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(54) **BATTERY PACK AND BATTERY SYSTEM**

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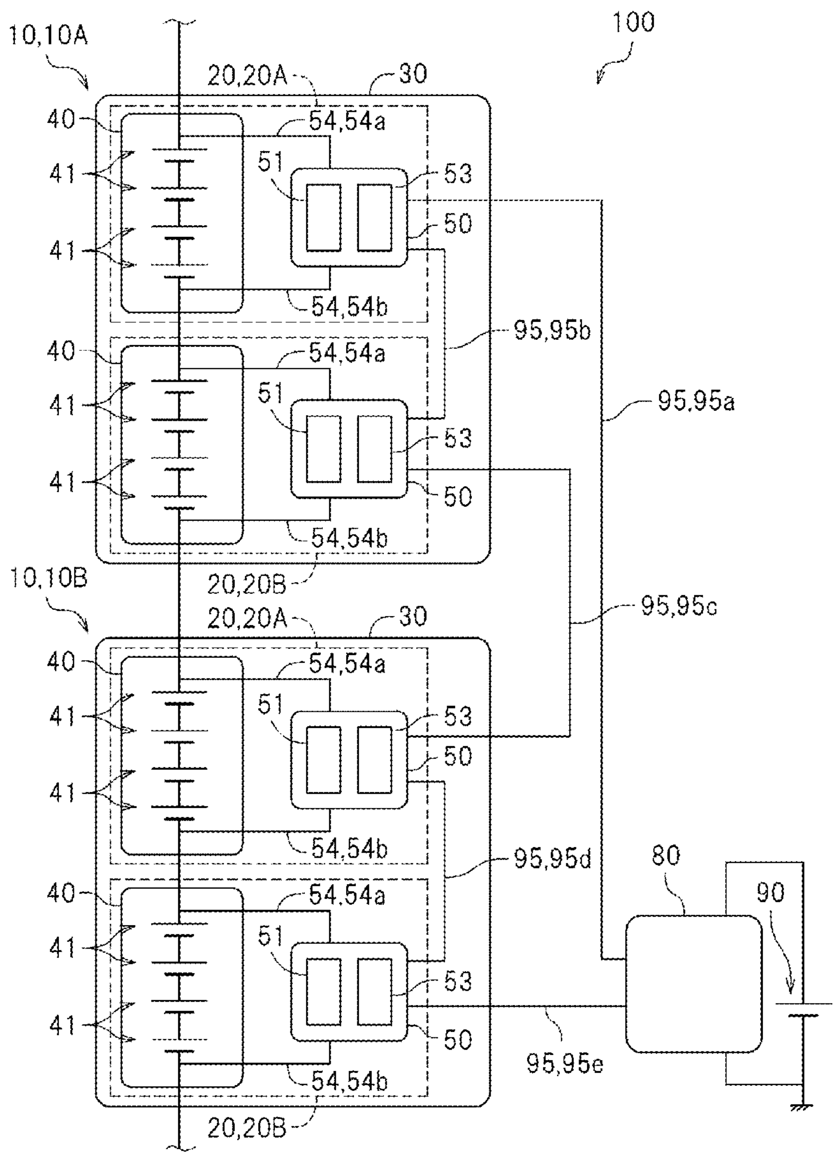
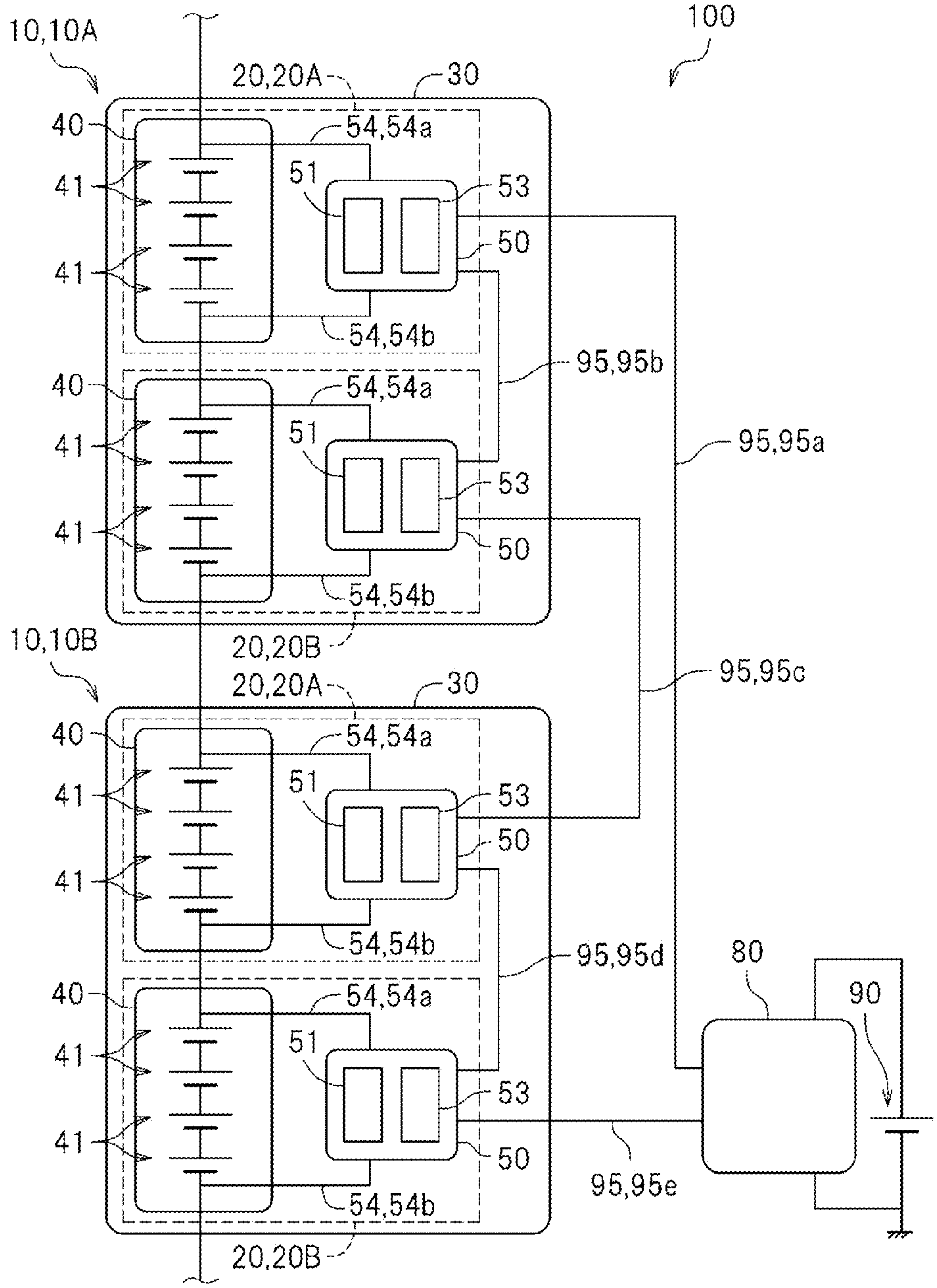
(57) **ABSTRACT**

