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(54) **BATTERY IDENTIFICATION DEVICE, BATTERY IDENTIFICATION METHOD, AND STORAGE MEDIUM**

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(57) **ABSTRACT**

A battery identification device for identifying a battery including a plurality of battery cells includes: a magnetic field measurer configured to measure a magnetic field which is generated by a current flowing in the battery; and a reader configured to read information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with the type of a battery.

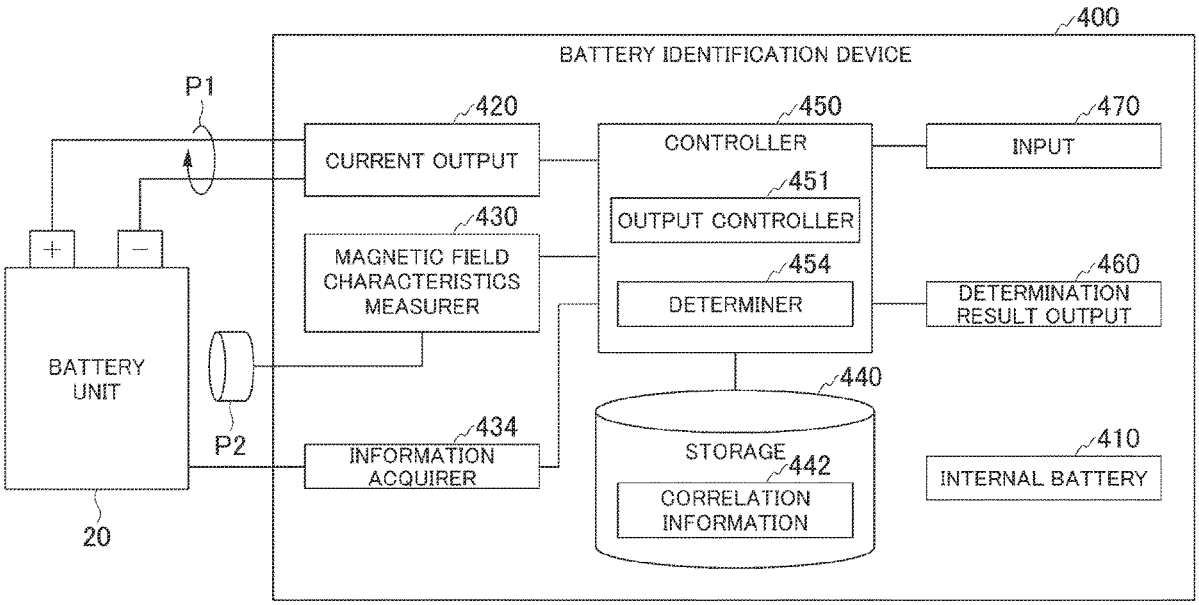


FIG. 1

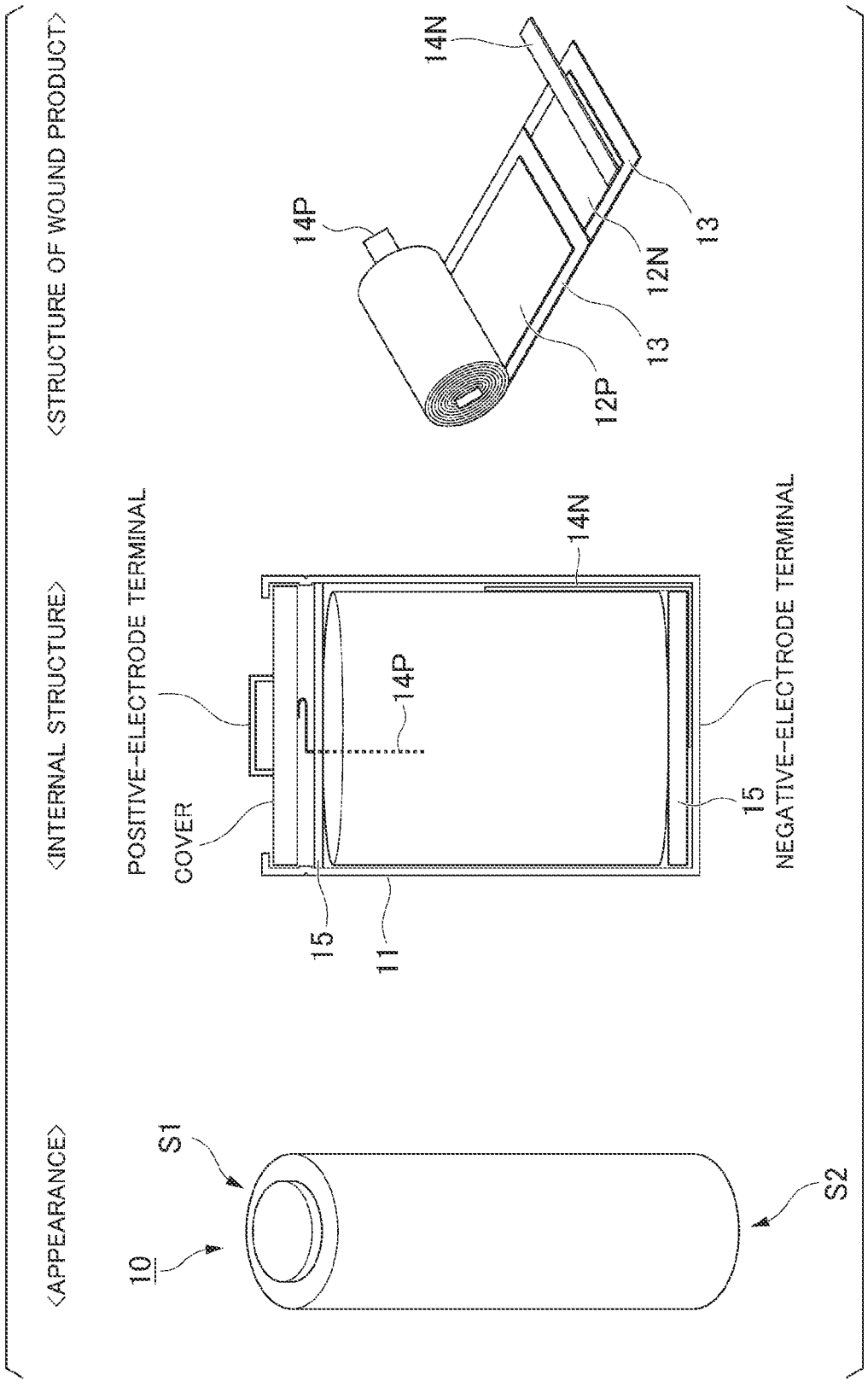

<APPEARANCE>
10
S1
S2
<INTERNAL STRUCTURE>
POSITIVE-ELECTRODE TERMINAL
COVER
14P
14N
15
11
15
NEGATIVE-ELECTRODE TERMINAL
<STRUCTURE OF WOUND PRODUCT>
14N
14P
12P
13
12N
13

FIG. 2

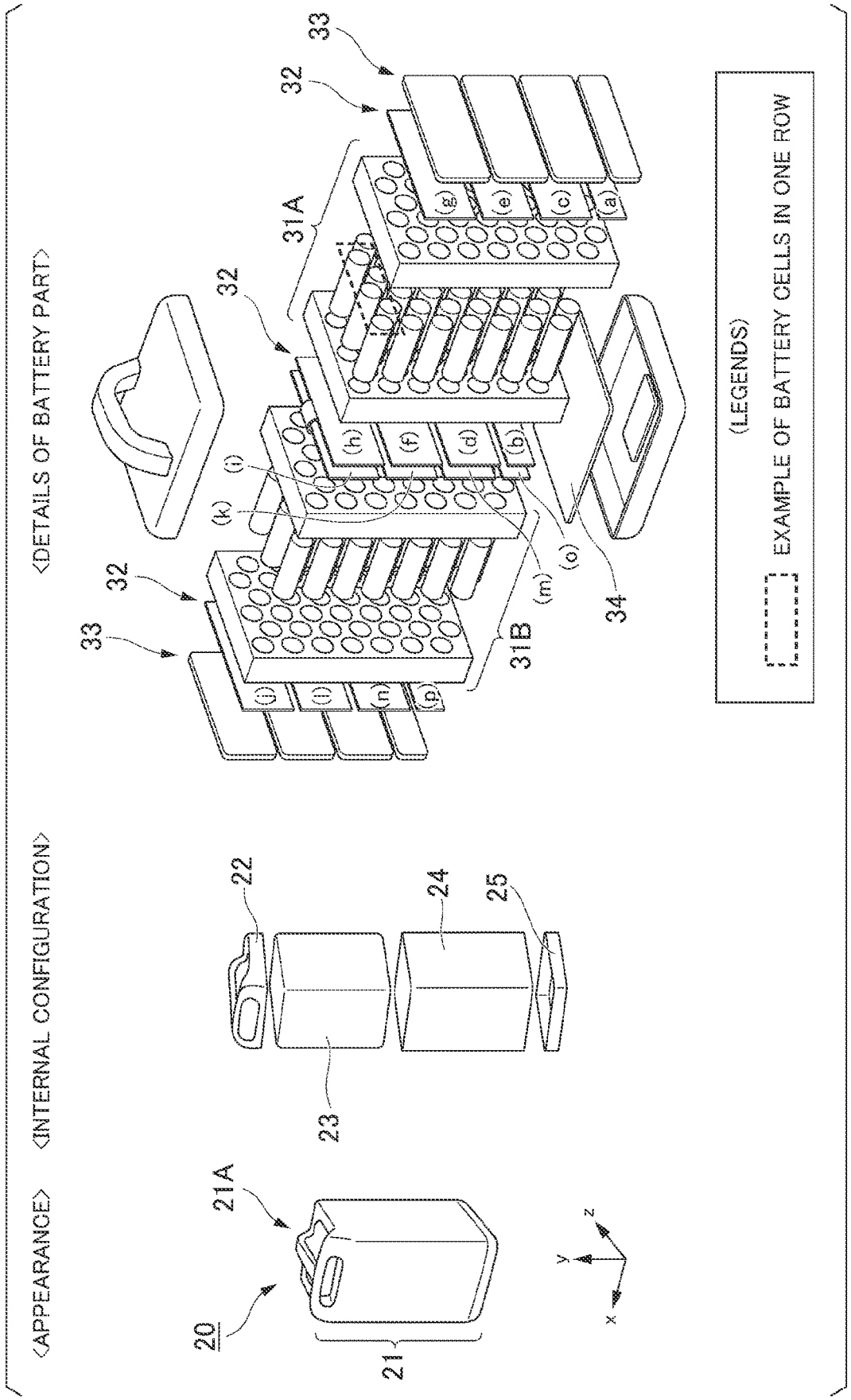

<APPEARANCE>
<INTERNAL CONFIGURATION>
<DETAILS OF BATTERY PART>
20
21
21A
22
23
24
25
31A
31B
32
33
34
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)
(m)
(n)
(o)
(p)
(LEGENDS)
EXAMPLE OF BATTERY CELLS IN ONE ROW
x
y
z

