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Datasheet for the decision of 23 March 2015

Case Number: T 0430/11 - 3.3.05

Application Number: 03702768.7

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Language of the proceedings: EN

Title of invention:
REDOX FLOW BATTERY

Applicant:
Renewable Energy Dynamics Technology Limited

Headword:
Redox flow battery/RENEWABLE ENERGY DYNAMICS TECHNOLOGY LTD.

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - main request (yes)

Decisions cited:

Catchword:

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Case Number: T 0430/11 - 3.3.05

D E C I S I O N
of Technical Board of Appeal 3.3.05
of 23 March 2015

Appellant: (Applicant)	Renewable Energy Dynamics Technology Limited 66 Lower Leeson Street Dublin 2 (IE)
Representative:	Brooks, Nigel Samuel Hill Hampton East Meon Petersfield, Hampshire GU32 1QN (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 13 October 2010 refusing European patent application No. 03702768.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Raths
Members:	H. Engl
	P. Guntz

Summary of Facts and Submissions

I. European patent application EP03702768.7, published as WO-A-03/069 692, is concerned with a redox flow battery and a method of charging of such a battery.

II. Documents cited in the International search report:

D1: WO 01/03221 A
D2: WO 01/76000 A
D3: US 5 804 329 A
D4: US 3 795 544 A.

III. The European patent application was refused by a decision of the examining division, posted with letter dated 13 October 2010, on the ground of lack of inventive step having regard to any of documents D1 to D3 in combination with document D4.

IV. The applicant's (henceforth: the appellant's) notice of appeal was received by letter dated 13 December 2010. The statement of grounds of appeal, dated 3 February 2011, was accompanied inter alia by two new sets of claims as a main request and an auxiliary request.

By letter dated 16 March 2015, the appellant filed a new set of claims as the main request, replacing the claims previously filed.

V. Claim 1 of the main request reads:

"1. A redox flow battery having:

at least one redox fuel cell (1), the cell having:
- an anode (5) in a catholyte compartment (3),
- a cathode (6) in an anolyte compartment (2) and

- an ion selective membrane separator (4) between the compartments, a pair of electrolyte reservoirs, i.e. one (7) for anolyte and the other (8) for catholyte,
- electrolyte supply means (9, 10, 11, 12; 37, 38, 39, 40, 41, 42), i.e. means for circulating anolyte from its reservoir, to an anolyte compartment in the cell and back to its reservoir and like circulating means for catholyte and electrolyte withdrawal and supply connections (21, 22, 23, 24; 35, 36) to its electrolyte reservoirs and/or its electrolyte supply means whereby the battery can be recharged by withdrawing spent electrolyte and replacing it with fresh electrolyte; and

wherein each electrolyte reservoir is provided with:

- a movable divider (31) for dividing the reservoir into two volumes, and one of the electrolyte withdrawal and supply connections is connected to one end of the reservoir and another electrolyte withdrawal and supply connection is connected to the other of the reservoir, whereby for recharging, the divider traverses along the reservoir with spent electrolyte being withdrawn from in front of the divider via one connector and fresh electrolyte being introduced behind it via another connector, with no communication between the spent and fresh electrolyte **OR**
- a rigid outer vessel (203) and two separate, collapsible tank liners (201, 202), the liners having at least two unions (204) passing through the wall (205) of the rigid outer vessel, and one of the electrolyte withdrawal and supply connections is connected to one end of the reservoir and another electrolyte withdrawal and supply connection is connected to the other of the reservoir, whereby for recharging one of the liners collapses as spent electrolyte is withdrawn from it via one connector and

the other is filled via another connector with fresh electrolyte to substantially the internal capacity of the outer vessel."

Claims 2 to 22 represent particular embodiments of the subject-matter of claim 1.

VI. The appellant argued in writing essentially as follows:

The examining division's refusal of the application based on D4 was wrong in that (i) D4 would not render the invention obvious and (ii) document D4 did not belong to the relevant prior art.

The appellant drew attention to the distinction between a fuel cell, such as the one disclosed in D4, and a battery. The battery of D4 was neither a "battery" nor was it "regenerative". The redox flow battery of the invention was a regenerative battery. It could be recharged in the manner of a lead acid battery. Indeed that was a major advantage of redox flow batteries. For these reasons was D4 not pertinent.

D1 disclosed conventional features of a redox flow battery, in particular, an anode in a catholyte compartment, a cathode in an anolyte compartment, an ion selective membrane separator, a pair of electrolyte reservoirs, and electrolyte supply means. The claimed invention was distinguished over D1 by providing, in each electrolyte reservoir, either a moveable divider or two collapsible tank liners.

The object of the invention was to provide a redox flow cell having improved means for charging, by providing means for a swift replacement of spent electrolyte with fresh electrolyte.

