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**D E C I S I O N**  
of 20 November 1995

**Case Number:** T 0919/92 - 3.4.1

**Application Number:** 88100193.7

**Publication Number:** 0323539

**IPC:** G01R 31/36

**Language of the proceedings:** EN

**Title of invention:**

Method for determining the state-of-charge of batteries,  
particularly lithium batteries

**Applicant:**

RAMOT UNIVERSITY, AUTHORITY FOR APPLIED RESEARCH & INDUSTRIAL  
DEVELOPMENT LTD.

**Opponent:**

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**Headword:**

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**Relevant legal provisions:**

EPC Art. 56

**Keyword:**

"Inventive step (yes, after amendment)"

**Decisions cited:**

-

**Catchword:**

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Case Number: T 0919/92 - 3.4.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.1  
of 20 November 1995

**Appellant:**

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**Representative:**

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**Decision under appeal:**

Decision of the Examining Division of the European  
Patent Office dated 15 July 1992 refusing European  
patent application No. 88 100 193.7 pursuant to  
Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** G. D. Paterson  
**Members:** H. J. Reich  
R. K. Shukla

## Summary of Facts and Submissions

- I. European patent application No. 88 100 193.7 (publication No. 0 323 539) was refused by a decision of the Examining Division.
- II. The reason given for the refusal was that the subject-matter of Claim 1 filed on 18 November 1991 did not satisfy the requirements of Articles 52(1) and 56 EPC having regard to document:

D1: US-A-4 322 685, or  
D3: US-A-4 193 025.

The Examining Division took the following view: the only apparent difference between the subject-matter of Claim 1 and the prior art disclosed in documents D1 or D3 is that in the claimed method the absolute state of charge of the battery is determined, whereas in the prior art test a value is compared against a reference and the battery is judged to pass or fail. Although after the cold cranking power test described in documents D1 and D3, the result of the subsequent bounce back test is merely used to decide whether the battery has passed or failed the test, nevertheless a skilled person would notice that the actual results from such a test have a continuous spread for different states of charge. The skilled person would realise that the teaching of document D1 is a simplification which can easily be extended from determining pass or fail to determining the absolute value, for instance by having multiple thresholds or by processing the measured data. Such adaptation would not involve any inventive activity.

III. The Appellant lodged an appeal against this decision. In the Statement of Grounds of Appeal the Appellant maintained the claims underlying the appealed decision and submitted that the bounce back test described in documents D1 or D3 is not intended to provide, and does not provide, any information indicating the state-of-charge of the battery before the test. The one conventional value of the bounce back reference voltage indicates that experimentally found higher bounce back voltages are caused by a defective cell of the battery and are not at all related to any absolute value of the state of charge in the battery. Hence, in the present application the results of the bounce-back test are used in a new manner and for a new and non-obvious purpose.

IV. In a communication accompanying a summons to oral proceedings, the Board expressed its preliminary view essentially as follows: The subject-matter of Claim 1 is distinguished from the method for determining the remaining capacity (state-of-charge) of a cell as disclosed in document:

D2: US-A-4 321 541

in that it comprises additionally the step of measuring the temperature of the battery and in determining the state-of-charge of the battery with the temperature as additional parameter. It would be obvious to take into account the temperature of the battery, because a skilled person would realise in practice that the method of document D2 gives unsatisfactory results. Moreover, document D3, Figure 4b teaches that the bounce back reference voltage is temperature dependent.

V. In reply, the Appellant submitted that none of the cited references recognises the critical aspect of the temperature factor on the measurement of a battery

charge. Sworn declarations by Professor Eliezer Gileadi and Mr Israel Reshef (one of the inventors), were filed by the Appellant, which respectively emphasised the importance of temperature dependence in the practical application of the claimed invention, and the commercial success and practical importance of the claimed invention.

VI. Oral proceedings were held on 20 November 1995, during which the Appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of Claims 1 to 5 as filed during oral proceedings.

VII. Claim 1 of the request reads as follows:

"1. The method of determining the state-of-charge of a particular type of battery (2) when it is disconnected from any non measurement load, particularly a battery having an unknown history, comprising the steps of:

(a) pre-preparing calibration curves or tables for said type of battery showing the interrelationship between parameters comprising recovery open-circuit voltage ( $OVC_R$ ) of said type of battery at different temperatures ( $T$ ), and different residual capacities of said type of battery after subjecting said type of battery a predetermined measurement load (4) for a predetermined loading time ( $t_L$ ), and after a predetermined recovery time ( $t_R$ ) between 0.1-1000 seconds;

(b) measuring the temperature ( $T$ ) of the battery (2);

(c) loading the battery (2) with said predetermined measurement load (4) to produce a high discharge for said predetermined loading time ( $t_L$ );

(d) after said predetermined recovery time ( $t_r$ ), measuring the recovery open-circuit-voltage ( $OVC_R$ ) of the battery (2); and

(e) determining the state of the charge of the battery (2) from the measured temperature (T) and from the measured recovery open-circuit-voltage ( $OCV_R$ ), by reference to said calibration curves or tables."

