United States Patent Application Publication	20250256337
Kind Code	A1
Publication Date	August 14, 2025
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POWER TOOL AND CONTROL MODULE THEREFOR

Abstract

A control module (**10**) for a power tool includes a box-shaped case (**60**), one side of which is open, and a circuit board (**50**) housed in the case. A microcomputer (**51**) and FETs (**52**) configured to control a brushless motor (**1**c) of the power tool are mounted on the circuit board. Movable switches (**30**) are mechanically linked to movement of a trigger (**20**) and are electrically connected to the circuit board. A cover (**70**) partially covers the opening of the case such that a portion of the circuit board and the movable switches are covered. Bonded parts (**14**) weld or otherwise materially bond the cover and the case to form an enclosed space (**13**), which encloses the movable switches.

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Family ID: **1000008433254**

Appl. No.: **19/015948**

Filed: **January 10, 2025**

Foreign Application Priority Data

JP	2024-020156	Feb. 14, 2024

Publication Classification

Int. Cl.: **B23B45/02** (20060101); **B25F5/02** (20060101); **H02K7/14** (20060101); **H02K11/33** (20160101)

U.S. Cl.:

CPC **B23B45/02** (20130101); **B25F5/02** (20130101); **H02K7/145** (20130101); **H02K11/33** (20160101); B23B2270/32 (20130101)

Background/Summary

CROSS-REFERENCE
[0001] The present application claims priority to Japanese patent application serial number 2024-020156 filed on Feb. 14, 2024, the contents of which are hereby fully incorporated by reference.
TECHNICAL FIELD
[0002] The present invention relates to a power tool and to a control module for a power tool. The control module integrally comprises a circuit board and trigger, which are, for example, associated with the control of a power tool motor.
BACKGROUND ART
[0003] A power tool disclosed in European Patent No. 2946886 has a brushless motor and a control module. The control module has a case that is open at the top and a circuit board that is housed in the case. FETs (field effect transistors), which are used to control the brushless motor, are provided on the circuit board. The control module further has a trigger and an actuator, which is movable in conjunction with the operation (movement) of the trigger. The actuator is connected to the circuit board and is covered by a cover. The cover is connected to the case by snap fitting. The actuator is provided in the enclosed space formed by the cover and the case, to protect the actuator.
SUMMARY OF THE INVENTION
[0004] However, snap fit connection may leave a gap between the cover and the case, such that the enclosed space may not be adequately dustproof or waterproof. Therefore, poor conduction may eventually occur at the contacts due to corrosion or covering caused by dust or water that has entered the enclosed space. There is, therefore, a need for a control module that can adequately dustproof or waterproof the enclosed space formed by the cover and the case.
[0005] According to one aspect of the present disclosure, a control module for a power tool includes a box-shaped case, one side of which is open, and a circuit board housed in the case. A microcomputer and FETs (field effect transistors), which are used to control a brushless motor of the power tool, are mounted on the circuit board. A manipulatable member (e.g., a trigger) is movably coupled to (partially disposed in) the case. Movable switches, which are mechanically linked to the movement of the manipulatable member, are connected to the circuit board; i.e. the movable switches preferably move together with the manipulatable member. The cover is partially overlaid on the opening of the case. The cover covers a portion of the circuit board and covers the movable switches. The control module further includes bonded parts, which weld or bond the cover and the case. The bonded parts form an enclosed space, which encloses the movable switches.
[0006] With regard to the bonded parts, at least portions of the cover and the case are melted so as to be welded to each other, or a bonding agent is used to bond the cover and the case to each other. Therefore, gaps between the cover and the case are filled by the bonded parts. Accordingly, the enclosed space is formed between the cover and the case. The enclosed space is more dustproof and waterproof than, for example, an enclosed space in which the cover and the case are connected to each other by snap fitting. The movable switches are protected by the enclosed space, more particularly by the case, cover and bonded parts. Thus, poor conduction caused by the ingress of dust or water is unlikely to occur in the movable switches.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0007] FIG. **1** is a right side view of a power tool according to the present disclosure, with the right side housing removed.
[0008] FIG. **2** is an exploded perspective view of the control module disassembled from the power

tool.
[0009] FIG. **3** is a right side view of the control module.
[0010] FIG. **4** is a perspective view of the control module.
[0011] FIG. **5** is an exploded perspective view of the control module.
[0012] FIG. **6** is an exploded perspective view in which FIG. **5** is seen from the left side.
[0013] FIG. **7** is a cross-sectional view along the line VII-VII in FIG. **3**.
[0014] FIG. **8** is a view of the cover and the trigger, seen from the left side.
[0015] FIG. **9** is a view corresponding to FIG. **8**, showing the state in which the trigger has been pulled.
[0016] FIG. **10** is an enlarged view of the upper region of the circuit board.
[0017] FIG. **11** is a perspective view corresponding to FIG. **4** showing the state in which the FETs are covered with a heat sink.
[0018] FIG. **12** is a perspective view showing the heat sink in another exemplary embodiment.
[0019] FIG. **13** is a perspective view showing the heat sink in yet another exemplary embodiment.
[0020] FIG. **14** is a perspective view showing the heat sink in yet another exemplary embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0021] According to another aspect of the present disclosure, a microcomputer (microprocessor, memory, etc.) and FETs are provided on the circuit board at positions clear (outside) of the enclosed space. Consequently, when the microcomputer and the FETs generate heat during operation of the power tool, the microcomputer and the FETs can effectively dissipate the heat, because the microcomputer and FETs are not disposed in the enclosed space of the control module.
[0022] According to another aspect of the present disclosure, the operation (starting, energization) and stopping of the brushless motor are switched by the movement of a movable switch, which is linked to the manipulatable member. Thus, the operation and stopping of the brushless motor are switched by manipulating (e.g., pulling, squeezing) the manipulatable member.
[0023] According to another aspect of the present disclosure, the movable switches include a power switch and a variable speed switch. The power switch is configured to electrically connect and disconnect the brushless motor and the battery. The variable speed switch is configured to control the output (in particular, rotational speed of a rotor) of the brushless motor according (proportional) to the amount of movement of the manipulatable member. Thus, the power switch and the variable speed switch are each controllable by manipulating the manipulatable member. The movable switches may further include a control switch that is configured to control operations in the microcomputer. The microcomputer may, for example, recognize the input of the control switch and light a power tool lamp. The lamp can, therefore, be reliably lit in response to manipulation the manipulatable member.
[0024] According to another aspect of the present disclosure, the case has a case bottom wall and case peripheral walls extending upright (at least substantially perpendicular) from peripheral edges of the case bottom wall. The cover has a cover bottom wall and cover peripheral walls extending upright (at least substantially perpendicular) from peripheral edges of the cover bottom wall. The bonded parts weld or bond, to each other, case facing-surfaces of the case peripheral walls and cover facing-surfaces of the cover peripheral walls, which face each other in the directions of extension. Thus, the mutually-facing surfaces of the case peripheral walls and the cover peripheral walls are welded or bonded together.
[0025] According to another aspect of the present disclosure, the cover has guide pieces, which extend toward the case beyond the cover facing-surfaces of the cover peripheral walls and extend so as to pass between the case peripheral walls and side surfaces of the circuit board. The guide pieces fit between the circuit board and the case peripheral walls. Thus, the cover is held stably with respect to the circuit board and the case by the guide pieces. Furthermore, the bonded parts may weld or bond the ends of the guide pieces to the case.
[0026] According to another aspect of the present disclosure, the cover is provided (disposed,

overlaid) at one end side of the case; i.e. the cover covers (encloses) a first end portion of the case in the elongation direction of the case. A wall part of the cover peripheral walls, which is located at an intermediate position of the case in the elongation direction of the case, extends into the interior of the case. This wall part of the cover and the circuit board are bonded (adhered) by a sealed part, e.g., an adhesive. A second end portion of the case that is not covered by the cover is covered by a resin molding; i.e. components disposed (mounted) in the second end portion of the case are potted (encapsulated) with a solid compound, such as a thermosetting plastic, a silicone rubber gel or an epoxy resin. Thus, electronic components on the other end side (disposed in the second end portion) of the case are protected (shielded) from dust or water by the resin molding. The resin molding is prevented (blocked) from entering the enclosed space by the cover peripheral walls and the sealed part. Thus, contact failure in the switches caused by ingress of the resin molding into the enclosed space can be avoided.

