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ELECTRIC TOOL

Abstract

An electric tool includes an output shaft, a drive shaft, a transmission mechanism, a plurality of bearings, and a seal member. The plurality of bearings are aligned in an axial direction of the output shaft and rotatably support the output shaft. The seal member has a through hole into which the output shaft is inserted. The seal member is disposed, in at least one space of spaces each sandwiched between each two adjacent bearings of the plurality of bearings, such that an inner circumferential surface of the through hole is in contact with the outer circumferential surface of the output shaft.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure generally relates to electric tools. The present disclosure specifically relates to an electric tool including an output shaft.

BACKGROUND ART

[0002] Patent Literature 1 discloses an impact rotary tool including: a driver having a motor: an output configured to output rotary driving of the driver; and an impactor configured to transmit the rotary driving of the driver to the output together with an impact movement. The impactor includes: a hammer configured to be rotated by the driver; an anvil having an impact receiving surface impacted by the hammer and configured to transmit the rotary driving to the output; and a buffer member attached to the anvil and having lower stiffness than the anvil. The buffer member protrudes beyond the impact receiving surface in a rotational direction of the anvil.

[0003] An electric tool, such as the impact rotary tool described above, may include a seal member provided therein, and the seal member is required to have high durability.

CITATION LIST

Patent Literature

[0004] Patent Literature **1**: JP 5525386 B2

SUMMARY OF INVENTION

[0005] It is an object of the present disclosure to provide an electric tool including a seal member with high durability.

[0006] An electric tool according to an aspect of the present disclosure includes an output shaft, a drive shaft, a transmission mechanism, a plurality of bearings, and a seal member. The output shaft includes a holder configured to hold a tip tool. The drive shaft is configured to be rotated by a driver. The transmission mechanism is disposed between the drive shaft and the output shaft to transmit rotation of the drive shaft to the output shaft. The plurality of bearings are aligned in an axial direction of the output shaft to rotatably support the output shaft. The seal member has a through hole in which the output shaft is inserted. The seal member is disposed, in at least one space of spaces each between two adjacent bearings of the plurality of bearings, such that an inner circumferential surface of the through hole is in contact with an outer circumferential surface of the output shaft.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. **1** is a sectional view of a main part of an electric tool according to an embodiment;

[0008] FIG. **2** is an exterior perspective view of the electric tool;

[0009] FIG. **3** is an exploded perspective view of the main part of the electric tool;

[0010] FIG. **4** is an exploded perspective view of the main part of the electric tool;

[0011] FIG. **5** is an enlarged sectional view of the main part of the electric tool;

[0012] FIG. **6** is a perspective view of a main part of the electric tool; and

[0013] FIG. **7** is an enlarged sectional view of a main part of an electric tool of a variation of the embodiment.

DESCRIPTION OF EMBODIMENTS

[0014] With reference to the drawings, an electric tool according to an embodiment will be described below. Note that the embodiment described below is a mere example of various embodiments of the present disclosure. Various modifications may be made to the embodiment described below depending on design or the like as long as the object of the present disclosure is achieved. Moreover, figures described in the following embodiment are schematic views. The ratio of sizes and the ratio of thicknesses of components in the figures do not necessarily reflect actual dimensional ratios.

(1) First Embodiment

(1-1) Overview

[0015] The overview of an electric tool **1** according to a first embodiment will be described below with reference to FIG. **1**.

[0016] As shown in FIG. **1**, the electric tool **1** according to the first embodiment includes an output shaft **2**, a drive shaft **3**, a transmission mechanism **4**, a plurality of bearings **5**, and a seal member **6**. A worker is assumed to use the electric tool **1** to perform a fastening operation of fastening a fastening part (such as a screw, a bolt, or a nut) to a work target (such as an electric appliance or furniture). Moreover, the electric tool **1** may be used by the worker to perform a removal operation of loosening a fastening part from a work target.

[0017] The output shaft **2** includes a holder **21** configured to hold a tip tool B**1**. The drive shaft **3** is rotated by a driver **8**. The transmission mechanism **4** is disposed between the drive shaft **3** and the output shaft **2** to transmit rotation of the drive shaft **3** to the output shaft **2**. The plurality of bearings **5** are aligned in an axial direction D**1** of the output shaft **2** to rotatably support the output shaft **2**. The seal member **6** has a through hole **61** into which the output shaft **2** is inserted. The seal member **6** is disposed, in at least one space of spaces between each two adjacent bearings **5** of the plurality of bearings **5**, such that an inner circumferential surface **610** of the through hole **61** is in contact with an outer circumferential surface **20** of the output shaft **2**.

[0018] In the electric tool **1** of the first embodiment, the output shaft **2** is supported by the plurality of bearings **5**. Therefore, when the rotation of the drive shaft **3** is transmitted to the output shaft **2** from the transmission mechanism **4** and the output shaft **2** rotates along the axial direction D**1**, the output shaft **2** can be suppressed from moving in a direction intersecting the axial direction D**1**. That is, the electric tool **1** of the first embodiment can reduce a rotational shake when the output shaft **2** rotates along the axial direction D**1**.

[0019] Therefore, the first embodiment suppresses the rotational shake from pushing the output shaft **2** against the seal member **6** disposed in the space between the adjacent bearings **5**. As a result, the electric tool **1** of the first embodiment provides the effect of suppressing the seal member **6** from being abraded by the output shaft **2**. That is, the electric tool **1** of the first embodiment has the advantages that the seal member **6** has high durability. As used herein, the “durability” is a property representing an extent to which the electric tool **1** is suppressed from deteriorating, for example, being abraded, over time of use.