A battery pack includes a plurality of cell module units and a pack case housing the plurality of cell module units. Each of the cell module units includes a cell module including a plurality of battery cells, an abnormality detection means electrically connected to the cell module to use the cell module as its power source. The abnormality detecting means is configured to output a signal to an external controller when detecting an abnormality in an entirety of the pack case.





100
10,10A
10,10B
20,20A
20,20B
30
40
41
50
51
53
54,54a
54,54b
95,95a
95,95b
95,95c
95,95d
95,95e
80
90

FIG.1

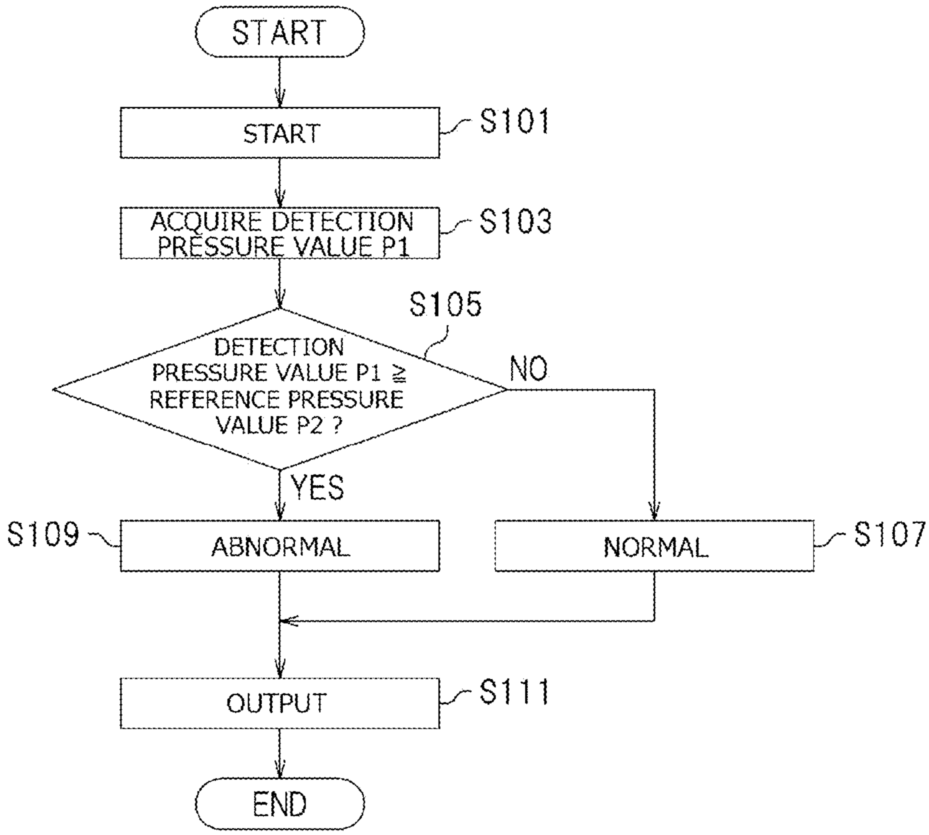

START
START
S101
ACQUIRE DETECTION PRESSURE VALUE P1
S103
S105
DETECTION PRESSURE VALUE P1 ≧ REFERENCE PRESSURE VALUE P2 ?
NO
YES
S109
ABNORMAL
NORMAL
S107
OUTPUT
S111
END

