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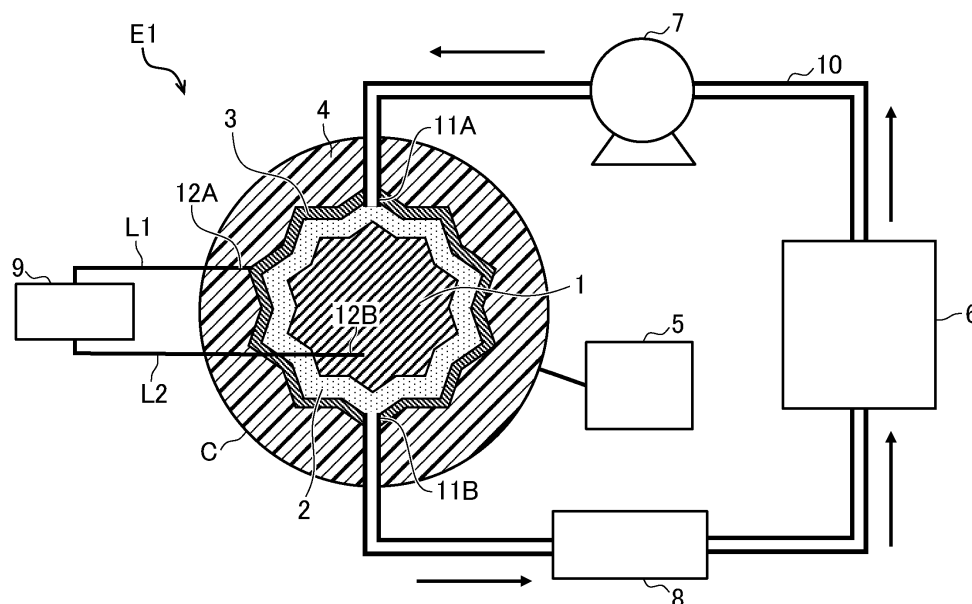
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(54) PLATING DEVICE AND PLATING FORMATION METHOD

(57) A plating device (E1) of the present invention includes a cell (C) including a porous body (2) surrounding a metal component (1) and impregnated with a plating solution, and a plating electrode (3) surrounding the

porous body (2), in which a distance between the plating electrode (3) and a surface of the metal component (1) is substantially uniform.

FIG. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a plating device and a plating formation method.

2. Description of the Related Art

[0002] In recent years, for environmental problems and securing of resources, attention has been paid to product regeneration by extending the life of industrial products and repair techniques for the purpose of waste reduction and resource saving. Examples of a repairing method of a metal component having a local and shallow deficit due to wear, corrosion, or the like include brush plating. However, brush plating, which is manual work, may cause an uneven plating film thickness distribution or a partial defect due to worker's manual technique.

[0003] Conventionally, there is known a plating device that forms a plating film on a surface of a base material by interposing a solid electrolyte film between a plate-shaped positive electrode and the base material (metal member) to be a negative electrode (see, for example, Patent Document 1). According to this plating device, a plating film having few defects can be formed on the surface of the base material.

[0004] Conventionally, there is known a plating device that forms a plating film on a surface while pressing and rotating a porous pad impregnated with a plating solution against a surface to be plated of the substrate (metal member) (see, for example, JP 2005-213596 A). According to this plating device, a plating film having a uniform film thickness distribution can be formed.

[Patent Documents]

[0005]

[Patent Document 1] JP 2016-169399 A

[Patent Document 2] JP 2005-213596 A

SUMMARY OF THE INVENTION

[0006] However, in conventional plating devices (see, for example, JP 2016-169399 A and JP 2005-213596 A), a surface to be plated of a target metal member is limited to a flat surface. Therefore, in the conventional plating devices, it is difficult to form a plating film having no defect and a uniform film thickness distribution with respect to a metal component whose surface to be plated changes three-dimensionally.

[0007] An object of the present invention is to form a plating film having a uniform film thickness distribution and no defect for a wide range of metal components

including a three-dimensional structure whose surface to be plated changes three-dimensionally not depending on a manual technique of a worker.

