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MEASUREMENT DEVICE AND ESTIMATION SYSTEM

Abstract

Provided is a measurement device which measures a magnetic flux density emitted from a battery cell, comprising: a sensor including sensor cells which measure the magnetic flux density; and a rotation holding unit which rotatably holds the battery cell in a state where a relative position of the battery cell with respect to the sensor cells is retained. The rotation holding unit may hold the battery cell such that the relative position between the battery cell and the sensor is changeable. The rotation holding unit may include a rotating portion which rotates the battery cell. The rotation holding unit may move the sensor cells with respect to the battery cell.

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Background/Summary

[0001] The contents of the following patent application(s) are incorporated herein by reference: NO. 2024-020940 filed in JP on Feb. 15, 2024
BACKGROUND
1. TECHNICAL FIELD
[0002] The present invention relates to a measurement device and an estimation system.
2. RELATED ART
[0003] A battery unit including a lithium-ion battery or the like is constituted by a plurality of battery cells and used as a power supply for an electrical car or the like.
[0004] Conventionally, there have been techniques for measuring magnetic flux density at a plurality of points around a battery (Patent Document 1).
PRIOR ART DOCUMENT
Patent Document
[0005] Patent Document 1: Japanese Unexamined Patent Publication No. 2018-46007

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0006] FIG. **1** illustrates a schematic view of a measurement device **10** according to the present embodiment.
[0007] FIG. **2** is a perspective view illustrating the rotation holding unit **30** in the measurement device **10** according to the present embodiment in more detail.
[0008] FIG. **3** is a schematic top plan view illustrating a holding jig **60** and a cell substrate **235**, which are parts of the rotation holding unit **30**.
[0009] FIG. **4** is a schematic perspective view of the holding jig **60**, which is a part of the rotation holding unit **30** when viewed from above.
[0010] FIG. **5** is a schematic perspective view of the holding jig **60**, which is a part of the rotation holding unit **30** when viewed from below.
[0011] FIG. **6** illustrates an arrangement of the sensor cells **22** and the battery cell **15** during the measurement.
[0012] FIG. **7** illustrates a schematic perspective view of the holding jig **60** in the rotation holding unit **30** of a first variant in the measurement device **10** of the present embodiment.
[0013] FIG. **8** illustrates a top plan view of the holding jig **60** of a first variant. FIG. **9** illustrates a schematic top plan view of a part of the rotation holding unit **30** of a second variant in the measurement device **10** of the present embodiment.
[0014] FIG. **10** is a flow diagram illustrating a measurement operation of the measurement device **10** of the present embodiment.
[0015] FIG. **11** illustrates an example of the measurement result database which records measurement results in the measurement device **10**.
[0016] FIG. **12** illustrates a schematic view of an estimation system **800** according to the present embodiment.
[0017] FIG. **13** illustrates a flow diagram of a genuine product determination operation in the estimation system **800** according to the present embodiment.
DESCRIPTION OF EXEMPLARY EMBODIMENTS
[0018] The present invention will be described below through embodiments of the invention, but the following embodiments do not limit the invention according to the claims. In addition, not all of the combinations of features described in the embodiments are essential to the solution of the

invention.

[0019] FIG. **1** illustrates a schematic view of a measurement device **10** according to the present embodiment. FIG. **1** illustrates the schematic view of the measurement device **10** on which a battery cell **15** to be measured is arranged.

[0020] Here, a magnetic field generated in a battery unit such as a lithium-ion battery during energizing (charging or discharging) varies due to a type and an arrangement of the battery cell **15** included therein. Thus, by energizing a battery unit that is already shipped to measure its magnetic flux density, it becomes possible to distinguish it from other individuals and determine that it is a genuine product. However, the magnetic flux density varies depending on an angle state of the battery cell **15** due to an arrangement of a battery tab (lead wire) inside the battery cell **15** or the like. Therefore, when a genuine product determination is performed on a battery unit from its magnetic flux density, measurement data of the magnetic flux density that differs depending on an angle state of a battery cell in a genuine battery unit is required in advance. In particular, in a case where a genuine product determination by means of machine learning is employed, a large amount of measurement data is required for training a determiner. The measurement device **10** of the present embodiment can acquire such measurement data for the genuine product determination on the battery unit by actually measuring it, as an example.

[0021] The measurement device **10** of the present embodiment measures the magnetic flux density emitted from the battery cell **15** at a plurality of rotation angles. The measurement device **10** includes a sensor **20**, a rotation holding unit **30**, and a control unit **40**. For the measurement device **10** of the present embodiment, the arrangement, the dimension, the number thereof, and the like in each configuration may be set depending on the battery cell **15** in the battery unit to be determined if it is a genuine product; and the arrangement of the battery cell **15** and the sensor **20** upon the genuine product determination, as an example.

[0022] The sensor **20** may output a measurement result depending on a magnetic field of at least one of an X-axis direction, a Y-axis direction, or a Z-axis direction. The sensor **20** includes a plurality of sensor cells **22** and is also referred to as a sensor array. The sensor cells **22** each are a Hall element, as an example. The sensor **20** may include the plurality of sensor cells **22** arranged in a two-dimensional array and each sensor cell **22** may output a measurement result of magnetic flux densities in the X-axis direction, the Y-axis direction, and the Z-axis direction.

[0023] The rotation holding unit **30** rotatably holds the battery cell **15** in a state where a relative position of the battery cell **15** with respect to the sensor cells **22** is retained. The rotation holding unit **30** may energize the battery cell **15** during the measurement.

[0024] The control unit **40** may be a computer such as a PC (Personal Computer), a tablet computer, a smartphone, a workstation, a server computer, or a general-purpose computer or may be a computer system in which a plurality of computers are connected. Such a computer system is also a computer in a broad sense. The control unit **40** may also be implemented by one or more executable virtual computer environments within a computer. The control unit **40** may also be an internal computer of the sensor **20**.

[0025] The control unit **40** is connected to the sensor **20** and the rotation holding unit **30**. The control unit **40** may control various operations in the rotation holding unit **30**. The control unit **40** may take in measurement results of a magnetic flux density at the sensor **20** at at least two rotation angles of the battery cell **15**. The control unit **40** includes a condition input unit **100**, an energization unit **110**, a drive unit **120**, a processing unit **130**, and a storage unit **140**.

[0026] The condition input unit **100** is connected to an input device **70**. A measurement condition on a magnetic flux density may be input from a user via the input device **70** to the condition input unit **100**. The input device **70** may be a terminal used by the user (a PC, a smartphone, or the like), a keyboard, a touch panel, a mouse, or the like.

[0027] The energization unit **110** is connected to the condition input unit **100**. In response to the measurement condition being input to the condition input unit **100**, the energization unit **110** may energize the battery cell **15**. The energization unit **110** may energize the battery cell **15** by controlling a power supply connected to the battery cell **15**. The energization unit **110** may pass through the battery cell **15** a current having a current value indicated in the measurement condition or a predetermined current value.