FIG.2

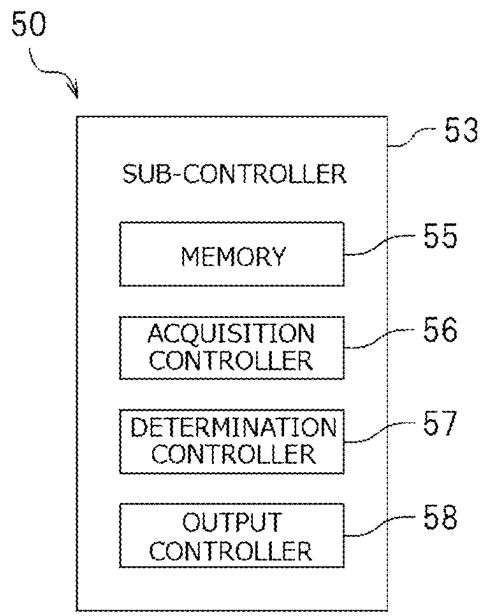
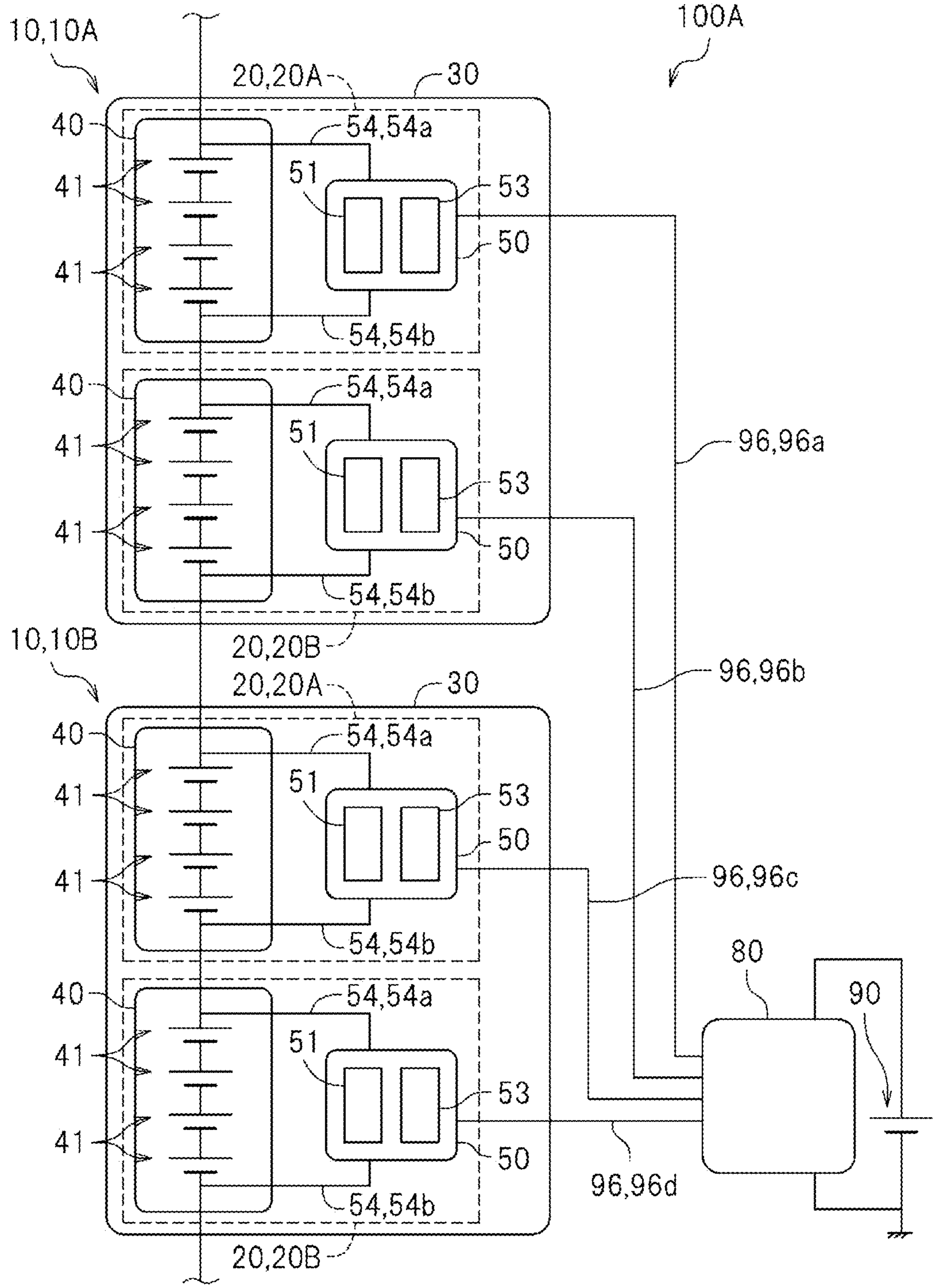

50
53
SUB-CONTROLLER
MEMORY
55
ACQUISITION CONTROLLER
56
DETERMINATION CONTROLLER
57
OUTPUT CONTROLLER
58

FIG.3



100A
10,10A
20,20A
30
40
41
54,54a
51
53
50
54,54b
20,20B
96,96a
96,96b
10,10B
96,96c
80
90
96,96d

FIG.4

BATTERY PACK AND BATTERY SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority from Japanese Patent Application No. 2024-023304 filed on Feb. 20, 2024, which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] The present invention relates to battery packs and battery systems.

[0003] JP 2010-080135 A, for example, discloses a battery system including a plurality of battery blocks connected in series, a battery status detection circuit, and a main control circuit. Each battery block includes a plurality of battery cells connected in series. The battery status detection circuit is connected to each of the battery cells, and includes a circuit that detects the voltage and temperature of the battery cells.

[0004] The battery status detection circuit outputs the voltage and temperature of each of the battery cells to the main control circuit. The main control circuit controls the status of each of the battery cells based on the voltage and temperature of each of the battery cells.

SUMMARY

[0005] In the battery system disclosed in JP 2010-080135 A, the battery status detection circuit is electrically connected to the battery block that is to be detected, to use the battery block as the power source. If an abnormality occurs in the battery block and power is not supplied to the battery status detection circuit, it may be possible that the electric power source for the battery status detection circuit is lost. In this case, there may be a risk that the battery status detection circuit does not start properly and is thus unable to detect the status of the battery block.

[0006] In accordance with the present disclosure, a battery pack includes a plurality of cell module units, and a pack case housing the plurality of cell module units. Each of the cell module units includes a cell module including a plurality of battery cells, an abnormality detection means electrically connected to the cell module to use the cell module as its power source. The abnormality detecting means is configured to output a signal to an external controller when detecting an abnormality in an entirety of the pack case.

[0007] In the battery pack disclosed herein, a plurality of cell modules are housed inside the pack case, and the abnormality detecting means is provided that is electrically connected to each of the cell modules. Therefore, even when an abnormality occurs in one of the plurality of cell modules and one of the plurality of abnormality detecting means loses power, it is possible to detect an abnormality in the entirety of the pack case by a remaining one of the abnormality detecting means.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a schematic view illustrating a battery system according to a first embodiment.

[0009] FIG. **2** is a flowchart illustrating an abnormality detection method.

[0010] FIG. **3** is a block diagram illustrating the configuration of a sub-controller.

[0011] FIG. **4** is a schematic view illustrating a battery system according to a second embodiment.

DETAILED DESCRIPTION

[0012] Hereinbelow, embodiments of the technology according to the present disclosure will be described with reference to the drawings. It should be noted, however, that the embodiments disclosed herein are, of course, not intended to limit the invention. The drawings are schematic illustrations, and do not necessarily reflect any actual product. The features and components that exhibit the same effects are designated by the same reference symbols as appropriate, and the description thereof will not be repeated as appropriate.

First Embodiment

[0013] FIG. **1** is a schematic view illustrating a battery system **100** according to a first embodiment. The battery system **100** according to the present embodiment is connected to a load, not shown. The load to be connected to the battery system **100** is not limited to any particular type of load. The load may be, for example, a load in a vehicle, which may include a drive device of the vehicle, such as an electric motor, or an inverter or the like. The battery system **100** is mounted in a vehicle, such as a hybrid electric vehicle and an battery electric vehicle, and is used as the power source to supply electric power to an electric motor for driving the vehicle. The battery system **100** is, however, not limited to those for use in vehicles.

[0014] As illustrated in FIG. **1**, the battery system **100** includes a plurality of battery packs **10**, a controller **80**, and an auxiliary equipment power supply **90**. The number of battery packs **10** is not limited to any particular number, but may be two herein. The number of battery packs **10** may also be three or more. In the following description, one of the two battery packs **10** may also be referred to as a battery pack **10**A and the other one may also be referred to as a battery pack **10**B. Herein, the battery packs **10**A and **10**B have the same configuration. Hereinafter, in the description common to the battery packs **10**A and **10**B, the battery pack may be referred to as a battery pack **10**.

