EUROPEAN PATENT SPECIFICATION

A METHOD OF CHARGING A BATTERY
Ein Batterieladeverfahren
Procede permettant de charger une batterie

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References cited:
FR-A- 2 550 396
US-A- 4 136 311

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Description

The subject invention concerns a method of charging a rechargeable battery, according to the preamble of appended claim 1.

The invention also concerns a device for charging a rechargeable battery according to the preamble of appended claim 4.

The invention is intended to be used in connection with recharging of the starter battery of marine motors. The invention has particular application in sailing boats, since the motors used in sailing boats normally are run a mere 20-30 minutes at each instance of operation. In consequence thereof, the battery may not always be recharged to its full capacity.

The recharge of a starter battery normally is effected with the aid of an AC generator. One such prior-art generator is supplied with regulating voltage from a voltage regulator which in turn senses a reference voltage from the positive terminal of the battery. If the reference voltage is lower than a value corresponding to a certain nominal charging voltage, the regulator will affect the generator, bringing the latter to increase the charging voltage supplied to the battery. In a corresponding manner, the generator will reduce the charging voltage supplied to the battery when the reference voltage exceeds the nominal reference voltage. This arrangement ensures that recharging of the battery always is effected at a voltage value that is essentially constant and equal to the nominal charging voltage.

It is generally desired that the battery may be charged as quickly as possible in order that the battery be ready quickly to cope with new current drains. In principle, this possibility is conditioned on the nominal value of the voltage being set to a comparatively high level to ensure that the charging of the battery progresses at a high level of charging current for as long as possible. In reality, however, it is necessary to restrict the nominal voltage, on the one hand not to risk damages on the battery, and on the other to avoid gassing in the battery, which would involve safety hazards.

From FR 2 550 396 is previously known a device by means of which a battery may be charged rapidly at a voltage not exceeding the nominal voltage. This is achieved by introducing a certain voltage drop between the positive terminal of the battery and the regulator, whereby the regulator is "conned" into acting as if the reference voltage is lower than it actually is. In this manner the voltage delivered by the generator will amount to the nominal voltage increased by the introduced voltage drop. In order not to risk that the battery be damaged, this voltage drop is maintained over a predetermined, restricted period of time, say over 30 minutes, after which period the charging again equals the nominal charging voltage.

One disadvantage inherent in this method is that it impossible to establish whether or not the battery has succeeded in reaching the fully charged condition after the lapse of the selected period. In accordance with one embodiment of this prior-art device the voltage drop therefore may be introduced in response to the magnitude of the battery charging current, which is measured and is compared with a predetermined limit value. As long as the charging current does not exceed this limit value, the voltage drop will be applied, and the battery will be charged at a voltage that is higher than the nominal voltage. This version, too, suffers from a disadvantage inasmuch as the measurement of the current is effected by means of a Hall probe with resulting too complicated and too expensive a measuring procedure.

Furthermore, the patent document US 4 136 311 discloses an arrangement for charging a rechargeable battery which comprises a dual rate voltage regulator. This arrangement charges, on startup, at a sufficiently high level of voltage regulation to afford quick charging of the engine battery to a predetermined level and thereafter to continue charging at a power level of voltage regulation.

The subject invention has its purpose to enable rapid charging of a rechargeable battery by optimum use of the generator capacity over a predetermined limited period of time. This purpose is achieved by means of a method and a device of the kind defined in the introduction, the characterising features of which are defined in subsequent claims 1 and 4 respectively.

The invention provides a device of simple construction having only small number of components and therefore possible to produce at a low cost. The very measuring of the battery voltage is effected by means of an uncomplicated voltage measuring circuit. In addition, the device may be installed in a simple manner in existing regulating equipment in that it may easily be connected between the battery and the regulator. The subject invention makes use of the generator capacity in a more optimum degree and the charging of the battery may be effected to a fuller extent than has hitherto been possible.

The invention will be described in closer detail in the following with reference to the accompanying drawings, wherein

Fig. 1 is a circuit diagram relating to a device in accordance with the invention,

Fig. 2 is a diagrammatic representation of a charging process in accordance with the prior-art technique, and

Fig. 3 is a similar diagrammatic representation of a corresponding charging process when using the invention.

