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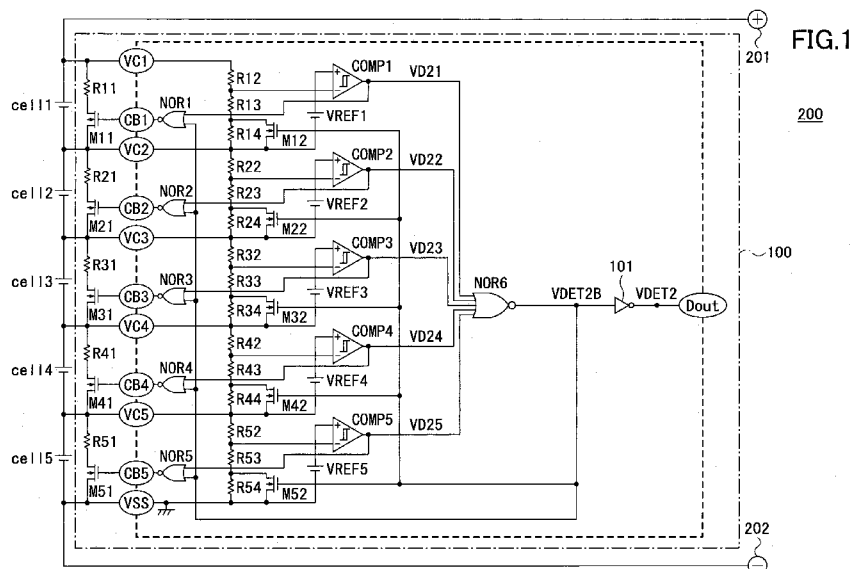
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(54) Title: SECONDARY CELL PROTECTION CIRCUIT AND BATTERY



(57) Abstract: A secondary cell protection circuit configured to protect plural secondary cells connected in series is disclosed that includes plural switching parts configured to be connected in parallel with the secondary cells respectively; and a charge controller configured to turn on the switching part connected to the secondary cell of which cell voltage is greater than or equal to a return voltage, and to turn off the switching part when all cell voltages of the secondary cells become greater than or equal to the return voltage, when the secondary cells are being charged.

DESCRIPTION**Title of Invention**

SECONDARY CELL PROTECTION CIRCUIT AND
BATTERY

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Technical Field

The present invention generally relates to a technique which is used for protecting a lithium-ion battery or the like, that is included in a battery pack of a secondary cell, from overcharge, over discharge, short circuit current or the like. The battery pack of a secondary cell, hereinafter referred to as a battery, is used for a voltage regulator or a voltage detector of a composite-type power supply IC which has plural delay time, and particularly for a portable electronic device or the like. The present invention particularly relates to a technique which is suitable for use in suppressing voltage variability of the battery, which is constituted of plural cells connected to each other in series in order to boost output voltage thereof, on a full charge.

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20**Background Art**

Patent document 1 (for example, Japanese Patent No. 3863031) discloses a technique for

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monitoring a state of a battery, which is constituted of plural secondary cells connected to each other in series in order to boost output voltage thereof, when the battery is being charged and discharged. Patent document 1 discloses a technique which prevents an occurrence of a mode in that voltage of the battery can not be supplied to a load by cancelling a charge inhibit signal, in a case where the charge inhibit signal is input to a microcomputer when overcurrent is detected.

Patent document 2 (for example, Japanese Patent Laid-Open Publication No. 2008-278688) discloses a protection circuit which keeps cell balance when battery voltage becomes greater than a predetermined voltage. According to this technique, it is possible to keep the cell balance when the battery voltage becomes greater than the predetermined voltage.

Herein, a technique for keeping the cell balance is a technique in that variability of amount of charge of each cell included in a battery is corrected. The variability of amount of charge is caused by variability of discharge rate of each cell. It is necessary to correct the cell balance particularly for a large battery in which a number of

cells are connected to each other in series.

According to the technique disclosed in patent document 2, each cell includes an over discharge detecting circuit which detects over
5 discharge of the cell, an overcharge detecting circuit which detects overcharge of the cell and a controller which controls turning on/off of a switch that is connected to the cell in parallel. In order to keep the cell balance, the controller turns on the switch
10 based on a detection result of the overcharge detecting circuit when the battery is being charged. When the battery is being discharged, the overcharge detecting circuit and the controller are turned off based on detection result of the over discharge
15 detecting circuit in order to keep the cell balance by decreasing power consumption and thereby decreasing discharge rate of the cell.

In a case where battery voltages of the cells include variability, and then battery voltage of
20 one of the cells decreases and becomes less than over discharge detect voltage faster than battery voltages of other cells, a state monitoring circuit of the battery detects decrease of battery voltage of the cell and discharge of the cell is suspended based on
25 detection result of the state monitoring circuit of

the battery. In this condition, power consumption of the cell becomes lower than other cells, and thus discharge rate of the cell becomes slower than other cells. Since other cells are discharged normally, it becomes possible to keep the cell balance between the cell and other cells.

On the contrary, in a case where battery voltages of the cells include variability, and then battery voltage of one of the cells increases and becomes greater than predetermined cell balance voltage faster than battery voltages of other cells, the switch which is connected in parallel to the cell is turned on. Then the cell is discharged, and it becomes possible to keep the cell balance.

According to the technique as described above, each cell includes the over discharge detecting circuit which detects over discharge, the overcharge detecting circuit which detects overcharge and the controller which controls turning on/off of the switch that is connected in parallel to the cell. In order to keep the cell balance, the controller turns on the switch based on the detection result of the overcharge detecting circuit when the battery is being charged. When the battery is being discharged, the overcharge detecting circuit and the controller are turned off

based on detection result of the over discharge
detecting circuit in order to keep the cell balance by
decreasing power consumption and thereby decreasing
discharge rate of the cell.

5 When over discharge of a cell is detected,
the controller does not control turning on/off of the
switch, and the overcharge detecting circuit and the
controller are turned off. Then the power consumption
is reduced and the discharge rate of the cell is
10 decreased in order to keep the cell balance. In this
condition, it is not possible to increase discharge
rate of other cells in a positive manner.

