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(54) **ELECTRIC POWER TOOL**

(57) An electric power tool (10) includes a manually-operated member (14) and a circuit board (15). A first subset of electrodes (P1a-PZa) is arranged in a first region of the circuit board (15) corresponding to a first operation direction (ND) of the manually-operated member (14). A second subset of electrodes (P1b-PZb) is ar-

ranged in a second region of the circuit board (15) corresponding to the second operation direction (OD) of the manually-operated member (14). The electrodes of the first and second subsets are electrically connected in common to a variable resistor unit (16).

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Description

[0001] The present disclosure relates to an electric power tool.

[0002] Japanese Laid-Open Patent Publication No. 2010-155295 describes a conventional electric power tool. The electric power tool includes a motor, a circuit board, and a manually-operated member. The manually-operated member includes a rotation axis and is manually rotated by a user in two rotation directions about the rotation axis for controlling the motor. A pair of variable resistor units, each including a plurality of printed resistors, is formed on the circuit board. One of the variable resistor units is formed in a clockwise-direction side of the manually-operated member and the other one of the variable resistor units is formed in a counterclockwise-direction side. A movable contact, which is integrally formed on the manually-operated member, makes sliding contact with the printed resistors of the variable resistor units when a user rotates the manually-operated member. The circuit board generates a voltage signal in accordance with the rotation angle of the manually-operated member and sends the voltage signal to the motor. The motor generates torque in accordance with the voltage signal.

[0003] In the conventional electric power tool described above, the circuit board requires at least two discrete variable resistor units formed at different positions that respectively correspond to the two rotation directions of the manually-operated member.

[0004] It is an object of the present disclosure to provide an electric power tool including a circuit board with simplified structure.

[0005] One aspect of the present invention is an electric power tool that includes the following: a manually-operated member moved in a first operation direction and a second operation direction opposite to the first operation direction, the manually-operated member including a movable contact; and a circuit board configured to generate a voltage signal depending on an operation amount of the manually-operated member. The circuit board includes a plurality of electrodes. The movable contact is arranged to make sliding contact with the circuit board and contacts one of the plurality of electrodes depending on the operation amount of the manually-operated member. A first subset of electrodes among the plurality of electrodes is arranged in a first region of the circuit board corresponding to the first operation direction of the manually-operated member. A second subset of electrodes among the plurality of electrodes is arranged in a second region of the circuit board corresponding to the second operation direction of the manually-operated member. The electrodes of the first and second subsets are electrically connected in common to a variable resistor unit.

[0006] The one aspect of the present disclosure provides an electric power tool including a circuit board with simplified structure. Other aspects and advantages of the invention will become apparent from the following

description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0007] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a schematic side view of an electric power tool according to a first embodiment;

Figs. 2(a) and 2(b) are plan views showing two opposite surfaces of a circuit board of the electric power tool of Fig. 1;

Fig. 3 is a circuit diagram of the electric power tool of Fig. 1; and

Fig. 4 is a circuit diagram of an electric power tool according to a second embodiment.

[0008] An electric power tool 10 according to a first embodiment is described below.

[0009] As shown in Fig. 1, the electric power tool 10 is of handheld type and includes a main body 11 and a handgrip 12 coupled to the main body 11. The main body 11 accommodates a motor M, which generates torque to rotate a chuck 13, such as a self-centering chuck. In the first embodiment, the main body 11 supports the handgrip 12 so that the handgrip 12 can pivot about a pivot axis, which may be orthogonal to or intersect with a rotary shaft of the chuck 13.

[0010] The chuck 13 is arranged at a distal end (a front end) of the main body 11 and detachably holds a bit, such as a driver bit and a tap. A manually-operated member 14, which may be arranged in a handgrip side of the main body 11, is configured to be operated in a first operation direction ND and a second operation direction OD opposite to the first operation direction ND. In the first embodiment, the first and second operation directions ND and OD correspond to a normal rotation direction and a reverse rotation directions of the motor M, respectively.

[0011] In the first embodiment, the manually-operated member 14 has a rotation axis, which may be orthogonal to or intersect with the rotary shaft of the chuck 13. The manually-operated member 14 may include a circular cylindrical body and one or more projections 14a radially outwardly projected from the circular cylindrical body. The main body 11 may include two openings 11a formed in two opposite side surfaces of the main body 11 to receive the projections 14a, respectively, so that a user can operate the manually-operated member 14 in the first operation direction ND and the second operation direction OD with his/her fingers. It is preferable that a biasing member (not shown) be arranged to bias the manually-operated member 14 so that the manually-operated member 14 automatically returns back to a neutral position when a user releases his/her finger from the manually-operated member 14. The neutral position may be referred to as a home position or a motor deactivation

position. The projection 14a may be positioned at a middle point or the center of the respective opening 11 a when the manually-operated member 14 is at the neutral position.

