US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12394775
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Goto; Satoshi

Producing method for rectangular battery and examining method for rectangular battery

Abstract

A producing method and an examining method for a rectangular battery in which an impregnated state of an electrolytic solution impregnated in an electrode body is appropriately examined are provided. A producing method for the rectangular battery includes a step of impregnation examining to determining an impregnated state of the electrolytic solution in the electrode body by holding and pressing a first side wall portion and a second side wall portion of the rectangular battery to bring their inside surfaces into contact with an electrode body, bringing a transmitting probe and a receiving probe into close contact with the first side wall portion and the second side wall portion respectively, and in a state that an absorption member is placed to absorb diffused ultrasonic wave or going-around ultrasonic wave, transmitting the post-penetrated ultrasonic wave to pass through the electrode body and others, and receiving it by the receiving probe.

Inventors: **Goto; Satoshi (Nagakute, JP)**

Applicant: **Prime Planet Energy & Solutions, Inc.** (Tokyo, JP)

Family ID: **1000008767615**

Assignee: **PRIME PLANET ENERGY & SOLUTIONS, INC. (Tokyo, JP)**

Appl. No.: **18/145856**

Filed: **December 23, 2022**

Prior Publication Data

Document Identifier	Publication Date
US 20230261170 A1	Aug. 17, 2023

Foreign Application Priority Data

JP	2022-020004	Feb. 11, 2022

Publication Classification

Int. Cl.: **H01M10/48** (20060101); **H01M4/04** (20060101); **H01M10/04** (20060101)

U.S. Cl.:

CPC **H01M4/0416** (20130101); **H01M10/0468** (20130101); **H01M10/48** (20130101);

Field of Classification Search

CPC: H01M (4/0416); H01M (10/0468); H01M (10/48); H01M (10/484); H01M (10/04); H01M (10/0431); H01M (10/0587); Y02P (70/50); Y10T (29/49108); H01G (9/15); C08L (23/0846)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
6343005	12/2001	Tadanobu	361/510	H01G 9/15
9879123	12/2017	Sano	N/A	C08L 23/0846
10347946	12/2018	Tamaki	N/A	H01M 50/423
2017/0358829	12/2016	Inoue	N/A	H01M 50/578

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2015197968	12/2014	JP	N/A

Primary Examiner: Nguyen; Donghai D

Attorney, Agent or Firm: HAUPTMAN HAM, LLP

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2022-020004, filed Feb. 11, 2022, the entire contents of which are incorporated herein by reference.

BACKGROUND

Technical Field

(2) The present disclosure relates to a producing method for a rectangular battery in which an electrode body and electrolytic solution are housed in a rectangular battery case and an examining method for a rectangular battery.

Related Art

(3) Heretofore, in a producing process of a battery, there is a case that an impregnated state of electrolytic solution impregnated in an electrode body is examined after assembling a battery and injecting the electrolytic solution in a battery case but before initial charging of the battery. For example, JP2015-197968A has disclosed an impregnation examination device and an impregnation examination method of examining an impregnated state of electrolytic solution in an electrode

body by use of ultrasonic wave. Specifically, in the impregnation examination method of this JP2015-197968A, an ultrasonic wave output section and an ultrasonic wave receipt section are placed to oppose each other with a battery sandwiched therebetween so that ultrasonic wave output from the ultrasonic wave output section toward the battery is received by the ultrasonic wave receipt section. Then, the impregnated state of the electrolytic solution into the electrode body is determined according to an attenuation ratio of the received ultrasonic wave relative to the output ultrasonic wave.

SUMMARY

Technical Problems

(4) However, in the impregnation examination method of JP2015-197968A, there are spaces between the ultrasonic wave output section and the battery and between the ultrasonic wave receipt section and the battery, and thus some batteries (especially, a battery having a thick thickness) cannot be appropriately determined the impregnated state of the electrolytic solution into the electrode body.

(5) On the other hand, when the ultrasonic wave output section and the ultrasonic wave receipt section are each brought into close contact with the battery case in order to avoid the above-mentioned problem, it has been confirmed that the impregnated state of the electrolytic solution cannot be appropriately determined since the ultrasonic wave output from the ultrasonic wave output section takes a roundabout path to propagate in the rectangular battery case and is received by the ultrasonic wave receipt section.

(6) The present inventors have further studied and confirmed that the impregnated state of the electrolytic solution cannot be appropriately determined when a layer of air exists between the rectangular battery case and the electrode body inside the battery.

(7) The present disclosure has been made in view of the above circumstances and has a purpose of providing a producing method for a rectangular battery which can be appropriately examined an impregnated state of electrolytic solution into an electrode body and an examining method for the rectangular battery.

Means of Solving the Problems

(8) One aspect of the present disclosure to solve the above problem is a producing method FOR a rectangular battery in which an electrode body and electrolytic solution are housed in a rectangular battery case, wherein the method includes impregnation examining performed by: holding and pressing a first side wall portion and a second side wall portion opposing each other with the electrode body sandwiched therebetween in the rectangular battery case of the rectangular battery that has been assembled and bringing an inside surface of the first side wall portion and an inside surface of the second side wall portion to be in respectively contact with the electrode body; bringing a transmitting probe into close contact with a first measured portion in an outside surface of the first side wall portion and bringing a receiving probe into close contact with a second measured portion in an outside surface of the second wall portion; in a state in which an absorption member is placed in a peripheral portion of at least any one of the first measured portion and the second measured portion, the absorption member absorbing at least any one of diffused ultrasonic wave to be spread and propagated to a periphery from the first measured portion and going-around ultrasonic wave to be propagated from a periphery of the second measured portion to the second measured portion, receiving post-penetrated ultrasonic wave which has been sent out from the transmitting probe and penetrated through the first side wall portion and the electrode body to reach the second side wall portion, and determining an impregnated state of the electrolytic solution into the electrode body based on a received signal obtained from the receiving probe.

(9) According to the above-mentioned producing method for the rectangular battery, in the process of impregnation examining, the first side wall portion and the second side wall portion of the rectangular battery case are held and pressed therebetween so that the inside surface of the first side wall portion and the inside surface of the second side wall portion are brought into contact with the

electrode body and that the transmitting probe and the receiving probe are brought into close contact with the first measured portion in the outside surface of the first side wall portion and with the second measured portion in the outside surface of the second side wall portion, respectively. Therefore, the transmitted ultrasonic wave sent out from the transmitting probe is directly transmitted to the first side wall portion, reaches the electrode body without passing through the air layer, penetrates through the electrode body, is further conveyed from the electrode body to the second side wall portion without passing through the air layer, and then is directly transmitted to the receiving probe from the second side wall portion. Thus, the post-penetrated ultrasonic wave that has been sent out from the transmitting probe and penetrated through the electrode body and others can be appropriately received by the receiving probe.

