(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 November 2014 (27.11.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/190183 A1

(51) International Patent Classification:
G01R 31/36 (2006.01) *H01M 10/48* (2006.01)
H02J 7/00 (2006.01) *G08C 17/02* (2006.01)

(21) International Application Number:
PCT/US2014/039201

(22) International Filing Date:
22 May 2014 (22.05.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/900,434 22 May 2013 (22.05.2013) US

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(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).

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: ENERGY STORAGE MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS

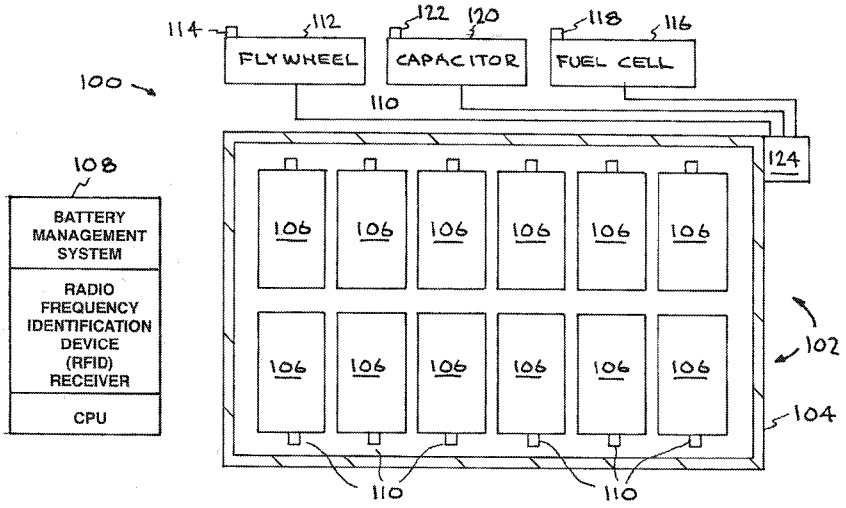


FIG. 1

(57) **Abstract**: An energy storage system having a multiple different types of energy storage and conversion devices. Each device is equipped with one or more sensors and RFID tags to communicate sensor information wirelessly to a central electronic management system, which is used to control the operation of each device. Each device can have multiple RFID tags and sensor types. Several energy storage and conversion devices can be combined.

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ENERGY STORAGE MANAGEMENT SYSTEM WITH DISTRIBUTED WIRELESS SENSORS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit under 35 U.S.C. § 119(e) of United States Provisional Patent Application No. 61/650,359 filed 5/22/2012 entitled "Thermally Integrated Fire Suppression System for Lithium-Ion Battery Packs" and United States Provisional Patent Application No. 61/650,649 filed 05/23/2012 entitled "Lithium Ion Battery Management System with Distributed Wireless & Fiber Optic Sensors, and Embedded Fire Suppression System. The disclosure of United States Provisional Patent Application No. 61/650,359 and No. 61/650,649 are hereby incorporated herein by reference in its entirety for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

[0002] The United States Government has rights in this invention pursuant to Contract No. DE-AC52-07NA27344 between the United States Department of Energy and Lawrence Livermore National Security, LLC for the operation of Lawrence Livermore National Laboratory.

BACKGROUND

Field of Endeavor

[0003] The present invention relates to energy storage and more particularly to an energy storage system having multiple different types of energy storage and conversion devices.

State of Technology

[0004] Lithium-ion batteries fail violently, especially when connected in large series parallel arrangements for battery packs. Many recent commercial and military events have shown the destructive power of these cells during thermal events. The key to mitigating thermal runaway is to stop the failing cell early by removing heat generated by the cell during one of these events, which include internal shorting, external shorting, overcharging, or some form of destroying the cell via force. Currently, the only means for containing an event is to douse the battery with hand held fire extinguisher.

SUMMARY

[0005] Features and advantages of the present invention will become apparent from the following description. Applicants are providing this description, which includes drawings and examples of specific embodiments, to give a broad representation of the invention. Various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this description and by practice of the invention. The scope of the invention is not intended to be limited to the particular forms disclosed and the invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims.

