

(51) International Patent Classification:
H01M 10/39 (2006.01)(21) International Application Number:
PCT/IB2014/000617(22) International Filing Date:
14 March 2014 (14.03.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/781,500 14 March 2013 (14.03.2013) US(71) Applicants: **MASSACHUSETTS INSTITUTE OF TECHNOLOGY** [US/US]; 77 Massachusetts Avenue, Cambridge, MA 02139 (US). **TOTAL MARKETING SERVICES** [FR/FR]; 24 Cours Michelet, 92800 Puteaux (FR).(72) Inventors: **CHUNG, Brice H.V.**; 15 Blackwood St., Apt 4, Boston, Massachusetts 02115 (US). **SADOWAY, Donald R.**; 243 Bent Street, Unit 2, Cambridge, MA 02141 (US).(74) Agent: **REGIMBEAU**; 139 rue Vendôme, F-69477 Lyon Cedex 06 (FR).(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

(88) Date of publication of the international search report:

31 December 2014

(54) Title: HIGH AMPERAGE BATTERIES WITH DISPLACEMENT SALT ELECTRODES

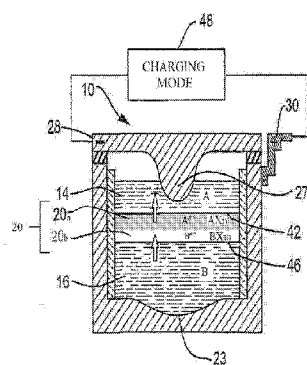


FIG 2A

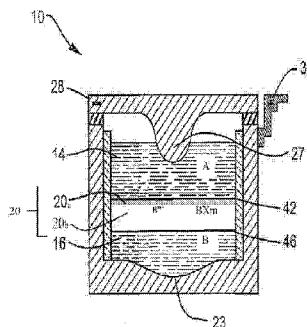


FIG 2B

(57) **Abstract:** An electrochemical cell includes a negative electrode comprising a first active metal, a positive electrode comprising a second active metal, and an electrolyte comprising salts of the two active metals, a salt of the cathodic metal and a salt of the anodic metal. In operation, the electrolyte composition varies such that in a charging mode the salt of the anodic salt decreases, while the salt of the cathodic salt increases, and in a discharging mode the salt of the anodic salt increases, while the salt of the cathodic salt decreases. The cell is operational for both storing electrical energy and as a source of electrical energy as part of an uninterruptible power system. The cell is particularly suited to store electrical energy produced by an intermittent renewable energy source.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/000617

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M10/39
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HOJONG KIM ET AL: "Liquid Metal Batteries: Past, Present, and Future", CHEMICAL REVIEWS, vol. 113, no. 3, 13 March 2013 (2013-03-13), pages 2075-2099, XP055131721, ISSN: 0009-2665, DOI: 10.1021/cr300205k	1-15, 18-25
A	figures 1-3 tables 1-2, 6, 10, 12, 14, 15 page 2076, left-hand column, line 4 - line 6 page 2077, paragraph 1.3 page 2084, paragraph 3.1.3 page 2086, left-hand column ----- -/--	16,17



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

29 July 2014

Date of mailing of the international search report

15/10/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Letilly, Marika

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2014/000617

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-25

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/000617

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SADOWAY D R ED - MOSELEY P T ET AL: "Block and graft copolymer electrolytes for high-performance, solid-state, lithium batteries", JOURNAL OF POWER SOURCES, ELSEVIER SA, CH, vol. 129, no. 1, 15 April 2004 (2004-04-15), pages 1-3, XP004502221, ISSN: 0378-7753, DOI: 10.1016/J.JPOWSOUR.2003.11.016 paragraph [0003]; figure 1 -----	16,17

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-25

The first invention is directed towards an electrochemical cell comprising:
a first phase defining a negative electrode comprising a first active metal;
a second phase separated from the first phase and defining a positive electrode comprising a second active metal; and
a third phase between the first and second phases and defining an electrolyte comprising a salt of the first active metal and a salt of the second active metal, the third phase defining first and second interfaces, the first phase being in contact with the third phase at the first interface and the second phase being in contact with the third phase at the second interface.

2. claims: 26, 27

The second invention is directed towards:
- an electrochemical cell comprising: a first phase defining a negative electrode comprising a first active metal; a second phase separated from the first phase and defining a positive electrode comprising a second active metal; a third phase defining an anolyte comprising a salt of the first active metal, the first phase being in contact with the third phase at a first interface; a fourth phase defining a catholyte comprising a salt of the second active metal, the second phase being in contact with the fourth phase at a second interface; and a selective ion conductive separator disposed between, and in contact with, the third and fourth phases.

or

- an electrochemical cell comprising: a first phase defining a negative electrode comprising a first active metal; a second phase separated from the first phase and defining a positive electrode comprising a second active metal; a third phase between the first and second phases and defining an electrolyte comprising a salt of the first active metal and a salt of the second active metal, the second phase being in contact with the third phase at an interface; and a selective ion conductive separator disposed between and in contact with the first and second phases.