(10) Further, at least any one of peripheral portions of the first measured portion to which the transmitting probe is closely contacted and the second measured portion to which the receiving probe is closely contacted in the rectangular battery case is provided with the absorption material absorbing the diffused ultrasonic wave or the going-around ultrasonic wave. Thereby, a part of the transmitted ultrasonic wave sent from the transmitting probe does not penetrate the electrode body but is diffused from the first measured portion to go around the rectangular battery case for propagation and to reach the second measured portion to be received by the receiving probe, thereby preventing the ultrasonic wave from turning to noise.

(11) As mentioned above, the impregnated state of the electrolytic solution into the electrode body can be appropriately examined.

(12) To be specific, when the electrolytic solution is well impregnated into the electrode body, after a certain elapsed time has passed since transmission of transmitted ultrasonic wave of a burst waveform from the transmitting probe has started, post-penetrated ultrasonic wave of the burst waveform having a similar frequency with the transmitted ultrasonic wave is received as the received ultrasonic wave. This is because the electrode body that has been impregnated well with the electrolytic solution can be easily penetrated by ultrasonic wave.

(13) However, when the electrolytic solution fails to be impregnated into the electrode body at all, even if the similar transmitted ultrasonic wave is sent from the transmitting probe, the receiving probe can hardly receive the post-penetrated ultrasonic wave as the received ultrasonic wave. This is because the ultrasonic wave cannot easily penetrate through the electrode body including the air layer due to no impregnation of the electrolytic solution.

(14) Further, when the impregnation of the electrolytic solution into the electrode body is not enough, timing of the received ultrasonic wave formed of the transmitted ultrasonic wave received by the receiving probe may be deviated from the above-mentioned elapsed time, or an amplitude of the receipt ultrasonic wave becomes smaller than that in a case of the electrolytic solution being impregnated well enough into the electrode body.

(15) Accordingly, in a producing process of the battery, the impregnated state for the electrolytic solution into the electrode body can be appropriately examined based on the received signal corresponding to the received ultrasonic wave by the post-penetrated ultrasonic wave.

(16) As an “electrode body” to be housed in a rectangular battery, for example, there are given a laminate-type electrode body in which a plurality of rectangular electrode plates are laminated with separators interposed therebetween and a flat-wound electrode body in which strip-shaped electrode plates are flat wound with strip-shaped separators interposed therebetween. Further, the rectangular battery may be a battery in which a single electrode body is housed in a rectangular battery case or a battery in which a plurality of electrode bodies are stacked in a direction orthogonal to a first side wall portion and a second side wall portion in the rectangular battery case.

(17) As an “absorption material” to absorb ultrasonic wave, for example, there may be given an absorption material made of rubber and an absorption material made of resin, clay, grease, gel, and the like.

(18) Further, another aspect of the present disclosure is an examining method for a rectangular

battery in which an electrode body and electrolytic solution are housed in a rectangular battery case, wherein the method includes impregnation examining performed by: holding and pressing a first side wall portion and a second side wall portion opposing each other with the electrode body sandwiched therebetween in the rectangular battery case of the rectangular battery that has been assembled and bringing an inside surface of the first side wall portion and an inside surface of the second side wall portion to be in respectively contact with the electrode body; bringing a transmitting probe into close contact with a first measured portion in an outside surface of the first side wall portion and bringing a receiving probe into close contact with a second measured portion in an outside surface of the second wall portion; in a state in which an absorption member is placed in a peripheral portion of at least any one of the first measured portion and the second measured portion, the absorption member absorbing at least any one of diffused ultrasonic wave to be spread and propagated to a periphery from the first measured portion and going-around ultrasonic wave to be propagated from a periphery of the second measured portion to the second measured portion, receiving post-penetrated ultrasonic wave which has been sent out from the transmitting probe and penetrated through the first side wall portion and the electrode body to reach the second side wall portion, and determining an impregnated state of the electrolytic solution into the electrode body based on a received signal obtained from the receiving probe.
(19) The above-mentioned examining method for the rectangular battery includes the above-mentioned process of impregnation examining, and thus a rectangular battery that has become an object to be examined can be appropriately examined its impregnated state of electrolytic solution into an electrode body.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a perspective view of a rectangular battery in embodiments 1 and 2;
(2) FIG. **2** is a flowchart indicating a producing process of the rectangular battery in the embodiment 1;
(3) FIG. **3** is a side view of an impregnation examination device and the rectangular battery disposed in the device when seen in a thickness direction of the rectangular battery in the embodiments 1 and 2;
(4) FIG. **4** is a sectional view of the impregnation examination device and the rectangular battery disposed in the device in the embodiments 1 and 2 taken along a line A-A in FIG. **3**;
(5) FIG. **5** is a graph showing a relation between an elapsed time from start of sending ultrasonic wave and an amplitude of transmitted ultrasonic wave sent out from a transmitting probe in an embodiment and comparative embodiments 1 and 2;
(6) FIG. **6**A is a graph indicating a relation between an elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of received ultrasonic wave received by a receiving probe in the embodiment, specifically indicating a case of a rectangular battery in which electrolytic solution is impregnated enough into an electrode body;
(7) FIG. **6**B is a graph indicating a relation between the elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of the received ultrasonic wave received by the receiving probe in the embodiment, specifically indicating a case of the rectangular battery in which the electrolytic solution is not impregnated at all into the electrode body in the example;
(8) FIG. **7** is a sectional view corresponding to FIG. **4** of the impregnation examination device and the rectangular battery disposed in the device in a comparative embodiment 1;
(9) FIG. **8**A is a graph indicating a relation between the elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of the received ultrasonic wave received by the receiving probe in the comparative embodiment 1, specifically indicating a case of the rectangular

battery in which the electrolytic solution is impregnated well enough into the electrode body;
(10) FIG. **8**B is a graph indicating a relation between the elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of the received ultrasonic wave received by the receiving probe in the comparative embodiment 1, specifically indicating a case of the rectangular battery in which the electrolytic solution is not impregnated at all into the electrode body;
(11) FIG. **9** is a sectional view corresponding to FIG. **4** of the impregnation examination device and the rectangular battery disposed in the device in the comparative embodiment 2;
(12) FIG. **10**A is a graph indicating a relation between the elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of the received ultrasonic wave received by the receiving probe in the comparative embodiment 2, specifically indicating a case of the rectangular battery in which the electrolytic solution is impregnated well enough in the electrode body;
(13) FIG. **10**B is a graph indicating a relation between the elapsed time from start of sending the transmitted ultrasonic wave and the amplitude of the received ultrasonic wave received by the receiving probe in the comparative embodiment 2, specifically indicating a case of the rectangular battery in which the electrolytic solution is not impregnated at all in the electrode body; and
(14) FIG. **11** is a flowchart of an examination process of a rectangular battery in an embodiment 2.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Embodiment 1