[0008] A plating device of the present invention includes a cell including a porous body surrounding a metal component and impregnated with a plating solution, and a plating electrode surrounding the porous body, in which a distance between the plating electrode and a surface of the metal component is substantially uniform.

[0009] A plating formation method of the present invention is a plating formation method using the plating device, the plating formation method including: disposing the plating electrode surrounding the metal component via the porous body having a constant thickness disposed so as to surround the metal component; and forming plating on a surface of the metal component by supplying electric energy so as to reduce a metal ion in a plating solution while supplying the plating solution to the porous body.

[0010] According to the present invention, it is possible to form a plating film having a uniform film thickness distribution and no defect with respect to a wide range of metal components including a three-dimensional structure whose surface to be plated changes three-dimensionally without depending on a manual technique of a worker.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a configuration explanatory diagram of a plating device according to a first embodiment of the present invention;

Fig. 2 is a configuration explanatory diagram of a plating device according to a second embodiment of the present invention;

Fig. 3A is a flowchart explaining a procedure executed by a porous body replacement period prediction unit constituting the plating device of Fig. 2;

Fig. 3B is a graph showing a relationship between an increase rate (%) of an electrical resistance value referred to by the porous body replacement period prediction unit of Fig. 2 and a remaining life (time) of a porous body;

Fig. 4 is a schematic diagram illustrating an example of an image projected on a display unit constituting the plating device;

Fig. 5 is a configuration explanatory diagram of a plating device according to a third embodiment of the present invention;

Fig. 6A is a flowchart explaining a procedure executed by a plating electrode replacement period prediction unit constituting the plating device of Fig. 5; and

Fig. 6B is a graph showing a relationship between an increase rate (%) of a potential difference referred to by the plating electrode replacement period predic-

tion unit of Fig. 5 and a remaining life (time) of a plating electrode.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A form (embodiment) for carrying out a plating device of the present invention will be described below in detail with reference to the drawings as appropriate.

[0013] The plating device of the present invention has a configuration suitable or repairing, by plating, a deficit portion due to wear or the like of a metal component during regeneration of an industrial product. That is, the plating device of the present invention can be applied even to a metal component whose surface to be plated changes three-dimensionally.

(First embodiment)

[0014] Fig. 1 is a configuration explanatory diagram schematically illustrating a plating device E1 according to the first embodiment of the present invention.

[0015] As illustrated in Fig. 1, the plating device E1 includes a cell C that forms a plating film (not illustrated) on the surface of a metal component 1.

[0016] The metal component 1 in the present embodiment is assumed to be a polygonal columnar body. A cross-sectional shape of this metal component 1 is assumed to be a star polygon (decagram) in which two regular pentagons are combined. However, the metal component 1 that can be applied to the plating device E1 is not limited to this, and includes various three-dimensional structures whose surfaces change three-dimensionally.

[0017] Hereinafter, the plating device E1 that forms a plating film (not illustrated) over the entire surface of such the metal component 1 will be described as an example.

[0018] As illustrated in Fig. 1, the cell C is formed by integrating a porous body 2, a plating electrode 3, and a casing 4.

[0019] The porous body 2 is disposed so as to entirely surround an outside of the metal component 1 with the metal component 1 being inside. Specifically, the porous body 2 is disposed so as to cover the entire surface of metal component 1 with a predetermined thickness. That is, the porous body 2 in the present embodiment is disposed so as to cover both end surfaces in a height direction (direction perpendicular to the paper surface of Fig. 1) and a peripheral side surface of the metal component 1 made of a polygonal columnar body.

[0020] The thickness of the porous body 2 is assumed to be constant in a direction (perpendicular direction to the surface) orthogonal to the surface of the metal component 1. Due to this, the outer shape of the porous body 2 has a similar shape larger than the outer shape of the metal component 1.

[0021] The porous body 2 in the present embodiment is made of resin and has many continuous pores. Due to

this, as described later, the porous body 2 contains a plating solution and comes into contact with the surface of the metal component 1 to follow the shape thereof. An interface between the porous body 2 and the metal component 1 is wetted with the plating solution. As described later, when the plating solution circulates between the cell C and a tank 6, the plating solution flows through the pores of the porous body 2.

