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### Electric working machine

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#### Abstract

An electric working machine may include an output shaft, a rotary blade attached to the output shaft, an output pulley fixed to the output shaft, an input shaft, an input pulley fixed to the input shaft, a transmission belt wrapped around the input pulley and the output pulley, an electric motor including a motor shaft and configured to rotate the motor shaft, a speed reducer configured to reduce a speed of rotation of the motor shaft and transmit the rotation to the input shaft, and a housing that houses the electric motor and the speed reducer, and rotatably supports the input shaft and the output shaft. A rotation axis of the motor shaft may be inclined with respect to a direction which is along a rotation axis of the output shaft.

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**Background/Summary**

**CROSS-REFERENCE TO RELATED APPLICATION**

(1) This application claims priority to Japanese Patent Application No. 2022-1684, filed on Jan. 7, 2022, the entire contents of which are incorporated herein by reference.

**TECHNICAL FIELD**

(2) The technique disclosed herein relates to an electric working machine.

## BACKGROUND

(3) Japanese Patent Application Publication No. 2016-43475 describes an electric working machine including: an output shaft; a rotary blade attached to the output shaft; an output pulley fixed to the output shaft; an input shaft; an input pulley fixed to the input shaft; a transmission belt wrapped around the input pulley and the output pulley; an electric motor including a motor shaft and configured to rotate the motor shaft; a speed reducer configured to reduce a speed of rotation of the motor shaft and transmit the rotation to the input shaft; and a housing that houses the electric motor and the speed reducer, and rotatably supports the input shaft and the output shaft.

## SUMMARY

(4) In a conventional electric working machine, a rotation axis of a motor shaft is arranged along a rotation axis of an output shaft, as described in Japanese Patent Application Publication No. 2016-43475. In general, a longitudinal direction of an electric motor coincides with a direction of the rotation axis of the motor shaft, thus the longitudinal direction of the electric motor of the conventional electric working machine extends along the rotation axis of the output shaft. Due to this, it was impossible to downsize the electric working machine in the direction of the rotation axis of the output shaft (axial direction of a rotary blade). The present disclosure provides a technique which enables downsizing of an electric working machine in a direction of a rotation axis of an output shaft.

(5) An electric working machine disclosed herein may comprise: an output shaft; a rotary blade attached to the output shaft; an output pulley fixed to the output shaft; an input shaft; an input pulley fixed to the input shaft; a transmission belt wrapped around the input pulley and the output pulley; an electric motor comprising a motor shaft and configured to rotate the motor shaft; a speed reducer configured to reduce a speed of a rotation of the motor shaft and transmit the rotation to the input shaft; and a housing that houses the electric motor and the speed reducer, and rotatably supports the input shaft and the output shaft. A rotation axis of the motor shaft may be inclined with respect to a direction which is along a rotation axis of the output shaft.

(6) According to the above configuration, a longitudinal direction of the electric motor is inclined with respect to the direction which is along the rotation axis of the output shaft. Thus, the electric working machine can be downsized in the direction of the rotation axis of the output shaft.

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## Description

### BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. 1 is a perspective view of an entire power cutter **10** of an embodiment viewed from the front right upper side.

(2) FIG. 2 is a side view of a structure of the power cutter **10** of the embodiment within a housing **14** viewed from the right side.

(3) FIG. 3 is an electric motor **4**, a power transmission part **8** and a rotary blade **12** arranged as illustrated in FIG. 2 in the power cutter **10** of the embodiment.

(4) FIG. 4 is a view illustrating positional relationships between the electric motor **4**, the rotary blade **12**, a battery interface **24** and a plurality of battery packs **60** when the power cutter **10** of the embodiment is viewed from the rear side.

(5) FIG. 5 is an enlarged view of a rear handle **20** included in the power cutter **10** of the embodiment viewed from the rear left upper side.

(6) FIG. 6 is a top view illustrating a position of the gravity center GT of the power cutter **10** of the embodiment.

(7) FIG. 7 is an enlarged view illustrating a fall-out suppression mechanism of a transmission belt **83** of the power cutter **10** of the embodiment and the state in which rotation of an output shaft **85** is

allowed at a lock mechanism of the output shaft **85**.

(8) FIG. **8** is a disassembled view of an output pulley **84** included in the power cutter **10** of the embodiment.

(9) FIG. **9** is an enlarged view illustrating the fall-out suppression mechanism of the transmission belt **83** of the power cutter **10** of the embodiment and the state in which rotation of the output shaft **85** is prohibited at the lock mechanism of the output shaft **85**.

#### DETAILED DESCRIPTION

(10) Representative, non-limiting examples of the present disclosure will now be described in further detail with reference to the attached drawings. This detailed description is merely intended to teach a person of skill in the art further details for practicing aspects of the present teachings and is not intended to limit the scope of the present disclosure. Furthermore, each of the additional features and teachings disclosed below may be utilized separately or in conjunction with other features and teachings to provide improved electric working machines as well as methods for using and manufacturing the same.

(11) Moreover, combinations of features and steps disclosed in the following detailed description may not be necessary to practice the present disclosure in the broadest sense, and are instead taught merely to particularly describe representative examples of the present disclosure. Furthermore, various features of the above-described and below-described representative examples, as well as the various independent and dependent claims, may be combined in ways that are not specifically and explicitly enumerated in order to provide additional useful embodiments of the present teachings.

(12) All features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original written disclosure, as well as for the purpose of restricting the claimed subject matter, independent of the compositions of the features in the embodiments and/or the claims. In addition, all value ranges or indications of groups of entities are intended to disclose every possible intermediate value or intermediate entity for the purpose of original written disclosure, as well as for the purpose of restricting the claimed subject matter.

(13) In one or more embodiments, the rotation axis of the motor shaft may be orthogonal to the direction which is along the rotation axis of the output shaft.

(14) According to the above configuration, the longitudinal direction of the electric motor is substantially orthogonal to the rotation axis of the output shaft. Thus, the electric working machine can be downsized in the direction of the rotation axis of the output shaft (axial direction of the rotary blade).