[0012] As shown in Fig. 2(b), the manually-operated member 14 includes a first movable contact 14b and a second movable contact 14c. The movable contacts 14b and 14c are integrally rotated with the manually-operated member 14.

[0013] A circuit board 15 is arranged adjacent to the manually-operated member 14 so that the movable contacts 14b and 14c make sliding contact with the circuit board 15. In the first embodiment, the circuit board 15 may be arranged immediately below an axial end surface of the manually-operated member 14. The circuit board 15 generates a voltage signal S in accordance with an operation amount (rotation angle) of the manually-operated member 14.

[0014] The motor M may be a direct-current (DC) motor operated under a pulse width modulation (PWM) control to generate torque in accordance with the voltage signal S. The motor M is coupled to and rotates the chuck 13, preferably via a power transmission (not shown).

[0015] As shown in Fig. 2(b), a plurality of electrodes P1 a, P2a, P3a, P4a, P5a, PZa, P1 b, P2b, P3b, P4b, P5b, and PZb are arranged on a first surface, which is one of the two opposite surfaces, of the circuit board 15 so that the first movable contact 14b makes sliding contact with the electrodes P1a, P2a, P3a, P4a, P5a, PZa, P1b, P2b, P3b, P4b, P5b, and PZb when the manually-operated member 14 is operated (rotated). A first subset of electrodes P1a, P2a, P3a, P4a, P5a, and PZa is arranged on a left side relative to the neutral position of the manually-operated member 14 as viewed in Fig. 2(b), or a first region of the circuit board 15 corresponding to the first operation direction ND of the manually-operated member 14. A second subset of electrodes P1 b, P2b, P3b, P4b, P5b, and PZb is arranged on a right side relative to the neutral position of the manually-operated member 14, or a second region of the circuit board 15 corresponding to the second operation direction OD of the manually-operated member 14.

[0016] The first movable contact 14b sequentially contacts the first subset of electrodes P1a-PZa when the manually-operated member 14 rotates from the neutral position in the first operation direction ND. The first movable contact 14b sequentially contacts the second subset of electrodes P1 b-PZb when the manually-operated member 14 rotates from the neutral position in the second operation direction OD. The first movable contact 14b is connected to a selected one of the first subset of electrodes P1 a-PZa depending on the operation amount of the manually-operated member 14 in the first operation direction ND. The first movable contact 14b is connected to a selected one of the second subset of electrodes P1 b-PZb depending on the operation amount of the manually-operated member 14 in the second operation direction OD.

[0017] In the first embodiment, the two electrodes PZa and PZb are positioned at maximum rotation positions in the first operation direction ND and the second operation direction OD, respectively. The manually-operated member 14 is rotatable within a rotatable angular range, which is defined between the two electrodes PZa and PZb.

[0018] A neutral-position electrode PGND is arranged on the first surface of the circuit board 15. The neutral-position electrode PGND is connected to the first movable contact 14b when the manually-operated member 14 is located at the neutral position.

[0019] A first common electrode PK1 is arranged on the first surface of the circuit board 15. The first movable contact 14b maintains contact with the first common electrode PK1 regardless of the operation amounts (rotation angles) of the manually-operated member 14 as long as the manually-operated member 14 is within the rotatable angular range.

[0020] A set of switching electrodes P11 a and P11 b are arranged on the first surface of the circuit board 15. The second movable contact 14c is connected to one of the switching electrodes P11 a and P11b when the manually-operated member 14 is moved to any position other than the neutral position. For example, the second movable contact 14c is connected to the switching electrode P11a when the manually-operated member 14 is operated (rotated) from the neutral position in the first operation direction ND. The second movable contact 14c is connected to the switching electrode P11b when the manually-operated member 14 is operated (rotated) from the neutral position in the second operation direction OD.

[0021] A second common electrode PK2 is arranged on the first surface of the circuit board 15. The second movable contact 14c maintains contact with the second common electrode PK2 regardless of the operation amounts (rotation angles) of the manually-operated member 14 as long as the manually-operated member 14 is within the rotatable angular range.

[0022] As shown in Fig. 2(a), a plurality of diodes D1-D5 and a plurality of resistors R1-R4 are mounted on a second surface, which is the other one of the two opposite surfaces, of the circuit board 15. As shown in Fig. 3, the resistor R1 and the diodes D1-D5 are connected in series. The series circuit of the resistor R1 and the diodes D1-D5 forms a variable resistor unit 16. Each of the resistor R1 and the diodes D1-D5 may be referred to as a resistive element, or a non-printed resistive element.