(1-2) Detailed Configuration

(1-2-1) Overall Configuration

[0020] A detailed configuration of the electric tool **1** of the first embodiment will be described below with reference to FIG. **1** to FIG. **6**.

[0021] As shown in FIG. **1**, the electric tool **1** includes the output shaft **2**, the drive shaft **3**, the transmission mechanism **4**, the plurality of bearings **5**, the seal member **6**, and a housing **7**, a driver **8**, a controller **91**, a planet gear mechanism **92**, and an operating member **93**.

[0022] In the following description, the axial direction D**1** of the output shaft **2** is defined as a forward/backward direction, wherein an anvil **42** is forward of a hammer **41** and the hammer **41** is backward of the anvil **42**. Moreover, in the following description, a direction in which a second part **72** which will be described later and a grip **74** which will be described later are aligned with each other is defined as an up/down direction (Y direction in FIG. **2**), wherein the second part **72** is upward of the grip **74** and the grip **74** is downward of the second part **72**. Moreover, a direction orthogonal to the forward/backward direction and the up/down direction is defined as a left/right direction. Note that these definitions do not intend to define a direction in which the electric tool **1** is used.

(1-2-2) Housing

[0023] As shown in FIG. **1**, the housing **7** houses at least part of the output shaft **2**, the drive shaft **3**, the transmission mechanism **4**, the plurality of bearings **5**, the seal member **6**, the driver **8**, the controller **91**, and the planet gear mechanism **92**. As shown in FIGS. **1** and **2**, the housing **7** includes a first part **71**, the second part **72**, a third part **73**, the grip **74**, and a battery applied part **75**.

(First Part)

[0024] As shown in FIGS. **3** and **4**, the first part **71** includes a first bottom part **711** and a first side part **712**. The first bottom part **711** has a disk shape. A thickness direction defined with respect to the first bottom part **711** is parallel to the forward/backward direction. The first bottom part **711** has a through hole **713** formed in the forward/backward direction. The through hole **713** is at the center of the first bottom part **711**. The output shaft **2** is inserted into the through hole **713**. The first side part **712** protrudes backward from a circumferential edge of the first bottom part **711**.

(Second Part)

[0025] As shown in FIGS. **3** and **4**, the second part **72** includes a second bottom part **721** and a second side part **722**. The second bottom part **721** has an elliptical plate shape. A thickness direction defined with respect to the second bottom part **721** is parallel to the forward/backward direction.

[0026] The second side part **722** has a circularly cylindrical shape. The second side part **722** protrudes forward from a circumferential edge of the second bottom part **721**.

[0027] As shown in FIG. **1**, the second side part **722** has a front opening covered with the first part **71**. More specifically, the front opening of the second side part **722** is covered with the first part **71** such that a front part of an inner surface of the second side part **722** is in close contact with an outer surface of the first side part **712**, and a front end part of the second side part **722** is in contact with a circumferential edge part of the first bottom part **711**.

[0028] As shown in FIGS. **3** and **4**, the second part **72** has a plurality of ventilation holes **723** formed in the second side part **722**. More specifically, the second part **72** has the plurality of ventilation holes **723** provided at a back portion of the second side part **722**.

(Third Part)

[0029] As shown in FIGS. **3** and **4**, the third part **73** includes a main part **731**, a cylindrical part **732**, and a third side part **733**. The main part **731** is a circularly annular plate member. The thickness direction defined with respect to the main part **731** is parallel to the forward/backward direction.

[0030] As shown in FIGS. **3** and **4**, the cylindrical part **732** has a circularly cylindrical shape with openings at both ends thereof. The cylindrical part **732** protrudes forward from an inner edge of the main part **731**. As shown in FIG. **1**, the cylindrical part **732** of the first embodiment houses the plurality of bearings **5** and the seal member **6**. The output shaft **2** is inserted in the cylindrical part **732**.

[0031] As shown in FIGS. **1** and **5**, the cylindrical part **732** supports the plurality of bearings **5**. In other words, the housing **7** supports the plurality of bearings **5**. The cylindrical part **732** has an inner diameter substantially equal to an outer shape of each of the plurality of bearings **5** or is slightly larger than the outer shape of each of the plurality of bearings **5**. As a result, each of the plurality of bearings **5** is fitted in the cylindrical part **732**, and thereby, the cylindrical part **732** supports the plurality of bearings **5**.

[0032] As shown in FIG. **5**, the cylindrical part **732** has a projection **76**. In other words, the housing **7** has the projection **76** at the cylindrical part **732**. The projection **76** protrudes from an inner circumferential surface of the cylindrical part **732** toward the output shaft **2**. The projection **76** extends, one circle, on the inner circumferential surface of the cylindrical part **732** along the circumferential direction of the cylindrical part **732**. That is, the projection **76** is circularly annularly provided on the inner circumferential surface of the cylindrical part **732**. The projection **76** is located in a space which is one of the spaces each between two adjacent bearings **5** of the plurality of bearings **5** and in which the seal member **6** is provided. This configuration provides the advantage that a gap between each two adjacent bearings **5** can be easily maintained, so that the seal member **6** is easily provided.

[0033] As shown in FIGS. **3** and **4**, the third side part **733** has a circularly cylindrical shape. The third side part **733** protrudes backward from an outer edge of the main part **731**. As shown in FIG. **1**, the third side part **733** of the first embodiment houses at least part of the drive shaft **3** and the transmission mechanism **4**. As shown in FIG. **1**, the third side part **733** has an outer surface closely in contact with the inner surface of the second side part **722** of the second part **72**.