(15) In one or more embodiments, when the electric working machine is placed on a placement surface, the rotation axis of the output shaft may be arranged along a left-right direction in a vicinity of a front end of the housing, and the rotation axis of the motor shaft may be inclined at an angle within a range from  $-45^{\circ}$  to  $45^{\circ}$  with respect to an up-down direction, in a side view of the electric working machine. In the present disclosure, an angle at which the rotation axis of the motor shaft is inclined with respect to the up-down direction will be explained describing the angle formed clockwise as a positive angle and the angle formed counterclockwise as a negative angle when the electric working machine is viewed from the right side.

(16) According to the above configuration, in the state where the electric working machine is placed on the placement surface, the electric working machine can be downsized in the left-right direction and also in the front-rear direction.

(17) In one or more embodiments, when the electric working machine is placed on the placement surface, the rotation axis of the motor shaft may be inclined with respect to the up-down direction such that the rotation axis of the motor shaft leans forward as it extends downward, in the side view of the electric working machine.

(18) According to the above configuration, when a user uses the electric working machine with the

rotary blade directed downward, the rotation axis of the motor shaft tends to be along the up-down direction. Consequently, the electric working machine can be downsized in the front-rear direction in the state where the user uses the electric working machine with the rotary blade directed downward. Accordingly, maneuverability for the user can be enhanced.

(19) In one or more embodiments, in the side view of the electric working machine, the rotation axis of the motor shaft may be substantially orthogonal to a line passing through the rotation axis of the output shaft and the rotation axis of the input shaft.

(20) According to the above configuration, the rotation axis of the motor shaft is substantially orthogonal to the radial direction of the rotary blade (i.e., substantially parallel to a tangential direction of the rotary blade). In other words, the longitudinal direction of the electric motor is substantially orthogonal to the radial direction of the rotary blade (i.e., substantially parallel to the tangential direction of the rotary blade). According to the above configuration, the electric working machine can be downsized in the radial direction of the rotary blade.

(21) In one or more embodiments, the electric working machine may further comprise: a first handle disposed on the housing and configured to be grasped by a user with one hand; and a second handle disposed on the housing and configured to be grasped by the user with the other hand. When the electric working machine is placed on the placement surface, the first handle may be offset rearwardly from the rotary blade and forwardly from the electric motor, and the second handle may be offset rearwardly from the electric motor.

(22) In general, maneuverability for the user increases as a position of the gravity center of the electric working machine is closer to a position of the gravity center of the user's body. Further, since the electric motor has a relatively large weight among components of the electric working machine, a position at which the electric motor is disposed greatly changes the position of the gravity center of the electric working machine. According to the above configuration, since the electric motor is disposed between the first handle and the second handle, the position of the gravity center of the electric working machine tends to be positioned close to the gravity center of the user's body when the user grasps the first handle and the second handle to use the electric working machine. Thus, maneuverability for the user can further be increased.

(23) In one or more embodiments, the electric working machine may further comprise at least one battery pack configured to be attached to and detached from the housing and supply power to the electric motor.

(24) When the electric working machine is driven using power from an external power source, it is necessary to attach a power cable to the electric working machine, which may decrease the maneuverability. According to the above configuration, it is not necessary to attach the power cable to the electric working machine, by which the maneuverability for the user can further be enhanced. Further, since it is possible to use the electric working machine even in a place where power cannot be externally supplied, user convenience can also be enhanced.

(25) In one or more embodiments, when the electric working machine is placed on the placement surface, the at least one battery pack may be offset rearwardly from the electric motor and forwardly from the second handle.

(26) Since the battery pack has a relatively large weight among the components of the electric working machine, a position at which the battery pack is disposed greatly changes the position of the gravity center of the electric working machine. According to the above configuration, since at least one of the battery packs is disposed between the first handle and the second handle, the position of the gravity center of the electric working machine tends to be positioned close to the gravity center of the user's body when the user grasps the first handle and the second handle to use the electric working machine. Thus, maneuverability for the user can further be increased.

(27) In one or more embodiments, in a rear view of the electric working machine, when the electric working machine is placed on the placement surface, the at least one battery pack and the electric motor may at least partially overlap.

(28) According to the above configuration, the electric motor and the at least one battery pack are disposed close to each other in the left-right direction and the up-down direction. According to the above configuration, in the state where the electric working machine is placed on the placement surface, the electric working machine can be downsized in the left-right direction and also in the up-down direction.

(29) In one or more embodiments, when the electric working machine is placed on the placement surface, in a rear view of the electric working machine, the rotary blade and the electric motor may at least partially overlap.

(30) According to the above configuration, the rotary blade and the electric motor are disposed close to each other in the left-right direction and the up-down direction. According to the above configuration, in the state where the electric working machine is placed on the placement surface, the electric working machine can be downsized in the left-right direction and also in the up-down direction.

(31) In one or more embodiments, the output pulley includes a first rotation member and a second rotation member fixed adjacent to the first rotation member in the direction of the rotation axis of the output shaft. The first rotation member includes a first column portion around which the transmission belt is wrapped and a flange extending radially outward from an end of the first column portion on a side not adjacent to the second rotation member. The second rotation member includes a second column portion whose outer diameter is greater than the first column portion, and a base extending radially inward from an end of the second column portion on a side adjacent to the first rotation member. The second column portion includes a plurality of lock holes defined at a predetermined interval in a circumferential direction. The electric working machine includes a lock pin which is movably held by the housing and configured to be inserted into any one of the plurality of lock holes.

(32) If a mechanism which suppresses the transmission belt from falling off from the output pulley and a mechanism to lock rotation of the output shaft are disposed in the output pulley, which is seamlessly and integrally formed, the output pulley would be formed into a complicated shape. Thus, when the electric working machine is assembled, attachment of the output pulley may be difficult. According to the above configuration, the output pulley is constituted of the first rotation member and the second rotation member. Thus, by separately attaching the first rotation member and the second rotation member at the time of assembly of the electric working machine, the output pulley can be easily attached. According to the above configuration, when the transmission belt wrapped around the first column portion moves in the direction of the rotation axis of the output shaft, the transmission belt abuts and is stopped by the flange of the first rotation member or the base of the second rotation member. Thus, the transmission belt is suppressed from falling off from the first column portion. Further, according to the above configuration, when the output pulley rotates with respect to the housing with the lock pin inserted into any one of the plurality of lock holes, the second rotation member abuts and is stopped by the lock pin. Thus, by inserting the lock pin into any one of the plurality of lock holes, the rotation of the output shaft can be locked.

