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Impact tool

Abstract

An impact tool includes: a brushless motor; a spindle, which is rotated by the brushless motor; a hammer, which is held on the spindle; an anvil, which is impacted in a rotational direction by the hammer, a polymer housing, which houses the brushless motor; a hammer case, which is connected to the polymer housing and houses the hammer and the spindle; and a light unit, which is held on the hammer case and comprises a plurality of light-emitting devices. The maximum tightening torque of the anvil is 1,000 N.Math.m or more and 2,500 N.Math.m or less.

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Background/Summary

CROSS-REFERENCE (1) This application is a continuation of U.S. patent application Ser. No. 18/060,094, filed on Nov. 30, 2022, now U.S. Pat. No. 11,958,170, which claims priority to Japanese Patent Application No. 2021-201914 filed on Dec. 13, 2021, and to Japanese Patent Application No. 2021-201915 filed on Dec. 13, 2021, the contents of both of which are incorporated herein by reference.

TECHNICAL FIELD

(1) Techniques disclosed in the present specification relate to an impact tool.

BACKGROUND ART

(2) A known impact driver comprising lights is disclosed in Japanese Patent No. 5900141.

SUMMARY

(3) It is one non-limiting object of the present teachings to disclose techniques for improving the ergonomics and/or work efficiency of an impact tool, such as an impact wrench and/or an impact driver.

(4) In one non-limiting aspect of the present teachings, an impact tool, such as an impact wrench or impact driver, may comprise: a brushless motor; a spindle, which is rotated by the brushless motor; a hammer, which is held on (and/or around) the spindle; an anvil, which is (configured to be) impacted in a rotational direction by the hammer; a resin (polymer) housing, which houses the brushless motor; and a hammer case, which is connected to the resin (polymer) housing and houses the hammer and the spindle. The impact tool may comprise a light unit, which is held on the hammer case and comprises a plurality of light-emitting devices. The maximum tightening torque of the anvil may be 1,000 N.Math.m or more and 2,500 N.Math.m or less.

(5) According to the techniques disclosed in the present specification, an impact tool having improved ergonomics and/or work efficiency is provided.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is a side view that shows an impact tool according to one representative, non-limiting embodiment of the present teachings.

(2) FIG. 2 is a front view that shows the impact tool according to the embodiment.

(3) FIG. 3 is a cross-sectional view that shows the impact tool according to the embodiment.

(4) FIG. 4 is an exploded, oblique view, viewed from the front, that shows a light unit according to the embodiment.

(5) FIG. 5 is a table that shows the specifications of a variety of known impact tools.

(6) FIG. 6 is a graph that shows the relationship between maximum tightening torque of an anvil and number of light-emitting devices according to the above-described known impact tools and the embodiment.

(7) FIG. 7 is a graph that shows the relationship between weight of the impact tool and number of light-emitting devices according to the above-described known impact tools and the embodiment.

(8) FIG. 8 is a graph that shows the relationship between overall length of the impact tool and number of light-emitting devices according to the above-described known impact tools and the embodiment.

(9) FIG. 9 is a graph that shows the relationship between maximum rotational speed of the anvil

and number of light-emitting devices according to the above-described known impact tools and the embodiment.

(10) FIG. 10 is a graph that shows the relationship between wrench width of the anvil and number of light-emitting devices according to the above-described known impact tools and the embodiment.

(11) FIG. 11 is a drawing that schematically shows a modified example of a light circuit board

(12) FIG. 12 is a drawing that schematically shows another modified example of the light circuit board.

(13) FIG. 13 is a drawing that schematically shows another modified example of the light circuit board.

DETAILED DESCRIPTION

(14) As was mentioned above, in one or more embodiments, an impact tool may comprise: a brushless motor; a spindle, which is rotated by the brushless motor; a hammer, which is held on the spindle; an anvil, which is impacted in a rotational direction by the hammer; a resin (polymer) housing, which houses the brushless motor; and a hammer case, which is connected to the resin (polymer) housing and houses the hammer and the spindle. The impact tool may comprise a light unit, which is held on the hammer case and comprises a plurality of light-emitting devices. The maximum tightening torque of the anvil may be 1,000 N.Math.m or more and 2,500 N.Math.m or less.

(15) According to the above-mentioned configuration, because the light unit comprises the plurality of light-emitting devices, the work environment is brightly illuminated with illumination light. In addition, the maximum tightening torque of the anvil is 1,000 N.Math.m or more and 2,500 N.Math.m or less. Consequently, an impact tool having improved ergonomics and/or work efficiency is provided.

(16) In one or more embodiments, at least three of the light-emitting devices may be provided.

(17) According to the above-mentioned configuration, because the light unit comprises at least three of the light-emitting devices, the work environment is brightly illuminated with illumination light. Consequently, an impact tool having improved ergonomics and/or work efficiency is provided.

(18) In one or more embodiments, a battery pack may be mounted on a battery-holding part, which is a portion of the resin (polymer) housing. The weight of the impact tool may be 2 kg or less.

(19) According to the above-mentioned configuration, because the impact tool, with the battery pack mounted thereon, has a weight of 2 kg or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(20) In one or more embodiments, a battery pack may be mounted on a battery-holding part, which is a portion of the resin (polymer) housing. At least three of the light-emitting devices may be provided. The weight of the impact tool may be 2 kg or more and 9 kg or less.

(21) According to the above-mentioned configuration, because the light unit comprises at least three of the light-emitting devices and the impact tool, with the battery pack mounted thereon, has a weight of 2 kg or more and 9 kg or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(22) In one or more embodiments, the spindle may be disposed forward of the brushless motor; the anvil may be disposed forward of the spindle; and the brushless motor may be housed in a motor-housing part, which is a portion of the resin (polymer) housing. The distance from a front-end portion of the anvil to a rear-end portion of the motor-housing part may be 155 mm or less.

(23) According to the above-mentioned configuration, because the overall length of the impact tool, which is defined as the distance between the front-end portion of the anvil and the rear-end portion of the motor-housing part, is 155 mm or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(24) In one or more embodiments, the spindle may be disposed forward of the brushless motor; the

anvil may be disposed forward of the spindle; and the brushless motor may be housed in a motor-housing part, which is a portion of the resin (polymer) housing. At least three of the light-emitting devices may be provided. The distance from a front-end portion of the anvil to a rear-end portion of the motor-housing part may be 200 mm or more and 400 mm or less.

(25) According to the above-mentioned configuration, because the light unit comprises at least three of the light-emitting devices and the overall length of the impact tool, which is defined as the distance from the front-end portion of the anvil to the rear-end portion of the motor-housing part, is 200 mm or more and 400 mm or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(26) In one or more embodiments, the maximum rotational speed of the anvil may be 3,000 rpm or less.

(27) According to the above-mentioned configuration, because the maximum rotational speed of the anvil is 3,000 rpm or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(28) In one or more embodiments, at least three of the light-emitting devices may be provided. The maximum rotational speed of the anvil may be 1,300 rpm or more and 2,300 rpm or less.

(29) According to the above-mentioned configuration, because the light unit comprises at least three of the light-emitting devices and the maximum rotational speed of the anvil is 1,300 rpm or more and 2,300 rpm or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(30) In one or more embodiments, the anvil may have a quadrangular-column part. The dimension of one side of a cross section of the quadrangular-column part may be 0.375 inches or less.