FIG. 3

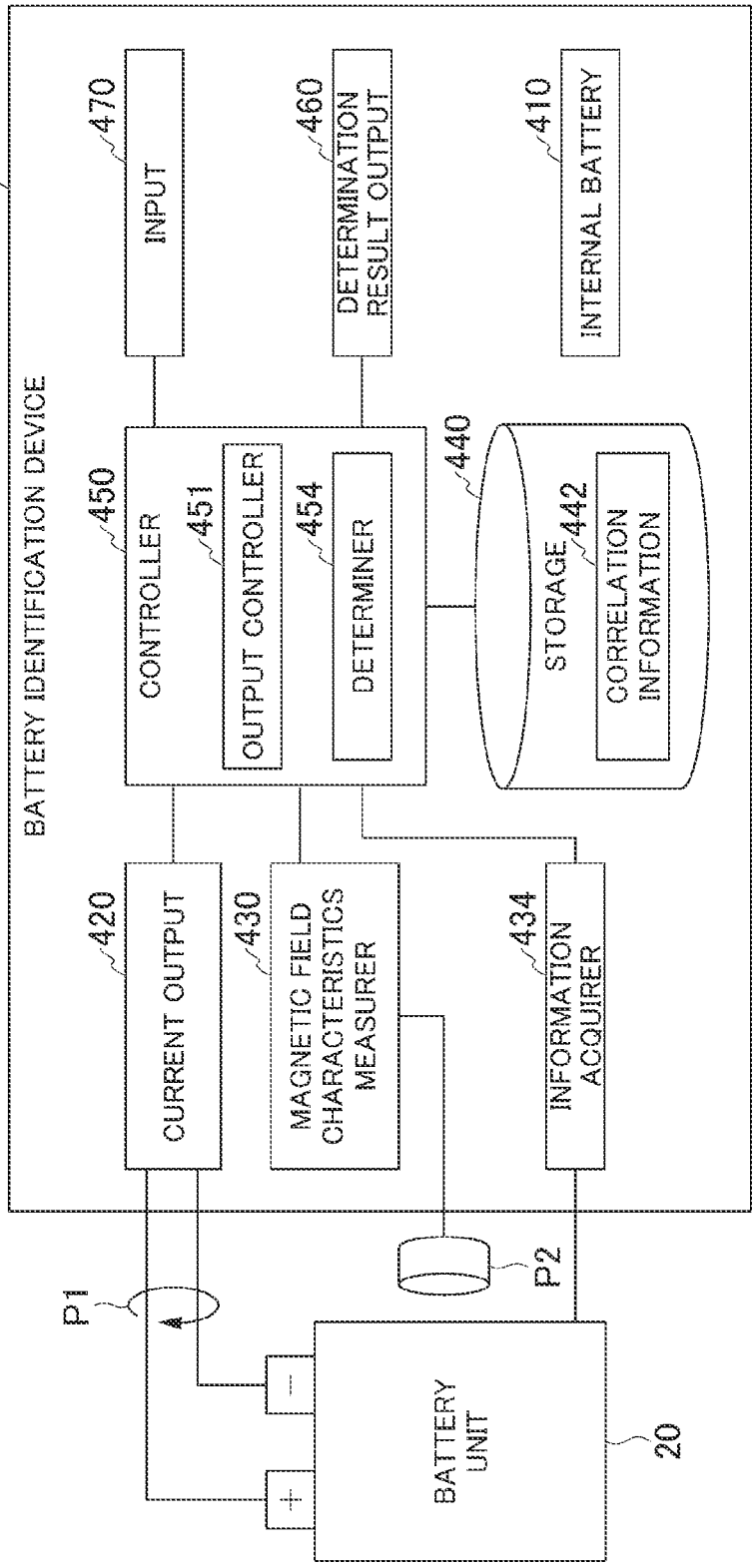

400
BATTERY IDENTIFICATION DEVICE
470
INPUT
460
DETERMINATION RESULT OUTPUT
410
INTERNAL BATTERY
450
CONTROLLER
451
OUTPUT CONTROLLER
454
DETERMINER
440
STORAGE
442
CORRELATION INFORMATION
420
CURRENT OUTPUT
430
MAGNETIC FIELD CHARACTERISTICS MEASURER
434
INFORMATION ACQUIRER
P1
P2
+
-
BATTERY UNIT
20

FIG. 4

442

BATTERY ID	MAGNETIC FIELD CHARACTERISTICS OBSERVED AT THE TIME OF APPLICATION OF IDENTIFICATION CURRENT	...
BT001	aaa~bbb	...
BT002	ccc~ddd	...
...	...	...