[0027] According to another aspect of the present disclosure, the manipulatable member is a trigger, which is manipulated by pulling. The trigger has a rod, which passes between the case and the cover. The rod (and thus the trigger) is physically connected to the movable switches in the enclosed space and is movable in an axial direction of the rod. Thus, after assembling the case and the cover, the rod is interposed between the case and the cover. The rod slides in the axial direction, relative to the case and the cover.

[0028] According to another aspect of the present disclosure, anti-dust grease is provided between the rod and the case, and between the rod and the cover. This anti-dust grease blocks dust from penetrating into the enclosed space through the annular gap between the cover, case and rod. In addition, a change switch (rotation switching device) is provided in the enclosed space, which when actuated changes the direction of rotation of the rotor of the brushless motor. A change bracket (mechanical connector) passes between the case and the cover and is physically connected to the change switch. Anti-dust grease is provided between the change bracket and the case, as well as between the change bracket and the cover.

[0029] According to another aspect of the present disclosure, the control module includes a spring that biases the manipulatable member. The spring is disposed in the enclosed space. Thus, difficulties in deforming the spring resulting from dust or water are curtailed because the spring is also disposed in the enclosed space.

[0030] According to another aspect of the present disclosure, the movable switches are disposed adjacent to one end side of the circuit board. The microcomputer is mounted on the other end side of the circuit board so as to be farther away from the movable switches than the FETs; i.e. the FETs are disposed between the movable switches and the microcomputer in the elongation direction of the case.

[0031] According to another aspect of the present disclosure, the case has case protrusions that project (inward) toward the circuit board so as to be clear of (avoid) screws provided in the main body of the power tool. The circuit board has board recesses into which the case protrusions are respectively inserted in a form fit manner. The circuit board is positioned relative to the case by the board recesses. Thus, the case protrusions of the case perform both the function of avoiding (clearing) the screws and the function of positioning the circuit board within the case.

[0032] According to another aspect of the present disclosure, the microcomputer (which preferably serves as a power tool controller) and a capacitor, which temporarily stores charge to be supplied to the motor, are provided on the circuit board. The capacitor is disposed at a position outside of the enclosed space. The capacitor is a relatively large component. Therefore, because the capacitor is disposed outside of the enclosed space, it is possible to avoid having to increase the size of the cover due to the capacitor. The capacitor has a capacitance of, for example, 100 μF to 1200 μF, preferably 500 μF to 1200 μF, and more preferably 1000 μF to 1200 μF.

[0033] According to another aspect of the present disclosure, the FETs are provided outside of the cover (i.e. outside of the enclosed space) and on the surface of the circuit board, which faces the

opening of the case. The FETs are covered (potted, encapsulated) by the resin molding. Therefore, because they are outside of the cover (enclosed space), it is easy for the FETs to dissipate heat. Furthermore, the FETs are protected (shielded) from dust or water by the resin molding.
[0034] According to another aspect of the present disclosure, the FETs include first FETs and second FETs that are provided along the circuit board, in a state such that an elongation direction of the second FETs are inclined by 80 to 100 degrees relative to an elongation direction of the first FETs. A heat sink is preferably overlaid so as to span (cover and contact) the first FETs and the second FETs. In such an embodiment, the heat sink can more efficiently dissipate heat from the first FETs and the second FETs.
[0035] According to another aspect of the present disclosure, the power tool has a grip extending from the tool body. The control module is disposed within the grip. The cover and the manipulatable member are disposed at the first end portion of the control module. Because the grip and the control module are both elongated structures, the control module has a rational component arrangement corresponding to the grip.
[0036] According to another aspect of the present disclosure, the power tool further includes a sensor board having at least one rotational sensor, which detects the rotational speed of the brushless motor. A first lead (wire(s)) extends from the sensor board to a position on the circuit board outside of the enclosed space. Thus, one end of the first lead can easily be provided on the circuit board.
[0037] According to another aspect of the present disclosure, the power tool further includes a lamp. A second lead (wire(s)) extends from the lamp to a position on the circuit board outside of the enclosed space. Thus, one end of the second lead can easily be provided on the circuit board.
[0038] Next, a first exemplary embodiment of the present teachings (a power tool **100**) will be described based on FIGS. **1** to **10**. As shown in FIG. **1**, the exemplary power tool **100** is a driver drill, which rotationally drives a removably mounted tool accessory **200**. The user grips the power tool **100** with one hand and stands on the left side in FIG. **1**. In the following description, the side closer to the user is defined as the rear direction (user side), and the side farther from the user is defined as the front direction. The up-down and left-right directions are defined based on the user holding the driver drill such that the tool accessory **200** is above a battery pack **3**.
[0039] As shown in FIG. **1**, the power tool **100** includes a tool body **1**. The tool body **1** has a substantially cylindrical housing **1***a*. The housing **1***a* extends along a prescribed drive axis **1***b*. The housing **1***a* houses a brushless motor **1***c* as a motive drive source and a drive mechanism **1***d* that drives the tool accessory **200** using the power of the brushless motor **1***c*. A mode changing ring (adjusting ring) **1***g* that changes the action mode of the power tool **100** and a chuck **1***h*, in which the tool accessory **200** is detachably attachable, are provided at the front end of the housing **1***a*. The mode changing ring **1***g* is provided so as to be rotatable about the drive axis **1***b*.
[0040] The power tool **100** has two action modes, namely: a drilling mode and a driving mode (also known as a screwdriving mode (rotation with clutch)). The drilling mode is an action mode in which drilling work is performed on a workpiece by rotationally driving a drill bit, which is one example of the tool accessory **200** according to the present teachings. The driving mode is an action mode in which fastening (driving, tightening) of screws, etc. is performed by rotationally driving a driver bit, which is another example of the tool accessory **200** according to the present teachings. The user can change the action mode of the power tool **100** by manually rotating the mode changing ring **1***g* about the drive axis **1***b*.
[0041] As shown in FIGS. **1** and **2**, a grip **2**, which is configured to be gripped by the user, is provided on the lower part of the housing **1***a*. The grip **2** is substantially cylindrical. The grip **2** extends downward. The housing **1***a* and the grip **2** are halved structures that are divided in the left-right direction. The left and right parts of the grip **2** are assembled (joined) to each other by screws **2***a*. Cylindrical projections (bosses) **2***b* into which the screws **2***a* are screwed are provided in the central part, in the up-down direction, of the grip **2**. A battery mounting part **2***c* is provided at the

lower part of the grip **2**. The battery **3** can be detachably mounted on the battery mounting part **2***c*. The battery **3** can be detached from the battery mounting part **2***c* and repeatedly used by recharging with a separately provided charger. The battery **3** functions as a power source that supplies power to the brushless motor **1***c*. The battery **3** can be attached to, and detached from, the battery mounting part **2***c* by sliding in the front-rear direction. More specifically, the battery **3** is mounted on the battery mounting part **2***c* by sliding rearward (mounting direction) with respect to the battery mounting part **2***c*. The battery **3** is removed by sliding frontward (removing direction) with respect to the battery mounting part **2***c*. The battery **3** can be attached and detached substantially parallel to the direction of movement of the trigger **20**, which will be described hereafter.

