof sealing member **171** and the annular portion **172**A of the restricting member **172** which restricts downward movement of the dust proof sealing member **171**. With this structure, frictional heat can be suppressed from being generated between the dust proof sealing member **171** and the annular portion **172**A. Further, the dimension in the radial direction of the dust proof sealing member **171** is smaller than the dimension in the radial direction of the dust proof sealing member **71** of the disc grinder **1**. Therefore, even when frictional heat is generated between the dust proof sealing member **171** and the annular portion **172**A, the generated frictional heat can be lowered.

Note that the same configurations in the disc grinder **101** as those in the disc grinder **1** exhibit the same functions and effects as those exhibited by the same configurations in the disc grinder **1**.

3. Description of Disc Grinder **201** According to Third Embodiment

Next, a disc grinder **201** as an example of a work machine according to a third embodiment of the present invention will be described with reference to FIGS. **10** through **12**. The disc grinder **201** has the same basic structure as the disc grinder **1** according to the first embodiment, and therefore, different structures from the first embodiment will be mainly described. Further, the same members, portions, and components in the disc grinder **201** as those in the disc grinder **1** will be designated by the same reference numerals to avoid duplicating description.

The disc grinder **201** is different from the disc grinder **1** in that the disc grinder **201** includes a bearing holding portion **332** and a dust proof portion **270** instead of the bearing holding portion **232** and the dust proof portion **7**.

3-1. Details of Bearing Holding Portion **332**

As illustrated in FIGS. **10** and **11**, the bearing holding portion **332** is different from the bearing holding portion **232** of the disc grinder **1** in that the bearing holding portion **332** includes a cylindrical supporting portion **332**A and a first annular protruding portion **332**B instead of the cylindrical supporting portion **232**A and the first annular protruding portion **232**B.

The cylindrical supporting portion **332**A is different from the cylindrical supporting portion **232**A in that the cylindrical supporting portion **332**A is formed with an annular recessed portion **332***a*. The annular recessed portion **332***a* is formed in the lower portion of the cylindrical supporting portion **332**A. The annular recessed portion **332***a* is recessed outward in the radial direction, and has an annular shape in a plan view. The upper end of the annular recessed portion **332***a* is in alignment with the lower end of the outer race **51**A with respect to the up-down direction.

The first annular protruding portion **332**B protrudes inward in the radial direction from the portion of the cylindrical supporting portion **332**A which is positioned lower than the portion where the annular recessed portion **332***a* is formed. The first annular protruding portion **332**B has an annular shape in a bottom view. The inward end in the radial direction of the first annular protruding portion **332**B is positioned further inward in the radial direction than the outer circumferential surface of the outer race **51**A and further outward in the radial direction than the inner circumferential surface of the outer race **51**A. The first annular protruding portion **332**B is an example of the "protruding portion" in the present invention.

3-2. Details of Dust Proof Portion **270**

As illustrated in FIG. **11**, the dust proof portion **270** includes a dust proof sealing member **271** and a restricting member **272**.

The dust proof sealing member **271** has an annular shape in a plan view, and is positioned between the first annular protruding portion **332**B of the bearing holding portion **332** and the spindle **61**. Specifically, the dust proof sealing member **271** is positioned further inward in the radial direction than the first annular protruding portion **332**B and further outward in the radial direction than the fourth solid cylindrical portion **614** of the spindle **61**. The dust proof sealing member **271** according to this embodiment is a felt impregnated with lubricating oil, as in the dust proof sealing member **71**. The dust proof sealing member **271** is an example of the "sealing member" in the present invention.

The dimension in the radial direction of the dust proof sealing member **271** is smaller than the dimension in the radial direction of the dust proof sealing member **71** of the disc grinder **1**. Specifically, the dimension in the radial direction of the dust proof sealing member **271** is smaller than the dimension in the radial direction of the outer race **51**A, the dimension in the radial direction of the inner race **51**B, and the dimension in the radial direction of the hollow cylindrical space.