FIG. 5

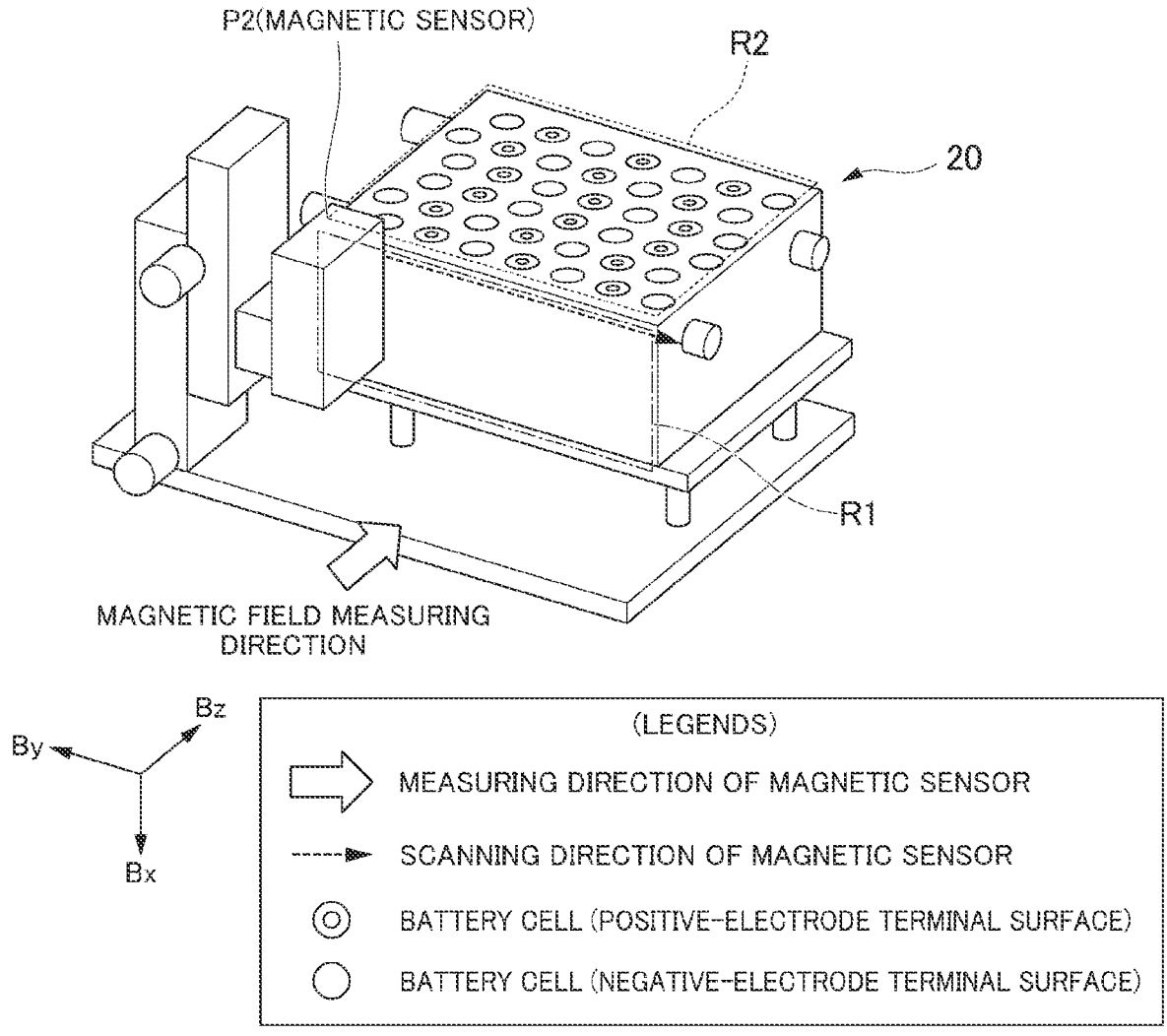


FIG. 6

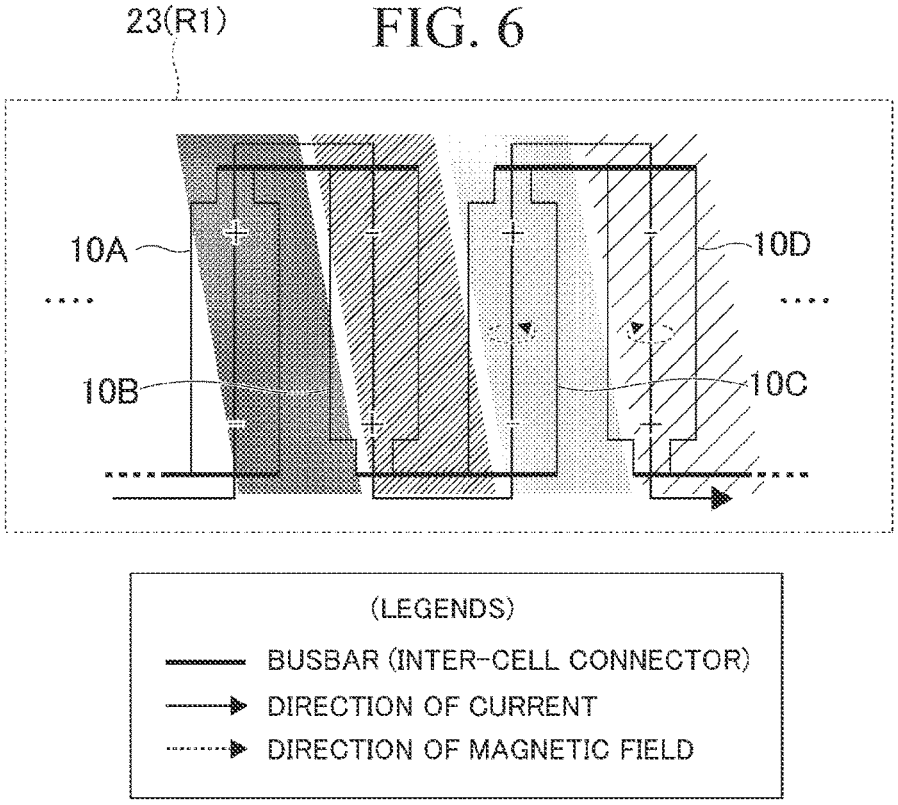

23(R1)
10A
10B
10C
10D
(LEGENDS)
BUSBAR (INTER-CELL CONNECTOR)
DIRECTION OF CURRENT
DIRECTION OF MAGNETIC FIELD

FIG. 7

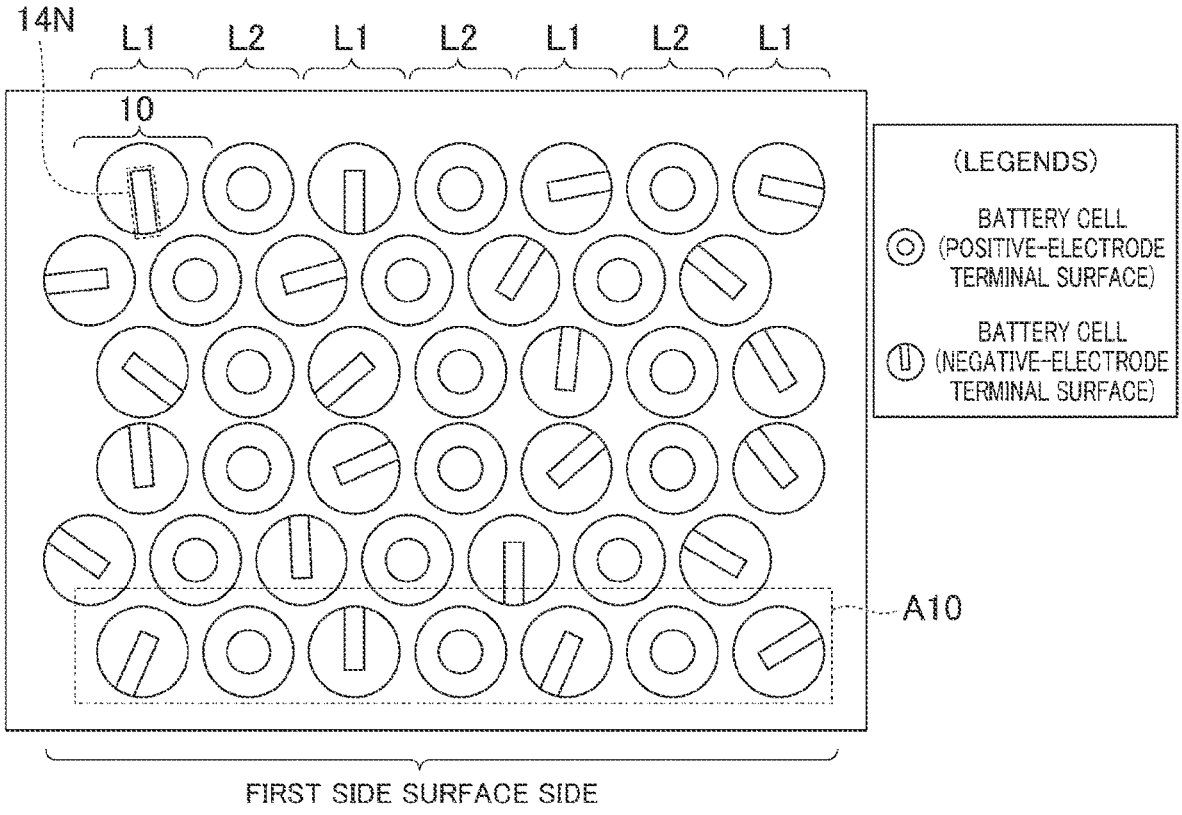

14N
L1
L2
L1
L2
L1
L2
L1
10
A10
(LEGENDS)
BATTERY CELL (POSITIVE-ELECTRODE TERMINAL SURFACE)
BATTERY CELL (NEGATIVE-ELECTRODE TERMINAL SURFACE)
FIRST SIDE SURFACE SIDE

FIG. 8

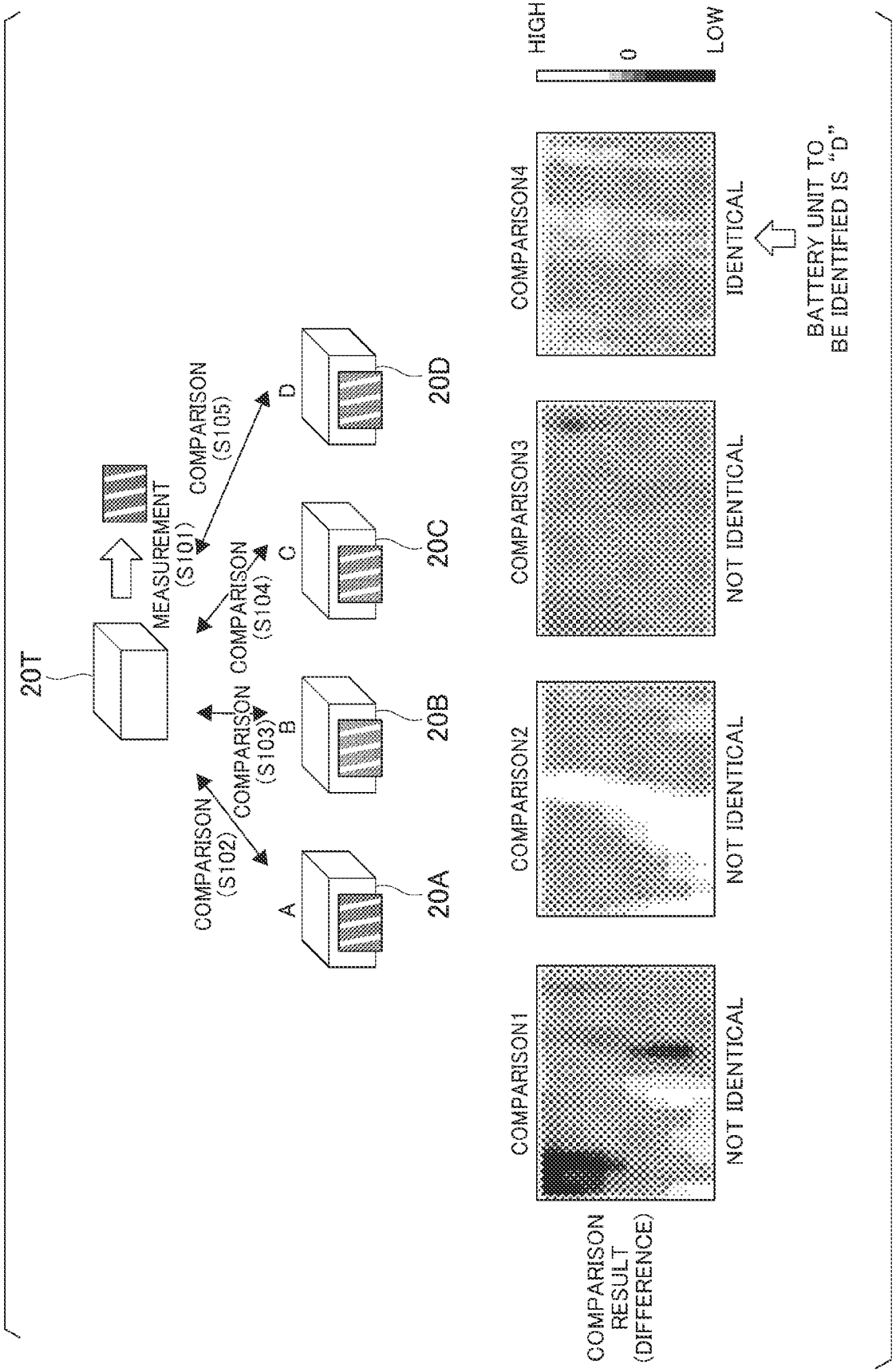

20T
MEASUREMENT
(S101)
COMPARISON
(S102)
COMPARISON
(S103)
COMPARISON
(S104)
COMPARISON
(S105)
A
B
C
D
20A
20B
20C
20D
COMPARISON1
COMPARISON2
COMPARISON3
COMPARISON4
NOT IDENTICAL
NOT IDENTICAL
NOT IDENTICAL
IDENTICAL
HIGH
0
LOW
COMPARISON RESULT (DIFFERENCE)
BATTERY UNIT TO BE IDENTIFIED IS "D"

