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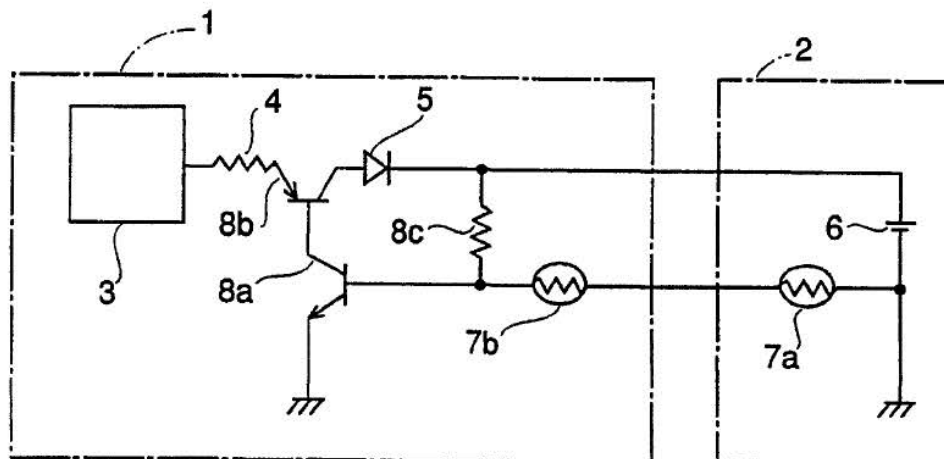
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(54) Battery charging apparatus

(57) The quasi-constant charging current provided by a constant voltage source 3 and a series resistor 4 is terminated in response to a temperature detector 7a within the battery 2. The temperature detector may be an NTC thermistor 7a which controls a transistor switching circuit 8a, 8b in the charger. Alternatively, the temperature detector may be a bimetal switch (7c, Fig. 5) carrying the charging current so that only a two-terminal connector is required between the charger and battery. The charging current may also be turned off in response to a high temperature in the charger as sensed by a further thermistor 7b or by a further bimetal switch (7d, Fig. 5). The system may be used for both nickel cadmium and nickel hydride batteries, eg. for charging the battery of a portable telephone from the cigarette lighter socket of an automobile.

