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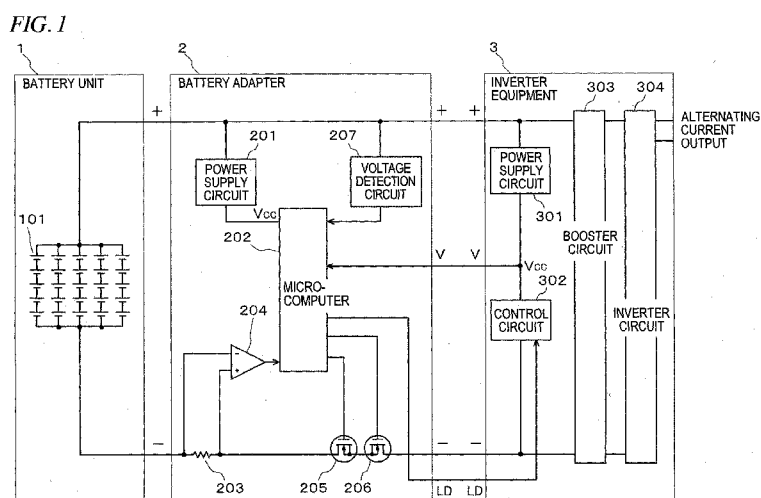
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(54) Title: POWER SUPPLY DEVICE



(57) **Abstract:** A power supply device for energizing electric equipment, the power supply device includes: a battery (1) configured to apply voltage to the electric equipment (3); an acquiring unit configured to acquire information regarding usage state of the electric equipment (3); and a controller (202) configured to switch whether or not to execute energization control based on the acquired information.

DESCRIPTION

TITLE OF INVENTION POWER SUPPLY DEVICE

TECHNICAL FIELD

The present invention relates to a power supply device for energizing electric equipment using battery voltage.

BACKGROUND ART

In a cordless electric tool, battery capacity is limited due to the weight saving in consideration of the hand-held work and therefore operating time is limited, so that a relatively short continuous operating time is assumed. Taking this into consideration, the Japanese Patent Laid-Open Publication No. Hei 11-101836 discloses a technique which gives an alert when the cumulative value of the electric quantity supplied to the electric tool exceeds a predetermined value, in a case where the cordless electric tool is energized by DC power supply device operating in voltage from commercial power source. In addition, the Japanese Patent Laid-Open Publication No. 2002-315321 discloses a technique which protects semiconductor elements such as FET by stopping the power supply when a condition where an average current value exceeds a predetermined value continues for a predetermined time or longer, in a case where the cordless electric tool is energized by DC power supply device.

Meanwhile, AC input electric equipment can be energized and operated by DC output power supply device using a storage battery as a power source via inverter equipment. Since it is assumed that the AC input electric equipment is connected to the commercial power source, for example, and continuously used for a long time, the rated time of the electric equipment which can be continuously used is long, unlike the cordless electric tool. Accordingly, in a case where the AC input electric equipment is used, it is desirable that the electric equipment can be continuously used as long as capacity (for example, capacity corresponding to ten battery packs) of the storage battery of the power supply device remains.

SUMMARY OF INVENTION

In a case where DC input electric equipment such as a cordless electric tool is energized by a power supply device using a large capacity battery, since the battery capacity is large, the electric equipment can be continuously used for a long time more than assumption. Accordingly, the above-described techniques to limit the continuous use beyond a certain level are required. However, in a case where the inverter equipment is driven (that is, AC input electric equipment is energized) by the power supply device using these techniques, the continuous use beyond a certain level is limited under the same condition as a case where DC input electric equipment is used, even when using AC input electric equipment whose rated time (allowing for continuous operation) is long. Consequently, there is a problem that the

continuous operating of the AC input electric equipment is unnecessarily hindered.

The present invention has been made in consideration of the above circumstances and an object of the present invention is to provide a power supply device in which energization control can be made in a more flexible manner, as compared to a case where protection from continuous use for a long time is uniformly applied to all electric equipment under the same conditions.

(1) A power supply device for energizing electric equipment, the power supply device comprising:

- a battery configured to apply voltage to the electric equipment;
- an acquiring unit configured to acquire information regarding usage state of the electric equipment; and
- a controller configured to switch whether or not to execute energization control based on the acquired information.

(2) A power supply device for energizing electric equipment, the power supply device comprising:

- a battery configured to apply voltage to the electric equipment;
- an acquiring unit configured to acquire information regarding integrated value of load current,
- a controller configured to switch whether or not to execute energization control based on the acquired information.

(3) A power supply device for energizing electric equipment, the power supply device comprising:

- a battery configured to apply voltage to the electric equipment;
- an acquiring unit configured to acquire information regarding integrated value of load current,
- a controller configured to execute energization control based on the acquired information when DC input electric equipment is energized,
- wherein the controller does not execute the energization control based on the information when AC input electric equipment is energized.

(4) The power supply device according to any one of (1) to (3), wherein the energization control based on the acquired information stops energization to the electric equipment or gives an alert to the outside when the information satisfies a predetermined condition.

(5) The power supply device according to (4), wherein the predetermined condition is selected from at least two conditions depending on the type of the electric equipment connected to the power supply device.

- (6) The power supply device according to (4) or (5), wherein
the predetermined condition becomes a loose condition when an electric tool for heavy load is connected to the power supply device, and
the predetermined condition becomes a strict condition when an electric tool for light load is connected to the power supply device.
- (7) A power supply device for energizing electric equipment, the power supply device comprising:
a battery configured to apply voltage to the electric equipment;
an acquiring unit configured to acquire information regarding integrated value of load current; and
a controller configured to execute energization control to stop energization to the electric equipment when the information satisfies a predetermined condition,
wherein the predetermined condition is selected from at least two conditions with different strictness.
- (8) The power supply device according to any one of (1) to (7) further comprising a determining unit configured to determine the type of the electric equipment connected to the power supply device,
wherein the controller automatically switch whether or not to execute the energization control based on the information depending on the type of the electric equipment.
- (9) The power supply device according to any one of (1) to (7) further comprising a switch configured to manually switch whether or not to execute the energization control based on the information.
- (10) The power supply device according to any one of (1) to (9), wherein
the information includes an integrated value of load current, and
the integrated value is increased when the load current is equal to or greater than a predetermined value and the integrated value is decreased when the load current is less than the predetermined value.
- (11) The power supply device according to any one of (1) to (10), wherein the information includes temperature information of a resistor provided on a path of load current.
- (12) The power supply device according to any one of (1) to (11), wherein the battery employs 18650 size cell which is a lithium ion secondary battery set and can output average 10 A or more.
- (13) The power supply device according to any one of (1) to (12), wherein the battery is a

lithium ion secondary battery set which has rated voltage in a range of 14.4 V to 42 V.

(14) The power supply device according to any one of (1) to (13), wherein the battery has rated capacity of 1000 Wh or more.

(15) The power supply device according to any one of (1) to (14), wherein the battery has weight in a range of 5 kg to 25 kg.

(16) A power supply device for energizing electric equipment, the power supply device comprising:

- a battery;
- a first terminal for applying voltage of the battery to the electric equipment, the first terminal being configured to be connected to the electric equipment;
- a second terminal configured to be connected to the electric equipment for receiving equipment identification from the electric equipment;
- an acquiring unit configured to acquire information regarding the electric equipment;
- a controller configured to execute energization control for controlling the voltage applied from the first terminal based on the information regarding the electric equipment, wherein the controller switches whether or not to execute the energization control according to the equipment identification acquired from the second terminal.

(17) The power supply device according to (16), wherein

- when the second terminal does not receive the equipment identification from the electric equipment, the controller executes the energization control, and
- when the second terminal receives the equipment identification from the electric equipment, the controller does not execute the energization control.

(18) The power supply device according to (16) or (17), wherein

- the controller executes the energization control when the equipment identification is indicative of DC input electric equipment, and
- the controller does not execute the energization control when the equipment identification is indicative of AC input electric equipment.

(19) The power supply device according to any one of (16) to (18), wherein the information regarding the electric equipment includes at least one of an integrated value of load current supplied to the electric equipment, operating time of the electric equipment, and temperature of a resistor provided on a path of the load current.

(20) The power supply device according to any one of (16) to (18), wherein

- the information regarding the electric equipment includes an integrated value of load current supplied to the electric equipment, and

the integrated value is increased when the load current is equal to or greater than a predetermined value and the integrated value is decreased when the load current is less than the predetermined value.

(21) The power supply device according to any one of (16) to (20), wherein the energization control stops energization to the electric equipment or gives an alert to the outside when the information satisfies a predetermined condition.

(22) The power supply device according to (21), wherein the predetermined condition is selected from at least two conditions depending according to the equipment identification.

(23) The power supply device according to (21) or (22), wherein
the predetermined condition becomes a loose condition when the equipment identification is indicative of an electric tool for heavy load, and
the predetermined condition becomes a strict condition when the equipment identification is indicative of an electric tool for light load.

Any combinations of the above components and modifications in a method or system of the present invention are also effective as an aspect of the present invention.

According to the present invention, it is possible to realize a power supply device in which energization control can be made in a more flexible manner, as compared to a case where protection from continuous use for a long time is uniformly applied to all electric equipment under the same conditions.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram showing a state where inverter equipment 3 is connected to a power supply device according to a first embodiment of the present invention.

Fig. 2 is a block diagram showing a state where an electric tool 4 is connected to the power supply device according to the first embodiment.

Fig. 3 is a flowchart showing an operation of the power supply device according to the first embodiment.

Fig. 4 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a second embodiment of the present invention.

Fig. 5 is a flowchart showing an operation of the power supply device according to the second embodiment.

Fig. 6 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a third embodiment of the present invention.

Fig. 7 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a fourth embodiment of the present invention.

Fig. 8 is a flowchart showing an operation of a power supply device according to a fifth embodiment.

Fig. 9 is a flowchart showing an operation of a power supply device according to a sixth embodiment.

Fig. 10 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a seventh embodiment of the present invention.

Fig. 11 is a flowchart showing an operation of a power supply device according to a seventh embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, a preferred embodiment of the present invention will be described in detail by referring to the accompanying drawings. The same or similar reference numerals are applied to the same or similar parts and elements throughout the drawings, and the duplicated description thereof will be omitted. Further, the embodiment is illustrative and not intended to limit the present invention. It should be noted that all the features and their combinations described in the embodiment are not necessarily considered as an essential part of the present invention.