[0034] To the third part **73**, the first part **71** is attached. More specifically, the first part **71** is attached to the third part **73** such that a front end part of the cylindrical part **732** borders the through hole **713** formed in the first bottom part **711** of the first part **71**.

(Grip)

[0035] The grip **74** protrudes from the second part **72**. More specifically, the grip **74** protrudes downward from the second part **72** as shown in FIG. **2**. The worker can hold the grip **74** to perform an operation such as fastening a screw.

(Battery Applied Part)

[0036] The battery applied part **75** is in the shape of a substantially rectangular parallelepiped. As shown in FIG. **2**, the battery applied part **75** is connected to a lower end of the grip **74**. To the battery applied part **75**, a rechargeable battery pack is detachably attached. The electric tool **1** operates by using the battery pack as a power supply. That is, the battery pack is a power supply which supplies a current for driving the driver **8**. The battery pack is not a component of the electric tool **1**. However, the electric tool **1** may include the battery pack. The battery pack includes: an assembled battery including a plurality of secondary batteries (e. g., lithium ion batteries) connected to each other in series: and a case housing the assembled battery.

(1-2-3) Driver

[0037] As shown in FIG. **1**, the driver **8** is housed at a back portion in the second part **72**. The driver **8** includes: a rotor **81** including a rotary shaft **811** and a permanent magnet; and a stator **82** including a coil. Electromagnetic interaction between the permanent magnet and the coil rotates the rotor **81** with respect to the stator **82**.

[0038] Moreover, the driver **8** is a servomotor. The torque and the rotational velocity of the driver **8** vary in accordance with control by the controller **91** (servo driver). More specifically, the controller **91** controls operation of the driver **8** by feedback control of controlling such that the torque and the rotational velocity of the driver **8** approximate target values.

(1-2-4) Drive Shaft

[0039] The drive shaft **3** is connected to the rotary shaft **811** via the planet gear mechanism **92**. As a result, the drive shaft **3** rotates along with the rotary shaft **811** of the driver **8**. That is, the drive shaft **3** is rotated by the driver **8**.

[0040] The planet gear mechanism **92** converts the rotational velocity and the torque of the rotary shaft **811** of the driver **8** into a rotational velocity and torque which are required for screw turning operation. The planet gear mechanism **92** is a decelerator. The torque of the rotary shaft **811** of the driver **8** is transmitted via the planet gear mechanism **92** to the drive shaft **3**.

(1-2-5) Transmission Mechanism

[0041] As shown in FIG. **1**, the transmission mechanism **4** is housed in the third part **73** of the housing **7**. The transmission mechanism **4** of the first embodiment includes an impact mechanism. That is, the electric tool **1** of the first embodiment is an electrically driven impacting tool which performs the fastening operation while performing impact operation by the impact mechanism. The impact mechanism generates, based on motive power of the driver **8**, an impacting force during the

impact operation and applies the impacting force to the tip tool B**1**.
[0042] As shown in FIG. **1**, the transmission mechanism **4** of the first embodiment further includes a hammer **41**, an anvil **42**, an elastic member **43**, and two balls (first balls) **47**. The torque transmitted to the drive shaft **3** is transmitted to the hammer **41**. This rotates the hammer **41**. The torque of the hammer **41** is transmitted to the anvil **42**. This rotates the anvil **42**.
[0043] The hammer **41** moves with respect to the anvil **42** and receives the motive power from the driver **8** to apply the impacting force to the anvil **42**. As shown in FIG. **6**, the hammer **41** includes a hammer body **410** and a plurality of (in this embodiment, two) hammer projections **411**. The hammer body **410** has a columnar shape. The hammer **41** is provided with the plurality of hammer projections **411** on the hammer body **410**. The plurality of hammer projections **411** protrude from a surface of the hammer body **410** facing the anvil **42**. The plurality of hammer projections **411** are disposed in the circumferential direction of the hammer body **410** at substantially equal intervals. When viewed from the front of the hammer **41**, the plurality of hammer projections **411** each have a fan shape.
[0044] As shown in FIG. **1**, the hammer body **410** has a through hole **412** in which the drive shaft **3** is inserted. More specifically, the through hole **412** is fitted to an outer circumferential surface of the drive shaft **3** such that the through hole **412** is movable in an axial direction of the drive shaft **3** and is rotatable in a rotational direction of the drive shaft **3**. That is, the hammer **41** is fitted to the outer circumferential surface of the drive shaft **3** such that the hammer **41** is rotatable and movable forward and backward.
[0045] The hammer body **410** has two grooves **413** in an inner circumferential surface of the through hole **412**. The drive shaft **3** has two grooves **31** in the outer circumferential surface thereof. The two grooves **31** may be connected to each other. Between the two grooves **413** and the two grooves **31**, two first balls **47** are sandwiched. The two grooves **413**, the two grooves **31**, and the two first balls **47** constitute a cam mechanism. The hammer **41** is movable with respect to the drive shaft **3** in the axial direction (forward/backward direction) of the drive shaft **3** and is rotatable with respect to the drive shaft **3** while the two first balls **47** move in the grooves **413** and the grooves **31**. As the hammer **41** moves along the axial direction of the drive shaft **3** in a direction toward the anvil **42** or in a direction away from the anvil **42**, the hammer **41** rotates with respect to the drive shaft **3**.
[0046] The anvil **42** is mechanically connected to the output shaft **2**. In the first embodiment, the anvil **42** is integral with the output shaft **2** as shown in FIGS. **1** and **6**. The anvil **42** rotates together with the output shaft **2**. As shown in FIG. **6**, the anvil **42** includes an anvil body **420** and a plurality of (two) anvil projections **421**. The anvil body **420** has a circularly annular shape. The anvil body **420** faces the hammer body **410** in the forward/backward direction. The plurality of anvil projections **421** protrude from the anvil body **420** in a radial direction of the anvil body **420**. The number of anvil projections **421** is equal to the number of hammer projections **411**. The plurality of anvil projections **421** are engageable with the plurality of hammer projections **411**.
[0047] When the impact mechanism does not perform the impact operation, the hammer **41** and the anvil **42** rotate together while the plurality of hammer projections **411** are in contact with the plurality of anvil projections **421** in the rotational direction of the drive shaft **3**. Therefore, at this time, the drive shaft **3**, the hammer **41**, the anvil **42**, and the output shaft **2** rotate together.
[0048] As shown in FIG. **1**, the elastic member **43** is sandwiched between the hammer **41** and the planet gear mechanism **92**. The elastic member **43** of the present embodiment is a conical coil spring. The transmission mechanism **4** further includes: a plurality of (in FIG. **1**, two) balls (second balls) **48** sandwiched between the hammer **41** and the elastic member **43**; and a ring **49**. Thus, the hammer **41** is rotatable with respect to the elastic member **43**. The hammer **41** receives a force toward the output shaft **2** (a forward force) from the elastic member **43** in a direction along the axial direction D**1** of the output shaft **2**.
[0049] In the following description, it is referred to as “the hammer **41** moves forward” that that the