FIG. 9

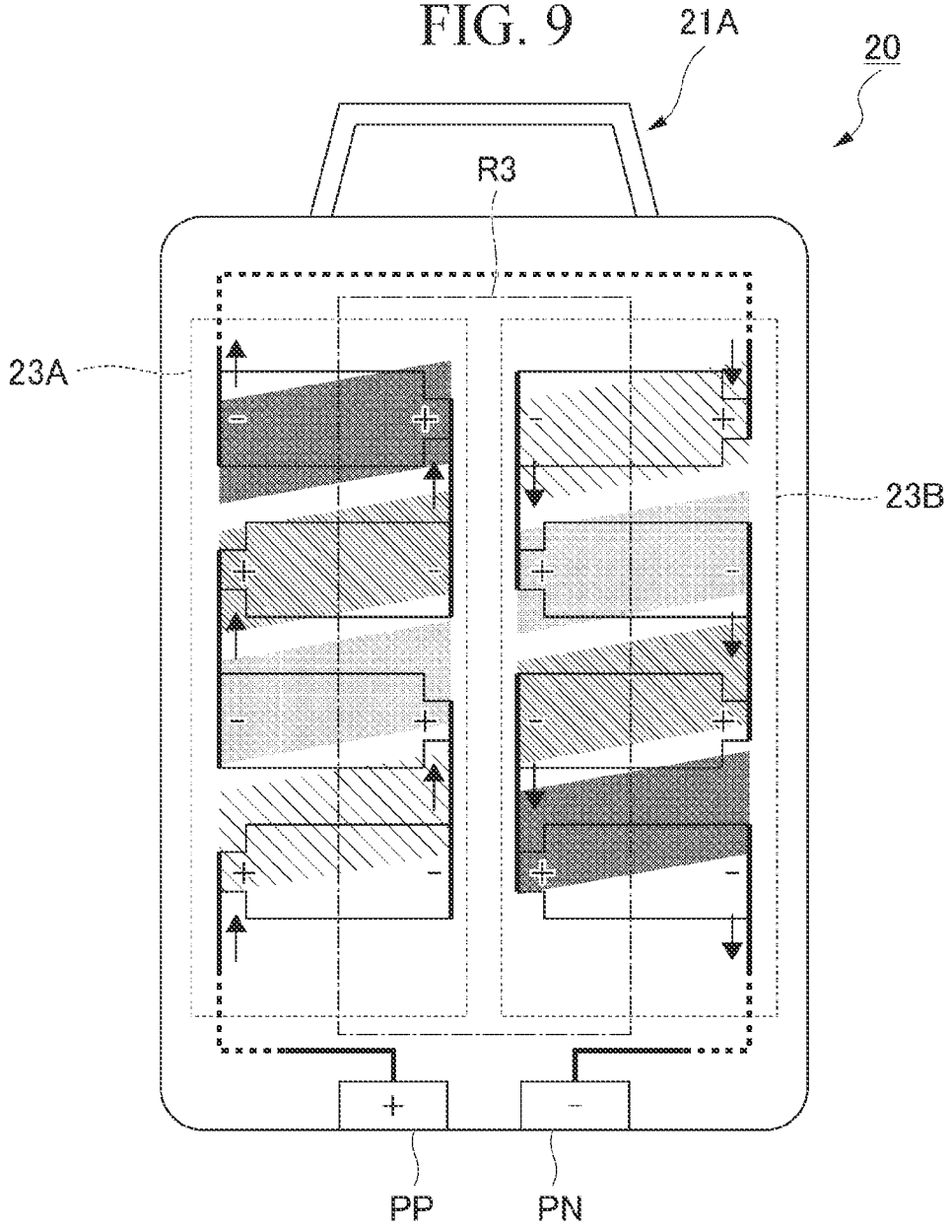

21A
20
R3
23A
23B
+
−
PP
PN
(LEGENDS)
BUSBAR (INTER-CELL CONNECTOR)
DIRECTION OF CURRENT

FIG. 10

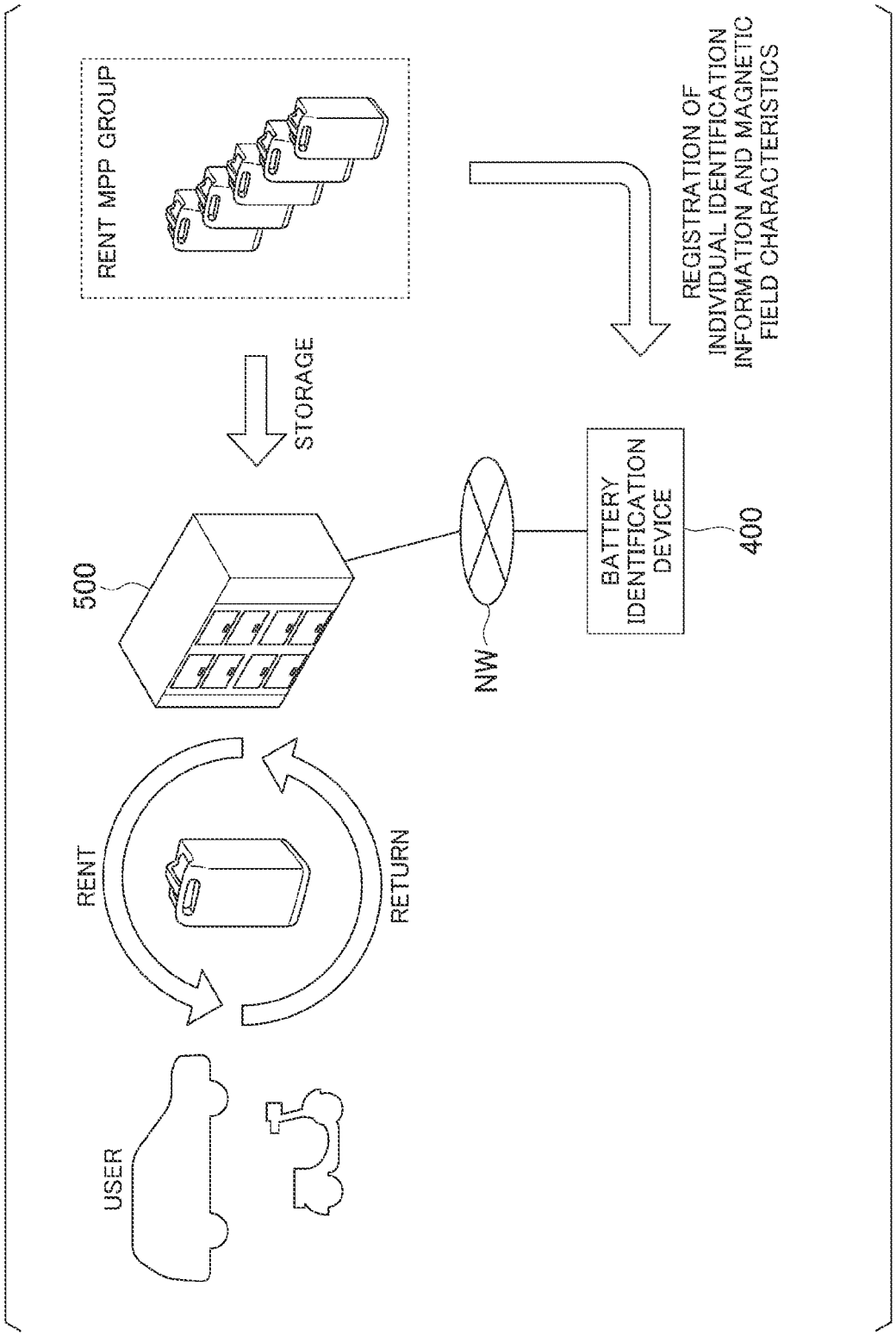
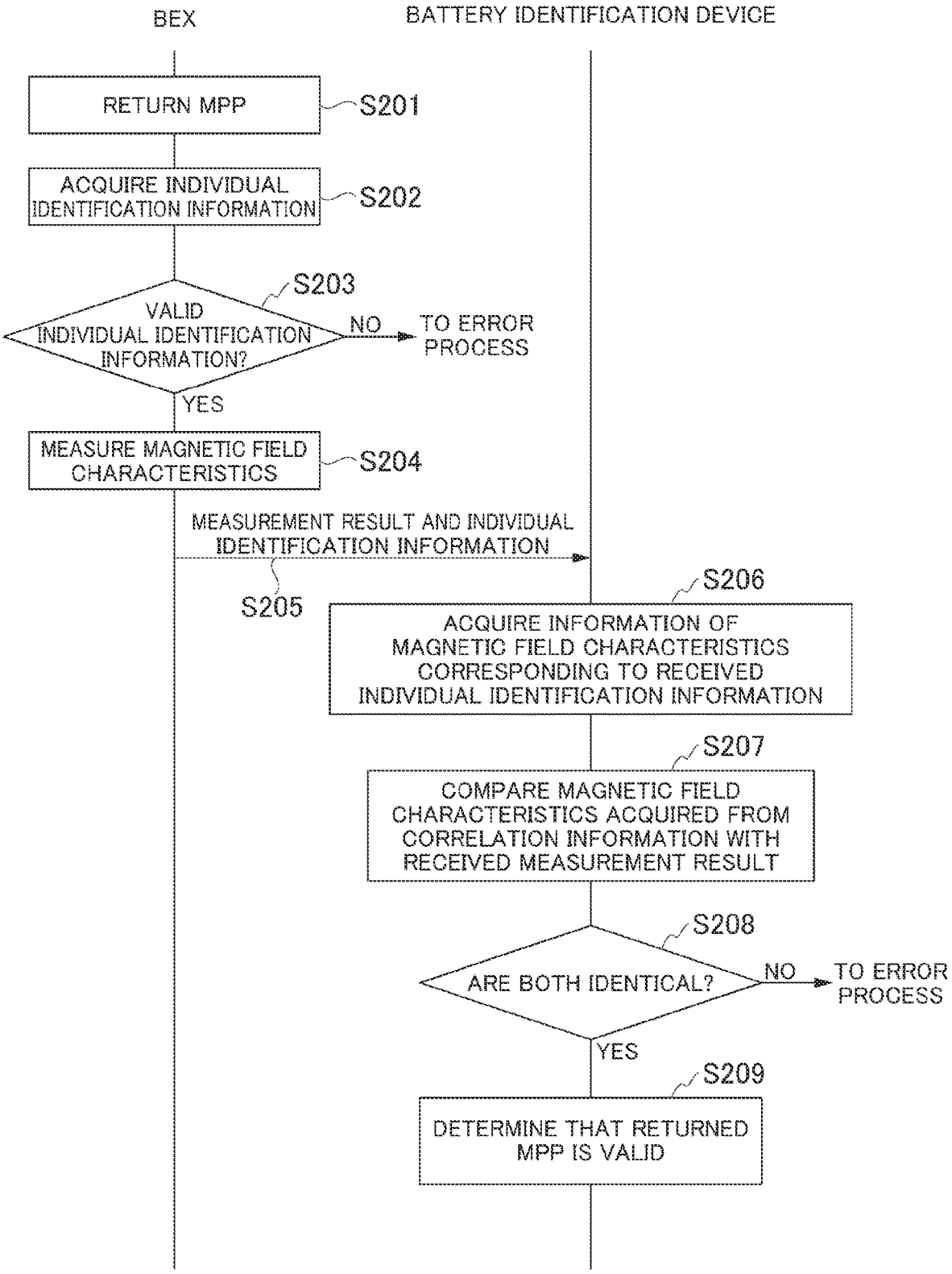

RENT MPP GROUP
STORAGE
REGISTRATION OF INDIVIDUAL IDENTIFICATION INFORMATION AND MAGNETIC FIELD CHARACTERISTICS
500
NW
BATTERY IDENTIFICATION DEVICE
400
RENT
RETURN
USER

FIG. 11


BEX
BATTERY IDENTIFICATION DEVICE
RETURN MPP
S201
ACQUIRE INDIVIDUAL IDENTIFICATION INFORMATION
S202
S203
VALID INDIVIDUAL IDENTIFICATION INFORMATION?
NO
TO ERROR PROCESS
YES
MEASURE MAGNETIC FIELD CHARACTERISTICS
S204
MEASUREMENT RESULT AND INDIVIDUAL IDENTIFICATION INFORMATION
S205
S206
ACQUIRE INFORMATION OF MAGNETIC FIELD CHARACTERISTICS CORRESPONDING TO RECEIVED INDIVIDUAL IDENTIFICATION INFORMATION
S207
COMPARE MAGNETIC FIELD CHARACTERISTICS ACQUIRED FROM CORRELATION INFORMATION WITH RECEIVED MEASUREMENT RESULT
S208
ARE BOTH IDENTICAL?
NO
TO ERROR PROCESS
YES
S209
DETERMINE THAT RETURNED MPP IS VALID

BATTERY IDENTIFICATION DEVICE, BATTERY IDENTIFICATION METHOD, AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Priority is claimed on Japanese Patent Application No. 2023-068124, filed Apr. 18, 2023, the content of which is incorporated herein by reference.