Fig. 1 illustrates schematically a device for performing the invention. A resistor 1 is connected to the positive terminal of the battery (not shown) via terminal B+. The opposite end of the resistor 1 is connected to a voltage divider formed by two additional resistors 2, 3. The voltage obtained at an outlet in the node point between the two resistors 2 and 3 is
applied to the positive input terminal of an operational amplifier 4 which is coupled as a comparator. A variable resistor 5 is connected between the positive terminal of the battery, indicated by B+ in the drawing figure, and the negative terminal of the battery, indicated by GND (ground). The variable central outlet of the resistor 5 is connected to the negative input terminal of the operational amplifier 4.

A capacitor 6 which is connected between the resistor 1 and earth is intended to eliminate the ripple effect, i.e. small voltage fluctuations. Two diodes 7, 8 which are coupled in parallel with the voltage divider 2, 3 serve to render the measuring of the battery voltage independent of temperature variations and to form a reference voltage that is supplied to the positive input terminal of the operational amplifier 4. One, 7, of the diodes has its anode connected to the positive terminal (B+) of the battery and its cathode is connected to the cathode of the second diode 8. The second diode 8, which is of zener type, has its anode connected to the negative terminal (GND) of the battery. The combination formed by diodes 7, 8 has a temperature compensating effect (diode 8 has a positive temperature coefficient whereas diode 7 has a negative temperature coefficient).

The base of a transistor 10 is connected to the output terminal of the operational amplifier 4 via a current-limiting resistor 11. A resistor, known as a pull-up resistor 12 is connected between the positive terminal (B+) of the battery and the output terminal of the operational amplifier 4 in order to supply current to the transistor 10. As long as the voltage value on the negative input terminal of the operational amplifier 4 is lower than the voltage value on the positive output terminal thereof, the output terminal of the operational amplifier 4 will be high, which means that the transistor 10 is turned on. In reality, this condition corresponds to the situation when the motor has just been started and the battery needs to be recharged as rapidly as possible.

A relay 13 which is connected in series with the transistor 10 and which is provided with a protective diode 16, is activated at this stage. This means that a contact 14 incorporated in the relay 13 is open. In consequence thereof a diode 15 which is coupled in parallel with the contact 14 and connected with its cathode to the voltage regulator (not shown) via a terminal R, is connected in the circuit between the battery and the voltage regulator. The voltage received by the regulator and now serving as the regulating voltage to allow the generator to recharge the battery, is at this stage equal to the battery voltage less the forward voltage drop existing across the diode 15. In other words, the regulator is "conned" into believing that the battery voltage is lower than it actually is.

As the battery is being recharged, the battery voltage will increase accordingly, and when the voltage has reached a certain upper limit value (which is determined by setting the variable resistor 5), the voltage on the negative input terminal of the operational amplifier 4 will be higher than the voltage on the positive input terminal thereof, which means that the output terminal of the operational amplifier 4 goes low and the transistor 10 is turned off. As a result, the relay 13 is deactivated, corresponding to closing of the contact 14. In turn, this means that the diode 15 is short-circuited. From the moment when the battery voltage has reached its upper limit value the voltage regulator thus will sense the "true" battery voltage.

When the battery voltage has again sunk to a level below a predetermined lower limit value, the voltage on the negative input terminal of the operational amplifier will again be lower than the voltage on its positive input terminal. The lower limit value is determined by the setting of a variable resistor 9 which is connected between the output terminal of the operational amplifier 4 and the positive input thereof. This creates a hysteresis effect. In conformity with the above description, the diode 15 will again be connected in the circuit and the charging of the battery is restarted. This lower limit value normally is selected so as to correspond to the situation when the motor has been turned off.

During the charging, the regulator thus senses a battery voltage that is lower than the actual voltage level, and consequently the battery charging will continue at the maximum charging current level from the generator during a longer period of time than it otherwise would have done, i.e. had said voltage drop not been introduced. The upper limit value of the battery voltage is chosen to a higher level than the nominal charging voltage level but still it is limited so as to ensure that the battery is not damaged or that dangerous gassing occurs.

The circuit also comprises a light-emitting diode 17 with an associated current-restricting resistor 18 which is coupled across the coil of the relay 13. The light-emitting diode 17 indicates that the transistor is turned on, i.e. that the diode 15 is connected in the circuit.