[0028] The drive unit **120** is connected to the condition input unit **100**. In response to the measurement condition being input to the condition input unit **100**, the drive unit **120** may control the driving of the rotation holding unit **30**. The drive unit **120** may control the driving of the rotation holding unit **30** so as to rotate the battery cell **15** at a rotation angle depending on the measurement condition. The drive unit **120** may control the driving of the rotation holding unit **30** so as to move a relative position between the battery cell **15** and the sensor **20** depending on the measurement condition.

[0029] The processing unit **130** is connected to the energization unit **110**, the drive unit **120**, and the sensor **20**. The processing unit **130** takes in the measurement result of the magnetic flux density measured by the sensor **20**. The processing unit **130** may receive from the energization unit **110** a current value of the current flowing through the battery cell **15**. The processing unit **130** may receive from the drive unit **120** data that indicates a state of the rotation holding unit **30** such as the rotation angle of the battery cell **15**. The processing unit **130** may perform pre-processing on the taken measurement result and output the pre-processed measurement result to the storage unit **140**.

[0030] The storage unit **140** is connected to the processing unit **130**. The storage unit **140** stores a measurement result database, which records measurement results obtained by actually measuring the magnetic flux density. The storage unit **140** may record in the measurement result database the measurement results in association with measurement conditions.

[0031] FIG. **2** is a perspective view illustrating the rotation holding unit **30** in the measurement device **10** according to the present embodiment in more detail. FIG. **3** is a schematic top plan view illustrating a holding jig **60** and a cell substrate **235**, which are parts of the rotation holding unit **30**. FIG. **4** is a schematic perspective view of the holding jig **60**, which is a part of the rotation holding unit **30** when viewed from above. FIG. **5** is a schematic perspective view of the holding jig **60**, which is a part of the rotation holding unit **30** when viewed from below. Note that an X axis, a Y axis, and a Z axis illustrated in each of all figures indicate the common directions. In addition, upward and downward in the description indicate the Z-axis direction.

[0032] For one battery cell **15** held by the rotation holding unit **30**, the measurement device **10** can measure its magnetic flux density while changing its angle state and its relative position with respect to the sensor cells **22**. Although an example is illustrated where the rotation holding unit **30** holds a cylindrical battery cell **15** in the present embodiment, the present embodiment is not limited thereto, and a battery cell **15** having a polyhedral shape such as a hexahedron may be a subject to be measured by the measurement device **10** of the present embodiment.

[0033] The rotation holding unit **30** includes a sensor substrate **200**, column portions **210** and **215**, a transversal portion **220**, a slider **225**, a sensor moving portion **230**, a cell substrate **235**, mounting portions **240** and **245**, a first energizing terminal **250**, a second energizing terminal **255**, and a rotating portion **260**. The cell substrate **235**, the mounting portions **240** and **245**, the first energizing terminal **250**, the second energizing terminal **255**, and the rotating portion **260** constitute the holding jig **60** which rotatably holds the battery cell **15** and energizes the battery cell **15**.

[0034] The sensor **20** is fixed to the sensor substrate **200**. The sensor **20** may be fixed to the sensor substrate **200** of the present embodiment such that the sensor **20** is arranged above the cell substrate **235** via the column portions **210** and **215**, the transversal portion **220**, the slider **225**, and the sensor moving portion **230**. The sensor **20** may be fixed to the sensor substrate **200** in a position where a magnetic flux density generated by the battery cell **15** is measurable in the measurement. The sensor substrate **200** may be a sheet-shaped member or may be formed of metal or resin, but is not limited thereto.

[0035] The sensor substrate **200** has a plurality of positioning holes **202** on its upper surface (e.g., a total of **28** positioning holes **202** in FIG. **3** of the present embodiment) for determining the relative position between the sensor **20** and the battery cell **15**. The plurality of positioning holes **202** may be for positioning the cell substrate **235** in a plurality of different positions. The plurality of positioning holes **202** may be through-holes or may be recessed portions of the sensor substrate **200**, which are not penetrated therethrough. The plurality of positioning holes **202** may be provided to individually correspond to positions of a plurality of battery cells **15** in the subject battery unit that is a genuine product. This enables the rotation holding unit **30** to hold the battery cell **15** such that the relative position between the battery cell **15** and the sensor **20** is changeable. The measurement device **10** can measure the magnetic field of the battery cell **15** in a plurality of different relative positions with respect to the sensor **20** by means of the plurality of positioning holes **202**.

[0036] Each of the two column portions **210** and **215** has its lower end fixed around a different end of the sensor substrate **200** and extends upward. The transversal portion **220** is fixed between an upper end of one of the column portions **210** and an upper end of another of the column portions **215** and transverses over the sensor substrate **200**. The slider **225** is fixed in a middle of the transversal portion **220** and has a recessed portion extending upward and downward.

[0037] The sensor moving portion **230** is installed to be movable along the recessed portion of the slider **225** and is fixed such that the sensor **20** faces the battery cell **15** to be measured (or the upper surface of the sensor substrate **200**). The sensor **20** may be fixed to the sensor moving portion **230** such that the plurality of sensor cells **22** in the two-dimensional array are arranged along an upper surface of the cell substrate **235**. The sensor moving portion **230** may be connected to the control unit **40** and include an actuator (an electric motor, a hydraulic cylinder, or the like, as an example), which moves up and down with respect to the slider **225** under the control by the control unit **40**. As such sensor moving portion **230** moves up and down, the sensor **20** fixed to the sensor moving portion **230** is moved up and down. The sensor moving portion **230** may be moved to a lower end of the slider **225** to arrange the sensor **20** so as to face in proximity to the battery cell **15** during the measurement and may be moved to an upper end of the slider **225** other than during the measurement such as during movement of the holding jig **60**. The sensor moving portion **230** may also be moved up and down with respect to the slider **225** manually by the user. Thanks to the fact that the rotation holding unit **30** includes the slider **225** and the sensor moving portion **230**, the rotation holding unit **30** can move the sensor cells **22** with respect to the battery cell **15**. Such up-and-down movement of the sensor **20** allows for installing the holding jig **60** in a measurement position.

[0038] The rotating portion **260** is fixed to the cell substrate **235**. The cell substrate **235** may be movable relative to the sensor substrate **200**. The cell substrate **235** may be detachably arranged on the sensor substrate **200**. The cell substrate **235** may be a sheet-shaped member or may be formed of metal or resin. The cell substrate **235** may include a positioning pin **237** to be inserted into the plurality of positioning holes **202** in the sensor substrate **200**. The cell substrate **235** may include a plurality of positioning pins **237**, and positioning thereof is performed by causing the plurality of positioning pins **237** to be individually inserted into the plurality of positioning holes **202**. The positioning pin **237** may be formed so as to protrude from a lower surface of the cell substrate **235**.

[0039] The mounting portions **240** and **245** are arranged between the first energizing terminal **250** and the second energizing terminal **255** and protrude from an upper surface of the cell substrate **235** to contact the battery cell **15** to be held. The mounting portions **240** and **245** have the battery cell **15** mounted on the upper surfaces thereof, and hold the battery cell **15** in a predetermined height position. Each of the mounting portions **240** and **245** may have a cuboidal shape and may include an anti-slip feature at a portion in contact with the battery cell **15** on the upper surface. A plurality of mounting portions **240** and a plurality of mounting portions **245** may be arranged between the first energizing terminal **250** and the second energizing terminal **255**.