[0022] Such the porous body 2 functions as a spacer that uniforms the distance between the surface of the metal component 1 and the plating electrode 3 in relation to the plating electrode 3 described later.

[0023] As the resin constituting the porous body 2, a resin having flexibility, chemical resistance, and hydrophilicity is preferable. Specifically, polyolefin, polyurethane, polyvinyl chloride, polyethylene, and ethylene copolymers are particularly preferable.

[0024] The plating electrode 3 is disposed so as to entirely surround the outside of the metal component 1 via the porous body 2. Specifically, the plating electrode 3 is disposed so as to cover the entire surface of the porous body 2 with a predetermined thickness. That is, in the present embodiment, the plating electrode 3 is disposed so as to cover both end surfaces in a height direction (direction perpendicular to the paper surface of Fig. 1) and a peripheral side surface of the porous body 2 made of a polygonal columnar body.

[0025] The thickness of the plating electrode 3 is assumed to be constant in a direction (perpendicular direction) orthogonal to the surface of the porous body 2. Due to this, the outer shape of the plating electrode 3 has a similar shape larger than the outer shape of the porous body 2. An inner surface of the plating electrode 3 and an outer surface of the porous body 2 are in close contact with each other. An interface between the plating electrode 3 and the porous body 2 is wetted with the plating solution. Due to this, the plating electrode 3 and the metal component 1 are electrically connected via the porous body 2 containing the plating solution.

[0026] The plating electrode 3 in the present embodiment is provided as a positive electrode for reducing a metal ion in the plating solution.

[0027] The plating electrode 3 in the present embodiment preferably has a mesh structure in which a wire forms a mesh. Among them, those having a mesh structure in which the diameter of the wire is 0.5 mm or less or the plating electrode thickness is 0.5 mm or less are particularly preferable.

[0028] The material of the plating electrode 3 is not particularly limited, but a material that is insoluble in a plating solution and has low electrical resistance and is chemically and electrochemically stable is preferable. Among them, platinum, iridium oxide, and ruthenium are preferable. Platinum is more preferably when plated on a titanium material.

[0029] As illustrated in Fig. 1, the casing 4 has a cylindrical shape with both ends sealed having an internal space where the plating electrode 3, the porous body

2, and the metal component 1 are disposed therein.

[0030] In Fig. 1, a sealing wall at an end of the casing 4 is omitted for convenience of drawing.

[0031] As illustrated in Fig. 1, an inner peripheral side of the casing 4 has a star polygon (decagram) in cross-sectional view so as to be in close contact with the shape of the outer peripheral side of the plating electrode 3.

[0032] The casing 4 is made of resin. Such the casing 4 can be formed by a 3D printer or injection molding. Among them, a method of forming the casing 4 by the 3D printer is preferable because design data of the metal component 1 performed with high accuracy can be shared.

[0033] As the resin forming the casing 4, a resin having electrical insulation properties, chemical resistance, and high mechanical strength is preferable.

[0034] Examples of the resin that forms the casing 4 by the 3D printer include, but are not limited to, a photo-sensitive epoxy resin, an acrylic resin, and a silicone resin. Examples of the resin that forms the casing 4 by injection molding include, but are not limited to, an ABS resin, polytetrafluoroethylene, polypropylene, and polyvinyl chloride.

[0035] In the cell C in the present embodiment, as described above, the casing 4, the plating electrode 3, and the porous body 2 are joined and integrated with one another.

[0036] The cell C is divided into a plurality of parts so that the plated metal component 1 can be extracted from the cell C.

[0037] Although not illustrated, the cell C in the present embodiment is assumed to be divided into two or more in an axial direction (direction perpendicular to the paper surface of Fig. 1). According to such the cell C, the metal component 1 can be extracted from the cell C by moving the divided cells C so as to be separated from each other in the axial direction.

[0038] When no undercut occurs in the surface shape of the metal component 1, the cell C can be divided so as to be separable in a direction intersecting the axis.

[0039] By dividing the cell C in this manner, the plating device E1 can repeatedly use the cell C.

