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AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
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KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
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RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ,
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MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
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16 January 2014

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see Notice of 28 November 2013

(54) Title: IMPROVED LEAD-ACID BATTERY CONSTRUCTION

(57) Abstract: Batteries comprise a carbon fibre electrode construction of the invention and have improved DCA and/or CCA, and/or may maintain DCA with an increasing number of charge-discharge cycles, and thus may be particularly suitable for use in hybrid vehicles.



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2013/000031

A. CLASSIFICATION OF SUBJECT MATTER

H01M 4/20 (2006.01) H01M 4/56 (2006.01) H01M 4/583 (2010.01) H01M 4/68 (2006.01) H01M 4/73 (2006.01)
H01M 4/74 (2006.01) H01M 4/80 (2006.01) H01M 4/82 (2006.01) C01B 31/08 (2006.01) C04B 35/52 (2006.01)

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)

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)

EPODOC and WPI: IPC symbols (H01M4/LOW OR H01M10/06/LOW) with keywords (CONDUCTIVE, CARBON, FIBRE, FIBER, WOVEN, NONWOVEN, FILAMENT, THREAD, WIRE, NANO, FELT, ANODE, CATHODE, ELECTRODE and similar terms)

USPTO patent applications database: similar, informal searches as above (details in the following box)

Patent documents cited in the application and other patent documents citing these documents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
4 November 2013

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04 November 2013

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INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. PCT/NZ2013/000031
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/078707 A1 (ABRAHAMSON, J.) 30 June 2011 Examples 4, 6, 8	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	WO 2010/098796 A1 (JOHNSON CONTROLS TECHNOLOGY COMPANY) 02 September 2010 Paragraphs [0003], [0052], [0070], [0084], [0094]-[0095]	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	WO 2010/062203 A1 (ABRAHAMSON, J. et al.) 03 June 2010 Figures 1 - 2; page 4 lines 10 - 12; page 10 lines 19 - 22	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	WO 2010/037451 A1 (HAMMOND GROUP, INC.) 11 March 2010 Claims 1 - 2, 10 - 11, 14 - 15, 23 - 24	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	US 2009/0269666 A1 (LARA-CURZIO, E. et al.) 29 October 2009 Paragraphs [0013], [0016], [0032], [0039], [0046]	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	WO 2008/070914 A1 (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION et al.) 19 June 2008 Page 18 line 31 - page 19 line 29	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	US 2006/0292448 A1 (GYENGE, E. et al.) 28 December 2006 Abstract; claims 15 - 21	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	WO 2006/105186 A2 (FIREFLY ENERGY INC.) 05 October 2006 Paragraph [21], [32]	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	US 6,733,547 B2 (MA, D.) 11 May 2004 Figures 1-6; column 3 lines 36 - 63	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
	US 2003/0175203 A1 (NITSCHKE, W. et al.) 18 September 2003	
Form PCT/ISA/210 (fifth sheet) (July 2009)		

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/NZ2013/000031
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Paragraph [0027]	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	US 6,617,071 A (CHEN, R. et al.) 09 September 2003 Abstract; claims 1-20	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	US 4,342,343 A (CLAGUE, R.E. et al.) 03 August 1982 Column 2 lines 5 - 60	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
A	GB 1 393 528 A (LUCAS INDUSTRIES LIMITED) 07 May 1975 Figure 1; page 1 lines 13 - 85	1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110

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 Supplemental Box for Details

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 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.:
1-85, 87-92, 96-99, 112-114, and, in so far as they do not depend upon claim 86, claim nos. 93-95 and 100-110
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.:

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.