(15) A first embodiment of the present disclosure is explained in detail below with reference to the accompanying drawings. FIG. **1** is a perspective view of a rectangular battery of an almost parallelepiped shape (hereinafter, simply also referred as a “battery”) **1**. Herein, in the following explanation, a vertical direction AH, a lateral direction BH, and a thickness direction CH of the battery **1** are defined as directions indicated in FIG. **1**. This battery **1** is a rectangular hermetically-closed lithium-ion secondary battery mounted on a hybrid car, a plug-in hybrid car, electric automobile, and others.
(16) The battery **1** is configured with a rectangular battery case (hereinafter, simply referred as a “battery case”) **10**, an electrode body **20** housed inside this battery case **10**, a positive electrode terminal **30** and a negative electrode terminal **40** which are supported by the battery case **10**, and others. Further, in the battery case **10**, electrolytic solution **50** is housed, and a part of the solution **50** is impregnated in the electrode body **20** and the other part of the solution **50** resides in a bottom portion of the battery case **10**.
(17) In these elements, the rectangular battery case **10** is of a parallelepiped box-like shape made of metal (in the present embodiment 1, aluminum) and includes an upper wall portion **13**, a lower wall portion **14** opposing the upper wall portion **13**, and four side wall portions (a first side wall portion **15** and a second side wall portion each having a wide area and opposing each other with the electrode body **20** interposed therebetween, and a third side wall portion **17** and a fourth side wall portion **18** each having a narrower area than the first and second side wall portions **15** and **16**). This battery case **10** is configured with a case body member **11** of a bottomed rectangular cylindrical shape having an opening **11***c*, and a case lid member **12** of a rectangular plate-like shape which is welded to close the opening **11***c* of the case body member **11**. The case lid member **12** is provided with a safety valve (not shown) which is to be broken when an inner pressure of the battery case **10** has reached a predetermined pressure. Further, the case lid member **12** is formed with an injection hole (not shown) to communicate inside and outside the battery case **10** and is hermetically closed by a closing member (not shown).
(18) Further, the case lid member **12** is fixedly provided with the positive electrode terminal **30** which is configured with a plurality of aluminum components in an insulated state from the case lid member **12**. This positive electrode terminal **30** is connected and electrically continued with a positive electrode plate **21** of the electrode body **20** inside the battery case **10** and also penetrates the case lid member **12** to extend outside the battery. Further, the case lid member **12** is fixedly provided with the negative electrode terminal **40** configured with a plurality of copper elements in

an insulated state from the case lid member **12**. This negative electrode terminal **40** is connected and electrically continued with a negative electrode plate **22** of the electrode body **20** inside the battery case **10** and also penetrates the case lid member **12** to extend outside the battery.

(19) The electrode body **20** is a flat-wound electrode body formed in a manner that a strip-shaped positive electrode plate **21** and a strip-shaped negative electrode plate **22** are laminated via a pair of strip-shaped separators **23** formed of resin-made porous film. This electrode body **20** is placed sideways and housed in the battery case **10**.

(20) Next, a producing method of the above-mentioned rectangular battery **1** is explained (see FIG. **2**). Firstly, in an "assembling step" S**1**, the battery **1** is assembled. Specifically, the case lid member **12** is prepared and the positive electrode terminal **30** and the negative electrode terminal **40** are fixedly set in this case lid member **12** (see FIG. **1**). Subsequently, the positive electrode terminal **30** and the negative electrode terminal **40** which are fixedly set in the case lid member **12** are welded to the positive electrode plate **21** and the negative electrode plate **22** of the electrode body **20** which are formed separately, respectively. The case body member **11** is then prepared. The electrode body **20** is inserted in the case body member **11**, and the opening **11***c* of the case body member **11** is closed by the case lid member **12**. After that, the case body member **11** and the case lid member **12** are welded over an entire circumference of the case lid member **12** to form the battery case **10**. Then, the electrolytic solution **50** is injected in the battery case **10** through an injection hole (not shown) of the case lid member **12**, and thereafter this injection hole is hermetically closed by a closing member (not shown).

(21) Subsequently, in an "impregnation examining step" S**2**, the battery **1** assembled in the assembling step S**1** is examined an impregnated state of the electrolytic solution **50** into the electrode body **20**. In the present embodiment 1, this impregnation examining step S**2** is carried out after three hours has passed since injection of the electrolytic solution **50** has been completed in the assembling step S**1**. An impregnation examination device **100** used for the impregnation examining step S**2** is now explained (see FIG. **3** and FIG. **4**). This impregnation examination device **100** is provided with a pair of binding plates **111** and **115** pressing and binding the battery **1** in the thickness direction CH, a transmitting probe **120** sending transmitted ultrasonic wave US**0** by transmission signal TS, a receiving probe **125** receiving received ultrasonic wave US**5** and outputting receipt signal RS, an absorption member **130** absorbing diffused ultrasonic wave US**1**, an absorption member **135** absorbing go-around ultrasonic wave US**2**, a probe drive unit **140** transmitting the transmission signal TS to the transmitting probe **120** and receiving the receipt signal RS from the receiving probe **125**, and a controller **150** performing control of the probe drive unit **140** and others.

(22) Among those elements, the binding plates **110** and **115** are each of a rectangular plate-like shape and made of metal (in the present embodiment 1, aluminum). The binding plates **110** and **115** are formed in their center with openings **110***c* and **115***c*, respectively to place the transmitting probe **120** or the receiving probe **125**. Further, neighbors of four corner portions of the binding plates **110** and **115** are formed with through holes **110***k* and **115***k* through which bolts **117** are inserted. The battery **1** is held by the pair of binding plates **110** and **115** in the thickness direction, and the bolts **117** are inserted in the through holes **110***k* and **115***k* of the binding plates **110** and **115**, respectively, to be screwed with nuts **118** so that the battery **1** is held and pressed in the thickness direction CH. Thus, the first side wall portion **15** and the second side wall portion **16** of the battery case **10** of the battery **1** are held and pressed by the binding plates **110** and **115** with the absorption members **130** and **135** interposed therebetween so that an inside surface **15***n* of the first side wall portion **15** and an inside surface **16***n* of the second side wall portion **16** of the battery case **10** are brought into contact with the electrode body **20**.

(23) The transmitting probe **120** is configured to send the transmitted ultrasonic wave US**0** by the transmission signal TS. This transmitting probe **120** is placed in the opening **110***c* of one binding plate **110** with a clearance and in an opening **130***c* of the absorption member **130** explained later