[0042] As shown in FIG. **1**, the brushless motor **1***c* is energized upon receiving a signal from a control module **10**, which will be described hereafter, to rotate a rotor. The rotor of brushless motor **1***c* rotates about the drive axis **1***b*. The rotational output of the brushless motor **1***c* is transmitted to a drive mechanism **1***d*. The drive mechanism **1***d* includes a reduction gear train (speed reducing mechanism) **1***e* operably coupled to the rotor of the brushless motor **1***c*, a spindle, which is not shown, and the chuck **1***h*. The reduction gear train **1***e* increases the torque that was output from the brushless motor **1***c*, and then outputs the increased torque to the spindle. The spindle is thereby rotationally driven about the drive axis **1***b*. The chuck **1***h* is coupled so as to rotate integrally with the spindle. Therefore, as the spindle rotates, the chuck **1***h* rotates coaxially with the spindle. The tool accessory **200** mounted in the chuck **1***h* is thereby rotationally driven.

[0043] As shown in FIG. **2**, the tool body **1** has a single sensor board **4**. The sensor board **4** has sensors **4***a*, such as Hall ICs. The sensors **4***a* detect the rotational position of permanent magnets provided in the rotor of the brushless motor **1***c*. The sensor board **4** thereby detects the rotational speed of the brushless motor **1***c*. The sensor board **4** can, therefore, ascertain the operating state of the brushless motor **1***c*. In addition, the power tool **100** has a lamp **5** that lights during operation of the tool body **1**. The lamp **5** is illuminated upon receiving a signal from a control module **10**.

[0044] As shown in FIG. **2**, the control module **10** is provided in the interior of the grip **2**. The control module **10** is a module that integrally comprises a manipulatable part **11**, which is manipulated by the user, and a control part **12**, which controls the operation of the power tool **100** in response to manipulation of the manipulatable part **11** and the like. The control part **12** has a single circuit board **50**. Control components such as a microcomputer **51** (e.g., one or more microprocessors, memory, storage, etc.), FETs **52** (preferably, power FETs), and a capacitor **53** are provided on the circuit board **50**. In addition, a plurality of leads (wires) **55** are connected to the circuit board **50**. Each of the leads **55** transmits or receives a signal or current between a control component and the brushless motor **1***c*, the lamp **5**, or the like.

[0045] As shown in FIG. **2**, the manipulatable part **11** includes a trigger **20**, which the user manipulates by pulling with a finger, and movable switches **30**, which are switched in conjunction with the pulling movement of the trigger **20**. The movable switches **30** comprise a power switch **35**, which electrically connects and disconnects the brushless motor **1***c* and the battery **3**, a variable speed switch **33**, which varies the rotational speed of the rotor of the brushless motor **1***c* according (proportional) to the amount by which the trigger **20** is pulled, and a control switch **31**, which turns on and off the lamp **5** in accordance with signals from the microcomputer **51**. The movable switches **30** are electrically connected to the circuit board **50** of the control part **12**. The control part **12** can thereby ascertain the operating states of the movable switches **30**.

[0046] As shown in FIG. **2**, the manipulatable part **11** includes a change switch **40** that changes the direction of rotation of the rotor of the brushless motor **1***c*. The change switch **40** is physically coupled, via a change bracket (connector) **42**, to a change button (reversing switch lever) **41**, which projects from the left and right sides of the housing **1***a*. The user manipulates change button (reversing switch lever) **41** by pushing with a finger in the left and right directions so that the change button (reversing switch lever) **41** slides relative to the housing **1***a*. The change switch **40** is switched in conjunction with such pushing manipulations of the change button **41**. The change

switch **40** is electrically connected to the circuit board **50** of the control part **12**. The control part **12** can thereby ascertain the operating state of the change switch **40**.

[0047] As shown in FIG. **2**, the control module **10** includes a case **60**, which integrally houses the manipulatable part **11** and the control part **12**, and a cover **70**, which is overlaid on the upper region of the case **60**. The cover **70** is integrally (fixedly) assembled (joined, specifically, materially bonded) to the case **60** by performing ultrasonic welding along a seam between the cover **70** and the case **60**. The cover **70** thereby covers the upper region of the case **60** without a gap between the cover **70** and the case **60**. The control module **10** thereby has an enclosed space **13** formed by the case **60** and the cover **70**, which have been materially bonded (e.g., welded) to each other without a gap. The movable switches **30** and the change switch **40** are disposed in the interior of this enclosed space **13**. The case **60** and the cover **70** can thereby protect the movable switches **30** and the change switch **40**. For example, the movable switches **30** and the change switch **40** can be advantageously protected from dust and water, which are often present in the vicinity of the power tool **100**.

[0048] As shown in FIG. **3**, a lower region of the case **60**, which is not covered by the cover **70**, is encapsulated (potted) by (with) a resin molding **6**. The FETs **52** and a portion of the capacitor **53**, which are housed in the lower region of the case **60**, are therefore covered by the resin molding **6**. The FETs **52** and the like can thereby be protected (shielded) from dust and water. This resin molding **6** does not penetrate into the interior of the enclosed space **13**. It is, therefore, unlikely that contact failure will occur in the movable switches **30** and the change switch **40** due to the presence of resin molding **6** inside the enclosed space **13**. It is noted that in the figures other than FIG. **3**, illustration of the resin molding **6** is omitted for explanatory expediency. In addition, a bonding agent **7** is also applied at the upper end of the case **60**, which is not covered by the cover **70**. It is noted that the upper end may be encapsulated by the resin molding **6**.

[0049] The structure of the control module **10** will now be described in greater detail below. As shown in FIG. **5**, the case **60** of the control module **10** is a box-shaped member extending so as to be elongated in the up-down direction. The case **60** has a concave shape, one side of which is open. The case **60** is disposed so that the opening faces rightward. The case **60** has a case bottom wall **61**, which forms a bottom surface at the bottom of the recess, and case peripheral walls **62**, which respectively rise in the form of upright (perpendicular) walls from the peripheral edges of the case bottom wall **61**. The case peripheral walls **62** extend in the rightward direction. In the upper region thereof, the case **60** has a rib **63** projecting in a substantially rectangular shape from the case bottom wall **61**. The rib **63** forms an auxiliary support that serves to prevent the circuit board **50** from bending greatly.

[0050] The case peripheral walls **62** comprise a case upper wall **62***a*, a case lower wall **62***b*, a case front wall **62***c*, and a case rear wall **62***d*. In parts of the upright ends of the case upper wall **62***a*, the case front wall **62***c*, and the case rear wall **62***d*, welding protrusions **64** are formed on case facing-surfaces **62***e*, which face the cover **70** in the left-right direction. Each of the welding protrusions **64** is fused by ultrasonic welding. The case **60** has two case protrusions **65**, which project inwardly in the front-rear direction at the centers, in the up-down direction, of the case front wall **62***c* and the case rear wall **62***d*. As shown in FIGS. **1** and **2**, owing to the case protrusions **65**, the case **60** can avoid interfering with the screws **2***a* and the projections **2***b* of the grip **2**. The screws **2***a* and projections **2***b* are inserted into the case protrusions **65**. The case **60** can thereby be positioned with respect to the grip **2**.

