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GB 2237696 A EP 0100753 A1 EP 0005841 A2
US 4727306 A US 3784892 A

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(54) **Battery charging circuit**

(57) The charging circuit can promptly detect a battery fault during quick charging of a secondary battery 1 from a constant current source 2, by sensing if the battery voltage rises to a reference level which is higher by a predetermined amount, eg. 15 to 25 per cent, and particularly 20 per cent, than the expected charge complete voltage. Quick charging is stopped by a microcomputer 4 in response to whichever occurs first of the conditions of this excess voltage state, a predetermined negative rate of change of voltage, a period of 15 minutes having elapsed since a certain peak voltage was detected, battery temperature exceeding a reference, and charging time exceeding a reference.

FIG.1

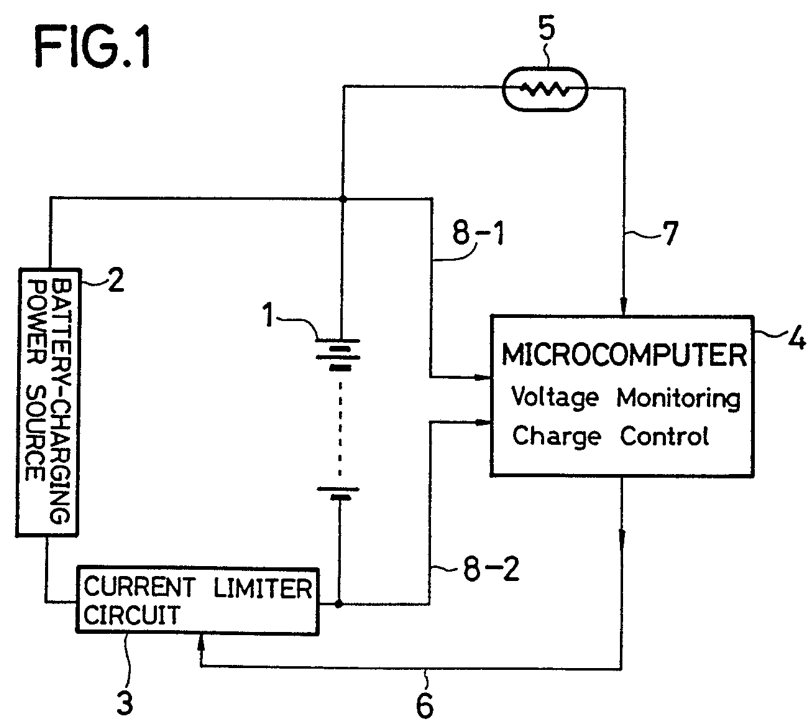

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FIG.1

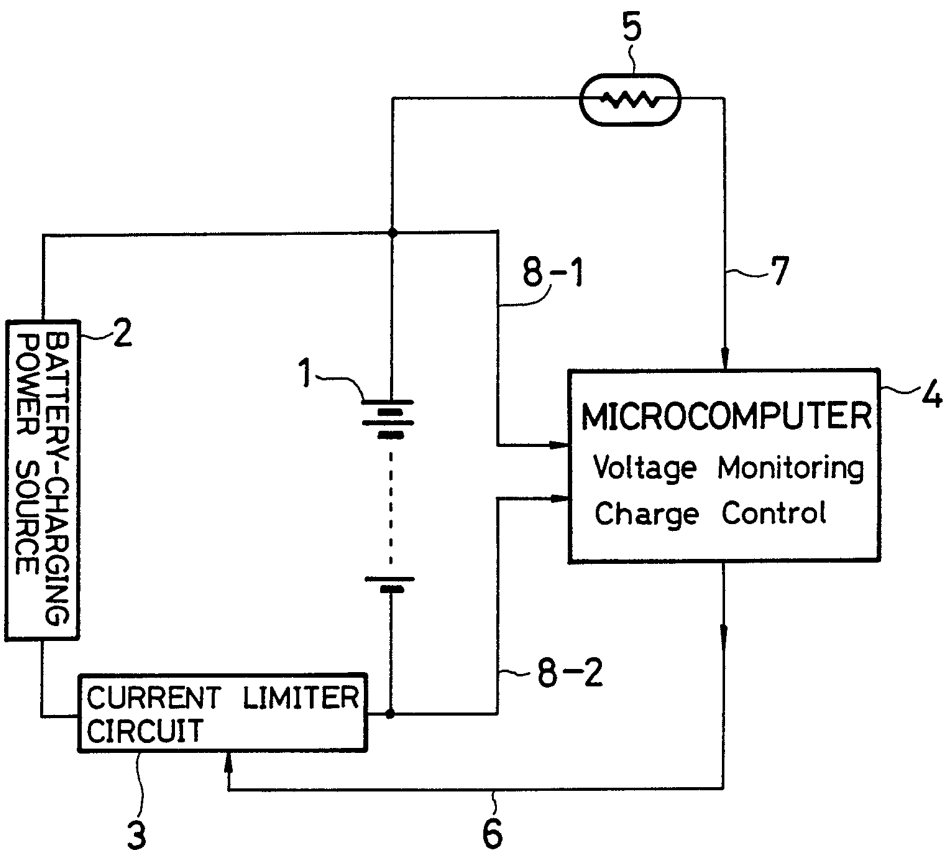
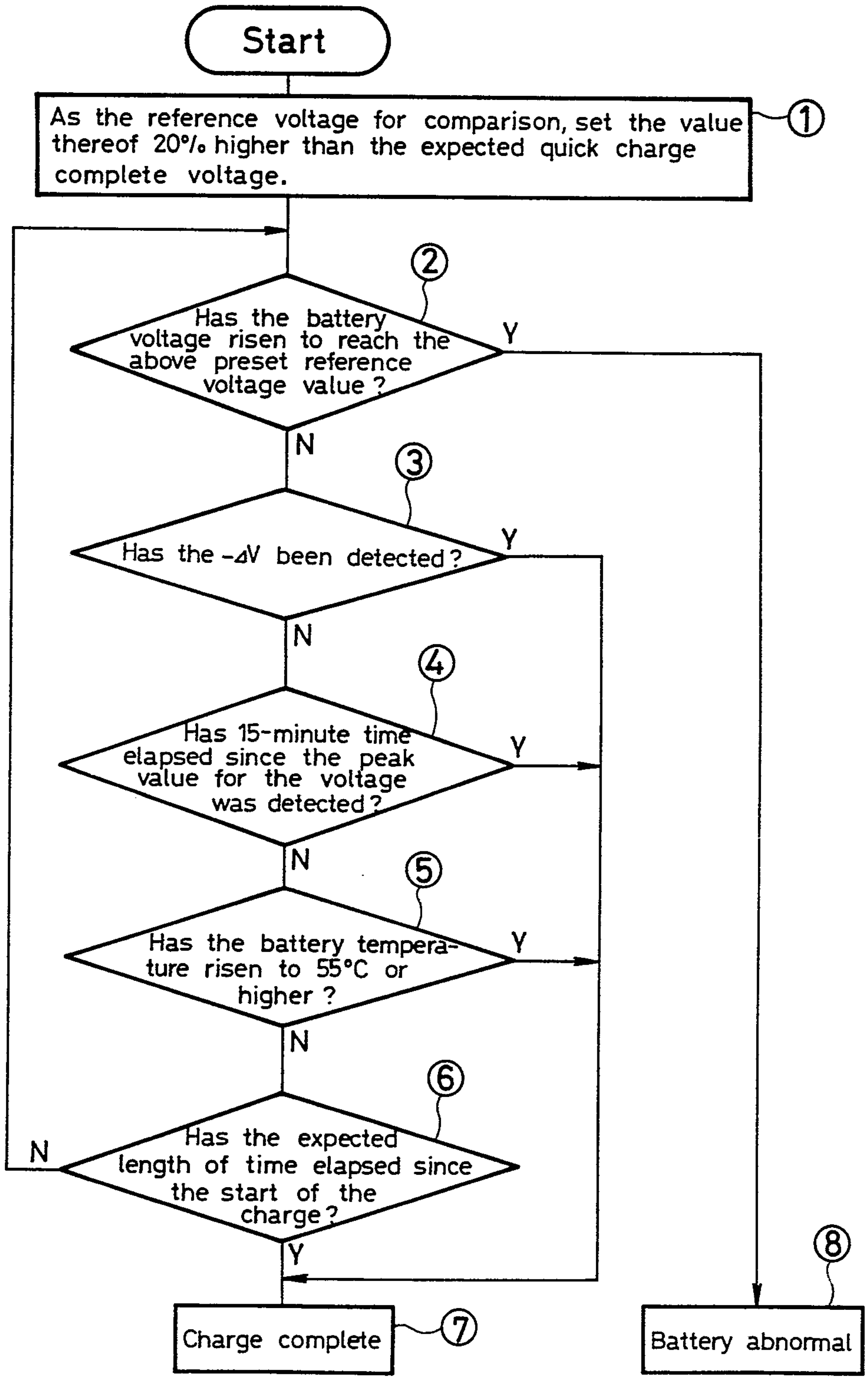