[0023] As shown in Figs. 2(a), 2(b), and 3, the circuit board 15 includes an external power input terminal (connector) VIN, an operation detection terminal SWIN, a power supply terminal VCC, a divided-voltage reception terminal VR, and a ground terminal GND.

[0024] Referring to Fig. 3, the electric power tool 10 includes the circuit board 15, the motor M, a battery B, a motor-current switch SW, a control circuit 21, and a switching device 22. The control circuit 21 may be referred to as a controller.

[0025] The external power input terminal VIN is con-

nected to the battery B via the motor-current switch SW. The control circuit 21 is connected to the operation detection terminal SWIN, the power supply terminal VCC, the divided-voltage reception terminal VR, and the ground terminal GND.

[0026] When the operation detection terminal SWIN receives electric power, the control circuit 21 supplies electric power to the power supply terminal VCC. The control circuit 21 generates a pulse signal having a duty ratio in accordance with a voltage signal S received via the divided-voltage reception terminal VR and sends the pulse signal to the switching device 22.

[0027] The external power input terminal VIN of the circuit board 15 is connected to the switching electrodes P11a and P11b. The second common electrode PK2 is connected to the operation detection terminal SWIN. Accordingly, when the manually-operated member 14 is operated, or rotated from the neutral position in the first operation direction ND or the second operation direction OD, the operation detection terminal SWIN is electrically connected to the external power input terminal VIN (the battery B) via the second movable contact 14c.

[0028] The power supply terminal VCC of the circuit board 15 is connected to the ground terminal GND via the variable resistor unit 16 (e.g., the series circuit of the resistor R1 and the diodes D1-D5).

[0029] The neutral-position electrode PGND of the circuit board 15 is connected to the cathode of the diode D5 and the ground terminal GND. Among the first subset of electrodes, the electrodes P1 a, P2a, P3a, and P4a are connected to the cathodes of the corresponding diodes D4, D3, D2, and D1, respectively. The electrodes P5a is connected to the anode of the diode D1. The electrodes PZa is connected to the resistor R2, which is a current limiting resistor that limits current value to a fixed value. The second subset of electrodes P1 b-PZb is likewise connected to the diodes D1-D5 and the resistor R2.

[0030] The first common electrode PK1 is connected to the divided-voltage reception terminal VR via the resistor R3, which is a protection resistor.

[0031] When the manually-operated member 14 is at the neutral position, the divided-voltage reception terminal VR is connected to the neutral-position electrode PGND, or grounded, and thus the control circuit 21 does not send a pulse signal to the switching device 22.

[0032] When the manually-operated member 14 is operated (rotated) from the neutral position, the first movable contact 14b connects the divided-voltage reception terminal VR to a selected one of the electrodes P1a-PZb that is located at the position corresponding to the operation amount (rotation angle) of the manually-operated member 14. This generates a voltage signal S corresponding to the operation amount (rotation angle) of the manually-operated member 14. The voltage signal S is fed to the control circuit 21. The control circuit 21 generates a pulse signal that has a duty ratio in accordance with the voltage signal S and sends the pulse signal to the switching device 22.

[0033] The motor-current switch SW functions as a motor-rotation direction switch that is configured to switch the rotation direction of the motor M between a normal rotation direction and a reverse rotation direction in accordance with the operation direction of the manually-operated member 14. As shown in Fig. 1, the motor-current switch SW may be arranged adjacent to the manually-operated member 14. The motor-current switch SW may include a first switch SWa and a second switch SWb. The first switch SWa connects a first terminal 22a of the motor M to the battery B if the manually-operated member 14 is being operated in the first operation direction ND. The first switch SWa connects the first terminal 22a of the motor M to the ground via the switching device 22 if the manually-operated member 14 is not being operated in the first operation direction ND. The second switch SWb connects a second terminal 22b of the motor M to the battery B if the manually-operated member 14 is being operated in the second operation direction OD. The second switch SWb connects the second terminal 22b of the motor M to the ground via the switching device 22 if the manually-operated member 14 is not being operated in the second operation direction OD.

[0034] An example of operations of the electric power tool 10 is described below.

[0035] When the manually-operated member 14 is operated in the first operation direction ND, the first terminal 22a and the second terminal 22b of the motor M are connected to the battery B and the ground (the switching device 22), respectively.

[0036] In response to the rotary motion of the manually-operated member 14 in the first operation direction ND, the second movable contact 14c connects the operation detection terminal SWIN to the external power input terminal VIN (the battery B), thereby supplying electric power to the control circuit 21. The control circuit 21 starts supplying electric power to the power supply terminal VCC.