[0051] As shown in FIG. **6**, the cover **70** of the control module **10** is a substantially rectangular member. The cover **70** forms a concave shape, one side of which is open. The cover **70** is disposed so that the opening faces leftward. The cover **70** has a cover bottom wall **71**, which forms a bottom surface at the bottom of the recess, and cover peripheral walls **72**, which respectively rise in the form of upright (perpendicular) walls from the peripheral edges of the cover bottom wall **71**. The cover peripheral walls **72** extend in the leftward direction. The cover peripheral walls **72** comprise a cover upper wall **72***a*, a cover lower wall **72***b*, a cover front wall **72***c*, and a cover rear wall **72***d*.

As shown in FIGS. **6** and **8**, in parts of the upright ends of the cover upper wall **72***a*, the cover front wall **72***c*, and the cover rear wall **72***d*, welding recesses **73** are formed on cover facing-surfaces **72***e* that face the case facing-surfaces **62***e* in the left-right direction. The welding recesses **73** correspond (are complementary) to the welding protrusions **64** on the case **60**. The cover **70** has guide pieces **74** extending, in the upright direction, beyond the ends of the cover front wall **72***c* and the cover rear wall **72***d*. The guide pieces **74** extend towards the case **60**, beyond the cover facing-surfaces **72***e*.

[0052] As shown in FIGS. **5** and **6**, the circuit board **50** is a plate-shaped member extending in the up-down direction. The circuit board **50** is disposed with the surfaces thereof respectively facing in the left-right directions. The circuit board **50** has two board recesses **50***d*, which are recessed to match the case protrusions **65** of the case **60**. Contacts **56**, **57**, and **58** for the switches, as well as the FETs **52**, the capacitor **53**, a first lead (wires) **55***a*, a second lead (wires) **55***b*, and a third lead (wires) **55***c*, are provided on a main surface **50***a* of the circuit board **50**. Six FETs **52** are provided on the main surface **50***a* of the circuit board **50**. The FETs **52** include first FETs **52***a* and second FETs **52***b*. The first FETs **52***a* and the second FETs **52***b* are disposed aligned in the front-rear direction. The first FETs **52***a* are configured (oriented) to be elongated in the up-down direction. Three first FETs **52***a* are provided aligned in the up-down direction. The second FETs **52***b* are configured to be elongated (oriented) in the front-rear direction. The second FETs **52***b* are provided along the circuit board **50** in a state inclined by approximately 90 degrees relative to the first FETs **52***a*. Three second FETs **52***b* are provided aligned (parallel) in the up-down direction. The microcomputer **51** is provided on the back surface **50***b* of the circuit board **50**. The microcomputer **51** is provided below the FETs **52** in the up-down direction. The capacitor **53** has a capacitance of, for example, 1000 μF. The capacitance of the capacitor **53** may be in the range of 100 μF to 1200 μF, preferably 500 μF to 1200 μF, and more preferably 1000 μF to 1200 μF.

[0053] As shown in FIGS. **5** and **6**, the first lead **55***a* is connected at the upper end of the circuit board **50**. The first lead **55***a* is formed from (comprises) five conductive wires. The first lead **55***a* is connected to the sensor board **4** (see FIG. **2**). The first lead **55***a* receives detection signals from the sensor board **4**. The second lead **55***b* is connected at the upper end of the circuit board **50**. The second lead **55***b* is formed from (comprises) two conductive wires. The second lead **55***b* is connected to the lamp **5** (see FIG. **2**). The second lead **55***b* supplies operating current to the lamp **5**. The third lead **55***c* is connected at the central part, in the up-down direction, of the circuit board. The third lead **55***c* is formed from (comprises) three conductive wires. The third lead **55***c* is connected to the brushless motor **1***c* (see FIG. **2**). The third lead **55***c* is engaged with an engagement part **76** formed on the outer peripheral surface of the cover **70**.

[0054] As shown in FIG. **4**, the circuit board **50** is housed in the interior of the case **60**. The case protrusions **65** of the case **60** are respectively inserted into the board recesses **50***d* of the circuit board **50**. The circuit board **50** is thereby positioned with respect to the case **60**. The back surface **50***b* of the circuit board **50** (see FIG. **6**) makes contact with the rib **63** of the case **60** (see FIG. **5**). The circuit board **50** and the rib **63** are sealed to each other without a gap by a bonding agent (adhesive). In the state in which the circuit board **50** is housed at the interior of the case **60**, the upper region thereof is covered by the cover **70**. The FETs **52** and the microcomputer **51** are disposed in regions outside of the enclosed space **13**. It is, therefore, possible to efficiently dissipate heat from the FETs **52** and the microcomputer **51**.

[0055] As shown in FIG. **7**, the cover **70** is overlaid on the case **60** so that the welding protrusions **64** of the case **60** are respectively inserted into the welding recesses **73** thereof. The ends of the cover upper wall **72***a* and the case upper wall **62***a*, the ends of the cover front wall **72***c* and the case front wall **62***c*, and the ends of the cover rear wall **72***d* and the case rear wall **62***d* are thereby each butted against each other. Then, the welding protrusions **64** and the welding recesses **73** that are fitted into each other are integrally welded (materially bonded) by ultrasonic welding (bonded parts **14**). The case facing-surfaces **62***e* and the cover facing-surfaces **72***e* are thereby welded to each

other. That is to say, the case peripheral walls **62** and the base parts of the guide pieces **74** of the cover **70** are welded to each other. The cover **70** is thereby integrally assembled (joined) to the case **60**.

[0056] As shown in FIG. **4**, in the assembly described above, the cover lower wall **72***b* projects into the interior of the case **60** along the case front wall **62***c* and the case rear wall **62***d*. The end of the projecting cover lower wall **72***b* makes contact with the main surface **50***a* of the circuit board **50**. The cover lower wall **72***b* and the circuit board **50** are bonded to each other with a bonding agent (sealed part **77**), such as an adhesive. The cover lower wall **72***b* and the circuit board **50** are thereby sealed to each other without a gap. Therefore, after the lower region of the case **60** is encapsulated with the resin molding **6** (see FIG. **3**), it is possible to curtail (block) entry of the resin molding **6** into the enclosed space **13** from the cover lower wall **72***b* side.

[0057] As shown in FIG. **7**, the guide pieces **74** of the cover **70** are respectively inserted into gaps between the circuit board **50** and the case front wall **62***c* and the case rear wall **62***d*. The cover **70** is thereby stably supported with respect to the case **60** and the circuit board **50**. As shown in FIGS. **5** and **6**, the side surface **50***c* of the circuit board **50** has recessed notched parts **50***e* matching the respective guide pieces **74**. By inserting each of the guide pieces **74** into the respective notched parts **50***e*, the guide pieces **74** can curtail rattling of the circuit board **50** in the up-down direction.

[0058] As shown in FIGS. **5** and **6**, upon being assembled to each other, the cover **70** and the case **60** form a front through hole **15**, which passes through in the front-rear direction. The front through hole **15** opens in a circular shape spanning between the case front wall **62***c* and the cover front wall **72***c*. In addition, upon being assembled to each other, the cover **70** and the case **60** form an upper through hole **16**, which passes through in the up-down direction. The upper through hole **16** opens in a circular shape spanning between the case upper wall **62***a* and the cover upper wall **72***a*. As shown in FIG. **8**, a rod **21** extending from the trigger **20** is inserted into, and extends through, the front through hole **15**. The change bracket **42** is inserted into, and extends through, the upper through hole **16**.