 Since the switches are controlled to be
turned on/off independently for each cell, the problem
15 described above is caused.

 Since the switches are controlled to be
turned on/off independently for each cell, it is not
possible to keep the cell balance in a manner that all
of the switches are turned on/off relative to one
20 another, when the cells are discharged and charged.

 According to the technique described above,
the cell balance can be kept by switching the switches
only when the battery is being charged, since the
switches are controlled to be turned on/off
25 independently for each cell. Thus, there is a problem

in that it is not possible to keep the cell balance by switching the switches when the battery is being discharged. There is another problem in that it is not possible to keep the cell balance in a manner that
5 all of the switches are turned on/off relative to one another, when the cells are discharged and charged.

SUMMARY OF THE INVENTION

It is a general object of the present
10 invention to provide a secondary cell protection circuit and a battery that can enhance efficiency of keeping cell balance by shortening amount of time necessary for fully charging cells. Further, it is a general object of the present invention to provide a
15 secondary cell protection circuit and a battery that controls cell balance based on at least one of cell voltages.

Features and advantages of the present invention will be set forth in the description which
20 follows, and in part will become apparent from the description and the accompanying drawings, or may be learned by practice of the invention according to the teachings provided in the description. Objects as well as other features and advantages of the present
25 invention will be realized and attained by a secondary

cell protection circuit particularly pointed out in the specification in such full, clear, concise, and exact terms as to enable a person having ordinary skill in the art to practice the invention.

5 To achieve these and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, an embodiment of the present invention provides a secondary cell protection circuit configured to protect plural
10 secondary cells connected in series including: plural switching parts configured to be connected in parallel with the secondary cells respectively; and a charge controller configured to turn on the switching part connected to the secondary cell of which cell voltage
15 is greater than or equal to a return voltage, and to turn off the switching part when all cell voltages of the secondary cells become greater than or equal to the return voltage, when the secondary cells are being charged.

20 Another embodiment of the present invention provides a secondary cell protection circuit configured to protect plural secondary cells connected in series including: plural switching parts configured to be connected in parallel with the secondary cells
25 respectively; plural over discharge detecting parts

configured to detect an over discharge state of the
secondary cells respectively; an over discharge
detection signal outputting part configured to output
an over discharge detection signal when any of the
5 plural over discharge detecting parts detect the over
discharge state; a discharge controller configured to
form a discharge path by turning on the switching part
in order to discharge the secondary cell, which is not
in the over discharge state, via the discharge path
10 when the over discharge detection signal outputting
part outputs the over discharge detection signal; a
charge controller configured to turn on the switching
part connected to the secondary cell of which cell
voltage is greater than or equal to a return voltage,
15 and to turn off the switching part when all cell
voltages of the secondary cells become greater than or
equal to the return voltage, when the secondary cells
are being charged; wherein the over discharge
detecting parts respectively detect the over discharge
20 state when the cell voltage becomes less than a
detection voltage, and the return voltage is greater
than or equal to the detection voltage.

Other objects, features and advantages of
the present invention will become more apparent from
25 the following detailed description when read in

conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic drawing showing an
5 example of a secondary cell protection circuit 100 and
a battery 200 according to the present embodiment; and

Fig. 2 shows a timing chart indicating an
operation of the secondary cell protection circuit 100
and a battery 200 according to the present embodiment.

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DESCRIPTION OF EMBODIMENTS

In the following, embodiments of the present
invention will be described with reference to the
accompanying drawings.

15 Fig. 1 is a schematic drawing showing an
example of a secondary cell protection circuit 100 and
a battery 200 according to the present embodiment.

Fig. 1 shows only a portion of the secondary cell
protection circuit 100 and the battery 200 that are
20 related to the present embodiment. The battery 200
includes the secondary cell protection circuit 100, a
cell 1, a cell 2, a cell 3, a cell 4, a cell 5, a
terminal 201 and a terminal 202. The secondary cell
protection circuit 100 is indicated by the alternate
25 long and short dash line. The secondary cell

protection circuit 100 includes resistors R11~R14,
R21~R24, R31~R34, R41~R44, R51~R54, transistors
(NMOS) M11, M12, M21, M22, M31, M32, M41, M42, M51,
M52, negative OR circuits (NOR circuits) NOR1~NOR6, an
5 inverter 101, comparators COMP1~COMP5, cell terminals
VC1~VC5, VSS, switch control terminals CB1~CB5,
reference power sources VREF1~VREF5 and a terminal
Dout. A portion of the secondary cell protection
circuit 100 included in the dotted line indicates a
10 portion which is constituted of an IC. The secondary
cell protection circuit 100 may be connected to a
battery which is included in notebook-size personal
computer and includes plural secondary cells connected
to each other in series.

15 When the cells 1~5 are being charged, the
secondary cell protection circuit 100 turns on
transistor(s), among the transistors M11~M51, that is
connected to cell(s), among the cells 1~5, of which
cell voltage becomes greater than or equal to a
20 predetermined return voltage. When all of the cell
voltages of the cells 1~5 becomes greater than or
equal to the return voltage, the secondary cell
protection circuit 100 turns off the transistors
M11~M51. Thus, it is possible to suppress variability
25 of the cell voltages on a full charge.

When the secondary cell protection circuit 100 detects over discharge of the cells 1~5 which is connected to each other in series, the NOR circuit NOR6 outputs an over discharge detection signal VDET2B which is used for suspending discharge of the cells 1~5. The over discharge detection signal VDET2B is input to the inverter 101, and inverted to an over discharge detection signal VDET2. The over discharge detection signal VDET2 is output from the terminal 10 Dout.

The transistors M11, M21, M31, M41 and M51 constitute switching parts, and are connected in parallel to the cells 1~5, respectively.

The comparators COMP1~COMP5, the resistors R11~R54, reference power sources VREF1~VREF5 and NOR circuit NOR6 constitute an over discharge detecting part. The over discharge detecting part outputs the over discharge detection signal from the NOR circuit NOR6 when at least one of the cells 1~5 becomes in an over discharge state in that the cell voltage becomes less than or equal to a predetermined detection voltage VDET, in a condition where a load is connected between the terminal 201 and the terminal 202.