BACKGROUND

Field of the Invention

[0002] The present invention relates to a battery identification device, a battery identification method, and a storage medium.

Description of Related Art

[0003] In the related art, a method of identifying a type of battery based on a direct-current internal resistance at the time of charging of the battery and a direct-current internal resistance at the time of discharging is known (PCT International Publication No. WO2015/133068). In this method, a resistor with a predetermined resistance value is attached to a battery in advance, and the type of battery is determined by measuring the resistance value at the time of identification. A method of attaching an IC chip to a battery and determining the type of battery based on an identification signal output from the IC chip is also known.

SUMMARY

[0004] However, in the related art, a component such as a resistor or an IC chip has to be attached to a battery, which increases costs. When such a component is imitated, the component may be attached to an unintended battery, and thus a type of the battery cannot be correctly identified. The type of battery mentioned herein includes a type indicating whether the battery is a valid battery and a type indicating whether the battery is an intended battery. In the related art, there is a likelihood that the validity or individuality of a battery will not be able to be correctly identified.

[0005] The present invention was made in consideration of the aforementioned circumstances, and an objective thereof is to provide a battery identification device, a battery identification method, and a storage medium that can identify the type of battery without attaching an identification component thereto.

[0006] A battery identification device, a battery identification method, and a storage medium according to the present invention employ the following configurations.

[0007] (1) According to an aspect of the present invention, there is provided a battery identification device for identifying a battery including a plurality of battery cells, the battery identification device including a storage device configured to store a program and a hardware processor, wherein the hardware processor executes the program stored in the storage device to perform: measuring a magnetic field which is generated by a current flowing in the battery; and reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with the type of battery.

[0008] (2) In the aspect of (1), an outer shape of each battery cell has substantially rotational symmetry with respect to one axis.

[0009] (3) In the aspect of (2), an internal structure of the battery cell has rotational symmetry with respect to the axis which is lower than the rotational symmetry outside of the internal structure or does not have rotational symmetry with respect to the axis.

[0010] (4) In the aspect of (1), the plurality of battery cells are arranged in the battery such that relative positional relationships therebetween are fixed.

[0011] (5) In the aspect of (1), the battery has a configuration in which a battery module including a plurality of battery cells is accommodated in a battery pack storing individual identification information, and the hardware processor stores the individual identification information as a type of the battery and stores the prescribed value of the magnetic field information in correlation with the individual identification information.

[0012] (6) In the aspect of (5), the hardware processor additionally acquires the individual identification information from the battery pack and identifies individual batteries by acquiring the prescribed value correlated with the individual identification information and comparing the acquired prescribed value with the magnetic field information.

[0013] (7) In the aspect of (1), the hardware processor additionally performs a control process of outputting electric power to the battery or the battery cell or receiving an input of electric power from the battery or the battery cell.

[0014] (8) In the aspect of (1), the battery has a configuration in which a plurality of battery modules each including a plurality of battery cells are accommodated in a battery pack, and the hardware processor performs measuring magnetic field characteristics in a range in which the magnetic field characteristics of the plurality of battery modules are observed.

[0015] (9) In the aspect of (1), the hardware processor measures the magnetic field using a magnetic element array board in which a plurality of magnetic elements are arranged.

[0016] (10) According to another aspect of the present invention, there is provided a battery identification method of identifying a battery including a plurality of battery cells that is performed by a battery identification device, the battery identification method including: measuring a magnetic field which is generated by a current flowing in the battery; and reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with the type of battery.

[0017] (11) According to another aspect of the present invention, there is provided a non-transitory storage medium storing a program, the program causing an identification device for identifying a battery including a plurality of battery cells to perform: measuring a magnetic field which is generated by a current flowing in the battery; and reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with the type of battery.

[0018] According to the aspects of (1) to (11), it is possible to nondestructively and noninvasively identify the type of battery without attaching an identification component thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** is a diagram schematically illustrating the configuration of the battery cell.

[0020] FIG. **2** is a diagram schematically illustrating the configuration of the battery unit.

[0021] FIG. **3** is a diagram schematically illustrating an example of a configuration of a battery identification device.

[0022] FIG. **4** is a diagram illustrating an example of details of correlation information.

[0023] FIG. **5** is a diagram schematically illustrating a configuration for measurement which is performed to identify a battery type of a target battery unit by the battery identification device.

[0024] FIG. **6** is a diagram schematically illustrating a magnetic field distribution which is measured through scanning of a first side surface.

[0025] FIG. **7** is a diagram illustrating an example of a CT image of a battery unit of which a second side surface is imaged.

[0026] FIG. **8** is a diagram illustrating a battery identification method of identifying a battery type of a battery unit based on magnetic field characteristics which are measured through scanning of a first side surface.

[0027] FIG. **9** is a diagram illustrating an example of a configuration of a battery unit according to a modified example.

[0028] FIG. **10** is a diagram illustrating an example of a configuration of a battery sharing system including a battery identification device and a BEX according to a modified example.

[0029] FIG. **11** is a sequence diagram illustrating an example of a process flow of verifying validity of a returned MPP which is performed by the battery sharing system.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Hereinafter, a battery identification device, a battery identification method, and a storage medium according to an embodiment of the present invention will be described with reference to the accompanying drawings.

[0031] In the following embodiment, a method of identifying the type of battery unit including a plurality of battery cells will be described. In this embodiment, an individual battery cell constituting the battery unit is based on the premise of a cylindrical battery cell including a wound product in which electrodes are wound and using circular top and bottom surfaces as a positive-electrode terminal or a negative-electrode terminal. The battery unit according to this embodiment is an example of a "battery" in the claims.

[0032] FIG. **1** is a diagram schematically illustrating the configuration of the battery cell. In FIG. **1**, the left part illustrates the appearance of a battery cell **10** according to the embodiment, and the central part is a sectional view schematically illustrating an internal structure of the battery cell **10**. The right part is a diagram illustrating a structure of a wound product in the battery cell **10**. As illustrated in FIG. **1**, the battery cell **10** has a cylindrical shape, one end surface thereof is formed as a positive-electrode terminal S**1**, and the other end surface is formed as a negative-electrode terminal S**2**. The battery cell **10** has a configuration in which a wound product **15** in which a stacked body in which a positive electrode **12**P and a negative electrode **12**N are separated by a separator **13** is wound, a positive-electrode tab **14**P provided on the positive electrode **12**P, a negative-electrode tab **14**N provided on the negative electrode **12**N, and an insulator **16** for insulating the wound product **15**, the positive-electrode terminal, and the negative electrode terminal from each other are accommodated in an outer can **11**. The positive electrode **12**P and the negative electrode **12**N are immersed in an electrolyte (not illustrated) in a state in which they are separated from each other by the separator **13** and are wound. The positive-electrode tab **14**P electrically connects the positive electrode **12**P and the positive-electrode terminal S**1**, and the negative-electrode tab **14**N electrically connects the negative electrode **12**N and the negative-electrode terminal S**2**. The positive-electrode tab **14**P is disposed at a winding start of the positive electrode **12**P, and the negative-electrode tab **14**N is disposed at a winding end of the negative electrode **12**N. The wound product **15** is wound such that the negative electrode **12**N faces outward.

[0033] FIG. **2** is a diagram schematically illustrating the configuration of the battery unit. In FIG. **2**, the left part illustrates an appearance of a battery unit **20** according to this embodiment, and the central part illustrates an internal configuration of the battery unit **20**. As illustrated in FIG. **2**, the battery unit **20** has a configuration in which a top case **22**, a battery part **23**, a side case **24**, and a bottom case **25** are accommodated in a housing **21** with a grip **21**A. A plurality of battery cells **10** are welded to a busbar which will be described later or are electrically connected through fastening with screws, are fixed such that they do not rotate, and are accommodated in cell holders **31**A and **31**B. In the battery unit **20**, the battery cells **10** are arranged such that battery cells of two neighboring columns alternate in polarity column by column.

[0034] In the battery unit **20**, a busbar **32** connecting the battery cells **10** in series is provided. The busbar **32** in the example illustrated in FIG. **2** includes sub-bars (a) to (p) to connect the battery cells **10** corresponding to a row (three battery cells) in series to the battery cells **10** in nearby columns. For example, one end sub-bar (a) of the busbar **32** is electrically connected to the positive-electrode terminal, and the other end sub-bar (p) is electrically connected to the negative-electrode terminal. With this configuration, the battery cells **10** in the rows are connected in series by the busbar **32** in the order of sub-bars (a) to (p). The sub-bars (h) and (i) of the busbar **32** are directly connected to each other, whereby a group of the battery cells **10** in the cell holder **31**B is connected in series to a group of the battery cells **10** in the cell holder **31**A. In the housing **21**, a battery management unit (BMU) **34** having a function of managing the battery part **23** in addition to a heat-dissipation heat transfer sheet **33** installed on side surfaces is provided. In the battery unit **20**, the plurality of battery cells **10** are arranged sideways on the bottom surface of the battery unit **20**. In other words, the plurality of battery cells **10** are arranged such that a cylindrical axis thereof is parallel to the bottom surface of the battery unit **20**.