5
8-1
7
2
BATTERY-CHARGING POWER SOURCE
1
MICROCOMPUTER
Voltage Monitoring
Charge Control
4
8-2
CURRENT LIMITER CIRCUIT
3
6

FIG.2


Start
As the reference voltage for comparison, set the value thereof 20% higher than the expected quick charge complete voltage.
①
Has the battery voltage risen to reach the above preset reference voltage value ?
②
Y
N
Has the -ΔV been detected ?
③
Y
N
Has 15-minute time elapsed since the peak value for the voltage was detected ?
④
Y
N
Has the battery temperature risen to 55°C or higher ?
⑤
Y
N
Has the expected length of time elapsed since the start of the charge ?
⑥
N
Y
Charge complete
⑦
Battery abnormal
⑧

BATTERY CHARGING CIRCUIT

This invention relates to a battery charging circuit for use in the rapid and repeated charging of a secondary battery.

Various kinds of secondary batteries are used as power sources for industrial and/or household electrical machines and appliances. Their range of application has now expanded to cover a wider area of use wherein a single small-sized secondary battery consisting of only one cell such as a Ni-Cd battery in particular or an assembled battery pack comprising two or more such batteries connected in series to one another, is used as the power source for a cordless telephone, a video recorder or other household electrical application (e.g. as a back-up power source for use during temporary interruptions in the mains power supply). In any of such applications, the secondary battery has to be charged repeatedly whenever necessary during use. In general, the most widely used type of charge is a quick or rapid charge carried out with a charging current of 0.5 A or higher rate. In this case, it is general that the quick charge is so controlled as to avoid possible overcharge of the secondary battery and the charge control system such as a $-\Delta V$ (rate of change of voltage) control system, a temperature control system or the like is selected for the purpose of charge control. After completion of the quick charge, it is a general practice to switch the charge to a trickle charge.

There are often problems associated with batteries which have been repeatedly charged and discharged during use. The worst problem, is loss of electrolyte so that the electrodes become at least partially inactive by oxidation. This brings about an excessive decrease in the charge capacity, thus making the battery unsuitable for reuse. And even when the battery has become faulty as mentioned above, it is not possible to detect this from its external appearance. In practice, therefore, the fault in the battery passes unnoticed even to the user, and a fast charge is continuously given to the battery by the $-\Delta V$ control system or/and the temperature control system or the like, as if the battery was operating normally.