The outer circumferential surface of the dust proof sealing member **271** is positioned further inward in the radial direction than the inner circumferential surface of the outer race **51**A and further outward in the radial direction than the outer circumferential surface of the inner race **51**B. The inner circumferential surface of the dust proof sealing member **271** is positioned further inward in the radial direction than the outer circumferential surface of the inner race **51**B and further outward in the radial direction than the inner circumferential surface of the inner race **51**B. That is, at least a part of the dust proof sealing member **271** is overlapped with the inner race **51**B in the axial direction. In other words, at least a part of the dust proof sealing member **271** is overlapped with the inner race **51**B as viewed in the up-down direction. More specifically, the portion other than the outward end portion in the radial direction of the dust proof sealing member **271** is overlapped with the inner race **51**B in the axial direction. Further, the inner circumferential surface of the dust proof sealing member **271** is in contact with the outer circumferential surface of the fourth solid cylindrical portion **614** of the spindle **61**.

The dimension in the up-down direction of the dust proof sealing member **271** is smaller not only than the dimension in the up-down direction of the dust proof sealing member **71** but also than the dimension in the up-down direction of the first annular protruding portion **332**B. The upper end of the dust proof sealing member **271** is in alignment with the upper end of the annular recessed portion **332***a* with respect to the up-down direction. The lower end of the dust proof sealing member **271** is positioned upper than the lower end of the first annular protruding portion **332**B. Further, the upper surface of the dust proof sealing member **271** is in contact with the lower surface of the inward portion in the radial direction of the first annular sealing member **51**D and the lower surface of the outward portion in the radial direction of the inner race **51**B. That is, the contact portion between the inner race **51**B and the first annular sealing member **51**D, which contact portion could be a pathway of entry of powder dust into the internal space of the first bearing **51**, is covered by the dust proof sealing member **271**.

The restricting member **272** holds the dust proof sealing member **271** in cooperation with the fourth solid cylindrical portion **614** of the spindle **61**. The restricting member **272** is a member for restricting the dust proof sealing member **271** from moving downward. The restricting member **272** is made of metal and has an annular shape in a plan view. The restricting member **272** is fixed to the first annular protruding portion **332**B of the bearing holding portion **332** as a result of molding the bearing holding portion **332** integrally with both the restricting member **272** and the first bearing **51**. The restricting member **272** includes an annular portion **272**A, a cylindrical portion **272**B, and a flange portion **272**C.

Integral molding of the bearing holding portion **332** with both the first bearing **51** and the restricting member **272** will be described with reference to FIGS. **12**A through **12**F. A predetermined mold N illustrated in FIGS. **12**A through **12**F is used for molding the bearing holding portion **332** integrally with the first bearing **51** and the restricting member **272**. The mold N is constituted by a plurality of mold members including a mold member N**1** used for molding the lower end part of the bearing holding portion **332**. The mold N can be assembled from the plurality of mold members, and can be disassembled into the plurality of mold members.

For molding the bearing holding portion **332** integrally with the first bearing **51** and the restricting member **272**, firstly, the restricting member **272** is placed on the upper surface of an annular wall portion N**2** of the mold member N**1**, as illustrated in FIG. **12**A. Then, the first bearing **51** is placed on the upper surface of the restricting member **272**, and then the restricting member **272** and the first bearing **51** are fixed to the mold member N**1** by a predetermined method. Note that the diameter of the annular wall portion N**2** is smaller than the diameter of the first bearing **51**, and the position in the radial direction of the outer circumferential surface of the annular wall portion N**2** is coincident with the position in the radial direction of the inner circumferential surface of the first annular protruding portion **332**B in the radial direction.

Thereafter, as illustrated in FIGS. **12**B and **12**C, the remaining mold members used for molding the remaining part of the bearing holding portion **332** which is positioned upper than the lower end part of the bearing holding portion **332** are assembled to the mold member N**1** to complete the mold N. In this state, liquid resin R heated to a high temperature is poured into the space defined in the mold N through a hole (not illustrated) formed in the mold N as illustrated in FIG. **12**D. After the resin R is solidified, the mold N is removed from the solidified resin R while being disassembled as illustrated in FIG. **12**E. As a result, as illustrated in FIG. **12**F, the bearing holding portion **332** on which both the restricting member **272** and the first bearing **51** have been held is molded (that is, the bearing holding portion **332** to which both the restricting member **272** and the first bearing **51** have been fixed is molded). In this way, the bearing holding portion **332** is molded integrally with the restricting member **272** and the first bearing **51**.