[0035] The BMU **34** has, for example, a function of controlling charging or discharging of the battery part **23**, a function of controlling a direction in which a current flows or a voltage value, a function of monitoring states of the

battery cells **10**, and an on/off control function of switching a battery circuit between an on state and an off state. The BMU **34** includes a storage unit for storing information required for various management functions or a communication unit for communicating with an external device.

[0036] FIG. **3** is a diagram schematically illustrating an example of a configuration of a battery identification device **400** according to this embodiment. The battery identification device **400** is a device that identifies a type of the battery unit **20**. The battery identification device **400** includes an internal battery **410**, a current output **420**, a magnetic field characteristics measurer **430**, an information acquirer **434**, a storage **440**, a controller **450**, a determination result output **460**, and an input **470**. These constituents are realized, for example, by causing a hardware processor such as a central processing unit (CPU) to execute a program (software). Some or all of the constituents may be realized by hardware (a circuit unit including circuitry) such as a large scale integration (LSI) circuit, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a graphics processing unit (GPU) or may be cooperatively realized by software and hardware. Here, the program may be stored in a storage device (a storage device including a non-transitory storage medium) such as a hard disk drive (HDD) or a flash memory in advance or may be stored in a detachable storage medium (a non-transitory storage medium) such as a DVD or a CD-ROM and installed by setting the storage medium into a drive device.

[0037] The internal battery **410** is a battery that supplies electric power required for operations of the battery identification device **400**. The functional units of the battery identification device **400** can operate with electric power supplied from the internal battery **410**. The internal battery **410** may be a battery or may be an interface that acquires electric power from another power supply.

[0038] The current output **420** is a current application circuit that is controlled to apply a specific current to the battery unit **20**. A specific current is a current (hereinafter referred to as an "identification current") applied to the battery unit **20** for the purpose of identifying a battery type of the battery unit **20**. The current output **420** applies a current with an intensity instructed by the controller **450** to the battery unit **20**. The current output from the current output **420** is applied to the battery unit **20** via a probe P**1**.

[0039] The magnetic field characteristics measurer **430** is a circuit that measures magnetic field characteristics of a measurement target based on a signal detected by a magnetic field detector P**2**. The magnetic field detector P**2** is, for example, a magnetic probe including a magnetic element therein or a magnetic element array board in which a plurality of magnetic elements are arranged. The magnetic elements in the magnetic element array board may be arranged at regular intervals or may be arranged at irregular intervals. Each magnetic element may be a single-axis measuring element or may be a three-axis measuring element. It is preferable that a single-axis measuring element be disposed such that a magneto-sensitive surface thereof faces a circumferential direction of the battery cell (a y-axis direction in FIG. **5**). This is for easily acquiring a magnetic field distribution in which direction arrangement of a battery cell **10** and a presence position of a collector tab are reflected by causing a macro current of the battery cell **10** and a current flowing in the collector tab to orthogonally cross the magneto-sensitive surface. Each magnetic element may be an analog element or may be a digital element. Each magnetic element may be, for example, a Hall element, a magnetoresistance element such as an anisotropic magnetoresistance effect (AMR) element, a giant magnetoresistance effect (GMR) element, or a tunnel magnetoresistance effect (TMR) element, a magneto-impedance (MI) element, a flux gate, or a thin-film magnetic element based on an anomalous Hall effect using a topological magnetic substance. When an alternating current flows in a measurement target, a pickup coil may be used as a magnetic element. A range in which a magnetic field is detected by the magnetic field detector P**2** may be the whole measuring surface of the battery unit **20** or an arbitrary part thereof as long as information sufficient to identify a battery type can be acquired. The magnetic element array board may have a size covering the whole measuring range of the measuring surface of the battery unit **20** or may scan the measuring surface with a size covering a part of the measuring range. A measuring position or a measuring timing of magnetic field characteristics or the like is assumed to be appropriately controlled by the controller **450**. The magnetic field characteristics measurer **430** outputs a measured value of the magnetic field characteristics acquired for the battery unit **20** to the controller **450**.

[0040] The information acquirer **434** is connected to an information communication terminal of the battery unit **20**. For example, the information acquirer **434** can acquire information stored in a storage of the battery unit **20** or transmit information to the storage of the battery unit **20** through communication with the battery unit **20**. For example, individual identification information of the battery unit **20** or the like is stored in the storage of the battery unit **20**. The individual identification information is, for example, a manufacturing ID. The individual identification information may be an example of a "battery type."

[0041] The storage **440** is configured, for example, using a magnetic storage device such as a hard disk drive (HDD) or a semiconductor storage device such as a solid state drive (SSD) or configured as a database (DB) in a cloud. The storage **440** provides a storage area for storing various types of information of the operations of the battery identification device **400**. Correlation information **442** on the battery unit **20** is stored in advance in the storage **440**. The correlation information **442** is information in which at least magnetic characteristics which are observed when an identification current is applied to the battery unit **20** are correlated with a type (a battery type) of the battery unit **20** (see FIG. **4**). For example, the correlation information **442** can be generated based on a result of a test for measuring magnetic field characteristics using an identification current for each battery type to be identified. In addition to the correlation information **442**, for example, a measurement result of magnetic field characteristics of the battery unit **20**, a determination result of a battery type, setting information of a current applied to the battery unit **20**, various programs for realizing the controller **450**, and the like may be stored in the storage **440**.

[0042] The controller **450** controls the constituents of the battery identification device **400** to identify a battery type of a target battery unit **20**. In the following description, a battery unit **20** of which a battery type is to be identified is referred to as a target battery unit **20**. The controller **450** includes, for example, an output controller **451** and a determiner **454**. The output controller **451** has a function of

applying an identification current to a target battery unit **20** by controlling an output intensity of the current output **420**. For example, the output controller **451** may apply an alternating current varying in a sinusoidal shape to the target battery unit **20** by continuously changing the output intensity of the current output **420**. The output controller **451** may apply a direct-current varying in a rectangular wave shape to the target battery unit **20** by changing the output intensity of the current output **420** at predetermined timings.

[0043] The output controller **451** may be configured to detect connection of the target battery unit **20** to the battery identification device **400** and to start application of an identification current to the target battery unit **20**. The battery identification device **400** includes an input device such as a mouse or a keyboard, the output controller **451** may be configured to start application of an identification current to the target battery unit **20** in response to a user's input operation.

[0044] The determiner **454** determines a battery type of the target battery unit **20** based on a value of the magnetic field characteristics measured from the target battery unit **20**. More specifically, the determiner **454** determines the battery type corresponding to the value of the magnetic field characteristics measured from the target battery unit **20** based on the correlation information **442**. For example, in the example illustrated in FIG. **4**, when the measured value of the magnetic field characteristics is in a range of "aaa to bbb," the determiner **454** can determine that the battery type of the target battery unit **20** is "BT001." The determiner **454** outputs the determination result of the battery type to the determination result output **460**. The determiner **454** is configured in cloud. The storage **440** and the determiner **454** are an example of a "reader." When at least one of the storage **440** and the determiner **454** is in cloud, the battery identification device **400** may have a function of communicating with the cloud and acquiring (reading) at least one of a prescribed value and information on identity from the cloud (may include a reader).

[0045] The correlation information **442** may be configured to store a feature quantity acquired based on magnetic field characteristics in correlation with the battery type instead of/in addition to the magnetic field characteristics. In this case, the determiner **454** may be configured to determine the battery type of the target battery unit **20** based on the feature quantity acquired based on the measured value instead of/in addition to the measured value of the magnetic field characteristics acquired from the target battery unit **20**. The feature quantity may have a value acquired for each individual measured value or may be a statistical value acquired for a plurality of measured values.

[0046] The determination result output **460** outputs the determination result of the battery type output from the determiner **454** in a predetermined form. For example, the determination result output **460** may display the determination result on a display device such as a liquid crystal display or an organic electroluminescence (EL) display. For example, the determination result output **460** may transmit the determination result to another communication device via a wired or wireless communication interface. The determination result output **460** may output voice indicating details of the determination result from a voice output device such as a speaker.

[0047] The input **470** has a function of inputting information to the battery identification device **400**. For example, the input **470** may be configured to receive an information input operation via an input device such as a mouse or a keyboard. The input **470** may be configured to input (receive) information by communication via a wired or wireless communication interface. The input **470** outputs the input information to the controller **450**.

[0048] FIG. **5** is a diagram schematically illustrating a configuration for measurement which is performed to identify a battery type of a target battery unit **20** by the battery identification device **400**. More specifically, the battery identification device **400** measures magnetic field characteristics in the vicinity of a first side surface R**1** of the target battery unit **20** in a state in which an identification current is applied. The battery identification device **400** recognizes a distribution of directions (angles) of the battery cells **10** in the target battery unit **20** based on the measurement result. Control of the magnetic field characteristics measurer **430** associated with measurement of magnetic field characteristics is performed by the controller **450**. In the following description, a view of an internal structure of the target battery unit **20** when seen from a second side surface R**2** side (FIG. **7**) will be described for describing the directions of the battery cells **10**. Measurement in the vicinity of the first side surface R**1** is an example, and measurement may be performed in the vicinity of the second side surface R**2**.

[0049] The first side surface R**1** is a side surface facing side surfaces of internal battery cells **10** out of the side surfaces of a battery unit **20**. In other words, the first side surface R**1** is a side surface parallel to a cylindrical center axis of each internal battery cell **10** out of the side surfaces of the battery unit **20**. On the other hand, the second side surface R**2** is a side surface facing a circular end surface of each internal battery cell **10** out of the side surfaces of the battery unit **20**. In other words, the second side surface R**2** is a side surface perpendicular to the cylindrical center axis of each internal battery cell **10** out of the sides surfaces of the battery unit **20**. There are four side surface candidates for the first side surface R**1** out of the side surfaces of the battery unit **20**, and which side surface is set as the first side surface R**1** may be arbitrarily selected according to a configuration of a measuring instrument, conditions of a measuring environment, or the like. Similarly, there are two side surface candidates for the second side surface R**2** out of the side surfaces of the battery unit **20**, and which side surface is set as the second side surface R**2** may be arbitrarily selected according to a configuration of a measuring instrument, conditions of a measuring environment, or the like.

[0050] Here, a direction perpendicular to the first side surface R**1** is defined as a z-axis direction, a direction perpendicular to the second side surface R**2** is defined as an x-axis direction, and a direction perpendicular to the bottom surface of the battery unit **20** is defined as a y-axis direction. In a measured magnetic field B, an x-axis component is referred to as Bx, a y-axis component is referred to as By, and a z-axis component is referred to as Bz. As illustrated in FIG. **5**, directions of terminals of a plurality of battery cells **10** in the battery unit **20** may not be uniform. For example, FIG. **5** illustrates an example in which a plurality of groups of battery cells **10** with the same direction of terminals are formed and the plurality of groups are arranged such that the directions of terminals alternate.