[0040] Then, it is desirable to provide a seal member that maintains the sealability of the internal space of the cell C at a joint between the divided cells C. In order to firmly join the divided cells C, for example, it is desirable to provide a belt, a fixing jig, or the like that tightens the outer peripheral portion of the cell C in a circumferential direction.

[0041] In addition to such the cell C, the plating device E1 of the present embodiment further includes a circulation mechanism of a plating solution, a plating power source 9, and a vibration generator 5.

[0042] As illustrated in Fig. 1, the circulation mechanism of a plating solution is configured to mainly include a tube 10, the tank 6 that stores the plating solution, a pump 7, and a filter 8.

[0043] The tube 10 connects an inflow port 11A of the

plating solution provided in the plating electrode 3 and an outflow port 11B of the plating solution provided in the plating electrode 3 on an opposite side of the inflow port 11A across the metal component 1.

[0044] Both ends of the tube 10 face the porous body 2 at the inflow port 11A and the outflow port 11B, respectively. In the present embodiment, the inflow port 11A is assumed to be provided above in the vertical direction, and the outflow port 11B is assumed to be provided below in the vertical direction.

[0045] The material of the tube 10 desirably has chemical resistance and is flexible.

[0046] The tank 6 is disposed in the middle of the extension of the tube 10.

[0047] The tank 6 stores a plating solution in an amount necessary for repairing the metal component 1.

[0048] As a material of the tank 6, a material having chemical resistance is desirable. The capacity of the tank 6 needs to be designed in accordance with the surface area and the plating thickness of the metal component 1, and is desirably 20 L or less in consideration of transportability.

[0049] The pump 7 is disposed in the middle of the extension of the tube 10 between the tank 6 and the inflow port 11A.

[0050] The pump 7 is driven so as to circulate the plating solution through the tube 10 between the cell C and the tank 6. The pump 7 in the present embodiment supplies the plating solution in the tank 6 to the porous body 2 via the inflow port 11A, and returns the plating solution in the porous body 2 to the tank 6 via the outflow port 11B.

[0051] As the pump 7, a circulation pump for a plating solution having general chemical resistance is desirable.

[0052] Among them, a magnet pump that is small in size and can adjust a discharge amount is preferable.

[0053] The filter 8 is disposed in the middle of the extension of the tube 10 between the outflow port 11B and the tank 6.

[0054] The filter 8 removes foreign matters and the like in the plating solution that may cause defects of the plating film.

[0055] As the filter 8, a filter for a plating solution having general chemical resistance is desired. Specifically, the filter 8 is preferably a yarn winding filter made of polypropylene.

[0056] The filter 8 may be a pump filter integrated with the pump 7.

[0057] The plating power source 9 is provided for supplying electric energy for reducing a metal ion in the plating solution. Specifically, the plating power source 9 forms a power feeding part 12A on the positive electrode side with the plating electrode 3 via a lead wire L1. The plating power source 9 forms a power feeding part 12B on the negative electrode side with the metal component 1 via a lead wire L2.

[0058] The plating power source 9 is preferably a direct-current power source that is transportable and small

in size. When it is desired to suppress an occurrence of a crack in the plating film or when it is desired to increase the hardness of the plating film, a pulse power source can also be used.

[0059] The vibration generator 5 is provided for suppressing the porous body 2 and the plating film from adhering to each other and for smoothing the surface of the plating film. As the vibration generator 5, a vibration generator of an electrodynamic type or an unbalanced mass type that can be downsized is preferable.

[0060] Next, a plating formation method using the plating device E1 will be described while describing the operation of the plating device E1 of the present embodiment with reference to Fig. 1.

[0061] This plating formation method includes: disposing the plating electrode 3 surrounding the metal component 1 via the porous body 2 having a constant thickness disposed so as to surround the metal component 1; and forming plating on the surface of the metal component 1 by supplying electric energy so as to reduce a metal ion in a plating solution while supplying the plating solution to the porous body 2.

[0062] First, in this plating formation method, the metal component 1 requiring surface repair is disposed in the cell C. The distance between the surface of the metal component 1 and the plating electrode 3 is uniform by the interposed porous body 2.