[0006] The present invention provides an energy storage system consisting of multiple different types of energy storage and conversion devices. Each device is

equipped with one or more sensors and RFID tags to communicate sensor information wirelessly to a central electronic management system, which is used to control the operation of each device. Each device can have multiple RFID tags and sensor types. Several energy storage and conversion devices can be combined, including, but not limited to: batteries, capacitors, fuel cells, flywheels, internal combustion engine, gas turbines, and/or multiple different types of each.

[0007] This system is used when multiple different types of energy storage and conversion systems are required to meet a range of operation conditions. For example, in an electric vehicle, capacitors can be used to deliver/absorb high-rate pulses (seconds) of energy, while a lithium-ion battery is used for delivering larger amounts of energy or a longer period of time (minutes to hours).

[0008] The invention is susceptible to modifications and alternative forms. Specific embodiments are shown by way of example. It is to be understood that the invention is not limited to the particular forms disclosed. The invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated into and constitute a part of the specification, illustrate specific embodiments of the invention and, together with the general description of the invention given above, and the detailed description of the specific embodiments, serve to explain the principles of the invention.

[0010] FIG. 1 illustrates the components of one embodiment of an energy storage management system of the present invention.

[0011] FIG. 2 illustrates the components of another embodiment of an energy storage management system of the present invention.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0012] Referring to the drawings, to the following detailed description, and to incorporated materials, detailed information about the invention is provided including the description of specific embodiments. The detailed description serves to explain the principles of the invention. The invention is susceptible to modifications and alternative forms. The invention is not limited to the particular forms disclosed. The invention covers all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the claims.

[0013] Referring now to the drawings and in particular to FIG. 1, the components of one embodiment of an energy storage management system of the present invention are illustrated. The energy storage management system is designated generally by the reference numeral 100. The energy storage management system 100 provides an energy storage system having multiple different types of energy storage and conversion devices. Each device is equipped with one or more sensors and RFID tags to communicate sensor information wirelessly to a central electronic management system, which is used to monitor and control the operation of each device. Each device can have multiple RFID tags and sensor types. Several energy storage and conversion devices can be combined, including, but not limited to: batteries, capacitors, fuel cells, flywheels, internal combustion engine, gas turbines, and/or multiple different types of each.

[0014] As illustrated in FIG. 1, an apparatus monitors parameters of an energy storage system including a battery pack 102 in a housing 104 that

includes a multiplicity of individual battery cells 106. A multiplicity of battery radio frequency identification and sensor units 110 are connected to each of the individual battery cells 106. The radio frequency identification and sensor units 110 operating to sense parameters of each individual battery cell 106 and provide radio frequency transmission of the parameters of each individual battery cell.

[0015] Also illustrated in FIG. 1 are a flywheel unit 112, a fuel cell unit 116, a capacitor unit 120, and a system connect 124. A fly wheel radio frequency identification and sensor unit 114 is connected to the fly wheel unit 112. The fly wheel radio frequency identification and sensor unit 114 operates to sense parameters of the fly wheel unit 112 and provide radio frequency transmission of the parameters of the fly wheel unit 112. A fuel cell radio frequency identification and sensor unit 118 is connected to the fuel cell unit 116. The fuel cell radio frequency identification and sensor unit 118 operates to sense parameters of the fuel cell unit 116 and provide radio frequency transmission of the parameters of the fuel cell 116. A capacitor radio frequency identification and sensor unit 122 is connected to the capacitor unit 120. The capacitor radio frequency identification and sensor unit 122 operates to sense parameters of the capacitor unit 120 and provide radio frequency transmission of the parameters of the capacitor unit 120. A management system 108 monitors the battery radio frequency identification transmissions, the fly wheel radio frequency identification transmissions, the fuel cell radio frequency identification transmissions, and the capacitor radio frequency identification transmissions for monitoring parameters of the energy storage system 100.