Hereinafter, for example, a case where the cell 1 becomes in the over discharge state and the

cells 2~5 do not become in the over discharge state will be described.

The comparators COMP1~COMP5 and NOR circuits NOR1~NOR6 constitute a discharge controller. When the NOR circuit NOR6 outputs the discharge detection signal VDET2B, the discharge controller does not turn on the transistor M11 that is connected to the cell 1. The discharge controller turns on rest of transistor M21~M51 that is connected to rest of the cells 2~5.

10 The cells 2~5 are discharged via discharge paths that include the resistors R21~R51 and the transistors M21~M51 respectively.

The comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6 constitute charge controller. The charge controller turns on the transistor M21~M51 which corresponds to the cells 2~5 when the cells 1~5 are being charged via the terminals 201 and 202. The charge controller turns on the transistor M21~M51 until all of the cell voltages of the cells 1~5 become greater than or equal to the return voltage VREL which is greater than or equal to the detection voltage VDET.

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The transistors M11, M21, M31, M41 and M51 constitute the switching parts, and are connected in parallel to the cells 1~5, respectively. The comparators COMP1~COMP5, the resistors R11~R54 and the

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reference power sources VREF1~VREF5 respectively constitute an over discharge detecting part. The comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources VREF1~VREF5, as the over
5 discharge detecting parts, detect the over discharge state of the cells 1~5 respectively and independently when the load is connected between the terminal 201 and the terminal 202. In the over discharge state, the cell voltage becomes less than or equal to the
10 detection voltage VDET.

The NOR circuit NOR6 constitutes the over discharge detection signal outputting part and outputs the over discharge detection signal when at least one of the over discharge detecting parts detects the over
15 discharge state. The over discharge detecting parts are constituted of the comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources VREF1~VREF5. The comparators COMP1~COMP5 and NOR circuits NOR1~NOR6 constitute a discharge controller.
20 When the NOR circuit NOR6 outputs the discharge detection signal VDET2B, the discharge controller does not turn on the transistor M11 that is connected to the cell 1. The discharge controller turns on rest of transistor M21~M51 that is connected to rest of the
25 cells 2~5. The cells 2~5 are discharged via discharge

paths that include the resistors R21~R51 and the transistors M21~M51 respectively.

The comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6 constitute the charge controller.

5 When the cells 1~5 are being charged via the terminals 201 and 202, the charge controller turns on the transistor M21~M51 which corresponds to the cells 2~5 when the cells 1~5 are being charged via the terminals 201 and 202. The charge controller turns on the
10 transistor M21~M51 until all of the cell voltages of the cells 1~5 become greater than or equal to the return voltage VREL which is greater than or equal to the detection voltage VDET.

The transistors M11, M21, M31, M41 and M51
15 constitute the switching parts, and are connected in parallel to the cells 1~5, respectively. The comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources VREF1~VREF5 respectively constitute an over discharge detecting part. The
20 comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources VREF1~VREF5, as the over discharge detecting parts, detect the over discharge state of the cells 1~5 respectively and independently when the load is connected between the terminal 201
25 and the terminal 202. In the over discharge state,

the cell voltage becomes less than or equal to the detection voltage VDET.

The NOR circuit NOR6 constitutes the over discharge detection signal outputting part and outputs
5 the over discharge detection signal when at least one of the over discharge detecting parts detects the over discharge state. The over discharge detecting parts are constituted of the comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources
10 VREF1~VREF5. The resistors R12~R14, R22~R24, R32~R34, R42~R44 and R52~R54 and the transistors M12, M22, M32, M42 and M52 constitute a detection level shifting part. When the NOR circuit NOR6 outputs the over discharge detection signal VDET2B, the detection level shifting
15 part shifts detection voltages of the over discharge detecting parts, which corresponds to the cells 2~5, to the return voltage VREL which is greater than or equal to the detection voltage VDET.

The comparators COMP1~COMP5 and the NOR
20 circuits NOR1~NOR6 constitute discharge controller. When the NOR circuit NOR6 outputs the discharge detection signal VDET2B, the discharge controller does not turn on the transistor M11 that is connected to the cell 1. The discharge controller turns on rest of
25 transistor M21~M51 that is connected to rest of the

cells 2~5. The cells 2~5 are discharged via discharge paths that include the resistors R21~R51 and the transistors M21~M51 respectively. The comparators COMP1~COMP5, the resistors R11~R54 and the reference power sources VREF1~VREF5 respectively constitute the over discharge detecting part. When the over discharge detecting parts detect the over discharge state of the cells 2~5, the transistors M21, M31, M41 and M51 are turned off, and the discharge paths that cause the cells 2~5 to discharge are shut off. In the over discharge state, cell voltages of the cells 2~5 become less than or equal to the return voltage VREL which is shifted by the detection level shifting part. The resistors R12~R14, R22~R24, R32~R34, R42~R44 and R52~R54 and the transistor switch M12, M22, M32, M42 and M52 constitute the detection level shifting part.

The comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6 constitute the charge controller. When the cells 1~5 are being charged via the terminals 201 and 202, the charge controller turns on the transistor M21~M51 which corresponds to the cells 2~5 when the cells 1~5 are being charged via the terminals 201 and 202. The charge controller turns on the transistor M21~M51 until all of the cell voltages of the cells 1~5 become greater than or equal to the

return voltage VREL which is greater than or equal to the detection voltage VDET.

As described above, the transistors M11, M21, M31, M41 and M51 are connected in parallel to the
5 cells 1~5, respectively. The secondary cell protection circuit 100 turns on/off the transistors M11, M21, M31, M41 and M51 respectively, in accordance with variations of cell voltage(s) of another cell(s). Accordingly, the secondary cell protection circuit 100
10 makes it possible to keep the cell balance, by turning on/off the transistors M11~M51, not only when the cells are being charged, but also when the cells are being discharged.