(33) In one or more embodiments, the first column portion and the flange are seamlessly and integrally formed. The second column portion and the base are seamlessly and integrally formed. Aluminum alloy is used for the first rotation member. Iron is used for the second rotation member.

(34) Since the output pulley is a member which rotates with the output shaft, it is desirable to use a material having a small mass for the output pulley. On the other hand, given that the lock pin is inserted into the output pulley to lock the rotation of the output shaft, it is desirable to use a material having rigidity and high strength for the output pulley. According to the above configuration, it is possible to secure required rigidity and strength by using iron for the second rotation member to which the rock pin is inserted and also reduce the entire weight of the output pulley by using an aluminum alloy for the first rotation member around which the transmission belt is wrapped.

## Embodiment

### (35) (Configuration of Power Cutter 10)

(36) As illustrated in FIG. 1, a power cutter 10 which is an example of an electric working machine is a handheld power tool and used to cut an object, mainly such as stone and iron. The power cutter 10 includes a rotary blade 12, a housing body 14a, a blade arm 14b, a blade cover 16, a front handle 18, a rear handle 20, a water supply hose 50, a right battery pack 60a, a left battery pack 60b and a guide roller 70. In the present disclosure, the right battery pack 60a and the left battery pack 60b may collectively be referred to as “a plurality of battery packs 60”. Further, the housing body 14a and the blade arm 14b may collectively be referred to as “housing 14”.

(37) As illustrated in FIG. 2, the power cutter 10 further includes an electric motor 4, a control board 6, a battery interface 24 and a power transmission part 8.

### (38) (Rotary Blade 12)

(39) The rotary blade 12 is a blade having a disk shape and it has a plurality of blade edges or grinding stones at its circumferential end. The rotary blade 12 may for example be a diamond wheel. The rotary blade 12 is a so-called consumable item, thus it is detachably attached to the blade arm 14b. A rotation axis of the rotary blade 12 extends in a direction orthogonal to the longitudinal direction of the blade arm 14b.

(40) Here, in the present disclosure, in the state where the power cutter 10 is placed on the placement surface H, a direction orthogonal to the placement surface H is defined as an up-down direction, a direction toward the power cutter 10 from the placement surface H is defined as an upward direction, and a direction from the power cutter 10 toward the placement surface H is defined as a downward direction. Moreover, a direction orthogonal to the up-down direction and along which the rotation axis of the rotary blade 12 extends is defined as left-right direction. A direction perpendicular to the up-down direction and the left-right direction is defined as a front-rear direction, the direction extending from the rear handle 20 to the front handle 18 is defined as a frontward direction, and a direction extending from the front handle 18 to the rear handle 20 is defined as a rearward direction. Hereafter, it should be noted that explanations are given assuming that the power cutter 10 is placed on the placement surface H, unless otherwise indicated.

### (41) (Electric Motor 4)

(42) As illustrated in FIG. 3, the electric motor 4 includes a motor housing 42 and a motor shaft 44 configured to rotate about the rotation axis A1 with respect to a motor housing 42. The electric motor 4 of the present embodiment is a brushless motor, and a stator and a rotor (illustration omitted) are housed in the motor housing 42. A part of the motor shaft 44 is fixed to the rotor in the motor housing 42. A first gear 80a is fixed to the rest of the motor shaft 44. In the present embodiment, the first gear 80a is a bevel gear. When power is supplied to the electric motor 4, the motor shaft 44 starts to rotate about the rotation axis A1. The longitudinal direction of the electric motor 4 is coincident with the direction along which the rotation axis A1 extends.

(43) As illustrated in FIG. 2, the electric motor 4 is housed in the housing body 14a. In the present embodiment, when the power cutter 10 is viewed from the right side, the rotation axis A1 of the motor shaft 44 (see FIG. 3) is inclined with respect to the up-down direction such that the rotation axis A1 of the motor shaft 44 leans forward as it extends downward. In the present embodiment, the angle at which the rotation axis A1 is inclined with respect to the up-down direction is  $-20^{\circ}$ . When the power cutter 10 is viewed from the right side, the rotation axis A1 is substantially orthogonal to a line Y which passes through a rotation axis A2 of an input shaft 81 (see FIG. 3) and a rotation axis A3 of an output shaft 85 (see FIG. 3).

(44) As illustrated in FIG. 4, in the rear view of the power cutter 10, the electric motor 4 partially overlaps with the rotary blade 12. The rotation axis A1 of the motor shaft 44 (see FIG. 3) of the electric motor 4 is orthogonal to the left-right direction. The rotation axis A1 of the motor shaft 44 is parallel to a reference plane P which is equivalent to a plane on which the rotary blade 12 extends. The reference plane P is a plane orthogonal to the rotation axis A3 (see FIG. 3) of the

output shaft **85** to be described alter. The rotation axis **A1** is disposed close to the reference plane **P**. In the present embodiment, a distance between the reference plane **P** and the rotation axis **A1** is 3.5 mm.

(45) (Power Transmission Part **8**)

(46) As illustrated in FIG. 3, the power transmission part **8** includes an input shaft **81**, an output shaft **85**, an input pulley **82** fixed to the input shaft **81**, an output pulley **84** fixed to the output shaft **85**, and a transmission belt **83** wrapped around the input pulley **82** and the output pulley **84**.

(47) The input shaft **81** and the input pulley **82** are rotatably supported about the rotation axis **A2** by the housing **14** (illustration omitted). The rotation axis **A2** of the input shaft **81** and the input pulley **82** is along the left-right direction. A second gear **80b** is fixed to the input shaft **81** at a position offset leftward from the input pulley **82**. In the present embodiment, the second gear **80b** is a bevel gear. The second gear **80b** is in mesh with the first gear **80a** of the motor shaft **44**. Since the first gear **80a** and the second gear **80b** are in mesh with each other, the input shaft **81** rotates simultaneously as the motor shaft **44** rotates. At this time, a speed of rotation of the input shaft **81** is reduced relative to a speed of rotation of the motor shaft **44** according to a gear ratio of the second gear **80b** to the first gear **80a**. In other words, the first gear **80a** and the second gear **80b** function not only as a mechanism which converts rotating movement of the motor shaft **44** about the rotation axis **A1** into rotating movement of the input shaft **81** about the rotation axis **A2** but also as a speed reducer. Therefore, in the present disclosure, the first gear **80a** and the second gear **80b** may collectively be referred to as “speed reducer **80**”.