[0016] The structural components of the energy storage management system 100 having been described the operation of the energy storage

management system 100 will now be considered. The energy storage management system 100 includes the steps of providing a battery energy storage unit having multiplicity of individual battery cells 106. Associating an individual battery radio frequency identification and sensor unit 110 with each individual battery cell. Using the individual battery radio frequency identification and sensor unit to sense battery parameters of the individual battery cells and provide battery radio frequency transmissions of the battery parameters. Providing at least one additional energy storage unit (112, 116, 120). Associating an individual additional energy storage unit radio frequency identification and sensor unit with the additional energy storage unit. Using the additional energy storage unit radio frequency identification and sensor unit to sense parameters of the additional energy storage unit and provide additional energy storage unit radio frequency transmissions. Monitoring the battery radio frequency transmissions and the additional energy storage unit radio frequency transmissions.

[0017] The energy storage management system 100 can be used when multiple different types of energy storage and conversion systems are required to meet a range of operation conditions. For example, in an electric vehicle, capacitors can be used to deliver/absorb high-rate pulses (seconds) of energy, while a lithium-ion battery is used for delivering larger amounts of energy or a longer period of time (minutes to hours). The energy storage management system 100 utilizes distributed addressable wireless sensors to directly measure several key operating parameters of lithium ion cells and battery packs that can be utilized to control their operation and serve as early indicators of the onset of thermal runaway. The specific cell parameters include voltage, temperature, and strain, which the latter serves as a proxy for internal cell pressure. Applicant has

developed a prototype version of this system, which has demonstrated wireless transmission data. By using very low profile sensors, every cell in the final battery deliverable can have its voltage, temperature, and sidewall strain monitored wireless. As a result of having a higher fidelity in the number of sensing points, the operation of the system 100 includes extensive monitoring to enable safe operation of very high energy density cells in a high packing factor. In addition, using sensors on the different energy storage systems and communicating this information wirelessly enables enhanced scalability, which can be facilitated by multiplexing this technology.

[0018] The energy storage management system's 100 deployment of large lithium-ion battery packs are made safer and more reliable by increasing the number of sensing points. By communicating this information wirelessly, the delivered hybrid energy storage system will monitor every module and sub module without the need for large bundles of cables to carry sensor signals to the energy management system. By increasing the number of sensors through the use of the wireless system, Applicant anticipates being able to safely deploy much higher energy density systems with increased modularity and the ability to extract performance information without any modifications or the utilization of additional cumbersome DAQ hardware. Finally, the by communicating wirelessly between the energy storage and management system, the system 100 will have greater flexibility to deploy multiple different types of energy storage systems in the most optimal arrangement.

[0019] Referring now to the drawings and in particular to FIG. 2, the components of another embodiment of an energy storage management system of the present invention are illustrated. The energy storage management system is designated generally by the reference numeral 200. The energy

storage management system 200 provides an energy storage system having multiple different types of energy storage and conversion devices. Each device is equipped with one or more sensors and RFID tags to communicate sensor information wirelessly to a central electronic management system, which is used to monitor and control the operation of each device. Each device can have multiple RFID tags and sensor types. Several energy storage and conversion devices can be combined, including, but not limited to: batteries, batteries, capacitors, fuel cells, flywheels, internal combustion engine, gas turbines, and/or multiple different types of each.

[0020] As illustrated in FIG. 2, an apparatus monitors parameters of an energy storage system including a battery type 1 (206) and a battery type 2 (206a) that includes a multiplicity of individual battery cells. A multiplicity of battery radio frequency identification and sensor units 210 and 210a are connected to each of the individual battery cells. The radio frequency identification and sensor units 210 and 210a operating to sense parameters of each individual battery cell and provide radio frequency transmission of the parameters of each individual battery cell.

[0021] Also illustrated in FIG. 2 are a flywheel unit 212, a fuel cell unit 216, a capacitor unit 220, and an internal combustion engine 224. A fly wheel radio frequency identification and sensor unit 214 is connected to the fly wheel unit 212. The fly wheel radio frequency identification and sensor unit 214 operates to sense parameters of the fly wheel unit 212 and provide radio frequency transmission of the parameters of the fly wheel unit 212. A fuel cell radio frequency identification and sensor unit 218 is connected to the fuel cell unit 216. The fuel cell radio frequency identification and sensor unit 218 operates to sense parameters of the fuel cell unit 216 and provide radio frequency transmission of the parameters of the fuel cell 216. A capacitor radio frequency identification

and sensor unit 222 is connected to the capacitor unit 220. The capacitor radio frequency identification and sensor unit 222 operates to sense parameters of the capacitor unit 220 and provide radio frequency transmission of the parameters of the capacitor unit 220. A radio frequency identification and sensor unit 226 is connected to the internal combustion engine 224. The radio frequency identification and sensor unit 226 operates to sense parameters of the internal combustion engine 224 and provide radio frequency transmission of the parameters of the internal combustion engine 224.