Thus, it becomes possible to increase the
15 discharge rate of the cells 2~5 other than the cell 1 which becomes in the over discharge state. Accordingly, it becomes possible to accomplish the cell balance more efficiently when the cells are being discharged.

20 Further, the resistors R12~R14, R22~R24, R32~R34, R42~R44 and R52~R54 and the transistors M12, M22, M32, M42 and M52 constitute the detection level shifting parts that shift the detection voltage. Thus, it becomes possible to control and keep the cell
25 balance by shifting the detection voltage based on the

cell voltage of any one of the cells 1~5.

Although, a case in that the cell 1 becomes in the over discharge state and the cells 2~5 do not become in the over discharge state is described above, 5 the same applies to a case in that any of the cells 1~5 become in the over discharge state and other cell(s) does not become in the over discharge state.

Hereinafter, a detailed configuration and an operation of the secondary cell protection circuit 100 10 will be described with reference to Fig. 1. Fig. 1 shows only a portion of the secondary cell protection circuit 100 and the battery 200 that are related to the present embodiment.

At first, the comparators COMP1~COMP5, the 15 detection voltage VDET and the return voltage VREL will be described.

Inverting levels of the comparators COMP1~COMP5 become levels as described below, in a case where an output of the NOR circuit NOR6 becomes 20 in High level (VDET2B=H) and the transistors M12, M22, M32, M42 and M52 are being turned on. The comparators COMP1~COMP5 include hysteresis characteristics. Hysteresis operation of the comparators COMP1~COMP5 are switched by the transistors M12, M22, M32, M42 and 25 M52. The inverting levels of the comparators

COMP1~COMP5, in this condition, constitute over discharge detection levels (detection voltages).

An inverting level VDET21 (detection voltage) of the comparator COMP1 is obtained from a
5 following formula.

$$VDET21 = VREF1 \times (R12 + R13) / R13$$

An inverting level VDET22 (detection voltage) of the comparator COMP2 is obtained from a following formula.

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$$VDET22 = VREF2 \times (R22 + R23) / R23$$

An inverting level VDET23 (detection voltage) of the comparator COMP3 is obtained from a following formula.

$$VDET23 = VREF3 \times (R32 + R33) / R33$$

15 An inverting level VDET24 (detection voltage) of the comparator COMP4 is obtained from a following formula.

$$VDET24 = VREF4 \times (R42 + R43) / R43$$

An inverting level VDET25 (detection
20 voltage) of the comparator COMP5 is obtained from a following formula.

$$VDET25 = VREF5 \times (R52 + R53) / R53$$

Inverting levels of the comparators
COMP1~COMP5 become levels as described below, in a
25 case where the output of the NOR circuit NOR6 becomes

in Low level (VDET2B=L) and the transistors M12, M22, M32, M42 and M52 are being turned off. Inverting levels of the comparators COMP1~COMP5, in this condition, constitute return levels (return voltages).

5 Inverting level VREL21 (return voltage) of the comparator COMP1 is obtained from a following formula.

$$VREL21 = VREF1 \times (R12 + R13 + R14) / (R13 + R14)$$

10 Inverting level VREL22 (return voltage) of the comparator COMP2 is obtained from a following formula.

$$VREL22 = VREF2 \times (R22 + R23 + R24) / (R23 + R24)$$

15 Inverting level VREL23 (return voltage) of the comparator COMP3 is obtained from a following formula.

$$VREL23 = VREF3 \times (R32 + R33 + R34) / (R33 + R34)$$

20 Inverting level VREL24 (return voltage) of the comparator COMP4 is obtained from a following formula.

$$VREL24 = VREF4 \times (R42 + R43 + R44) / (R43 + R44)$$

 Inverting level VREL25 (return voltage) of the comparator COMP5 is obtained from a following formula.

$$VREL25 = VREF5 \times (R52 + R53 + R54) / (R53 + R54)$$

25 In the next, an operation of a returning

operation from the over discharge state will be described.

For example, a case where only the cell voltage of the cell 1 begins to decrease when all of the cell voltages of the cells 1~5 are greater than or equal to the return levels (return voltages) will be described.

When all of the cell voltages of the cells 1~5 are greater than or equal to the return levels (return voltages), the output of the NOR circuit NOR6 becomes in High level ($V_{DET2B}=H$) and the transistors M12, M22, M32, M42 and M52 are being turned on.

In this condition, as the cell voltage of the cell 1 decreases and input voltage of an inverting input (an input to the minus terminal) of the comparator COMP1 becomes less than V_{REF1} , an output signal VD21 of the comparator COMP1 turns from L level to H level. The input voltage of the inverting input of the comparator COMP1 is divided by the resistors R12 and R13.

The output signal VD21 is input to the NOR circuit NOR6, and then the over discharge detection signal VDET2B which is output from the NOR circuit NOR6 turns from H level to L level. The over discharge detection signal VDET2B is input to the

inverter 101, and then the over discharge detection
signal VDET2 which is output from the inverter 101
turns from L level to H level. Thus, the over
discharge of the cell 1 is detected, and then the over
5 discharge detection signal of H level is output from
the terminal Dout. Herein, the over discharge
detection signal of H level means that the over
discharge is detected.

Herein, the transistors M12, M22, M32, M42
10 and M52 are turned off, since the over discharge
detection signal VDET2B turns from H level to L level.

Therefore, the input voltage of an inverting
input (the input to the minus terminal) of the
comparator COMP1 increases, and then the hysteresis
15 characteristics that makes the output signal VD21 of
the comparator COMP1 even harder to return to L level
is obtained.

In the next, an operation of the secondary
cell protection circuit 100 in that the cell voltage
20 of the cell 1 begins to increase from the condition as
described above will be described.

As the cell voltage of the cell 1 increases
and input voltage of an inverting input (the input to
the minus terminal) of the comparator COMP1 becomes
25 greater than or equal to VREF1, the output signal VD21

of the comparator COMP1 turns from H level to L level. The input voltage of the inverting input of the comparator COMP1 is divided by the resistors R12, R13 and R14.