[0037] Simultaneously, the first movable terminal 14b connects the divided-voltage reception terminal VR to a selected one of the first subset of electrodes P1a-PZa that corresponds to the operation amount (rotation angle) of the manually-operated member 14 in the first operation direction ND, thereby providing the control circuit 21 with a voltage signal S corresponding to the operation amount (rotation angle) of the manually-operated member 14. The control circuit 21 generates a pulse signal having a duty ratio in accordance with the voltage signal S, and sends the pulse signal to the switching device 22 to rotate the motor M in the normal rotation direction. This rotates the chuck 13 and the bit held by the chuck 13 in the normal rotation direction.

[0038] When the manually-operated member 14 is operated in the second operation direction OD, the first terminal 22a and the second terminal 22b of the motor M are connected to the ground (the switching device 22) and the battery B, respectively.

[0039] In response to the rotary motion of the manually-

operated member 14 in the second operation direction OD, the second movable contact 14c connects the operation detection terminal SWIN to the external power input terminal VIN (the battery B), thereby supplying electric power to the control circuit 21. The control circuit 21 starts supplying electric power to the power supply terminal VCC. The first movable terminal 14b connects the divided-voltage reception terminal VR to a selected one of the second subset of electrodes P1 b-PZb that corresponds to the operation amount (rotation angle) of the manually-operated member 14 in the second operation direction OD, thereby providing the control circuit 21 with a voltage signal S corresponding to the operation amount (rotation angle) of the manually-operated member 14. The control circuit 21 generates a pulse signal having a duty ratio in accordance with the voltage signal S, and sends the pulse signal to the switching device 22 to rotate the motor M in the reverse rotation direction. This rotates the chuck 13 and the bit held by the chuck 13 in the reverse rotation direction.

[0040] The electric power tool 10 of the first embodiment has the advantages described below.

(1) The first subset of electrodes P1 a, P2a, P3a, P4a, P5a, and PZa is arranged in the first local zone of the circuit board 15 corresponding to the first operation direction ND of the manually-operated member 14. The second subset of electrodes P1 b, P2b, P3b, P4b, P5b, and PZb is arranged in the second local zone of the circuit board 15 corresponding to the second operation direction OD of the manually-operated member 14. The electrodes P1a, P2a, P3a, P4a, P5a, PZa, P1 b, P2b, P3b, P4b, P5b, and PZb are connected in common to a single variable resistor unit, e.g., the variable resistor unit 16. This reduces the number of variable resistor units of the circuit board 15 and thus simplifies the circuit board 15.

(2) It is apparent to those skilled in the electric power tool field that manufacturers capable of forming a printed resistive element on a circuit board are limited and that non-printed resistive elements are easily available. In the first embodiment, the resistor R1 and the diodes D1-D5, which are non-printed resistive elements, are used to form the variable resistor unit 16. This facilitates manufacture of the circuit board 15 and reduces the cost for manufacturing the electric power tool 10.

[0041] The structure of the electric power tool of the present invention is not limited to the above embodiment. It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

[0042] The control circuit 21 may be configured to de-

tect forward voltage of one or more diodes D1-D5, determine a signal level of the voltage signal S based at least on the forward voltage, and generate a pulse signal in accordance with the signal level of the voltage signal S.

[0043] For example, as illustrated in Fig. 4, a circuit board 15 according to a second embodiment includes a forward-voltage detection terminal SET connected to the anode of the diode D1 and the control circuit 21. The control circuit 21 detects or monitors an overall forward voltage of the diodes D1-D5 through the forward-voltage detection terminal SET when electric power being supplied to the operation detection terminal SWIN. The control circuit 21 determines the signal level of the voltage signal S based at least on the overall forward voltage. For example, since the voltage signal S becomes high level when the overall forward voltage of the diodes D1-D5 increases, the control circuit changes a threshold based on the overall forward voltage to accurately determine level or the operation amount of the manually-operated member 14. The control circuit 21 provides the switching device 22 with a pulse signal corresponding to the determined level. This reduces or eliminates the inappropriate influence of temperature-dependent changes in the forward voltage of the diodes D1-D5. As a result, the control circuit 21 can accurately determine the actual operation amount (level) of the manually-operated member 14 and appropriately drive the motor M regardless of temperature changes.

[0044] It will be apparent to those skilled in the electric power tool field from the present disclosure that the control circuit 21 of Fig. 4 is not limited to detect or monitor the overall forward voltage of the diodes D1-D5 and can be changed to detect or monitor a forward voltage other than the overall forward voltage of the diodes D1-D5. For example, the forward-voltage detection terminal SET is connected to the anode of the diode D5 so that the control circuit 21 detects the forward voltage of the diode D5.