[0040] The first energizing terminal **250** is connected to one electrode of the battery cell **15** (a plus electrode, as an example) and the second energizing terminal **255** is connected to another electrode of the battery cell **15** (a minus electrode, as an example). Each of the first energizing terminal **250** and the second energizing terminal **255** may include a metal part for energizing the battery cell **15** and an anti-slip feature around the metal part for contacting with and holding the battery cell **15**. In the present embodiment, the first energizing terminal **250** and the second energizing terminal **255** are connected to an electrode on one end surface of the cylindrical battery cell **15** and an electrode on another end surface, and sandwich and hold the battery cell **15** on the mounting portions **240** and **245**.

[0041] The rotating portion **260** rotates the battery cell **15**. The rotating portion **260** may enable the battery cell **15** to be rotated while retaining the relative position of the battery cell **15** with respect to the sensor **20**. For example, the rotating portion **260** may cause the battery cell **15** to be rotated about its rotational axis in the Y-axis direction in a state where the battery cell **15** is held between the first energizing terminal **250** and the second energizing terminal **255**. The rotating portion **260** may rotate the battery cell **15** by rotating the first energizing terminal **250** and the second energizing terminal **255** about the rotational axis in the Y-axis direction in the holding state. The rotational axis may be an axis that passes through centers of two end surfaces of the battery cell **15** (an axis that passes through centers of two circular end surfaces of the battery cell **15** in a case of the battery cell **15** having the cylindrical shape, as an example). The rotating portion **260** may be an actuator (a stepper motor, a servo motor, a hydraulic cylinder, or the like, as an example) connected to the control unit **40**, which rotates the battery cell **15** under the control by the control unit **40**. The rotating portion **260** may also enable the battery cell **15** to be rotated manually by the user.

[0042] FIG. **6** illustrates an arrangement of the sensor cells **22** and the battery cell **15** during the measurement. FIG. **6** illustrates an example where data for the genuine product determination for a battery unit within which seven battery cells **15** are arranged in each of two lines is acquired

[0043] The measurement device **10** can perform the measurement while moving one battery cell **15** held by the holding jig **60** in a plurality of cell positions a1 to an (where $n>1$, and in the present embodiment, $n=14$) with respect to the sensor cells **22** in the two-dimensional array. Each of the cell positions may be the relative position between the sensor cells **22** and the battery cell **15**. The measurement device **10** performs the measurement at each angle state while rotating the battery cell **15** in each cell position ai ($1 \leq i \leq n$). In the example of FIG. **1**, an example of the measurement in the relative position a**1** is illustrated.

[0044] FIG. **7** illustrates a schematic perspective view of the holding jig **60** in the rotation holding unit **30** of a first variant in the measurement device **10** of the present embodiment. FIG. **7** illustrates the holding jig **60** with the battery cell **15** in the first variant being held. FIG. **8** illustrates a schematic top plan view of the holding jig **60** with the battery cell **15** in the first variant not being held. The holding jig **60** in the first variant has a configuration and functionality similar to those of the holding jig **60** of the rotation holding unit **30** in the embodiment of FIG. **1** to FIG. **6**, and, in the rotation holding unit **30**, is interchangeable with the holding jig **60** in FIG. **1** to FIG. **6**. For the holding jig **60** in the first variant, differences with respect to the holding jig **60** in FIG. **1** to FIG. **6** will be mainly described below.

[0045] The holding jig **60** includes the cell substrate **235**, two mounting portions **300** and **302**, the first energizing terminal **250**, the second energizing terminal **255**, the rotating portion **260**, a cell holding portion **305**, and a support portion **310**. The cell substrate **235**, the first energizing terminal **250**, and the second energizing terminal **255** may have configurations and functionalities similar to those of the holding jig **60** of the measurement device **10** in the embodiment of FIG. **1** to FIG. **6**.

[0046] The two mounting portions **300** and **302** are arranged between the first energizing terminal **250** and the second energizing terminal **255**. The mounting portions **300** and **302** each protrude from the upper surface of the cell substrate **235** to contact with the cell holding portion **305** into which the battery cell **15** is inserted. The mounting portions **300** and **302** have the cell holding portion **305** mounted on the upper surfaces thereof, and hold the battery cell **15** in a predetermined height position. The mounting portions **300** and **302** each have a recessed portion at their upper end portions when viewed in an X-Z cross section and have the battery cell **15** mounted on the recessed portion. In FIG. **7** and FIG. **8**, the mounting portions **300** and **302** each have a V-shaped recessed portion at the upper end portions when viewed in the X-Z cross section. Note that, the shape of the recessed portion is not limited thereto, and it may also be a U-shaped recessed portion along a shape of a side surface of the battery cell **15**. The mounting portions **300** and **302** may each include an anti-slip feature at a portion in contact with the battery cell **15** on the upper surface of the recessed portion.

[0047] The cell holding portion **305** has the battery cell **15** inserted thereinto and includes a recessed portion for defining a rotation angle. The cell holding portion **305** may have a hollow portion into which the battery cell **15** is to be inserted. The cell holding portion **305** may have a shape that fits the shape of the battery cell **15**, and, in the present embodiment, is a hollow cylindrical shape. The cell holding portion **305** may be arranged to contact with the mounting portions **300** and **302** in a state where the battery cell **15** is inserted during the measurement. The cell holding portion **305** may include a plurality of recessed portions formed for each predetermined rotation angle on its side surface (at predetermined angle intervals). The recessed portions may be formed to be penetrated through the side surface of the cell holding portion **305** and expose the side surface of the battery cell **15** to be held, or may be formed not to be penetrated through the side surface of the cell holding portion **305**. The recessed portions may be formed to be elongated along the side surface of the cell holding portion **305**. The recessed portions may be formed in a position that will be located between the two mounting portions **300** and **302** during the measurement. The cell holding portion **305** may be formed of metal or resin.

[0048] The support portion **310** is fixed to the cell substrate **235** and contacts with and supports the recessed portion of the cell holding portion **305**. The support portion **310** may be arranged between the two mounting portions **300** and **302**. The support portion **310** may have a shape such that it can be inserted into the recessed portion of the cell holding portion **305**. For example, the support portion **310** may have a pin-like shape formed to protrude from the upper surface of the cell substrate **235** and, when the cell holding portion **305** into which the battery cell **15** is inserted is mounted on the mounting portions **300** and **302**, may be inserted into the recessed portion of the cell holding portion **305**. This allows for easily adjusting the angle of the battery cell **15** by the recessed portion of the cell holding portion **305** even when placing the cell holding portion **305** manually by the user.

[0049] The support portion **310** may be rotatable about a rotational axis that is the same as the rotational axis of the battery cell **15**. The support portion **310** may be fixed to the two mounting portions **300** and **302** and be rotatable about the rotational axis that is the same as the rotational axis of the battery cell **15** together with the mounting portions **300** and **302** with respect to the cell substrate **235**. The support portion **310** may be rotatable by a rotation angle less than an angle between adjacent recessed portions of the cell holding portion **305**. As an example, when the recessed portions of the cell holding portion **305** are formed around the rotational axis in 10-degree intervals, the support portion **310** and the mounting portions **300** and **302** may be rotatable by ±5 degrees about the rotational axis. This allows for adjusting the angle between the adjacent recessed portions of the cell holding portion **305**. The support portion **310** may be connected to the control unit **40** and may include an actuator (an electric motor such as a brush motor, a hydraulic cylinder, or the like, as an example), which rotates the support portion **310** under the control by the control unit **40**.