[0022] A management system 208 and 208a monitors the battery radio frequency identification transmissions, the fly wheel radio frequency identification transmissions, the fuel cell radio frequency identification transmissions, and the capacitor radio frequency identification transmissions for monitoring parameters of the energy storage system 200.

[0023] The structural components of the energy storage management system 200 having been described the operation of the energy storage management system 200 will now be considered. The energy storage management system 200 includes the steps of providing a battery energy storage unit having multiplicity of individual battery cells 206. An individual battery radio frequency identification and sensor unit 210 is associated with each individual battery cell. The individual battery radio frequency identification and sensor unit is used to sense battery parameters of the individual battery cells and provide battery radio frequency transmissions of the battery parameters. In the system, at least one additional energy storage unit is provided (212, 216, 220, 224), and each individual additional energy storage unit is associated with a radio frequency identification and sensor unit (214, 218, 222, and 226 respectively). These additional energy storage unit

radio frequency identification and sensor units sense parameters of the additional energy storage unit and provide additional energy storage unit radio frequency transmissions, while monitoring both the battery radio frequency transmissions and the additional energy storage unit radio frequency transmissions.

[0024] Although the description above contains many details and specifics, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. Other implementations, enhancements and variations can be made based on what is described and illustrated in this patent document. The features of the embodiments described herein may be combined in all possible combinations of methods, apparatus, modules, systems, and computer program products. Certain features that are described in this patent document in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub combination or variation of a sub combination. Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. Moreover, the separation

of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments.

[0025] Therefore, it will be appreciated that the scope of the present invention fully encompasses other embodiments which may become obvious to those skilled in the art. In the claims, reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." All structural and functional equivalents to the elements of the above-described preferred embodiment that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device to address each and every problem sought to be solved by the present invention, for it to be encompassed by the present claims. Furthermore, no element or component in the present disclosure is intended to be dedicated to the public regardless of whether the element or component is explicitly recited in the claims. No claim element herein is to be construed under the provisions of 35 U.S.C. 112, sixth paragraph, unless the element is expressly recited using the phrase "means for."

[0026] While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

THE INVENTION CLAIMED IS

Claim 1. An apparatus for monitoring parameters of an energy storage system, comprising:

a battery energy storage unit having a multiplicity of individual battery storage cells in subsets;

a battery radio frequency identification and sensor unit connected to each of said multiplicity of individual battery storage cells subsets, said battery radio frequency identification and sensor units operating to sense parameters of each said multiplicity of individual battery storage cells and provide radio frequency transmission of said parameters of each individual energy storage cell;

at least one additional energy storage unit;

an additional radio frequency identification and sensor unit connected to said at least one additional energy storage unit, said additional radio frequency identification and sensor unit operating to sense parameters of said at least one additional energy storage unit and provide radio frequency transmission of said parameters of said at least one additional energy storage unit; and

a management system that monitors said radio frequency transmissions from said battery radio frequency identification and sensor units and said at least one additional energy storage unit.

Claim 2. The apparatus for monitoring parameters of an energy storage system of claim 1, wherein said at least one additional energy storage unit is a capacitor.

Claim 3. The apparatus for monitoring parameters of an energy storage system of claim 1, wherein said at least one additional energy storage unit is a fly wheel unit.

Claim 4. The apparatus for monitoring parameters of an energy storage system of claim 1, wherein said at least one additional energy storage unit is a fuel cell or an internal combustion engine or a gas turbine or multiple combinations of each.