5 The output signal VD21 is input to the NOR circuit NOR6, and then the over discharge detection signal VDET2B which is output from the NOR circuit NOR6 turns from L level to H level. The over discharge detection signal VDET2B is input to the
10 inverter 101, and then the over discharge detection signal VDET2 which is output from the inverter 101 turns from H level to L level. Thus, the cell 1 is returned from the over discharge state, and then the over discharge detection signal of L level is output
15 from the terminal Dout. Herein, the over discharge detection signal of L level means that the over discharge is not detected.

 Herein, the transistors M12, M22, M32, M42 and M52 are turned on, since the over discharge
20 detection signal VDET2B turns from L level to H level.

 Therefore, the input voltage of an inverting input (the input to the minus terminal) of the comparator COMP1 decreases, and then the hysteresis characteristics that makes the output signal VD21 of
25 the comparator COMP1 even harder to return to H level

is obtained.

The secondary cell protection circuit 100 keeps the cell balance by turning on/off the transistors M12, M22, M32, M42 and M52 at the earlier
5 stage of charging the cell 1 during the returning operation from the over discharge state.

Although, a case in that the cell 1 becomes in the over discharge state and the cells 2~5 do not become in the over discharge state is described above,
10 the same applies to a case in that any of the cells 1~5 become in the over discharge state and other cell(s) does not become in the over discharge state.

In the following, the operation of the secondary cell protection circuit 100 will be
15 described with reference to Fig. 2.

In the first period (1) as shown in Fig. 2, the output signals VD21, VD22, VD23, VD24 and VD25 are in L level, since all of the cell voltages of the cells 1~5 are greater than the over discharge
20 detection levels (detection voltages VDET21, VDET22, VDET23, VDET 24 and VDET 25). In this condition, the output of the NOR circuit NOR6 are in H level (VDET2B=H) and the transistors M12, M22, M32, M42 and M52 are being turned on. Thus, the inverting levels
25 of the comparators COMP1~COMP5 are set to be VDET21,

VDET22, VDET23, VDET24 and VDET25, respectively.

In the second period (2), the output signal VD21 becomes in H level, since the cell voltage of the cell 1 becomes less than the level of the over
5 discharge detection signal VDET2 (detection voltage). Thus, the output of the NOR circuit NOR6 becomes in L level (VDET2B=L), and the transistors M12, M22, M32, M42 and M52 are turned off. Therefore, the inverting level of the comparators COMP1~COMP5 becomes in VREL21,
10 VREL22, VREL23, VREL24 and VREL 25.

Since the cell voltages of the cells 2~5 are respectively greater than VREL22, VREL23, VREL24 and VREL 25, the output signals VD22, VD23, VD24 and VD25 are in L level. Since the output of the NOR circuit
15 NOR6 is in L level (VDET2B=L), respective output signals CB2, CB3, CB4 and CB5 of the NOR circuits NOR2, NOR3, NOR4 and NOR5 become in H level.

As the output signals CB2, CB3, CB4 and CB5 become in H level, the transistors M21, M31, M41 and
20 M51 are turned on. Thus the discharge paths of the cells 2~5 are formed. The discharge paths are used for keeping the cell balance and for allowing charging current to flow out. In the second period (2), the cell voltage of the cell 2 is decreasing.

25 In the third period (3), the output signal

VD22 becomes in H level, since the cell voltage of the cell 2 becomes less than the inverting level VREL22. Thus, the output signal CB2 becomes in L level, and the transistor M21 is turned off. Therefore, the
5 discharge path which is connected in parallel with the cell 2 is shut off, and then the discharge of the cell 2 is stopped.

In the fourth period (4), the cell voltage of the cell 3 begins to decrease by being discharged.

10 In the fifth period (5), the output signal VD23 becomes in H level, since the cell voltage of the cell 3 becomes less than the inverting level VREL23. Thus, the output signal CB3 becomes in L level, and the transistor M31 is turned off. Therefore, the
15 discharge path which is connected in parallel with the cell 3 is shut off, and then the discharge of the cell 3 is stopped.

As described above, the discharges of the cells 2 and 3 are stopped respectively when the cell
20 voltages of the cells 2 and 3 become equal to the inverting levels VREL22 and VREL23. The inverting levels VREL22 and VREL23 are higher than the inverting level VDET21 (detection voltage) of cell 1. The discharges of the cells 2 and 3 are operated in order
25 to keep the cell balance. Thus, it becomes possible

to shorten the amount of time which is necessary to fully charge the cells.

In the sixth period (6), similar operations that are performed with regard to the cells 2 and 3 are performed with regard to the cells 4 and 5. Thus the detailed operations of the cells 4 and 5 are omitted, and a charge operation will be described hereinbelow.

In the seventh period (7), the cell voltage of the cell 3 increases and becomes greater than the inverting level VREL23, since charge operation of the cell 3 is started in the sixth period (6). Thus, the output signal VD23 becomes in L level. Then, the output signal CB3 becomes in H level, and the transistor M31 is turned on. Therefore, the discharge path which is connected in parallel with the cell 3 is formed.

In the eighth period (8), the output signal VD22 becomes in H level, since the cell voltage of the cell 2 becomes greater than the inverting level VREL22. Thus, the output signal CB2 becomes in H level, and the transistor M21 is turned on. Therefore, the discharge path which is connected in parallel with the cell 2 is formed.

Accordingly, it becomes possible to suppress

a further increase of the cell voltages of the cells 2 and 3 in the seventh and eighth periods (7) and (8) by forming the discharge paths that are connected in parallel with the cells 2 and 3. Thus, it becomes possible to control and suppress overcharge of the cells 2 and 3.

Herein, in the sixth period (6), similar operations, for controlling and suppressing the overcharge, that are performed with regard to the cells 2 and 3 are performed with regard to the cells 4 and 5.

In the ninth period, the output signal VD21 becomes in L level, since the cell voltage of the cell 1 becomes greater than the inverting level VREL21.

At this stage, since all of the cell voltages of the cells 1~5 are greater than the inverting levels VREL21, VREL22, VREL23, VREL24 and VREL25, the output of the NOR circuit NOR6 becomes in High level (VDET2B=H).