The annular portion **272**A constitutes the inward portion in the radial direction of the restricting member **272**, and has an annular shape in a plan view. The annular portion **272**A is positioned outward of the spindle **61** in the radial direction with a slight gap formed between the inward edge portion of the annular portion **272**A and the fourth solid cylindrical portion **614** of the spindle **61**.

The outward end in the radial direction of the annular portion **272**A is positioned further outward in the radial direction than the outer circumferential surface of the inner race **51**B and further inward in the radial direction than the inner circumferential surface of the outer race **51**A. The inward end in the radial direction of the annular portion **272**A is positioned further outward in the radial direction than the inner circumferential surface of the inner race **51**B and further inward in the radial direction than the outer circumferential surface of the inner race **51**B.

Further, the upper surface of the annular portion **272**A is in contact with the lower surface of the dust proof sealing member **271**. Hence, further downward movement of the dust proof sealing member **271** is restricted. Accordingly, the dust proof sealing member **271** is suppressed from slipping and falling off from the disc grinder **201**.

The cylindrical portion **272**B has a hollow cylindrical shape and extends upward from the outer circumferential edge portion in the radial direction of the annular portion **272**A. The cylindrical portion **272**B is positioned further outward in the radial direction than the dust proof sealing member **271**, and the upper surface of the cylindrical portion **272**B is in contact with the lower surface of the first annular sealing member **51**D of the first bearing **51**. Further, the cylindrical portion **272**B is in contact with the outer circumferential surface of the dust proof sealing member **271** to nip and hold the dust proof sealing member **271** in cooperation with the fourth solid cylindrical portion **614** with the dust proof sealing member **271** compressively deformed slightly in the radial direction.

The flange portion **272**C extends outward in the radial direction from the outer circumferential surface of the upper end portion of the cylindrical portion **272**B, and has an annular shape in a plan view. The extending end portion (i.e., the outward end portion in the radial direction) of the flange portion **272**C is fixed to (held by) the cylindrical supporting portion **332**A in a state where the extending end portion of the flange portion **272**C is accommodated in the annular recessed portion **332***a* formed in the cylindrical supporting portion **332**A. Hence, the outward end in the radial direction of the flange portion **272**C is positioned further outward in the radial direction than both the outer circumferential surface of the outer race **51**A and the inner circumferential surface of the first annular protruding portion **332**B. The upper end portion of the cylindrical portion **272**B is an example of the "end portion in the second direction of the cylindrical portion" in the present invention.

Further, the flange portion **272**C is positioned below the first bearing **51**. The upper surface of the flange portion **272**C is in contact with the entire lower surface of the outer race **51**A and the lower surface of the first annular sealing member **51**D which neighbors the lower surface of the outer race **51**A. That is, the contact portion between the outer race **51**A and the first annular sealing member **51**D, which contact portion could be a pathway of entry of powder dust into the internal space of the first bearing **51**, is covered by the flange portion **272**C. Accordingly, the restricting member **272** functions also as a dust proof member for suppressing powder dust from entering the internal space of the first bearing **51**.

### 3-3. Functions and Effects in Disc Grinder **201**

In the disc grinder **201** according to the third embodiment described above, the restricting member **272** held by the bearing holding portion **332** restricts downward movement of the dust proof sealing member **271** at a position where the dust proof sealing member **271** is overlapped with the inner race **51**B of the first bearing **51** in the axial direction. Hence, despite the configuration where the bearing holding portion **332** molded integrally with the first bearing **51** is employed, the position of the dust proof sealing member **271** can be fixed at the overlapping position with the inner race **51**B of the first bearing **51** in the axial direction, thereby reducing production cost and providing suitable sealability. Accordingly, powder dust generated in machining work can be suitably suppressed from entering the first bearing **51**, thereby favorably maintaining workability.

Note that the same configurations in the disc grinder **201** as those in the disc grinder **1** or the disc grinder **101** exhibit the same functions and effects as those exhibited by the same configurations in the disc grinder **1** or the disc grinder **101**, as the case may be.

### 4. Other Modifications

The work machine according to the present invention is not limited to the above-described embodiments, but various modification and improvement may be conceivable within the scope of the claims.