Fig. 1 is a block diagram showing a state where inverter equipment 3 is connected to a power supply device according to a first embodiment of the present invention. The power supply device (for example, a portable power supply) includes a battery unit 1 and a battery adapter 2. The battery unit 1 is a lithium battery set including one or more lithium battery cells 101, for example, and serves as a power source (a power supply source) for driving electric equipment. In the illustrated example, five battery cells 101 are connected in series and this series connection is connected in parallel in five rows. Although the series connection number and the parallel connection number can be appropriately set in accordance with the necessary voltage or capacity, four series to ten series are desirable.

Positive and negative output terminals of the battery unit 1 are connected to the battery adapter 2. A power supply circuit 201 and a micro-computer 202 are provided in the battery adapter 2. The micro-computer 202 includes a processor and a memory which stores a program for performing the following processing. Alternatively, the micro-computer 202 may be a ASIC (Application Specific Integrated Circuit) for performing the following processing. The power supply circuit 201 converts voltage from the battery unit 1 into a predetermined constant voltage V_{cc} (for example, 5 V) and supplies the converted voltage to a micro-computer 202 as an operating voltage. A current detection resistor 203 is inserted in a negative line and output of an amplifier 204 for amplifying the voltage across the current detection resistor 203 is outputted to the micro-computer 202. In this way, the micro-computer 202 is able to detect the charging/discharging current of the battery unit 1. An input control FET 205 to control the charging of the battery unit 1 and an output control FET (output FET) 206 to control the discharging of the battery unit are also provided in the

negative line. FETs 205, 206 are controlled to be turned on/off by the micro-computer 202. Further, output of a voltage detection circuit 207 to detect the voltage of the battery unit 1 is also inputted to the micro-computer 202 and therefore it is possible to detect battery voltage. Positive/negative terminal for outputting the battery voltage, LD terminal for outputting discharge control signal and V terminal for equipment identification are provided in the battery adapter 2.

The inverter equipment 3 is removably mounted to the battery adapter 2. Positive/negative terminal for inputting the battery voltage, LD terminal for receiving discharge control signal and V terminal for equipment identification are provided in the inverter equipment 3. In addition, a power supply circuit 301 is connected to the positive terminal. The power supply circuit 301 converts voltage from the battery unit 1 into a predetermined constant voltage V_{cc} (for example, 5 V) and supplies the converted voltage to a control circuit 302 as an operating voltage. The constant voltage V_{cc} outputted from the power supply circuit 301 is also outputted to the V terminal. The discharge control signal from the battery adapter 2 is also inputted to the control circuit 302 via the LD terminal. Further, the inverter equipment 3 is further provided with a booster circuit 303 and an inverter circuit 304 which are controlled by the control circuit 302. The booster circuit 303 boosts voltage from the battery unit 1 and the inverter circuit 304 converts the output voltage (direct current) of the booster circuit 303 into alternating current. The output voltage of the inverter circuit 304 is, for example, AC 100 V and can be used to drive the AC input electric equipment.

Fig. 2 is a block diagram showing a state where an electric tool 4 is connected to the power supply device according to the first embodiment. The battery unit 1 and the battery adapter 2 have the same configuration as described above and therefore a description thereof is omitted. The electric tool 4 is a cordless electric tool and illustrated as an example of the DC input electric equipment. The electric tool 4 is removably mounted to the battery adapter 2 directly or via a cable (not shown) or the like. Positive/negative terminal for inputting the battery voltage and LD terminal for receiving discharge control signal are provided in the electric tool 4. One end of a motor 401 and a control circuit 402 are connected to the positive terminal via a trigger switch 404 which is operated by a user. The other end of the motor 401 is connected to the negative terminal via FET 403. The FET 403 is controlled to be turned on/off by the control circuit 402. The discharge control signal from the battery adapter 2 is inputted to the control circuit 402 via the LD terminal. A user can activate the control circuit 402 by operating the trigger switch 404 and the FET 403 can be turned on by the operation of the control circuit 402, thereby driving the motor 401. Here, the electric tool 4 does not include the V terminal.

Fig. 3 is a flowchart showing an operation of the power supply device according to the first embodiment.

At the beginning, a case where the inverter equipment 3 is connected to the power supply device will be described. First, when the micro-computer 202 is activated by the power supply circuit 201 of the battery adapter 2, the micro-computer 202 after the initial setting turns on the output FET 206 to output the voltage of the battery unit (Step S101). Then, the power supply circuit 301 of the inverter equipment 3 is activated, so that the control circuit 302 is activated and the constant voltage V_{cc} from the power supply circuit 301 is inputted to the micro-computer 202 of the battery adapter 2 via the V terminal. If the micro-computer 202 detects the voltage at the V terminal (No in Step S102), the micro-computer 202 invalidates energization control based on integrated value-related information of the load current (Step S103). Meanwhile, the inverter equipment 3 outputs a predetermined AC voltage to operate the AC input electric equipment (not shown). The current (load current) supplied from the power supply device to the electric equipment via the inverter equipment 3 is converted into voltage by the current detection resistor 203, amplified by the amplifier 204 and then inputted to the micro-computer 202. Here, since the energization control based on the integrated value-related information is invalidated, the micro-computer 202 does not execute the calculation of the integrated value of the load current and the power supply device continues to output (continues to energize the AC input electric equipment) until capacity of the battery unit 1 is used up. Meanwhile, normal protection function such as over-discharge protection, over-current protection or temperature protection can be appropriately executed, as necessary.

Next, a case where the electric tool 4 is connected to the power supply device will be described. First, when the micro-computer 202 is activated by the power supply circuit 201 of the battery adapter 2, the micro-computer 202 after the initial setting turns on the output FET 206 to output the voltage of the battery unit (Step S101). Then, since the electric tool 4 does not include the V terminal, the micro-computer 202 of the battery adapter 2 does not detect the voltage of the V terminal (Yes in Step S102) and executes the energization control based on the integrated value-related information, as will be described below.

As a user turns on the trigger switch 404 of the electric tool 4, current flows from the battery unit 1 to drive the motor 401, as described above. Then, since the current is converted into voltage by the current detection resistor 203, amplified by the amplifier 204 and then inputted as a signal to the micro-computer 202, the micro-computer 202 detects load current i by the inputted signal (Step S104). Next, it is determined whether the detected load current i is greater than a predetermined value I_0 or not (Step S105). When it is determined that the load current i is greater than the predetermined value I_0 (Yes in Step S105), a predetermined value (for example, $|i - I_0| \times \Delta t$) is added to the present value of the current integrated value C that is an example of the integrated value-related information (Step S106). Here, since the current integrated value C is obtained by integrating the load current i , the current integrated value may be calculated by adding $(i - I_0)$ regardless of time in a case where

the load current is detected at regular time intervals, for example. On the contrary, in a case where the load current is detected at irregular time intervals, a weight of detection time interval Δt can be taken into account when the load current is calculated.

The micro-computer 202 determines whether the current integrated value C exceeds a predetermined value C_1 (de-energization threshold) or not (Step S107). When it is determined that the current integrated value C does not exceed the predetermined value C_1 (No in Step S107), the process returns to Step S102 (the electric tool 4 continues to drive). On the contrary, when it is determined that the current integrated value C exceeds the predetermined value C_1 (Yes in Step S107), the output FET 206 is turned off (Step S108). In this way, it is possible to prevent the electric tool 4 from being over-heated. Alternatively, the electric tool 4 may be protected by outputting signal of the LD terminal and thus turning off the FET 403 by the control circuit 402 of the electric tool 4. Further, in order to allow a user to see, a signal indicating that output is stopped due to protection may be outputted in a display form.

Meanwhile, when the load current i is smaller than the predetermined value I_0 , heat generation is considered to be small because current is small. In this case (No in Step S105), a predetermined value (for example, $|i-I_0|\times\Delta t$) is subtracted from the present value of the current integrated value C (Step S109). Here, the cooling due to heat dissipation is taken into account. Then, the micro-computer 202 determines whether the current integrated value C is smaller than a predetermined value C_2 (energization restart threshold) or not (Step S110). Herein, it is assumed that the predetermined value C_2 (energization restart threshold) is smaller than the predetermined value C_1 (de-energization threshold). When the current integrated value C is not smaller than the predetermined value C_2 (that is, when the current integrated value C is larger than the predetermined value C_2) (No in Step S110), the process returns to Step S102. On the contrary, when the current integrated value C is smaller than the predetermined value C_2 (Yes in Step S110), the output FET 206 is turned on (Step S111). Here, the turn-on of the output FET 206 in Step S111 refers to conversion (energization restart) from an off-state to an on-state when the output FET 206 just before the turn-on is in an off-state and continuation (energization maintenance) of an on-state when the output FET 206 just before the turn-on is in an on-state. Accordingly, even when the current integrated value C exceeds the predetermined value C_1 and thus the output FET 206 is turned off (Step S108), the current integrated value C is reduced along with heat dissipation of the electric tool 4 over time, so that the output FET 206 is automatically turned on again and therefore the electric tool 4 returns to an available state.

Next, specification of the battery unit 1 will be described. First, a rated voltage of the battery unit is preferably in a range of 14.4 V to 36 V which is a rated voltage of a normal cordless electric tool. When the rated voltage of the battery unit is less than the above range, efficiency of the booster circuit of the inverter equipment is lowered and thus energy can be

wasted. On the contrary, when the rated voltage of the battery unit is higher than the above range, a terminal structure or protection for prevention against electric shock is required and therefore cost is increased. In the case of continuous use of the inverter equipment, the capacity of the battery unit is advantageously larger. Since many of AC electric equipment have power of about 100 W on average (for example, light: 60 W, oil fan heater: 90 W, small LCD TV: 100W), the battery unit 1 preferably has battery capacity of 1000 Wh or more so that the electric equipment can be driven for ten hours (overnight). For portability, lighter weight is preferable. It is possible to maintain the portability by making the weight of the battery in a range of 5 kg to 25 kg.

According to the present embodiment, the following effects can be achieved.

(1) Since energization control based on the current integrated value C is executed when the DC input electric equipment (such as a cordless electric tool operated on direct current) is used, it is possible to limit energization in accordance with the time rating of the electric equipment and therefore it is possible to prevent a failure such as a motor burnout. On the contrary, since energization control based on the current integrated value C is invalidated when continuous drivable electric equipment such as electric equipment having inverter equipment connected thereto is used (when the AC input electric equipment is used), continuous output can be made until the capacity of the battery unit 1 is used up as described above and therefore convenience is ensured.

(2) Since the micro-computer 202 can automatically determine the electric equipment connected to the power supply device by the presence or absence of V terminal voltage (identifying signal), convenience is improved.