[0050] Note that the cell holding portion **305** may include a protruding portion, and in this case, the support portion **310** may be for contacting with and holding the protruding portion of the cell holding portion **305**. For example, the cell holding portion **305** may include a plurality of pin-like protruding portions radially protruding from the side surface of the cell holding portion **305**. When the cell holding portion **305** into which the battery cell **15** is inserted is mounted on the mounting portions **300** and **302**, the support portion **310** may have a recessed upper end portion into which one of the protruding portions of the cell holding portion **305** is inserted. The support portion **310** may also be formed on the upper surface of the cell substrate **235** as a recessed portion into which one of the protruding portions of the cell holding portion **305** is inserted.

[0051] FIG. **9** illustrates a schematic top plan view of a part of the rotation holding unit **30** of a second variant in the measurement device **10** of the present embodiment. FIG. **9** illustrates some part of the rotation holding unit **30** and omits other parts thereof. The rotation holding unit **30** of a second variant has a configuration and functionality similar to those of the rotation holding unit **30** of the measurement device **10** of the embodiment in FIG. **1** to FIG. **6**, except that it does not include the plurality of positioning holes **202**, but includes rails **400**, **405**, **410**, and **415** and a cell moving portion **420**. Differences with respect to the rotation holding unit **30** in FIG. **1** to FIG. **6** will be mainly described below.

[0052] The sensor substrate **200** includes rails **400**, **405**, **410**, and **415** for moving the relative position between the sensor **20** and the battery cell **15**. The rails **400**, **405**, **410**, and **415** are for moving the cell substrate **235** with respect to the sensor **20**. The rails **400**, **405**, **410**, and **415** each are recessed to extend on the upper surface of the sensor substrate **200** in the X-axis direction, and the cell substrate **235** is movable along the rails **400**, **405**, **410**, and **415**. The positioning pins **237** on the lower surface of the cell substrate **235** may be inserted into the rails **400**, **405**, **410**, and **415**, and the cell substrate **235** may be movable along the rails **400**, **405**, **410**, and **415** in the X-axis direction. The rails **400**, **405**, **410**, and **415** allows for positioning in the Y-axis direction by moving the cell substrate **235** between the different rails **400**, **405**, **410**, and **415**. A plurality of rails **400**, **405**, **410**, and **415** may be arranged in parallel with each other. In the present embodiment, each of two positioning pins **237** of the cell substrate **235** are inserted into each of two rails **400** and **410**, and the holding jig **60** is movable manually by the user between two different positions in the Y-axis direction, that is, between a set of two rails **400** and **410** and a set of two rails **405** and **415**. This allows for moving the cell substrate **235** on the plurality of rails **400**, **405**, **410**, and **415**, and, when the subject battery unit is constituted by the battery cells **15** in multiple lines, allows for acquiring data depending on the subject battery unit. In addition, these rails may be any mechanism that allows the sensor **20** and the battery cell **15** to move relatively to each other on the sensor substrate **200**, for example, may be grooves.

[0053] The cell moving portion **420** moves the relative position between the sensor **20** and the battery cell **15**. The cell moving portion **420** may move the holding jig **60** holding the battery cell **15** on the rails **400**, **405**, **410**, and **415**. The cell moving portion **420** may be fixed to the sensor substrate **200** and may move the cell substrate **235** on the rails **400**, **405**, **410**, and **415** with respect to the sensor substrate **200**. The cell moving portion **420** may include a telescoping portion **425**. One end of the telescoping portion **425** may be fixed to the cell substrate **235**. The cell moving portion **420** may move the cell substrate **235** on the rails **400**, **405**, **410**, and **415** by causing the telescoping portion **425** to telescope in the X-axis direction by means of an actuator (an electric motor such as a brush motor, a hydraulic cylinder, or the like, as an example). The cell moving portion **420** may be connected to the drive unit **120** of the control unit **40** and may cause the telescoping portion **425** to telescope under the control by the control unit **40**. Thereby, the control unit **40** may control the relative position between the sensor **20** and the battery cell **15**, and, in each of at least two relative positions, take in measurement results at at least two rotation angles. Note that the cell moving portion **420** may automatically move the holding jig **60** in the Y-axis direction under the control by the control unit **40**. In this case, the cell moving portion **420** may move the holding jig **60** by ascending it in the Z-axis direction from the two rails **400** and **410**, moving it in the Y-axis direction, and then descending it onto the different rails **405** and **415**.

[0054] Note that a part of the configurations of the rotation holding unit **30** in the variants 1 and 2 may be interchangeable with any part of that of the rotation holding unit **30** of the measurement device **10** in FIG. **1** to FIG. **6**.

[0055] FIG. **10** is a flow diagram illustrating a measurement operation of the measurement device **10** of the present embodiment. The measurement device **10** may start the measurement operation once a power supply is turned ON. In the present embodiment, as an example, the measurement device **10** generates a measurement result database used for the genuine product determination on the battery unit including the battery cells **15** arranged as illustrated in FIG. **6**.
[0056] In Step S**500**, a measurement condition may be input from the user via the input device **70** to the condition input unit **100**. The measurement condition including at least one of a current value of a current caused to flow through the battery cell **15** during the measurement, an interval between the rotation angles of the battery cell **15**, a number of times of the measurement at each cell position and each angle state, information about the cell positions (a number of cell positions, coordinates indicating cell positions with respect to the sensor **20**, or the like), information indicating the battery cell **15** to be measured (a type, a shape, product identification information, or the like), or information indicating the genuine battery unit (a number, an arrangement, an angle state, a type, a shape, or product identification information of the battery cell **15** included therein, or the like) may be input to the condition input unit **100**.
[0057] In Step S**510**, the measurement device **10** places one battery cell **15** in the cell position ai. At a first measurement (the rotation angle θ=0 degree, the cell position a**1**), the user may manually place the battery cell **15**. A reference marker for the rotation angle may be applied to the battery cell **15** in the position of the battery tab or the like. At the first measurement, the user may cause the first energizing terminal **250** and the second energizing terminal **255** to sandwich and hold the battery cell **15** such that the reference marker coincides with a predetermined position (a position in which it faces right above, as an example) in the holding jig **60**. The drive unit **120** may control to ascend the sensor moving portion **230** on the slider **225** before the placement of the battery cell **15**, and to descend the sensor moving portion **230** on the slider **225** such that the sensor **20** is placed in the measurement position after the placement of the battery cell **15**.
[0058] In Step S**520**, the measurement device **10** measures a magnetic flux density by the sensor **20** in a state where the held battery cell **15** is not energized. The processing unit **130** may take in each magnetic flux density from each of the plurality of sensor cells **22**. This enables the processing unit **130** to acquire the magnetic flux density.
[0059] In Step S**530**, the measurement device **10** measures the magnetic flux density in the state where the battery cell **15** is energized. The energization unit **110** may pass a current through the battery cell **15** via the first energizing terminal **250** and the second energizing terminal **255** depending on a registered current value indicated in the input measurement condition. Here, the registered current value may be a set current value of the current to be passed through the battery cell **15** within the battery unit in the genuine product determination. For example, the control unit **40** may take in a measurement result of the magnetic flux density at the sensor **20** by the processing unit **130** when passing a current having a current value higher than the registered current value through the battery cell **15** by the energization unit **110**. As an example, the energization unit **110** may pass a current having a current value calculated by multiplying the registered current value by a predetermined energizing coefficient (a value depending on a number of the battery cells **15** in the subject battery unit (hereinafter, also referred to as a total number of cells), as an example) through the battery cell **15**. As an example, the predetermined energizing coefficient may be V (total number of cells). Passing such a current having a high current value depending on the number of the battery cells **15** can reduce noises in the magnetic field measurement by division by the same energizing coefficient when using the measurement result of the measurement device **10** in the genuine product determination on the battery unit.
[0060] The processing unit **130** may output a difference between the magnetic flux density measured in the state of energizing and the magnetic flux density measured in Step S**520** as the measurement result to the storage unit **140**.
[0061] In Step S**540**, the storage unit **140** receives from the processing unit **130** the measurement