(31) According to the above-mentioned configuration, because the dimension of one side of a cross section of the quadrangular-column part is 0.375 inches or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(32) In one or more embodiments, the anvil may have a quadrangular-column part. At least three of the light-emitting devices may be provided. The dimension of one side of a cross section of the quadrangular-column part may be 0.6 inches or more and 0.9 inches or less.

(33) According to the above-mentioned configuration, because the light unit comprises at least three of the light-emitting devices and the dimension of one side of a cross section of the quadrangular-column part is 0.6 inches or more and 0.9 inches or less, an impact tool having improved ergonomics and/or work efficiency is provided.

(34) In one or more embodiments, the light unit may comprise: a light circuit board, which is disposed at least partially around the hammer case and holds the plurality of light-emitting devices; and optical members, which are disposed forward of the light-emitting devices and the light circuit board.

(35) According to the above-mentioned configuration, the light-emitting devices and the light circuit board are protected by the optical members.

(36) An embodiment is explained below, with reference to the drawings. In the embodiment, positional relationships among the parts are explained using the terms left, right, front, rear, up, and down. These terms indicate relative position or direction, wherein the center of an impact tool **1** is the reference. The impact tool **1** comprises a motor **6**, which serves as a motive power supply.

(37) In the embodiment, the direction parallel to rotational axis AX of the motor **6** is called the axial direction where appropriate, the direction that goes around rotational axis AX is called the circumferential direction or the rotational direction where appropriate, and the radial direction of rotational axis AX is called the radial direction where appropriate.

(38) Rotational axis AX extends in a front-rear direction. One side in the axial direction is forward, and the other side in the axial direction is rearward. In addition, in the radial direction, a location that is proximate to or a direction that approaches rotational axis AX is called radially inward where appropriate, and a location that is distant from or a direction that leads away from rotational

axis AX is called radially outward where appropriate.

(39) Impact Tool

(40) FIG. 1 is a side view that shows the impact tool 1 according to one representative, non-limiting embodiment of the present teachings. FIG. 2 is a front view that shows the impact tool 1 according to the embodiment. FIG. 3 is a cross-sectional view that shows the impact tool 1 according to the embodiment. In the embodiment, the impact tool 1 is an impact wrench.

(41) The impact tool 1 comprises a housing 2, a hammer case 4, a hammer-case cover 5, the motor 6, a speed-reducing mechanism 7, a spindle 8, an impact mechanism 9, an anvil 10, a fan 12, a battery-mounting part 13, a trigger switch 14, a forward/reverse-change lever 15, an action-mode-change switch 16, a controller 17, and a light unit 18.

(42) The housing 2 houses at least the motor 6. The housing 2 is made of a synthetic resin (polymer), such as nylon. Thus, the housing 2 is a resin (polymer) housing. The housing 2 comprises a pair of half housings. The housing 2 comprises a left housing 2L and a right housing 2R, which is disposed rightward of the left housing 2L. The left housing 2L and the right housing 2R are fixed to each other by a plurality of screws 2S.

(43) The housing 2 comprises a motor-housing part 21, a grip part 22, and a battery-holding part 23.

(44) The motor-housing part 21 houses the motor 6. The motor-housing part 21 comprises: a tubular part 21A, which is disposed around the motor 6; and a rear-cover part 21B, which is disposed at a rear-end portion of the tubular part 21A.

(45) The grip part 22 is gripped by a user. The grip part 22 protrudes downward from the tubular part 21A. The trigger switch 14 is provided at an upper portion of the grip part 22.

(46) The battery-holding part 23 holds a battery pack 25 via the battery-mounting part 13. The battery-holding part 23 houses the controller 17. The battery-holding part 23 is connected to a lower-end portion of the grip part 22. In both the front-rear direction and the left-right direction, the dimension of the outer shape of the battery-holding part 23 is larger than the dimension of the outer shape of the grip part 22.

(47) The hammer case 4 houses the speed-reducing mechanism 7, the spindle 8, the impact mechanism 9, and at least a portion of the anvil 10. The hammer case 4 is made of metal. The hammer case 4 has a tube shape. The hammer case 4 is connected to a front portion of the motor-housing part 21. The hammer case 4 is sandwiched between the left housing 2L and the right housing 2R. A bearing box 24 is fixed to a rear portion of the hammer case 4. The bearing box 24 is fixed to both the motor-housing part 21 and the hammer case 4.

(48) The hammer-case cover 5 covers at least a portion of the surface of the hammer case 4. The hammer-case cover 5 is made of a synthetic resin (polymer), such as nylon. The hammer-case cover 5 protects the hammer case 4. The hammer-case cover 5 blocks contact between the hammer case 4 and objects around the impact tool 1. The hammer-case cover 5 blocks contact between the hammer case 4 and the user.

(49) The motor 6 is the motive power supply of the impact tool 1. The motor 6 is an inner-rotor-type brushless motor. The motor 6 is housed in the motor-housing part 21, which is a portion of the housing 2.

(50) The motor 6 comprises a stator 26 and a rotor 27. The stator 26 is supported in the motor-housing part 21. At least a portion of the rotor 27 is disposed in the interior of the stator 26. The rotor 27 rotates relative to the stator 26. The rotor 27 rotates about rotational axis AX, which extends in the front-rear direction.

(51) The stator 26 comprises a stator core 28, a front insulator 29, a rear insulator 30, and coils 31.

(52) The stator core 28 is disposed more radially outward than the rotor 27; i.e. the stator core 28 radially surrounds the rotor 27. The stator core 28 comprises a plurality of laminated steel sheets. Each of the steel sheets is a sheet made of a metal in which iron is the main component. The stator core 28 has a tube shape. The stator core 28 comprises a plurality of teeth that supports the coils 31.

(53) The front insulator **29** is provided at a front portion of the stator core **28**. The rear insulator **30** is provided at a rear portion of the stator core **28**. The front insulator **29** and the rear insulator **30** are each an electrically insulating member that is made of a synthetic resin (polymer). The front insulator **29** is disposed such that it covers a portion of the surface of each of the teeth. The rear insulator **30** is disposed such that it covers a portion of the surface of each of the teeth.

(54) The coils **31** are mounted on the stator core **28** via the front insulator **29** and the rear insulator **30**. A plurality of the coils **31** is disposed. The coils **31** are respectively disposed around the teeth of the stator core **28** via (over) the front insulator **29** and the rear insulator **30**. The coils **31** and the stator core **28** are electrically insulated from each other by the front insulator **29** and the rear insulator **30**. Pairs of the coils **31** are respectively electrically connected via bus bars.

(55) The rotor **27** rotates about rotational axis AX. The rotor **27** comprises a rotor core **32**, a rotor shaft **33**, and rotor magnets **34**.

(56) The rotor core **32** and the rotor shaft **33** are each made of steel. A front portion of the rotor shaft **33** protrudes forward from a front-end surface of the rotor core **32**. A rear portion of the rotor shaft **33** protrudes rearward from a rear-end surface of the rotor core **32**. The front portion and the rear portion of the rotor shaft **33** are each supported in a rotatable manner by rotor bearings **39**. The rotor bearing **39** on the front side is held by the bearing box **24**. The rotor bearing **39** on the rear side is held by the rear-cover part **21B**. A front-end portion of the rotor shaft **33** is disposed in the internal space of the hammer case **4** through an opening in the bearing box **24**. The rotor magnets **34** are fixed to the rotor core **32**.