(48) As illustrated in FIG. 2, the transmission belt **83** is housed in the blade arm **14b** together with the input pulley **82** and the output pulley **84**. In the present embodiment, the input pulley **82** and the output pulley **84** are geared pulleys, and the transmission belt **83** is a geared belt. The input pulley **82** and the transmission belt **83** are in mesh with each other. The output pulley **84** and the transmission belt **83** are also in mesh with each other. Consequently, when the input shaft **81** rotates, the output pulley **84** rotates simultaneously via the transmission belt **83** and the input pulley **82** fixed to the input shaft **81**. In the present embodiment, a pulley diameter of the output pulley **84** is greater than a pulley diameter of the input pulley **82**. Thus, the speed of rotation of the output pulley **84** is reduced relative to the speed of rotation of the input pulley **82**.

(49) As illustrated in FIG. 3, the output pulley **84** and the output shaft **85** are rotatably supported about the rotation axis **A3** by the housing **14** (not illustrated). The rotation axis **A3** of the output pulley **84** and the output shaft **85** is along the left-right direction. The rotary blade **12** is attached to the output shaft **85** at a position offset leftward from the output pulley **84**. Thus, when the output pulley **84** rotates, the rotary blade **12** also rotates simultaneously via the output shaft **85**. In other words, the rotation axis **A3** is an axis equivalent to a rotation axis of the rotary blade **12**.

(50) As described above, the power transmission part **8** transmits power from the electric motor **4** to the rotary blade **12**. Consequently, the rotary blade **12** can be rotated by the electric motor **4** in the power cutter **10**.

(51) (Control Board **6**)

(52) As illustrated in FIG. 2, the control board **6** is housed in the housing body **14a**. The control board **6** is disposed above the electric motor **4** in the direction along which the rotation axis **A1** of the motor shaft **44** (see FIG. 3) extends. The control board **6** is disposed along the plane which is substantially orthogonal to the rotation axis **A1** of the motor shaft **44**. The control board **6** is electrically connected to the plurality of battery packs **60**, and adjusts power supplied from the plurality of battery packs **60** and supplies the same to the electric motor **4**. In the present embodiment, since the electric motor **4** is a brushless motor, the control board **6** further includes an inverter circuit (illustration omitted). The inverter circuit electrically connects the plurality of battery packs **60** to the electric motor **4**, converts DC power from the plurality of battery packs **60** into three-phase AC power and supplies the same to the electric motor **4**. The control board **6** is also electrically connected to lightings (not illustrated) of the housing **14**, and can adjust the power



supplied from the plurality of battery packs **60** and supply the same to the lightings.

(53) (Plurality of Battery Packs **60** and Battery Interface **24**)

(54) The plurality of battery packs **60** includes at least one secondary battery cell (illustration omitted). The plurality of battery packs **60** is detachably attached to the battery interface **24** and can supply power to the electric motor **4**. The battery interface **24** is arranged on the housing body **14a** at a position offset rearwardly from the electric motor **4**. The battery interface **24** is arranged on the housing body **14a** such that the right battery pack **60a** (see FIG. 1) and the left battery pack **60b** are attached to the battery interface **24** with their longitudinal directions being substantially parallel to the direction which is along the rotation axis **A1** of the motor shaft **44** (see FIG. 3). In other words, in the power cutter **10**, the electric motor **4** and the plurality of battery packs **60** are disposed such that the respective longitudinal directions are substantially parallel.

(55) As illustrated in FIG. 4, in the rear view of the power cutter **10**, the battery interface **24** and the rotary blade **12** partially overlap. In the rear view of the power cutter **10**, the right battery pack **60a** and the left battery pack **60b** attached to the battery interface **24** partially overlap the electric motor **4**. The right battery pack **60a** and the left battery pack **60b** are symmetrical relative to the reference plane **P** which is equivalent to a plane on which the rotary blade **12** extends.

(56) (Front Handle **18** and Rear Handle **20**)

(57) As illustrated in FIG. 1, the front handle **18** and the rear handle **20** are disposed on the housing body **14a**. The front handle **18** extends rightward and leftward from above the housing body **14a**. One end of the front handle **18** is attached to the vicinity of the center of the right side surface of the housing body **14a** and the other end is attached to a lower portion of the left side surface of the housing body **14a**. The rear handle **20** extends rearward from the housing body **14a**.

(58) As illustrated in FIG. 2, the front handle **18** is offset rearwardly from the rotary blade **12** and forwardly from the electric motor **4**. The rear handle **20** is offset rearwardly from the battery interface **24**. The user usually holds the power cutter **10** by grasping the front handle **18** with his/her left hand and grasps the rear handle **20** with his/her right hand. At this time, the user can adjust a posture of the power cutter **10** by changing a position at which the user grasps the front handle **18**.

(59) As illustrated in FIG. 5, the rear handle **20** includes a main switch **30** which the user can operate with his/her finger of the hand grasping the rear handle **20**. In the present embodiment, when the user operates the main switch **30**, the control board **6** (see FIG. 2) starts supplying power to the electric motor **4** and when the operation on the main switch **30** is stopped, the control board **6** stops supplying the power to the electric motor **4**. In other words, the power cutter **10** is configured to rotate the rotary blade **12** only when the main switch **30** is being operated.

(60) The rear handle **20** further includes a lock-off switch **32**. The lock-off switch **32** is held such that it can slide in the left-right direction relative to the rear handle **20**. Although not illustrated, when the lock-off switch **32** is not pushed rightward relative to the rear handle **20**, the main switch **30** is in mechanical interference with the lock-off switch **32**, by which operation on the main switch **30** is prohibited. When the lock-off switch **32** is pushed rightward relative to the rear handle **20**, the main switch **30** is not in mechanical interference with the lock-off switch **32**, by which operation on the main switch **30** is allowed.