Claims 2 to 5 are dependent on Claim 1.

VIII. In support of this request the Appellant argued essentially as follows:

(a) New Claim 1 includes the subject-matter of former Claims 2, 5 and 6 and is limited in particular to the measurement of the recovery open-circuit **voltage** after a predetermined recovery time between 0.1 to 1000 seconds. In the conventional method disclosed in document D2, recovery open-circuit **voltage** is not measured but the restoration **time** of the battery, after the load test, to reach again a predetermined reference voltage level ( $\alpha$  in Figure 5). In document D2 there is no reference to a correlation between the recovery open-circuit voltage and the state-of-charge of the battery. The correlation with said restoration time leads away from the invention.

(b) The method disclosed in document D2 produces unreliable results. Temperature variations during the measurement of the restoration time have a large influence on its experimentally determined value. Each drop by  $10^\circ\text{C}$  will cause a lengthening by a factor of two. Some types of battery have

extremely flat restoration curves. Under certain temperatures the restoration time will be unduly long.

- (c) Moreover, the method claimed in Claim 1 has the advantage of better noise and oscillation indifference. The observed recovery curves are not smooth but have abrupt spikes and oscillations. Such spikes simulate an apparent recovery of the reference voltage level  $\alpha$  which distorts any reliability of the method disclosed in document D2. Such unreliable results may have dramatic consequences when the incorrectly tested battery is for instance used in the nocturnal vision device of a helicopter pilot.
  
- (d) Figure 4b of document D3 shows the temperature dependence of the bounce back reference voltage limiting the defective cell region. There is no information in document D3 from which a skilled person can derive that the recovery open-circuit voltage varies with the temperature for one and the same state-of-charge of the battery. The fact that in Figure 4b of document D3 the bounce back reference voltage linearly **increases** with the temperature whereas the recovery open-circuit voltage **decreases** with the temperature (see Figure 4 of the present application), demonstrates that the teaching of document D3 cannot be used in the line of thoughts which have led to the present invention.

IX. At the conclusion of the oral proceedings, the decision was announced that the decision of the Examining Division is set aside and that the case is remitted to

the first instance with an order to grant the patent on the basis of Claims 1 to 5 as filed during oral proceedings, with description to be adapted accordingly.

### Reasons for the Decision

1. The subject-matter of Claim 1 of the above request is disclosed in original Claims 1, 2, 3, 7 and 8. Claims 2, 3 and 4 correspond to original Claims 5, 6 and 9 respectively. The features of Claim 5 are disclosed in original Claim 10 in combination with the description column 6, lines 44 to 47. There is, therefore, no objection to such amended claims under Article 123(2) EPC.

2. *Novelty*

2.1 Document D2 discloses in the wording of Claim 1:

"The method of determining the state-of-charge of a particular type of battery (see document D2, column 3, lines 41 and 42) when it is disconnected from any non measurement load (see D2, 18 in Figures 6 and 7; the wording in column 1, lines 5 to 9 concern the background art; the abstract and the summary of the invention in column 3, lines 40 to 43 and column 12, lines 1 to 20 are in line with said figures, indicating that the battery is not tested within a watch or camera, but **used** as a power source for such a portable implement), particularly a battery having an unknown history, comprising the steps of:...

- (c) loading the battery (18 in Figure 6 with a predetermined load (20) to produce a high discharge for said predetermined loading time ( $t_0$  in Figure 5 and column 3, lines 58 to 62)."

The subject-matter of Claim 1 differs from the conventional method disclosed in document D2 in that it correlates the state-of-charge of the tested battery with the recovery open-circuit **voltage** measured after a fixed predetermined recovery time instead with the measurement of the length of the restoration **time** required after the release of the load to restore a predetermined reference voltage  $\alpha$ , and in that additionally the temperature of the battery is measured as the second parameter correlated with the state-of-charge. Moreover, document D2 is silent about calibration curves or tables with which the measured parameters are compared in order to determine the state-of-charge.

2.2 The methods disclosed in documents D1 and D3 have a different purpose. They are exclusively used for detecting the presence of a defective cell (in a lead-acid storage battery), not for determination of the state of charge. All other methods disclosed in the documents cited in the European Search Report, do not come closer to the subject-matter claimed in Claim 1.