In addition, there is a danger that a faulty battery could give rise to unusual great heat generation during quick charging. Furthermore, when a plurality of batteries, in particular, for instance, an assembled battery, or a battery pack comprising a plurality of secondary batteries, connected in series to one another and packed together, is fast charged under a temperature control system, it is considered to have been fully charged when a sensor placed in or near the battery or battery pack detects a rise in temperature to a predetermined level. Thus, if the battery is faulty and hence develops excessive heat during fast charging, the temperature control circuit will switch off the charge before the battery is fully charged, and no indication will be given that the battery is faulty. Whereupon the battery pack will continue to be used, although it is no longer serviceable.

The present invention seeks to provide a battery charging circuit which is capable of promptly detecting the aforementioned fault in the secondary battery while rapid charging is taking place, thereby doing away with the above-mentioned disadvantage of the convention arrangement.

According to the present invention there is provided a battery charging circuit comprising:

a battery charging power source having constant-current characteristics;

a voltage measuring device for measuring the battery voltage at predetermined regular time intervals;

a voltage-setting device for presetting a reference voltage value at a level higher by a predetermined magnitude than an expected charge complete voltage;

a comparator device for comparison between the said reference voltage value and a battery voltage actually measured by the voltage-measuring device; and

a current limiter circuit designed to stop the charge when the secondary battery voltage has increased to the preset reference voltage value.

The quick charge of the secondary battery starts at a charging current of 0.5 A to 2 A supplied to the battery by the battery charging power source, which has a constant-current characteristic. The battery voltage measured by the voltage-measuring device at predetermined regular time intervals is taken as one of the two voltages for comparison by the comparator device. The preset reference voltage value is the other value used for comparison by the comparator device, and may be set at a level higher by a predetermined magnitude, for instance, about 20% higher than the voltage expected to be attained upon completion of a quick charge. Therefore, when the battery voltage, measured and detected during the quick charge, has reached the preset reference voltage value, the comparator device produces an output signal, whereby the current limiter circuit is actuated to stop the quick charge. As a result, the presence of a battery fault is indicated and the quick charge operation is discontinued.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a block diagram showing a battery-charging circuit;

Figure 2 is a flow chart showing operation of the micro-computer incorporated in the battery-charging circuit shown in Fig. 1.

Referring to the accompanying drawings, Fig. 1 is a block diagram showing the whole set up of the battery-charging circuit. In Fig. 1, a numeral 1 denotes a secondary battery to be charged by means of a quick charge operation, said secondary battery being, for example, a so-called battery pack, namely, an assembled battery comprising; for instance, ten single cell Ni-Cd battery units, each with a nominal voltage of 1.2 V, connected in series to one another and packed in a thermal-shrink type package. Numeral 2 denotes a battery-charging power source for the assembled battery 1, to which is connected a current limiter circuit 3 (e.g. a switch). The battery charging circuit further comprises a microcomputer 4, a thermistor 5, a quick charge stop signal line 6, a temperature detection line 7 and voltage detection lines 8-1 and 8-2. As discussed later in more detail, the microcomputer 4 is an apparatus capable of comprehensively dealing with measuring the voltage of the assembled battery 1 at predetermined regular time intervals, presetting the predetermined reference voltage value which may be, for example, 20% high than the secondary battery voltage expected to be attained upon completion of the charge, and comparing a secondary battery voltage actually measured and detected, with the reference voltage value preset at the predetermined value. In greater detail, the microcomputer 4 comprises a voltage-measuring device for measuring the secondary battery voltage at predetermined regular time intervals, a voltage-setting device for presetting the reference voltage value at a level exceeding by a predetermined magnitude the voltage expected to be attained upon completion of the charge, and a comparator device for comparison between a measured secondary battery voltage and a preset reference voltage value, and further performing monitoring of these voltages. Furthermore, as explained later in more detail, the microcomputer 4 is such that it permits on the one hand battery-charge control under which the quick charge is stopped through comparison of the detected battery voltage value with the preset reference voltage value and on the other hand a -ΔV control system or/and a temperature control system under which the charge is controlled. In addition, the microcomputer 4 receives input of temperatures of the assembled battery 1 through the voltage detection lines 8-1 and 8-2 and measures the said temperatures by means of the temperature detection line 7 equipped with the thermistor 5. The preset reference voltage value, which exceeds by a predetermined magnitude, (say, 20% higher than) the secondary battery voltage expected to be attained upon completion of the charge, may be set as described in the following:

When charging the assembled battery 1 comprising ten single cell Ni-Cd batteries units, connected in series to one another, the battery voltage expected to be attained upon completion of the charge is 15 V, namely, 1.5 V per cell. The reference voltage value for comparison, by which to determine if the above assembled battery has developed a fault, in this case is 18 V, i.e. 1.8 V per cell. The reference voltage value of 18 V is taken as one of the two voltage values for comparison by the comparator device.

A trickle battery-charging circuit (not shown) may be additionally included in the battery-charging circuit of the present invention, so that when the quick charge of the assembled battery 1 has been completed normally, the charging channel may be switched over by means of a control line (not shown) for a trickle charge of the battery.

When the microcomputer decides, through the voltage detection lines 8-1 and 8-2, that the secondary battery pack (being charged by means of a quick charge with a charging current of, for instance, 1 A) has been charged sufficiently, so that its voltage at both terminals thereof has risen to the above-mentioned preset voltage of 18 V, the microcomputer 4 cuts off the current limiter circuit 3 through the quick charge stop signal line 6, thereby carrying out the battery-charge control to stop the quick charge. As long as the battery pack which is undergoing a quick charge shows the battery voltage remaining normal or within the allowable range, the quick charge is allowed to go on under the charge control carried out by means of the -ΔV control system or the temperature control system until it has become fully charged. Indicator lamps may be used to indicate the battery temperature during the quick charge operation or the premature stoppage of the quick charge due to an excessive rise in battery voltage, thus making it easier to monitor the state of the charge and the condition of the battery. In this way, a battery fault is easily detected, if such is present, in which case the battery pack is deemed to be unserviceable and is preferably replaced with a new battery pack.

Fig. 2 is a flow charge showing the operation of the microcomputer 4. With reference to Fig. 2, in step [1], following the start of the battery-charge operation, the reference voltage value 20% higher than the expected quick charge complete voltage value of 15 V (namely 1.5 V per cell) of the assembled battery is set as one of the two voltages for the voltage comparison and then inputted into the microcomputer 4 as the preset reference voltage value. In step [2], the voltage of the assembled battery is compared at predetermined regular time intervals with the reference voltage value. When the voltage of the assembled battery has reached 18 V (or 1.8 V per cell), the microcomputer advances to step [8] and the battery is dealt with as abnormal. If the decision in step [2] is negative or no, the operation is advanced to step [3] where it is determined as to whether or not the quick-charge operation is proceeding. Whether or not the predetermined rate of change of voltage -ΔV has been detected is also determined in step [3]. If it has, then the battery pack is considered to be fully charged and the charging operation ceases. Otherwise operation is advanced to step [4]. In step [4], whether or not 15 minutes of time have elapsed from when the peak value of 15 V for the voltage at both terminals of the assembled battery was detected is determined. If it has, the battery is considered to be fully charged and the charging operation is stopped. If the 15 minutes has not elapsed the microcomputer advances to step [5]. In step [5] a determination is made as to whether the battery temperature has risen to exceed 55°C. If it has, then charging is stopped. Otherwise, the microcomputer advances to step [6] in which a determination is made as to whether or not more than the expected time length for completion of the quick charge has elapsed. As explained above if the decision is affirmative or yes in each of the steps [3] to [6], the operation is then advanced directly to step [7] to complete the charge. The battery may be switched over for a trickle charge if necessary. If the decision in step [6] is negative or no, it indicates that the quick charge is not complete, so that the microcomputer returns to step [2] to repeat the voltage comparison operation all over again.