[0059] As shown in FIG. **8**, the trigger **20** has the rod **21**, which extends through the front through hole **15** into the interior of the cover **70**, and a switch holder **22** provided at the tip of the rod **21**. The rod **21** and the switch holder **22** slide in the front-rear direction in conjunction with the pulling manipulation of the trigger **20**. Anti-dust grease **24** is provided between the rod **21** and the front through hole **15**. The grease **24** can curtail ingress of dust and the like into the enclosed space **13** through the front through hole **15**. It is noted that, together with the grease **24**, a seal such as an O-ring may be provided between the rod **21** and the front through hole **15**.

[0060] As shown in FIG. **8**, a spring **75** biasing the switch holder **22** in the frontward direction is mounted on the interior side of the cover **70**. The spring **75** biases the trigger **20** in the frontward direction. A control brush **32** for the control switch **31** and a variable speed brush **34** for the variable speed switch **33** are provided on the switch holder **22**. The control brush **32** and the variable speed brush **34** are disposed aligned (parallel) in the up-down direction. In addition, in the interior of the cover **70**, a movable sheet metal piece **35***a*, which is bent to be substantially L-shaped, and power supply contacts **35***e*, which are provided on the rear of the movable sheet metal piece **35***a* and on an inner surface of the cover **70**, are provided to constitute the power switch **35**.

[0061] In addition, a change holder **43**, which is coupled to the change bracket **42**, is provided in the interior of the cover **70**. The change holder **43** can slide in the front-rear direction in the interior of the cover **70**. The change holder **43** slides in the front-rear direction in conjunction with the rotation of the change bracket **42** accompanying pushing movements of the change buttons **41** (see FIG. **2**). A change brush **44** for the change switch **40** is provided in the change holder **43**. The change bracket **42** extends through the upper through hole **16** into the interior of the cover **70**. Anti-dust grease **46** is provided between the change bracket **42** and the upper through hole **16**. The grease **46** can curtail ingress of dust and the like into the enclosed space **13** through the upper through hole **16**. It is noted that, together with the grease **46**, a seal such as an O-ring may be

provided between the change bracket **42** and the upper through hole **16**.

[0062] As shown in FIG. **10**, control contacts **56** for the control switch **31**, variable speed contacts **57** for the variable speed switch **33**, and change contacts **58** for the change switch **40** are provided on the upper part of the main surface **50***a* of the circuit board **50**. The control contacts **56** include a front control contact **56***a* and a rear control contact **56***b*. A gap **56***c* is formed (provided) between the front control contact **56***a* and the rear control contact **56***b*. The variable speed contacts **57** include a front variable speed contact **57***a* and a rear variable speed contact **57***b*. A plurality of second slits **57***c* are formed (defined) in the front variable speed contact **57***a*. The change contacts **58** include a front change contact **58***a* and a rear change contact **58***b*. Two third slits **58***c* are formed (defined) in the front change contact **58***a*.

[0063] As shown in FIGS. **9** and **10**, when the power supply contacts **35***e* of the power switch **35** are in contact with each other, the battery **3**, the control module **10**, and the brushless motor **1***c* are electrically connected. When the control contacts **56** of the control switch **31** are connected to each other via the control brush **32**, the microcomputer **51** is started. Then, the microcomputer **51** recognizes pulling manipulation of the trigger **20** and lights the lamp **5**. In addition, when to the variable speed contacts **57** of the variable speed switch **33** are connected to each other via the variable speed brush **34**, the magnitude of the voltage value input to the microcomputer **51** is determined.

[0064] As shown in FIGS. **8** through **10**, in an initial state, in which the trigger **20** is not yet pulled, the state is such that the power supply contacts **35***e* do not to make contact with each other. In the initial state, the control contacts **56** are not connected to each other. In the initial state, the variable speed contacts **57** are connected to each other and a relatively large voltage value is input to the microcomputer **51**. Pulling of the trigger **20** first causes the power supply contacts **35***e* to come into contact with each other. Then, by continuing the pulling, the control contacts **56** become connected to each other. With further pulling, the variable speed contacts **57** switch the connection so as to gradually decrease the voltage value that is input to the microcomputer **51**. The microcomputer **51** outputs operating signals to the FETs **52** to energize (drive) the brushless motor **1***c* when the input voltage value falls below a predetermined value.

[0065] As shown in FIGS. **8** and **9**, the movable sheet metal piece **35***a* of the power switch **35** is supported so as to be rotatable in the up-down direction about a supporting sheet metal piece **35***c*, serving as a pivot. The rear of the movable sheet metal piece **35***a* is pulled downward by a tension spring **35***d*. That is to say, the movable sheet metal piece **35***a* is biased in a direction in which the power supply contacts **35***e* make contact with each other. However, in the initial state, owing to the spring force of the spring **75**, the switch holder **22** presses the engagement part **35***b* at the front of the movable sheet metal piece **35***a* frontward. The rear of the movable sheet metal piece **35***a* is thereby rotated upward against the pulling force of the tension spring **35***d*. The power supply contacts **35***e* are therefore held in a non-contact state. When the trigger **20** is pulled, the switch holder **22** moves rearward. The rear of the movable sheet metal piece **35***a* thereby rotates downward. The power supply contacts **35***e* therefore make contact with each other. The power switch **35** is thus switched to the ON state. As a result, the battery **3**, the control module **10**, and the brushless motor **1***c* are electrically connected, as described above.

[0066] As shown in FIGS. **8** and **9**, because the cover **70** is overlaid on the upper portion of the circuit board **50**, the control brush **32** of the control switch **31** is disposed so as to face the control contacts **56**. In the initial state in which the user has not yet pulled the trigger **20**, the front end of the control brush **32** contacts the front control contact **56***a*. The rear end of the control brush **32** contacts a portion of the board in the gap **56***c* between the control contacts **56**. In this state, the control contacts **56** are not connected, and the control switch **31** is in the OFF state. This OFF state is maintained by the spring force of the spring **75**. Then, when the user pulls the trigger **20**, the switch holder **22** moves rearward. The control brush **32** thereby also moves rearward. As a result, the rear end of the control brush **32** makes contact with the rear control contact **56***b*. The control

contacts **56** are thereby connected and the control switch **31** is in the ON state. The microcomputer **51** is started due to the ON state of the control switch **31**. The microcomputer **51** recognizes the pulling manipulation of the trigger **20**, and lights the lamp **5**.

[0067] In addition, the variable speed brush **34** of the variable speed switch **33** is disposed so as to face the variable speed contacts **57**. In the initial state in which the user has not yet pulled the trigger **20**, the front end of the variable speed brush **34** contacts the front part of the front variable speed contact **57***a*. The rear end of the variable speed brush **34** contacts the rear variable speed contact **57***b*. In this initial connection state, a relatively large voltage value is input to the microcomputer **51**. This initial connection state is maintained by the spring force of the spring **75**. Then, when the user pulls the trigger **20**, the switch holder **22** and variable speed brush **34** move rearward. The front end of the variable speed brush **34** is thereby caused to move sequentially past the second slits **57***c* of the front variable speed contact **57***a* toward the rear of the front variable speed contact **57***a*. The more the front end of the variable speed brush **34** moves rearward, the lower the voltage value input to the microcomputer **51**. When the voltage value falls below a predetermined value, the microcomputer **51** outputs signals to rotationally drive the brushless motor **1***c*. Then, the microcomputer **51** performs operations so as to increase the rotational speed of the brushless motor **1***c* in accordance with the decrease in voltage values. The rotational speed of the brushless motor **1***c* is thereby increased with greater pulling of the trigger **20** by the user. It is noted that the voltage value input to the microcomputer **51** may also be controlled so as to be relatively low in the initial state and to increase as the front end of the variable speed brush **34** moves rearward. In such an embodiment, the microcomputer **51** may output signals to rotationally drive the brushless motor **1***c* when the input voltage value exceeds a predetermined value and to increase the rotational speed as the voltage value increases.