Fig. 2 illustrates in a diagramme the sequence of charging a battery in accordance with prior-art technique, i.e. where no device in accordance with the invention has been used. The Y-axis of the diagramme indicates the battery voltage \( U \) and the battery current \( I \), i.e. the current delivered by the generator to the battery. The X-axis denotes the time \( t \). The battery voltage \( U \) is indicated in the diagramme by a continuous line whereas the battery current \( I \) is indicated by a dash-and-dot line. The level of the nominal voltage \( U_{\text{nom}} \) is indicated by a broken line.

When the battery charging starts, at time \( t_1 \), the battery current will assume a high level with the result that a considerable charge will be delivered to the battery. The battery voltage \( U \), originally at a comparatively low level, will increase until, at a certain time \( t_2 \), it reaches the value of the nominal voltage \( U_{\text{nom}} \) whereupon the regulator will signal to the generator to deliver a lower battery voltage, resulting in a reduction of current \( I \). The
battery voltage is thereafter maintained at a level essentially agreeing with the nominal voltage. In a conventional battery of 12 V, the nominal voltage preferably is chosen to approximately 14.0 - 14.2 V, at a temperature of 20-25°C.

Fig. 3 illustrates a sequence of charging a battery when the device in accordance with the invention has been used. The battery voltage U, i.e. the voltage existing between switches B+ and GND (see Fig. 1), is comparatively low in the initial stage, and for this reason a voltage drop will be introduced in accordance with the description above. In a conventional battery of 12 V, having a nominal voltage of 14.0 V, and with the introduction of a voltage drop across the diode 15 of for instance 0.6 V, the regulator thus will bring the generator to deliver maximum level battery current to the battery until the "true" battery voltage U has risen to 14.6 V. This is indicated in the diagramme by time t₂. "True" battery voltage U of 14.6 V then corresponds to a voltage level of 14.0 V received by the regulator.

Practical tests have shown that in conventional charging (according to Fig. 2) the time t₂ occurs approximately 24 minutes after time t₁. In charging in accordance with the invention (according to Fig. 3) time t₂ occurs about 34 minutes after time t₁. This corresponds to an increase of the charge, i.e. the number of ampere hours delivered to the battery, of about 9% when the invention is used, compared to the situation when conventional techniques are used.

Claims

1. A method of charging a rechargeable battery, the charging being effected by means of a generator which is operated for charging said battery by means of a motor and being supplied with regulating voltage from a voltage regulator receiving a value indicative of the battery voltage in order to regulate the generator in response to said voltage in relation to a predetermined nominal charging voltage and according to which a voltage drop may be introduced between the battery and the regulator in dependence of the operational condition of the battery, said voltage drop reducing the value of the battery voltage received by the regulator, and being introduced between the positive terminal (B+) of the battery and an input terminal (R) of the regulator which receives regulating voltage, by connection of a diode (15) which is forward biased, characterised in that the voltage drop is introduced in dependence of a detected value of the battery voltage, that said diode (15) is short-circuited when the battery voltage has reached a first predetermined value, thereby removing said voltage drop, and that the connection and short-circuiting of the diode is effected by hysteresis, whereby said first predetermined value exceeds a second predetermined value, which corresponds to the value of the level at which the diode is connected, said second predetermined value corresponding to a situation in which said motor is turned off.

2. A method as claimed in claim 1, characterized in that the connection of the diode (15) is effected by opening an electronically controllable contact (14) which is connected in parallel with the diode (15).

3. A method as claimed in claim 2, characterized in that the contact (14) incorporated in a relay (13, 16) the function of which is controlled by a comparator (4) comparing the battery voltage with a reference voltage.