(57) A sensor board **37** is mounted on the rear insulator **30**. The sensor board **37** comprises: a circuit board, which has a disk shape wherein a hole is provided at the center; and a rotation-detection device, which is supported by the circuit board. The rotation-detection device detects the position of the rotor **27** in the rotational direction by detecting the positions of the rotor magnets **34**.

(58) A pinion gear **41** is formed at a front-end portion of the rotor shaft **33**. The pinion gear **41** is coupled to at least a portion of the speed-reducing mechanism **7**. The rotor shaft **33** is coupled to the speed-reducing mechanism **7** via the pinion gear **41**.

(59) The speed-reducing mechanism **7** couples the rotor shaft **33** and the spindle **8** to each other. The speed-reducing mechanism **7** transmits the rotation of the rotor **27** to the spindle **8**. The speed-reducing mechanism **7** causes the spindle **8** to rotate at a rotational speed that is lower than the rotational speed of the rotor **27**, but at higher torque. The speed-reducing mechanism **7** comprises a planetary-gear mechanism. The speed-reducing mechanism **7** is disposed more forward than the motor **6**.

(60) The speed-reducing mechanism **7** comprises a plurality of planet gears **42** disposed around the pinion gear **41** and an internal gear **43** disposed around the plurality of planet gears **42**. The pinion gear **41**, the planet gears **42**, and the internal gear **43** are each housed in the hammer case **4** and the bearing box **24**. Each of the planet gears **42** meshes with the pinion gear **41**. The planet gears **42** are supported in a rotatable manner by the spindle **8** via pins **42P**. The spindle **8** is rotated by the planet gears **42**. The internal gear **43** has inner teeth, which mesh with the planet gears **42**. The internal gear **43** is fixed to the bearing box **24**. The internal gear **43** is always non-rotatable relative to the bearing box **24**.

(61) When the rotor shaft **33** rotates in response to the operation (energization) of the motor **6**, the pinion gear **41** rotates, and the planet gears **42** revolve around the pinion gear **41**. The planet gears **42** revolve while meshing with the inner teeth of the internal gear **43**. In response to the revolving of the planet gears **42**, the spindle **8**, which is connected to the planet gears **42** via the respective pins **42P**, rotates at a rotational speed that is lower than the rotational speed of the rotor shaft **33**.

(62) The spindle **8** is rotated by the motor **6**. The spindle **8** rotates in response to the rotational force of the rotor **27** transmitted by the speed-reducing mechanism **7**. The spindle **8** is housed in the hammer case **4**. The spindle **8** is disposed forward of the motor **6**. At least a portion of the spindle **8**

is disposed forward of the speed-reducing mechanism 7.

(63) The spindle 8 comprises a spindle-shaft part 8A and a flange part 8B, which is disposed at a rear portion of the spindle-shaft part 8A. The spindle-shaft part 8A protrudes forward from the flange part 8B. The planet gears 42 are supported in a rotatable manner by the flange part 8B via the respective pins 42P. The rotational axis of the spindle 8 and rotational axis AX of the motor 6 coincide with each other. The spindle 8 rotates about rotational axis AX.

(64) The spindle 8 is supported in a rotatable manner by a spindle bearing 44. The spindle bearing 44 is held by the bearing box 24.

(65) The impact mechanism 9 impacts the anvil 10 in the rotational direction in response to transmission of the rotational force of the spindle 8. The rotational force of the motor 6 is transmitted to the impact mechanism 9 via the speed-reducing mechanism 7 and the spindle 8. The impact mechanism 9 comprises a hammer 47, balls 48, and a coil spring 49. The impact mechanism 9, which comprises the hammer 47, is housed in the hammer case 4.

(66) The hammer 47 is configured to impact (strike) the anvil 10 in the rotational direction, as will be further described below. The hammer 47 is held on the spindle 8. The hammer 47 is disposed around the spindle-shaft part 8A. The balls 48 are disposed between the spindle 8 and the hammer 47. The coil spring 49 is supported by both the spindle 8 and the hammer 47.

(67) The hammer 47 is rotatable, together with the spindle 8, in response to transmission of the rotational force of the spindle 8. The rotational axis of the hammer 47, the rotational axis of the spindle 8, and rotational axis AX of the motor 6 coincide with each other. The hammer 47 rotates about rotational axis AX.

(68) Each of the balls 48 is made of a metal such as steel. The balls 48 are disposed between the spindle-shaft part 8A and the hammer 47. The spindle 8 has spindle grooves, in which at least portions of the balls 48 are respectively disposed. The spindle grooves are provided in portions of an outer surface of the spindle-shaft part 8A. The hammer 47 has hammer grooves, in which at least portions of the balls 48 are respectively disposed. The hammer grooves are provided in portions of an inner surface of the hammer 47. The balls 48 are respectively disposed between the spindle grooves and the hammer grooves. The balls 48 can respectively roll in each of the interiors of the spindle grooves and the interiors of the hammer grooves. The hammer 47 is capable of moving along with the balls 48. The spindle 8 and the hammer 47 are capable of relative movement in both the axial direction and the rotational direction within a movable range that is defined by the spindle grooves and the hammer grooves.

(69) The coil spring 49 generates an elastic restoring force, which causes (biases) the hammer 47 to move forward. The coil spring 49 is disposed between the flange part 8B and the hammer 47. A recessed portion is provided on a rear surface of the hammer 47. The recessed portion recesses forward from a rear surface of the hammer 47. A washer 45 is provided in the interior of the recessed portion. A rear-end portion of the coil spring 49 is supported by the flange part 8B. A front-end portion of the coil spring 49 is supported by the washer 45.

(70) The anvil 10 is the output part of the impact tool 1, on which a tool accessory is mounted. The anvil 10 is disposed forward of the spindle 8. The anvil 10 is connected to a front-end portion of the spindle-shaft part 8A. At least a portion of the anvil 10 is disposed forward of the hammer 47. The anvil 10 comprises a quadrangular-column part 10C, on which a socket, which is a tool accessory, is mounted.

(71) The anvil 10 comprises an anvil-shaft part 10A and anvil-projection parts 10B. The quadrangular-column part 10C is provided at a front-end portion of the anvil-shaft part 10A. The anvil-projection parts 10B protrude radially outward from a rear-end portion of the anvil-shaft part 10A.

(72) The anvil 10 is supported in a rotatable manner by a bearing 46. The rotational axis of the anvil 10, the rotational axis of the hammer 47, the rotational axis of the spindle 8, and rotational axis AX of the motor 6 coincide with each other. The anvil 10 rotates about rotational axis AX. The

bearing **46** is held by the hammer case **4**. An iron sleeve (e.g., made of an oil-impregnated metal) is an illustrative example of the bearing **46**.

(73) At least portions of the hammer **47** are capable of making contact with the anvil-projection parts **10B**. Hammer-projection parts, which protrude forward, are provided at a front portion of the hammer **47**. The hammer-projection parts of the hammer **47** and the anvil-projection parts **10B** are capable of making contact with each another. In the state in which the hammer **47** and the anvil-projection parts **10B** are in contact with each another, the anvil **10** rotates together with the hammer **47** and the spindle **8** in response to the operation (energization) of the motor **6**.