hammer **41** moves in the axial direction D**1** of the output shaft **2** toward the output shaft **2**. Moreover, in the following description, it is referred to as "the hammer **41** moves backward" that the hammer **41** moves in the axial direction D**1** of the output shaft **2** away from the output shaft **2**.

[0050] The impact mechanism performs the impact operation when a torque condition regarding the magnitude of torque applied to the output shaft **2** (hereinafter referred to as load torque) is satisfied. The impact operation is an operation of applying the impacting force from the hammer **41** to the anvil **42**. In the present embodiment, the torque condition is that the load torque increases to be greater than a prescribed value. That is, as the load torque increases, a component of a force which is generated between the hammer **41** and the anvil **42** and which moves the hammer **41** backward also increases. When the load torque increases to be greater than or equal to the prescribed value, the hammer **41** moves backward while compressing the elastic member **43**. Then, the hammer **41** moves backward, and thereby, the hammer **41** rotates while the plurality of hammer projections **411** climb over the plurality of anvil projections **421**. Thereafter, the hammer **41** receives a return force from the elastic member **43** to move forward. Then, when the drive shaft **3** makes a substantially half turn, the plurality of hammer projections **411** collide with side surfaces of the plurality of anvil projections **421**. In the impact mechanism, each time the drive shaft **3** makes a substantially half turn, the plurality of hammer projections **411** collide with the plurality of anvil projections **421**. That is, each time the drive shaft **3** makes a substantially half turn, the hammer **41** applies the impacting force (rotational striking force) to the anvil **42**.

[0051] Thus, in the impact mechanism, the hammer **41** repeatedly collides with the anvil **42**. The torque resulting from the collision enables a fastening part to be tightly fastened as compared with the case without the collision.

(1-2-6) Output Shaft

[0052] As shown in FIG. **6**, the output shaft **2** has a columnar shape. The axial direction D**1** of the output shaft **2** is the forward/backward direction. The output shaft **2** protrudes forward from the anvil body **420**.

[0053] The output shaft **2** is inserted into the through hole **713** formed in the first part and the cylindrical part **732** of the third part **73**. The output shaft **2** has a front portion protruding from the through hole **713** formed in the first part. That is, the front portion of the output shaft **2** is exposed outside the housing **7**.

[0054] As shown in FIG. **1**, the output shaft **2** has the holder **21** configured to hold the tip tool B**1**. The holder **21** is provided at an end of the output shaft **2** protruding from the through hole **713** formed in the first part. That is, the holder **21** is provided at a front end of the output shaft **2**. The output shaft **2** is rotated together with the tip tool B**1** by the driver **8**.

[0055] In the present embodiment, the tip tool B**1** (see FIGS. **1** and **2**) is detachably attached to the holder **21** via a chuck. Note that the tip tool B**1** may be detachably attached directly to the holder **21**. Alternatively, the holder **21** and the tip tool B**1** may be formed integrally with each other. The tip tool B**1** is, for example, a driver bit. The tip tool B**1** fitted in the fastening part rotates, thereby enabling an operation such as fastening or loosening the fastening part.

(1-2-7) Bearing

[0056] The plurality of bearings **5** rotatably support the output shaft **2**. In other words, the plurality of bearings **5** pivotally support the output shaft **2**. Specifically, the plurality of bearings **5** are fit between the cylindrical part **732** of the housing **7** and the output shaft **2**, thereby rotatably supporting the output shaft **2** as shown in FIG. **5**.

[0057] The first embodiment includes two bearings **5**. The two bearings **5** are aligned in the axial direction D**1** (forward/backward direction) of the output shaft in the cylindrical part **732** of the housing **7**. In the first embodiment, the bearing **5** on the front side is a ball bearing **51**, and the bearing **5** on the rear side is a slide bearing **52**. The ball bearing **51** is disposed between an inner surface of the cylindrical part **732** forward of the projection **76** and the output shaft **2**. In contrast, the slide bearing **52** is disposed between the inner surface of the cylindrical part **732** backward of the projection **76** and the output shaft **2**.