Fig.3



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Fig.1

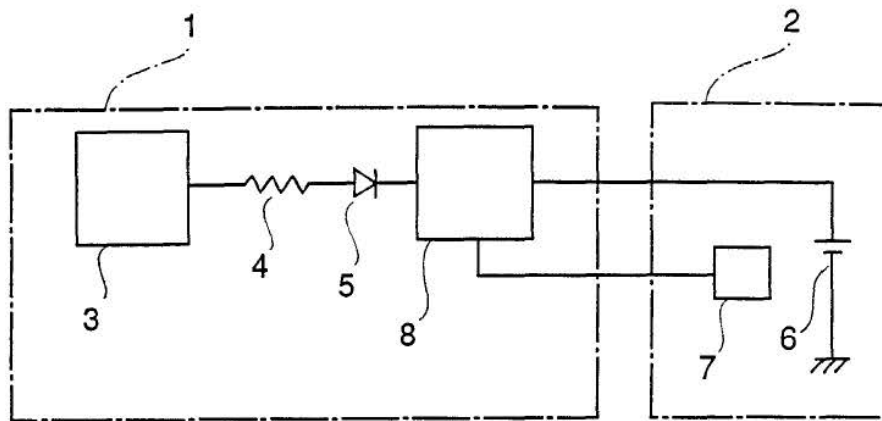


Fig.2

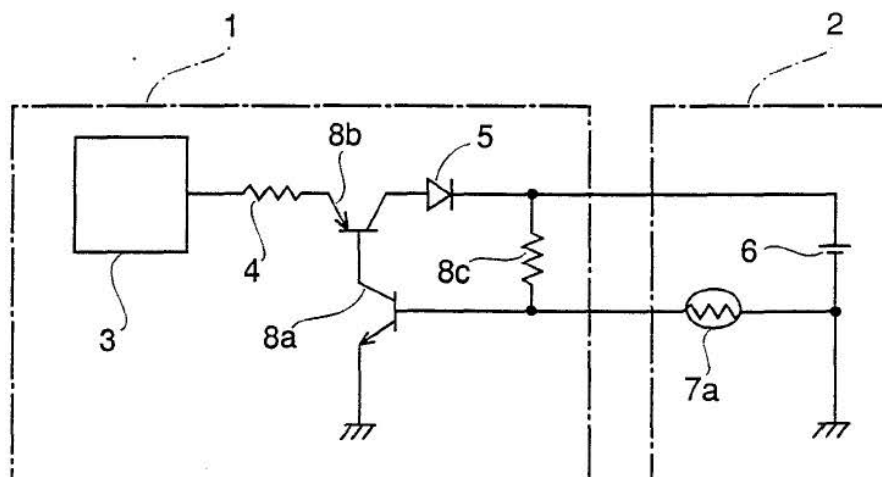


Fig.3

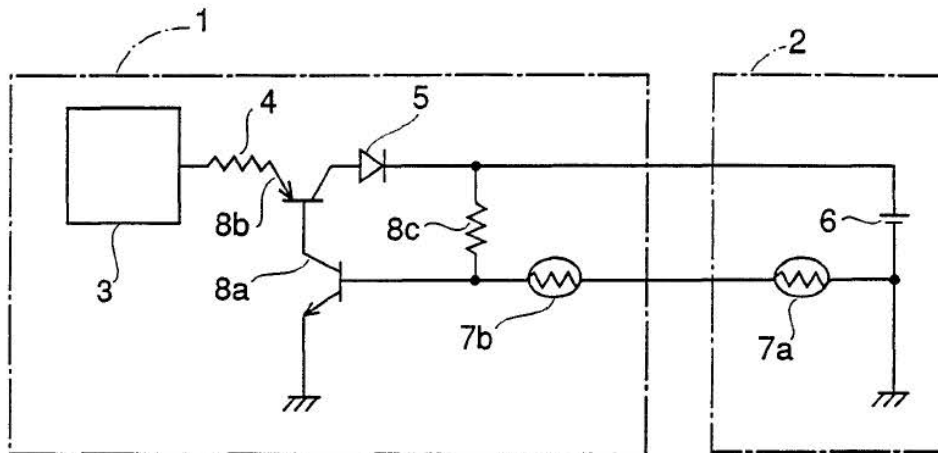


Fig.4

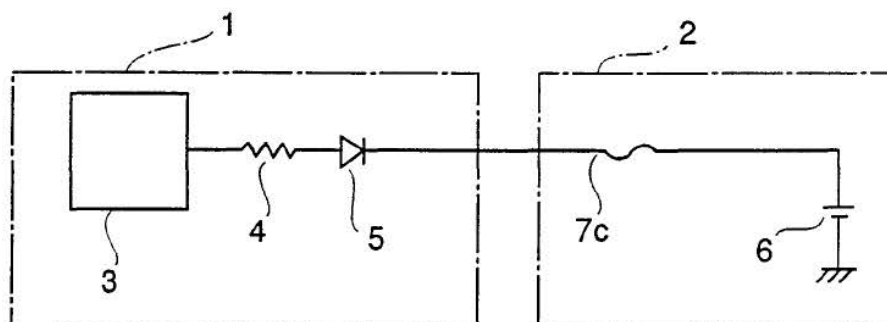


Fig.5

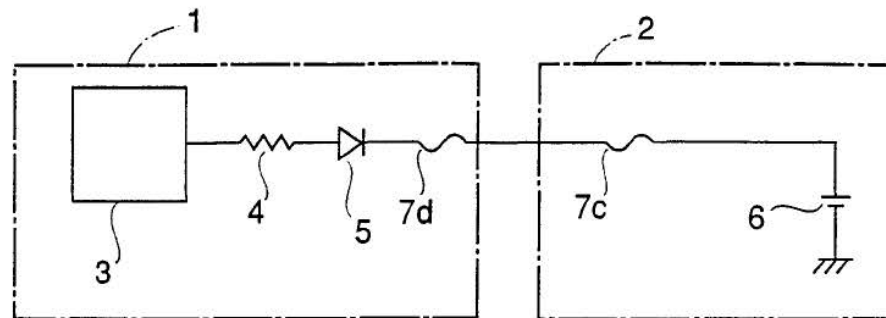


Fig.6 (Prior Art)