(61) The rear handle **20** further includes an operation button **34**. In the present embodiment, the control board **6** (see FIG. 2) starts or stops the supply of power to lightings (not illustrated) in accordance with operation on the operation button **34**. In other words, the operation button **34** is a button to switch the lightings on and off

(62) (Blade Cover **16**)

(63) As illustrated in FIG. 1, the blade cover **16** is attached to the vicinity of the front end of the blade arm **14b** and covers a part of the rotary blade **12**. The blade cover **16** suppresses cutting dust generated by the rotary blade **12** from flying toward the user. The blade cover **16** of the present embodiment is configured to circumferentially cover a part of the rotary blade **12** (e.g., an angular

area of 175° or more). At least a part of the blade cover **16** may be movable relative to the blade arm **14b**.

(64) (Water Supply Hose **50**)

(65) The water supply hose **50** is disposed at the right side of the power cutter **10**. The distal end of the water supply hose **50** is attached to the outer side surface of the blade cover **16** via the plug **52**. The proximal end of the water supply hose **50** is attached to a lower portion of the rear handle **20**. A water supply connector **54** is disposed at the proximal end of the water supply hose **50**. The water supply connector **54** is held by the housing body **14a**, and can be connected to an external water source such as a tap faucet via a hose (illustration omitted). Thus, the water supply hose **50** can supply water into the blade cover **16**.

(66) (Guide Roller **70**)

(67) As illustrated in FIG. 2, the guide roller **70** is attached to a lower portion of the housing **14**. The guide roller **70** includes a pair of left and right wheels **72** (see FIG. 1, FIG. 6). In the state where the power cutter **10** is placed on the placement surface H, the pair of left and right wheels **72** is arranged such that the wheels **72** are not in contact with the placement surface H. The user who uses the power cutter **10** can stably move the rotary blade **12** forward and rearward relative to an object to be cut by performing work with the pair of left and right wheels **72** being in contact with a plane (e.g., the placement surface H).

(68) (Position of Gravity Center GT of Power Cutter **10**)

(69) As illustrated in FIG. 6, the position of gravity center GT of the power cutter **10** of the present embodiment which is configured as described above is positioned between the front handle **18** and the rear handle **20**, in the vicinity of the reference plane P. Consequently, when the user holds the power cutter **10** by grasping the front handle **18** with his/her left hand and the rear handle **20** with his/her right hand, a posture of the power cutter **10** tends to be stabilized.

(70) (Lock Mechanism of Output Shaft **85** and Fall-Out Suppression Mechanism of Transmission Belt **83**)

(71) As illustrated in FIG. 7, a lock pin **140** is disposed at the blade arm **14b** of the present embodiment. The lock pin **140** is held such that it can slide with respect to the blade arm **14b** in a direction substantially orthogonal to the rotation axis A3 of the output shaft **85**. The lock pin **140** is biased toward the outside of the blade arm **14b** by a coil spring (illustration omitted).

(72) The output pulley **84** of the present embodiment includes a first rotation member **110** around which the transmission belt **83** is wrapped and a second rotation member **120** into which the lock pin **140** is inserted. The first rotation member **110** is fixed to the output shaft **85**. The details will be described later, however, the second rotation member **120** is fixed to the first rotation member **110**. In other words, the first rotation member **110** and the second rotation member **120** are members which rotate about the rotation axis A3 along with the output shaft **85**.

(73) As illustrated in FIG. 8, the first rotation member **110** includes a first column portion **112**, a flange **114** extending radially outward from the right end of the first column portion **112** and a first base **116** extending radially inward from the left end from the first column portion **112**. In the present embodiment, a plurality of gears is formed on the first column portion **112** at a predetermined interval in the circumferential direction, and is in mesh with the plurality of gears formed on the transmission belt **83** (see FIG. 7). The transmission belt **83** is wrapped around the first column portion **112**. The first column portion **112**, the flange **114** and the first base **116** are seamlessly and integrally formed. In the present embodiment, an aluminum alloy is used for the first rotation member **110**.

(74) The second rotation member **120** includes a second column portion **122** and a second base **124** extending radially inward from the right end of the second column portion **122**. The second column portion **122** includes a plurality of lock holes **126** defined at a predetermined interval in the circumferential direction. In the present embodiment, the plurality of lock holes **126** is four lock holes, and they are defined every ¼ rotation in the circumferential direction of the second column

portion **122**. An outer diameter of the second column portion **122** is greater than an outer diameter of the first column portion **112**. The second base **124** is fixed to the first base **116** of the first rotation member **110** by screw(s) (illustration omitted). The second column portion **122** and the second base **124** are seamlessly and integrally formed. In the present embodiment, iron is used for the second rotation member **120**.

(75) As illustrated in FIG. **9**, when the lock pin **140** is pushed against biasing force of the coil spring in the state in which the output shaft **85** is rotated and any one of the plurality of lock holes **126** is positioned in the slide direction of the lock pin **140**, the lock pin **140** is inserted into the lock hole **126**. In the state where the lock pin **140** is inserted into the lock hole **126**, the lock pin **140** and the lock hole **126** are in mechanical interference with each other, by which rotation of the output shaft **85** about the rotation axis **A3** is prohibited. On the other hand, as illustrated in FIG. **7**, in the state where the lock pin **140** is not inserted into the lock hole **126**, the lock pin **140** and the lock hole **126** are not in mechanical interference with each other, by which the rotation of the output shaft **85** about the rotation axis **A3** is allowed.

(76) When the transmission belt **83** wrapped around the first column portion **112** moves rightward in a direction of the rotation axis **A3** of the output shaft **85**, the transmission belt **83** abuts and is stopped by the flange **114** on the right side of the transmission belt **83**. When the transmission belt **83** moves leftward in the direction of the rotation axis **A3**, the transmission belt **83** abuts and is stopped by the second base **124** on the left side of the transmission belt **83**. Consequently, the transmission belt **83** is suppressed from falling out from the output pulley **84**.

(77) (Variants)

(78) In the above embodiment, the power cutter **10** was described as an example of an electric working machine. In another embodiment, the electric working machine may be an electric working machine other than the power cutter **10**, such as an electric circular saw or a grinder.

(79) In the above embodiment, the configuration in which the electric motor **4** is a brushless motor was described. In another embodiment, the electric motor **4** may be a motor other than a brushless motor. For example, the electric motor **4** may be a brushed motor.