[0068] In addition, the change brush **44** of the change switch **40** is disposed so as to face the change contacts **58**. When the change holder **43** is disposed at the front of the cover **70**, the front end of the change brush **44** makes contact with the front of the front change contact **58***a*. The rear end of the change brush **44** makes contact with the rear change contact **58***b*. In this state, the microcomputer **51** determines that the change switch **40** has been placed in the forward rotation position. Consequently, when transmitting an operating signal to the brushless motor **1***c*, the microcomputer **51** causes the rotor of the brushless motor **1***c* to rotate in the forward direction, e.g., clockwise. When the change holder **43** moves to the central part of the cover **70**, the front end of the change brush **44** passes the front third slit **58***c* and makes contact with the central part of the front change contact **58***a*. In this state, the microcomputer **51** determines that the change switch **40** has been placed in the neutral position. In that state, the microcomputer **51** does not send an operating signal to the brushless motor **1***c* even if the input voltage value is below the predetermined value. Therefore, the tool body **1** does not operate, even if the user pulls the trigger **20**. It is thereby possible to prevent the tool body **1** from operating when not intended to do so by the user. When the change holder **43** moves to the rear of the cover **70**, the front end of the change brush **44** passes the rear third slit **58***c* and makes contact with the rear of the front change contact **58***a*. In this state, the microcomputer **51** determines that the change switch **40** has been placed in the reverse rotation position. Consequently, when transmitting an operating signal to the brushless motor **1***c*, the microcomputer **51** causes the rotor of the brushless motor **1***c* to rotate in the reverse direction, e.g., counterclockwise.

[0069] As shown in FIG. **1** and as described above, the control module **10** includes the box-shaped case **60**, one side of which is open, and the circuit board **50** housed in the case **60**. As shown in FIG. **4**, the microcomputer **51** and the FETs **52** (field effect transistors), which are used to control the brushless motor **1***c* of the power tool **100**, are mounted on the circuit board **50**. The trigger **20** is movably coupled to the case **60**. The movable switches **30**, which are mechanically linked to the movement of the trigger **20**, are connected to the circuit board **50**. The cover **70** is partially overlaid on the opening of the case **60**. The cover **70** covers a portion of the circuit board **50** and, in

particular, covers the movable switches **30**. The control module **10** has bonded parts **14**, which weld or bond the cover **70** and the case **60** together. The case **60**, cover **70** and bonded parts **14** form an enclosed space **13**, which encloses the movable switches **30**.

[0070] In the bonded parts **14**, at least portions of the cover **70** and the case **60** are melted or otherwise fused so as to be materially bonded (e.g., welded) to each other. Gaps between the cover **70** and the case **60** are therefore filled by the bonded parts **14**. The enclosed space **13** is formed between the cover **70** and the case **60**. The enclosed space **13** has better dustproofing and waterproofing than, for example, a closed space in which the cover **70** and the case **60** are connected to each other by a snap fit. The movable switches **30** are protected by the enclosed space **13**. Thus, poor conduction in the movable switches **30** due to dust or water is unlikely to occur.

[0071] As shown in FIG. **4**, the microcomputer **51** and the FET **52** are provided on the circuit board **50** in positions clear (outside) of the enclosed space **13**. Therefore, when the microcomputer **51** and the FET **52** generate heat, the microcomputer **51** and the FET **52** can effectively dissipate the heat.

[0072] As shown in FIG. **2**, the operation (starting) and stopping of the brushless motor **1***c* is switched in response to the movement of the movable switches **30**, which are mechanically linked to the trigger **20**. Thus, the operation and stopping of the brushless motor **1***c* is switched by manipulating the trigger **20**.

[0073] As shown in FIG. **2**, the movable switches **30** include a power switch **35** and a variable speed switch **33**. The power switch **35** electrically connects and disconnects the brushless motor **1***c* and the battery **3**. The variable speed switch **33** controls the output of the brushless motor **1***c* according to the amount of movement of the trigger **20**. Thus, the power switch **35** and the variable speed switch **33** are each controllable by manipulating the trigger **20**. The movable switches **30** may further include a control switch **31** that controls the operation of the microcomputer **51**. The microcomputer **51** may, for example, recognize input from the control switch **31** and light the lamp **5** of the power tool **100**. The lamp **5** can therefore be reliably lit upon manipulation of the trigger **20**.

[0074] As shown in FIG. **7**, the case **60** has the case bottom wall **61** and the case peripheral walls **62**, which extend upright (perpendicular) from the peripheral edges of the case bottom wall **61**. The cover **70** has the cover bottom wall **71** and the cover peripheral walls **72**, which extend upright (perpendicular) from the peripheral edges of the cover bottom wall **71**. The bonded parts **14** weld or otherwise materially bond case facing-surfaces **62***e* of the case peripheral walls **62** and the cover facing-surfaces **72***e* of the cover peripheral walls **72**, which face each other in the directions of extension. Thus, the mutually-facing surfaces of the case peripheral walls **62** and the cover peripheral walls **72** are welded or bonded together.

[0075] As shown in FIG. **7**, the cover **70** has the guide pieces **74**, which extend toward the case **60** beyond the cover facing-surfaces **72***e* of the cover peripheral walls **72** and extend so as to pass between the case peripheral walls **62** and the side surfaces **50***c* of the circuit board **50**. The guide pieces **74** fit between the circuit board **50** and the case peripheral walls **62**. Thus, the cover **70** is held stably with respect to the circuit board **50** and the case **60** by the guide pieces **74**. Furthermore, the bonded parts **14** may weld or otherwise materially bond the ends of the guide pieces **74** to the case **60**.

[0076] As shown in FIGS. **3** and **4**, the cover **70** is provided at one end side (a first end portion) of the case **60**. The cover lower wall **72***b* of the cover peripheral walls **72**, which is located at an intermediate location of the case **60**, extends into the interior of the case **60**. This cover lower wall **72***b* of the cover **70** and the circuit board **50** are bonded by the sealed part **77**. The other end side (a second end portion) of the case **60**, which is not covered by the cover **70**, is covered (potted, encapsulated) by the resin molding **6**. Thus, the electronic components on the other end side (in the second end portion) of the case **60** are protected from dust or water by the resin molding **6**. The resin molding **6** is prevented (blocked) from entering the enclosed space **13** by the cover peripheral walls **72** and the sealed part **77**. Thus, contact failure in the movable switches **30** due to the