[0058] As shown in FIG. **5**, the ball bearing **51** includes an inner ring **511**, an outer ring **512**, and a plurality of balls **513**. The inner ring **511** and the outer ring **512** are circularly annular members. The inner ring **511** is disposed inside the outer ring **512**. That is, the inner ring **511** has an outer diameter smaller than an inner diameter of the outer ring **512**.

[0059] Moreover, the inner ring **511** has an inner diameter substantially equal to an outer diameter of the output shaft **2** or slightly larger than the outer diameter of the output shaft **2**. In contrast, the outer ring **512** has an outer diameter substantially equal to an inner diameter of the cylindrical part **732** forward of the projection **76** or slightly smaller than the inner diameter of the cylindrical part **732** forward of the projection **76**.

[0060] The inner ring **511** has a groove **5111** formed in the outer circumferential surface thereof. Similarly, the outer ring **512** has a groove **5121** formed in the inner circumferential surface thereof. The plurality of balls **513** are sandwiched by the groove **5111** of the inner ring **511** and the groove **5121** of the outer ring **512** at equal intervals.

[0061] Thus, when the output shaft **2** rotates, the inner ring **511** rotates together with the output shaft **2**, and the plurality of balls **513** roll between the groove **5111** of the inner ring **511** and the groove **5121** of the outer ring **512**. In contrast, also when the output shaft **2** rotates, the outer ring **512** does not rotate and is fixed to the cylindrical part **732** of the housing **7**. That is, when the output shaft **2** rotates, the inner ring **511** rotates relative to the outer ring **512**.

[0062] The slide bearing **52** is formed from one circularly annular member. The slide bearing **52** has an inner diameter substantially equal to the outer diameter of the output shaft **2** or slightly larger than the outer diameter of the output shaft **2**. In contrast, the slide bearing **52** has an outer diameter substantially equal to the inner diameter of the cylindrical part **732** backward of the projection **76** or slightly smaller than the inner diameter of the cylindrical part **732** backward of the projection **76**. Between the slide bearing **52** and the output shaft **2**, a lubricant agent such as grease or lubricating oil is applied. Also when the output shaft **2** rotates, the slide bearing **52** does not rotate and is fixed to the cylindrical part **732** of the housing **7**.

(1-2-8) Seal Member

[0063] The seal member **6** is a disk-shaped plate member. As shown in FIG. **1**, the seal member **6** has the through hole **61** into which the output shaft **2** is inserted. That is, the seal member **6** has a circularly annular shape as shown in FIGS. **3** and **4**. The seal member **6** has an inner diameter substantially equal to the outer diameter of the output shaft **2**. Therefore, the inner circumferential surface **610** of the through hole **61** of the seal member **6** is in contact with the outer circumferential surface **20** of the output shaft **2**. In contrast, the seal member **6** has an outer diameter slightly smaller than an inner diameter of the projection **76**. Thus, a gap is provided between the seal member **6** and the projection **76** of the housing **7**.

[0064] The seal member **6** of the first embodiment is made of an oil absorbing material having oil absorptiveness. As used herein, the “oil absorptiveness” is a property of absorbing oil such as grease or lubricating oil. The oil absorbing material is, for example, felt. The seal member **6** formed from the felt has a function of capturing a foreign substance which is about to pass through the seal member **6**. Note that the oil absorbing material for the seal member **6** is not limited to the felt but may be unwoven cloth, paper, woven fabric, or knit fabric.

[0065] The seal member **6** is disposed in at least one space of spaces each between two adjacent bearings **5** of the plurality of bearings **5**. In the first embodiment, the seal member **6** is disposed in a space between the ball bearing **51** and the slide bearing **52** as shown in FIG. **1**. More specifically, the seal member **6** is disposed in the space between the ball bearing **51** and the slide bearing **52** such that the inner circumferential surface **610** of the through hole **61** is in contact with the outer circumferential surface **20** of the output shaft **2** as shown in FIG. **1**. Therefore, the seal member **6** of the first embodiment rotates together with the output shaft **2**. Note that the seal member **6** does not rotate together with the output shaft **2** and may be fixed to the housing **7**.