[0051] FIG. **6** is a diagram schematically illustrating a magnetic field distribution (a By component) which is measured through scanning of the first side surface R**1**. As

described above with reference to FIG. **5**, a plurality of battery cells **10** are arranged in different directions of terminals in the battery unit **20**. FIG. **6** schematically illustrates a magnetic field distribution measured in the vicinity of the plurality of battery cells **10** arranged such that the directions terminals alternate. For example, FIG. **6** illustrates a magnetic field distribution of magnetic fields measured from a shallow side of the drawing surface on the first side surface R**1** of the battery part **23** of the battery unit **20**. As can be seen from FIG. **6**, when an identification current is applied to a battery cell **10**, a current density distribution in the battery cell **10** is higher in a part of a collector tab (a negative-electrode tab). Accordingly, a stronger magnetic field is observed in the battery cell **10** of which the collector tab is closer to the first side surface R**1** out of the battery cells **10** with the same current direction. For example, in the example illustrated in FIG. **6**, a stronger magnetic field than in a battery cell **10**C is observed in a battery cell **10**A, and a stronger magnetic field than in a battery cell **10**D is observed in a battery cell **10**B. Accordingly, in this case, it is predicted that a collector tab is present on the first side surface R**1** side (a shallow side in the drawing) in the battery cell **10**A and the battery cell **10**B. This difference in a magnetic field intensity may be used as a feature quantity for identifying a battery type.

[0052] FIG. **6** illustrates an example in which battery cells **10** with different directions of terminals are connected in series and illustrates a state in which a plurality of battery cells **10** are connected by a busbar. In this configuration, it can be seen that the directions of the measured magnetic field distributions alternate along an array of the battery cells **10** (that is, signs are inverted) as illustrated in FIG. **6**. That is, since a direction of a current flowing in the battery unit **20** changes when the direction of the battery cells **10** changes, a direction of a current for generating a magnetic field can be said to be change according to the directions of the battery cells **10**. A size (thickness or length) of a battery cell **10** is reflected in a width of the alternating magnetic field distributions. In this way, since arrangement of the battery cells **10** and arrangement, length, or the like of busbars accompanying the arrangement affect a distribution of a measured magnetic field, the magnetic field distribution on the first side surface R**1** can be used as a feature quantity for identifying a battery type of the battery unit **20**. Directions of terminals of a plurality of battery cells **10** may be different from the example illustrated in FIG. **5** or **6** as long as features of a magnetic field (features based on directions of collector tabs of cylindrical battery cells **10** in the battery unit **20**)) for identifying the same type of (with the same design or structure) battery unit **20**.

[0053] FIG. **7** is a diagram illustrating an example of an internal structure of a battery unit **20** when seen from the second side surface R**2** side. That is, FIG. **7** illustrates a sectional surface of the battery unit **20** taken along a plane parallel to a yz plane. FIG. **7** illustrates an image obtained by imaging the battery unit **20** in which battery cells **10** with different directions of terminals are arranged in a layered shape. In FIG. **7**, a first layer L**1** in which negative-electrode terminal surfaces face the shallow side of the drawing surface and a second layer L**2** in which positive-electrode terminal surfaces face the shallow side of the drawing surface are alternately arranged. In FIG. **7**, each circular image is a circular end surface of each of a plurality of battery cells **10**. A rectangular object in some circular end surfaces is a negative-electrode tab **14**N connected to the negative electrode **12**N.

[0054] A battery cell **10** according to this embodiment has a cylindrical outer shape (rotational symmetry) and thus a direction thereof cannot be ascertained from the outer shape. On the other hand, as illustrated in FIG. **7**, the internal structure of the battery cell **10** has no rotational symmetry due to presence of a negative-electrode tab. That is, with attention to the internal structure, each battery cell **10** has a direction. In the process of manufacturing the battery unit **20**, directions at the time of arranging a plurality of battery cells **10** are not controlled. Accordingly, the directions of the plurality of battery cells **10** in the battery unit **20** are random, thus the direction of the negative-electrode tab **14**N is also random, and the direction cannot be visually ascertained due to rotational symmetry of the outer shape. In this way, the battery unit **20** is manufactured such that the angles of the negative-electrode tabs **14**N of the plurality of battery cells **10** are allowed to be random. On the other hand, the positive-electrode terminals S**1** of the battery cells **10** in the second layer L**2** cannot be seen from FIG. **7** because the positive-electrode terminals S**1** face the shallow side, but the angles of the negative-electrode tabs **14**N of the battery cells **10** in the second layer L**2** are similarly random. On the other hand, since the end surfaces of the battery cells **10** are fixed to the busbars, the angles of the negative-electrode tabs **14**N of the battery cells **10** in the manufactured battery unit **20** are considered not to change.

[0055] In this way, randomness in angle of the negative-electrode tabs **14**N can be used as a feature quantity for identifying individuality of the battery unit **20**. In FIG. **7**, the internal structure of the whole second side surface R**2** is illustrated for the purpose of easy understanding, but the feature quantity of the whole second side surface R**2** does not need to be acquired as long as randomness required for identifying the individuality can be secured. As described above, when an identification current is applied to a battery cell **10**, a current density distribution in the battery cell **10** is higher in a part corresponding to the collector tab (the negative-electrode tab). Therefore, the battery identification device **400** may be configured to identify the battery unit **20** based on measurement results of magnetic field characteristics of the first side surface R**1**. With measurement of a magnetic field on the first side surface R**1**, an influence of battery cells **10** other than a first row (a range indicated by a dotted line A**10**) may be included in the measurement results, which is good for acquiring features specific to individuals. In this case, the angle of the collector tab does not need to be identified in identifying an individual. That is, a magnetic field distribution (characteristics) specific to an individual (which varies depending on the individuals) which is generated according to the direction of the collector tab specific to the individual can be observed by measuring the magnetic field characteristics of the first side surface R**1**. The angle of the negative-electrode tab is mentioned herein, but an angle of a positive-electrode tab may be used according to the structure of the battery cells **10**.

[0056] For example, it is assumed that the battery identification device **400** stores a collector tab feature quantity acquired at the time of delivery of the battery unit **20** in the storage **440** in correlation with individual identification information in advance. In this case, by identifying a collector tab feature quantity identical to (or having high

identity to) the collector tab feature quantity acquired at the time of inspection out of the collector tab feature quantities stored in the storage **440**, the battery identification device **400** can identify the individuality of the target battery unit **20** the individual identification information correlated therewith. In addition to the timing of delivery of a product, the collector tab feature quantity may be acquired at each measuring timing, and a magnetic field of which identity between individuals has been ascertained may be stored for reference. By updating a width of an individual identification determination value, it is possible to improve reliability of identification at a next timing. Data stored as described above may be weighted along the time axis and used for determination. There is a likelihood that slight change in an internal state due to dust or vibration attached to an armor during operation or the like has been absorbed.

[0057] The collector tab feature quantity can also be used for ascertaining whether the battery unit **20** has been altered. For example, it is assumed that collector tab feature quantities acquired at the time of delivery of battery units **20** are stored in storages of the battery units **20**. In this case, the battery identification device **400** determines whether a battery unit **20** has been altered by determining whether the collector tab feature quantity stored in the storage of the battery unit **20** is identical to the collector tab feature quantity acquired at the time of inspection. Since an angle of a collector tab does not change after manufacturing as described above, the battery identification device **400** determines that "it has not been altered" when both angles are identical and determine that "it has been altered" when both angles are not identical.

[0058] The battery identification device **400** may perform determination based on identity in individual identification information in addition to determination based on the collector tab feature quantity. For example, it is assumed that individual identification information of a battery unit **20** is stored in the storage of the battery unit **20** and a collector tab feature quantity of the battery unit **20** is stored in the storage **440** of the battery identification device **400** in correlation with the individual identification information. In this case, the battery identification device **400** reads the individual identification information from the battery unit **20** and acquires the collector tab feature quantity correlated with the individual identification information from the storage **440**. The battery identification device **400** may determine that an internal component (such as a battery cell **10**) of the battery unit **20** is a valid product (that alteration of the component or the like has not been performed) when the acquired collector tab feature quantity is identical to the collector tab feature quantity acquired at the time of inspection.

[0059] FIG. **8** is a diagram illustrating images of a battery identification method of identifying a battery type of a battery unit **20** based on magnetic field characteristics which are measured through scanning of the first side surface R**1**. In FIG. **8**, an example in which a battery unit **20**T is an identification target and a battery unit **20**D corresponding thereto is identified out of battery units **20**A, **20**B, **20**C, and **20**D is illustrated. In this case, it is assumed that the battery identification device **400** stores correlation information **442** of magnetic field characteristics measured from the first side surface R**1** in advance (for example, at the time of delivery of a product) for each of the battery units **20**A, **20**B, **20**C, and **20**D.

[0060] In this case, first, the battery identification device **400** measures the magnetic field characteristics of the first side surface R**1** of the battery unit **20**T (S**101**). Subsequently, the battery identification device **400** determines whether the magnetic field characteristics of the battery unit **20**T measured in Step S**101** are identical to the magnetic field characteristics of the battery unit **20**A (S**102**). For example, when the magnetic field characteristics are acquired as a planar distribution of a magnetic field as illustrated in FIG. **6**, the battery identification device **400** calculates a difference at the same position between the magnetic field characteristics of the battery unit **20**T and the magnetic field characteristics of the battery unit **20**A. When both are identical (when the battery unit **20**T is the battery unit **20**A herein), the difference is 0 on the whole area of the first side surface R**1**. When both are not identical, there is a difference in a certain area.

[0061] As in images of planar distributions illustrated in FIG. **8**, a uniform image with no shade as a whole is obtained when there is no difference, and a different part is displayed as a shade when there is a difference. FIG. **8** illustrates that there is a difference between the battery unit **20**T and the battery unit **20**A as a result of comparison. In this case, the battery identification device **400** determines that the battery unit **20**T is not the battery unit **20**A. Similarly, the battery identification device **400** determines that the battery unit **20**T is not the battery unit **20**B through comparison between the battery unit **20**T and the battery unit **20**B (S**103**). Similarly, the battery identification device **400** determines that the battery unit **20**T is not the battery unit **20**C through comparison between the battery unit **20**T and the battery unit **20**C (S**104**).