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Group 1: Claims 1-11, 18-81 (when appended to any of claims 1-11), 93-110 (when appended to any of claims 1-11), 112-113 are directed to a lead-acid cell and a method of manufacturing a cell including at least one electrode comprising as a current collector a conductive fibre material comprising, when fully charged (voidage) the fractional volume occupied by the pores between lead and conductive fibres are of between about at least about 0.3, and a mass loading ratio of lead to the mass of conductive fibres, when converted to volume ratio, in the range above 0.7:1 to about 15:1 or in the range of 1:1 to about 10:1. The feature of the lead acid cell comprising specific voidage and mass loading ratio between lead and conductive fibres is specific to this group of claims.
- Group 2: Claims 12-14, 18-81 (when appended to any of claims 12-14), 93-110 (when appended to any of claims 12-14) and 114 are directed to a lead-acid cell and a method of manufacturing a cell including at least one electrode comprising as a current collector a conductive fibre material comprising, when fully charged (voidage) the fractional volume occupied by the pores between lead and conductive fibres are of between about at least about 0.3, and loading ratio volume of lead to the volume of conductive fibres which together define a point on a plot of voidage (x axis) versus loading ratio volume (y axis) that falls within an area defined by one line on said plot from an x axis voidage value of about 98% with a slope of about -1/0.02 and the another line on said plot an x axis voidage value of about 70% with a slope of about -1/0.3. The feature of the lead acid cell having certain characteristics when plotted on the graph of voidage versus loading ratio of volume of lead to conductive fibres is specific to this group of claims.
- Group 3: Claims 15-17 and 18-81 (when appended to any of claims 15-17), 93-110 (when appended to any of claims 15-17) are directed to a lead-acid cell including at least one electrode comprising as a current collector a carbon fibre material having a carbon fibre volume fraction of less than 40%, and a loading ratio of the volume of lead to the volume of carbon fibres greater than 0.5. The feature of the lead acid cell having specific carbon fibre volume fraction and loading ratio of volume of lead to carbon fibres is specific to this group of claims.
- Group 4: Claims 82-85, 93-110 (when appended to any of claims 82-85) are directed to a lead-acid battery cell including at least one electrode comprising as a current collector a conductive fibrous material, and comprising a metal grid, the electrode also comprising a current generating electrolyte active mass at least 20% of which is in the conductive fibrous material. The feature of the lead acid cell comprising a metal grid and specific active mass of current generating electrolyte in the conductive material is specific to this group of claims.
- Group 5: Claims 86, 93-95 (when appended to any of claim 86), 100-110 (when appended to any of claims 86) are directed a lead-acid cell including at least one electrode comprising as a current collector a conductive fibrous material, and comprising a metal grid, the electrode also comprising a current generating electrolyte active mass, the conductive fibrous material having a bulk resistivity of less than 10 Ω mm. The feature of the lead acid cell comprising a metal grid and specific bulk resistivity conductive fibrous material is specific to this group of claims.
- Group 6: Claims 87-92, 93-95 (when appended to claims 87-92), 100-110 (when appended to claims 87-92) are directed to a lead-acid cell wherein conducting chains of Pb-based particles attached to a conductive fibre material have been formed by impregnating a paste comprising Pb-based particles and an extender at between about 0.09% and 0.15% by weight of the paste, and passing a formation current through the electrode. The feature of the lead acid cell comprising a conductive fibrous material formed from impregnating paste made from Pb based particles and an extender having 0.09% and 0.15% by weight of the paste is specific to this group of claims.

Supplemental Box

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is a lead-acid cell including at least one electrode comprising as a current collector made from a conductive fibre material. Further the common feature between Group 4 and Group 5 claims is a current collector comprising metal grid.

However this feature does not make a contribution over the prior art because it is disclosed in:

WO 2011/078707 A1 (ABRAHAMSON) 30 June 2011

This document discloses common features to all of the claimed inventions. It is mentioned as applicant's earlier application in the description (page 3 lines 16-19).

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

Given the different search results for the six inventions mentioned, search of Groups 2-6 inventions would have involved more than a little additional searching effort over that for the first-mentioned invention and thus an additional search fee for each additional invention was considered to be warranted.

In response to the invitation, the applicant paid additional fees and requested that the inventions of Groups 1-4 and 6 be searched. However, the applicant, in error, paid 5 additional search fees (instead of 4 additional search fees required for 5 inventions). The additional fee in respect of the Group 5 invention paid in error will be refunded.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/NZ2013/000031	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
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		CN 102782905 A	14 Nov 2012
		EP 2517287 A1	31 Oct 2012
		JP 2013516035 A	09 May 2013
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		CA 2680743 A1	19 Jun 2008
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.			

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.
Form PCT/ISA/210 (Family Annex)(July 2009)

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/NZ2013/000031	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
		CN 101641809 A	03 Feb 2010
		EP 2108201 A1	14 Oct 2009
		JP 2010512622 A	22 Apr 2010
		KR 20090107498 A	13 Oct 2009
		RU 2009126584 A	20 Jan 2011
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		WO 2008070914 A1	19 Jun 2008
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			

INTERNATIONAL SEARCH REPORT		International application No.	
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Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
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		EP 1449269 A1	25 Aug 2004
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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.			

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/NZ2013/000031	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			