[0066] In the first embodiment, the dimension of the seal member **6** in the axial direction D**1** is smaller than the dimension of the projection **76** of the housing **7** in the axial direction D**1** as shown in FIG. **5**. Therefore, the seal member **6** of the first embodiment is spaced from both the ball bearing **51** and the slide bearing **52**. That is, in the first embodiment, the seal member **6** is not compressed along the axial direction D**1** by the ball bearing **51** and the slide bearing **52**. Therefore, there is the advantage that the seal member **6** formed from a felt member efficiently absorbs the lubricant agent which is about to pass through the seal member **6** or efficiently captures the foreign substance which is about to pass through the seal member **6**.
[0067] The seal member **6** suppresses a foreign substance present outside the housing **7** from entering the housing **7**. As used herein, the "foreign substances" are, for example, powder dust such as iron powder or liquid such as rainwater. This configuration provides the advantage of reducing the possibility that the foreign substance causes a failure in, or a malfunction of, the electric tool **1**.
[0068] The seal member **6** suppresses the lubricant agent present in the housing **7** from leaking out of the housing **7**. As used herein, the "lubricant agent" is, for example, grease or lubricating oil and is applied between the slide bearing **52** and the output shaft **2**. Moreover, the "lubricant agent" is not limited to an agent applied between the slide bearing **52** and the output shaft **2** but may be an agent applied to the transmission mechanism **4** or the driver **8**. That is, a location to which the "lubricant agent" is to be applied is not limited to a particular location in the housing **7**. This configuration provides the advantage of reducing the possibility that a work target or a fastening part is stained with the lubricant agent.
(1-2-9) Operating Member
[0069] As shown in FIGS. **1** and **2**, the operating member **93** protrudes from the grip **74**. The operating member **93** receives an operation for controlling the rotation of the rotary shaft **811** of the driver **8**. The operation of pulling the operating member **93** can switch on and off the driver **8**. Moreover, the rotational velocity of the rotary shaft is adjustable by a pulled amount indicating how deep the operating member **93** is pulled. As the pulled amount increases, the rotational velocity of the rotary shaft increases.
(1-2-10) Controller
[0070] The controller **91** rotates or stops the rotary shaft **811** of the driver **8** and controls the rotational velocity of the rotary shaft in accordance with the pulled amount indicating how deep the operating member **93** is pulled.
[0071] The controller **91** includes, for example, a microcontroller. The controller **91** can change the rotational velocity of the rotary shaft **811**, thereby changing the rotational velocity of the output shaft **2** and the tip tool B**1**. The controller **91** changes, for example, electric power to be supplied to the driver **8**, thereby changing the rotational velocity of the rotary shaft **811**.
(1-3) Variations
[0072] Variations of the first embodiment described above will be enumerated below. The variations described below may be accordingly combined with each other.
[0073] In the first embodiment described above, the bearing **5** on the front side is the ball bearing **51**, and the bearing **5** on the rear side is the slide bearing **52**. However, both of the two bearings **5** may be ball bearings **51** or may be slide bearings **52**.
[0074] In the first embodiment described above, the seal member **6** is formed from the felt and thus has both oil absorptiveness and the function of capturing the foreign substance which is about to pass through the seal member **6**. However, the seal member **6** may have only oil absorptiveness or may have only the function of capturing the foreign substance.
[0075] Moreover, in the first embodiment described above, the seal member **6** is spaced from both the ball bearing **51** and the slide bearing **52**. However, the seal member **6** may be spaced from one of the ball bearing **51** and the slide bearing **52** and may be in contact with the other of the ball bearing **51** and the slide bearing **52**. That is, the seal member **6** may be spaced from at least one of the ball bearing **51** or the slide bearing **52**.

[0076] Moreover, in the first embodiment described above, the seal member **6** is not compressed along the axial direction D**1** by the ball bearing **51** and the slide bearing **52** but may be compressed along the axial direction D**1** by the ball bearing **51** and the slide bearing **52**. That is, the seal member **6** may be in contact with both the ball bearing **51** and the slide bearing **52**.
[0077] Moreover, in the first embodiment described above, the outer diameter of the seal member **6** is slightly smaller than the inner diameter of the projection **76**. However, the outer diameter of the seal member **6** may be substantially equal to the inner diameter of the projection **76**. That is, the seal member **6** may be in contact with the projection **76** of the housing **7**.
[0078] In the first embodiment described above, the first part **71** and the third part **73** of the housing **7** are separate components but being the separate components is not essential. The first part **71** and the third part **73** may be formed as a single component.
(2) Second Embodiment
(2-1) Overview
[0079] With reference to FIG. **7**, an electric tool **1***a* according to a second embodiment will be described below. Components similar to those in the first embodiment are denoted by the same reference signs as those in the first embodiment, and the description thereof is omitted.
[0080] The electric tool **1***a* of the second embodiment is different from the electric tool **1** of the first embodiment in that a seal member **6***a* is made of a rubber material.
(2-2) Details
[0081] The seal member **6***a* of the second embodiment is made of a rubber material. This configuration provides the effect that the seal member **6***a* can seal between a cylindrical part **732** of a housing **7** and an output shaft **2**. Therefore, there is the advantage that the seal member **6***a* can suppress a lubricant agent present in the housing **7** from leaking out of the housing **7** and a foreign substance present outside the housing **7** from entering the housing **7**. As used in the present disclosure, the “rubber material” is a material having the property (elasticity) that when a force is applied to the material, the material deforms along the direction of the force thus applied, and the material returns to its original shape when the force causing the deformation is removed. In other words, the “rubber material” is an elastic material.
[0082] Similarly to the seal member **6** of the first embodiment, the seal member **6***a* of the second embodiment is a disk-shaped plate member having a through hole **61** into which the output shaft **2** is inserted. That is, the seal member **6***a* has a circularly annular shape. Moreover, the seal member **6***a* has an inner diameter substantially equal to an outer diameter of the output shaft **2**. Therefore, an inner circumferential surface **610** of the through hole **61** of the seal member **6***a* is in contact with an outer circumferential surface **20** of the output shaft **2**. In contrast, the seal member **6***a* has an outer diameter slightly smaller than an inner diameter of a projection **76**. Therefore, a gap is provided between the seal member **6***a* and the projection **76** of the housing **7**.
[0083] In the second embodiment, the dimension of the seal member **6***a* in an axial direction D**1** is greater than the dimension of the projection **76** in the axial direction D**1**. Therefore, the seal member **6***a* is in contact with each of two adjacent bearings **5**. Specifically, the seal member **6***a* of the second embodiment is in contact with each of a ball bearing **51** and a slide bearing **52** as shown in FIG. **7**. That is, the seal member **6***a* is held between the ball bearing **51** and the slide bearing **52** along the axial direction D**1**. The seal member **6***a* held between the ball bearing **51** and the slide bearing **52** is compressed along the axial direction D**1**. More specifically, the seal member **6***a* is compressed along the axial direction D**1** so that the dimension in the axial direction D**1** of the seal member **6***a* held between the ball bearing **51** and the slide bearing **52** becomes substantially equal to the dimension in the axial direction D**1** of the projection **76**. This configuration provides the effect that the seal member **6***a* can further seal between the cylindrical part **732** of the housing **7** and the output shaft **2**. Therefore, there is the advantage that the seal member **6***a* can further suppress a lubricant agent present in the housing **7** from leaking out of the housing **7** and a foreign substance present outside the housing **7** from entering the housing **7**.