[0063] Next, the pump 7 of the plating device E1 is driven to start circulation of the plating solution through the tube 10 between the cell C and the tank 6. Due to this, the plating solution is supplied to the porous body 2 of the cell C. The surface of the metal component 1 and the plating electrode 3 opposed thereto are electrically connected by the porous body 2 containing the plating solution.

[0064] On the other hand, when the plating power source 9 supplies electric energy to the cell C, a plating film is formed on the surface of the metal component 1 having a partial deficit due to wear or the like. At this time, the cell C is applied with vibration by the vibration generator 5. The surface of the metal component 1 with which the porous body 2 of the cell C is in contact forms a plating film under vibration.

[0065] The plating solution having consumed the metal ion by forming the plating film is returned to the tank 6 by the circulation mechanism of the plating solution. The porous body 2 is supplied with a new plating solution in which a metal ion is maintained at a predetermined concentration by the circulation mechanism of the plating solution.

[0066] On the surface of the metal component 1 in contact with the plating solution, a sound plating film is formed while sufficient metal ions are supplied.

[0067] Thereafter, the metal component 1 is extracted from the divided cell C, whereby the series of plating formation process in the present embodiment ends.

<Actions and Effects>

[0068] Next, actions and effects of this plating device E1 of the present embodiment and the plating formation method using this plating device E1 will be described.

[0069] The plating device E1 of the present embodiment includes the cell C including the porous body 2 surrounding the metal component 1 and impregnated with the plating solution, and the plating electrode 3 surrounding the porous body 2, and the distance between the plating electrode 3 and the surface of the metal component 1 is substantially uniform. The plating formation method includes: disposing the plating electrode 3 surrounding the metal component 1 via the porous body 2 having a constant thickness disposed so as to surround the metal component 1; and forming plating on the surface of the metal component 1 by supplying electric energy so as to reduce a metal ion in a plating solution while supplying the plating solution to the porous body 2.

[0070] According to such the plating device E1 and the plating formation method, the plating electrode 3 surrounds the metal component 1 via the porous body 2 containing the plating solution, and thus a sound plating film free from a defect can be formed even for the metal component 1 whose surface to be plated changes three-dimensionally.

[0071] According to this plating device E1, the distance between the plating electrode 3 and the surface of the metal component 1 is uniformed by the porous body 2 interposed between the plating electrode 3 and the metal component 1. Due to this, the film thickness of plating becomes constant at the time of repair, and plating quality can be improved.

[0072] According to this plating device E1, the plating electrode 3 surrounds the metal component 1 via the porous body 2, and thus the plating range for the metal component 1 can be widened. Due to this, repair can be performed in a short time as compared with the conventional brush plating technique.

[0073] According to this plating device E1, the surface of the metal component 1 is applied with plating by the plating solution contained in the porous body 2. Due to this, the plating device E1 can reduce the usage amount of the plating solution, unlike a plating device that performs plating by immersing the metal component 1 into a plating solution stored in a plating tank, for example. The structure in which the plating electrode 3 surrounds the metal component 1 via the porous body 2, and the reduction in the usage amount of the plating solution make it possible to downsize this plating device E1, leading to excellent transportability.

[0074] Therefore, according to this plating device E1, a non-flat metal component such as a large infrastructure facility installed outdoors, for example, can be quickly repaired by plating at the installation site. Therefore, the present invention can solve the problem that it is difficult to transport and use the conventional plating device to the site because of its large size.

[0075] The plating device E1 further includes the vibration generator 5 that vibrates the cell C.

[0076] According to this plating device E1, since the vibration generator 5 forms the plating film on the surface of the metal component 1 while vibrating the cell C, the porous body 2 and the surface of the metal component 1 are prevented from being fixed via the plating film. This avoids the plating film from being damaged when the metal component 1 is extracted from the cell C.

[0077] According to this plating device E1, since the vibration generator 5 forms the plating film on the surface of the metal component 1 while vibrating the cell C, the surface of the plating film can be smoothed.

[0078] According to such the plating device E1, unlike formation of a plating film by conventional brush plating, a plating film having a uniform film thickness distribution and no defect can be formed not depending on the manual technique of the worker.