[0015] The battery pack **10** includes a plurality of cell module units **20** and a pack case **30**. The plurality of cell module units **20** are housed in the pack case **30**. The pack case **30** is a hermetically sealed case. Herein, the phrase "hermetically sealed" means a condition in which no external air enters the inside of the pack case **30**, and a condition in which the pressure inside the pack case **30** does not change due to external factors. The pack case **30** is formed of a metal, for example. However, the material that forms the pack case **30** is not limited to any particular material.

[0016] The number of the cell module units **20** housed in one pack case **30** is not limited to any particular number as long as it is plural. In the present embodiment, the number of the cell module units **20** housed in one pack case **30** is two. Herein, one of the two cell module units **20** may also be referred to as a cell module unit **20**A and the other one may also be referred to as a cell module unit **20**B. The cell module units **20**A and **20**B have the same configuration. Hereinafter, in the description common to the cell module units **20**A and **20**B, each cell module unit may be referred to as a cell module unit **20**.

[0017] In the present embodiment, the cell module unit **20** includes a cell module **40** and an abnormality detecting means **50**. The cell module **40** includes a plurality of battery cells **41**. The battery cells **41** are ones that are capable of being charged and discharged. Each of the battery cells **41** may be, for example, a secondary battery in which repeated charging and discharging are possible by means of migration of charge carriers through an electrolyte between a pair of electrodes (for example, positive electrode and negative electrode). Each of the battery cells **41** may be a lithium-ion secondary battery, a nickel-metal hydride battery, or the like, for example. In the present embodiment, the plurality of battery cells **41** are connected in series. Herein, the plurality of battery cells **41** are connected in series via a bus bar, not shown. However, it is also possible that the plurality of battery cells **41** may be connected in parallel. The number of battery cells **41** in each one cell module **40** is not limited to any particular number and may be a predetermined number. The number of battery cells **41** in the cell module **40** in each of the cell module units **20** may be the same or different.

[0018] The abnormality detecting means **50** is a means that detects an abnormality in the entirety of the pack case **30**. Herein, the phrase "abnormality in the entirety of pack case **30**" refers to an abnormality of a component, such as a battery cell **41** of the cell module **40**, that is housed in the pack case **30**. The abnormality of the cell module **40** (for example, a battery cell **41**) may be, for example, a high temperature abnormality that occurs due to a high temperature of the battery cell **41**. The abnormality detecting means **50** is configured to output a signal to an external controller **80** when detecting an abnormality in the entirety of the pack case **30**. In the following description, the phrase "abnormality in the entirety of pack case **30**" may also be referred to as "abnormality inside pack case **30**". As illustrated in FIG. **1**, the abnormality detecting means **50** housed in the pack case **30**. However, at least some of the parts that constitute the abnormality detecting means **50** may be provided external to the pack case **30**. In the present embodiment, the abnormality detecting means **50** uses the plurality of battery cells **41** contained in the cell module **40** as its power source. The abnormality detecting means **50** is electrically connected to the cell module **40** (in other words, the plurality of battery cells **41**). In the present embodiment, the abnormality detecting means **50** is electrically connected to the cell module **40** via a power wire **54**. The power wire **54** includes a first power wire **54***a* that is electrically connected to the positive electrode side of the cell module **40** and a second power wire **54***b* that is electrically connected to the negative electrode side of the cell module **40**.

[0019] Note that the configuration of the abnormality detection element **50** is not particularly limited. Herein, as illustrated in FIG. **1**, the abnormality detecting means **50** includes a pressure sensor **51** and a sub-controller **53**. The pressure sensor **51** is housed in the pack case **30**. In the present embodiment, each one pack case **30** houses a plurality of pressure sensors **51** (two pressure sensors **51** herein). The pressure sensor **51** detects the pressure inside the pack case **30**. In the present embodiment, for example, when an abnormality occurs in the entirety of the pack case **30**, the pressure inside the pack case **30** may become higher. Accordingly, the abnormality detecting means **50** detects that an abnormality is occurring in the entirety of the pack case **30** when the pressure inside the pack case **30** that is detected by the pressure sensor **51** has become higher.

[0020] The sub-controller **53** determines whether or not an abnormality is occurring in the entirety of the pack case **30**, and outputs a signal to the external controller **80** if it is determined that the abnormality is occurring. The sub-controller **53** is composed of an ASIC (Application Specific Integrated Circuit), for example. However, the sub-controller **53** may be composed of a microcomputer, for example. The sub-controller **53** may include a communication interface, a central processing unit (CPU) that executes control program instructions, a read only memory (ROM) that stores programs executed by the CPU, a random access memory (RAM) used as a working area for deploying the programs, and a storage device, such as a memory, that stores the foregoing programs and various data. Note that the sub-controller **53** may be composed of a single device (for example, a single CPU) or may be configured to execute control operations by a plurality of devices in cooperation with each other.

[0021] In the present embodiment, the sub-controller **53** is housed in the pack case **30**. However, it is also possible that the sub-controller **53** may be provided external to the pack case **30**. The sub-controller **53** is communicably connected to the pressure sensor **51** that is in the same cell module unit **20**. For example, the sub-controller **53** acquires a detected pressure value P1 (see FIG. **2**) inside the pack case **30**, which is detected by the pressure sensor **51**. Then, based on the detected pressure value P1 acquired from the pressure sensor **51**, the sub-controller **53** determines whether or not an abnormality is occurring in the entirety of the pack case **30**. Herein, for example, the sub-controller **53** determines whether or not the detected pressure value P1 inside the pack case **30** is higher (for example, higher than later-described reference pressure value P2 (see FIG. **2**)). Then, if the sub-controller **53** determines that the detected pressure value P1 is higher (for example, higher than the reference pressure value P2), the sub-controller **53** determines that an abnormality is occurring inside the pack case **30**. At this time, if the sub-controller **53** determines that an abnormality is occurring in the entirety of the pack case **30**, it outputs a signal to the external controller **80**. For example, the sub-controller **53** outputs an abnormality signal, which indicates that an abnormality is occurring inside the pack case **30**, to the external controller **80**.