Since the output of the NOR circuit NOR6 becomes in High level (VDET2B=H), the respective output signals CB2, CB3, CB4 and CB5 of the NOR circuits NOR2, NOR3, NOR4 and NOR5 become in L level. Thus, the transistors M21, M31, M41 and M51 are turned off, and then the discharge paths that are connected

in parallel with the cells 2~5, respectively, are shut off.

According to the present embodiment, when the over discharge of at least one of the cells is
5 detected, the rest of the cell(s) of which the cell voltage(s) is greater than or equal to the return voltage is discharged by corresponding transistor(s) among M11, M21, M31, M41 and M51.

When at least one of the cells is being
10 charged from the over discharge state, all of the cell voltages of the cells are balanced at around the return voltage. Then all of the cells are begun to be fully charged. Thus, it becomes possible to suppress the variability of the cell voltages on a full charge.

15 As shown in Figs. 1 and 2, the secondary cell protection circuit 100 protects plural secondary cells 1~5 connected in series. The secondary cell protection circuit 100 includes the plural switching parts (the transistors M11, M21, M31, M41, M51) and
20 the charge controller (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6). The plural switching parts (the transistors M11, M21, M31, M41, M51) are connected in parallel with the secondary cells (cells 1~5) respectively. The charge controller (the
25 comparators COMP1~COMP5 and the NOR circuits

NOR1~NOR6) turns on the switching part connected to the secondary cell of which cell voltage is greater than or equal to the return voltage. The charge controller turns off the switching part when all cell
5 voltages of the secondary cells become greater than or equal to the return voltage, when the secondary cells are being charged.

The secondary cell protection circuit 200 includes the plural switching parts (the transistors
10 M11, M21, M31, M41, M51), the plural over discharge detecting parts (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6), the over discharge detection signal outputting part (the NOR circuit NOR6), the detection level shifting part (the resistors R12~R14,
15 R22~R24, R32~R34, R42~R44 and R52~R54 and the transistors M12, M22, M32, M42 and M52), the discharge controller (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6) and the charge controller (the comparators COMP1~COMP5 and the NOR circuits
20 NOR1~NOR6). The plural switching parts (the transistors M11, M21, M31, M41, M51) are connected in parallel with the secondary cells (cells 1~5) respectively. The plural over discharge detecting parts (the comparators COMP1~COMP5 and the NOR
25 circuits NOR1~NOR6) detect the over discharge state of

the secondary cells respectively. The over discharge detection signal outputting part (the NOR circuit NOR6) outputs the over discharge detection signal when any of the plural over discharge detecting parts

5 detect the over discharge state. The detection level shifting part (the resistors R12~R14, R22~R24, R32~R34, R42~R44 and R52~R54 and the transistors M12, M22, M32, M42 and M52) shifts detection voltages of the over discharge detecting part which does not detect the

10 over discharge state to the return voltage when the over discharge detection signal outputting part outputs the over discharge detection signal. The discharge controller (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6) forms the discharge path

15 by turning on the switching part in order to discharge the secondary cell, which is not in the over discharge state, via the discharge path when the over discharge detection signal outputting part outputs the over discharge detection signal. The charge controller

20 (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6) turns on the switching part connected to the secondary cell of which cell voltage is greater than or equal to the return voltage, and to turn off the switching part when all cell voltages of the

25 secondary cells become greater than or equal to the

return voltage, when the secondary cells are being charged. The over discharge detecting parts (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6) respectively detect the over discharge
5 state when the cell voltage becomes less than the detection voltage, and the return voltage is greater than or equal to the detection voltage. When any of the over discharge detecting parts (the comparators COMP1~COMP5 and the NOR circuits NOR1~NOR6) detect the
10 over discharge state of the cell by detecting that the cell voltage becomes less than or equal to the detection voltage which is shifted to the return voltage by the detection level shifting part, the discharge controller shuts off the discharge path by
15 turning off the switching part corresponding to the cell of which the over discharge state is detected by the over discharge detecting part.

According to the present embodiment, the secondary cell protection circuit 100 controls and
20 links a discharge monitoring part which monitors discharge state of each cell, a charge monitoring part which monitors charging state of each cell and a switching part which controls discharge path. Thus, it becomes possible to keep the cell balance of plural
25 cells based on at least one of the cell voltage.

For example, when the secondary cell protection circuit 100 charges the cells in a condition where at least one of the cells is in the over discharge state, the secondary cell protection circuit 100 balances all of the cell voltages of the cells at around the return voltage before fully charging all of the cells. Thus, it becomes possible to suppress the variability of cell voltages on a full charge. When the over discharge state of one of the cells is detected and the discharge path(s) are formed with regard to the rest of the cell(s), the secondary cell protection circuit 100 shifts the inverting levels from VDET to VREL. Thus, it becomes possible to shorten the amount of time necessary for fully charging the cells, while keeping the cell balance. Particularly, it becomes possible to shorten the amount of time necessary for fully charging the cells that are not in the over discharge state.

The present invention is not limited to the embodiments as described above and as shown in Figs. 1 and 2. For example, the number of cell may be changed from five to three or four. The battery 200 may include at least two cells.

It becomes possible to provide the battery 200 which has enhanced charge performance by including

the secondary cell protection circuit 100 thereinto.

The present invention is not limited to the specifically disclosed embodiments, and variations and modifications may be made without departing from the
5 scope of the present invention.

The present application is based on Japanese priority application No. 2010-041385 filed on February 26, 2010 with the Japanese Patent Office, the entire contents of which are hereby incorporated herein by
10 reference.

Claims

5

Claim 1. A secondary cell protection circuit configured to protect plural secondary cells connected in series comprising:

plural switching parts configured to be
10 connected in parallel with the secondary cells respectively; and

a charge controller configured to turn on the switching part connected to the secondary cell of which cell voltage is greater than or equal to a
15 return voltage, and to turn off the switching part when all cell voltages of the secondary cells become greater than or equal to the return voltage, when the secondary cells are being charged.