result that indicates the magnetic flux density and records it in the measurement result database. The storage unit **140** may record in the measurement result database the measurement result in association with the registered current value. The storage unit **140** may further record in the measurement result database at least one of a current value in the measurement received from the energization unit **110**, information indicating the drive of the rotation holding unit **30** received from the drive unit **120** (the rotation angle, the cell position, or the like), or information indicating the subject battery unit input to the condition input unit **100**, in association with the measurement result.

[0062] In Step S**550**, the measurement device **10** determines whether the rotation angle **0** of the current battery cell **15** is less than 360 degrees. The measurement device **10** may calculate a total rotation angle θ of the battery cell **15** in the current cell position from the information received from the drive unit **120** (information of the rotation angle and a number of rotations, as an example). When the rotation angle is less than 360 degrees (Yes in S**550**), the measurement device **10** proceeds to Step **510**. When the rotation angle is greater than or equal to 360 degrees (No in S**550**), the measurement device **10** proceeds to Step **560**.

[0063] In Step S**510** that follows Step S**550**, the measurement device **10** changes the rotation angle of the battery cell **15** into a next angle state. For example, the drive unit **120** rotates the battery cell **15** by a predetermined rotation angle by the rotating portion **260**. As an example, the drive unit **120** rotates the battery cell **15** by the predetermined rotation angle (e.g., 10 degrees) by the rotating portion **260** about a rotational axis that passes through a center of the first energizing terminal **250** and a center of the second energizing terminal **255**. Then, Steps S**520** to S**550** may be repeated.

[0064] In Step S**560**, the measurement device **10** determines whether the value i of the cell position ai of the current battery cell **15** is less than the total number of cells in the subject battery unit. The measurement device **10** may acquire the total number of cells from the measurement condition input to the condition input unit **100**. In an example where data is acquired for the genuine product determination of the battery unit within which seven battery cells **15** are arranged in each of two lines as illustrated in FIG. **6**, if the current cell position ai in which the magnetic flux density is measured is the cell position a**14**, the measurement device **10** may determine that the value i is not less than the total number of cells, or if the current cell position ai is any of the cell positions a**1** to a**13**, the measurement device **10** may determine that the value i is less than the total number of cells.

[0065] When the value i of the cell position ai of the current battery cell **15** is less than the total number of cells (Yes in S**560**), the measurement device **10** proceeds to Step **510**. When the value i of the current cell position ai is greater than or equal to the total number of cells (No in S**560**), the measurement device **10** may end the measurement operation.

[0066] In Step S**510** that follows Step S**560**, the measurement device **10** moves the position of the battery cell **15** to a next cell position. For example, in the case of the rotation holding unit **30** of the second variant in FIG. **9**, the drive unit **120** moves the holding jig **60** on the rails **400**, **405**, **410**, and **415** in the X-axis direction at a predetermined distance by the cell moving portion **420**. Then, Steps S**520** to S**560** may be repeated.

[0067] Note that the measurement device **10** may perform pre-processing on the measurement result recorded in the measurement result database after ending the measurement operation, and record the pre-processed measurement result in the measurement result database. In Steps S**500** to S**560**, the processing unit **130** of the control unit **40** may take in a plurality of measurement results of the magnetic flux density at the sensor **20** at each of at least two rotation angles, calculate an average value of the plurality of measurement results at each rotation angle by pre-processing, and record the calculated average value in the measurement result database. The user may input to the condition input unit **100** a measurement condition for performing the measurement at multiple rotations (the total number of cells×360 degrees, as an example) in each cell position. This enables the measurement device **10** to repeat Steps S**500** to S**560** even after ending the measurement operation in Step S**560** (No in S**560**). The measurement device **10** can take in a same number of magnetic flux densities as a number of rotations at each rotation angle in each cell position (a same number of magnetic flux densities as the total number of cells, as an example) by the processing unit **130** by performing the measurement while rotating the battery cell **15** multiple times in each cell position. Therefore, the processing unit **130** may calculate the average value of the plurality of magnetic flux densities taken in at each rotation angle in each cell position, and record it in the measurement result database. As an example, the processing unit **130** can take in a same number of measurement results as the total number of cells at each rotation angle in each cell position to calculate the average value.

[0068] Calculating such an average value can suppress a standard deviation of noises in the measurement results to e.g., 1/V (total number of cells) times. Thus, thanks to pre-processing by repeating the magnetic field measurement of the battery cell **15** a same number of times as the total number of cells, noises superposed by adding the measurement result in each cell position during the genuine product determination can be reduced in advance by means of the pre-processing.

[0069] Note that the measurement device **10** may omit Step S**540**, store the measurement result in the processing unit **130**, also perform the pre-processing on the stored measurement result before ending the measurement operation, and record the pre-processed measurement result in the measurement result database after ending the measurement operation.

[0070] FIG. **11** illustrates an example of the measurement result database which records measurement results in the measurement device **10**. The measurement result database records the measurement results in association with the cell position a**1** to the cell position an. FIG. **11** omits measurement results in a cell position a**2** to a cell position an−1.

[0071] The measurement result database records each rotation angle and corresponding magnetic flux densities in the X axis, the Y axis, and the Z axis in each cell position. In FIG. **11**, the rotation angle is a rotation angle of the battery cell **15** from a reference position (the rotation angle is 0 degrees).