(74) However, the anvil **10** is always configured to be impacted (struck) in the rotational direction by the hammer **47**. For example, during screw-tightening work, there are situations in which, when the load that is acting on the anvil **10** becomes high (exceeds a predetermined threshold), the anvil **10** can no longer be caused to rotate merely by the power generated by the motor **6**. Instead, when the anvil **10** can no longer be caused to rotate merely by the power generated by the motor **6**, rotation of the anvil **10** and the hammer **47** will temporarily stop. The spindle **8** and the hammer **47** can move relative to each another in the axial direction and the circumferential direction via the balls **48**. Even though rotation of the hammer **47** temporarily stops, rotation of the spindle **8** continues owing to the power generated by the motor **6**. In the state in which rotation of the hammer **47** has temporarily stopped but the spindle **8** continues to rotate, the balls **48** move rearward while being guided by the respective spindle grooves and hammer grooves. The hammer **47** receives a force from the balls **48** and moves rearward along with the balls **48**. That is, in the state in which the rotation of the anvil **10** is temporarily stopped, the hammer **47** moves rearward in response to the rotation of the spindle **8**. The contact between the hammer **47** and the anvil-projection parts **10B** is released by the movement of the hammer **47** rearward.

(75) As was noted above, because the coil spring **49** generates an elastic restoring force, it causes (urges) the hammer **47** to move forward. Therefore, after the hammer **47** has been caused to move rearward, it will subsequently move forward owing to the elastic force of the coil spring **49**. When the hammer **47** moves forward, it receives a force in the rotational direction from the balls **48**. That is, the hammer **47** moves forward while rotating. When the hammer **47** moves forward while rotating, the hammer **47** makes contact with (impacts, strikes) the anvil-projection parts **10B** while rotating. Thereby, the anvil-projection parts **10B** are impacted in the rotational direction by the hammer **47**. At this time, both the power of the motor **6** and the inertial force of the hammer **47** act on the anvil **10**. As a result, the anvil **10** can be caused to rotate about rotational axis AX with a higher torque.

(76) The fan **12** generates an airflow for cooling the motor **6**. The fan **12** is fixed to a front portion of the rotor shaft **33**. The fan **12** rotates in response to the rotation of the rotor **27**. In other words, in response to the rotor shaft **33** rotating, the fan **12** rotates together with the rotor shaft **33**. The motor-housing part **21** is provided with both air-intake openings **19** and air-exhaust openings **20**. In response to the rotation of the fan **12**, air in the external space of the housing **2** flows into the internal space of the housing **2** via the air-intake openings **19**. The air that has flowed into the internal space of the housing **2** flows through the internal space of the housing **2**, and thereby cools the motor **6**. In response to the rotation of the fan **12**, the air that has flowed through the internal space of the housing **2** flows out to the external space of the housing **2** via the air-exhaust openings **20**.

(77) The battery-mounting part **13** is connected to the battery pack **25**. The battery pack **25** is mounted on the battery-mounting part **13**. The battery pack **25** is detachable from the battery-mounting part **13**. The battery-mounting part **13** is disposed at a lower portion of the battery-holding part **23**. The battery pack **25** is mounted on the battery-holding part **23**, which is a portion of the housing **2**, via the battery-mounting part **13**.

(78) The battery pack **25** comprises secondary batteries. In the embodiment, the battery pack **25** comprises rechargeable lithium-ion batteries. By being mounted on the battery-mounting part **13**,

the battery pack **25** can supply electric power (current) to the impact tool **1**. The motor **6** operates (is energized) using electric power supplied from the battery pack **25**. The controller **17** operates (is powered) using electric power supplied from the battery pack **25**.

(79) In the embodiment, the rated voltage of the battery pack **25** is 18 V.

(80) The trigger switch **14** is manipulated (e.g., pressed) by the user in order to start (the energization of) the motor **6**. The trigger switch **14** is provided on the grip part **22**. The trigger switch **14** comprises a trigger lever **14A** and a switch main body **14B**. The switch main body **14B** is housed in the grip part **22**. The trigger lever **14A** protrudes forward from an upper portion of a front portion of the grip part **22**. In response to the trigger lever **14A** being manipulated by the user, the motor **6** is switched between operation (energization) and stoppage.

(81) The forward/reverse-change lever **15** is manipulated (pressed, slid) by the user in order to change the rotational direction of the motor **6** from one of the forward-rotational direction and the reverse-rotational direction to the other. The forward/reverse-change lever **15** is provided at an upper portion of the grip part **22**. In response to the forward/reverse-change lever **15** being manipulated, the rotational direction of the motor **6** is changed from one of the forward-rotational direction and the reverse-rotational direction to the other. In response to the rotational direction of the motor **6** being changed, the rotational direction of the spindle **8** is changed.

(82) The action-mode-change switch **16** is manipulated by the user in order to change the control mode of the motor **6**, e.g., a sequence of motor rotational speeds. The action-mode-change switch **16** is provided on the battery-holding part **23**.

(83) The controller **17** outputs control signals that control at least (the energization of) the motor **6**. The controller **17** is housed in the battery-holding part **23**. The controller **17** comprises a circuit board on which a plurality of electronic components is mounted. A processor, such as a CPU (central processing unit); nonvolatile memory, such as ROM (read-only memory) and storage; volatile memory, such as RAM (random-access memory); transistors; and resistors are illustrative examples of the electronic components mounted on the circuit board.

(84) Light Unit

(85) FIG. **4** is an exploded, oblique view, viewed from the front, that shows the light unit **18** according to the embodiment. The light unit **18** emits illumination light. The light unit **18** illuminates the anvil **10** and the periphery of the anvil **10** with illumination light. The light unit **18** illuminates forward of the anvil **10** with illumination light. In addition, the light unit **18** illuminates the tool accessory mounted on the anvil **10** and the periphery of the tool accessory with illumination light.

(86) The light unit **18** is held on the hammer case **4**. The light unit **18** is disposed at a front portion of the hammer case **4**. The light unit **18** is disposed at least partially around the hammer case **4**.

(87) The hammer case **4** comprises a hammer-housing part **4A** and a bearing-retaining part **4B**. The hammer-housing part **4A** has a tube shape. The hammer-housing part **4A** is disposed around the impact mechanism **9**. The hammer-housing part **4A** houses at least the hammer **47**. The bearing-retaining part **4B** has a tube shape. The bearing-retaining part **4B** is disposed more forward than the hammer-housing part **4A**. The outer diameter of the bearing-retaining part **4B** is smaller than the outer diameter of the hammer-housing part **4A**. The bearing-retaining part **4B** is disposed around the bearing **46**. The bearing-retaining part **4B** holds the bearing **46**.

(88) The light unit **18** is disposed around the bearing-retaining part **4B**. A rear portion of the hammer-housing part **4A** is housed in the motor-housing part **21**.

(89) The light unit **18** comprises light-emitting devices **60**, a light circuit board **61**, optical members **62**, and a light cover **63**.

(90) Each of the light-emitting devices **60** is a light source that emits illumination light. Light-emitting diodes (LEDs: light-emitting diodes) are illustrative examples of the light-emitting devices **60**.

(91) The plurality of the light-emitting devices **60** is provided such that the light-emitting devices

60 are spaced apart around the anvil **10**. The number of light-emitting devices **60** is, for example, two or more and eight or less. At least three of the light-emitting devices **60** may be provided. The number of light-emitting devices **60** may be, for example, three or more and six or less. In the embodiment, four of the light-emitting devices **60** are provided around the anvil **10**.

(92) The light circuit board **61** supports the plurality of light-emitting devices **60**. The light circuit board **61** is disposed at least partially around the hammer case **4**. In the embodiment, the light circuit board **61** is disposed partially around the hammer case **4**. The light circuit board **61** is disposed partially around the bearing-retaining part **4B**.