with a clearance while the transmitting probe **120** is in close contact with a first measured portion **15***ma* in a center of an outside surface **15***m* of the first side wall portion **15** of the battery case **10**. According to this configuration, the transmitted ultrasonic wave US**0** can be directly transmitted to the first measured portion **15***ma* of the first side wall portion **15** from the transmitting probe **120**.
(24) On the other hand, the receiving probe **125** is configured to output the received ultrasonic wave US**5** as the receipt signal RS. This receiving probe **125** is placed in the opening **115***c* of the other binding plate **115** with a clearance and in the opening **135***c* of the absorption member **135** explained later with a clearance while the receiving probe **125** is in close contact with a second measured portion **16***ma* in a center of the outside surface **16***m* of the second side wall portion **16** of the battery case **10**. Thus, the received ultrasonic wave US**5** that has reached the second measured portion **16***ma* of the second side wall portion **16** from every part can be directly received by the receiving probe **125** to generate the receipt signal RS.
(25) The absorption members **130** and **135** are each of a rectangular plate-like shape and made of natural rubber. The absorption members **130** and **135** are formed in their center with the openings **130***c* and **135***c*, respectively, to be set with the transmitting probe **120** or the receiving probe **125**. One absorption member **130** is held between the binding plate **110** and the first side wall portion **15** of the battery case **10** and is in close contact with a peripheral portion **15***mb* surrounding the first measured portion **15***ma* of the first side wall portion **15**. Thus, of the transmitted ultrasonic wave US**0** that has been sent to the first measured portion **15***ma* from the transmitting probe **120**, the diffused ultrasonic wave US**1** (indicated with an upward arrow and a downward arrow in FIG. **4**), which is propagated to the first side wall portion **15** to expand around the first measured portion **15***ma*, is absorbed by this absorption member **130** so that the diffused ultrasonic wave US**1** is prevented from expanding over the first side wall portion **15** for further propagation. Further, the other absorption member **135** is held between the binding plate **115** and the second side wall portion **16** of the battery case **10** and is in close contact with a peripheral portion **16***mb* surrounding the second measured portion **16***ma* of the second side wall portion **16**. Thus, the going-around ultrasonic wave US**2** (indicated with a downward arrow and an upward arrow in FIG. **4**), which is propagated to the second side wall portion **16** toward the second measured portion **16***ma* from the periphery of the second measured portion **16***ma* of the second side wall portion **16**, can be absorbed by this absorption member **135** to prevent the going-around ultrasonic wave US**2** from reaching the second measured portion **16***ma*.
(26) The probe drive device **140** is Ultrasonic Pulser & Receiver JPR-600 made by JAPAN PROBE CO., LTD. in the present embodiment 1. This probe drive device **140** is connected with the transmitting probe **120** and the receiving probe **125** and is configured to generate the transmission signal TS to transmit the transmitted ultrasonic wave US**0** from the transmitting probe **120** and to receive the receipt signal RS generated in the receiving probe **125** corresponding to the received ultrasonic wave US**5**.
(27) The controller **150** includes a microcomputer including a CPU, an ROM, and an RAM, which are not shown and being operated by a determined control program that has been stored in the ROM and the like. The controller **150** is connected with the probe drive device **140** to control the probe drive device **140**. Further, the controller **150** determines an impregnated state of the electrolytic solution **50** into the electrode body **20** based on the receipt signal RS received by the probe drive device **140** as explained later.
(28) Next, an impregnation examining step S**2** performed by the above-mentioned impregnation examination device **100** is explained. The battery **1** is firstly set in the impregnation examination device **100**. Specifically, the first side wall portion **15** and the second side wall portion **16** of the battery case **10** of the battery **1** are held and pressed by the pair of binding plates **110** and **115** so that the inside surface **15***n* of the first side wall portion **15** and the inside surface **16***n* of the second side wall portion **16** are brought into contact with the electrode body **20**. At this time, the binding plates **110** and **115** have the absorption members **130** and **135** interposed respectively in each space

with the battery **1** so that the absorption member **130** is in close contact with the peripheral portion **15***mb* around the first measured portion **15***ma* of the first side wall portion **15** and the absorption member **135** is in close contact with the peripheral portion **16***mb* around the second measured portion **16***ma* of the second side wall portion **16**. Further, after binding, the transmitting probe **120** is brought into close contact with the first measured portion **15***ma* of the first side wall portion **15** and the receiving probe **125** is brought into close contact with the second measured portion **16***ma* of the second side wall portion **16**.

(29) Then, the transmitted ultrasonic wave US**0** is sent from the transmitting probe **120** by the transmission signal TS which is generated in the probe drive device **140**. In the present embodiment 1, as shown in FIG. **5**, the transmitted ultrasonic wave US**0** of a burst waveform at a frequency of 0.8 MHz with three waves included (continuing for about 5 pec) is sent. A most part of the transmitted ultrasonic wave US**0** sent out from the transmitting probe **120** advances straight in the thickness direction CH of the battery **1** and is transmitted to the first side wall portion **15** (its first measured portion **15***ma*) as pre-penetrated ultrasonic wave UST. The ultrasonic wave further advances straight in the thickness direction CH, passes through the electrode body **20**, and reaches the second side wall portion **16** (its second measured portion **16***ma*) as post-penetrated ultrasonic wave USR. Finally, the ultrasonic wave is received by the receiving probe **125** as the received ultrasonic wave US**5**.

(30) In the present embodiment 1, the transmitting probe **120** is brought into close contact with the first measured portion **15***ma* of the first side wall portion **15** with no clearance created between the transmitting probe **120** and the first measured portion **15***ma*, so that the transmitted ultrasonic wave US**0** is easily transmitted to the first measured portion **15***ma* from the transmitting probe **120**. Further, the receiving probe **125** is brought into close contact with the second measured portion **16***ma* of the second side wall portion **16** with no clearance created between the second measured portion **16***ma* and the receiving probe **125**, so that the received ultrasonic wave US**5** is easily conveyed to the receiving probe **125** from the second measured portion **16***ma*.

(31) Further, the inside surface **15***n* of the first side wall portion **15** and the inside surface **16***n* of the second side wall portion **16** of the battery case **10** are each in contact with the electrode body **20**, so that there is no layer of air in each space between the first side wall portion **15** and the electrode body **20** and between the second side wall portion **16** and the electrode body **20**. Therefore, the pre-penetrated ultrasonic wave UST sent to the first measured portion **15***ma* as a part of the transmitted ultrasonic wave US**0** is easily transmitted to the electrode body **20** from the first side wall portion **15**. Further, the post-penetrated ultrasonic wave USR is easily conveyed to the second side wall portion **16** from the electrode body **20**.

(32) On the other hand, the diffused ultrasonic wave US**1** of the transmitted ultrasonic wave US**0**, which is diffused to be propagated from the first measured portion **15***ma* of the first side wall portion **15** toward its periphery (upward and downward directions in FIG. **4**), is absorbed by the absorption member **130** placed in the peripheral portion **15***mb* around the first measured portion **15***ma* and restrained from further propagation. Similarly, the going-around ultrasonic wave US**2** which is to be propagated from the periphery of the second measured portion **16***ma* of the second side wall portion **16** to the second measured portion **16***ma* (the downward and upward direction in FIG. **4**), is absorbed by the absorption member **135** in the peripheral portion **16***mb* around the second measured portion **16***ma* and restrained from reaching the second measured portion **16***ma*. Accordingly, it is possible to effectively restrain the diffused ultrasonic wave US**1**, which is sent from the transmitting probe **120** to the first side wall portion **15**, from going around to propagate in the battery case **10** and being received by the receiving probe **125** as the going-around ultrasonic wave US**2**.

(33) Subsequently, the controller **150** determines the impregnated state of the electrolytic solution **50** into the electrode body **20** in the battery **1** based on the receipt signal RS which is obtained by the receiving probe **125**.