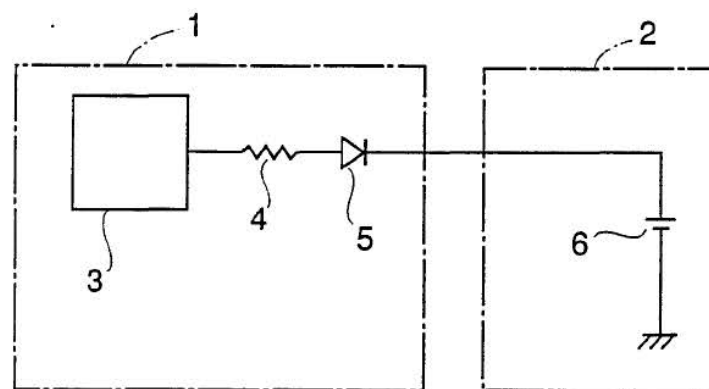
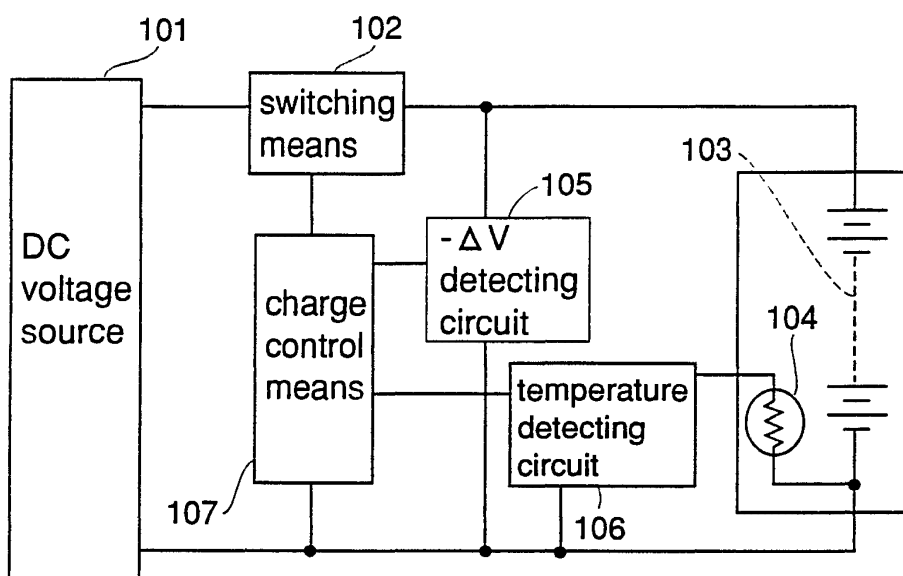


Fig.7 (Prior Art)



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CHARGING APPARATUS

FIELD OF THE INVENTION

The present invention relates to a charging apparatus and, more particularly, to an improvement in a quasi-constant current charging system used mainly in such as a miniature portable apparatus.

BACKGROUND OF THE INVENTION

Figure 6 is a circuit diagram of a prior art quasi-constant current charging apparatus used in such as a portable telephone. In the figure, reference numeral 1 designates a charger for charging a secondary battery 6, and this charger includes a constant voltage source 3 outputting a constant voltage signal, a resistor 4, and a diode 5. In this charger, reference numeral 3 designates a constant voltage source, numeral 4 designates a resistor, and numeral 5 designates a diode. The anode of the diode 5 is connected to the other end of the resistor 4 and the output of the charger 1 is output from the cathode of the diode 5. Reference numeral 2 designates a battery cell including the secondary battery 6.

A description is given of the operation. A direct current voltage from an external power supply such as a cigarette lighter of an automobile is converted to a dc voltage of a predetermined value by the constant voltage source 3 to generate a voltage of a predetermined value.