[0022] In the present embodiment, as illustrated in FIG. **1**, a plurality of cell module units **20** (i.e., the cell module units **20**A and **20**B herein) are connected in series in each one battery pack **10**. The plurality of cell modules **40** included in the plurality of cell module units **20** (in other words, the plurality of battery cells **41** connected in series) are connected in series. In addition, the plurality of battery packs **10** (battery packs **10**A and **10**B herein) included in the battery system **100** are connected in series. In other words, the cell modules **40** included in the plurality of battery packs **10** are connected in series. However, it is also possible that the plurality of cell modules **40** may be connected in parallel.

[0023] The controller **80**, like the sub-controller **53**, may be composed of, for example, an ASIC, but may also be composed of a microcomputer. The controller **80**, like the sub-controller **53**, may include a communication interface, a central processing unit, a ROM, a RAM, a storage device, and the like. The controller **80** may be composed of a single device (for example, a single CPU) or may be configured to execute control operations by a plurality of devices in cooperation with each other. The controller **80** is provided external to the pack case **30**.

[0024] In the present embodiment, the controller **80** does not use the cell modules **40** of the battery packs **10** as the power source, but uses the auxiliary equipment power supply **90** as the power source. The controller **80** is electrically connected to the auxiliary equipment power supply **90**. The type of the auxiliary equipment power supply **90** may be, but is not particularly limited to, a storage battery (a lead-acid battery herein), for example.

[0025] In the present embodiment, the controller **80** is communicably connected to each of the abnormality detecting means **50** respectively included in the plurality of battery packs **10**. Herein, the controller **80** is communicably connected to the plurality of sub-controllers **53** in the plurality of abnormality detecting means **50**. In the present embodiment, when a sub-controller **53** detects that an abnormality is occurring in the entirety of the pack case **30**, the controller **80** receives information (for example, an abnormality signal indicating that an abnormality is occurring in the entirety of the pack case **30**) that is output from the sub-controller **53**. By receiving the abnormality signal, the controller **80** is able to judge that an abnormality is occurring in the battery pack **10** (more specifically, inside the pack case **30**) that includes the sub-controller **53** that has output the abnormality signal.

[0026] In the present embodiment, as illustrated in FIG. **1**, the controller **80** and the plurality of abnormality detecting means **50** (more specifically, a plurality of sub-controllers **53**) are communicably connected to each other to form a ring topology. The connection topology of the controller **80** and the plurality of sub-controllers **50** is a ring topology. In other words, the controller **80** and the plurality of abnormality detecting means **50** are connected so as to be able to communicate with each other in a loop fashion.

[0027] As illustrated in FIG. **1**, for example, the controller **80** and the plurality of abnormality detecting means **50** are communicably connected via communication wires **95**. Two communication wires **95** are connected to each of the controller **80** and the plurality of sub-controllers **50**. The sub-controllers **53** of the plurality of abnormality detecting means **50** are able to output signals in two directions to the controller **80**. In the present embodiment, the controller **80** is communicably connected to the abnormality detecting means **50** of the cell module unit **20**A in the battery pack **10**A via a communication wire **95***a*. The abnormality detecting means **50** of the cell module unit **20**A in the battery pack **10**A is communicably connected to the abnormality detecting means **50** of the cell module unit **20**B in the battery pack **10**A via a communication wire **95***b*. The abnormality detecting means **50** of the cell module unit **20**B in the battery pack **10**A is communicably connected to the abnormality detecting means **50** of the cell module unit **20**A in the battery pack **10**B via a communication wire **95***c*. The abnormality detecting means **50** of the cell module unit **20**A in the battery pack **10**B is communicably connected to the abnormality detecting means **50** of the cell module unit **20**B in the battery pack **10**B via a communication wire **95***d*. Then, the abnormality detecting means **50** of the cell module unit **20**B in the battery pack **10**B is communicably connected to the controller **80** via a communication wire **95***e*.

[0028] Hereinabove, an exemplary configuration of the battery system **100** according to the present embodiment has been described. Next, an abnormality detection method as to whether or not an abnormality has occurred in the entirety of the pack case **30** of one of the plurality of battery packs **10** included in the battery system **100** will be described with reference to the flowchart of FIG. **2**.

[0029] FIG. **3** is a block diagram illustrating the configuration of the sub-controller **53**. In the present embodiment, in order to sequentially execute the flowchart shown in FIG. **2**, the sub-controller **53** of each of the abnormality detection means **50** includes a memory **55**, an acquisition controller **56**, a determination controller **57**, and an output controller **58**. Each unit of the sub-controller **53** may be implemented by a single processor or a plurality of processors, or may be implemented by a circuit.

[0030] In the present embodiment, at step S**101** of FIG. **2**, the battery system **100** is started. Herein, the controller **80** executes a predetermined start-up process. This start-up process causes the pressure sensor **51** and the sub-controller **53** of each of the abnormality detection means **50** to start. Herein, the start-up process by the controller **80** causes electric power to be supplied the pressure sensor **51** and the sub-controller **53** of each of the abnormality detecting means **50** from the respective cell module **40** (a plurality of battery cells **41** herein) that is electrically connected thereto via the power wire **54**, to thereby start the pressure sensor **51** and the sub-controller **53** of each of the abnormality detecting means **50**. Herein, the starting of the pressure sensor **51** means a state in which it can detect the detected pressure value Pl (see FIG. **2**) inside the pack case **30**. The starting of the sub-controller **53** means a state in which it can acquire the detected pressure value P1 detected by the pressure sensor **51** to output the detected pressure value P1 to the controller **80**.

[0031] In the present embodiment, after having been started up, the pressure sensor **51** detects (i.e., measures) a detection pressure value P1 in the pack case **30** each time a predetermined sampling time elapses. However, it is also possible, for example, that the pressure sensor **51** may be configured to detect the detection pressure value P1 inside the pack case **30** at a time when it receives the detection signal transmitted from the sub-controller **53**.

[0032] Next, at step S**103** shown in FIG. **2**, the acquisition controller **56** of the sub-controller **53** shown in FIG. **3** acquires the detection pressure value P1. In the present embodiment, when receiving a command from the controller **80**, the sub-controller **53** executes an abnormality detection method. Herein, the controller **80** transmits a detection signal to each of the sub-controllers **53** (more specifically, to the sub-controllers **53** of the respective abnormality detecting means **50** of the cell module units **20**A and **20**B in the respective battery packs **10**A and **10**B) each time a predetermined detection time elapses. The sub-controller **53** that has received the detection signal starts abnormality detection. At this time, the acquisition controller **56** of the sub-controller **53** acquires the detection pressure value P1 from the pressure sensor **51**. The detection pressure value P1 acquired by the acquisition controller **56** is stored in the memory **55** shown in FIG. **3**.