In the descriptions made to the present embodiments, the disc grinders **1**, **101**, **201** have been exemplified as the work machine. However, the present invention can be applied to work machines other than the disc grinder, such as a circular saw and a drilling tool which are provided with a spindle and a bearing rotatably supporting the spindle.

In the above-described embodiments, the dust proof sealing members **71**, **171**, and **271** are each a felt impregnated with lubricating oil. However, any member is available as the dust proof sealing members **71**, **171**, and **271** as long as the member has dust proofing effect. For example, an elastic body such as rubber can be employed as the dust proof sealing members **71**, **171**, and **271**, instead of the felt.

### REFERENCE SIGNS LIST

**1**, **101**, **201**: disc grinder, **2**: housing, **3**: motor, **4**: power transmission portion, **5**: output shaft supporting portion, **6**: output shaft portion, **7**, **170**, **270**: dust proof portion; **8**: wheel guard, **21**: motor housing, **22**: tail housing, **23**: gear housing, **51**: first bearing, **51**A: outer race, **51**B: inner race, **52**: second bearing, **61**: spindle, **62**: tip tool attachment portion, **71**, **171**, **271**: dust proof sealing member, **72**, **172**, **272**: restricting member, **72**A, **172**A, **272**A: annular portion, **72**B, **172**B, **272**B: cylindrical portion, **72**C, **172**C, **272**C: flange portion, **231**: gear cover, **232**, **332**: bearing holding portion, **232**A, **332**A: cylindrical supporting portion, **232**B, **332**B: first annular protruding portion, **A1**: first rotation axis, **A2**: second rotation axis, P: tip tool, R: resin

The invention claimed is:

**1**. A work machine comprising:

a gear housing;

a spindle protruding in a downward direction from the gear housing;

a bearing held by the gear housing and comprising an inner race and an outer race, the bearing rotatably supporting the spindle;

a tip tool attachment portion to which a tip tool is attachable, the tip tool attachment portion being provided at the spindle;

a sealing member positioned below the bearing; and

an annular element restricting the sealing member from moving in the downward direction,

wherein the gear housing comprises a bearing holding portion holding the bearing,

wherein the bearing holding portion comprises:

a cylindrical portion extending in an up-down direction, the cylindrical portion being in contact with an outer circumferential surface of the outer race to support the outer race; and

a first protruding portion positioned below the outer race, the first protruding portion protruding inward in a radial direction of the spindle from the cylindrical portion, the first protruding portion being in contact with a lower surface of the outer race from below to restrict the bearing from moving in the downward direction,

a second protruding portion positioned above the outer race, the second protruding portion protruding inward in the radial direction of the spindle from the cylindrical portion, the second protruding portion being in contact with an upper surface of the outer race from above to restrict the bearing from moving in an upward direction,

wherein the annular element is held either by the spindle or by the gear housing,

wherein the cylindrical portion, the first protruding portion and the second protruding portion are included in the gear housing and are formed as a single member, and

wherein the first protruding portion is positioned further outward in the radial direction than a lower end of an inner circumferential surface of the outer race, and

wherein the second protruding portion is positioned further outward in the radial direction than an upper end of the inner circumferential surface of the outer race.

**2**. The work machine according to claim **1**,

wherein an inward end in the radial direction of the first protruding portion is positioned further inward in the radial direction than the outer circumferential surface of the outer race and further outward in the radial direction than the inner circumferential surface of the outer race, and

wherein the sealing member is provided between the spindle and the first protruding portion in the radial direction.

**3**. The work machine according to claim **2**,

wherein the annular element is fixed to the bearing holding portion.

**4**. The work machine according to claim **3**,

wherein the annular element further comprises:

an annular portion positioned outward of the spindle in the radial direction;

the cylindrical portion extending in the up-down direction from an outer circumferential edge in the radial direction of the annular portion; and

a flange portion extending outward in the radial direction from an outer circumferential surface of an end portion in the up-down direction of the cylindrical portion, the flange portion being fixed to the bearing holding portion, and

wherein the sealing member is positioned between the spindle and the cylindrical portion.

**5**. The work machine according to claim **3**,

wherein the annular element is fixed to the bearing holding portion by press-fitting.

**6**. The work machine according to claim **3**,

wherein the annular element is fixed to the bearing holding portion by molding the bearing holding portion integrally with the annular element.