Described in the foregoing is an embodiment in which the battery-charging circuit is used for the quick charge of an assembly of ten batteries, each comprising one cell. The battery-charging circuit may equally be applied to any of the following:

an assembly of two or more secondary batteries, each comprising a plurality of cells;

a secondary battery consisting of one cell; and

a secondary battery comprising two or more cells.

When the voltage across each type of battery listed above has reached the reference voltage value (so set as to exceed by a predetermined magnitude an expected quick charge complete voltage as described in the foregoing) an abnormality in the battery is detected and the quick charge operation is thereafter discontinued. Thus, overcharging the battery can be avoided, which would otherwise bring about the danger of an abnormal generation of heat.

In addition to Ni-Cd batteries, Ni-MH(nickel-hydrogen) batteries and various other types of secondary batteries can be charged likewise through the battery-charging circuit according to the present invention, so that battery faults, if present, can be detected at an early stage during the charge operation, as described in the foregoing. The preset reference voltage value, for detection of a battery fault, can vary with the type of secondary battery being used and is determined on the basis of the normal voltage range applicable to each particular battery type.

Constructed as described in the foregoing, the battery-charging circuit according to the present invention brings about the advantage that when the quick charge, using the above battery-charging circuit, is applied to a secondary battery which includes one or more abnormal cells having decreased electrolyte or inactive electrodes resulting in an increase in electrical resistance, the circuit can detect such abnormality thereof, since the battery voltage in such a case rises so much as to reach the reference voltage value (set to exceed by a predetermined magnitude the expected charge complete voltage), and stops the quick charge at that moment. In conventional battery charging devices, even when a secondary battery includes an abnormal cell, the abnormality passes unnoticed so that the battery is fully charged by the quick charge controlled by a $-\Delta V$ control system or/and the temperature control system alone, so that the faulty battery remains undetected and is continually reused. This problem is overcome by the above described embodiment of the present invention.

CLAIMS

1. A battery charging circuit comprising:

a battery charging power source having constant-current characteristics;

a voltage measuring device for measuring the battery voltage at predetermined regular time intervals;

a voltage-setting device for presetting a reference voltage value at a level higher by a predetermined magnitude than an expected charge complete voltage;

a comparator device for comparison between the said reference voltage value and a battery voltage actually measured by the voltage-measuring device; and

a current limiter circuit designed to stop the charge when the secondary battery voltage has increased to the preset reference voltage value.

2. A battery charging circuit as claimed in claim 1, in which the reference voltage is set at a value between 15 and 25% greater than the expected charge complete value.

3. A battery charging circuit, as claimed in claim 2, in which the reference voltage value is set at a value 20% greater than the expected charge complete value.

4. A battery charging circuit substantially as described herein, with reference to, and as shown in, the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

9124568.8

Relevant Technical fields

(i) UK Cl (Edition K) H2H HBCD

(ii) Int Cl (Edition 5) H02H 7/18;H02J 7/00,7/02, 7/04,7/06,7/08,7/10,7/12

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

M J BILLING

Date of Search

18 FEBRUARY 1992

Documents considered relevant following a search in respect of claims 1,2,3

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2237696 A (WU) eg see page 65 lines 11-20, page 68 lines 11-19	1 at least
X	EP 0100753 A1 (INDESIT) eg see Figure 9, page 9 line 12 - page 10 line 16	1,2 at least
X	EP 0005841 A2 (BLACK & DECKER) eg see page 20 line 7-14, page 33 line 37 page 34 line 13	1 at least
X	US 4727306 A (MOTOROLA) eg see column 4 lines 18-50	1,2,3 at least
X	US 3784892 A (GENERAL SYSTEMS) eg see column 5 lines 15-26	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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