As a solution the claim proposes features involving either a moveable divider OR two collapsible tank liners, neither of which were found in the relevant prior art. In particular, the moveable divider feature was not disclosed in or suggested by D4.

VII. Requests

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the claims of the main request, filed with letter dated 16 March 2015, or the auxiliary request, filed with the statement of grounds of appeal.

Reasons for the Decision

1. Amendments (main request)

Claim 1 is based on the disclosure of claims 1, 5 and 6 of the application as originally filed and published as WO-A-03/069 692.

Dependent claims 2 to 22 are based on original claims 7 to 27, respectively.

The requirements of Article 123(2) EPC are met.

2. Novelty (main request)

The board concurs with the examining division in its finding of novelty having regard to D1 to D3 (see the contested decision, reasons, point 2 (iv)).

As regards document D4, the claimed subject-matter is considered novel by the fact that the prior art document does not disclose, and relate to, a redox flow battery, but to a fuel cell. As such, during production of electricity it consumes a fuel (hydrazine) and an oxidant (hydrogen peroxide) both of which must be supplied externally and cannot be regenerated. Such a fuel cell significantly differs from the presently claimed redox flow battery both in construction and operation.

The requirements of Article 54 EPC are thus met.

3. Inventive step (main request)

3.1 Invention

The invention is concerned with a redox flow battery, i.e. a fuel cell type battery with external storage and supply of the reactants, wherein the anolyte and the catholyte contain redox ions in different states of oxidation.

More specifically, the aim of the application under appeal is to provide improved means of charging a redox flow battery (see description, page 2, lines 8 and 9 and 22 to 24).

3.2 Closest prior art

3.2.1 The board recalls that according to the jurisprudence of the Boards of Appeal, the closest prior art is normally represented by a document disclosing subject-matter conceived for the same or similar use, purpose and effect as the invention at issue, and requiring the minimum of structural and functional modifications.

Such closest prior art will normally belong to the same technical field.

3.2.2 As argued by the appellant, **D4** is not a suitable starting point and belongs to a different technical field (see 3.6.2, first paragraph). The fuel cell system according to D4 does not represent a regenerative battery (see points 2. above and 3.6.2 below), in contrast to the redox battery according to the invention which is regenerative and can be recharged in the manner of a lead acid battery.

3.2.3 In view of the above considerations and for the following reasons, the board takes **D2** as the closest prior art.

Document **D2** discloses a redox flow battery and a method of operating it. D2 is concerned with the problem of bypass currents which reduce the efficiency in such redox flow cells (see page 4, lines 1 to 3, 16 to 23). Figure 2 reveals a stack of membrane-separated bipolar electrolytic cells, connected via pumps P, check valves CK and valves V1 to V4 and V1' to V4' to four electrolyte tanks ("charged" electrolyte tanks T1 and T1' and "spent" electrolyte tanks T2 and T2') during the discharging process and vice versa during the charge process. Said check valves CK as well as the valves V1 to V4 and V1' to V4' hydraulically isolate the cells from the electrolyte reservoirs T_i when the battery is stopped, thereby preventing self-discharge of the volume of electrolytes retained in the respective compartments of the cell stack in idle periods (see page 15, lines 5 to 9).

3.3 Problem

According to the application under appeal, the technical problem was to improve means of charging a redox flow battery (see description, page 2, lines 8 and 9, 22 to 24).

3.4 Solution

As a solution to this problem, the application proposes a redox flow battery in accordance with claim 1 of the main request having a pair of electrolyte reservoirs, i.e. one for anolyte and the other one for catholyte, characterised in that each electrolyte reservoir is provided with:

- **EITHER** a movable divider (31) for dividing the reservoir into two volumes, and one of the electrolyte withdrawal and supply connections is connected to one end of the reservoir and another electrolyte withdrawal and supply connection is connected to the other end of the reservoir, whereby for recharging, the divider traverses along the reservoir with spent electrolyte being withdrawn from in front of the divider via one connector and fresh electrolyte being introduced behind it via another connector, with no communication between the spent and fresh electrolyte;

- **OR** a rigid outer vessel (203) and two separate, collapsible tank liners (201, 202), the liners having at least two unions (204) passing through the wall (205) of the rigid outer vessel, and one of the electrolyte withdrawal and supply connections is connected to one end of the reservoir and another electrolyte withdrawal and supply connection is connected to the other end of the reservoir, whereby

for recharging one of the liners collapses as spent electrolyte is withdrawn from it via one connector and the other is filled via another connector with fresh electrolyte to substantially the internal capacity of the outer vessel.