[0072] The magnetic flux densities (in the X axis) are magnetic flux densities in the X-axis direction measured from one battery cell **15** at corresponding rotation angles and are measured values taken in from the plurality of sensor cells **22**. As an example, Bx0 is a magnetic flux density of the plurality of sensor cells **22** in the X-axis direction at the rotation angle 0 degrees in the cell position a**1**, and therefore indicates a same number of the magnetic flux densities as the number of the sensor cells **22**. The magnetic flux densities (in the Y axis) are magnetic flux densities in the Y-axis direction measured from one battery cell **15** at corresponding rotation angles and are magnetic flux densities taken in from the plurality of sensor cells **22**. As an example, By0 is a magnetic flux density of the plurality of sensor cells **22** in the Y-axis direction at the rotation angle 0 degrees in the cell position a**1**, and therefore indicates a same number of the magnetic flux densities as the number of the sensor cells **22**. The magnetic flux densities (in the Z axis) are magnetic flux densities in the Z-axis direction measured from one battery cell **15** at corresponding rotation angles and are magnetic flux densities taken in from the plurality of sensor cells **22**. As an example, Bz0 is a magnetic flux density of the plurality of sensor cells **22** in the Z-axis direction at the rotation angle 0 degrees in the cell position a**1**, and therefore indicates a same number of the magnetic flux densities as the number of the sensor cells **22**. Each magnetic flux density may be recorded in the measurement result database in association with corresponding positional information of the sensor cells **22**.

[0073] Note that the measurement result database as illustrated in FIG. **11** may be stored in association with information (such as identification information) of the subject battery unit in the storage unit **140**.

[0074] The measurement device **10** of the present embodiment can acquire data capable of expressing individuals of numerous battery units at a small number of times of the measurement by measuring the battery cells **15** one by one. For example, in the case of predicting the magnetic flux density of the battery unit constituted by 14 battery cells **15**, once the rotation angle of each battery cell **15** is rotated 360 degrees in 45-degree increments, there are 8.sup.14 magnetic flux densities in all combinations. However, by measuring the magnetic flux densities of the battery cells **15** one by one the measurement device **10** of the present embodiment to acquire 8×14 measurement results and superpose the measurement results, the magnetic flux densities of all combinations can be reproduced.

[0075] FIG. **12** illustrates a schematic view of an estimation system **800** according to the present embodiment. The estimation system **800** estimates a magnetic flux density generated by a battery unit **810** to be determined, and determines whether the battery unit **810** to be determined is a genuine product using the estimation result. The battery unit **810** may be a lithium-ion battery or the like and includes the plurality of battery cells **15** therein. The estimation system **800** includes the measurement device **10**, a detection device **840**, an input device **850**, a determination device **900**, and a display device **950**. The measurement device **10** may be similar to the measurement device **10** of the present embodiment described in FIG. **1** to FIG. **11**, and the description thereof is omitted.

[0076] The detection device **840** detects the magnetic flux density generated by the battery unit **810** while energizing (charging or discharging) the battery unit **810** to be determined. The detection device **840** may detect the magnetic flux density from the battery unit **810** by the sensor **845** similar to the sensor **20** of the measurement device **10** on a same condition as the measurement condition of the measurement device **10** (such as the relative position between the battery cell **15** and the sensor cell **22**).

[0077] The input device **850** may be a terminal used by the user (a PC, a smartphone, or the like), a keyboard, a touch panel, a mouse, or the like. Various information for the genuine product determination is input from the user to the input device **850**.

[0078] The determination device **900** determines whether the battery unit **810** to be determined is a genuine product from the magnetic flux density detected by the detection device **840**. The determination device **900** includes a state input unit **905**, an acquisition unit **910**, an estimation unit **920**, a measurement unit **925**, and a comparison unit **930**.

[0079] The state input unit **905** is connected to the input device **850**. Information of the battery unit **810** to be determined is input via the input device **850** to the state input unit **905**. For example, for the battery unit **810** including a plurality of battery cells **15**, state data indicating the arrangement and the angle state of each of the battery cells **15** within the battery unit **810** is input to the state input unit **905**. The state data may be information assuming that the battery unit **810** is a genuine product.

[0080] The acquisition unit **910** is connected to the state input unit **905** and the measurement device **10**. The acquisition unit **910** may include an acquisition database. The acquisition unit **910** acquires a measurement result actually measured using the measurement device **10** to record it in the acquisition database. For at least one type of the battery cells **15** used for the battery unit **810**, the acquisition database records the measurement result obtained by actually measuring the magnetic flux density for each angle state when passing a current while changing the angle state of the battery cells **15**.

[0081] The estimation unit **920** is connected to the acquisition unit **910**. The estimation unit **920**, based on the angle state of each of the battery cells **15** and the measurement result recorded in the acquisition database, determines the magnetic flux density generated by each of the battery cells **15**, and, based on the magnetic flux density generated by each of the battery cells **15** and the arrangement of each of the battery cells **15** in the battery unit **810**, performs the estimation to yield an estimated magnetic flux density generated by the battery unit **810**.

[0082] The measurement unit **925** is connected to the detection device **840**. The measurement unit **925** may control the sensor **845** of the detection device **840** to measure the magnetic flux density of the battery unit **810** to be determined, and takes in the measurement result of the magnetic flux density in the sensor **845**.

[0083] The comparison unit **930** is connected to the estimation unit **920** and the measurement unit **925**. The comparison unit **930** compares the measurement result of the magnetic flux density taken in by the measurement unit **925** with the estimated magnetic flux density yielded by the estimation by the estimation unit **920** to perform the genuine product determination of the battery unit **810** to be determined.

[0084] The display device **950** is connected to the comparison unit **930**. The display device **950** may be a PC, a display, or the like, and may display a result of the genuine product determination by the comparison unit **930**.

[0085] FIG. **13** illustrates a flow diagram of the genuine product determination operation in the estimation system **800** according to the present embodiment.

[0086] In Step S**600**, state data is input to the state input unit **905**. The state data may include information indicating the battery unit **810**. For example, the state data may include at least one of a number, a type, or an arrangement of the plurality of battery cells **15** within the battery unit **810**, an angle state in a position of each battery cell **15** (an angle state with a position of a lead wire being set as a reference position of **0** degrees, or the like, as an example), or identification information of the battery unit **810** (a manufacturing number, a type, or the like). Here, the arrangement of the plurality of battery cells **15** may be a relative position of each battery cell **15** with respect to the sensor **845**, for example, may be coordinates with respect to a center of an X-Y plane in the battery unit **810**. The state data may also be input from the detection device **840** to the state input unit **905**. The state input unit **905** outputs the state data to the acquisition unit **910**.

[0087] In Step S**610**, the acquisition unit **910** acquires the measurement result to be estimated from the measurement device **10** depending on the state data input to the state input unit **905**, and records the acquired measurement result in the acquisition database. The acquisition unit **910** may have information such as the angle state or the arrangement of the battery cells **15** for the battery unit **810**, and, once the state data including the identification information of the battery unit **810** is input, may acquire from the measurement device **10** a measurement result depending on the information such as the angle state or the arrangement corresponding to the state data. The acquisition unit **910** may associate the cell positions, the rotation angles, and the magnetic flux densities with each other and record them in the acquisition database, similar to the measurement result database of the measurement device **10** as illustrated in FIG. **11**. The acquisition unit **910** may acquire the measurement result corresponding to each angle state in all cell positions in the measurement database.