Claim 5. An apparatus for monitoring parameters of an energy storage system, comprising:

a battery pack that includes a multiplicity of individual battery cells;

a multiplicity of battery radio frequency identification and sensor units connected to each of said individual battery cells, said radio frequency identification and sensor unit operating to sense the parameters of each individual battery cell and provide radio frequency transmission of said parameters of each individual battery cell;

a capacitor;

a capacitor radio frequency identification and sensor unit connected to said capacitor, said capacitor radio frequency identification and sensor unit operating to sense the parameters of said capacitor and provide radio frequency transmission of the parameters of said capacitor;

a fuel cell;

a fuel cell radio frequency identification and sensor unit connected to said fuel cell, said fuel cell radio frequency identification and sensor unit operating

to sense the parameters of said fuel cell and provide radio frequency transmission of the parameters of said fuel cell; and

a management system that monitors

said battery radio frequency identification transmissions,

said capacitor radio frequency identification transmissions, and

said fuel cell radio frequency identification transmissions.

Claim 6. The apparatus for monitoring parameters of an energy storage system of claim 5 further comprising a fly wheel unit and a fly wheel radio frequency identification and sensor unit connected to said fly wheel unit, said fly wheel radio frequency identification and sensor unit operating to sense parameter of said fly wheel unit and provide radio frequency transmissions of the parameters of said fly wheel unit; wherein said management system further monitors said fly wheel radio frequency identification transmissions.

Claim 7. An apparatus for monitoring parameters of an energy storage system, comprising:

a battery pack that includes a multiplicity of individual battery cells;

a multiplicity of battery radio frequency identification and sensor units connected to each of said individual battery cells, said radio frequency identification and sensor unit operating to sense parameters of each individual battery cell and provide radio frequency transmission of said parameters of each individual battery cell;

a fly wheel unit,

a fly wheel radio frequency identification and sensor unit connected to said fly wheel unit, said fly wheel radio frequency identification and sensor

unit operating to sense parameters of said fly wheel unit and provide radio frequency transmission of said parameters of said fly wheel unit;

a fuel cell,

a fuel cell radio frequency identification and sensor unit connected to said fuel cell, said fuel cell radio frequency identification and sensor unit operating to sense parameters of said fuel cell and provide radio frequency transmission of said parameters of said fuel cell;

a capacitor,

a capacitor radio frequency identification and sensor unit connected to said capacitor, said capacitor radio frequency identification and sensor unit operating to sense parameters of said capacitor and provide radio frequency transmission of said parameters of said capacitor; and

a management system that monitors

said battery radio frequency identification transmissions,

said fly wheel radio frequency identification transmissions,

said fuel cell radio frequency identification transmissions, and

said capacitor radio frequency identification transmissions

for monitoring parameters of the energy storage system.

Claim 8. The apparatus for monitoring parameters of an energy storage system of claim 7 wherein said parameters of each individual battery cell include temperature of each said individual battery cell.

Claim 9. The apparatus for monitoring parameters of an energy storage system of claim 7 wherein said parameters of each individual battery cell include voltage of each said individual battery cell.

Claim 10. The apparatus for monitoring parameters of an energy storage system of claim 7 wherein said parameters of each individual battery cell include strain parameters of each said individual battery cell.

Claim 11. The apparatus for monitoring parameters of an energy storage system of claim 7 wherein said parameters of each individual battery cell include temperature, voltage, and strain parameters of each said individual battery cell.

Claim 12. A method monitoring parameters of an energy storage system, comprising the steps of:

providing a battery energy storage unit having multiplicity of individual battery cells;

associating an individual battery radio frequency identification and sensor unit with each said individual battery cells;

using said individual battery radio frequency identification and sensor unit to sense battery parameters of said individual battery cells and provide battery radio frequency transmissions of said battery parameters;

providing at least one additional energy storage unit;

associating an individual additional energy storage unit radio frequency identification and sensor unit with said additional energy storage unit;

using said additional energy storage unit radio frequency identification and sensor unit to sense parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions; and

monitoring said battery radio frequency transmissions and said additional energy storage unit radio frequency transmissions.

Claim 13. The method monitoring parameters of an energy storage system of claim 12 wherein said step of providing at least one additional energy storage unit comprises providing a capacitor energy storage unit.

Claim 14. The method monitoring parameters of an energy storage system of claim 12 wherein said step of providing at least one additional energy storage unit comprises providing a fly wheel energy storage unit.