(93) The light circuit board **61** comprises a printed wiring board (PWB) or printed circuit board (PCB). The light circuit board **61** has wiring (traces, conductive paths) that is (are) connected to the light-emitting devices **60**. Electric power (current) is supplied to the light-emitting devices **60** via the wiring of the light circuit board **61**. The light-emitting devices **60** are mounted on a front surface of the light circuit board **61**. In the embodiment, the light unit **18** comprises surface-mount-type (SMD: surface-mount device) light-emitting diodes. Each of the light-emitting devices **60** comprises a so-called chip LED.

(94) The voltage input to each one of the light-emitting devices **60** is 1.0 volt (V) or more and 10.0 V or less. The voltage applied to each one of the light-emitting devices **60** may be, for example, 2.0 V or more and 8.0 V or less or may be 2.5 V or more and 5.0 V or less.

(95) Electric current supplied to each one of the light-emitting devices **60** is 5 milliamps (mA) or more and 100 mA or less. Electric current supplied to each one of the light-emitting devices **60** may be 10 mA or more and 50 mA or less or may be 15 mA or more and 30 mA or less.

(96) The light beam of the illumination light emitted from each one of the light-emitting devices **60** is 1 lumen (lm) or more and 20 lm or less. The light beam of the illumination light emitted from each one of the light-emitting devices **60** may be 3 lm or more and 15 lm or less or may be 5 lm or more and 10 lm or less.

(97) The luminous intensity of the illumination light emitted from each one of the light-emitting devices **60** is 0.5 candela (cd) or more and 10 cd or less. The luminous intensity of the illumination light emitted from each one of the light-emitting devices **60** may be 1 cd or more and 7 cd or less or may be 2 cd or more and 5 cd or less.

(98) As shown in FIG. 4, the outer shape of each one of the light-emitting devices **60** is substantially rectangular-parallelepiped-shaped.

(99) Width W of each one of the light-emitting devices **60** is 0.5 millimeters (mm) or more and 3 mm or less. Width W of each one of the light-emitting devices **60** may be 1 mm or more and 2 mm or less or may be 1.2 mm or more and 1.8 mm or less.

(100) Length L of each one of the light-emitting devices **60** is 1.5 mm or more and 6 mm or less. Length L of each one of the light-emitting devices **60** may be 2.5 mm or more and 3.5 mm or less.

(101) Thickness H of each one of the light-emitting devices **60** is 0.2 mm or more and 2 mm or less. Thickness H of each one of the light-emitting devices **60** may be 0.3 mm or more and 1 mm or less or may be 0.4 mm or more and 0.8 mm or less.

(102) The optical members **62** are disposed forward of the light-emitting devices **60** and the light circuit board **61**. Each of the optical members **62** comprises: light-transmitting parts **62A**, which transmits the illumination light emitted from the corresponding light-emitting devices **60**; and a coupling part **62B**, which is connected to the light-transmitting parts **62A**.

(103) In the embodiment, the optical members **62** comprise an optical member **62L**, which is disposed more leftward than rotational axis AX, and an optical member **62R**, which is disposed more rightward than rotational axis AX. As can be seen, e.g., in FIG. 4, the optical members **62L**, **62R** do not directly contact each other when integrated into the light cover **63**, but are indirectly connected (linked) to each other via the material of the light cover **63** in the integrated state. The optical member **62L** comprises two of the light-transmitting parts **62A**. The optical member **62R** comprises two of the light-transmitting parts **62A**. Of the four light-emitting devices **60**, the two

light-emitting devices **60** disposed more leftward than rotational axis AX respectively oppose the two light-transmitting parts **62A** of the optical member **62L**. Of the four light-emitting devices **60**, the two light-emitting devices **60** disposed more rightward than rotational axis AX respectively oppose the two light-transmitting parts **62A** of the optical member **62R**.

(104) Each of the optical members **62** is formed of an optically transmissive synthetic resin (polymer). In the embodiment, each of the optical members **62** is formed of a polycarbonate resin (polymer). It is noted that each of the optical members **62** may be formed of an acrylic resin (polymer).

(105) Each of the light-transmitting parts **62A** has a lens function. Each of the light-transmitting parts **62A** refracts illumination light emitted from the corresponding light-emitting device **60**. It is noted that each of the light-transmitting parts **62A** does not have to have a lens function.

(106) The light cover **63** is disposed forward of the light-emitting devices **60** and the light circuit board **61**. In the embodiment, the light cover **63** is substantially ring-shaped.

(107) The light cover **63** is formed of a synthetic resin (polymer). The light cover **63** may be formed of a material the same as that of the optical members **62**. The light cover **63** may be formed of a material that differs from that of the optical members **62**. In the embodiment, the light cover **63** is formed of a polycarbonate resin (polymer). It is noted that the light cover **63** may be formed of an acrylic resin (polymer). The optical members **62** and the light cover **63** are integrally molded. The optical members **62** and the light cover **63** are integrated by, for example, insert molding.

(108) As can be seen in FIG. 4, openings **63A** are provided spaced part in different portions of the light cover **63**. The light-transmitting parts **62A** of the optical members **62** are respectively disposed in the openings **63A** of the light cover **63** such that the light-transmitting parts **62A** are separated from each other on the outer surface of the light cover **63**. The light-transmitting parts **62A** are not covered by the light cover **63**. That is, the light cover **63** is not disposed forward or rearward of the light-transmitting parts **62A**. The coupling parts **62B** of the optical members **62** are fixed to the light cover **63**.

(109) The optical members **62** and the light cover **63** are disposed around the bearing-retaining part **4B**. The optical members **62** and the light cover **63** are supported on the hammer case **4** via the hammer-case cover **5**.

(110) The optical members **62** and the light cover **63** protect the light-emitting devices **60** and the light circuit board **61**. The optical members **62** and the light cover **63** block contact between objects around the impact tool **1** on one side and the light-emitting devices **60** and the light circuit board **61** on the other side. The optical members **62** and the light cover **63** are integrally molded such that a gap is not formed between the optical members **62** and the light cover **63**. The optical members **62** and the light cover **63** have a dustproofing function that inhibits the ingress of moisture to the light-emitting devices **60** and the light circuit board **61**. The optical members **62** and the light cover **63** have a dustproofing function that inhibits the ingress of dust to the light-emitting devices **60** and the light circuit board **61**.

(111) Relationship Between Maximum Tightening Torque and Number of Light-Emitting Devices

(112) FIG. 5 is a table that shows the specifications of a variety of known impact wrenches according. More particularly, FIG. 5 shows the specifications for: Product A, Product B, and Product C, which are impact wrenches manufactured and sold by Company α ; Product D, Product E, and Product F, which are impact wrenches manufactured and sold by Company β ; Product G, Product H, and Product I, which are impact wrenches manufactured and sold by Company γ ; and Product J, Product K, and Product L, which are impact wrenches manufactured and sold by Company δ . Each product from Product A to Product L has structural elements equivalent to the structural elements of the impact tool **1**, which was described above with reference to FIG. 1 to FIG. 4. A battery pack is mounted on each product from Product A to Product L.