4. A device for charging a rechargeable battery, comprising a generator and a voltage regulator, the generator being operated for charging said battery by means of a motor and being supplied with regulating voltage from said voltage regulator, which in turn is adapted for receiving a value indicative of the battery voltage in order to regulate the generator in response to said voltage in relation to a predetermined nominal charging voltage, said device being adapted for introducing a voltage drop between the battery and the regulator in dependence of the operational condition of the battery, said voltage drop reducing the value of the battery voltage received by the regulator, said device comprising a diode (15) which is forward biased between the positive terminal (B+) of the battery and an input terminal (R) of the regulator which receives regulating voltage, and an electronically controllable contact (14) which is coupled in parallel with the diode (15), characterised in that it comprises a comparator (4) which is arranged to control the function of the contact (14) in response to a detected value of the battery voltage so that said diode (15) is short-circuited by means of said contact (14) when the battery voltage has reached a first predetermined value, whereby said voltage drop is removed, and that said comparator (4) is operated in a manner so that the connection and short-circuiting of the diode is effected by hysteresis, whereby said first predetermined value exceeds a second predetermined value, which corresponds to the value of the level at which the diode is connected, said second predetermined value corresponding to a situation in which said motor is turned off.

Patentansprüche

1. Verfahren zum Aufladen einer wiederaufladbaren Batterie, wobei das Aufladen mittels eines Generators erfolgt, der für das Aufladen der Batterie durch einen Motor betrieben wird, wobei der Generator
mit einer von einem Spannungsregulator ausgehenden Reguliererspannung versorgt wird, wobei der Spannungsregulator einen Wert empfängt, der die Batteriespannung zur Regulierung des Generators in Abhängigkeit von der Spannung in Bezug auf eine vorbestimmte nominale Ladungsspannung an gibt und dementsprechend ein Spannungsabfall zwischen der Batterie und dem Regulator in Abhängigkeit von dem Betriebzustand der Batterie her vorragbar ist, wobei der Spannungsabfall den Wert der von dem Regulator empfangenen Batteriespannung vermindert und zwischen einem positiven Anschluß (B+) der Batterie und einem Eingangsanschluß (R) des Regulators, welcher die regulierende Spannung empfängt, durch Verbindung einer Diode (15), die vorwärts gepolt ist, eingeführt wird, dadurch gekennzeichnet, daß der Spannungsabfall in Abhängigkeit von einem erfaßten Wert der Batteriespannung eingeführt bzw. hervorgerufen wird, daß die Diode (15) kurz geschlossen wird, wenn die Batteriespannung einen ersten vorbestimmten Wert erreicht hat, wodurch der Spannungsabfall entfernt wird, und das die Verbindung und der Kurzschluß der Diode durch Hysterese erfolgt, wobei der erste vorbestimmte Wert einen zweiten vorbestimmten Wert überschreitet, der dem Wert des jenigen Pegels entspricht, bei dem die Diode verbunden ist, wobei der zweite vorbestimmte Wert einer Situation entspricht, in welcher der Motor abgeschaltet ist.

2. Verfahren nach Anspruch 1 dadurch gekennzeichnet, daß die Verbindung der Diode (15) durch Öffnung eines elektronisch steuerbaren Kontakts (14) erfolgt, der parallel zu der Diode (15) angeschlossen ist.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß der Kontakt (14) sich in einem Relais (13,16) befindet, dessen Funktion durch einen Komparator (4), welcher die Batteriespannung mit einer Referenzspannung vergleicht, steuerbar ist.

4. Vorrichtung zum Aufladen einer wiederaufladbaren Batterie mit einem Generator (A), welcher mit einer von dem Spannungsgenerator ausgehenden Regulierspannung versorgt wird, wobei der Spannungsregener seinerseits zum Empfang eines Wertes fähig ist, welcher die Batteriespannung zur Regulierung des Generators in Abhängigkeit von der Spannung in Bezug auf eine vorbestimmte nominale Ladungsspannung angibt, wobei die Vorrichtung zum Einführen eines Spannungsabfalls zwischen der Batterie und dem Regulator in Abhängigkeit von dem Betriebszustand der Batterie geeignet ist, wobei der Spannungsabfall den durch den Regulator empfangenen Wert der Batteriespannung vermindert, wobei die Vorrichtung eine Diode (15) aufweist, die zwischen dem positiven Anschluß (B+) der Batterie und einem Eingangsanschluß (R) des Regulators, welcher die Regulationsspannung empfängt, vorwärts gepolt ist und einen steuerbaren Kontakt (14), der parallel zu der Diode (15) gekoppelt ist, dadurch gekennzeichnet, daß die Vorrichtung einen Komparator (4) aufweist, welcher zur Steuerung der Funktion des Kontaktes (14) in Abhängigkeit von einem erfaßten Wert der Batteriespannung derart angeordnet ist, so daß die Diode (15) mittels des Kontaktes (14) kurzgeschlossen ist, wenn die Batteriespannung einen ersten vorbestimmten Wert erreicht hat, wobei der Spannungsabfall entfernt wird, und daß der Komparator (4) in der Weise betrieben wird, daß die Verbindung und der Kurzschluß der Diode durch Hysterese erfolgt, wobei der erste vorbestimmte Wert einen zweiten vorbestimmten Wert überschreitet, der demjenigen Pegelwert entspricht, bei welchem die Diode verbunden ist, wobei der zweite vorbestimmte Wert einer Situation entspricht, in welcher der Motor abgeschaltet ist.