**7**. The work machine according to claim **1**,

wherein the annular element comprises:

an annular portion extending in the radial direction;

a cylindrical portion extending in the up-down direction to connect the annular portion and a flange portion; and

the flange portion extending in the radial direction at a position different from the annular portion in the up-down direction, and

wherein the cylindrical portion holds the sealing member, the cylindrical portion being entirely positioned inward than the first protruding portion in the radial direction.

**8**. A work machine comprising:

a gear housing;

a spindle protruding in a downward direction from the gear housing;

a bearing held by the gear housing and comprising an inner race and an outer race, the bearing rotatably supporting the spindle;

a tip tool attachment portion to which a tip tool is attachable, the tip tool attachment portion being provided at the spindle;

a sealing member positioned below the bearing; and

an annular element restricting the sealing member from moving in the downward direction,

wherein the gear housing comprises a bearing holding portion holding the bearing,

wherein the bearing holding portion comprises:

a cylindrical portion extending in an up-down direction, the cylindrical portion being in contact with an outer circumferential surface of the outer race to support the outer race; and

a protruding portion positioned below the outer race, the protruding portion protruding inward in a radial direction of the spindle from the cylindrical portion, the protruding portion being in contact with a lower surface of the outer race from below to restrict the bearing from moving in the downward direction,

wherein an inward end in the radial direction of the protruding portion is positioned further inward in the radial direction than the outer circumferential surface of the outer race and further outward in the radial direction than an inner circumferential surface of the outer race,

wherein the sealing member is positioned in a space between the spindle and the protruding portion in the radial direction,

wherein the annular element is held by the spindle and is configured to rotate together with the spindle, and

wherein the annular element restricts a movement of the sealing member in the downward direction by contact with a lower surface of the sealing member.

**9**. The work machine according to claim **8**,

wherein the annular element is fixed to an outer circumferential surface of the spindle.

**10**. The work machine according to claim **9**,

wherein the annular element further comprises:

an annular portion fixed to the spindle;

a cylindrical portion extending in the downward direction from an outer circumferential edge in the radial direction of the annular portion; and

a flange portion extending outward in the radial direction from an outer circumferential surface of an end portion in the downward direction of the cylindrical portion, and

wherein the annular element is positioned outward of the cylindrical portion in the radial direction.

**11**. A work machine comprising:

a gear housing;

a spindle protruding in a downward direction from the gear housing;

a bearing held by the gear housing, the bearing comprising an inner race and an outer race, the bearing rotatably supporting the spindle;

a tip tool attachment portion to which a tip tool is attachable, the tip tool attachment portion being provided at the spindle;

a sealing member positioned below the bearing; and

an annular element including:

a first portion extending in a radial direction, the first portion being nipped between the spindle and the inner race in an up-down direction;

a second portion extending downward from an outer circumferential portion in the radial direction of the first portion; and

a third portion extending outward in the radial direction from the second portion, the third portion being positioned below the sealing member for restricting the sealing member from moving in the downward direction,

wherein the gear housing comprises a bearing holding portion holding the bearing,

wherein the bearing holding portion comprises:

a cylindrical portion extending in the up-down direction, the cylindrical portion being in contact with an outer circumferential surface of the outer race to support the outer race; and

a protruding portion below the outer race, the protruding portion protruding inward in the radial direction of the spindle from the cylindrical portion, the protruding portion being in contact with a lower surface of the outer race from below to restrict the bearing from moving in the downward direction,

wherein the sealing member is positioned between the spindle and the protruding portion in the radial direction, and

wherein the annular element is fixed to the spindle by the first portion being nipped between the spindle and the inner race in the up-down direction.



**12**. The work machine according to claim **11**,

wherein the third portion is in contact with a lower surface of the sealing member.

**13**. The work machine according to claim **11**,

wherein the spindle comprises a large diameter portion,

wherein the first portion is nipped between the large diameter portion and the inner race in the up-down direction, and

wherein the sealing member is disposed between the protruding portion and the large diameter portion in the radial direction.

**14**. The work machine according to claim **11**,

wherein the second portion is positioned apart from both the spindle and the protruding portion in the radial direction, and

wherein the sealing member is disposed between the second portion and the protruding portion in the radial direction or between the second portion and the spindle in the radial direction.

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