Claim 15. The method monitoring parameters of an energy storage system of claim 12 wherein said step of providing at least one additional energy storage unit comprises providing a fuel cell energy storage unit.

Claim 16. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said individual battery radio frequency identification and sensor unit to sense battery parameters of said individual battery cells and provide battery radio frequency transmissions of said battery parameters comprises using said individual battery radio frequency identification and sensor unit to sense temperature parameters of said individual battery cells and provide battery radio frequency transmissions of said temperature parameters.

Claim 17. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said individual battery radio frequency

identification and sensor unit to sense battery parameters of said individual battery cells and provide battery radio frequency transmissions of said battery parameters comprises using said individual battery radio frequency identification and sensor unit to sense voltage parameters of said individual battery cells and provide battery radio frequency transmissions of said voltage parameters.

Claim 18. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said individual battery radio frequency identification and sensor unit to sense battery parameters of said individual battery cells and provide battery radio frequency transmissions of said battery parameters comprises using said individual battery radio frequency identification and sensor unit to sense strain parameters of said individual battery cells and provide battery radio frequency transmissions of said strain parameters.

Claim 19. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said individual battery radio frequency identification and sensor unit to sense battery parameters of said individual battery cells and provide battery radio frequency transmissions of said battery parameters comprises using said individual battery radio frequency identification and sensor unit to sense temperature, voltage, and strain parameters of said individual battery cells and provide battery radio frequency transmissions of said temperature, voltage, and strain parameters.

Claim 20. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said additional energy storage unit radio frequency identification and sensor unit to sense parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions using said additional energy storage unit radio frequency identification and sensor unit to sense temperature parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions of said temperature parameters.

Claim 21. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said additional energy storage unit radio frequency identification and sensor unit to sense parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions using said additional energy storage unit radio frequency identification and sensor unit to sense voltage parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions of said voltage parameters.

Claim 22. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said additional energy storage unit radio frequency identification and sensor unit to sense parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions using said additional energy storage unit radio frequency identification and sensor unit to sense strain parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions of said strain parameters.

Claim 23. The method monitoring parameters of an energy storage system of claim 12 wherein said step of using said additional energy storage unit radio frequency identification and sensor unit to sense parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions using said additional energy storage unit radio frequency identification and sensor unit to sense temperature, voltage, and strain parameters of said additional energy storage unit and provide additional energy storage unit radio frequency transmissions of said temperature, voltage, and strain parameters.