(3) Since the voltage of the lithium battery set used in the battery unit 1 is in a range of 14.4 V to 36 V, the battery unit can be used in a normal cordless electric tool. Further, it is possible to secure continuous operating time by providing battery capacity of 1 kWh or more and it is possible to maintain portability by providing battery weight in a range of 5 kg to 25 kg.

Fig. 4 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a second embodiment of the present invention. Unlike the first embodiment shown in Fig. 1, etc., in the power supply device of the second embodiment, a changing-over switch 202 is provided in the battery adapter 2 and allows a user to manually switch the validation and invalidation of the energization control based on the current integrated value. For example, a user can validate the energization control based on the current integrated value C by turning on the changing-over switch 208 and invalidate the energization control by turning off the changing-over switch 208. Further, although the equipment connected to the power supply device is determined by the presence or absence of

V terminal voltage in the first embodiment, the connected equipment is determined by the magnitude (level) of the V terminal voltage in the present embodiment. That is, the battery adapter 2 includes resistors 211, 212 which are connected in series between the constant voltage terminal (voltage Vcc) and the V terminal and the electric tool 4 includes an identification resistor 405 whose resistance value varies according to the type of its own. When the electric tool 4 is connected to the battery adapter 2, series connection of the resistors 211, 212 and the identification resistor 405 is formed and voltage at the interconnection points of the resistors 211, 212 is inputted as the V terminal voltage (identifying signal) to the micro-computer 202.

For example, resistance value of the identification resistor 405 is large in electric tools for heavy load and small in electric tools for light load. Then, the level of the V terminal voltage inputted to the micro-computer 202 is the highest in Vcc when the inverter equipment 3 is connected to the power supply device, is secondarily high in a case of the electric tool for heavy load and the lowest in a case of the electric tool for light load. Meanwhile, the level of the V terminal voltage inputted to the micro-computer 202 is not limited to the above three types but can be set arbitrarily.

Fig. 5 is a flowchart showing an operation of the power supply device according to the second embodiment. The flowchart shown in Fig. 5 is different from the flowchart shown in Fig. 3 in that determination (Step S102A) of V terminal voltage and setting (Step S102B) of de-energization threshold C_1 and energization restart threshold C_2 are provided. That is, when the V terminal voltage is Vcc (Yes in Step S102A), the micro-computer 202 invalidates the energization control based on the current integrated value (Step S103). This corresponds to a case where the inverter equipment 3 is connected to the battery adapter 2. On the contrary, when the V terminal voltage is not Vcc (No in Step S102A), the micro-computer 202 sets the de-energization threshold C_1 and the energization restart threshold C_2 according to the level of the V terminal voltage (identifying signal) (Step S102B). Herein, the de-energization threshold C_1 is large when the level of the V terminal voltage is high and small when the level of the V terminal voltage is low. That is, the de-energization threshold C_1 is large in a case of the electric tool for heavy load (that is, condition is loose) and the de-energization threshold C_1 is small in a case of the electric tool for light load (that is, condition is strict).

Other points of the present embodiment are the same as in the first embodiment.

According to the present embodiment, in addition to the effects of the first embodiment, it is possible to realize the energization control (protection from the continuous use) suitable for the type of the electric tool by switching an allowable load current integrated value according to the type of the electric tool. Further, since a user can manually switch the validation and invalidation of the energization control based on the current integrated value,

convenience is improved.

Fig. 6 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a third embodiment of the present invention. This power supply device is the same as the second embodiment shown in Fig. 4, except that the function of the battery adapter 2 is integrally provided to the battery unit 1.

Fig. 7 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a fourth embodiment of the present invention. This power supply device is the same as the second embodiment shown in Fig. 4, except that a resistor 213 and a thermistor 214 are connected in parallel between the constant voltage terminal (voltage V_{cc}) and the negative input terminal, the thermistor 214 is disposed in the vicinity of the current detection resistor 203 and the voltage at the interconnection points of the resistor 213 and the thermistor 214 is inputted to the micro-computer 202. The resistance value of the thermistor 214 is changed according to the temperature of the current detection resistor 203 which is, in turn, changed according to the integrated value of the load current. That is, in the present embodiment, the temperature information (the temperature T which is specified from the voltage at the interconnection points of the resistor 213 and the thermistor 214) of the current detection resistor 203 is used as the integrated value-related information of the load current, instead of the current integrated value C . The energization control similar to the fourth embodiment can be executed by setting a de-energization threshold T_1 and an energization restart threshold T_2 to the temperature information. Meanwhile, the energization control may be performed by monitoring both the current integrated value C and the temperature T .

While description has been made in connection with particular embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modification may be made therein without departing from the present invention. A modification thereof will be described.

Although the energization control based on the integrated value-related information is invalidated when the inverter equipment 3 is connected to the power supply device in the illustrative embodiments, the energization control based on the integrated value-related information may be executed when the inverter equipment 3 is connected to the power supply, in the loose conditions as compared to a case where the DC input electric equipment is connected to the power supply device. Also in this case, it is possible to secure long continuous usable time of the inverter equipment 3 (eventually, the AC input electric equipment), as compared to a case where the energization control based on the integrated value-related information is executed in the same condition as a case where the DC input electric equipment is connected to the power supply device. Further, the energization control based on the integrated value-related information may be substantially invalidated when the

inverter equipment 3 is connected to the power supply by sufficiently increasing the de-energization threshold (C_1 or T_1) of the current integrated value C or the temperature T .

Although the energization from the power supply device is stopped when the integrated value-related information satisfies predetermined conditions in the illustrative embodiments, the power supply device may give a warning to the outside by sound or light, in addition to or in place of the stopping of the energization.

Although control based on the integrated value-related information is executed in the illustrative embodiments, for example, control according to a fifth embodiment may be executed by measuring operating time by a timer, in addition to or in place of this control. The operating time measured by the timer is an example of the information regarding usage state of the electric equipment. Control in this case is shown in Fig. 8. In a case where voltage of the V terminal is not detected (Yes in Step S102), the micro-computer 202 starts a timer (Step S104C). When a predetermined time T_a has been elapsed (Yes in Step S105C), current is lowered (Step S106C). Further, when a predetermined time has been elapsed and then a total elapsed time exceeds T_b (Yes in Step S107), the output FET 206 is turned off (Step S108). As a result, it is possible to suppress the generation of heat in a motor or the like due to long-term use. Further, control based on both a timer and a motor temperature may be executed in such a way that the motor temperature of electric equipment is detected and current is lowered when the motor temperature exceeds a predetermined temperature.

Although, according to the first to fifth embodiments, the output voltage of the battery adapter 2 does not change, the output voltage of the battery adapter 2 may be changed according to a rated voltage of the electric tool 4 connected to the battery adapter 2. The structure of the battery adapter 2 according to the sixth embodiment is almost the same as the structure according to the fourth embodiment, however, the changing-over switch 208 is not provided in the battery adapter 2.

In the sixth embodiment, the electric tool 4 includes an identification resistor 405 whose resistance value varies according to rating voltage of its own. In the same manner as the fourth embodiment, voltage at the interconnection points of the resistors 211, 212 is inputted as the V terminal voltage indicative of the rating voltage of the electric tool 4 to the micro-computer 202. The micro-computer 202 which receives the V terminal voltage performs PWM (Pulse Width Control) control to the FET 206 according to the V terminal voltage, thereby controlling the output voltage of the battery adapter 2.

Fig. 9 is a flowchart showing an operation of a power supply device according to a sixth embodiment.

At the beginning, in S601, the micro-computer 202 switches the FET 206 at a duty cycle D2 which is smaller than 100%. Then, the micro-computer 202 detects the V terminal voltage to determine the rating voltage of the electric tool connected to the battery adapter 2. In S602, the micro-computer 202 judges whether the V terminal voltage is higher than a first threshold voltage V1. If the V terminal voltage is higher than the first threshold voltage V1 (yes in S602), in step S603, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is an AC input electric equipment (inverter) and therefore the micro-computer 202 switches the FET 206 at a duty cycle D1 of 100%.

If the V terminal voltage is not higher than the first threshold voltage V1 (no in S602), then the micro-computer 202 judges whether the V terminal voltage is higher than a second threshold voltage V2 which is lower than the first threshold voltage V1 in S604. If the V terminal voltage V is higher than the second threshold voltage V2 (yes in S604), in step S605, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is a DC input electric equipment with high rating voltage (for example, 36V) and therefore the micro-computer 202 sets a current value threshold I_0 to I_{01} , a de-energization threshold C_1 to C_{11} , an energization restart threshold value C_2 to C_{21} and switches the FET 206 at the duty cycle D1 of 100 %.

If the V terminal voltage is not higher than the second threshold voltage V2 (no in S604), then the micro-computer 202 judges whether the V terminal voltage is higher than a third threshold voltage V3 which is lower than the second threshold voltage V2 in S706. If the V terminal voltage V is higher than the third threshold voltage V3 (yes in S606), in step S607, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is an DC input electric equipment with low rating voltage (for example, 18V) and therefore the micro-computer 202 sets current value threshold I_0 to I_{02} smaller than I_{01} , the de-energization threshold C_1 to C_{12} smaller than C_{11} and the energization restart threshold value C_2 to C_{22} smaller than C_{21} and switches the FET 206 at the duty cycle D2 smaller D1 to step down the output voltage of the battery adapter.

Thereafter, the micro-computer 202 detects the load current i in S608. In S609, the micro-computer 202 judges whether the detected load current i is higher than the current value threshold I_0 or not. If the detected load current i is higher than the current value threshold I_0 (yes in S609), the micro-computer 202 calculates the current integrated value C in S610, and judges whether the current integrated value C is higher than the de-energization threshold C_1 or not in S611. If the current integrated value C is higher than the de-energization threshold C_1 , the micro-computer 202 turns off the FET 206 in S612. If the current integrated value C is not higher than the de-energization threshold C_1 , the process is returned to S602.

If the detected load current i is lower than the current value threshold I_0 (no in S609), the micro-computer 202 subtracts a predetermined value from the current integrated value C in

S613. Then, micro-computer 202 judges whether the current integrated value C is lower than the energization restart threshold value C_2 or not in S614. If the current integrated value C is lower than the energization restart threshold value C_2 , the microcomputer 202 switches the FET 206 at the duty cycle $D2$ to protect the tool in S615. If the current integrated value C is not lower than the energization restart threshold value C_2 , the process is returned to S602.