(80) In the above embodiments, the configuration in which, when the power cutter **10** is viewed from the right side, the rotation axis **A1** of the motor shaft **44** is inclined with respect to the up-down direction such that the rotation axis leans forward as it extends downward and the angle at which the rotation axis **A1** is inclined with respect to the up-down direction is  $-20^\circ$  was described. In another embodiment, when the power cutter **10** is viewed from the right side, the angle at which the rotation axis **A1** is inclined with respect to the up-down direction may not be  $-20^\circ$ . In this case, the angle at which the rotation axis **A1** is inclined with respect to the up-down direction may be suitably changed within a range from  $-45^\circ$  to  $45^\circ$ . In yet another embodiment, when the power cutter **10** is viewed from the right side, the angle at which the rotation axis **A1** is inclined with respect to the up-down direction may not be within a range from  $-45^\circ$  to  $45^\circ$ .

(81) In the above embodiment, the configuration in which, when the power cutter **10** is viewed from the right side, the rotation axis **A1** is substantially orthogonal to the line **Y** passing through the rotation axis **A2** of the input pulley **82** and the rotation axis **A3** of the output pulley **84** was described. In another embodiment, when the power cutter **10** is viewed from the right side, the rotation axis **A1** may not be substantially orthogonal to the line **Y** passing through the rotation axis **A2** and the rotation axis **A3**.

(82) In the above embodiment, the configuration in which the first gear **80a** and the second gear **80b** are bevel gears was described. In another embodiment, the first gear **80a** and the second gear **80b** may be gears other than bevel gears. For example, the first gear **80a** and the second gear **80b** may be worm gears.

(83) In the above embodiment, the configuration in which the input pulley **82** and the output pulley **84** are geared pulleys, the transmission belt **83** is a geared belt, and power is transmitted between the input pulley **82**, the transmission belt **83** and the output pulley **84** mainly by meshing of the

respective gears was described. In another embodiment, the input pulley **82** and the output pulley **84** may be pulleys other than geared pulleys, and the transmission belt **83** may be a belt other than a geared belt. For example, the input pulley **82** and the output pulley **84** may be pulleys including V-shaped grooves, and the transmission belt **83** may be a flat belt or a V belt. In this case, power is transmitted between the input pulley **82**, the transmission belt **83** and the output pulley **84** mainly by friction between these members.

(84) In the above embodiment, the configuration in which the pulley diameter of the output pulley **84** is greater than the pulley diameter of the input pulley **82** was described. In another embodiment, the pulley diameter of the output pulley **84** may be the same as the pulley diameter of the input pulley **82** or may be smaller than the pulley diameter of the input pulley **82**.

(85) In the above embodiment, the configuration in which the electric working machine (the power cutter **10**) includes the plurality of battery packs **60** and power is supplied from the plurality of battery packs **60** to the electric motor **4** was described. In another embodiment, the electric working machine (the power cutter **10**) may include a power cable connected to an external power source instead of the plurality of battery packs **60**, and power may be supplied from the external power source to the electric motor **4** via the power cable. In yet another embodiment, the electric working machine (the power cutter **10**) may include one battery pack instead of the plurality of battery packs **60**.

(86) In the above embodiment, the configuration in which the plurality of battery packs **60** is two battery packs (the right battery pack **60a** and the left battery pack **60b**) was described. In another embodiment, the plurality of battery packs **60** may be three or more battery packs. For example, the plurality of battery packs **60** may be four battery packs.

(87) Unlike the above embodiment, the power cutter **10** may further include a battery pack cover which covers the plurality of battery packs **60** and is configured to open and close. In this case, it is possible to protect the plurality of battery packs **60** from moisture and cutting dust.

(88) In the above embodiment, the configuration in which the front handle **18** is offset rearwardly from the rotary blade **12** and forwardly from the electric motor **4** and the rear handle **20** is offset rearwardly from the battery interface **24** was described. In another embodiment, the front handle **18** and the rear handle **20** may be disposed at any positions as long as the front handle **18** is offset forwardly from the rear handle **20**.

(89) Unlike the above embodiment, the power cutter **10** may further include a water supply tank connected to the water supply connector **54**. In this case, it is not necessary to attach a hose or the like to the water supply connector **54** to connect with an external water source, thus maneuverability for the user can further be enhanced. Moreover, it is possible to use the power cutter **10** even in a place where water cannot be supplied externally, thus user convenience can also be enhanced.

(90) In the above embodiment, the configuration in which an aluminum alloy is used for the first rotation member **110** and iron is used for the second rotation member **120** was described. In another embodiment, a material other than an aluminum alloy may be used for the first rotation member **110** and a material other than iron may be used for the second rotation member **120**. For example, resin may be used for the first rotation member **110** and an aluminum alloy may be used for the second rotation member **120**.

(91) In the above embodiment, the configuration in which the plurality of lock holes **126** is four lock holes and they are defined every  $\frac{1}{4}$  rotation in the circumferential direction of the second column portion **122** was described. In another embodiment, the four lock holes may be defined at an interval shorter than every  $\frac{1}{4}$  rotation in the circumferential direction of the second column portion **122**. In yet another embodiment, the plurality of lock holes **126** may be two, three, five, or more lock holes.

(92) (Corresponding Relationships)

(93) As described above, in one or more embodiments, the power cutter **10** (an example of the

electric working machine) comprises: the output shaft **85**; the rotary blade **12** attached to the output shaft **85**; the output pulley **84** fixed to the output shaft **85**; the input shaft **81**; the input pulley **82** fixed to the input shaft **81**; the transmission belt **83** wrapped around the input pulley **82** and the output pulley **84**; the electric motor **4** comprising the motor shaft **44** and configured to rotate the motor shaft **44**; the speed reducer **80** configured to reduce the speed of the rotation of the motor shaft **44** and transmit the rotation to the input shaft **81**; and the housing **14** that houses the electric motor **4** and the speed reducer **80**, and rotatably supports the input shaft **81** and the output shaft **85**. The rotation axis **A1** of the motor shaft **44** is substantially orthogonal to (an example of being inclined with respect to) the left-right direction which is along the rotation axis **A3** of the output shaft **85**.