3.5 Success of the solution

The functioning of the two alternative embodiments proposed by the present application is explained on page 3, lines 9 to 21 and in Figure 2, and on page 9, lines 8 to 15 and in Figure 8, respectively. Evidently, both embodiments of the invention allow a re-charging of the redox flow battery by withdrawing spent electrolyte and replacing it with fresh electrolyte. Thanks to the separation of the reservoirs, it is not necessary to flush the reservoirs with excess electrolyte (see page 2, lines 26 to 31).

The board is thus satisfied that the problem of improving the charging of a redox flow battery has been successfully solved.

There is no need to reformulate the problem in the light of D2.

3.6 Obviousness

3.6.1 It remains to be decided whether the proposed solution (exemplified here by two embodiments) is obvious having regard to the prior art.

3.6.2 As discussed before (see point 2. above), document D4 relates to a pressure-balanced fuel cell system for underwater vehicles operating on externally supplied fuels (hydrazine) and oxidants (hydrogen peroxide).

These fuel cell systems cannot be regenerated (recharged) as fuel and oxidant are irreversibly consumed during operation.

Although D4 superficially discloses features similar to the present application, in particular as regards the fuel and oxidant supply tanks 17 and 42, divided into two compartments by a collapsible bladder (18, 43), the purpose and the function of the said compartmented tanks are different from those according to the invention. In D4, the compartmented tanks do not enable re-fueling/re-charging of the fuel cell system with fresh fuel and oxidant, but are designed to provide a pressure balance, either by returning spent anolyte to compartment 45 of tank 42, or sea water to compartment 22 of tank 17 (see Figure 1; column 1, lines 52 to 62; column 2, lines 5 to 14, 43 to 55). It is thus seen that D4 belongs to a different technical field and solves a different technical problem.

Following the appellant's arguments, it is arguable whether the skilled person aiming to improve re-charging of redox flow batteries would have resorted to a document such as D4 which does not relate to this particular class of rechargeable batteries. D4 neither deals with the problem of re-charging nor discloses the use of variable-size electrolyte reservoirs for a quick re-charge of a battery. So, it can be concluded that D4 does not give any hints to the solution proposed by the application in suit.

3.6.3 Document **D1** discloses a so-called regenerative fuel cell (RFC) based on Br^-/Br_2//sulphur/polysulphide chemistry (see page 1, lines 3 to 7 and 20 to 33). According to Figures 1 and 2, it consists of a rechargeable battery system comprising one or more

redox fuel cells 20 having an anode (12) / anolyte reagent (22) and a cathode (14) / catholyte reagent (24) in respective adjacent compartments separated by cation exchange membrane 16. Associated therewith are respective electrolyte reservoirs 32 and 34. The respective redox electrolytes are recirculated by respective pumps 26 and 28. Fresh anolyte and catholyte are provided via refilling tanks 32 and 34 from charged supply sources via lines 32R and 34R with corresponding lines provided for draining spent (discharged) reagent.

In the fuel cell of **D1**, because of the two half cells being based on different chemical species, the problem of diffusion of unwanted species across the membrane arises (see page 3, line 25 to page 4, line 20). The aim of D1 is to provide a process of rebalancing the electrolytes in order to compensate for the unbalancing effects of crossover of sulfide and/or polysulfide electrolyte species into the bromine electrolyte. Accordingly, D1 proposes an electrochemical system characterized by means for rebalancing the electrolytes by circulating a fraction of electrolyte 1 or electrolyte 2 through the positive chamber of an auxiliary cell 51 operating so as to oxidise sulfide ions to sulfur or bromide ions to bromine (see page 6, lines 17 to 32; Figure 3).

This problem and its solution are substantially different from the present application. Notably, D1 does not hint at electrolyte reservoirs having collapsible or moveable dividers or tank liners.

3.6.4 **D3** discloses an electrochemical storage medium (referred to as an "Electroconversion Cell") based on a borohydride compound oxidisable to an oxidized boron-containing compound, in electrochemical contact with an

electrode for carrying a current generated during that oxidation (see claim 1; column 10, line 61 to column 11, line 23). The cell is rechargeable either via a second set of electrodes or by replenishing the electrolyte in tank 1 (see column 13, lines 43 to 45; column 10, lines 49 to 57; Figure 3).

This art is remote from what is presently claimed. It cannot suggest the characterising key features of the present invention.

3.7 In view of the above, the subject-matter of claim 1 meets the requirements of Article 56 EPC.

The same arguments apply to the dependent claims which derive their patentability from claim 1.

3.8 As the main request is allowable, there is no need to consider the claims of the auxiliary request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent on the basis of the following application documents:

- claims 1 to 22, filed with letter dated 16 March 2015;
- description, pages 1 to 10, in accordance with the main request filed with the statement of grounds of appeal,
- drawings, substitute sheets 1/5 to 5/5, as published in WO-A-03/069 692.

The Registrar: The Chairman:

C. Vodz G. Raths

Decision electronically authenticated