This constant voltage is applied to the resistor 4 for making the charging circuit of a high impedance and the diode 5 for preventing discharging, whereby a quasi-constant current which is an approximately a constant current is supplied to the secondary battery 6 included in the battery cell 2. Thus, it is possible to charge the secondary battery by this quasi-constant current.

The prior art constant current charging apparatus has such a construction, and it is possible to charge the secondary battery by quite a simple construction. However, because it does not include a charging control apparatus, it is likely to occur overcharging.

This overcharging results in dissolving the electrolyte of the battery and shortens the lifetime of the battery and also the battery is heated to a high temperature, resulting a danger in use.

With an increase in the utilization range of a portable apparatus such as a portable telephone, a demand for a secondary battery such as a nickel-cadmium battery is rapidly increases, and also a nickel hydride battery attracts attention as one offering a secondary battery having a further high capacity. It has also a merit of having a compatibility with the nickel cadmium due to having a battery voltage of about 1.2 V that is the same as that of the nickel cadmium battery.

In this way, since the nickel hydride battery present almost similar characteristic as that of the nickel cadmium battery, it is possible to carry out charging by the same control method as that for the nickel cadmium battery under normal temperature. However, when the charging is carried out under a high temperature ambient above of 40 °C, while there arises only a temperature rise of about 15 - 20 °C in the nickel cadmium battery, there arises a temperature rise of 35 - 45 °C in the nickel hydride battery. Accordingly, in the case of nickel hydride battery, the lifetime characteristics under an ambient of 40 °C is extraordinarily inferior to that of the nickel cadmium battery, and unexpected temperature rise of the battery occurs, unfavorably affecting the lifetime characteristic and the safe use.

Japanese Published Patent Application Hei. 4-138029 discloses a charging apparatus which can prevent such abnormal heating during charging under a high temperature ambient of the nickel hydride battery in its figure 1. Figure 7 in this application shows this figure 1 of the published application.

In figure 7, reference numeral 101 designates a dc voltage source supplying a power for charging the nickel hydride battery. Numeral 102 designates a switching means for cutting or supplying the charging current. This

switching means 102 is controlled by the charging control means 107 which receives a signal from the $-\Delta V$ detecting circuit 105 for detecting the reduced voltage of the battery 103 during the charging and a signal from a temperature detecting circuit 106 for detecting the temperature of the battery 103 from the resistance of the thermistor 104, and it is controlled to be switched by an output signal from the charging control means 107. The charging control means 107 controls the switching means 102 in accordance with the output of the $-\Delta V$ detecting circuit 105 when the temperature of the battery is lower than the set temperature value and controls the same in accordance with the output signal of the temperature detecting circuit 106 which is a signal finalizing the charging, thereby controlling the switching means 102 from on to off.

In the charging apparatus of such a construction, by setting the set temperature of the charging apparatus within $50 \sim 70^{\circ}\text{C}$ and controlling the charging current, it is possible to prevent the abnormal heating of the battery during charging under high temperature ambient as well as maintaining the lifetime characteristics of the battery in good state. In addition, this charging apparatus can perform charging of the nickel cadmium battery.

However, in the apparatus of figure 7, in order to detect the over-charging of the secondary battery, it is

necessary to provide a $-\Delta V$ detecting circuit for detecting reduction in the voltage of the secondary battery during charging after it once rises accompanying the advance of the charging. This $-\Delta V$ detecting circuit is a large sized one which judges the voltage which is converted into a digital value by an A/D conversion circuit by such as a microcomputer, and further a temperature detecting circuit for detecting the temperature rise of the secondary battery for securing a fail safe of the operation of the $-\Delta V$ detecting circuit, thereby resulting in an increased circuit size. Therefore, it is difficult to include a charging function in the apparatus itself including the secondary battery.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a charging apparatus that can charge both of the nickel cadmium battery having a small temperature rise during charging and the nickel hydride battery having a large temperature rise during charging as well as can prevent of overcharging by a simple circuit construction and can easily include a simple charging function, i.e., a function of charging the battery while using an apparatus which is driven by a battery, with driving the same by an external power supply.