[0079] Such the plating device E1 includes the tank 6 that stores the plating solution to be supplied to the porous body 2, the tube 10 that circulates the plating solution between the tank 6 and the cell C, the pump that circulates the plating solution, the filter 8 that filters the plating solution, and the plating power source 9 that supplies electric energy to the inside of the cell C.

[0080] In this plating device E1, the plating solution from which foreign substances are removed by the filter 8 circulates between the tank 6 and the cell C. According to this plating device E1, it is possible to prevent foreign matters from adhering to the surface of the metal component 1, and it is possible to avoid a metal ion in the plating solution contained in the porous body 2 from decreasing to a predetermined concentration or less due to formation of the plating film. Due to this, the plating device E1 can improve the quality of the plating film formed on the surface of the metal component 1.

[0081] In such the plating device E1, the plating electrode 3 has a shape formed to surround the metal component 1, and the porous body 2 is positioned between the plating electrode 3 and the metal component 1.

[0082] According to this plating device E1, the distance between the plating electrode 3 and the surface of the metal component 1 can be made uniform more reliably. Due to this, the plating device E1 can improve the plating quality more reliably.

[0083] In such the plating device E1, the porous body 2 is formed of at least one material selected from polyolefin, polyurethane, polyvinyl chloride, polyethylene, and an ethylene copolymer, the porous body 2 has a pore structure of continuous pores, the porous body 2 has a porosity of 70% or more, and the porous body 2 has a thickness of 10 mm or less.

[0084] According to this plating device E1, chemical resistance of the porous body 2 can be improved, and flow performance of the plating solution in pores of the porous body 2 and transfer efficiency of metal ions between the plating electrode 3 and the metal component 1 can be improved.

[0085] In such the plating device E1, the plating electrode 3 is an insoluble plating electrode containing at least one material selected from platinum, iridium oxide, and ruthenium, and has a mesh structure having a thickness of 0.5 mm or less or a wire diameter of 0.5 mm or less.

[0086] According to this plating device E1, a good electrode potential can be maintained over a long period of time, and the shape followability of the plating electrode 3 with respect to the shape of the metal component 1 is excellent.

(Second embodiment)

[0087] Next, a plating device E2 according to the second embodiment of the present invention will be described.

[0088] Fig. 2 is a configuration explanatory diagram schematically illustrating a plating device E2 according to the second embodiment of the present invention. In the present embodiment, constituent elements similar to those in the first embodiment are given identical reference signs, and detailed description thereof will be omitted.

[0089] In the plating device E1 (see Fig. 1), when the number of times of plating treatment to be performed increases, wear of the porous body 2 due to contact with the metal component 1, dissolution of the porous body 2 due to a plating solution, clogging of pores of the porous body 2, and the like may occur. Therefore, it is desirable to replace the porous body 2 of the plating device E1 in which the number of times of plating treatment is increased.

[0090] However, the replacement period of the porous body 2 cannot be simply determined by the type of the plating solution to be used, the plating treatment time of the metal component 1 per one, and the like.

[0091] As illustrated in Fig. 2, unlike the plating device E1 of the first embodiment (see Fig. 1), the plating device E2 of the second embodiment includes a resistance value measurement unit 13, a porous body replacement period prediction unit 21, and a display unit 20 for the replacement period of the porous body 2.

[0092] The resistance value measurement unit 13 measures an electrical resistance value between the plating electrode 3 and the metal component 1 via the porous body 2 containing the plating solution based on a current value and a voltage value of the plating power source 9 at the time of plating treatment on the metal component 1.

[0093] The resistance value measurement unit 13 is not particularly limited, but an electrical resistance measuring device that is small in size and can be transported is desirable. The resistance value measurement unit 13 may have a configuration of being incorporated in the plating power source 9. Due to this, the plating device E2 can be made compact by reduction of the number of components.

[0094] The porous body replacement period prediction unit 21 predicts a replacement period of the porous body 2 based on the electrical resistance value between the plating electrode 3 and the metal component 1 output from the resistance value measurement unit 13.