[0045] In the illustrated embodiments, the plurality of resistive elements, namely, the resistor R1 and the diodes D1-D5, form the variable resistor unit 16. It will be apparent to those skilled in the electric power tool field from the present disclosure that the structure of the variable resistor unit 16 can be changed to different structures if needed and/or desired. For example, the variable resistor unit 16 may be formed with printed resistors. All resistive elements of the variable resistor unit 16 may be resistors. All resistive elements of the variable resistor unit 16 may be diodes. In this case, it is preferable that a resistor be connected to the diodes in series to regulate electric current to a fixed value. The numbers of the resistive elements of the variable resistor unit 16 and/or the numbers of the voltage signal S may be changed if needed and/or desired.

[0046] It will be apparent to those skilled in the electric power tool field from the present disclosure that the manually-operated member 14 is not limited to be rotatable. For example, the manually-operated member 14 can be changed to be linearly movable from a neutral/home po-

sition in opposite directions.

[0047] The present disclosure includes the following embodiments.

[0048] In a certain implementation, an electric power tool that includes: a manually-operated member moved in a first operation direction and a second operation direction opposite to the first operation direction, the manually-operated member including a movable contact; and a circuit board configured to generate a voltage signal depending on an operation amount of the manually-operated member, the circuit board includes a plurality of electrodes, the movable contact is arranged to make sliding contact with the circuit board and contacts one of the plurality of electrodes depending on the operation amount of the manually-operated member, a first subset of electrodes among the plurality of electrodes is arranged in a first region of the circuit board corresponding to the first operation direction of the manually-operated member, a second subset of electrodes among the plurality of electrodes is arranged in a second region of the circuit board corresponding to the second operation direction of the manually-operated member, and the electrodes of the first and second subsets are electrically connected in common to a variable resistor unit, which may be a single variable resistor unit.

[0049] In a certain implementation, a plurality of resistive elements forms the variable resistor unit.

[0050] In a certain implementation, the plurality of resistive elements includes at least one diode.

[0051] In a certain implementation, the plurality of resistive elements includes a resistor.

[0052] In a certain implementation, the electric power tool includes a controller configured to detect a forward voltage of the at least one diode and determine a signal level of the voltage signal based at least on the forward voltage.

[0053] In a certain implementation, the controller detects an overall forward voltage of a plurality of diode in the variable resistor unit and determines a signal level of the voltage signal based at least on the overall forward voltage.

[0054] In a certain implementation, the manually-operated member is rotatable in the first and second operation directions.

[0055] In a certain implementation, the electric power tool includes a motor, which is under control of the controller and rotates in normal and reverse rotation directions when the manually-operated member is moved in the first and second operation directions.

[0056] In a certain implementation, the circuit board includes a neutral position between the first and second regions.

[0057] Some of the components may be omitted from the components described in the embodiments (or one or more aspects thereof). Further, components in different embodiments may be appropriately combined. The scope of the present invention and equivalence of the present invention are to be understood with reference to

the appended claims.

Claims

1. An electric power tool (10) comprising:

a manually-operated member (14) moved in a first operation direction (ND) and a second operation direction (OD) opposite to the first operation direction (ND), the manually-operated member (14) including a movable contact (14b); and

a circuit board (15) configured to generate a voltage signal (S) depending on an operation amount of the manually-operated member (14), wherein the circuit board (15) includes a plurality of electrodes (P1a-PZa, P1b-PZb), the movable contact (14b) is arranged to make sliding contact with the circuit board (15) and contacts one of the plurality of electrodes (P1a-PZa, P1b-PZb) depending on the operation amount of the manually-operated member (14),

the electric power tool being **characterized in that:**

a first subset of electrodes (P1a-PZa) among the plurality of electrodes is arranged in a first region of the circuit board (15) corresponding to the first operation direction (ND) of the manually-operated member (14),

a second subset of electrodes (P1b-PZb) among the plurality of electrodes is arranged in a second region of the circuit board (15) corresponding to the second operation direction (OD) of the manually-operated member (14), and

the electrodes of the first and second subsets are electrically connected in common to a variable resistor unit (16).

2. The electric power tool (10) according to claim 1, wherein a plurality of resistive elements (D1-D5, R1) form the variable resistor unit (16).

3. The electric power tool (10) according to claim 2, wherein the plurality of resistive elements (D1-D5, R1) includes at least one diode (D1-D5).

4. The electric power tool (10) according to claim 2 or 3, wherein the plurality of resistive elements (D1-D5, R1) includes a resistor (R1).

5. The electric power tool (10) according to claim 3, further comprising a controller (21) configured to detect a forward voltage of the at least one diode (D1-D5) and determine a signal level of the voltage signal

(S) based at least on the forward voltage.