In the sixth embodiment, it is assumed that the battery output voltage of the battery unit 1 is constant (36V). However, in the same manner as the first embodiment in which the battery unit is detachable from the battery adapter, the micro-computer 202 may detect the battery output voltage in the same manner as detecting the V terminal voltage, and may set the various thresholds, and the duty cycle for the FET according to the battery output voltage and the rating voltage of the electric tool. For example, the battery output voltage of the battery unit 1 can be detected by the voltage detecting circuit 207.

Although in the sixth embodiment, the output voltage of the battery adapter 2 is changed according to a rated voltage of the electric tool 4 connected to the battery adapter 2 by switching the FET at the given duty cycle, a boosting circuit for changing the output voltage of the battery adapter may be provided in the battery adapter.

Fig. 10 is a block diagram showing a state where the electric tool 4 is connected to a power supply device according to a seventh embodiment of the present invention. Unlike the sixth embodiment, in the power supply device of the seventh embodiment, a boosting circuit 220 for changing the output voltage of the battery adapter is provided in the battery adapter 2. The micro-computer 202 generates a voltage instruction value U to the boosting circuit 220 and the boosting circuit 220 boosts the output voltage of the battery adapter according to the voltage instruction value U . In this embodiment, the battery output voltage of the battery unit is 14.4V. The other structures of the battery adapter according to the seventh embodiment are the same as the structures of the battery adapter according to the sixth embodiment.

Fig. 11 is a flowchart showing an operation of a power supply device according to the seventh embodiment.

At the beginning, in S701, the micro-computer 202 turns on the FET 206. Then, the micro-computer 202 detects the V terminal voltage to determine the rating voltage of the electric tool connected to the battery adapter 2. In S702, the micro-computer 202 judges whether the V terminal voltage is higher than a first threshold voltage $V1$. If the V terminal voltage is higher than the first threshold voltage $V1$ (yes in S702), in step S703, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is an AC input electric equipment (inverter) and therefore the micro-computer 202 sets the voltage instruction value U to $U1$ so that the output voltage of the battery adapter becomes AC100V.

If the V terminal voltage is not higher than the first threshold voltage V1 (no in S702), then the micro-computer 202 judges whether the V terminal voltage is higher than a second threshold voltage V2 which is lower than the first threshold voltage V1 in S704. If the V terminal voltage V is higher than the second threshold voltage V2 (yes in S704), in step S705, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is a DC input electric equipment with high rating voltage (for example, 36V) and therefore the micro-computer 202 sets a current value threshold I_0 to I_{01} , a de-energization threshold C_1 to C_{11} , an energization restart threshold value C_2 to C_{21} and generates the voltage instruction value U2 to the boosting circuit 220 so that the output voltage of the battery adapter becomes DC36V.

If the V terminal voltage is not higher than the second threshold voltage V2 (no in S704), then the micro-computer 202 judges whether the V terminal voltage is higher than a third threshold voltage V3 which is lower than the second threshold voltage V2 in S706. If the V terminal voltage V is higher than the third threshold voltage V3 (yes in S706), in step S707, the micro-computer 202 determines that the electric tool 4 connected to the battery adapter 2 is an DC input electric equipment with low rating voltage (for example, 18V) and therefore the micro-computer 202 sets current value threshold I_0 to I_{02} smaller than I_{01} , the de-energization threshold C_1 to C_{12} smaller than C_{11} and the energization restart threshold value C_2 to C_{22} smaller than C_{21} and generate the voltage instruction value U3 to the boosting circuit 220 so that the output voltage of the battery adapter becomes DC18V.

Thereafter, the micro-computer 202 detects the load current i in S708. In S709, the micro-computer 202 judges whether the detected load current i is higher than the current value threshold I_0 or not. If the detected load current i is higher than the current value threshold I_0 (yes in S709), the micro-computer 202 calculates the current integrated value C in S610, and judges whether the current integrated value C is higher than the de-energization threshold C_1 or not in S711. If the current integrated value C is higher than the de-energization threshold C_1 , the micro-computer 202 turns off the FET 206 in S712. If the current integrated value C is not higher than the de-energization threshold C_1 , the process is returned to S602.

If the detected load current i is lower than the current value threshold I_0 (no in S709), the micro-computer 202 subtracts a predetermined value from the current integrated value C in S713. Then, micro-computer 202 judges whether the current integrated value C is lower than the energization restart threshold value C_2 or not in S714. If the current integrated value C is lower than the energization restart threshold value C_2 , the microcomputer 202 turns on the FET 206. If the current integrated value C is not lower than the energization restart threshold value C_2 , the process is returned to S702.

In the seventh embodiment, it is assumed that the battery output voltage of the battery unit 1 is constant (14.4V). However, if the rating voltage of the electric tool is 14.4V, the

battery output voltage of the battery unit can be output to the electric tool without boosting the voltage by the boosting circuit. Further, if the battery unit which has different voltage is attached to the battery adapter, the micro-computer 202 may detect the battery output voltage of the battery unit connected to the voltage detecting circuit, and may control the boosting circuit according to the detected battery output voltage and the rating voltage of the electric tool connected to the battery adapter.

This application is based upon and claims the benefit of priority of Japanese Patent Application No. 2012-159568 filed on July 18, 2012, the contents of which are incorporated herein by reference in its entirety.

CLAIMS

1. A power supply device for energizing electric equipment, the power supply device comprising:
 - a battery configured to apply voltage to the electric equipment;
 - an acquiring unit configured to acquire information regarding usage state of the electric equipment; and
 - a controller configured to switch whether or not to execute energization control based on the acquired information.
2. A power supply device for energizing electric equipment, the power supply device comprising:
 - a battery configured to apply voltage to the electric equipment;
 - an acquiring unit configured to acquire information regarding integrated value of load current,
 - a controller configured to switch whether or not to execute energization control based on the acquired information.
3. A power supply device for energizing electric equipment, the power supply device comprising:
 - a battery configured to apply voltage to the electric equipment;
 - an acquiring unit configured to acquire information regarding integrated value of load current,
 - a controller configured to execute energization control based on the acquired information when DC input electric equipment is energized,
 - wherein the controller does not execute the energization control based on the information when AC input electric equipment is energized.
4. The power supply device according to any one of claims 1 to 3, wherein the energization control based on the acquired information stops energization to the electric equipment or gives an alert to the outside when the information satisfies a predetermined condition.
5. The power supply device according to claim 4, wherein the predetermined condition is selected from at least two conditions depending on the type of the electric equipment connected to the power supply device.
6. The power supply device according to claim 4 or 5, wherein
 - the predetermined condition becomes a loose condition when an electric tool for heavy load is connected to the power supply device, and
 - the predetermined condition becomes a strict condition when an electric tool for light

load is connected to the power supply device.

7. A power supply device for energizing electric equipment, the power supply device comprising:

a battery configured to apply voltage to the electric equipment;

an acquiring unit configured to acquire information regarding integrated value of load current; and

a controller configured to execute energization control to stop energization to the electric equipment when the information satisfies a predetermined condition,

wherein the predetermined condition is selected from at least two conditions with different strictness.

8. The power supply device according to any one of claims 1 to 7 further comprising a determining unit configured to determine the type of the electric equipment connected to the power supply device,

wherein the controller automatically switch whether or not to execute the energization control based on the information depending on the type of the electric equipment.

9. The power supply device according to any one of claims 1 to 7 further comprising a switch configured to manually switch whether or not to execute the energization control based on the information.

10. The power supply device according to any one of claims 1 to 9, wherein the information includes an integrated value of load current, and

the integrated value is increased when the load current is equal to or greater than a predetermined value and the integrated value is decreased when the load current is less than the predetermined value.

11. The power supply device according to any one of claims 1 to 10, wherein the information includes temperature information of a resistor provided on a path of load current.

12. The power supply device according to any one of claims 1 to 11, wherein the battery employs 18650 size cell which is a lithium ion secondary battery set and can output average 10 A or more.

13. The power supply device according to any one of claims 1 to 12, wherein the battery is a lithium ion secondary battery set which has rated voltage in a range of 14.4 V to 42 V.

14. The power supply device according to any one of claims 1 to 13, wherein the battery has rated capacity of 1000 Wh or more.