(113) The number of light-emitting devices, the maximum tightening torque [N.Math.m] of the anvil, the rated voltage [V] of the battery pack, the weight [kg] of the impact wrench in the state in

which the battery pack is mounted, the overall length [mm] indicating the distance from the front-end portion of the anvil to the rear-end portion of the motor-housing part, the maximum rotational speed [rpm] of the anvil, and the wrench width [inches], which is defined as the dimension of one side of a cross section of the quadrangular-column part, are illustrative examples of the specifications of the impact wrench.

(114) As shown in FIG. 5, the number of light-emitting devices is three for Product A, and similarly is three for Product B, one for Product C, three for Product D, one for Product E, three for Product F, one for Product G, three for Product H, one for Product I, one for Product J, one for Product K, and zero for Product L.

(115) As shown in FIG. 5, the maximum tightening torque is 192 N.Math.m for Product A, and, expressed in a similar manner, is 339 N.Math.m for Product B, 949 N.Math.m for Product C, 2,576 N.Math.m for Product D, 2,034 N.Math.m for Product E, 339 N.Math.m for Product F, 678 N.Math.m for Product G, 115 N.Math.m for Product H, 181 N.Math.m for Product I, 100 N.Math.m for Product J, 260 N.Math.m for Product K, and 1,057 N.Math.m for Product L.

(116) The values of the rated voltage (V) of the battery pack, the weight (kg) of the impact wrench in the state in which the battery pack is mounted, the overall length (mm), which is defined as the distance from the front-end portion of the anvil to the rear-end portion of the motor-housing part, the maximum rotational speed (rpm) of the anvil, and the wrench width (inches), which is defined as the dimension of one side of a cross section of the quadrangular-column part, are as shown in FIG. 5.

(117) In each product from Product A to Product L, the rated voltage of the battery pack is roughly 18 V.

(118) FIG. 6 is a graph that shows the relationship between maximum tightening torque of the anvil and number of light-emitting devices according to both the above-described known impact tools and the embodiment. In the graph shown in FIG. 6, the abscissa is the number of light-emitting devices, and the ordinate is the maximum tightening torque of the anvil. The points shown in FIG. 6 plot the relationship between maximum tightening torque of the anvil and number of the light-emitting devices for each product from Product A to Product L shown in FIG. 5.

(119) To provide an impact tool 1 having improved ergonomics and/or work efficiency, it is effective to brightly illuminate the work environment with illumination light using the light unit 18. In addition, for the same purpose, it is effective to shorten the overall length. On the other hand, if the maximum tightening torque becomes large, there is a tendency for the overall length of the impact tool 1 to become large. It is important to decide on a suitable tradeoff between overall length and maximum tightening torque of the impact tool 1.

(120) As described above, the impact tool 1 comprises a plurality of structural elements, such as the motor 6, the spindle 8, the impact mechanism 9, the anvil 10, and the light unit 18. By optimizing these structural elements, an improved impact tool 1 can be provided. In the present specification, the structural elements of the impact tool 1 are optimized, and thereby the impact tool 1, in which ergonomics and/or work efficiency is (are) better than in the above-described known impact wrenches, is provided.

(121) With regard to the impact tool 1 according to the embodiment, the battery pack 25 having a rated voltage of 18V is mounted.

(122) As shown by the hatched area in FIG. 6, the impact tool 1 according to the embodiment comprises the plurality of light-emitting devices 60, and the maximum tightening torque of the anvil 10 is 1,000 N.Math.m or more and 2,500 N.Math.m or less. An impact wrench comprising a plurality of light-emitting devices and wherein the maximum tightening torque of the anvil 10 is 1,000 N.Math.m or more and 2,500 N.Math.m or less does not exist in the above-described known impact tools.

(123) Relationship Between Weight and Number of Light-Emitting Devices

(124) In addition, to provide an impact tool 1 having improved ergonomics and/or work efficiency,

it is effective to optimize the weight of the impact tool **1**. In the embodiment, the weight of the impact tool is the weight of the impact tool in the state in which the battery pack is mounted.

(125) FIG. 7 is a graph that shows the relationship between weight of the impact tool and number of the light-emitting devices according to both the above-described known impact tools and the embodiment. In the graph shown in FIG. 7, the abscissa is the number of light-emitting devices, and the ordinate is the weight of the impact tool. The points shown in FIG. 7 plot the relationship between the weight of the impact tool and the number of the light-emitting devices for each product from Product A to Product L shown in FIG. 5.

(126) As shown by the hatched area in FIG. 7, the impact tool **1** according to the embodiment comprises at least three of the light-emitting devices **60** and has a weight of 2 kg or more and 9 kg or less. An impact wrench comprising at least three of the light-emitting devices and having a weight of 2 kg or more and 9 kg or less does not exist in the above-described known impact tools.

(127) It is noted that, in the impact tool **1** comprising the plurality of light-emitting devices **60** and wherein the maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less, the weight of the impact tool **1** may be 2 kg or less.

(128) Relationship Between Overall Length and Number of Light-Emitting Devices

(129) In addition, to provide an impact tool **1** having improved ergonomics and/or work efficiency, it is effective to optimize the overall length of the impact tool **1**. As shown in FIG. 1, overall length La of the impact tool **1** is the distance from a front-end portion of the anvil **10** to a rear-end portion of the motor-housing part **21**.

(130) FIG. 8 is a graph that shows the relationship between overall length of the impact tool and number of the light-emitting devices according to both the above-described known impact tools and the embodiment. In the graph shown in FIG. 8, the abscissa is the number of light-emitting devices, and the ordinate is the overall length of the impact tool. The points shown in FIG. 8 plot the relationship between overall length of the impact tool and number of the light-emitting devices for each product from Product A to Product L shown in FIG. 5.

(131) As shown by the hatched area in FIG. 8, the impact tool **1** according to the embodiment comprises at least three of the light-emitting devices **60**, and has overall length La of 200 mm or more and 400 mm or less. An impact wrench comprising at least three of the light-emitting devices and having an overall length of 200 mm or more and 400 mm or less does not exist in the above-described known impact tools.

(132) It is noted that, in the impact tool **1** comprising the plurality of light-emitting devices **60** and wherein the maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less, overall length La of the impact tool **1** may be 155 mm or less.

(133) Relationship Between Maximum Rotational Speed of Anvil and Number of Light-Emitting Devices

(134) In addition, to provide an impact tool **1** having improved ergonomics and/or work efficiency, it is effective to optimize the maximum rotational speed of the anvil **10**.

(135) FIG. 9 is a graph that shows the relationship between maximum rotational speed of the anvil and number of the light-emitting devices according to both the above-described known impact tools and the embodiment. In the graph shown in FIG. 9, the abscissa is the number of light-emitting devices, and the ordinate is the maximum rotational speed of the anvil. The points shown in FIG. 9 plot the relationship between maximum rotational speed of the anvil and number of the light-emitting devices for each product from Product A to Product L shown in FIG. 5.

(136) As shown by the hatched area in FIG. 9, the impact tool **1** according to the embodiment comprises at least three of the light-emitting devices **60** and wherein the maximum rotational speed of the anvil **10** is 1,300 rpm or more and 2,300 rpm or less. An impact wrench comprising at least three of the light-emitting devices and wherein the maximum rotational speed is 1,300 rpm or more and 2,300 rpm or less does not exist in the above-described known impact tools.

(137) It is noted that, in the impact tool **1** comprising the plurality of light-emitting devices **60** and

wherein the maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less, the maximum rotational speed of the anvil **10** may be 3,000 rpm or less.