Revidendations

1. Procédé de charge d'une batterie d'accumulateurs rechargeables, la charge étant réalisée à l'aide d'une génératrice qui est commandée pour la charge de la batterie par un moteur, la génératrice recevant une tension de régulation d'un régulateur de tension qui reçoit une valeur représentative de la tension de la batterie pour régler la génératrice en fonction d'une tension qui dépend d'une tension nominale prédéterminée de charge et selon laquelle une chute de tension peut être introduite entre la batterie et le régulateur en fonction des conditions de fonctionnement de la batterie, la chute de tension réduisant la valeur de la tension de la batterie reçue par le régulateur et étant introduite entre la borne positive (B+) de la batterie et une borne d'entrée de référence (R) du régulateur qui reçoit la tension de régulation, par connexion d'une diode (15) qui est polarisée dans le sens direct, caractérisé en ce que la chute de tension est introduite en fonction d'une valeur détectée de la tension de la batterie, en ce que la diode (15) est en court-circuit lorsque la tension de la batterie a atteint une première valeur prédéterminée, si bien que la chute de tension est supprimée, et en ce que la connexion et la mise en court-circuit de la diode sont réalisées par un phénomène d'hystérésis, si bien que la première valeur prédéterminée déborde une seconde valeur prédéterminée qui correspond à la valeur du niveau auquel la diode est connectée, la seconde valeur prédéterminée correspondant à une situation dans laquelle le moteur est arrêté.
2. Procédé selon la revendication 1, caractérisé en ce que la connexion de la diode (15) est réalisée par ouverture d’un contact (14) qui peut être commandé électroniquement et qui est connecté en parallèle avec la diode (15).

3. Procédé selon la revendication 2, caractérisé en ce que le contact (14) est incorporé à un relais (13, 16) dont le fonctionnement est commandé par un comparateur (4) qui compare la tension de la batterie à une tension de référence.

4. Dispositif de charge d’une batterie d’accumulateurs rechargeables, comprenant une génératrice et un régulateur de tension, la génératrice étant commandée afin qu’elle charge la batterie à l’aide d’un moteur et recevant une tension de régulation du régulateur de tension qui est lui-même destiné à recevoir une valeur représentative de la tension de la batterie pour régler la génératrice en fonction de cette tension d’après une tension prédéterminée nominale de charge, le dispositif étant destiné à introduire une chute de tension entre la batterie et le régulateur en fonction des conditions de fonctionnement de la batterie, la chute de tension réduisant la valeur de la tension de la batterie reçue par le régulateur, le dispositif comprenant une diode (15) qui est polarisée dans le sens direct entre une borne positive (B+) de la batterie et une borne d’entrée (R) du régulateur qui reçoit une tension de régulation, et un contact (14) qui peut être commandé électroniquement et qui est couplé en parallèle avec la diode (15), caractérisé en ce qu’il comprend un comparateur (4) destiné à commander le fonctionnement du contact (14) en fonction de la valeur détectée de la tension de la batterie afin que la diode (15) soit mise en court-circuit par le contact (14) lorsque la tension de la batterie a atteint une première valeur prédéterminée, si bien que la chute de tension est supprimée, et en ce que le comparateur (4) est commandé d’une manière telle que la connexion et la mise en court-circuit de la diode sont réalisées par un phénomène d’hystérésis, si bien que la première valeur prédéterminée dépasse une seconde valeur prédéterminée qui correspond à la valeur du niveau auquel la diode est connectée, la seconde valeur prédéterminée correspondant à une situation dans laquelle le moteur est arrêté.