presence of resin molding **6** in the enclosed space **13** can be avoided.
[0077] As shown in FIG. **8**, the manipulatable member is the trigger **20** that is manipulated by pulling. The trigger **20** has the rod **21**, which passes between the case **60** and the cover **70**. The rod **21** is physically connected to the movable switches **30** in the enclosed space **13** and is movable in the axial direction of the rod **21**. Thus, when the case **60** and the cover **70** are joined together, the rod **21** is interposed between the case **60** and the cover **70**. The rod **21** slides in the axial direction, relative to the case **60** and the cover **70**.
[0078] As shown in FIG. **8**, anti-dust grease **24** is provided between the rod **21** and the case **60**, and between the rod **21** and the cover **70**. This grease can curtail ingress of dust into the interior of the cover **70**. In addition, the change switch **40** is provided in the enclosed space **13**, and is configured to change the direction of rotation of the rotor of the brushless motor **1***c*. The change bracket **42** passes between the case **60** and the cover **70**, and is physically connected (linked) to the change switch **40**. Anti-dust grease **46** is provided between the change bracket **42** and the case **60**, as well as between the change bracket **42** and the cover **70**.
[0079] As shown in FIG. **8**, the spring **75** biases the manipulatable member. The spring **75** is disposed in the enclosed space **13**. Thus, difficulties in deforming the spring **75** resulting from dust or water are curtailed by the enclosed space **13**.
[0080] As shown in FIG. **4**, the movable switches **30** are disposed on one end side (an upper region) of the circuit board **50**. The microcomputer **51** is mounted on the other end side (a lower region) of the circuit board **50** so as to be farther away from the movable switches **30** than the FETs **52**.
[0081] As shown in FIG. **1**, the case **60** has the case protrusions **65**, which project toward the circuit board **50**, so as to be clear of (avoid) the screws **2***a* provided in the main body of the power tool **100**. As shown in FIGS. **5** and **6**, the circuit board **50** has board recesses **50***d*, into which the case protrusions **65** are respectively inserted. The circuit board **50** is positioned relative to the case **60** by the board recesses **50***d*. Thus, the case protrusions **65** of the case **60** perform both the function of clearing (avoiding) the screws **2***a* and the function of fixedly positioning the circuit board **50** within the case **60**.
[0082] As shown in FIG. **4**, the capacitor **53**, which temporarily stores charge to be applied to the brushless motor **1***c*, is provided on the circuit board **50**. The capacitor **53** is disposed at a position outside of the enclosed space **13**. The capacitor **53** is a relatively large component. Therefore, it is possible to avoid having to increase the size of the cover **70** to accommodate the capacitor **53** within the enclosed space **13**. The capacitor **53** has a capacitance of, for example, 100 μF to 1200 μF, preferably 500 μF to 1200 μF, and more preferably 1000 μF to 1200 μF.
[0083] As shown in FIGS. **3** and **4**, the FETs **52** are provided outside of the cover **70** (i.e. outside of the enclosed space **13**), and on the main surface **50***a* of the circuit board **50**, which faces the opening of the case **60**. The FETs **52** are covered by the resin molding **6**. Thus, because they are outside the cover **70**, it is easy for the FETs **52** to dissipate heat. Furthermore, the FETs **52** are protected from dust or water by the resin molding **6**.
[0084] As shown in FIGS. **4** and **11**, the FETs **52** include the first FETs **52***a* and the second FETs **52***b*. The second FETs **52***b* are provided along the circuit board **50** in a state inclined by 80 to 100 degrees relative to the first FETs **52***a*. A heat sink **54** is overlaid so as to span (cover) the first FETs **52***a* and the second FETs **52***b*. Thus, the heat sink **54** can more efficiently dissipate heat from the first FETs **52***a* and the second FETs **52***b*.
[0085] As shown in FIG. **1**, the power tool **100** has the grip **2** extending from the tool body **1**. The control module **10** is disposed within the grip **2**. The cover **70** and the trigger **20** are disposed at one end side of the control module **10**. Because both the grip **2** and the control module **10** are elongated structures, the control module **10** has a rational component arrangement corresponding to the grip **2**.
[0086] As shown in FIG. **2**, the power tool **100** has the sensor board **4** provided with the sensors **4***a*,

which detect the rotational speed of the brushless motor **1***c*. The first lead **55***a* extends from the sensor board **4** to a position on the circuit board **50** outside of the enclosed space **13**. Thus, one end of the first lead **55***a* can easily be provided on the circuit board **50**.

[0087] As shown in FIG. **2**, the power tool **100** has the lamp **5**. The second lead **55***b* extends from the lamp **5** to a position on the circuit board **50** outside of the enclosed space **13**. Thus, one end of the second lead **55***b* can easily be provided on the circuit board **50**.

[0088] Various changes can be made to the exemplary embodiment described above. For example, although the exemplary power tool according to the present teachings was illustrated as a driver drill, Alternatively, the control module of the present disclosure can be similarly applied to, e.g., impact drivers, impact wrenches, chain saws, hammer drills, reciprocating saws, grinders, polishers, portable band saws, circular saws, sliding circular saws, cutters, planes, earth auger drills, screwdrivers, and multi-tools (oscillating multi-tools or oscillating saws), and the like. Shared use of batteries is possible for all the types of power tools mentioned above.

[0089] The control module may be configured to have two or more circuit boards. The manipulatable member may be configured to have only a rod without having a trigger. The manipulatable member may be a paddle switch. In addition to ultrasonic welding, the bonded parts may also have a configuration in which the case and cover are bonded to each other using bonding agent (adhesive). The manipulatable member may be configured to move in the up- down direction.

[0090] The cover may be configured to be directly welded or otherwise materially bonded to a portion of the main surface of the circuit board, without being welded or bonded to the case. In such an embodiment, the case may be configured to house the circuit board, and may also be welded or bonded to the back surface of the circuit board so as to cover a portion of the back surface of the circuit board. In addition, the control module may also be configured so as not to have a case. In such an embodiment, for example, the circuit board to which the cover has been bonded is placed in a temporary holding case, and the portions other than the enclosed space are covered with a resin molding. By subsequently removing the case, the circuit board can be appropriately covered with a resin molding. If it does not have a case, the control module can be reduced in size by an amount corresponding to the thickness of the case.

[0091] The case may be configured to open to the left. The cover may be configured to be overlaid, not only on the upper region of the case, but also on a lower region or a central region in the up-down direction. The cover may be configured such that only the ends of the cover front wall and the cover rear wall are welded or bonded to the ends of the case peripheral walls. In such an embodiment, the cover may be configured such that the cover upper wall and the cover lower wall extend into the interior of the case and bonding to the circuit board is performed by a sealed part. A configuration in which the welding protrusions are formed on the case was illustrated. Alternatively, welding protrusions may be formed on the cover. In conjunction therewith, welding recesses may be formed in the case.

[0092] The microcomputer may be provided on the main surface of the circuit board. The microcomputer may be provided above the FETs in the up-down direction. The FETs were illustrated in a configuration which six FETs were provided on the circuit board. Alternatively, any number thereof may be provided, so long as this is a multiple of 3, such as 3 or 12. A heat sink may be mounted on the FETs. For example, as shown in FIG. **11**, a heat sink **54** overlying the FETs **52** may be mounted on the circuit board **50**. The heat sink **54** has a bottom plate **54***a* extending along the circuit board **50** and a plurality of fins **54***b* projecting rightward from the bottom plate **54***a*. Each of the fins **54***b* forms a rectangular prism shape. The heat sink **54** is mounted such that a bottom plate **54***a* thereof covers all of the FETs **52**. The heat sink **54** is mounted on the FETs **52** with an insulator such as a bonding agent or heat dissipating sheet therebetween. By providing the heat sink **54**, the FET **52** can dissipate heat more efficiently. It is noted that, as shown in FIGS. **12-14**, the heat sink **54** may have fins in various different shapes. For example, these may be thin plate-like fins **54***c*, **54***d*, or fins **54***e* projecting in truncated square pyramids, or the like.

[0093] 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 power tools.

[0094] 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.