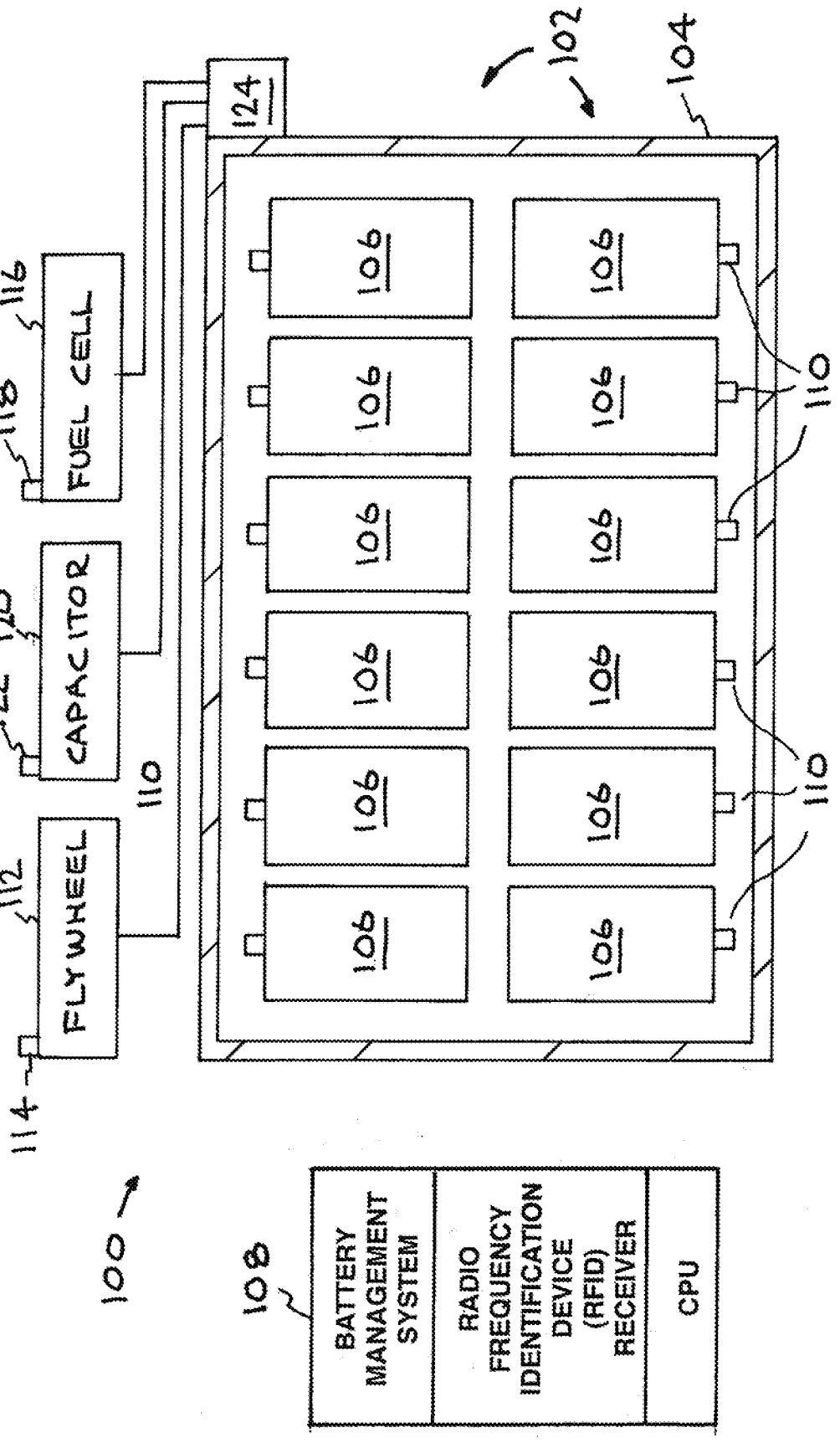

100
102
104
106
108
110
112
114
116
118
120
122
124
FUEL CELL
CAPACITOR
FLYWHEEL
BATTERY MANAGEMENT SYSTEM
RADIO FREQUENCY IDENTIFICATION DEVICE (RFID) RECEIVER
CPU