[0088] As an example, in a case of the arrangement where seven battery cells **15** are arranged in each of two lines as illustrated in FIG. **6**, when the state data indicates that the rotation angle in the cell position a**1** is one degree, . . . , and that the rotation angle in the cell position an (where, n=14 in the case of the battery unit **810** in FIG. **6**) is 50 degrees, the acquisition unit **910** may acquire from the measurement device **10** the magnetic flux densities Bx1, By1, and Bz1 in the cell position a**1** in FIG. **11**, . . . , and the magnetic flux densities Bx50, By50, and Bz50 in the cell position an. The acquisition unit **910** may acquire from the measurement device **10** the measurement results of the plurality of sensor cell **22** at each rotation angle in each cell position to record them in the acquisition database. As an example, the acquisition unit **910** may record, as the magnetic flux density Bx50, a same number of magnetic flux densities in the X-axis direction as the number of the sensor cells **22** in association with information of the arrangement of the sensor cells **22** (the identification information, coordinates, or the like) in the acquisition database.

[0089] In addition, the acquisition unit **910** may acquire a measurement condition in the measurement device **10** (a current value when energizing the battery cell **15** during the measurement, an energizing coefficient, a registered current value, or the like, as an example) to record it in association with the measurement result in the acquisition database.

[0090] In Step S**620**, the estimation unit **920** estimates the magnetic flux density generated by the battery unit **810** using the measurement results recorded in the acquisition database. For one combination of the arrangements and the angle states of the plurality of battery cells **15** indicated in the state data, the estimation unit **920** may estimate a sum of the acquired magnetic flux densities as the estimated magnetic flux density generated by the battery unit **810**. The estimation unit **920** may estimate a sum of the magnetic flux densities in each of three axis directions as the estimated magnetic flux density. When the sensor **20** includes the plurality of sensor cells **22**, the estimation unit **920** may estimate, for each of the sensor cells **22**, a sum of the magnetic flux densities in all cell positions a**1** to an (i.e., a value obtained by summing a same number of the magnetic flux densities as the total number of cells) as the estimated magnetic flux density. This enables the estimation unit **920** to calculate the estimated magnetic flux density in a position where the sensor cells **22** are arranged and to obtain a distribution of the estimated magnetic flux density in the X-Y plane.

[0091] As an example, in the case of the arrangement where seven battery cells **15** are arranged in each of two lines as illustrated in FIG. **6**, when the state data indicates that the rotation angle of the cell position a**1** is one degree, . . . , and that the rotation angle of the cell position an is 50 degrees, the estimation unit **920** may calculate, for the measurement result of each sensor cell **22** in the X-axis direction, a sum of the magnetic flux densities in the cell position a**1** to an (Bx1+ . . . +Bx50) as the estimated magnetic flux density in the X-axis direction. Similarly, the estimation unit **920** may calculate, for the measurement result of each sensor cell **22** in the Y-axis direction, a sum of the magnetic flux densities in the cell position al to an (By1+ . . . +By50) as the estimated magnetic flux density in the Y-axis direction. Similarly, the estimation unit **920** may calculate, for the measurement result of each sensor cell **22** in the Z-axis direction, a sum of the magnetic flux densities in the cell position a**1** to an (Bz1+ . . . +Bz50) as the estimated magnetic flux density in the Z-axis direction.

[0092] When an energizing coefficient is associated with the measurement result acquired by the acquisition unit **910**, the estimation unit **920** may remove noises during the measurement by dividing the magnetic flux density of the measurement result by the energizing coefficient. The estimation unit **920** may divide the sum of the measurement results by the energizing coefficient to calculate the estimated magnetic flux density.

[0093] The estimation unit **920** may calculate a difference between the sum of the measurement results acquired by the acquisition unit **910** (i.e., the estimated magnetic flux density obtained by estimation similar to the above) and a reference magnetic flux density as the estimated magnetic flux density. The estimation unit **920** may acquire measurement results with the same arrangement and different angle states of the battery cells **15** as/than those in the measurement results to be estimated indicated in the state data (e.g., measurement results obtained by the same measurement device **10** as that performed the measurement and yielded the measurement results to be estimated and with the angle state being 0 degrees in all cell positions) via the acquisition unit **910**. For the acquired measurement results, the estimation unit **920** may calculate to yield the sum of them similar to the measurement results to be estimated and regard the sum as the reference magnetic flux density. For the measurement result on each sensor cell **22**, the estimation unit **920** may calculate the distribution of the estimated magnetic flux density in the positions of the plurality of sensor cell **22** by calculating the difference between the sum of the measurement results to be estimated and the reference magnetic flux density. This allows for removing from the estimated magnetic flux density noises caused by the magnetic field from the configuration of the measurement device **10**.

[0094] The estimation unit **920** may also calculate the distribution of the estimated magnetic flux density that is weighted depending on a current proportion of currents flowing through the respective battery cells **15** in the battery unit **810**. The estimation unit **920** may perform weighting by multiplying the magnetic flux density by a different weight for each cell position and regard a sum of the weighted magnetic flux densities as the estimated magnetic flux density. The current proportion of the currents flowing through the respective battery cells **15** in the battery unit **810** may be determined in advance by means of an experiment or a simulation on a genuine product corresponding to the battery unit **810**. The estimation unit **920** may multiply the magnetic flux density measured in a cell position having a higher current proportion by a higher weight and multiply the magnetic flux density measured in a cell position having a lower current proportion by a lower weight. This enables the estimation unit **920** to perform the estimation to yield the estimated magnetic flux density that reflects the bias in currents through the plurality of battery cells **15** in the battery unit **810** during energizing.

[0095] In Step S**630**, the measurement unit **925** takes in the magnetic flux density detected by the detection device **840** with the battery unit **810** to be determined being energized. As an example, the detection device **840** may be arranged in a charging station where a car equipped with the battery unit **810** to be determined or the like is charged, and come into proximity of the battery unit **810** to be determined upon charging to detect the magnetic flux density. Upon detecting, the battery unit **810** to be determined and the sensor **845** may be arranged in the detection device **840** in a positional relationship that is the same as the relative position between the sensor **20** (sensor cells **22**) and the battery unit (battery cells **15**) in the measurement device **10** as illustrated in FIG. **2** and FIG. **6**. The detection device **840** may detect the magnetic flux density in response to the start of charging of the battery unit **810** to be determined and output the measurement result to the measurement unit **925**. The detection device **840** may output to the comparison unit **930** the distribution of the magnetic flux density in the X axis, the distribution of the magnetic flux density in the Y axis, and the distribution of the magnetic flux density in the Z axis respectively obtained by detecting the magnetic flux densities in the X-axis, Y-axis, and Z-axis directions by the plurality of sensor cells of the sensor **845**.

[0096] In Step S**640**, the comparison unit **930** compares the magnetic flux density detected by the detection device **840** with the estimated magnetic flux density obtained by estimation by the estimation unit **920**. The comparison unit **930** may compare between the detected magnetic flux density and the estimated magnetic flux density in corresponding positions of the measurement device **10** and the detection device **840** (the sensor cell in the same position). If the difference between the detected magnetic flux density and the estimated magnetic flux density is within a predetermined range, the comparison unit **930** may determine that the battery unit **810** to be determined is a genuine product. If the difference between the detected magnetic flux density and the estimated magnetic flux density is outside the predetermined range, the comparison unit **930** may determine that the battery unit **810** to be determined is not a genuine product.

[0097] In Step S**650**, the comparison unit **930** outputs a comparison result. The comparison unit **930** may output display data for displaying the comparison result on the display device **950**.