[0033] Next, at step S**105** of FIG. **2**, the determination controller **57** of the sub-controller **53** shown in FIG. **3** determines whether or not an abnormality is occurring inside the pack case **30**. Herein, the determination controller **57** determines whether or not the detection pressure value P1 is higher than or equal to a predetermined reference pressure value P2. For example, when an abnormality occurs in one of the plurality of cell modules **40** housed in a pack case **30**, the pressure inside the pack case **30** increases. When an abnormality occurs inside the pack case **30**, for example, the detection pressure value P1 detected by the pressure sensor **51** becomes higher. Therefore, the determination controller **57** determines whether or not the detection pressure value PI is higher than or equal to the reference pressure value P2 at step S**105**. The reference pressure value P2 is stored in advance in the memory **55** (see FIG. **3**) of each of the sub-controllers **53**. The reference pressure value P2 is set based on the pressure value inside a pack case **30** that is expected when an abnormality occurs in the pack case **30**.

[0034] At step S**105**, if the determination controller **57** determines that the detection pressure value P1 is lower than the reference pressure value P2, the process next proceeds to step S**107** shown in FIG. **2**. At step S**107**, the sub-controller **53** determines that the inside of the pack case **30** is normal. On the other hand, if the determination controller **57** determines that the detection pressure value P1 is higher than or equal to the reference pressure value P2 at step S**105**, the process next proceeds to step S**109** shown in FIG. **2**. At step S**109**, the sub-controller **53** determines that an abnormality is occurring inside the pack case **30**.

[0035] In the present embodiment, both when it is determined that the inside of the pack case **30** is normal at step S**107** and when it is determined that an abnormality is occurring inside the pack case **30** at step S**109**, the process proceeds to step S**111** shown in FIG. **2**.

[0036] At step S**111**, the output controller **58** of the sub-controller **53** shown in FIG. **3** outputs the status inside the pack case **30** (pack status information herein) to the controller **80**. Herein, the status inside the pack case **30** is either of normal status or abnormal status. According to the status inside the pack case **30**, the output controller **58** outputs pack status information to the controller **80**.

[0037] At step S**107** of FIG. **2**, for example, if the sub-controller **53** determines that the inside of the pack case **30** is normal, the output controller **58** outputs (e.g., transmits), to the controller **80**, normal information, which indicates that the inside of the pack case **30** is normal, as the pack status information at step S**111**. Herein, the output controller **58** transmits a normal signal to the controller **80** as the normal information. On the other hand, at step S**109** of FIG. **2**, for example, if the sub-controller **53** determines that an abnormality is occurring inside the pack case **30**, the output controller **58** outputs, to the controller **80**, abnormal information, which indicates that an abnormality is occurring inside the pack case **30**, as the pack status information at step S**111**. Herein, the output controller **58** transmits an abnormal signal to the controller **80** as the abnormal information.

[0038] In the above-described manner, the processes shown in the flowchart of FIG. **2** are executed in sequence to perform the abnormality detection method. In the present embodiment, the controller **80** transmits a detection signal to each of the sub-controllers **53** each time the predetermined detection time elapses. Each of the sub-controllers **53** executes step S**103** through step S**111** shown in FIG. **2** sequentially at a time when it receives the detection signal.

[0039] Note that the controller **80** performs control operations based on the pack status information that is output from each of the sub-controllers **53**. As illustrated in FIG. **1**, in the present embodiment, a plurality of (two herein) abnormality detecting means **50** are provided for each one pack case **30**. Therefore, when the pack status information that is output from either one of the sub-controllers **53** of the two abnormality detecting means **50** is abnormal information, the controller **80** judges that an abnormality is occurring in that pack case **30** and thus an abnormality is occurring in the battery system **100**. If the controller **80** determines that an abnormality is occurring in the battery system **100**, the controller **80** executes a predetermined abnormality process. This abnormality process may be, but is not particularly limited to, a process of stopping the battery system **100**, for example, or may be a process of sending a notification to a higher-level controller (for example, an overall controller of the vehicle in which the battery system **100** is incorporated). It should be noted that if all of the pack status information that is output from all the sub-controllers **53** is normal information, it means that the battery system **100** is normal, so the controller **80** does not perform any special control operation.

[0040] In the present embodiment, an abnormality in the entirety of the pack case **30** is detected by a plurality of abnormality detecting means **50** for each one battery pack **10**, as described above. In other words, an abnormality in the entirety of one pack case **30** is detected by a plurality of abnormality detecting means **50** that are housed in that one pack case **30**. A possible cause of an abnormality that occurs in the entirety of a pack case **30** may be, for example, an abnormality of one of the plurality of cell modules **40** housed in the pack case **30** (for example, a high temperature abnormality that occurs because the cell module **40** (at least one of the plurality of battery cells **41**) reaches a high temperature).

[0041] Here, it is assumed that an abnormality has occurred in the cell module **40** of the cell module unit **20**B of the cell module units **20**A and **20**B in the battery pack **10**A as illustrated in FIG. **1**. In this case, the inside of the pack case **30** of the battery pack **10**A reaches a high temperature, and both of the abnormality detecting means **50** in the cell module units **20**A and **20**B detect the abnormality inside the pack case **30**.

[0042] For example, if an abnormality has occurred in the cell module **40** of the cell module unit **20**B, it is possible that power may not be supplied to the abnormality detecting means **50** of the cell module unit **20**B, to which power is supplied from the cell module **40** in which the abnormality has occurred. When power is not supplied thereto, the abnormality detecting means **50** is unable to start properly and therefore unable to detect an abnormality inside the pack case **30**. However, according to the present embodiment, both of the abnormality detecting means **50** in the cell module units **20**A and **20**B detect an abnormality inside the pack case **30**. Therefore, even if the abnormality detecting means **50** of the cell module unit **20**B loses power and is unable to operate, the abnormality detecting means **50** of the cell module unit **20**A is able to operate to detect an abnormality inside the pack case **30**.

[0043] In the present embodiment, as illustrated in FIG. **1**, the connection topology of the controller **80** and the plurality of abnormality detecting means **50** (more specifically, the sub-controllers **53**) is a ring topology. The pack status information is output from the sub-controllers **53** to the controller **80** through the communication wires **95**. If an abnormality occurs in the cell module **40** of the cell module unit **20**B of the battery pack **10**A and thus the abnormality detecting means **50** in the cell module unit **20**B of the battery pack **10**A is unusable as described above, the communication wires **95**b and **95**c that are connected to that abnormality detecting means **50** are accordingly unusable. For this reason, in this case, the output controller **58** of the sub-controller **53** in the cell module unit **20**A of the battery pack **10**A, for example, outputs the pack status information to the controller **80** through the communication wire **95**a. The output controller **58** of the sub-controller **53** in the cell module unit **20**A of the battery pack **10**B, for example, outputs the pack status information to the controller **80** through the communication wires **95**d and **95**e.