(34) Herein, when the battery **1** to be examined is a battery **1** in which the electrolytic solution **50** is well impregnated in the electrode body **20**, as shown in FIG. **6**A, after a certain elapsed time ta (in the present embodiment 1, ta=about 23 μsec) has passed since the transmitted ultrasonic wave US**0** (see FIG. **4**) of the burst waveform has started (the elapsed time t=0) to be sent out from the transmitting probe **120**, the received ultrasonic wave US**5**, which is of a burst waveform having a frequency as similar to that of the transmitted ultrasonic wave US**0** (see FIG. **5**) with a large amplitude AR, is received by the receiving probe **125** for about a term of 10 μsec and the receipt signal RS corresponding to this ultrasonic wave US**5** is obtained.
(35) In the battery **1** in which the electrolytic solution **50** is impregnated enough in the electrode body **20**, the electrolytic solution **50** is filled in between the positive electrode plate **21** or the negative electrode plate **22** and the separator **23** which constitute the electrode body **20** and inside the separator **23**, and thus it is presumed that pre-penetrated ultrasonic wave UST passes through the electrode body **20** with less attenuation and is penetrated through the second measured portion **16***ma* as post-penetrated ultrasonic wave USR and further conveyed to the receiving probe **125** as the received ultrasonic wave US**5**. As a result of this, the battery **1** which has thus obtained the receipt signal RS is determined to be a non-defective product with preferable impregnated state of the electrolytic solution **50** into the electrode body **20**.
(36) On the other hand, to the semblance of the battery **1** in which the electrolytic solution **50** is not impregnated at all in the electrode body **20**, FIG. **6**B shows a result of the impregnation examination carried out for the battery **1** in which no electrolytic solution **50** is injected. In this case, even if the transmitted ultrasonic wave US**0** of the burst waveform is transmitted from the transmitting probe **120**, the received ultrasonic wave US**5** received by the receiving probe **125** rarely includes a signal of a burst waveform. In the battery **1** in which the electrolytic solution **50** is rarely impregnated in the electrode body **20**, a space between the positive electrode plate **21** or the negative electrode plate **22** and the separator **23** those of which constitute the electrode body **20** and inside the separator **23** are filled with air, causing large attenuation of the pre-penetrated ultrasonic wave UST while the pre-penetrated ultrasonic wave UST is to be penetrated through the electrode body **20**. This makes it difficult for the pre-penetrated ultrasonic wave UST to pass through the electrode body **20** and to be conveyed to the second measured portion **16***ma* as the post-penetrated ultrasonic wave USR. Accordingly, it is presumed that the received ultrasonic wave US**5** could not be detected the signal of the burst waveform at a time around the elapsed time ta. The battery **1** which has obtained the receipt signal RS as mentioned above is determined to be a defect product in which the impregnated state of the electrolytic solution **50** into the electrode body **20** is unpreferable.
(37) Further, when the electrolytic solution **50** is not impregnated enough into the electrode body **20** (data is not shown), a shape of the burst waveform appearing in the received ultrasonic wave US**5** which is received by the receiving probe **125** is delayed from the above-mentioned elapsed time ta, and a degree of the amplitude AR of the received ultrasonic wave US**5** becomes smaller than that in a case of the electrolytic solution **50** being impregnated well enough into the electrode body **20** (see FIG. **6**A). In the battery **1** in which impregnation of the electrolytic solution **50** into the electrode body **20** is not enough, the electrolytic solution **50** exists in the space between the positive electrode plate **21** or the negative electrode plate **22** and the separator **23** which constitute the electrode body **20** and in a part of the inside of the separator **23**, while other parts are filled with air. Accordingly, it is presumed that when the pre-penetrated ultrasonic wave UST is conveyed to the electrode body **20**, a path of conveying the ultrasonic wave could be long and attenuation of the ultrasonic wave could occur. The battery **1** obtained with such a receipt signal RS is also determined as a defective product in which the impregnated state of the electrolytic solution **50** is unpreferable.
(38) Thereafter, the batteries **1** performed with the impregnation examination are taken out of the impregnation examination device **100**, and the batteries **1** examined to be non-defective are left

while the batteries **1** determined to be defective are excluded.

(39) Subsequently, in an "initial charging step" S**3** (see FIG. **2**), the (non-defective) battery **1** is connected with a charging device (not shown) and performed with initial charging to SOC 100% by charging at Constant Current Constant Voltage (CCCV) under an environmental temperature of 25° C.

(40) Subsequently, in an "aging step" S**4**, the initially charged battery **1** is left as it is for ten hours under the environmental temperature of 60° C. in a state in which terminals are kept open for applying high-temperature aging to the battery **1**. Thereafter, this battery **1** is performed with various tests. In this manner, production of the battery **1** is completed.

Comparative Embodiment 1

(41) Next, a comparative embodiment 1 of the above-mentioned embodiment 1 is explained (see FIG. **7**, FIG. **8**A, and FIG. **8**B). The comparative embodiment 1 is also performed with the steps S**1** to S**4** as similar to the embodiment 1 for producing the battery **1**. In the impregnation examining step S**2** of those steps, the transmitting probe **120** and the receiving probe **125** are used as similar to the embodiment 1, but unlike the above-mentioned impregnation examination device **100**, an impregnation examination device C**1** not performing binding of the battery **1** by the binding plates **110** and **115** and absorption of the ultrasonic wave by the absorption members **130** and **135** but only performing retention of the transmitting probe **120** and the receiving probe **125** relative to the battery **1** is adapted, which is different from the embodiment 1. To be specific, the impregnation examination device C**1** does not utilize the binding plates **110** and **115** and the absorption members **130** and **135**, but instead uses a not-shown holding part to bring the transmitting probe **120** into close contact with the first measured portion **15***ma* of the first side wall portion **15** of the battery case **10** and bring the receiving probe **125** into close contact with the second measured portion **16***ma* of the second side wall portion **16** of the battery case **10** for holding. Then, as similar to the embodiment 1, the transmitted ultrasonic wave US**0** is sent from the transmitting probe **120** (see FIG. **5**), and the received ultrasonic wave US**5** is received by the receiving probe **125**.

(42) In the above-mentioned embodiment 1, when the non-defective battery **1** in which the electrolytic solution **50** is impregnated well enough into the electrode body **20** is examined, there is generated a signal of a burst waveform at a similar frequency (0.8 MHz) to the transmitted ultrasonic wave US**0** on the receipt signal RS after the elapsed time ta (in the embodiment 1, ta=23 pec) has passed since the transmitted ultrasonic wave US**0** of the burst waveform has been started to be sent from the transmitting probe **120** (elapsed time t=0) (see FIG. **6**A).

(43) On the other hand, in the present comparative embodiment 1, when the non-defective battery **1** in which the electrolytic solution **50** is impregnated well enough into the electrode body **20** is examined, the received ultrasonic wave US**5** (the receipt signal RS) shown in FIG. **8**A, which is different from the case of the embodiment 1 (see FIG. **6**A), is obtained. Namely, in the present comparative embodiment 1, in examining the non-defective battery **1**, the received ultrasonic wave US**5** having a burst waveform with large amplitude is received for a term of about 12 μsec (see FIG. **8**A) after elapse of a certain elapsed time tc (in the present comparative embodiment 1, tc=about 8 pec) which is shorter than the elapsed time ta of the embodiment 1 since the transmitting probe **120** has started sending the transmitted ultrasonic wave US**0** of the burst waveform (t=0).