[0098] The present embodiment allows for efficiently estimating the magnetic flux density of the genuine product with less data by superposing the magnetic flux densities actually measured in the respective cell positions in advance. This allows for efficiently determining the battery unit including a battery cell that is not a genuine product.

[0099] Note that the estimation system **800** can also perform the genuine product determination by the genuine product determination operation of the present embodiment on the battery unit **810** for which the angle state of the battery cell **15** is not specified. In this case, the determination device **900** may perform estimation to yield a plurality of estimated magnetic flux densities for a plurality of combinations of angle states of the battery cell **15** to compare each of the plurality of estimated magnetic flux densities with the magnetic flux density detected by the detection device **840**. The present example will be described below.

[0100] Firstly in Step S**600**, for one arrangement of a plurality of battery cells **15** in the Z-Y plane of the battery units **810**, a plurality of combinations of angle states of the battery cells **15** (e.g., a plurality of different combinations with an angle interval being predetermined) may be input to the state input unit **905** as state data. As an example, for the arrangement of cell positions as illustrated in FIG. **6**, state data may be input to the state input unit **905**, wherein the state data indicates a combination in which the rotation angle of the cell position a**1** is zero degrees, the rotation angle of the cell position a**2** is 10 degrees, . . . , and the rotation angle of the cell position an is 10 degrees; a combination in which the rotation angle of the cell position a**1** is 10 degrees, the rotation angle of the cell position a**2** is 10 degrees, . . . , and the rotation angle of the cell position an is 10 degrees; and a combination in which the rotation angle of the cell position a**1** is 20 degrees, the rotation angle of the cell position a**2** is 10 degrees, . . . , and the rotation angle of the cell position an is 10 degrees.

[0101] Then in Step S**610**, the acquisition unit **910** may individually acquire measurement results of the plurality of combinations of the angle states depending on the state data. In Step S**620**, the estimation unit **920** may individually estimate the plurality of estimated magnetic flux densities from the measurement results of the acquired plurality of combinations. In Step S**640**, the comparison unit **930** compares the magnetic flux density detected by the detection device **840** with each of the plurality of estimated magnetic flux densities obtained by estimating by the estimation unit **920**. If a difference between at least one of the plurality of estimated magnetic flux densities and the detected magnetic flux density is within a predetermined range, the comparison unit **930** can determine that the battery unit **810** to be determined is a genuine product. On the contrary, if the difference between any of all the plurality of estimated magnetic flux densities and the detected magnetic flux density is outside the predetermined range, the comparison unit **930** can determine that the battery unit **810** to be determined is not a genuine product.

[0102] Note that, the state input unit **905**, the acquisition unit **910**, and the estimation unit **920** may be included in the measurement device **10** and the estimated magnetic flux density obtained by estimating by the estimation unit **920** may be recorded in the measurement database in the storage unit **140** of the measurement device **10**.

[0103] While the present invention has been described with the embodiments, the technical scope of the present invention is not limited to the above-described embodiments. It is apparent to persons skilled in the art that various alterations or improvements can be added to the above-described embodiments. It is also apparent from the description of the claims that the form to which such alterations or improvements are made can be included in the technical scope of the present invention.

[0104] It should be noted that each process of the operations, procedures, steps, stages, and the like performed by an apparatus, system, program, and method shown in the claims, the specification, or the drawings can be realized in any order as long as the order is not indicated by “prior to,” “before,” or the like and as long as the output from a previous process is not used in a later process. Even if the operation flow is described by using phrases such as “first” or “next” for the sake of convenience in the claims, specification, and drawings, it does not necessarily mean that the process must be performed in this order.

Claims

1. A measurement device which measures a magnetic flux density emitted from a battery cell, comprising: a sensor including sensor cells which measure the magnetic flux density; and a rotation holding unit which rotatably holds the battery cell in a state where a relative position of the battery cell with respect to the sensor cells is retained.

2. The measurement device according to claim 1, wherein the rotation holding unit holds the battery cell such that the relative position between the battery cell and the sensor is changeable.

3. The measurement device according to claim 1, wherein the rotation holding unit includes a rotating portion which rotates the battery cell.

4. The measurement device according to claim 3, wherein the rotation holding unit moves the sensor cells with respect to the battery cell.

5. The measurement device according to claim 3, further comprising a control unit which takes in measurement results of the magnetic flux density at the sensor at at least two rotation angles of the battery cell.
6. The measurement device according to claim 5, wherein the control unit controls the relative position between the sensor and the battery cell and, in each of at least two relative positions, each relative position being identical to the relative position, takes in the measurement results at the at least two rotation angles.
7. The measurement device according to claim 3, wherein the rotation holding unit further includes: a cell substrate to which the rotating portion is fixed; and a sensor substrate to which the sensor is fixed, wherein the cell substrate is movable relative to the sensor substrate.
8. The measurement device according to claim 7, wherein the sensor substrate includes a plurality of positioning holes for determining the relative position between the sensor and the battery cell, and the cell substrate includes a positioning pin to be inserted into the plurality of positioning holes.
9. The measurement device according to claim 7, wherein the sensor substrate includes a rail for moving the relative position between the sensor and the battery cell.
10. The measurement device according to claim 1, wherein the rotation holding unit includes a moving portion which moves the relative position between the sensor and the battery cell.
11. The measurement device according to claim 7, wherein the rotation holding unit includes: a cell holding portion which has the battery cell inserted thereinto and includes a recessed portion or a protruding portion for defining a rotation angle; and a support portion which is fixed to the cell substrate and contacts with and supports the recessed portion or the protruding portion of the cell holding portion.
12. The measurement device according to claim 11, wherein the support portion is rotatable about a rotational axis that is the same as a rotational axis of the battery cell.
13. The measurement device according to claim 5, wherein the control unit takes in a plurality of measurement results of the magnetic flux density at the sensor at each of the at least two rotation angles and records an average value of the plurality of measurement results at each rotation angle in a database.
14. The measurement device according to claim 5, wherein the control unit takes in a measurement result of the magnetic flux density at the sensor when passing a current having a current value higher than a registered current value through the battery cell and records in a database the measurement result of the magnetic flux density in association with the registered current value.
15. An estimation system comprising: a database which, for at least one type of a battery cell used for a battery unit, records a measurement result obtained by actually measuring a magnetic flux density for each angle state when passing a current while changing the angle state of the battery cell; a state input unit to which, for the battery unit including a plurality of battery cells, each battery cell being identical to the battery cell, state data indicating an arrangement and an angle state of each of the battery cells within the battery unit is input; and an estimation unit which, based on the angle state and the measurement result recorded in the database, determines a magnetic flux density generated by each of the battery cells, and, based on the magnetic flux density generated by each of the battery cells and the arrangement of each of the battery cells, estimates a magnetic flux density generated by the battery unit.
16. The estimation system according to claim 15, further comprising an acquisition unit which acquires the measurement result actually measured using a measurement device to record it in the database, wherein the measurement device measures a magnetic flux density emitted from a battery cell and comprises: a sensor including sensor cells which measure the magnetic flux density; and a rotation holding unit which rotatably holds the battery cell in a state where a relative position of the battery cell with respect to the sensor cells is retained.