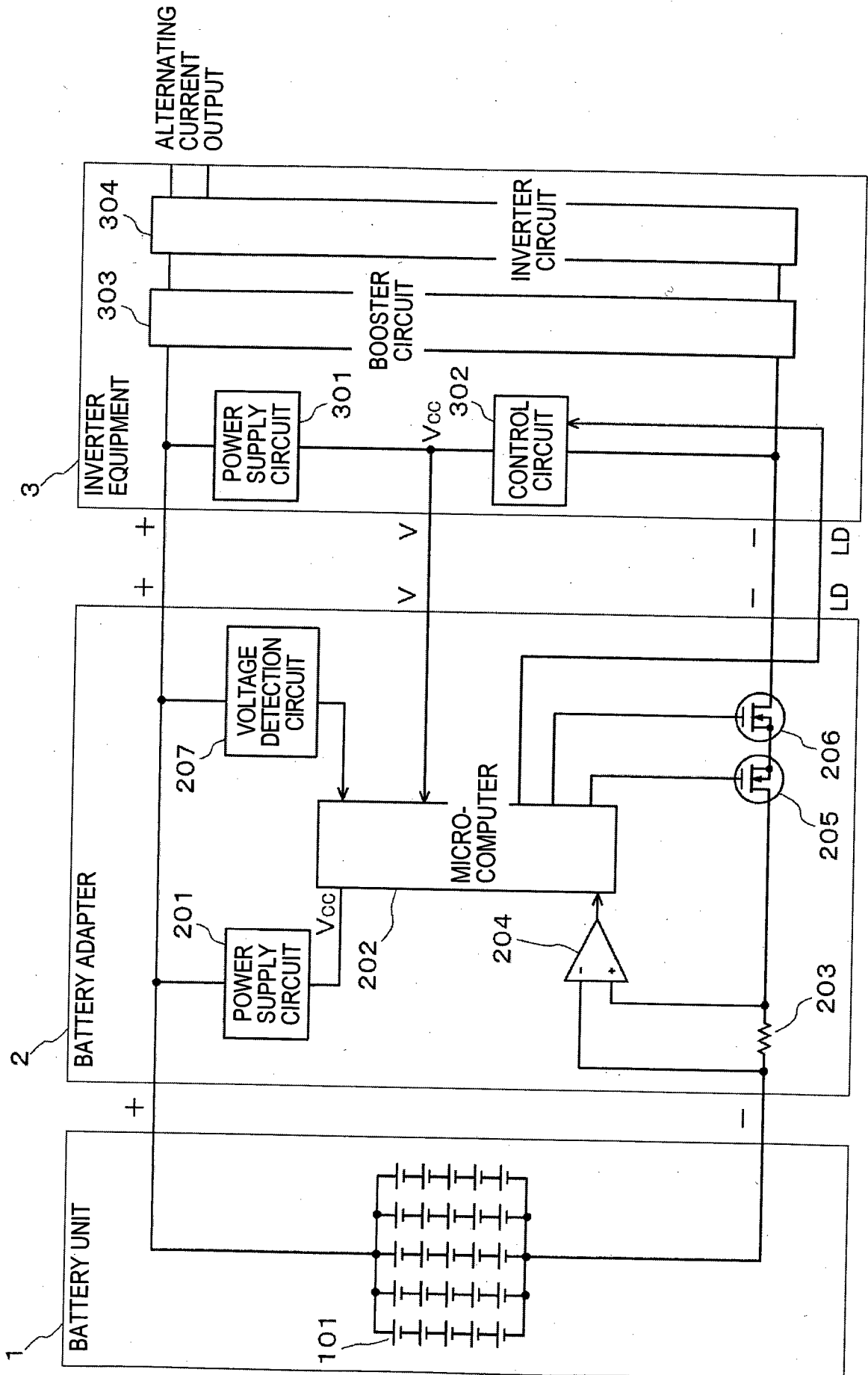
15. The power supply device according to any one of claims 1 to 14, wherein the battery has weight in a range of 5 kg to 25 kg.
16. A power supply device for energizing electric equipment, the power supply device comprising:
- a battery;
 - a first terminal for applying voltage of the battery to the electric equipment, the first terminal being configured to be connected to the electric equipment;
 - a second terminal configured to be connected to the electric equipment for receiving equipment identification from the electric equipment;
 - an acquiring unit configured to acquire information regarding the electric equipment;
 - a controller configured to execute energization control for controlling the voltage applied from the first terminal based on the information regarding the electric equipment, wherein the controller switches whether or not to execute the energization control according to the equipment identification acquired from the second terminal.
17. The power supply device according to claim 16, wherein
- when the second terminal does not receive the equipment identification from the electric equipment, the controller executes the energization control, and
 - when the second terminal receives the equipment identification from the electric equipment, the controller does not execute the energization control.
18. The power supply device according to claim 16 or 17, wherein
- the controller executes the energization control when the equipment identification is indicative of DC input electric equipment, and
 - the controller does not execute the energization control when the equipment identification is indicative of AC input electric equipment.
19. The power supply device according to any one of claims 16 to 18, wherein the information regarding the electric equipment includes at least one of an integrated value of load current supplied to the electric equipment, operating time of the electric equipment, and temperature of a resistor provided on a path of the load current.
20. The power supply device according to any one of claims 16 to 18, wherein
- the information regarding the electric equipment includes an integrated value of load current supplied to the electric equipment, and
 - the integrated value is increased when the load current is equal to or greater than a predetermined value and the integrated value is decreased when the load current is less than the predetermined value.
21. The power supply device according to any one of claims 16 to 20, wherein the

energization control stops energization to the electric equipment or gives an alert to the outside when the information satisfies a predetermined condition.

22. The power supply device according to claim 21, wherein the predetermined condition is selected from at least two conditions depending according to the equipment identification.

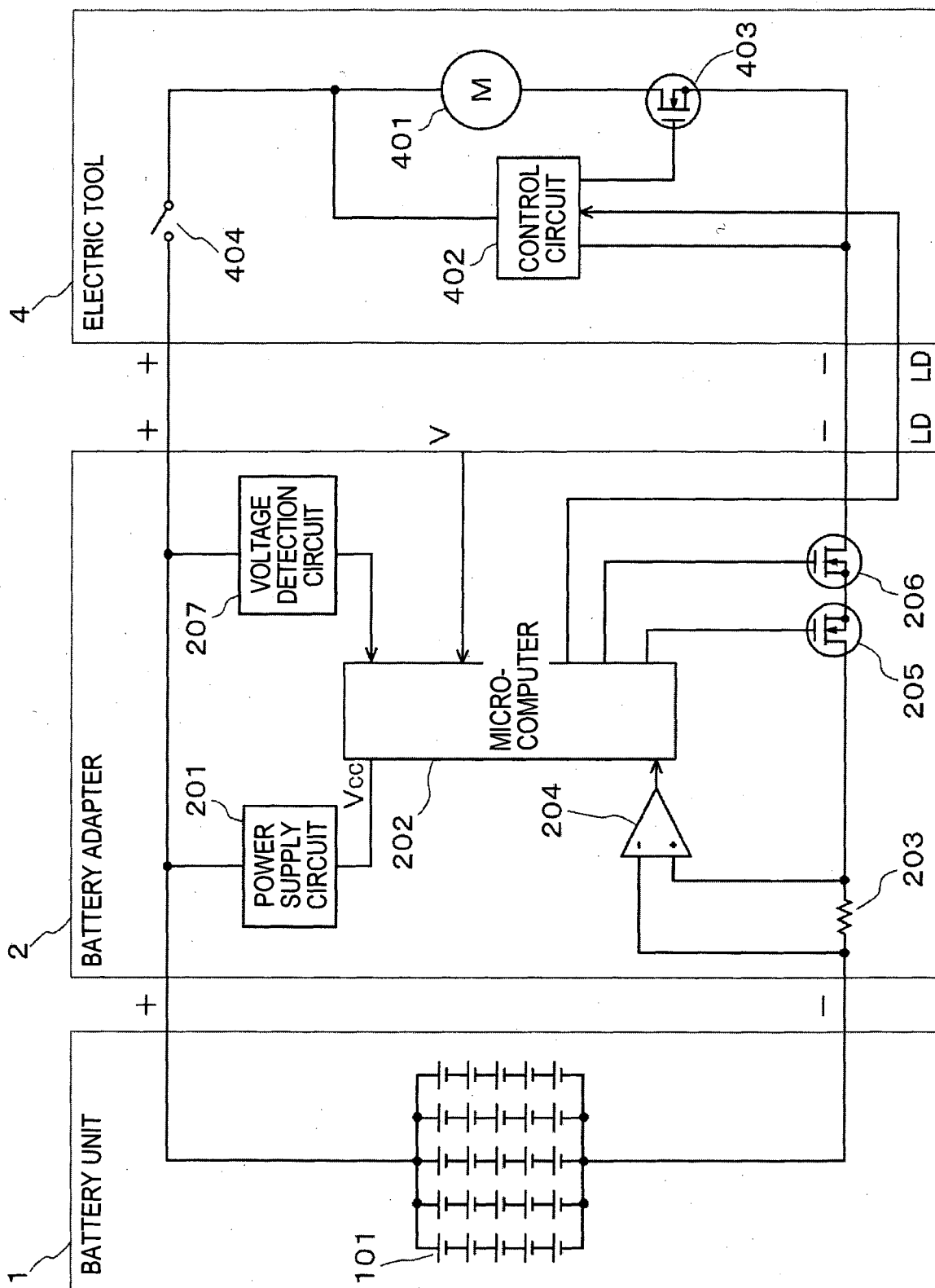
23. The power supply device according to claim 21 or 22, wherein
the predetermined condition becomes a loose condition when the equipment identification is indicative of an electric tool for heavy load, and
the predetermined condition becomes a strict condition when the equipment identification is indicative of an electric tool for light load.

FIG. 1



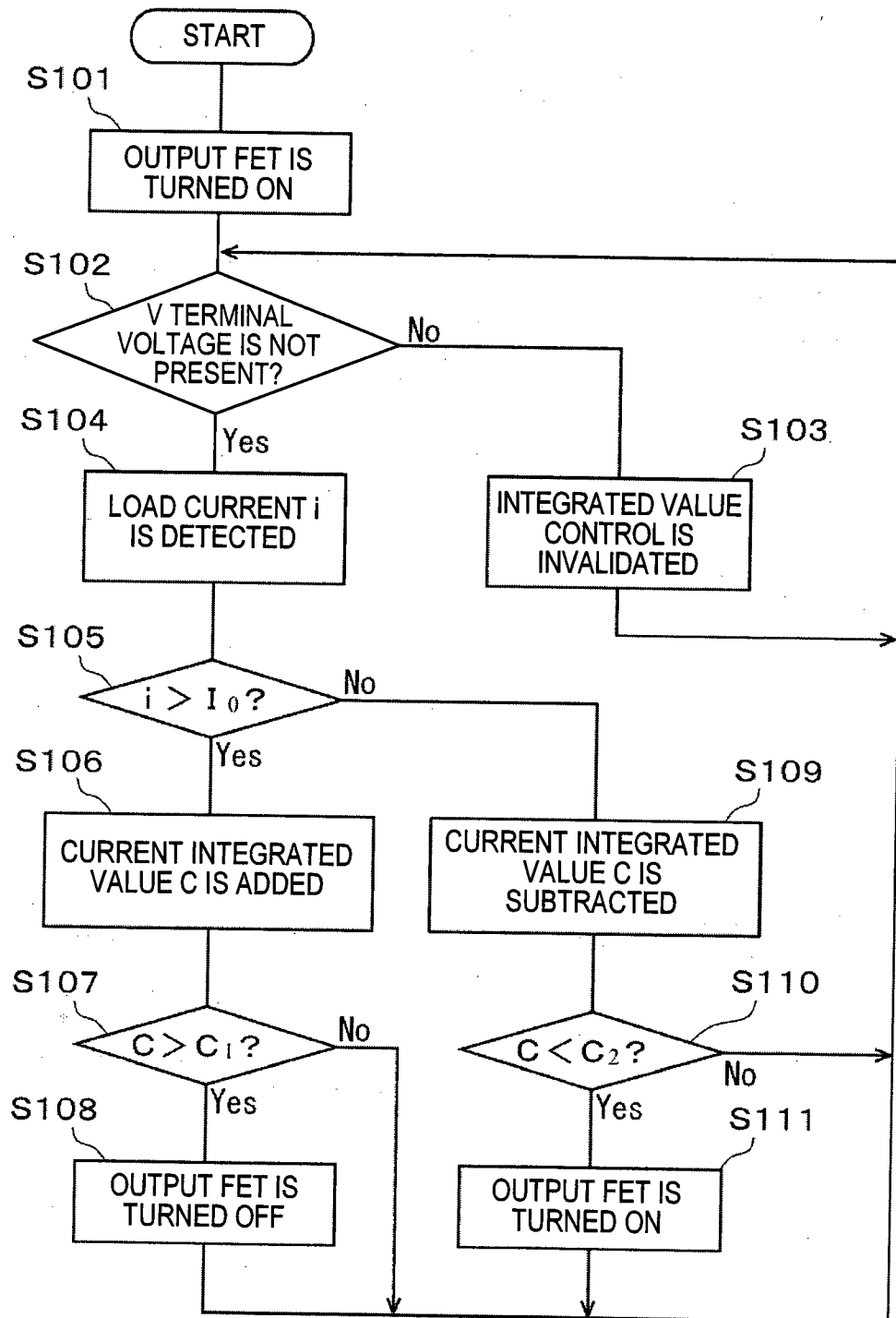
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FIG. 2