Other objects and advantages of the present invention

will become apparent from the detailed description given hereinafter; it should be understood, however, that the detailed description and specific embodiment are given by way of illustration only, since various change and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

According to a charging apparatus of the present invention, a temperature detecting element detecting the temperature of a secondary battery is included in a battery cell, a charging stopping switching element is included in the charger performing charging of a secondary battery by a quasi-constant current charging system. When the temperature detecting element detects the temperature rise of the secondary battery, the charging of the charging circuit is stopped. Therefore, a proper charging is performed preventing overcharging and ordinary lifetime characteristics of a secondary battery is obtained as well.

According to a second aspect of the present invention, the charger also includes a second temperature detecting element for detecting the temperature of the charger, and the charging stopping switching element also stops the charging by the charging circuit when the temperature rise of the charger is detected. Therefore, the stability of the charging operation even during when the charger is at high

temperature is secured.

According to a third aspect of the present invention, a bimetal is employed as the temperature detecting element. Therefore, the detection of temperature is performed at a low cost and the connection between the battery cell and the charger is realized by a two-terminal connector.

According to a fourth aspect of the present invention, a nickel hydride battery is employed as the secondary battery. Therefore, the charging of the nickel hydride battery occurring a significant temperature rise during charging, while having a large capacity relative to a nickel cadmium battery can be realized by a simple circuit and safely.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a circuit diagram illustrating a quasi-constant current charging system provided with a temperature detecting controlling function according to an embodiment of the present invention.

Figure 2 is a circuit diagram illustrating a concrete quasi-constant current charging system provided with a temperature detecting controlling function according to an embodiment of the present invention.

Figure 3 is a circuit diagram illustrating a more concrete construction of a quasi-constant current charging system provided with a temperature detecting controlling

function according to a second embodiment of the present invention.

Figure 4 is a circuit diagram illustrating a more concrete construction of a quasi-constant current charging system provided with a temperature detecting controlling function according to a third embodiment of the present invention.

Figure 5 is a circuit diagram illustrating a more concrete construction of a quasi-constant current charging system provided with a temperature detecting controlling function according to a fourth embodiment of the present invention.

Figure 6 is a circuit diagram illustrating a prior art quasi-constant current charging apparatus.

Figure 7 is a diagram illustrating a prior art charging apparatus disclosed in Japanese Published Patent Application Hei. 4-138029.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description is given of an embodiment of the present invention. Figure 1 is a diagram illustrating a construction of a charging apparatus according to a first embodiment of the present invention. In the figure, reference numeral 1 designates a charger for charging a secondary battery 6. This charger 1 includes a constant voltage source 3, a resistor 4, a diode 5, and a charging

stopping switching element 8. In this charger 1, reference numeral 3 designates a constant voltage source generating a constant voltage, for example, converting a voltage taken out from a cigarette lighter to a dc voltage of $8.5\text{ V} \pm 10\%$, to output the same. Numeral 4 designates a resistor having an end connected to the output of the constant voltage source 3 and having, for example, a resistance of $44\ \Omega$. Reference numeral 5 designates a diode having an anode connected to the other end of the resistor 4. This diode 5 constitutes a charging circuit with the constant voltage source 3 and the resistor 4. Reference numeral 8 designates a switching element for stopping charging, having an input connected to the cathode of the diode 5, having a control input connected to the output of the temperature detecting element 7, and having an output from which the output of the charger 1 is taken out. Reference numeral 2 designates a battery cell including a secondary battery 6 and a temperature detecting element 7 for detecting the temperature of the secondary battery 6. The charger 1 and the battery cell 2 are connected with each other employing a three-terminal connector and these are both included in the apparatus using the secondary battery.