(2-3) Variations
[0084] Variations of the second embodiment described above will be enumerated below. The variations described below may be accordingly combined with each other.
[0085] The seal member **6***a* may rotate together with the output shaft **2** or does not have to rotate together with the output shaft **2** and may be fixed to the housing **7**.
[0086] In the second embodiment described above, similarly to the first embodiment, the bearing **5** on the front side is a ball bearing **51**, and the bearing **5** on the rear side is a slide bearing **52** as shown in FIG. **6**. However, both of the two bearings **5** may be ball bearings **51** or may be slide bearings **52**. When both the two bearings **5** are the ball bearing **51**, the seal member **6***a* desirably rotate together with the output shaft **2**. In contrast, when both the two bearings **5** are the slide bearings **52**, the seal member **6***a* does not rotate together with the output shaft **2** and is desirably fixed to the housing **7**.
(Summary)
[0087] An electric tool (**1**, **1***a*) of a first aspect includes an output shaft (**2**), a drive shaft (**3**), a transmission mechanism (**4**), a plurality of bearings (**5**), and a seal member (**6**, **6***a*). The output shaft (**2**) includes a holder (**21**) configured to hold a tip tool (B**1**). The drive shaft (**3**) is configured to be rotated by a driver (**8**). The transmission mechanism (**4**) is disposed between the drive shaft (**3**) and the output shaft (**2**) to transmit rotation of the drive shaft (**3**) to the output shaft (**2**). The plurality of bearings (**5**) are aligned in an axial direction (D**1**) of the output shaft (**2**) to rotatably support the output shaft (**2**). The seal member (**6**, **6***a*) has a through hole (**61**) in which the output shaft (**2**) is inserted. The seal member (**6**, **6***a*) is disposed, in at least one space of spaces each between two adjacent bearings (**5**) of the plurality of bearings (**5**), such that an inner circumferential surface (**610**) of the through hole (**61**) is in contact with an outer circumferential surface (**20**) of the output shaft (**2**).
[0088] This aspect provides the advantage that the seal member (**6**, **6***a*) has high durability.
[0089] An electric tool (**1**, **1***a*) of a second aspect referring to the first aspect further includes a housing (**7**) in which at least part of the output shaft (**2**) is housed. The housing (**7**) supports the plurality of bearings (**5**).
[0090] This aspect provides the advantage that the seal member (**6**, **6***a*) can be suppressed from being abraded by the output shaft (**2**).
[0091] In an electric tool (**1**, **1***a*) of a third aspect referring to the second aspect, the seal member (**6**, **6***a*) is configured to suppress a foreign substance present outside the housing (**7**) from entering the housing (**7**).
[0092] This aspect provides the advantage of reducing the possibility that the foreign substance causes a failure in, or a malfunction of, the electric tool (**1**, **1***a*).
[0093] In an electric tool (**1**, **1***a*) of a fourth aspect referring to the second aspect, the seal member (**6**, **6***a*) is configured to suppress a lubricant agent present in the housing (**7**) from leaking out of the housing (**7**).
[0094] This aspect provides the advantage of reducing the possibility that a work target or a fastening part from being stained with the lubricant agent.
[0095] In an electric tool (**1**, **1***a*) of a fifth aspect referring to any one of the first to fourth aspects, the transmission mechanism (**4**) includes a hammer (**41**) and an anvil (**42**). The hammer (**41**) is fitted to an outer circumferential surface (**20**) of the drive shaft (**3**) such that the hammer (**41**) is rotatable and is movable forward and backward, the hammer (**41**) including a plurality of hammer projections (**411**). The anvil (**42**) includes a plurality of anvil projections (**421**) engageable with the plurality of hammer projections (**411**), the anvil (**42**) being mechanically connected to the output shaft (**2**).
[0096] This aspect provides the advantage that the seal member (**6**, **6***a*) of the impact electric tool can be suppressed from being abraded.
[0097] In an electric tool (**1**) of a sixth aspect referring to any one of the first to fifth aspects, the