FIG. 1

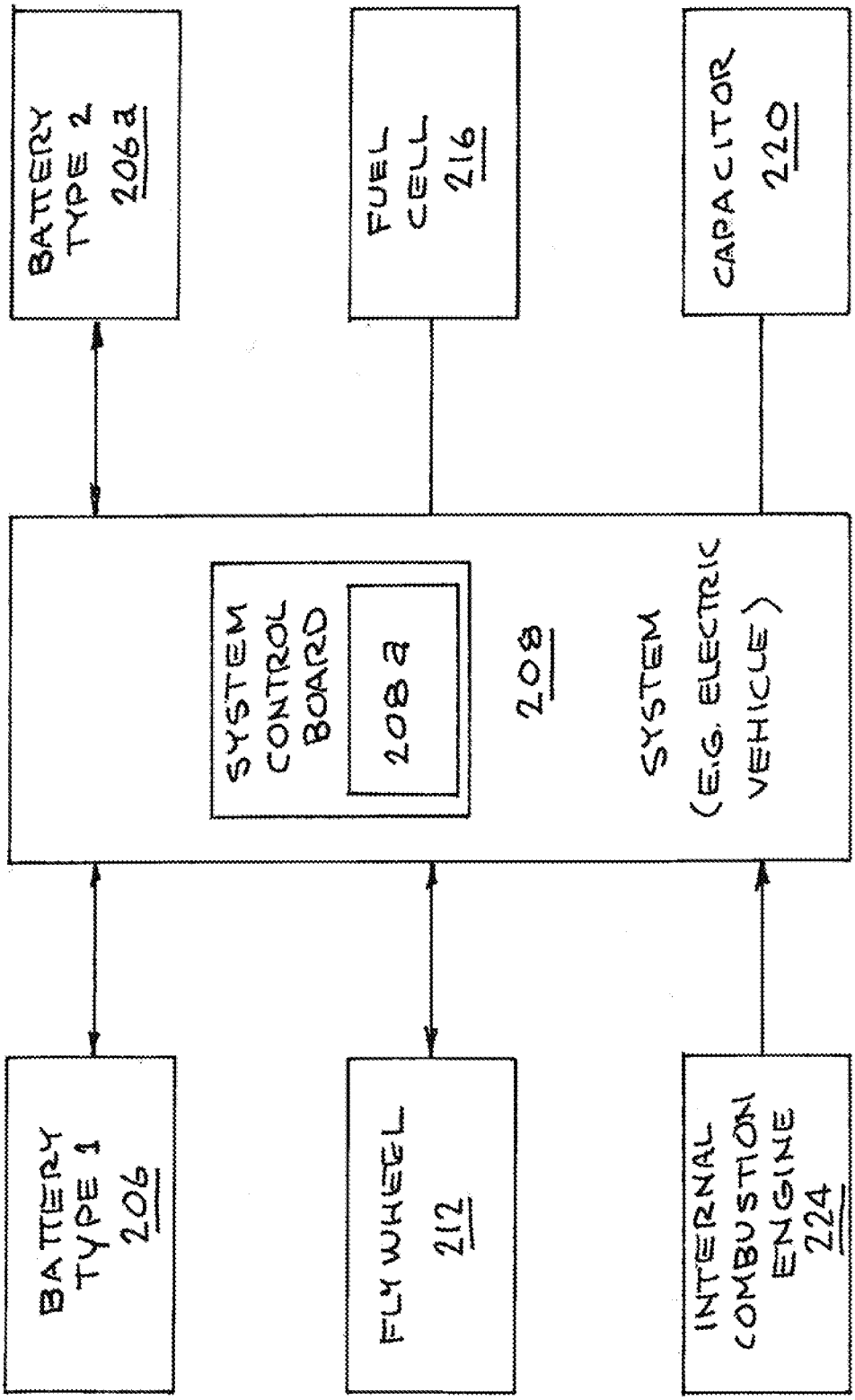

BATTERY TYPE 2 206a
FUEL CELL 216
CAPACITOR 220
SYSTEM CONTROL BOARD
208a
208
SYSTEM (E.G. ELECTRIC VEHICLE)
BATTERY TYPE 1 206
FLY WHEEL 212
INTERNAL COMBUSTION ENGINE 224

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/039201

A. CLASSIFICATION OF SUBJECT MATTER

G01R 31/36(2006.01)i, H02J 7/00(2006.01)i, H01M 10/48(2006.01)i, G08C 17/02(2006.01)i

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)
G01R 31/36; H01M 8/04; B65B 3/00; G06F 19/00; G08B 21/00; H02J 7/00; G01R 21/00; H01M 10/48; G08C 17/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: battery, cell, RFID, sensor, multiplicity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0127954 A1 (WALLEY et al.) 02 June 2011 See abstract, paragraphs [0143]-[0147], claims 1-7 and figures 25-26.	1-4,12-23
A		5-11
Y	US 2009-0220827 A1 (KNAGGS et al.) 03 September 2009 See abstract, paragraphs [0017], [0032]-[0047], claims 1-6, 26 and figures 1-2B.	1-4,12-23
A		5-11
A	US 2006-0019135 A1 (CURELLO et al.) 26 January 2006 See paragraphs [0047]-[0099], claims 1-10 and figures 1-5.	1-23
A	US 2010-0114511 A1 (STEWART) 06 May 2010 See abstract, paragraphs [0035]-[0050] and figures 1-3.	1-23
A	US 6313751 B1 (WHITMIRE et al.) 06 November 2001 See abstract, claims 1-2 and figures 1-3.	1-23

☐ 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
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"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	Date of mailing of the international search report
25 September 2014 (25.09.2014)	**25 September 2014 (25.09.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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