Figure 2 is a diagram illustrating a construction of the circuit of the embodiment of figure 1 more concretely. In the figure, reference numeral 7a designates a thermistor

as an element for detecting the temperature of the secondary battery 6. This thermistor 7a has a resistance value of $10\text{ k}\Omega \pm 1\%$ at $25\text{ }^{\circ}\text{C}$, a B constant of $3370\text{ K} \pm 1\%$ at $25 \sim 50\text{ }^{\circ}\text{C}$, and a B constant of 3491 K at $25 \sim 85\text{ }^{\circ}\text{C}$, and also has an end connected to the cathode side of the second battery 6. Here, the B constant is generally called as a thermistor constant and is defined by $\Delta E/2k$. The ΔE is an activation energy of semiconductor constituting a thermistor and k is a Boltzmann constant. Reference numerals 8a, 8b, and 8c designate circuit elements constituting the switching element 8. Reference numeral 8b designates a PNP transistor having an emitter connected to the other end of the resistor 4 and a connector connected to the anode of the diode 5. Reference numeral 8a designates an NPN transistor having a collector connected to the gate of the PNP transistor 8b and a base connected to the other end of the thermistor 7a. Reference numeral 8c designates a resistor connected between the cathode of the diode 5 and the base of the transistor 8a, for example, having a resistance value of $12\text{ k}\Omega$.

A description is given of the operation. In the figure 2, when the energy stored in the secondary battery is dissipated and the voltage thereof is abnormally reduced, it is required to performing charging. Before starting charging, the transistor 8a is turned off because the voltage applied to the base of the transistor 8a that is

obtained by the resistor dividing by the resistor 8c and the thermistor 7a is low, and the transistor 8a is also turned off according thereto. When the charging is started, during the usual charging, the voltage of the secondary battery 6 is divided by the resistance dividing by the resistor 8c and the thermistor 7a, whereby the NPN transistor 8a is turned on. Then, a current flows from the emitter of the PNP transistor 8b to the ground through the NPN transistor 8a, and the PNP transistor 8b is turned on, whereby a path between the constant voltage source 3 and the secondary battery 6 is conducted and charging at a quasi constant voltage is performed.

However, when the temperature of the battery cell 2 rises or the environment temperature of the battery cell 2 exceeds a constant temperature of, for example, 60 °C, the resistance value of the thermistor 7a is lowered, the voltage applied to the base of the transistor 8a is reduced below the threshold value of the transistor 8a, whereby the PNP transistor 8b is turned off, halting the quasi-constant current charging of the secondary battery 6.

In this embodiment, a thermistor for detecting temperature is included in a secondary battery, the resistance value of the thermistor is lowered during rising of temperature, and the transistor for charging the secondary battery is turned off. Therefore, in the quasi-

constant current charging system, a charging stopping switch operating at a constant temperature is inserted in a charging circuit, whereby charging with performing temperature detecting control can be carried out. In addition, the charging is not performed also when the battery cell is at high temperature, whereby an improper charging is avoided. Also the overcharging and overheating are prevented, whereby deterioration in the characteristic such as reduction in lifetime of the secondary battery is prevented. Further, overcharging and heating of the secondary battery is prevented by a simple circuit without employing a ΔV detecting circuit including an A/D converter and a microcomputer and resulting in a large circuit size. Therefore, a simple charging function of charging a secondary battery simultaneously with using the secondary battery in an apparatus employing the secondary battery as a power source, such as a portable telephone and also connecting the apparatus to an external power source, can be easily provided in the apparatus.

In addition, this embodiment can be employed for charging not only a nickel hydride battery but also for charging a nickel cadmium battery. In this case, it is possible to a charging apparatus in which the temperature detecting element is intentionally broken down or a charging apparatus which originally includes no temperature detecting

element.

While in the first embodiment, a thermistor is included only in a battery cell, a thermistor may be included in the charger as shown in figure 3.

Figure 3 illustrates a charging apparatus according to a second embodiment of the present invention. In figure 2, reference numeral 7b designates a thermistor included inside the charger 1. An end of the thermistor 7b is connected to the connection node of the resistor 8c and the other end of the NPN transistor 8a, and the other end of the thermistor 7b is connected to the other end of the thermistor 7a included in the battery cell 2.

In this way, a thermistor 7a is also included in the charger 1, so that the quasi-constant current charging is halted even when the environment temperature of the charger 1 is high, thereby securing a safe charging.

Embodiment 3.

While in the first embodiment a thermistor 2a is included in the secondary battery as a temperature detecting element, a bimetal may be employed.