[0062] Subsequently, the battery identification device **400** compares the battery unit **20**T with the battery unit **20**D. In this case, since there is no difference, the battery identification device **400** determines that the battery unit **20**T is the battery unit **20**D (S**105**).

[0063] With the aforementioned battery identification device **400** according to this embodiment, it is possible to identify a battery type of a target battery unit **20** by comparing a measurement result of magnetic field characteristics of the first side surface R**1** of the target battery unit **20** with existing information. With this configuration, the battery identification device **400** according to the embodiment can identify the type of battery without attaching an identification component.

First Modified Example

[0064] FIG. **9** is a diagram illustrating a modified example of the first side surface R**1**. The magnetic field characteristics measurer **430** may be configured to perform measurement in a range (for example, a range R**3** in the drawing) in which both the magnetic field generated in a battery cell **10** held by the first cell holder **31**A and the magnetic field generated in a battery cell **10** held by the second cell holder **31**B are observed out of the range of the first side surface R**1**. By measuring magnetic field characteristics in this range, magnetic field characteristics of more battery cells **10** can be measured at a time, which is highly efficient. With this configuration, since collection of both magnetic field characteristics can be used as the magnetic field characteristics stored as correlation information, it is possible to simplify a configuration and to curb an increase in a load in management.

Second Modified Example

[0065] The battery unit **20** described above in the embodiment is assumed to be mainly used for a vehicle, but the present invention is not limited thereto. The battery identification device **400** may be configured to determine a battery type of a so-called mobile power pack (MPP) which is a detachable portable battery which can be used as a power of a small electric mobile vehicle or a household power source. The MPP is an example of the battery unit **20**. A part or whole of the battery identification device **400** may be provided in a battery charging device or a battery returning device (a so-called battery exchanger (BEX)) that can recover and charge a used MPP and re-lend a charged MPP. The battery identification device **400** may be configured as a unified body with the BEX or may be configured as a separate body.

[0066] For example, FIG. **10** illustrates an example of a configuration of a battery sharing system **1** including a battery identification device **400** and a BEX **500**. The battery sharing system **1** provides a battery sharing service of lending or recovering an MPP to or from a registered user. The battery sharing system **1** has a function of charging an MPP and can charge a recovered MPP and re-lend the charged MPP. For example, a user rents an MPP from the BEX **500** and drives an electric vehicle such as an automobile or a motorbike using the rented MPP. When the state of charge of the MPP in use decreases, the user can return the MPP to the BEX **500** and rent another charged MPP. In the battery identification device **400**, information of magnetic field characteristics measured in advance from MPPs used in the battery sharing service is stored as correlation information **442**.

[0067] In the battery sharing system **1**, the battery identification device **400** and the BEX **500** are communicatively connected to each other and can cooperate as in an example illustrated in FIG. **11** to ascertain validity of an MPP returned to the BEX **500**. FIG. **11** is a sequence diagram illustrating an example of a process flow of verifying validity of a returned MPP which is performed by the battery identification device **400** and the BEX **500**. First, an MPP is returned to the BEX **500** (S**201**). Subsequently, the BEX **500** acquires individual identification information from the returned MPP (S**202**). The BEX **500** determines whether the acquired individual identification information is valid (S**203**). For example, with reference to management information of the MPP, the BEX **500** determines that the acquired individual identification information is valid when the individual identification information is registered in the management information and determines that the acquired individual identification information is not valid when the individual identification information is not registered. When it is determined that the individual identification information is valid, the BEX **500** measures magnetic field characteristics of the returned MPP (S**204**) and transmits the measurement result along with the individual identification information to the battery identification device **400** (S**205**). On the other hand, when it is determined that the individual identification information is not valid, the BEX **500** performs an appropriate error process.

[0068] Subsequently, the battery identification device **400** determines a battery type of the returned MPP based on the individual identification information and the measurement result of magnetic field characteristics received from the BEX **500**. More specifically, the battery identification device **400** acquires information of magnetic field characteristics corresponding to the received individual identification information from the correlation information **442** (S**206**), compares the acquired information of magnetic field characteristics with the measurement result of magnetic field characteristics received from the BEX **500** (S**207**), and determines whether both are identical (S**208**). The battery identification device **400** determines that the returned MPP is valid when both are identical (S**209**), and determines that the returned MPP is not valid and appropriately performs an error process when both are not identical. As described above, in the battery sharing system **1**, individual identification information of the MPP is acquired by the BEX **500**. Accordingly, In this case, the battery identification device **400** may not include the information acquirer **434**.

Other Modified Examples

[0069] In the aforementioned embodiment, a cylindrical battery cell **10** is described as a battery cell included in the battery unit **20**, but the battery identification method according to the embodiment is based on rotational symmetry of the battery cell **10** and randomness in position of an internal structure (for example, a negative-electrode tab) of the battery cell **10**. Accordingly, the battery identification method according to the embodiment can also be applied to identification of a battery unit including battery cells having the same characteristics (rotational symmetry and randomness). For example, the battery identification method according to the embodiment can also be applied to a battery unit including square tubular battery cells (four-times rotational symmetry) or a battery unit including regular-triangle tubular battery cells (three-times rotational symmetry). The randomness in position of the internal structure may be realized due to rotational asymmetry of the internal structure such as a negative-electrode tab. The randomness in position of the internal structure may be realized due to lower rotational symmetry of the internal structure than rotational symmetry of a structure outside of the internal structure (a cylinder in the embodiment).

[0070] A mode in which the battery identification device **400** applies an identification current to a battery unit **20** may be based on charging or based on discharging. The output controller **451** may control charging of the battery unit **20** or/and discharging of the battery unit **20**.

[0071] In the aforementioned embodiment, identification of a battery type may be identifying whether an internal component of the battery unit **20** is a valid product. Since the magnetic field characteristics observed at the time of application of an identification current can also vary when an abnormality occurs in the battery unit **20**, the battery identification device **400** may be configured as an abnormality detection device for the battery unit **20** by storing a correlation of the variation in magnetic field characteristics with a type of an abnormality as correlation information **442**.

[0072] With the battery identification device **400** according to the aforementioned embodiment, it is also possible to identify a battery type of a battery (or a battery cell) in which an IC chip or the like that can output an identification signal is not mounted. Accordingly, it is not necessary to mount an IC chip in a battery, and thus it is possible to solve a problem of a battery due to an interface or the durability of the IC chip.

[0073] In the aforementioned embodiment, the battery identification device **400** identifies a battery type based on

magnetic field characteristics which are observed when an identification current is applied to a battery cell **10**. With measurement of magnetic field characteristics based on application of an identification current, there is a merit that identification accuracy can be secured by applying a current for generating a magnetic field which is not embedded in noise of the terrestrial magnetism or the ambient magnetic field. On the other hand, when a current value applied to a battery cell **10** is monitored, a feature quantity not depending on the current value can be obtained by dividing an intensity of the observed magnetic field by the current value. The battery identification device **400** may be configured to store a correlation of the feature quantity with a battery type as correlation information. In this case, the battery identification device **400** can identify a battery type by comparing the feature quantity observed with application of an arbitrary current to a target battery cell **10** with the correlation information. In this way, whether the battery identification device **400** is to apply an identification current to a battery cell **10** or to apply an arbitrary current thereto may be appropriately selected according to nature or characteristics of an identification target, identification purpose or usage, or the like.

[0074] Since a battery configuration is symmetric in the concepts of a positive electrode and a negative electrode, the battery cell **10**, the battery unit **20**, and the battery identification device **400** may have opposite configurations in view of conceptual symmetry of a positive electrode and a negative electrode.

[0075] In the aforementioned embodiment, magnetic field characteristics of a battery cell **10** are measured by scanning the first side surface R**1** with a probe P**2**, but the magnetic field characteristics of a battery cell **10** may be measured together using a sensor array.

[0076] While a mode for carrying out the present invention has been described above in conjunction with an embodiment, the present invention is not limited to the embodiment, and various modifications and replacements can be added without departing from the gist of the present invention.

What is claimed is:

1. A battery identification device for identifying a battery including a plurality of battery cells, the battery identification device comprising:

a storage device configured to store a program; and

a hardware processor,

wherein the hardware processor executes the program stored in the storage device to perform:

measuring a magnetic field which is generated by a current flowing in the battery; and

reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with a type of battery.

2. The battery identification device according to claim **1**, wherein an outer shape of each battery cell has substantially rotational symmetry with respect to one axis.

3. The battery identification device according to claim **2**, wherein an internal structure of the battery cell has rotational symmetry with respect to the axis which is lower than the rotational symmetry outside of the internal structure or does not have rotational symmetry with respect to the axis.

4. The battery identification device according to claim **1**, wherein the plurality of battery cells are arranged in the battery such that relative positional relationships therebetween are fixed.

5. The battery identification device according to claim **1**, wherein the battery has a configuration in which a battery module including a plurality of battery cells is accommodated in a battery pack storing individual identification information, and

wherein the hardware processor stores the individual identification information as a type of the battery and stores the prescribed value of the magnetic field information in correlation with the individual identification information.

6. The battery identification device according to claim **5**, wherein the hardware processor additionally acquires the individual identification information from the battery pack and identifies individual batteries by acquiring the prescribed value correlated with the individual identification information and comparing the acquired prescribed value with the magnetic field information.

7. The battery identification device according to claim **1**, wherein the hardware processor additionally performs a control process of outputting electric power to the battery or the battery cell or receiving an input of electric power from the battery or the battery cell.

8. The battery identification device according to claim **1**, wherein the battery has a configuration in which a plurality of battery modules each including a plurality of battery cells are accommodated in a battery pack, and

wherein the hardware processor performs measuring magnetic field characteristics in a range in which the magnetic field characteristics of the plurality of battery modules are observed.

9. The battery identification device according to claim **1**, wherein the hardware processor measures the magnetic field using a magnetic element array board in which a plurality of magnetic elements are arranged.

10. A battery identification method of identifying a battery including a plurality of battery cells that is performed by a battery identification device, the battery identification method comprising:

measuring a magnetic field which is generated by a current flowing in the battery; and

reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with a type of battery.

11. A non-transitory storage medium storing a program, the program causing an identification device for identifying a battery including a plurality of battery cells to perform:

measuring a magnetic field which is generated by a current flowing in the battery; and

reading information on identity between both results which is determined by comparing a measurement result of the measured magnetic field with a prescribed value of magnetic field information correlated with a type of battery.

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