(94) According to the above configuration, the longitudinal direction of the electric motor **4** is inclined with respect to the left-right direction which is along the rotation axis **A3** of the output shaft **85**. Consequently, the power cutter **10** can be downsized in the direction of the rotation axis **A3** of the output shaft **85**.

(95) In one or more embodiments, the rotation axis **A1** of the motor shaft **44** is orthogonal to the left-right direction which is along the rotation axis **A3** of the output shaft **85**.

(96) According to the above configuration, the longitudinal direction of the electric motor **4** is substantially orthogonal to the rotation axis **A3** of the output shaft **85**. Consequently, the power cutter **10** can further be downsized in the direction of the rotation axis **A3** of the output shaft **85**.

(97) In one or more embodiments, when the power cutter **10** is placed on the placement surface **H**, the rotation axis **A3** of the output shaft **85** is arranged along the left-right direction in the vicinity of the front end of the housing **14**, and in the side view of the power cutter **10**, the rotation axis **A1** of the motor shaft **44** is inclined at an angle within a range from  $-45^{\circ}$  to  $45^{\circ}$  with respect to the up-down direction.

(98) According to the above configuration, in the state where the power cutter **10** is placed on the placement surface **H**, the power cutter **10** can be downsized in the left-right direction and also in the front-rear direction.

(99) In one or more embodiments, when the power cutter **10** is placed on the placement surface **H**, in the side view of the power cutter **10**, the rotation axis **A1** of the motor shaft **44** is inclined with respect to the up-down direction such that the rotation axis **A1** leans forward as it extends downward.

(100) According to the above configuration, when the user uses the power cutter **10** with the rotary blade **12** directed downward, the rotation axis **A1** of the motor shaft **44** tends to be positioned along the up-down direction. Consequently, the power cutter **10** can be downsized in the front-rear direction in the state in which the user uses the power cutter **10** with the rotary blade **12** directed downward. Accordingly, maneuverability for the user can be enhanced.

(101) In one or more embodiments, in the side view of the power cutter **10**, the rotation axis **A1** of the motor shaft **44** is substantially orthogonal to the line **Y** passing through the rotation axis **A3** of the output shaft **85** and the rotation axis **A2** of the input shaft **81**.

(102) According to the above configuration, the rotation axis **A1** of the motor shaft **44** is substantially orthogonal to the radial direction of the rotary blade **12** (i.e., substantially parallel to a tangential direction of the rotary blade **12**). In other words, the longitudinal direction of the electric motor **4** is substantially orthogonal to the radial direction of the rotary blade **12** (i.e., substantially parallel to the tangential direction of the rotary blade **12**). According to the above configuration, the power cutter **10** can be downsized in the radial direction of the rotary blade **12**.

(103) In one or more embodiments, the power cutter **10** further comprises: the front handle **18** (an example of the first handle) disposed on the housing **14** and configured to be grasped by the user with his/her left hand (an example of one hand); and the rear handle **20** (an example of the second handle) disposed on the housing **14** and configured to be grasped by the user with his/her right hand (an example of the other hand). When the power cutter **10** is placed on the placement surface

H, the front handle **18** is offset rearwardly from the rotary blade **12** and forwardly from the electric motor **4**, and the rear handle **20** is offset rearwardly from the electric motor **4**.

(104) In general, maneuverability for the user increases as the position of the gravity center GT of the power cutter **10** is closer to the gravity center of the user's body. Further, since the electric motor **4** has a relatively large weight among the components of the power cutter **10**, a position at which the electric motor **4** is disposed greatly changes the position of the gravity center GT of the power cutter **10**. According to the above configuration, since the electric motor **4** is disposed between the front handle **18** and the rear handle **20**, the position of the gravity center GT of the power cutter **10** tends to be positioned close to the gravity center of the user's body when the user grasps the front handle **18** and the rear handle **20** to use the power cutter **10**. Thus, maneuverability for the user can further be increased.

(105) In one or more embodiments, the power cutter **10** further comprises the plurality of battery packs **60** (an example of at least one battery pack) configured to be attached to and detached from the housing **14** and supply power to the electric motor **4**.

(106) When the power cutter **10** is driven using power from an external power source, it is necessary to attach a power cable to the power cutter **10**, which may decrease the maneuverability. According to the above configuration, it is not necessary to attach the power cable to the power cutter **10**, by which the maneuverability for the user can further be enhanced. Further, since it is possible to use the power cutter **10** even in a place where power cannot be externally supplied, user convenience can also be enhanced.

(107) In one or more embodiments, when the power cutter **10** is placed on the placement surface H, the plurality of battery packs **60** is offset rearwardly from the electric motor **4** and forwardly from the rear handle **20**.

(108) Since the plurality of battery packs **60** has a relatively large weight among the components of the power cutter **10**, a position at which the plurality of battery packs **60** is disposed greatly changes the position of the gravity center GT of the power cutter **10**. According to the above configuration, since the plurality of battery packs **60** is disposed between the front handle **18** and the rear handle **20**, the position of the gravity center GT of the power cutter **10** tends to be positioned close to the gravity center of the user's body when the user grasps the front handle **18** and the rear handle **20** to use the power cutter **10**. Thus, maneuverability for the user can further be increased.

(109) In one or more embodiments, when the power cutter **10** is placed on the placement surface H, in the rear view of the power cutter **10**, the plurality of battery packs **60** and the electric motor **4** at least partially overlap.

(110) According to the above configuration, the electric motor **4** and the plurality of battery packs **60** are disposed close to each other in the left-right direction and the up-down direction. According to the above configuration, with respect to the state in which the power cutter **10** is placed on the placement surface H, the power cutter **10** can be downsized in the left-right direction and also in the up-down direction.

(111) In one or more embodiments, when the power cutter **10** is placed on the placement surface H, in the rear view of the power cutter **10**, the rotary blade **12** and the electric motor **4** at least partially overlap.

(112) According to the above configuration, the rotary blade **12** and the electric motor **4** are disposed close to each other in the left-right direction and the up-down direction. According to the above configuration, in the state where the power cutter **10** is placed on the placement surface H, the power cutter **10** can be downsized in the left-right direction and also in the up-down direction.