(138) Relationship Between Wrench Width of Anvil and Number of Light-Emitting Devices In addition, to provide an impact tool **1** having improved ergonomics and/or work efficiency, it is effective to optimize the wrench width of the anvil **10**. As shown in FIG. 2, wrench width **W1** of the anvil **10** is the dimension of one side of a cross section of the quadrangular-column part **10C**.

(139) FIG. 10 is a graph that shows the relationship between wrench width of the anvil and number of the light-emitting devices according to both the above-described known impact tools and the embodiment. In the graph shown in FIG. 10, the abscissa is the number of light-emitting devices, and the ordinate is the wrench width of the anvil. The points shown in FIG. 10 plot the relationship between wrench width of the anvil and number of the light-emitting devices for each product from Product A to Product L shown in FIG. 5.

(140) As shown by the hatched area in FIG. 10, the impact tool **1** according to the embodiment comprises at least three of the light-emitting devices **60** and wherein the wrench width **W1** of the anvil **10** is 0.6 inches or more and 0.9 inches or less. An impact wrench comprising at least three of the light-emitting devices and wherein the wrench width is 0.6 inches or more and 0.9 inches or less does not exist in the above-described known impact tools.

(141) It is noted that, in the impact tool **1** comprising the plurality of light-emitting devices **60** and wherein the maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less, wrench width **W1** may be 0.375 inches or less.

Effects

(142) As explained above, an impact tool **1** comprises: a motor **6**; a spindle **8**, which is rotated by the motor **6**; a hammer **47**, which is held on the spindle **8**; an anvil **10**, which is impacted in a rotational direction by the hammer **47**; a housing **2**, which houses the motor **6**; and a hammer case **4**, which is connected to the housing **2** and houses the hammer **47** and the spindle **8**. The impact tool **1** comprises a light unit **18**, which is held on the hammer case **4** and comprises a plurality of light-emitting devices **60**. The maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less.

(143) According to the above-mentioned configuration, because the light unit **18** comprises the plurality of light-emitting devices **60**, the work environment is brightly illuminated with illumination light. In addition, the maximum tightening torque of the anvil **10** is 1,000 N.Math.m or more and 2,500 N.Math.m or less. Consequently, an impact tool **1** having improved ergonomics and/or work efficiency is provided.

(144) In the embodiment, at least three of the light-emitting devices **60** are provided.

(145) According to the above-mentioned configuration, because the light unit **18** comprises at least three of the light-emitting devices **60**, the work environment is brightly illuminated with illumination light. Consequently, an impact tool **1** having improved ergonomics and/or work efficiency is provided.

(146) In the embodiment, a battery pack **25** is mounted on a battery-holding part **23**, which is a portion of the housing **2**. The weight of the impact tool **1** is 2 kg or less.

(147) According to the above-mentioned configuration, because the impact tool **1**, with the battery pack **25** mounted thereon, has a weight of 2 kg or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.

(148) In the embodiment, a battery pack **25** is mounted on a battery-holding part **23**, which is a portion of the housing **2**. At least three of the light-emitting devices **60** are provided. The weight of the impact tool **1** is 2 kg or more and 9 kg or less.

(149) According to the above-mentioned configuration, because the light unit **18** comprises at least three of the light-emitting devices **60** and the impact tool **1**, with the battery pack **25** mounted thereon, has a weight of 2 kg or more and 9 kg or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.

- (150) In the embodiment, the spindle **8** is disposed forward of the motor **6**; the anvil **10** is disposed forward of the spindle **8**; and the motor **6** is housed in a motor-housing part **21**, which is a portion of the housing **2**. The overall distance L_a , which is defined as the distance from a front-end portion of the anvil **10** to a rear-end portion of the motor-housing part **21**, is 155 mm or less.
- (151) According to the above-mentioned configuration, because the overall length L_a of the impact tool **1**, which is defined as the distance between the front-end portion of the anvil **10** and the rear-end portion of the motor-housing part **21**, is 155 mm or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (152) In the embodiment, the spindle **8** is disposed forward of the motor **6**; the anvil **10** is disposed forward of the spindle **8**; and the motor **6** is housed in a motor-housing part **21**, which is a portion of the housing **2**. At least three of the light-emitting devices **60** are provided. The overall distance L_a , which is defined as the distance from a front-end portion of the anvil **10** to a rear-end portion of the motor-housing part **21**, is 200 mm or more and 400 mm or less.
- (153) According to the above-mentioned configuration, because the light unit **18** comprises at least three of the light-emitting devices **60** and the overall length L_a of the impact tool **1**, which is defined as the distance from the front-end portion of the anvil **10** to the rear-end portion of the motor-housing part **21**, is 200 mm or more and 400 mm or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (154) In the embodiment, the maximum rotational speed of the anvil **10** is 3,000 rpm or less.
- (155) According to the above-mentioned configuration, because the maximum rotational speed of the anvil **10** is 3,000 rpm or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (156) In the embodiment, at least three of the light-emitting devices **60** are provided. The maximum rotational speed of the anvil **10** is 1,300 rpm or more and 2,300 rpm or less.
- (157) According to the above-mentioned configuration, because the light unit **18** comprises at least three of the light-emitting devices **60** and the maximum rotational speed of the anvil **10** is 1,300 rpm or more and 2,300 rpm or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (158) In the embodiment, the anvil **10** has a quadrangular-column part **10C**. The wrench width $W1$, which is defined as the dimension of one side of a cross section of the quadrangular-column part **10C**, is 0.375 inches or less.
- (159) According to the above-mentioned configuration, because the wrench width $W1$, which is defined as the dimension of one side of a cross section of the quadrangular-column part **10C**, is 0.375 inches or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (160) In one or more embodiments, the anvil **10** has a quadrangular-column part **10C**. At least three of the light-emitting devices **60** are provided. The wrench width $W1$, which is defined as the dimension of one side of a cross section of the quadrangular-column part **10C**, is 0.6 inches or more and 0.9 inches or less.
- (161) According to the above-mentioned configuration, because the light unit **18** comprises at least three of the light-emitting devices **60** and the wrench width $W1$, which is defined as the dimension of one side of a cross section of the quadrangular-column part **10C**, is 0.6 inches or more and 0.9 inches or less, an impact tool **1** having improved ergonomics and/or work efficiency is provided.
- (162) In the embodiment, the light unit **18** comprises: a light circuit board **61**, which is disposed at least partially around the hammer case **4** and holds a plurality of the light-emitting devices **60**; and optical members **62**, which are disposed forward of the light-emitting devices **60** and the light circuit board **61**.
- (163) According to the above-mentioned configuration, the light-emitting devices **60** and the light circuit board **61** are protected by the optical members **62**.

Modified Examples

(164) FIGS. 11-13 schematically show modified examples of the light circuit board 61 according to the above-described embodiment. As shown in FIG. 11, a light circuit board 61A may have a ring shape. As shown in FIG. 12, a light circuit board 61B may have an arc shape. A gap 61G is provided between one-end portion and the other-end portion of the light circuit board 61B. As shown in FIG. 13, the gap 61G between one-end portion and the other-end portion of a light circuit board 61C may be large.

(165) In the embodiments described above, it is assumed that the impact tool 1 is an impact wrench. The impact tool 1 may be an impact driver.

(166) In the embodiments described above, the power supply of the impact tool 1 does not have to be the battery pack 25 and may be commercial power supply (AC power supply).