Figure 4 illustrates a charging apparatus according to a third embodiment of the present invention. In the figure, reference numeral 7c designates a bimetal connected in series to the secondary battery inside the battery cell 2.

As shown in figure 4, the bimetal 7c is employed as the

temperature detecting element so that the detection of the temperature rise and the control of charging of the secondary battery can be performed at low cost.

While in the first embodiment and the second embodiment, the charger and the battery cell are connected by employing a three-terminal connector, in this third embodiment employing the bimetal the charger and the battery cell can be connected by employing a two-metal connector so that the apparatus can be constituted at low cost.

Embodiment 4.

While in the third embodiment the bimetal 7c is included in the secondary battery as a temperature detecting element, a bimetal may be employed also in the charger.

Figure 5 illustrates a fourth embodiment of the present invention. In figure 5, reference numeral 7d designates a bimetal included in the charger 1. One end of the bimetal 7d is connected to a cathode of the diode 5 and the other end of the bimetal 7d is connected to the other end of the bimetal 7c included in the battery cell 2.

In this way, the bimetal 7d is provided also in the charger 1, whereby even when the environment temperature of the charger 1 is high, the quasi-constant current charging can be stopped.

While in the first embodiment and the second embodiment, it is required to connect the charger and the

battery cell with a three-terminal connector, the charger and the battery cell can be connected with a two-terminal connector and the apparatus can be constituted at low cost.

As described above, according to a charging apparatus of the present invention, a temperature detecting element detecting the temperature of the secondary battery is included in the battery cell, so that when the temperature detecting element detects the temperature rise of the secondary battery by the charging stopping switching element, the charging stopping switching element included in the charger for charging the secondary battery employing the quasi-constant current charging system, functions to stop the charging by the charger. Therefore, overcharging and overheating can be prevented so that the charging employing the quasi-constant current charging system is carried out properly, and overcharging and overheating of the secondary battery can be prevented by a simple circuit.

According to a charging apparatus of the present invention, a second temperature detecting element for detecting the temperature of the charger is also included in the charger, so that also when this second temperature detecting element detects the temperature of the charger, the charging by the charging circuit is stopped, whereby the stability of the charging operation when the charger is at high temperature is secured.

According to a charging apparatus of the present invention, a bimetal is employed as a temperature detecting element and, therefore, the temperature can be detected at low cost, and the battery cell and the charger can be connected by employing a two-terminal connector, whereby the device can be constituted at low cost.

According to a charging apparatus of the present invention, a nickel hydride battery is employed as a secondary battery. Therefore, the nickel hydride battery, which has a large capacity and also a large temperature rise during charging relative to a nickel cadmium battery, and also having likelihood that the electrolysis of the battery is dissolved by overcharging and that the battery is thereby destroyed, can be charged in safety without inviting the destruction and the charging can be performed by a simple circuit as well.

CLAIMS:

1. A charging apparatus comprising:
a battery cell including a secondary battery and a temperature detecting element for detecting the temperature of said secondary battery; and
a charger including a charging circuit for charging said secondary battery in accordance with a quasi-constant current system and a charging stopping switching element for stopping the charging by the charger when said temperature detecting element detects the temperature rise of said secondary battery.
2. The charging apparatus of Claim 1, wherein:
said charger includes a second temperature detecting element for detecting the temperature of said charger; and
said charging stopping switching element stops the charging by said charging circuit when said second temperature detecting element detects the temperature rise of said charger.
3. The charging apparatus of Claim 1, wherein:
said temperature detecting element comprises a bimetal.
4. The charging apparatus of Claim 2, wherein:

said temperature detecting element comprises a
bimetal.

5. The charging apparatus of Claim 1, wherein:
said secondary battery comprises a nickel
hydride battery.

6. The charging apparatus of Claim 2, wherein
said secondary battery comprises a nickel hydride
battery.

7. The charging apparatus of Claim 3, wherein:
said secondary battery comprises a nickel hydride
battery.

8. The charging apparatus of Claim 4, wherein:
said secondary battery comprises a nickel hydride
battery.