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FIG. 3



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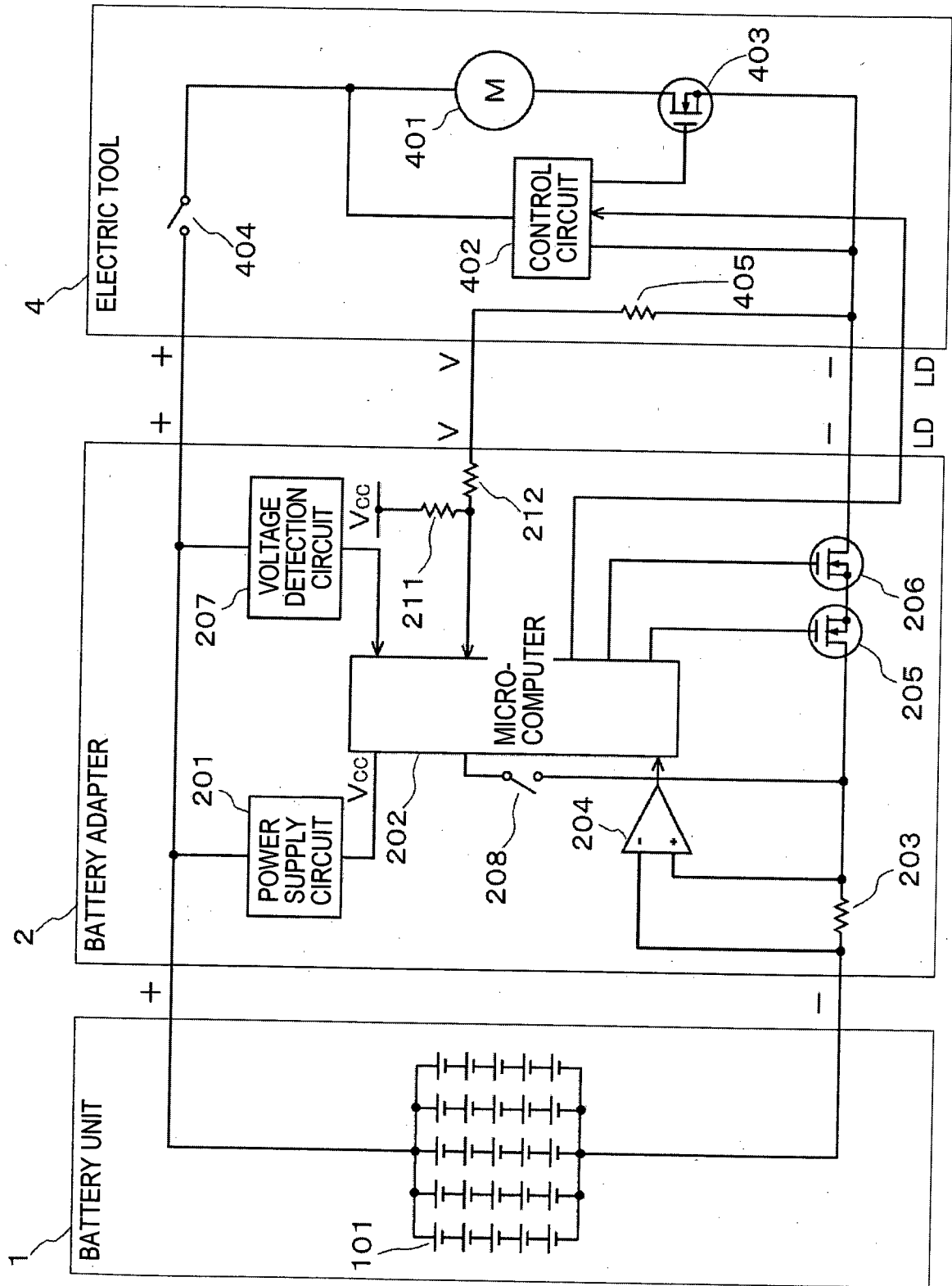
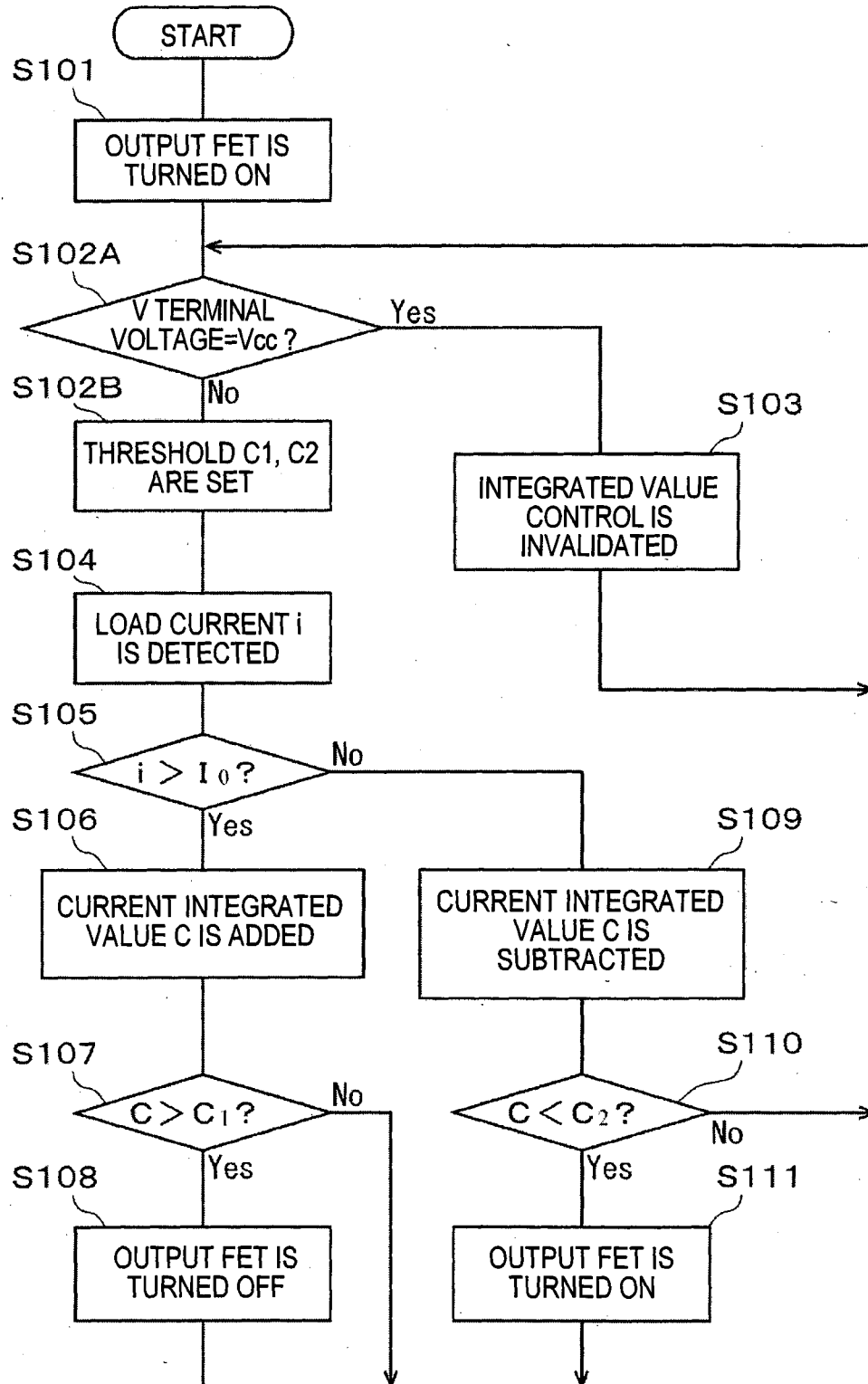