20

Claim 2. The secondary cell protection circuit as claimed in claim 1, further comprising:

25 an over discharge detecting part configured

to detect an over discharge state of any of the
secondary cells; and

a discharge controller configured to form a
discharge path by turning on the switching part in
5 order to discharge the secondary cell, which is not in
the over discharge state, via the discharge path when
the over discharge detecting part detects the over
discharge state of any of the secondary cells;

wherein the over discharge detecting part
10 detects the over discharge state when the cell voltage
becomes less than a detection voltage, and the return
voltage is greater than or equal to the detection
voltage.

15

Claim 3. A secondary cell protection
circuit configured to protect plural secondary cells
20 connected in series comprising:

plural switching parts configured to be
connected in parallel with the secondary cells
respectively;

plural over discharge detecting parts
25 configured to detect an over discharge state of the

secondary cells respectively;

an over discharge detection signal
outputting part configured to output an over discharge
detection signal when any of the plural over discharge
5 detecting parts detect the over discharge state;

a discharge controller configured to form a
discharge path by turning on the switching part in
order to discharge the secondary cell, which is not in
the over discharge state, via the discharge path when
10 the over discharge detection signal outputting part
outputs the over discharge detection signal;

a charge controller configured to turn on
the switching part connected to the secondary cell of
which cell voltage is greater than or equal to a
15 return voltage, and to turn off the switching part
when all cell voltages of the secondary cells become
greater than or equal to the return voltage, when the
secondary cells are being charged;

wherein the over discharge detecting parts
20 respectively detect the over discharge state when the
cell voltage becomes less than a detection voltage,
and the return voltage is greater than or equal to the
detection voltage.

Claim 4. The secondary cell protection circuit as claimed in claim 3, further comprising:

5 a detection level shifting part configured to shift detection voltage of the over discharge detecting part which does not detect the over discharge state to the return voltage when the over discharge detection signal outputting part outputs the
10 over discharge detection signal;

wherein, when any of the over discharge detecting parts detect the over discharge state of the cell by detecting that the cell voltage becomes less than or equal to the detection voltage which is
15 shifted to the return voltage by the detection level shifting part, the discharge controller shuts off the discharge path by turning off the switching part corresponding to the cell of which the over discharge state is detected by the over discharge detecting part.

20

Claim 5. A battery comprising:

25 a plurality of secondary cells; and

the secondary cell protection circuit as
claimed in claim 1.

5

Claim 6. A battery comprising:
a plurality of secondary cells; and
the secondary cell protection circuit as
10 claimed in claim 2.

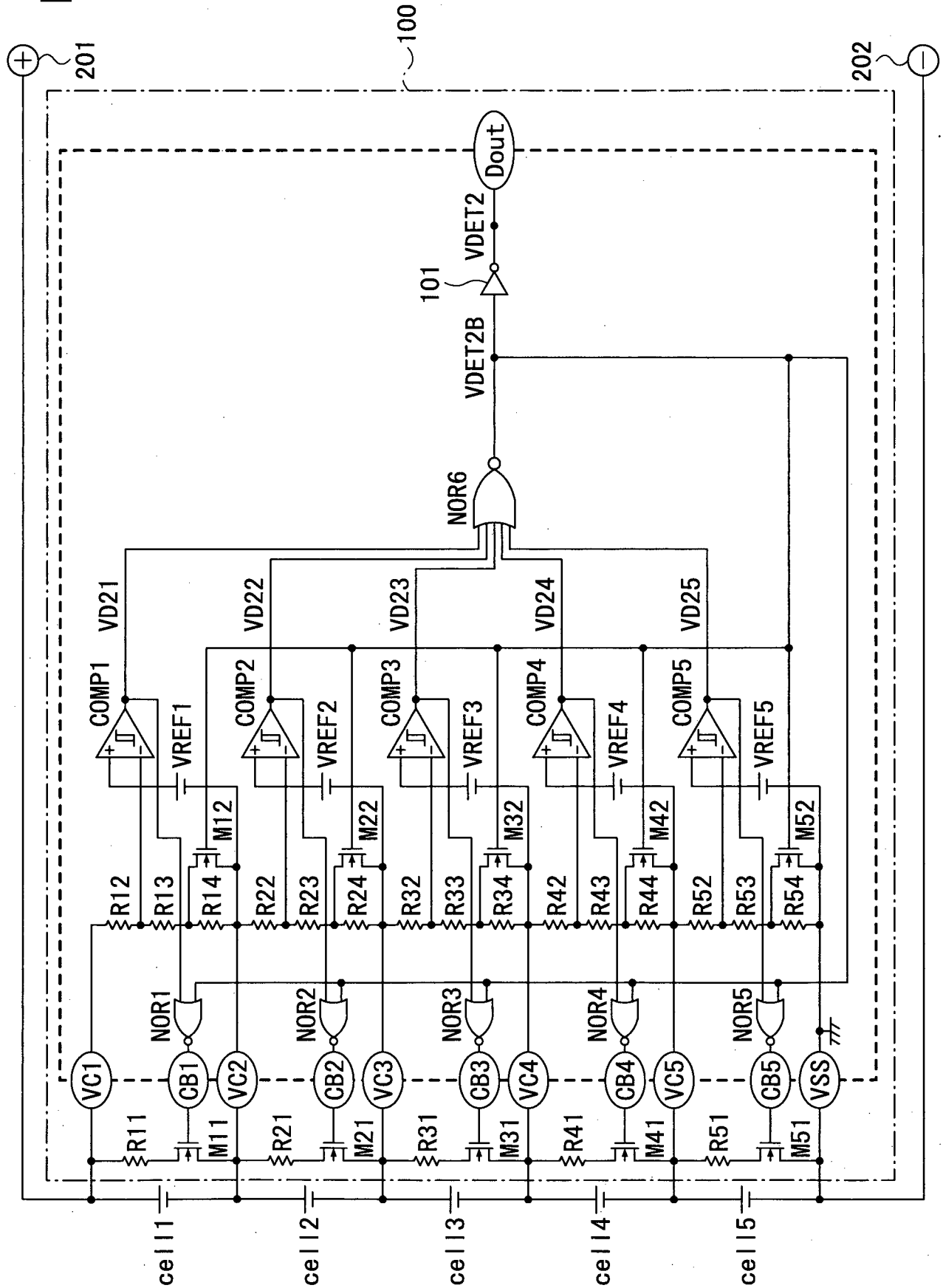
15 Claim 7. A battery comprising:
a plurality of secondary cells; and
the secondary cell protection circuit as
claimed in claim 3.