[0095] The porous body replacement period prediction unit 21 in the present embodiment can be configured to include a read only memory (ROM) that stores a program for predicting the replacement period of the porous body 2, a random access memory (RAM) that reads and develops the program stored in the ROM, and a central processing unit (CPU) that executes the developed program and calculates the replacement period of the porous body 2.

[0096] Fig. 3A is a flowchart explaining the procedure executed by the porous body replacement period prediction unit 21 (see Fig. 2). Fig. 3B is a graph showing the relationship between an increase rate (%) of an electrical resistance value referred to by the porous body replacement period prediction unit 21 (see Fig. 2) and a remaining life (time) of a porous body.

[0097] As shown in Fig. 3A, the porous body replacement period prediction unit 21 (see Fig. 2) acquires the electrical resistance value between the plating electrode 3 (see Fig. 2) output from the resistance value measurement unit 13 (see Fig. 2) and the metal component 1 (see Fig. 2) (see S step 101).

[0098] Next, the CPU of the porous body replacement period prediction unit 21 (see Fig. 2) calculates the increase rate (%) of the acquired electrical resistance value (see S step 102). The increase rate (%) of this electrical resistance value is defined by a relational expression of $100(R2 - R1)/R1$, where R1 represents the electrical resistance value between the plating electrode 3 and the metal component 1 at the time of initial setting of the porous body 2, and R2 represents the electrical resistance value acquired from the resistance value measurement unit 13.

[0099] Next, the CPU of the porous body replacement period prediction unit 21 (see Fig. 2) calculates the remaining life of the porous body 2 corresponding to the increase rate (%) of the electrical resistance value based on a preset function (see S step 103).

[0100] The function used for the calculation by the porous body replacement period prediction unit 21 (see Fig. 2) expresses the relationship between the increase rate (%) of the electrical resistance value and the remaining life (time) of the porous body 2.

[0101] Such the relationship between the increase rate (%) of the electrical resistance value and the remaining life (time) of the porous body 2 can be expressed by a graph showing a correspondence relationship between the increase rate (%) of the electrical resistance value and the remaining life (time) of the porous body 2 as shown in Fig. 3B. Such a correspondence relationship can be determined by simulation performed in advance.

[0102] The ROM of the porous body replacement period prediction unit 21 (see Fig. 2) stores a plurality of

functions in accordance with the plating solution to be used, the area of the surface to be plated of the metal component 1, the thickness of the plating film, and the like.

[0103] Returning to Fig. 3A, by using the time at which the electrical resistance value is acquired from the resistance value measurement unit 13 (see Fig. 2), the porous body replacement period prediction unit 21 (see Fig. 2) calculates the time at which the porous body 2 reaches the end of life (see S step 104).

[0104] Next, the porous body replacement period prediction unit 21 (see Fig. 2) outputs a signal indicating the time at which the porous body 2 reaches the end of life to the display unit 20 (see Fig. 2) described below (see S step 105). This ends the series of procedures performed by the porous body replacement period prediction unit 21 (see Fig. 2).

[0105] The series of process performed by the porous body replacement period prediction unit 21 corresponds to the "predicting a replacement period of the porous body" in the plating formation method of the present invention.

[0106] The display unit 20 (see Fig. 2) receives a signal from the porous body replacement period prediction unit 21 (see Fig. 2), and displays, as a guide for replacement time of the porous body 2, the time at which the porous body 2 reaches the end of life that is calculated by the porous body replacement period prediction unit 21 (see Fig. 2).

[0107] Examples of the display unit 20 (see Fig. 2) include, but are not limited to, one that digitally displays time by light emission of a light-emitting diode (LED). The display unit 20 (see Fig. 2) can also be configured to display the time by voice in response to a request by turning on a predetermined switch or the like in accordance with the need of the user.

[0108] Fig. 4 is a schematic diagram illustrating an example of an image projected on the display unit 20.

[0109] As illustrated in Fig. 4, the display unit 20 can also be configured by a touchscreen including a liquid crystal display unit that allows input by the user. This display unit 20 displays a time "AA (month), BB (day), XX (hour):YY (minute)" at which the specific porous body 2 reaches the end of life at any time during operation of the plating device E2 or in response to a user's timely request.