(44) On the other hand, to the semblance of the battery **1** in which the electrolytic solution **50** is not impregnated at all in the electrode body **20**, the receipt signal RS shown in FIG. **8**B different from the case of the embodiment 1 (see FIG. **6**B) is obtained when the impregnation examining step S**2** is carried out for the battery **1** with no injection of the electrolytic solution **50**. When the battery **1** with no injection is examined, as explained in the embodiment 1, even if the transmitted ultrasonic wave US**0** is sent from the transmitting probe **120**, the receiving probe **125** should be rarely able to receive the ultrasonic wave as the received ultrasonic wave US**5** in the first place (see FIG. **6**B). However, in the present comparative embodiment 1, on and after the elapsed time td=about 8 μsec,

a large ultrasonic wave is received as the received ultrasonic wave US**5** for a long term more than the elapsed time t=50 μsec (see FIG. **8**B).
(45) As it would be easily understood by comparing with a case of the embodiment 1 (see FIG. **6**A), in any cases (see FIG. **8**A and FIG. **8**B), the received ultrasonic wave US**5** of a burst waveform or a long-term wave that has been received on or after the elapsed time tc or td (tc, td=about 8 μsec) has a frequency higher (about as three times as high) than the frequency (0.8 MHz) of the transmitted ultrasonic wave US**0**. Therefore, in this comparative embodiment, the received ultrasonic wave US**5** of the burst waveform or the long-term wave, which has been received on or after the predetermined elapsed time tc, td has elapsed, is not conceived to be an ultrasonic wave received by the receiving probe **125** as the received ultrasonic wave US**5**, which is a part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** that advances straight in the thickness direction CH of the battery **1** to be conveyed to the first measured portion **15***ma* of the first side wall portion **15** as the pre-penetrated ultrasonic wave UST and further penetrates through the electrode body **20** and then reaches the second measured portion **16***ma* of the second side wall portion **16** as the post-penetrated ultrasonic wave USR.
(46) In the comparative embodiment 1, a reason is not sure for obtention of the received ultrasonic wave US**5** of the burst waveform or the long-term wave with the higher frequency than the frequency of the transmitted ultrasonic wave US**0** in a term of the elapsed time t=8 to 20 μsec in a case of the non-defective battery **1** or on or after the elapsed time t=8 μsec in a case of the battery **1** with no injection.
(47) It is however conceivable that in the comparative embodiment 1, the impregnation examination device C**1** does not utilize the binding plates **110** and **115** and thus the device C**1** does not bind the battery **1**. Namely, the battery case **10** is not pressed by the binding plates **110** and **115**, and thus it is conceived that there are air layers AR**1** and AR**2** (see FIG. **7**) between the first side wall portion **15** and the electrode body **20** and between the second side wall portion **16** and the electrode body **20**, respectively.
(48) Accordingly, a part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** is hard to be transmitted as the pre-penetrated ultrasonic wave UST to the electrode body **20** from the first measured portion **15***ma* of the first side wall portion **15**. Further it is also considered that the post-penetrated ultrasonic wave USR that has passed through the electrode body **20** is difficult to be conveyed to the second measured portion **16***ma* of the second side wall portion **16**.
(49) Further in the present comparative embodiment 1, the absorption members **130** and **135** for absorbing the ultrasonic wave are not in close contact with the battery case **10**. Therefore, a large part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** is transmitted not as the pre-penetrated ultrasonic wave UST but as the diffused ultrasonic wave US**1** to expand from the first measured portion **15***ma* of the first side wall portion **15** to its surroundings (upward and downward directions in FIG. **7**). Then, it is conceived that the ultrasonic wave takes a roundabout path to propagate in the battery case **1** to become the going-around ultrasonic wave US**2** propagating toward the second measured portion **16***ma* (the downward and upward directions in FIG. **7**) from the surroundings of the second measured portion **16***ma* of the second side wall portion **16** and then is received by the receiving probe **125** as the received ultrasonic wave US**5**. The diffused ultrasonic wave US**1** and the going-around ultrasonic wave US**2** propagate in the battery case **10** made of metal (in the present comparative embodiment 1, aluminum) in a propagation direction. Accordingly, it is conceived that the received ultrasonic wave US**5** of the burst waveform has reached on and after the elapsed time tc and td (=about 8 μsec) which is faster than the elapsed time to (=23 μsec) in the embodiment 1 since propagation speed (sonic speed) of the ultrasonic wave in the battery case (made of aluminum) is fast even though a propagation distance is longer than in the case of passing through the electrode body **20**.
(50) Further, in a case that the battery **1** with no injection of the electrolytic solution **50** is examined (see FIG. **8**B), the long-term continuing received ultrasonic wave US**5** is received on and after the

elapsed time td. On the other hand, when the non-defective battery **1** in which the electrolytic solution **50** is impregnated enough in the electrode body **20** is examined (see FIG. **8**A), the received ultrasonic wave US**5** of the burst waveform is received for about 12 pec on and after the elapsed time tc has passed. In the battery **1** in which the electrolytic solution **50** is injected, while the going-around ultrasonic wave US**2** takes a roundabout path in the battery case **10** for propagation, there is generated mutual propagation of the ultrasonic wave between the battery case **10** and the electrolytic solution **50** contacted to the battery case **10**. However, energy loss easily occurs during this mutual propagation, and thus it is conceived that the going-around ultrasonic wave US**2** has attenuated early. On the contrary, the battery **1** with no injection is hardly generated with attenuation of the going-around ultrasonic wave US**2** that propagates in the battery case **10**, and accordingly it is conceived that the large ultrasonic wave as the received ultrasonic wave US**5** is received for a long term (see FIG. **8**B).

(51) Further, in this comparative embodiment 1, as the received ultrasonic wave US**5** of the burst waveform or the long-term wave, the received ultrasonic wave US**5** having the frequency higher (about as three times as high) than the frequency (0.8 MHz) of the transmitted ultrasonic wave US**0** has been received. Reason for this is also unsure, but it is conceived that when the transmitted ultrasonic wave US**0** being sent from the transmitting probe **120** and advancing in the thickness direction CH changes its direction to expand and propagate toward the surroundings of the first measured portion **15***ma* from the first measured portion **15***ma* of the first side wall portion **15** (the upward and downward directions in FIG. **7**) as the diffused ultrasonic wave US**1**, the transmitted ultrasonic wave US**0** turns to the diffused ultrasonic wave US**1** with harmonic (triple harmonic) wave by non-linear effect and propagates, and then turns to the going-around ultrasonic wave US**2** and then to the received ultrasonic wave US**5** to be observed by the receiving probe **125**.