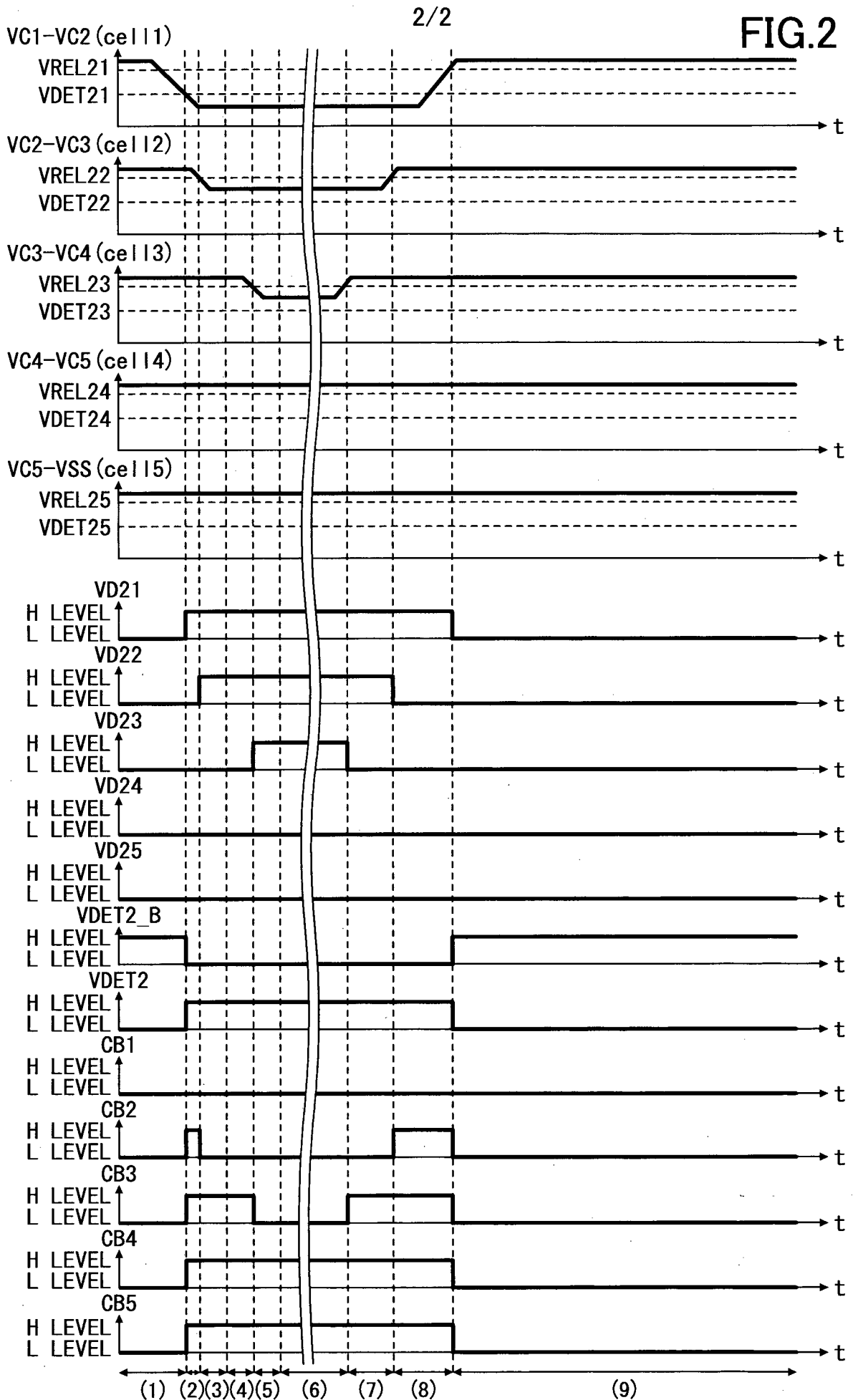
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Claim 8. A battery comprising:
a plurality of secondary cells; and
25 the secondary cell protection circuit as

claimed in claim 4.

FIG.1





INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/053602

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H02J7/02 (2006.01) i, H01M2/10 (2006.01) i, H01M10/42 (2006.01) i

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)

Int.Cl. H02J7/02, H01M2/10, H01M10/42

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2011
 Registered utility model specifications of Japan 1996-2011
 Published registered utility model applications of Japan 1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2009-131060 A (Honda Motor Co., Ltd.)	1, 5
Y	2009.06.11, claims 1, 2, [0019], [0023], [0028],	2, 3, 6, 7
A	[0029], Figs.1, 4 (No Family)	4, 8
Y	JP 5-049181 A (SONY CORPORATION) 1993.02.26,	2, 3, 6, 7
A	[0011]-[0024], Figs.1-5 & US 5547775 A & EP 525744	1, 4, 5, 8
	A1 & DE 69218848 D & DE 69218848 T	
A	JP 2001-268817 A (Hitachi, Ltd.) 2001.09.28,	1-8
	[0010], Figs.1, 4 (No Family)	
A	JP 2002-078218 A (Fujitsu Limited) 2002.03.15,	1-8
	[0003]-[0019], Fig.3 & US 2002/0024319 A1 & TW	
	513839 B	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

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“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/053602

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-154317 A (Matsushita Electric Industrial Co. Ltd) 2008.07.03, [0037]-[0071], Figs.1-3 & US 2010/0019725 A & WO 2008/072650 A1 & CN 101563827 A	1-8
A	JP 2006-338995 A (Nissan Motor Co., Ltd.) 2006.12.14, claim 2, [0017], [0026], Figs.1-3, 5 (No Family)	1-8