[0095] 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 NUMERALS

[0096] **100**: power tool [0097] **200**: tool accessory [0098] **1**: tool body [0099] **1***a*: housing [0100] **1***b*: drive axis [0101] **1***c*: brushless motor [0102] **1***d*: drive mechanism [0103] **1***e*: reduction gear train [0104] **1***g*: mode changing ring [0105] **1***h*: chuck [0106] **2**: grip [0107] **2***a*: screw [0108] **2***b*: projection [0109] **2***c*: battery mounting part [0110] **3**: battery [0111] **4**: sensor board [0112] **4***a*: sensor [0113] **5**: lamp [0114] **6**: resin molding [0115] **10**: control module (control module for a power tool) [0116] **11**: manipulatable part [0117] **12**: control part [0118] **13**: enclosed space [0119] **14**: bonded part [0120] **15**: front through hole [0121] **16**: upper through hole [0122] **20**: trigger (manipulatable member) [0123] **21**: rod [0124] **22**: switch holder [0125] **24**: grease (anti-dust grease) [0126] **30**: movable switches [0127] **31**: control switch [0128] **32**: control brush [0129] **33**: variable speed switch [0130] **34**: variable speed brush [0131] **35**: power switch [0132] **35***a*: movable sheet metal piece [0133] **35***b*: engagement part [0134] **35***c*: supporting sheet metal piece [0135] **35***d*: tension spring [0136] **35***e*: power supply contact [0137] **40**: change switch [0138] **41**: change button [0139] **42**: change bracket [0140] **43**: change holder [0141] **44**: change brush [0142] **46**: grease (anti-dust grease) [0143] **50**: circuit board [0144] **50***a*: main surface [0145] **50***b*: back surface [0146] **50***c*: side surface [0147] **50***d*: board recess [0148] **50***e*: notched part [0149] **51**: microcomputer [0150] **52**: FET [0151] **52***a*: first FET [0152] **52***b*: second FET [0153] **53**: capacitor [0154] **54**: heat sink [0155] **54***a*: bottom plate [0156] **54***b*: fin [0157] **54***c*: fin [0158] **54***d*: fin [0159] **54***e*: fin [0160] **55**: lead [0161] **55***a*: first lead [0162] **55***b*: second lead [0163] **55***c*: third lead [0164] **56**: control contact [0165] **56***a*: front control contact [0166] **56***b*: rear control contact [0167] **56***c*: gap [0168] **57**: variable speed contact [0169] **57***a*: front variable speed contact [0170] **57***b*: rear variable speed contact [0171] **57***c*: second slit [0172] **58**: change contact [0173] **58***a*: front change contact [0174] **58***b*: rear change contact [0175] **58***c*: third slit [0176] **60**: case [0177] **61**: case bottom wall [0178] **62**: case peripheral wall [0179] **62***a*: case upper wall [0180] **62***b*: case lower wall [0181] **62***c*: case front wall [0182] **62***d*: case rear wall [0183] **62***e*: case facing-surface [0184] **63**: rib [0185] **64**: welding protrusion [0186] **65**: case protrusion [0187] **70**: cover [0188] **71**: cover bottom wall [0189] **72**: cover peripheral wall [0190] **72***a*: cover upper wall [0191] **72***b*: cover lower wall (wall part) [0192] **72***c*: cover front wall [0193] **72***d*: cover rear wall [0194] **72***e*: cover facing-surface [0195] **73**: welding recess [0196] **74**: guide piece [0197] **75**: spring [0198] **76**: engagement part [0199] **77**: sealed part

Claims

1. A control module for a power tool, including: a box-shaped case, one side of which is open; a circuit board housed in the case; a microcomputer and field effect transistors (FETs), which are mounted on the circuit board and are configured to control a brushless motor of the power tool; a manipulatable member, which is movable relative to the case; one or more movable switches electrically connected to the circuit board and mechanically linked to movement of the manipulatable member; a cover, which partially overlays the case opening so as to cover a portion of the circuit board and so as to cover the movable switch(es); and bonded parts that form an enclosed space, which encloses the movable switch(es), by welding or otherwise materially bonding the cover to the case.
2. The control module for a power tool according to claim 1, wherein: the microcomputer and the FETs are provided on the circuit board at positions outside of the enclosed space.
3. The control module for a power tool according to claim 1, wherein: the microcomputer is configured to switch the brushless motor between operating and stopping in response to movement of the movable switch(es), linked to the manipulatable member.
4. The control module for a power tool according to claim 3, wherein: the one or more movable switches include: a power switch, which electrically connects and disconnects the brushless motor and the battery; and a variable speed switch, which controls the output of the brushless motor in accordance with the amount by which the manipulatable member is moved.
5. The control module for a power tool according to claim 1, wherein: the case has a case bottom wall and case peripheral walls extending perpendicular from peripheral edges of the case bottom wall; the cover has a cover bottom wall and cover peripheral walls extending perpendicular from peripheral edges of the cover bottom wall; and the bonded parts weld or otherwise materially bond, to each other, case facing-surfaces of the case peripheral wall and cover facing-surfaces of the cover peripheral wall, which face each other in their directions of extension.
6. The control module for a power tool according to claim 5, wherein: the cover has guide pieces, which extend toward the case beyond the cover facing-surfaces of the cover peripheral walls and extend so as to pass between the case peripheral walls and side surfaces of the circuit board, the guide pieces fitting between the circuit board and the case peripheral walls.
7. The control module for a power tool according to claim 6, wherein: the bonded parts weld or otherwise materially bond extending ends of the guide pieces to the case.
8. The control module for a power tool according to claim 5, wherein: the cover is provided on a first end portion of the case; a wall part of the cover peripheral walls, which is located at an intermediate portion of the case, extends into the interior of the case and is bonded to the circuit board by a sealed part; and a second end portion of the case that is not covered by the cover is covered by a resin molding.
9. The control module for a power tool according to claim 1, wherein: the manipulatable member is a trigger that is manipulated by pulling; the trigger has a rod, which passes between the case and the cover; and the rod is physically connected to the movable switch(es) in the enclosed space and is movable in the axial direction of the rod.
10. The control module for a power tool according to claim 9, wherein: anti-dust grease is provided between the rod and the case and between the rod and the cover.
11. The control module for a power tool according to claim 1, further including: a spring that biases the manipulatable member, wherein the spring is disposed in the enclosed space.
12. The control module for a power tool according to claim 1, wherein: the movable switch(es) is/are disposed on a first end portion of circuit board; and the microcomputer is mounted on a second end portion of the circuit board so as to be farther away from the movable switch(es) than the FETs.

13. The control module for a power tool according to claim 1, wherein: the case has case protrusions that project toward the circuit board so as to avoid screws provided in the main body of the power tool; and the circuit board has board recesses into which the case protrusions are respectively inserted, such that the case protrusions and the board recesses position the circuit board relative to the case.

14. The control module for a power tool according to claim 1, further comprising: a capacitor, which temporarily stores charge to be supplied to the brushless motor, provided on the circuit board, the capacitor being located outside of the enclosed space.

15. The control module for a power tool according to claim 14, wherein: the capacitor has a capacitance of 100 μF to 1200 μF.

16. The control module for a power tool according to claim 1, wherein: the FETs are located outside of the enclosed space, and on a main surface of the circuit board, which faces the opening of the case, and the FETs are covered by a resin molding.

17. The control module for a power tool according to claim 1, wherein: the FETs include first FETs and second FETs provided along the circuit board, such that an elongation direction of the second FETs is inclined by 80 to 100 degrees relative to an elongation direction of the first FETs; and a heat sink is overlaid so as to span the first FETs and the second FETs.

18. A power tool, including: a grip extending from a tool body, wherein: the control module according to claim 1 is disposed within the grip; and the cover and the manipulatable member are disposed at one end side of the control module.

19. The power tool according to claim 18, further including: a sensor board having at least one sensor configured to detect the rotational speed of the brushless motor; and a first lead, which extends from the sensor board to a position on the circuit board outside of the enclosed space.

20. The power tool according to claim 18, further including: a lamp; and a second lead, which extends from the lamp to a position on the circuit board outside of the enclosed space.