6. The electric power tool (10) according to claim 5, wherein the controller (21) detects an overall forward voltage of a plurality of diode (D1-D5) in the variable resistor unit (16) and determines a signal level of the voltage signal (S) based at least on the overall forward voltage.

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Fig.1

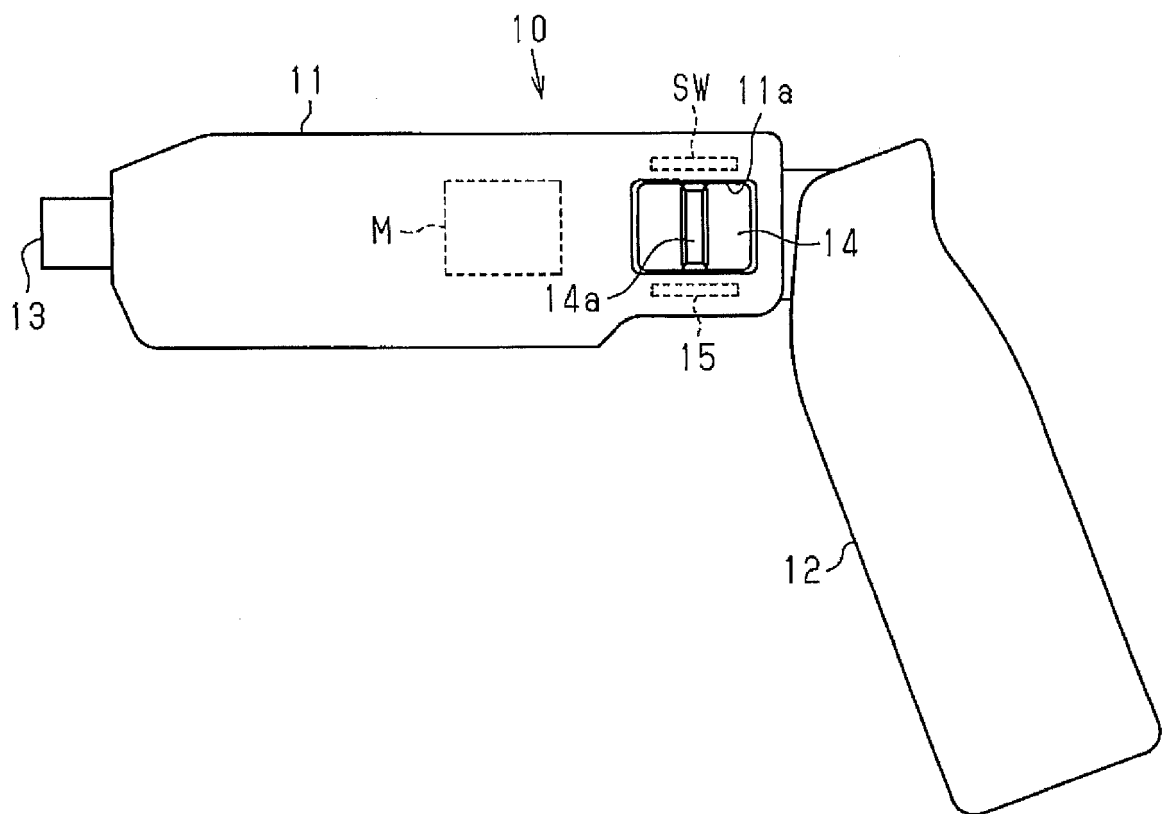


Fig.2(a)

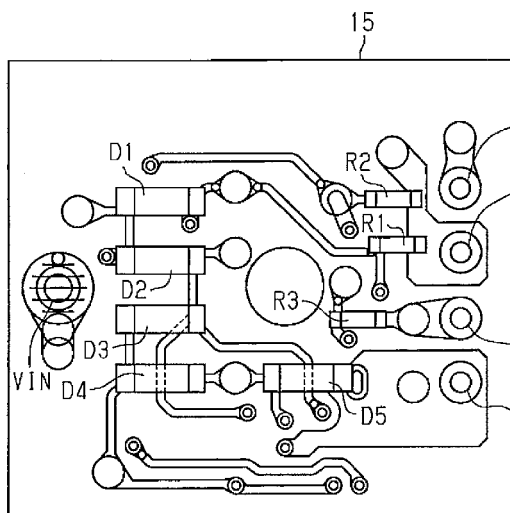


Fig.2(b)