seal member (**6**) is made of an oil absorbing material having oil absorptiveness.
[0098] This aspect provides the advantage that oil, such as grease or lubricating oil, present in the housing (**7**) can be absorbed.
[0099] In an electric tool (**1**) of a seventh aspect referring to the sixth aspect, the oil absorbing material is felt.
[0100] This aspect provides the advantage that the foreign substance which is about to pass though the seal member (**6**) can be captured.
[0101] An electric tool (**1**) of an eighth aspect referring to the seventh aspect further includes a housing (**7**) in which at least part of the output shaft (**2**) is housed. The housing (**7**) includes a projection (**76**) located in the at least one space in which the seal member (**6**) is disposed.
[0102] This aspect provides the advantages that the seal member (**6**) is easily provided.
[0103] In an electric tool (**1**) of a ninth aspect referring to the eighth aspect, a dimension of the seal member (**6**) in the axial direction (D**1**) is smaller than a dimension of the projection (**76**) in the axial direction (D**1**).
[0104] This aspect provides the advantage that the seal member (**6**) can efficiently absorb the oil or efficiently capture the foreign substance.
[0105] In an electric tool (**1***a*) of a tenth aspect referring to any one of the first to fifth aspects, the seal member (**6***a*) is made of a rubber material.
[0106] This aspect provides the advantage that the seal member (**6***a*) can seal between the housing (**7**) and the output shaft (**2**).
[0107] An electric tool (**1***a*) of an eleventh aspect referring to the tenth aspect further includes a housing (**7**) in which at least part of the output shaft (**2**) is housed. The housing (**7**) has a projection (**76**) located in the at least one space in which the seal member (**6***a*) is disposed.
[0108] This aspect provides the advantage that the seal member (**6***a*) is easily provided.
[0109] In an electric tool (**1***a*) of a twelfth aspect referring to the eleventh aspect, a dimension of the seal member (**6***a*) in the axial direction (D**1**) is greater than a dimension of the projection (**76**) in the axial direction (D**1**).
[0110] This aspect provides the advantage that the seal member (**6***a*) can further seal between the housing (**7**) and the output shaft (**2**).
[0111] An electric tool (**1***a*) of a thirteenth aspect referring to the twelfth aspect, the seal member (**6***a*) is in contact with each of the two adjacent bearings (**5**).
[0112] This aspect provides the advantage that the seal member (**6***a*) can further seal between the housing (**7**) and the output shaft (**2**).
[0113] Note that the first and second embodiments described above are mere examples of the present invention. Therefore, the present invention is not limited to the first and second embodiments described above. Even in configurations other than that illustrated in these embodiments, various modifications may be made depending on design and the like without departing from the technical idea of the present invention.
REFERENCE SIGNS LIST
[0114] **1**, **1***a* Electric Tool [0115] **2** Output Shaft [0116] **20** Outer Circumferential Surface [0117] **21** Holder [0118] **3** Drive Shaft [0119] **31** Groove [0120] **4** Transmission Mechanism [0121] **41** Hammer [0122] **411** Hammer Projection [0123] **42** Anvil [0124] **421** Anvil Projection [0125] **5** Bearing [0126] **51** Ball Bearing [0127] **52** Slide Bearing [0128] **6**, **6***a* Seal Member [0129] **61** Through Hole [0130] **610** Inner Circumferential Surface [0131] **7** Housing [0132] **76** Projection [0133] B**1** Tip Tool [0134] D**1** Axial Direction

Claims

1. An electric tool comprising: an output shaft including a holder configured to hold a tip tool; a drive shaft configured to be rotated by a driver; a transmission mechanism disposed between the drive shaft and the output shaft to transmit rotation of the drive shaft to the output shaft; a plurality of bearings aligned in an axial direction of the output shaft to rotatably support the output shaft; and a seal member having a through hole in which the output shaft is inserted, the seal member being disposed, in at least one space of spaces each between two adjacent bearings of the plurality of bearings, such that an inner circumferential surface of the through hole is in contact with an outer circumferential surface of the output shaft.

2. The electric tool of claim 1, further comprising: a housing in which at least part of the output shaft is housed, wherein the housing supports the plurality of bearings.

3. The electric tool of claim 2, wherein the seal member is configured to suppress a foreign substance present outside the housing from entering the housing.

4. The electric tool of claim 2, wherein the seal member is configured to suppress a lubricant agent present in the housing from leaking out of the housing.

5. The electric tool of claim 1, wherein the transmission mechanism includes a hammer fitted to an outer circumferential surface of the drive shaft such that the hammer is rotatable and is movable forward and backward, the hammer including a plurality of hammer projections and an anvil including a plurality of anvil projections engageable with the plurality of hammer projections, the anvil being mechanically connected to the output shaft.

6. The electric tool of claim 1, wherein the seal member is made of an oil absorbing material having oil absorptiveness.

7. The electric tool of claim 6, wherein the oil absorbing material is felt.

8. The electric tool of claim 7, further comprising a housing in which at least part of the output shaft is housed, wherein the housing includes a projection located in the at least one space in which the seal member is disposed.

9. The electric tool of claim 8, wherein a dimension of the seal member in the axial direction is smaller than a dimension of the projection in the axial direction.

10. The electric tool of claim 1, wherein the seal member is made of a rubber material.

11. The electric tool of claim 10, further comprising a housing in which at least part of the output shaft is housed, wherein the housing has a projection located in the at least one space in which the seal member is disposed.

12. The electric tool of claim 11, wherein a dimension of the seal member in the axial direction is greater than a dimension of the projection in the axial direction.

13. The electric tool of claim 12, wherein the seal member is in contact with each of the two adjacent bearings.

14. The electric tool of claim 2, wherein the transmission mechanism includes a hammer fitted to an outer circumferential surface of the drive shaft such that the hammer is rotatable and is movable forward and backward, the hammer including a plurality of hammer projections and an anvil including a plurality of anvil projections engageable with the plurality of hammer projections, the anvil being mechanically connected to the output shaft.

15. The electric tool of claim 2, wherein the seal member is made of an oil absorbing material having oil absorptiveness.

16. The electric tool of claim 15, wherein the oil absorbing material is felt.

17. The electric tool of claim 16, further comprising a housing in which at least part of the output shaft is housed, wherein the housing includes a projection located in the at least one space in which the seal member is disposed.

18. The electric tool of claim 17, wherein a dimension of the seal member in the axial direction is smaller than a dimension of the projection in the axial direction.

19. The electric tool of claim 2, wherein the seal member is made of a rubber material.

20. The electric tool of claim 19, further comprising a housing in which at least part of the output shaft is housed, wherein the housing has a projection located in the at least one space in which the seal member is disposed.