[0044] As described above, in the present embodiment, the battery system **100** includes a battery pack **10** and a controller **80**, as illustrated in FIG. **1**. The battery pack **10** includes a plurality of cell module units **20** and a pack case **30** housing the plurality of cell module units **20**. Each of the cell module units **20** includes a cell module **40** including a plurality of battery cells **41**, an abnormality detection means **50** electrically connected to the cell module **40** to use the cell module **40** as its power source. The abnormality detecting means **50** is configured to output a signal to an external controller **80** when detecting an abnormality in the entirety of the pack case **30**. The controller **80** is communicably connected to the plurality of the abnormality detecting means **50** in the battery pack **10** and is provided external to the pack case **30**. This means that a plurality of cell modules **40** are housed inside one pack case **30**, and the abnormality detecting means **50** electrically connected to the respective cell modules **40** are provided inside the one pack case **30**. Therefore, even when an abnormality occurs in one of the plurality of cell modules **40** and one of the plurality of abnormality detecting means **50** loses power, it is possible to detect an abnormality in the entirety of the pack case **30** by a remaining one of the abnormality detecting means **50**.

[0045] For example, in FIG. **1**, the pack case **30** of the battery pack **10**A houses the cell modules **40** of the cell module units **20**A and **20**B. Therefore, an abnormality in the entirety of the pack case **30** is detected by the two abnormality detecting means **50**. For example, even when an abnormality occurs in the cell module **40** of the cell module unit **20**B and the abnormality detecting means **50** of the cell module unit **20**B loses power, it is possible to detect an abnormality in the entirety of the pack case **30** by the abnormality detecting means **50** of the cell module unit **20**A. Thus, it is possible to detect an abnormality in the entirety of the pack case **30** appropriately.

[0046] In the present embodiment, the pack case **30** is hermetically sealed. The abnormality detecting means **50** includes a pressure sensor **51** that detects a detection pressure value P1 (see FIG. **2**) inside the pack case **30**. Herein, because the pack case **30** is hermetically sealed, the pressure inside the pack case **30** may become higher when an abnormality occurs inside the pack case **30**. Accordingly, by detecting the detection pressure value Pl inside the pack case **30** with the pressure sensor **51**, the abnormality detecting means **50** is able to detect an abnormality inside the pack case **30** based on the detection pressure value P1.

[0047] In the present embodiment, the abnormality detecting means **50** includes a sub-controller **53**. The sub-controller **53** includes an acquisition controller **56** (see FIG. **3**) that acquires a detection pressure value P1 from the pressure sensor **51**, and a determination controller **57** (see FIG. **3**) that determines whether or not the detection pressure value P1 acquired by the acquisition controller **56** is higher than or equal to a predetermined reference pressure value P2 (see FIG. **2**). The sub-controller **53** is configured to detect that, if the determination controller **57** determines that the detection pressure value P1 is higher than or equal to the reference pressure value P2, an abnormality is occurring in the entirety of the pack case **30**. Herein, the reference pressure value P2 may be the minimum pressure value inside the pack case **30** that is expected when an abnormality occurs inside the pack case **30**. This makes it possible to detect an abnormality inside the pack case **30** by a simple control operation of determining whether or not the detection pressure value P1 is higher than or equal to the reference pressure value P2.

[0048] In the present embodiment, as illustrated in FIG. **1**, the battery system **100** includes a plurality of battery packs **10**. The connection topology of the controller **80** and the plurality of abnormality detecting means **50** in the plurality of battery packs **10** is a ring topology. Thus, by employing a ring topology for connecting the plurality of abnormality detecting means **50** and the controller **80** in this way, additional battery packs **10** may be connected more easily even when the number of the battery packs **10** needs to be increased, resulting in higher scalability. For example, in the example of FIG. **1**, when one additional battery pack **10** needs to be provided, the one additional battery pack **10** may be disposed between the abnormality detecting means **50** of the cell module unit **20**B of the battery pack **10**B and the communication wire **95**e.

[0049] Moreover, in the present embodiment, by employing a ring topology for the above-mentioned connection topology, the abnormality detecting means **50** is able to output a signal to the controller **80** in two directions. For example, the abnormality detecting means **50** of the cell module unit **20**A of the battery pack **10**A is able to output a signal from two directions, the communication wire **95**a end and the communication wire **95**b end, to the controller **80**. Therefore, even if the abnormality detecting means **50** of the cell module unit **20**B of the battery pack **10**A loses power, the abnormality detecting means **50** of the cell module unit **20**A of the battery pack **10**A is able to output a signal to the controller **80** through the communication wire **95**a.

Second Embodiment

[0050] Next, a battery system **100**A according to a second embodiment will be described. FIG. **4** is a schematic view illustrating the battery system **100**A according to the second embodiment. As illustrated in FIG. **4**, in the present embodiment, the battery system **100**A includes a plurality of battery packs **10** (battery packs **10**A and **10**B herein), a controller **80**, and an auxiliary equipment power supply **90**. Except for the connection topology of the respective abnormality detecting means **50** in the plurality of battery packs **10** and the controller **80**, the configuration of the battery system **100**A is identical to that of the battery system **100** according to the first embodiment, and therefore, the description of the configuration of the battery system **100**A will be omitted as appropriate.

[0051] In the present embodiment, the connection topology of the controller **80** and the plurality of abnormality detecting means **50** (more specifically, the sub-controllers **53**) in the plurality of battery packs **10** (the battery packs **10**A and **10**B herein) is a star topology. That is, the plurality of abnormality detecting means **50** are communicably connected to the controller **80** independently.

[0052] As illustrated in FIG. **4**, the sub-controllers **53** of the plurality of abnormality detecting means **50** are communicably connected to the controller **80** via communication wires **96**. Herein, the sub-controller **53** of the cell module unit **20**A of the battery pack **10**A is communicably connected to the controller **80** via a communication wire **96***a*, and the sub-controller **53** of the cell module unit **20**B of the battery pack **10**A is communicably connected to the controller **80** via a communication wire **96***b*. Likewise, the sub-controller **53** of the cell module unit **20**A of the battery pack **10**B is communicably connected to the controller **80** via a communication wire **96***c*, and the sub-controller **53** of the cell module unit **20**B of the battery pack **10**B is communicably connected to the controller **80** via a communication wire **96***d*. Note that although one communication wire **96** connects the sub-controller **53** of each one abnormality detecting means **50** and the controller **80** to each other in the present embodiment, it is also possible to use a plurality of communication wires **96** to connect them.