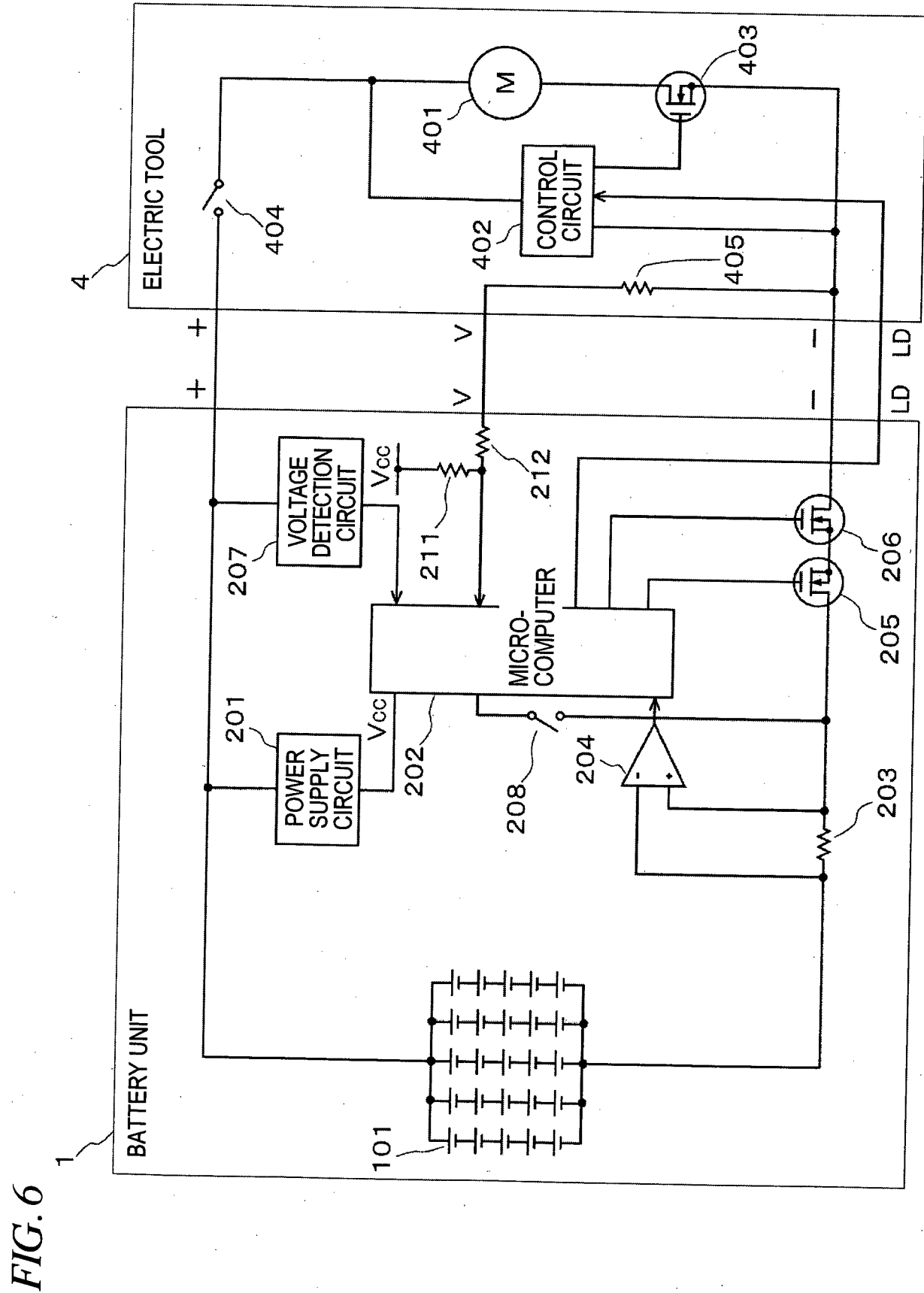
FIG. 4

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FIG. 5

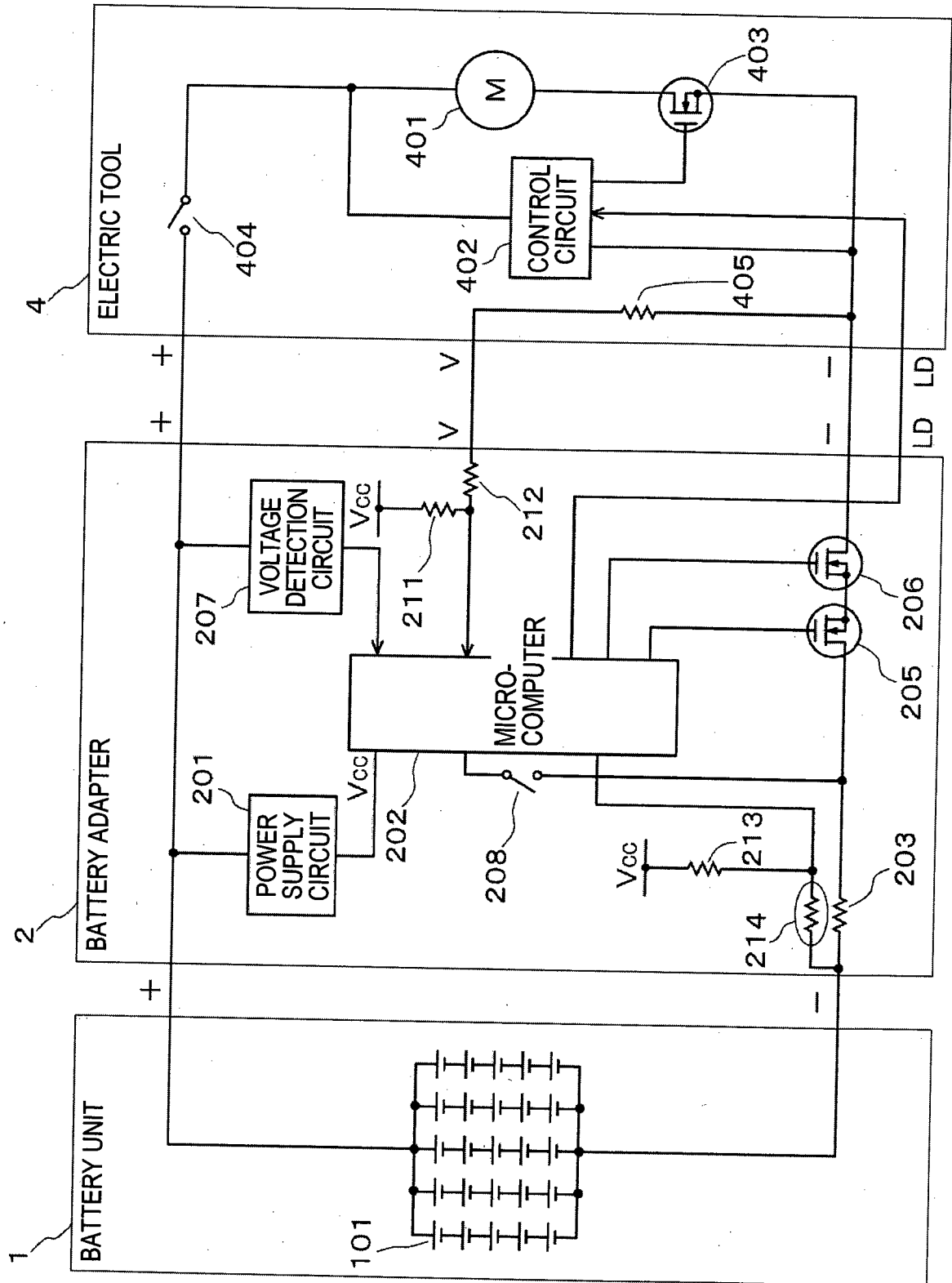


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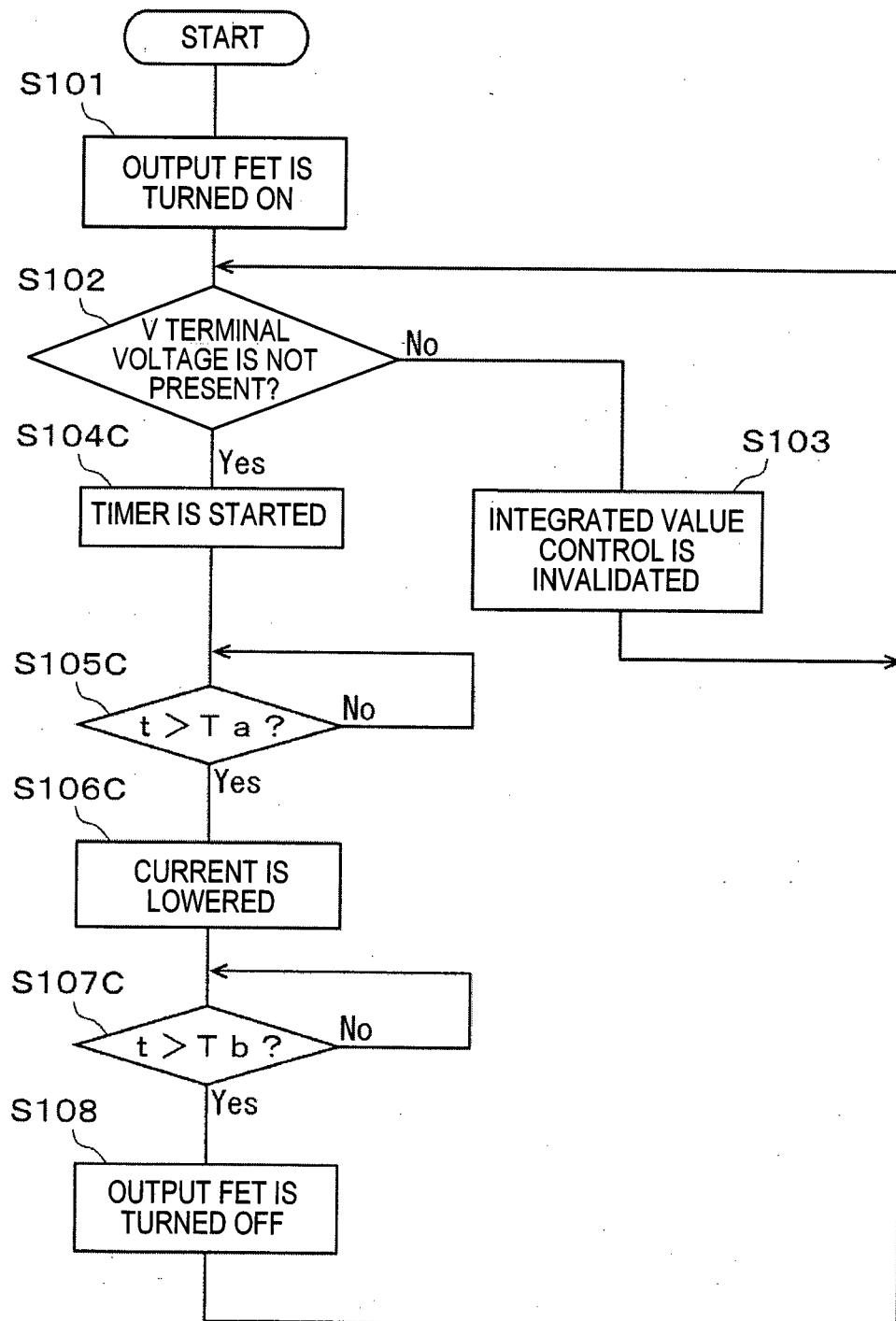
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FIG. 7