(167) Representative, non-limiting examples of the present invention were described above in 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 preferred aspects of the present teachings and is not intended to limit the scope of the invention. Furthermore, each of the additional features and teachings disclosed above may be utilized separately or in conjunction with other features and teachings to provide improved impact tools, such as impact wrenches and impact drivers.

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

(169) 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.

EXPLANATION OF THE REFERENCE NUMBERS

(170) 1 Impact tool 2 Housing 2L Left housing 2R Right housing 2S Screw 4 Hammer case 4A Hammer-housing part 4B Bearing-retaining part 5 Hammer-case cover 6 Motor 7 Speed-reducing mechanism 8 Spindle 8A Spindle-shaft part 8B Flange part 9 Impact mechanism 10 Anvil 10A Anvil-shaft part 10B Anvil-projection part 10C Quadrangular-column part 12 Fan 13 Battery-mounting part 14 Trigger switch 14A Trigger lever 14B Switch main body 15 Forward/reverse-change lever 16 Mode-change switch 17 Controller 18 Light unit 19 Air-intake opening 20 Air-exhaust opening 21 Motor-housing part 21A Tubular part 21B Rear-cover part 22 Grip part 23 Battery-holding part 24 Bearing box 25 Battery pack 26 Stator 27 Rotor 28 Stator core 29 Front insulator 30 Rear insulator 31 Coil 32 Rotor core 33 Rotor shaft 34 Rotor magnet 37 Sensor board 39 Rotor bearing 41 Pinion gear 42 Planet gear 42P Pin 43 Internal gear 44 Spindle bearing 45 Washer 46 Bearing 47 Hammer 48 Ball 49 Coil spring 60 Light-emitting device 61 Light circuit board 61A Light circuit board 61B Light circuit board 61C Light circuit board 61G Gap 62 Optical member 62A Light-transmitting part 62B Coupling part 62L Optical member 62R Optical member 63 Light cover 63A Opening AX Rotational axis H Thickness L Length La Overall length W Width W1 Wrench width

Claims

1. An impact tool comprising: a brushless motor, which includes a stator and a rotor configured to rotate relative to the stator; a spindle, which is rotated by the brushless motor; a hammer, which is

held on the spindle, an anvil, which is impacted in a rotational direction by the hammer, the anvil having a quadrangular-column part and having a maximum tightening torque of 1,000 N.Math.m or more and 2,500 N.Math.m or less; a polymer housing, which houses the brushless motor; a hammer case, which is connected to the polymer housing and houses the hammer and the spindle, the hammer case including a hammer-housing part that houses the hammer and a bearing-retaining part that holds a bearing; a cover, which covers at least a portion of the hammer case; three or more optical members, which are held on the cover; three or more light-emitting devices, which are respectively disposed rearward of the three or more optical members; and a light circuit board on which the three or more light-emitting devices are fixed; wherein: the three or more optical members respectively face the light-emitting devices and are configured to transmit illumination light emitted from the three or more light-emitting devices; and the cover, the three or more optical members, the three or more light-emitting devices, and the light circuit board are all disposed around the bearing-retaining part and forward of a rear end of the anvil.

2. The impact tool according to claim 1, wherein the impact tool has a weight of 2 kg or more and 9 kg or less.

3. The impact tool according to claim 1, wherein a distance from a front end of the anvil to a rear end of the polymer housing is 200 mm or more and 400 mm or less.

4. The impact tool according to claim 3, wherein: the three or more optical members are composed of a first material, and the cover is composed of a second material that differs from the first material.

5. The impact tool according to claim 4, wherein the cover has three or more openings that are spaced apart in different portions of the cover such that portions of the three or more optical members are respectively disposed in the three or more openings.

6. The impact tool according to claim 1, wherein the anvil has a maximum rotational speed of 1,300 rpm or more and 2,300 rpm or less.

7. The impact tool according to claim 1, wherein: the three or more optical members are composed of a first material, and the cover is composed of a second material that differs from the first material.

8. The impact tool according to claim 7, wherein: the three or more optical members do not directly contact each other; and the three or more optical members and the cover are integrated such that the three or more optical members are indirectly connected to each other via the second material.

9. The impact tool according to claim 1, wherein the cover has three or more openings that are spaced apart in different portions of the cover such that portions of the three or more optical members are respectively disposed in the three or more openings.

10. The impact tool according to claim 1, wherein the bearing rotatably supports the anvil.

11. The impact tool according to claim 10, wherein the cover is ring-shaped and radially surrounds the anvil.

12. The impact tool according to claim 1, wherein the three or more optical members are optically independent from each other.

13. An impact tool, comprising: a brushless motor, which includes a stator and a rotor configured to rotate relative to the stator; a spindle, which is rotated by the brushless motor; a hammer, which is held on the spindle, an anvil, which is impacted in a rotational direction by the hammer; a polymer housing, which houses the brushless motor; a hammer case, which is connected to the polymer housing and houses the hammer and the spindle; a cover, which covers at least a portion of the hammer case; three or more optical members, which are held on the cover; and three or more light-emitting devices, which are respectively disposed rearward of the three or more optical member; wherein: the three or more optical members respectively face the light-emitting devices and are configured to transmit illumination light emitted from the three or more light-emitting devices; the three or more optical members are composed of a first material that comprises a polycarbonate or an acrylic, the cover is composed of a second material that differs from the first material, and the

second material comprises a polycarbonate or an acrylic.

14. The impact tool according to claim 13, wherein the anvil has a maximum tightening torque of 1,000 N.Math.m or more and 2,500 N.Math.m or less.

15. The impact tool according to claim 14, wherein the cover has three or more openings that are spaced apart in different portions of the cover such that portions of the three or more optical members are respectively disposed in the three or more openings.

16. The impact tool according to claim 15, wherein the impact tool has a weight of 2 kg or more and 9 kg or less.

17. The impact tool according to claim 16, wherein a distance from a front end of the anvil to a rear end of the polymer housing is 200 mm or more and 400 mm or less.

18. The impact tool according to claim 17, wherein: the three or more optical members do not directly contact each other; and the three or more optical members and the cover are integrated such that the three or more optical members are indirectly connected to each other via the second material.

19. An impact tool comprising: a brushless motor, which includes a stator and a rotor configured to rotate relative to the stator; a spindle, which is rotated by the brushless motor; a hammer, which is held on the spindle, an anvil, which is impacted in a rotational direction by the hammer, the anvil having a quadrangular-column part and having a maximum tightening torque of 1,000 N.Math.m or more and 2,500 N.Math.m or less; a polymer housing, which houses the brushless motor; a hammer case, which is connected to the polymer housing; a cover, which covers at least a portion of the hammer case; three or more optical members, which are held on the cover; three or more light-emitting devices, which are respectively disposed rearward of the three or more optical members; and a light circuit board on which the three or more light-emitting devices are fixed; wherein: the three or more optical members respectively face the light-emitting devices and are configured to transmit illumination light emitted from the three or more light-emitting devices, and the cover and the three or more optical members are integrally molded such that a gap is not formed therebetween, so as to inhibit ingress of moisture or dust.

20. The impact tool according to claim 19, wherein the cover is ring-shaped and radially surrounds the anvil.

21. The impact tool according to claim 20, wherein: the three or more optical members are composed of a first material, and the cover is composed of a second material that differs from the first material.

22. The impact tool according to claim 21, wherein: the three or more optical members do not directly contact each other; and the three or more optical members and the cover are integrated such that the three or more optical members are indirectly connected to each other via the second material.