(113) In one or more embodiments, the output pulley **84** includes the first rotation member **110** and the second rotation member **120** fixed adjacent to the first rotation member **110** in the direction of the rotation axis A3 of the output shaft **85**. The first rotation member **110** includes the first column portion **112** around which the transmission belt **83** is wrapped and the flange **114** extending radially

outward from the right end of the first column portion **112** (an example of the end on the side not adjacent to the second rotation member). The second rotation member **120** includes the second column portion **122** whose outer diameter is greater than the first column portion **112**, and the second base **124** (an example of the base) extending radially inward from the right end of the second column portion **122** (an example of the end on the side adjacent to the first rotation member). The second column portion **122** includes the plurality of lock holes **126** defined at a predetermined interval in the circumferential direction. The power cutter **10** further includes the lock pin **140** which is movably held by the housing **14** and configured to be inserted into any one of the plurality of lock holes **126**.

(114) If a mechanism which suppresses the transmission belt **83** from falling off from the output pulley and a mechanism to lock the rotation of the output shaft **85** are disposed at the output pulley which is seamlessly and integrally formed, the output pulley may be formed into a complicated shape. Thus, when the power cutter **10** is assembled, attachment of output pulley may be difficult. According to the above configuration, the output pulley **84** is constituted of the first rotation member **110** and the second rotation member **120**. Thus, by separately attaching the first rotation member **110** and the second rotation member **120** at the time of assembly of the power cutter **10**, the output pulley **84** can be easily attached. According to the above configuration, when the transmission belt **83** wrapped around the first column portion **112** moves in the direction of the rotation axis **A3** of the output shaft **85**, the transmission belt **83** abuts and is stopped by the flange **114** of the first rotation member **110** or the second base **124** of the second rotation member **120**. Thus, the transmission belt **83** is suppressed from falling off from the first column portion **112**. Further, according to the above configuration, when the output pulley **84** rotates with respect to the housing **14** with the lock pin **140** inserted into any one of the plurality of lock holes **126**, the second rotation member **120** abuts and is stopped by the lock pin **140**. Thus, by inserting the lock pin **140** into any one of the plurality of lock holes **126**, the rotation of the output shaft **85** can be locked.

(115) In one or more embodiments, the first column portion **112** and the flange **114** are seamlessly and integrally formed. The second column portion **122** and the second base **124** are seamlessly and integrally formed. An aluminum alloy is used for the first rotation member **110**. Iron is used for the second rotation member **120**.

(116) Since the output pulley **84** rotates along with the output shaft **85**, it is desirable to use a material having a small mass for the output pulley **84**. On the other hand, given that the lock pin **140** is inserted into the output pulley **84** to lock the rotation of the output shaft **85**, it is desirable to use a material having rigidity and high strength for the output pulley **84**. According to the above configuration, it is possible to secure required rigidity and strength by using iron for the second rotation member **120** to which the lock pin **140** is inserted and also reduce the entire weight of the output pulley **84** by using an aluminum alloy for the first rotation member **110** around which the transmission belt **83** is wrapped.

## Claims

1. An electric working machine comprising: an output shaft; a rotary blade attached to the output shaft; an output pulley fixed to the output shaft; an input shaft; an input pulley fixed to the input shaft; a transmission belt wrapped around the input pulley and the output pulley; an electric motor comprising a motor shaft and configured to rotate the motor shaft; a speed reducer configured to reduce a speed of rotation of the motor shaft and transmit the rotation to the input shaft; and a housing that houses the electric motor and the speed reducer, and rotatably supports the input shaft and the output shaft, wherein a rotation axis of the motor shaft is inclined with respect to a direction which is along a rotation axis of the output shaft, and when the electric working machine is placed on a placement surface, the rotation axis of the output shaft is arranged along a left-right direction in a vicinity of a front end of the housing, and in a side view of the electric working

machine, the rotation axis of the motor shaft is inclined at an angle within a range from  $-45^{\circ}$  to  $45^{\circ}$  with respect to an up-down direction.

2. The electric working machine according claim 1, wherein the rotation axis of the motor shaft is orthogonal to the direction which is along the rotation axis of the output shaft.

3. The electric working machine according claim 1, wherein when the electric working machine is placed on the placement surface, in the side view of the electric working machine, the rotation axis of the motor shaft is inclined with respect to the up-down direction such that the rotation axis of the motor shaft leans forward as it extends downward.

4. The electric working machine according claim 3, wherein, in the side view of the electric working machine, the rotation axis of the motor shaft is substantially orthogonal to a line passing through the rotation axis of the output shaft and the rotation axis of the input shaft.

5. The electric working machine according claim 1, further comprising: a first handle disposed on the housing and configured to be grasped by a user with one hand; and a second handle disposed on the housing and configured to be grasped by the user with the other hand, wherein when the electric working machine is placed on the placement surface, the first handle is offset rearwardly from the rotary blade and forwardly from the electric motor, and the second handle is offset rearwardly from the electric motor.

6. The electric working machine according claim 5, further comprising at least one battery pack configured to be attached to and detached from the housing and supply power to the electric motor.

7. The electric working machine according claim 6, wherein when the electric working machine is placed on the placement surface, the at least one battery pack is offset rearwardly from the electric motor and forwardly from the second handle.

8. The electric working machine according claim 7, wherein when the electric working machine is placed on the placement surface, in a rear view of the electric working machine, the at least one battery pack and the electric motor at least partially overlap.

9. The electric working machine according claim 7, wherein when the electric working machine is placed on the placement surface, in a rear view of the electric working machine, the rotary blade and the electric motor at least partially overlap.

10. The electric working machine according claim 4, further comprising: a first handle disposed on the housing and configured to be grasped by a user with one hand; a second handle disposed on the housing and configured to be grasped by the user with the other hand; and at least one battery pack configured to be attached to and detached from the housing and supply power to the electric motor, wherein when the electric working machine is placed on the placement surface, the first handle is offset rearwardly from the rotary blade and forwardly from the electric motor, the second handle is offset rearwardly from the electric motor, the at least one battery pack is offset rearwardly from the electric motor and forwardly from the second handle, in a rear view of the electric working machine, the at least one battery pack and the electric motor at least partially overlap, and in the rear view of the electric working machine, the rotary blade and the electric motor at least partially overlap.

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