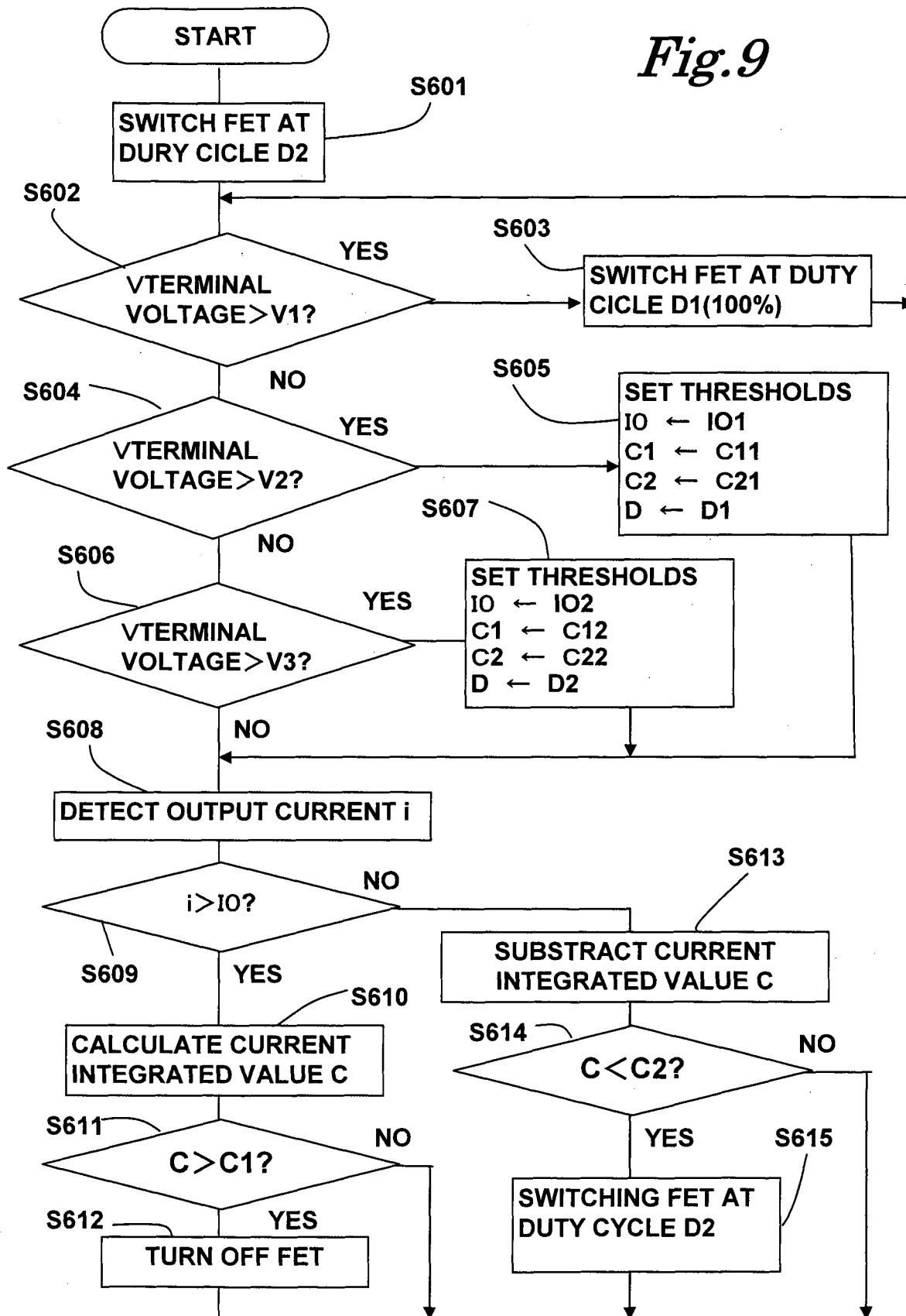
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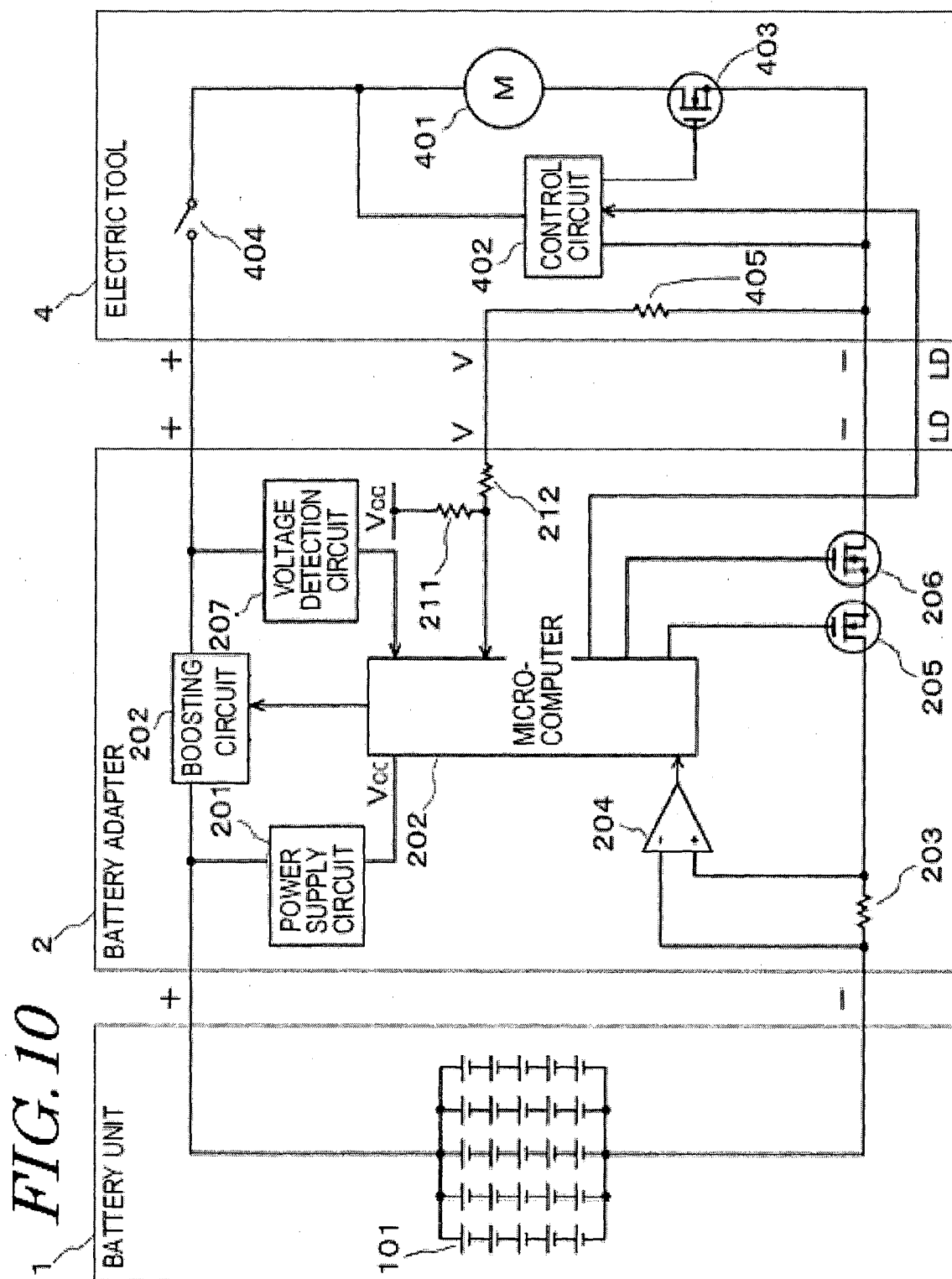
FIG. 8



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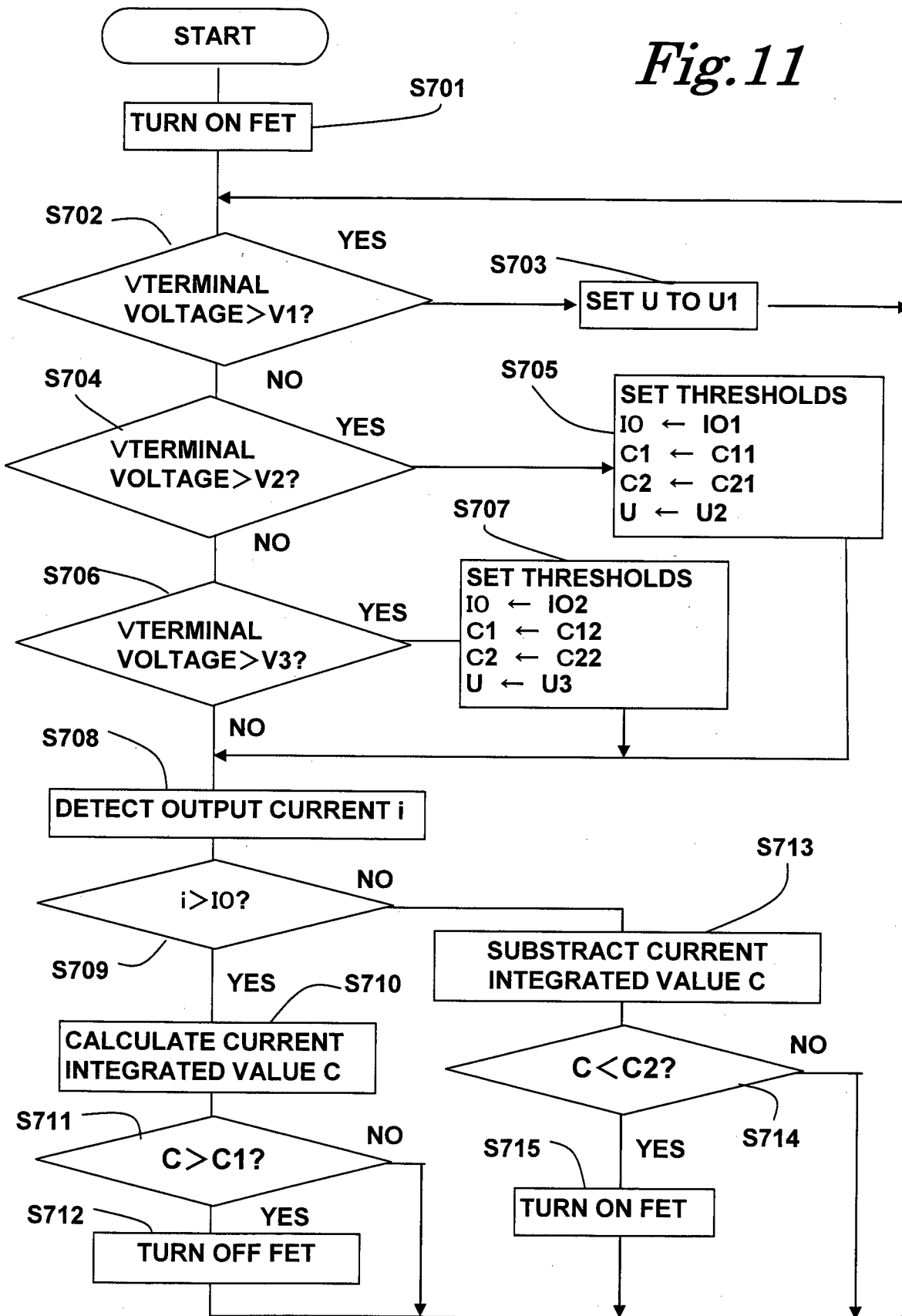
Fig. 9





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Fig. 11



INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2013/070124

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02J7/00 B25F5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02J B25F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 October 2013

Date of mailing of the international search report

12/11/2013

Name and mailing address of the ISA/

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Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No

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