Comparative Embodiment 2

(52) Next, a second comparative embodiment is explained (see FIG. **9**, FIG. **10**A, and FIG. **10**B). Also in the present comparative embodiment 2, each step of S**1** to S**4** as similar to the embodiment 1 is performed for producing the battery **1**. In the impregnation examining step S**2** of those steps, the transmitting probe **120** and the receiving probe **125** are used as similar to the embodiment 1, but unlike the above-mentioned impregnation examination device **100**, an impregnation examination device C**2** of binding the battery **1** by the binding plates **110** and **115** and retaining the transmitting probe **120** and the receiving probe **125** without using the absorption members **130** and **135**, which is different from the embodiment 1. To be specific, the battery **1** is directly pressed and bound by the binding plates **110** and **115** without using the absorption members **130** and **135** so that the transmitting probe **120** is brought into close contact with the first measured portion **15***ma* of the first side wall portion **15** and the receiving probe **125** is brought into close contact with the second measured portion **16***ma* of the second side wall portion **16**. Then, as similar to the embodiment 1, the transmitted ultrasonic wave US**0** is transmitted from the transmitting probe **120** (see FIG. **5**) and the received ultrasonic wave US**5** is received by the receiving probe **125**.

(53) In the present comparative embodiment 2, when the non-defective battery **1** in which the electrolytic solution **50** is impregnated enough in the electrode body **20** is examined, the received ultrasonic wave US**5** (the receipt signal RS) shown in FIG. **10**A which is different from the cases of the embodiment 1 (see FIG. **6**A) and the comparative embodiment 1 (see FIG. **8**A). Namely, in the present comparative embodiment 2, as a result of examining the non-defective battery **1**, the received ultrasonic wave US**5** of the burst waveform with large amplitude is received (see FIG. **10**A) for a period of time of about 8 μsec of an elapsed time t=8 to 16 μsec on and after elapse of a certain elapsed time te (in the present comparative embodiment 2, te=about 8 μsec) which is shorter than the elapsed time to of the embodiment 1 but almost same as the elapsed time tc of the comparative embodiment 1 since the transmitted ultrasonic wave US**0** of the burst waveform has started to be sent (t=0) from the transmitting probe **120**.

(54) On the other hand, when the battery **1** with no injection of the electrolytic solution **50** to the

semblance of a case of examining the battery **1** in which the electrolytic solution **50** is not impregnated at all in the electrode body **20**, the receipt signal RS shown in FIG. **10**B which is different from those of the embodiment 1 (see FIG. **6**B) and the comparative embodiment 1 (see FIG. **8**B) is obtained. When the battery **1** with no injection is examined, even when the transmitted ultrasonic wave US**0** is sent from the transmitting probe **120**, the ultrasonic wave should have been rarely received as the received ultrasonic wave US**5** by the receiving probe **125** (see FIG. **6**B) as explained in the embodiment 1, in the first place. However, in the present comparative embodiment 2, the received ultrasonic wave US**5** of the burst waveform with a large amplitude is received for a term of about 10 μsec of the elapsed time t=8 to 18 μsec on and after elapse of a certain time tf (in the present comparative embodiment 2, tf=about 8 μsec) which is almost similar to the elapsed time tc in the comparative embodiment 1 (see FIG. **10**B).

(55) However, as easily understood by comparing with the embodiment 1 (see FIG. **6**A), the received ultrasonic wave US**5** of the burst waveform which is received on and after the elapsed time te or tf (te, tf=about 8 μsec) has the frequency higher (as about three times as high) than the frequency (0.8 MHz) of the transmitted ultrasonic wave US**0** in any cases (see FIG. **10**A and FIG. **10**B). Accordingly, in this comparative embodiment 2, the received ultrasonic wave US**5** of the burst waveform received on and after the elapsed time te and tf is not perceived as the ultrasonic wave similar to the one obtained in the embodiment 1, that is a part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** advancing straight in the thickness direction CH of the battery **1** and being transmitted to the first measured portion **15***ma* of the first side wall portion **15** as the pre-penetrated ultrasonic wave UST and further penetrated through the electrode body **20**, reaching the second measured portion **16***ma* of the second side wall portion **16** as the post-penetrated ultrasonic wave USR, and then being received by the receiving probe **125** as the received ultrasonic wave US**5**.

(56) There is no clear detailed reason for obtention of the received ultrasonic wave US**5** of the burst waveform with high frequency higher than the frequency of the transmitted ultrasonic wave US**0** for the elapsed time t=8 to 16 μsec in the non-defective battery **1** in which the electrolytic solution **50** is impregnated enough in the electrode body **20** and for the elapsed time t=8 to 18 μsec in the battery **1** with no injection in the comparative embodiment 2.

(57) However, it is estimated that in the present comparative embodiment 2, the impregnation examination device C**2** utilizes the binding plates **110** and **115** to bind the battery **1**, but the absorption members **130** and **135** for absorbing the ultrasonic wave are not provided to be in close contact with the battery case **10**. Therefore, a part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** is transmitted from the first measured portion **15***ma* of the first side wall portion **15** to the electrode body **20** as the pre-penetrated ultrasonic wave UST, and then the post-penetrated ultrasonic wave USR having passed through the electrode body **20** is conveyed to the second measured portion **16***ma* of the second side wall portion **16**.

(58) However, a part of the transmitted ultrasonic wave US**0** transmitted from the transmitting probe **120** has become the diffused ultrasonic wave US**1** with harmonic (triple harmonic) wave faster than the above-mentioned post-penetrated ultrasonic wave USR and propagates to expand toward the surroundings (the upward and downward directions in FIG. **7**) of the first measured portion **15***ma* from the first measured portion **15***ma*. Then, it is perceived that the diffused ultrasonic wave US**1** takes a roundabout path to propagate in the battery case **10** to become the going-around ultrasonic wave US**2** that is propagated from the surroundings of the second measured portion **16***ma* of the second side wall portion **16** to the second measured portion **16***ma* (the downward and upward directions in FIG. **7**), and thus the ultrasonic wave is received in the second measured portion **16***ma* by the receiving probe **125** as the received ultrasonic wave US**5**.