2.3 Thus, the subject-matter of Claim 1 is considered new in the sense of Article 54 EPC.

### 3. *Inventive step*

3.1 Starting from the closest prior art method according to document D2, the objective problem underlying the present invention is to improve the usability and reliability of this conventional method.

- 3.2 This problem is solved by combining claimed steps (a), (b), (d) and (e) with the conventional step (c).
- 3.3 In the assessment of inventive step the question which needs to be considered is whether a skilled person was able to foresee that a replacement of the conventional basic state-of-charge indicator, i.e. the restoration time of a predetermined reference voltage in document D2, by the claimed one, i.e. the recovery open circuit voltage regained at a predetermined (fixed) recovery time, would provide an improvement over the conventional method.
- 3.4 The cited documents do not suggest to a skilled person to determine the state-of-charge of a battery by correlating it with an open-circuit voltage at the terminals of the battery measured at a predetermined fixed time during a recovery period. In the Board's view, it would involve hindsight to conclude that a skilled person would be able to recognise on the basis of the proportionality shown in Figure 5 of document D2 - between states-of-charge C15, C16, C17 and the recovery open-circuit voltages of corresponding curves 15, 16 and 17 at a predetermined time (for instance  $t_{15}$ ) - that it is possible to use such voltages as the principal parameter to be measured for determining the state-of-charge of a battery.

Documents D1 and D3 teach the correlation of an open-ended voltage **region** above a critical reference value with the presence of a defective part of a battery (a defective cell in a lead-acid storage battery), rather than the correlation of a single voltage value. In the Board's view, a skilled person would interpret documents D1 and D3 as teaching that such a voltage increase above a critical threshold value is caused by the increased internal resistance of a defective cell. When the load

current stops to flow through the serial connection of acceptable **and defective** cells of the battery, the increased voltage drop across a defective cell no longer reduces the terminal voltage of the battery and produces a larger bounce back voltage than the lower internal resistance of an acceptable cell. Hence, there is no hint in documents D1 and D3 from which a skilled person would learn that a single numeric value of the terminal voltage, when measured as claimed, can be indicative of the existing integral state-of-charge of an acceptable battery. In the Board's view, such findings do not result from a skilled person's general knowledge and cannot be regarded as the result of the normal unimaginative logical thinking which can be expected from a skilled person.

- 3.5 Moreover, the above identification of the recovery open-circuit voltage as a crucial test parameter only reveals the intellectual possibility of its use, so that a skilled person might have made use of this parameter. According to the established practice of the EPO, such a possibility is not sufficient to establish obviousness of a technical measure. The decisive issue is not whether a skilled person **could** have made use of a technical measure, but whether he **would** have used it. In the Board's judgement, a skilled person would not have replaced the conventional parameter - restoration time - in the method disclosed in document D2 by the claimed measurement of the recovery open-circuit voltage, since there is no pointer in the prior art that such replacement provides any improvement of the conventional method, and also because on the basis of his routine thinking a skilled person would not foresee any inherent advantage in this replacement. In particular the Board regards it to be not obvious to a skilled person that this replacement allows the implementation of the claimed method in a device which renders the test result

insensitive to noise and spikes in the terminal voltage of the tested battery such as caused by random electromagnetic disturbances in the measuring instrument. The Board accepts the Appellant's argument that in the conventional method of document D2 such spikes may simulate a high state-of-charge by prematurely stopping the counter for the restoration time, whereas in realising the claimed measurement of a voltage, disturbing spikes can be verified and easily eliminated from the result of the measurement; see also paragraph VIII-(c) above.

- 3.6 For the reasons set out in paragraphs 3.1 to 3.5 above, in the Board's judgment the correlation of the state-of-charge of a tested battery with the resulting recovery open-circuit **voltage** measured after a predetermined fixed recovery time and subsequent to a load test involves an inventive step in the sense of Article 56 EPC.
  
4. Thus, Claim 1 is allowable under Article 52(1) EPC. Dependent Claims 2 to 5 concern particular embodiments of the method claimed in Claim 1 and are, therefore, likewise allowable.
  
5. The case is remitted to the Examining Division in order that the description should be adapted to the above set of claims.

**Order**

**For these reasons it is decided that:**

1. The decision of the Examining Division is set aside.
2. The case is remitted to the first instance with an order to grant the patent on the basis of claims 1 to 5 as filed during the oral proceedings, with description to be adapted accordingly.

The Registrar:

The Chairman:

M. Beer

G. D. Paterson