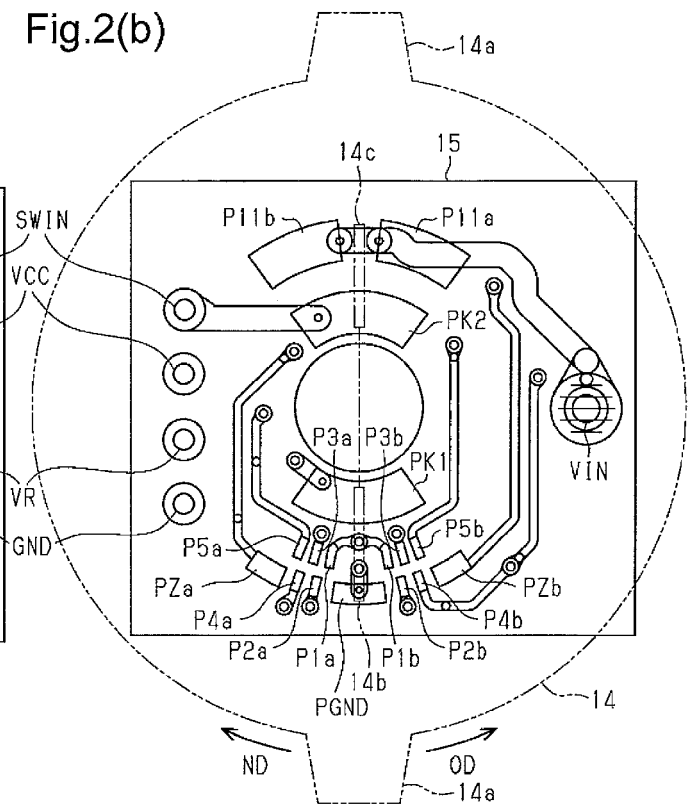


Fig.3

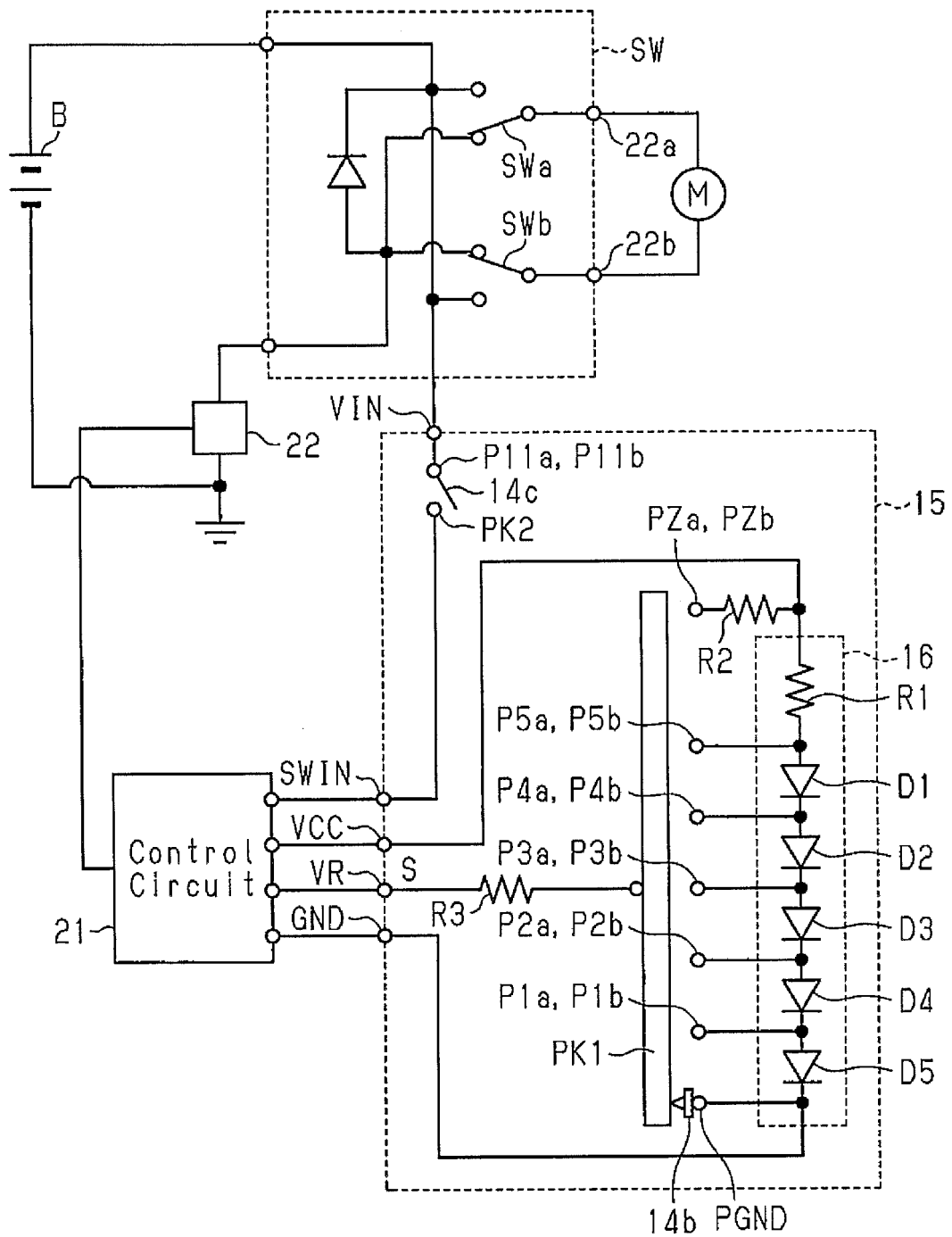
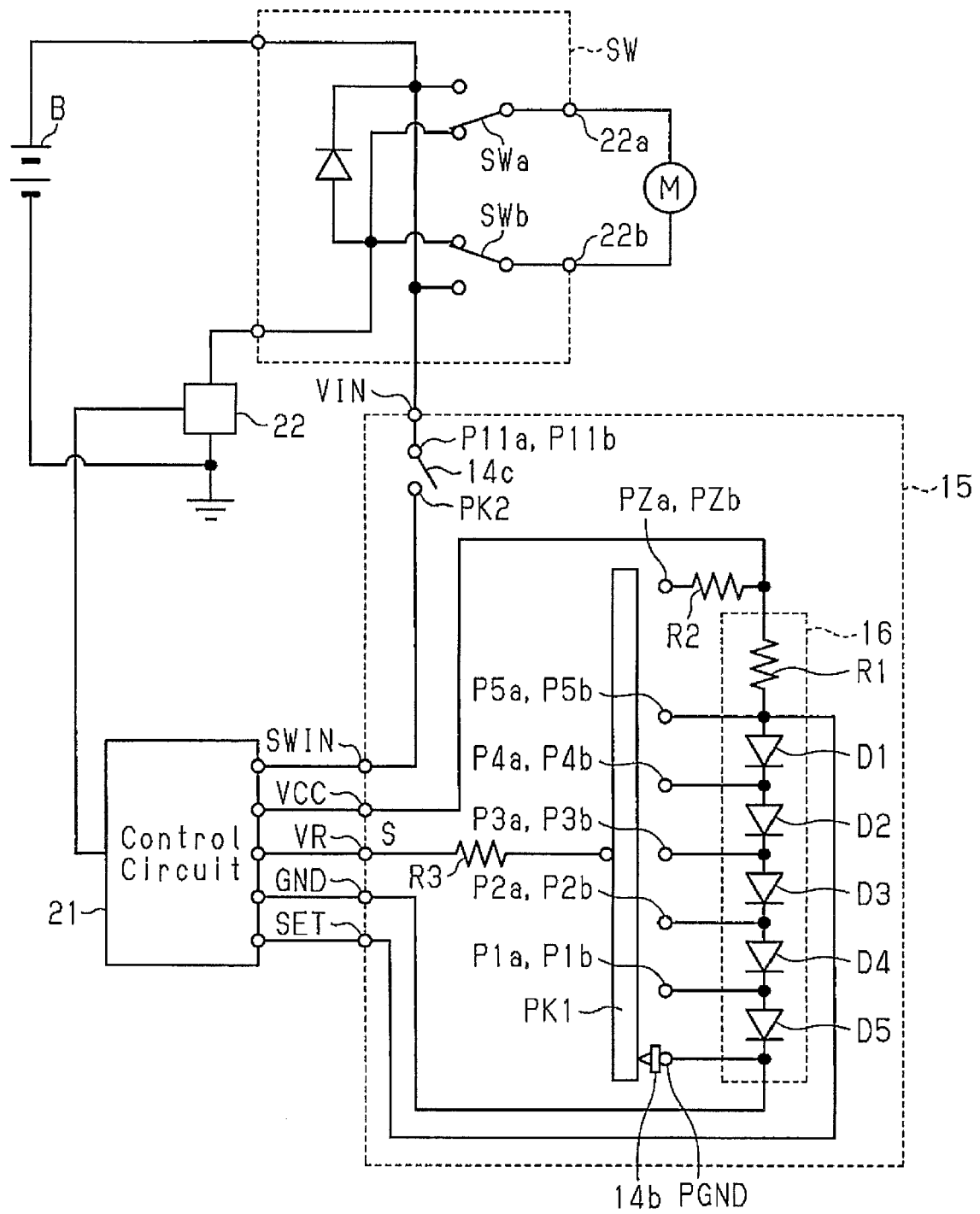


Fig.4





EUROPEAN SEARCH REPORT

Application Number
EP 16 18 0371

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 January 2017	Examiner van Woerden, N
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 18 0371

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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