(59) Further, in the present comparative embodiment 2, the absorption members **130** and **135** for absorbing the ultrasonic wave are not in close contact with the battery case **10**, but both in the case of examining the non-defective battery **1** (see FIG. **10**A) and in the case of examining the battery **1**

with no injection (see FIG. **10**B), the received ultrasonic wave US**5** of the burst waveform continuing for about 8 μsec or for about 10 μsec is obtained. In the present comparative embodiment 2, the impregnation examination device C**2** utilizes the binding plates **110** and **115** to bind the battery **1** such that the inside surface **15***n* of the first side wall portion **15** and the inside surface **16***n* of the second side wall portion **16** of the battery case **10** are brought into contact with the electrode body **20**, respectively. Accordingly, it is assumed that while the diffused ultrasonic wave US**1** or the going-around ultrasonic wave US**2** propagates in the battery case **10**, there is generated mutual propagation of the ultrasonic wave between the battery case **10** and the electrode body **20** contacted thereto or further between the battery case **10** and the electrolytic solution **50** but energy loss easily occurs at this time of mutual propagation, so that the going-around ultrasonic wave US**2** has attenuated early.
(60) As explained above, in the producing method of the battery **1**, the first side wall portion **15** and the second side wall portion **16** of the battery case **1** are held and pressed in the impregnation examining step S**2** to bring the inside surface **15***n* of the first side wall portion **15** and the inside surface **16***n* of the second side wall portion **16** into contact with the electrode body **20** and that the transmitting probe **120** and the receiving probe **125** are brought into close contact with the first measured portion **15***ma* inside the outside surface **15***m* of the first side wall portion **15** and the second measured portion **16***ma* inside the outside surface **16***m* of the second side wall portion **16**, respectively. Accordingly, the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** is directly transmitted to the first side wall portion **15**, reaches the electrode body **20** without intervened by the air layer, passes through this electrode body **20**, and further is transmitted to the second side wall portion **16** from the electrode body **20** without intervened by the air layer, so that the ultrasonic wave is directly conveyed to the receiving probe **125** from the second side wall portion **16**. Thus, the post-penetrated ultrasonic wave USR that has been sent from the transmitting probe **120** and has passed through the electrode body **20** and others can be properly received by the receiving probe **125**.
(61) On the other hand, in the battery case **10**, the absorption member **130** for absorbing the diffused ultrasonic wave US**1** is placed in the peripheral portion **15***mb* of the first measured portion **15***ma* to which the transmitting probe **120** is in close contact, and the absorption member **135** for absorbing the going-around ultrasonic wave US**2** is placed in the peripheral portion **16***mb* of the second measured portion **16***ma* to which the receiving probe **125** is in close contact. Arrangement of these absorption members can restrain occurrence of noise which is generated by a part of the transmitted ultrasonic wave US**0** sent from the transmitting probe **120** being diffused from the first measured portion **15***ma* without passing through the electrode body **20**, going around and propagating in the battery case **10**, and reaching the second measured portion **16***ma* to be received by the receiving probe **125**.
(62) By the above configuration, the impregnated state of the electrolytic solution **50** in the electrode body **20** of the battery **1** can be appropriately examined.
Embodiment 2
(63) Next, a second embodiment is explained. The embodiment 1 is illustrated with a case of performing the impregnation examining step S**2** during the production process of the battery **1**. On the other hand, the embodiment 2 is different in a manner that the impregnation examining step S**2** is performed for the battery **1** after shipping (see FIG. **11**). The impregnation examining step S**2** itself is same as the one in the embodiment 1.
(64) In the case of performing the impregnation examination for the battery **1** after shipping, too, the impregnated state of the electrolytic solution **50** in the electrode body **20** can be appropriately examined as explained in the embodiment 1.
(65) As mentioned above, the present disclosure has been explained in the embodiments 1 and 2, but the present disclosure is not limited to the embodiments 1 and 2 and may be applied with any appropriate modifications without departing from the scope of the subject matter.

(66) For example, in the embodiments 1 and 2, the absorption members **130** and **135** for absorbing the ultrasonic wave US are placed in both the peripheral portion **15***mb* of the first measured portion **15***ma* and the peripheral portion **16***mb* of the second measured portion **16***ma* in the battery case **10**, but alternatively, the absorption member may be placed in any one of the peripheral portions. Further, the absorption members **130** and **135** may be made not only of rubber but also of resin, clay, grease, and gel.

REFERENCE SIGNS LIST

(67) **1** Rectangular battery (battery) **10** Rectangular battery case (battery case) **15** First side wall portion **15***n* Inside surface (of the first side wall portion) **15***m* Outside surface (of the first side wall portion) **15***ma* First measured portion **15***mb* Peripheral portion (of the first measured portion) **16** Second side wall portion **16***n* Inside surface (of the second side wall portion) **16***m* Outside surface (of the second side wall portion) **16***ma* Second measured portion **16***mb* Peripheral portion (of the second measured portion) **20** Electrode body **50** Electrolytic solution **100**, C**1**, C**2** Impregnation examination device **110**, **115** Binding plate **120** Transmitting probe **125** Receiving probe **130**, **135** Absorption member **140** Probe drive device **150** Controller TS Transmission signal RS Receipt signal US**0** Transmitted ultrasonic wave UST Pre-penetrated ultrasonic wave USR Post-penetrated ultrasonic wave US**1** Diffused ultrasonic wave US**2** Going-around ultrasonic wave US**5** Received ultrasonic wave t, ta, tc, td, te, tf Elapsed time (elapsed from start of transmission) AT, AR Amplitude S**1** Assembling step S**2** Impregnation examining step S**3** Initial charging step S**4** Aging step

Claims

1. A producing method for a rectangular battery in which an electrode body and electrolytic solution are housed in a rectangular battery case, wherein the method includes impregnation examining performed by: holding and pressing a first side wall portion and a second side wall portion opposing each other with the electrode body sandwiched therebetween in the rectangular battery case of the rectangular battery that has been assembled and bringing an inside surface of the first side wall portion and an inside surface of the second side wall portion to be in respectively contact with the electrode body; bringing a transmitting probe into close contact with a first measured portion in an outside surface of the first side wall portion and bringing a receiving probe into close contact with a second measured portion in an outside surface of the second wall portion; in a state in which an absorption member is placed in a peripheral portion of at least any one of the first measured portion and the second measured portion, the absorption member absorbing at least any one of diffused ultrasonic wave to be spread and propagated to a periphery from the first measured portion and going-around ultrasonic wave to be propagated from a periphery of the second measured portion to the second measured portion, receiving post-penetrated ultrasonic wave which has been sent out from the transmitting probe and penetrated through the first side wall portion and the electrode body to reach the second side wall portion, and determining an impregnated state of the electrolytic solution into the electrode body based on a received signal obtained from the receiving probe.

2. An examining method for a rectangular battery in which an electrode body and electrolytic solution are housed in a rectangular battery case, wherein the method includes impregnation examining performed by: holding and pressing a first side wall portion and a second side wall portion opposing each other with the electrode body sandwiched therebetween in the rectangular battery case of the rectangular battery that has been assembled and bringing an inside surface of the first side wall portion and an inside surface of the second side wall portion to be in respectively contact with the electrode body; bringing a transmitting probe into close contact with a first measured portion in an outside surface of the first side wall portion and bringing a receiving probe into close contact with a second measured portion in an outside surface of the second wall portion;

in a state in which an absorption member is placed in a peripheral portion of at least any one of the first measured portion and the second measured portion, the absorption member absorbing at least any one of diffused ultrasonic wave to be spread and propagated to a periphery from the first measured portion and going-around ultrasonic wave to be propagated from a periphery of the second measured portion to the second measured portion, receiving post-penetrated ultrasonic wave which has been sent out from the transmitting probe and penetrated through the first side wall portion and the electrode body to reach the second side wall portion, and determining an impregnated state of the electrolytic solution into the electrode body based on a received signal obtained from the receiving probe.