[0053] Thus, when the connection topology of the respective abnormality detecting means **50** in the plurality of battery packs **10** and the controller **80** is a star topology as well, the abnormality detecting means **50** are likewise able to output signals to the controller **80** even if the electric power source for another abnormality detecting means **50** is lost. Therefore, it is possible to obtain the same advantageous effects as those obtained by the first embodiment.

[0054] In each of the above-described embodiments, the abnormality detecting means **50** includes a pressure sensor **51** and detects the detection pressure value P1 inside the pack case **30** with the pressure sensor **51**. Then, based on the detection pressure value P1, the abnormality detecting means **50** detects an abnormality inside the pack case **30** when the detection pressure value P1 is higher than or equal to the reference pressure value P2. However, the abnormality detecting means **50** may detect an abnormality inside the pack case **30** based on a value other than the pressure inside the pack case **30**.

[0055] For example, the abnormality detecting means **50** may also include a gas sensor that detects a detected gas concentration of a predetermined type of gas inside the pack case **30**. In this case, the sub-controller **53** of the abnormality detecting means **50** may acquire the detected gas concentration in the pack case **30** that has been detected by the gas sensor and detect an abnormality in the entirety of the pack case **30** when the detected gas concentration is higher than or equal to a predetermined reference concentration.

[0056] The abnormality detecting means **50** may also include a thermal fuse that is housed in the pack case **30** and that blows out when the temperature inside the pack case **30** increases (for example, when the temperature reaches higher than or equal to a predetermined reference temperature). In this case, the abnormality detecting means **50** may detect an abnormality in the entirety of the pack case **30** by blowing out of the thermal fuse. In addition, the abnormality detecting means **50** may also include a temperature sensor that detects a detection temperature inside the pack case **30**. In this case, the sub-controller **53** of the abnormality detecting means **50** may detect an abnormality in the entirety of the pack case **30** when the detected temperature inside the pack case **30** that is detected by the temperature sensor is higher than or equal to a predetermined reference temperature.

[0057] Various embodiments of the invention have been described hereinabove according to the present disclosure. Unless specifically stated otherwise, the embodiments described herein do not limit the scope of the present invention. It should be noted that various other modifications and alterations may be possible in the embodiments of the invention disclosed herein. In addition, the features, structures, or steps described herein may be omitted as appropriate, or may be combined in any suitable combinations, unless specifically stated otherwise.

[0058] As has been described above, the present description contains the disclosure as set forth in the following items.

[0059] Item 1:

[0060] A battery pack including:

[0061] a plurality of cell module units; and

[0062] a pack case housing the plurality of cell module units, wherein:

[0063] each of the cell module units includes:

- **[0064]** a cell module including a plurality of battery cells; and
- **[0065]** an abnormality detecting means electrically connected to the cell module to use the cell module as its power source; and

[0066] the abnormality detecting means is configured to output a signal to an external controller when detecting an abnormality in an entirety of the pack case.

[0067] Item 2:

[0068] The battery pack according to item 1, wherein:

[0069] the pack case is hermetically sealed; and

[0070] the abnormality detecting means includes a pressure sensor detecting a detection pressure value inside the pack case.

[0071] Item 3:

[0072] The battery pack according to item 2, wherein:

[0073] the abnormality detecting means includes a sub-controller;

[0074] the sub-controller includes:

- **[0075]** an acquisition controller acquiring the detection pressure value from the pressure sensor; and
- **[0076]** a determination controller determining whether or not the detection pressure value acquired by the acquisition controller is higher than or equal to a predetermined reference pressure value; and

[0077] the sub-controller is configured to detect that, if the determination controller determines that the detection pressure value is higher than or equal to the reference pressure value, an abnormality is occurring in an entirety of the pack case.

[0078] Item 4:

[0079] A battery system including:

[0080] at least one battery pack according to any one of items 1 through 3; and

[0081] a controller, communicably connected to a plurality of the abnormality detecting means in the at least one battery pack and disposed external to the pack case.

[0082] Item 5:

[0083] The battery system according to item 4, wherein:

[0084] the at least one battery pack includes a plurality of battery packs; and

[0085] the plurality of abnormality detecting means in the plurality of battery packs and the controller are connected in a ring topology.

[0086] Item 6:

[0087] The battery system according to item **4**, wherein:

[0088] the at least one battery pack includes a plurality of battery packs; and

[0089] the plurality of abnormality detecting means in the plurality of battery packs and the controller are connected in a star topology.

What is claimed is:

1. A battery pack comprising:

a plurality of cell module units; and

a pack case housing the plurality of cell module units, wherein:

each of the cell module units includes:

a cell module including a plurality of battery cells; and

an abnormality detecting means electrically connected to the cell module to use the cell module as its power source; and

the abnormality detecting means is configured to output a signal to an external controller when detecting an abnormality in an entirety of the pack case.

2. The battery pack according to claim **1**, wherein:

the pack case is hermetically sealed; and

the abnormality detecting means includes a pressure sensor detecting a detection pressure value inside the pack case.

3. The battery pack according to claim **2**, wherein:

the abnormality detecting means includes a sub-controller;

the sub-controller includes:

an acquisition controller acquiring the detection pressure value from the pressure sensor; and

a determination controller determining whether or not the detection pressure value acquired by the acquisition controller is higher than or equal to a predetermined reference pressure value; and

the sub-controller is configured to detect that, if the determination controller determines that the detection pressure value is higher than or equal to the reference pressure value, an abnormality is occurring in an entirety of the pack case.

4. A battery system comprising:

at least one battery pack according to claim **1**; and

a controller, communicably connected to a plurality of the abnormality detecting means in the at least one battery pack and disposed external to the pack case.

5. The battery system according to claim **4**, wherein:

the at least one battery pack includes a plurality of battery packs; and

the plurality of abnormality detecting means in the plurality of battery packs and the controller are connected in a ring topology.

6. The battery system according to claim **4**, wherein:

the at least one battery pack includes a plurality of battery packs; and

the plurality of abnormality detecting means in the plurality of battery packs and the controller are connected in a star topology.

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