[0110] The display unit 20 includes touchscreen sections of "Yes" and "No", which are user selection buttons for accepting the presence or absence of an intention of advance replacement of the porous body 2. In such the display unit 20, it is also possible to further display the standard, inventory status, and the like of the porous body 2 in use by the touch input to "Yes" by the user. Depending on the touch input to "No" by the user, the plating device E2 continues the operation as it is.

<Actions and Effects>

[0111] Next, actions and effects of this plating device E2 of the present embodiment and the plating formation method using this plating device E2 will be described.

[0112] The plating device E2 of the present embodiment includes the resistance value measurement unit 13 that measures the electrical resistance value between the plating electrode 3 and the metal component 1 via the porous body 2, and the porous body replacement period prediction unit 21 that predicts the replacement period of the porous body 2 based on the increase rate (%) of the electrical resistance value.

[0113] The plating formation method further includes a process of predicting a replacement period of the porous body 2 in addition to the process of constituting the plating formation method using the plating device E1.

[0114] According to this plating device E2 and the plating formation method using this plating device E2, it is possible to accurately grasp the replacement period of the porous body 2. In particular, when the porous body is surrounded by the cell and the state of the porous body cannot be confirmed at a glance as in the plating device E2 of the present invention, the state of the porous body can be confirmed by the porous body replacement period prediction unit 21. By confirming the state of the porous body and eliminating clogging or the like of the porous body in advance, it is possible to suppress consumption of an extra plating solution used at the time of plating and power consumption. This makes it possible to reduce an environmental load at the time of repairing plating.

(Third embodiment)

[0115] Next, a plating device E3 according to the third embodiment of the present invention will be described.

[0116] Fig. 5 is a configuration explanatory diagram schematically illustrating a plating device E3 according to the third embodiment of the present invention. In the present embodiment, constituent elements similar to those in the first embodiment are given identical reference signs, and detailed description thereof will be omitted.

[0117] In the plating device E1 (see Fig. 1), the plating electrode 3 may be locally damaged when the number of times of plating treatment to be performed increases. Therefore, it is desirable to replace the plating electrode 3 in a timely manner.

[0118] As illustrated in Fig. 5, unlike the plating device E1 of the first embodiment (see Fig. 1), the plating device E3 of the third embodiment includes a potential difference measurement unit 15, a plating electrode replacement period prediction unit 22, and the display unit 20.

[0119] The potential difference measurement unit 15 measures a potential difference between the plating power source 9 and a reference electrode 14 at the time of plating treatment on the metal component 1.

[0120] The potential difference measurement unit 15 is

not particularly limited, but an electrometer that is small in size and can be transported is desirable.

[0121] As illustrated in Fig. 5, the reference electrode 14 in the present embodiment is immersed in a plating solution (not illustrated) in the tank 6.

[0122] The reference electrode 14 in the present embodiment preferably has the same specifications as those of the plating electrode 3. That is, when the plating electrode 3 has a mesh structure formed of a wire made of a predetermined material, the reference electrode 14 also preferably has a mesh structure formed of a wire made of a predetermined material.

[0123] When the plating electrode 3 is formed by plating a titanium material with platinum, it is desirable that the reference electrode 14 is also formed by plating a titanium material with platinum, and the thickness of the platinum plating is set to be the same.

[0124] The plating electrode replacement period prediction unit 22 predicts the replacement period of the plating electrode 3 based on the potential difference between the plating electrode 3 and the reference electrode 14 output by the potential difference measurement unit 15.

[0125] The plating electrode replacement period prediction unit 22 in the present embodiment can be configured to include a read only memory (ROM) that stores a program for predicting the replacement period of the plating electrode 3, a random access memory (RAM) that reads and develops the program stored in the ROM, and a central processing unit (CPU) that executes the developed program and calculates the replacement period of the plating electrode 3.

[0126] Fig. 6A is a flowchart explaining the procedure executed by the plating electrode replacement period prediction unit 22 (see Fig. 5). Fig. 6B is a graph showing the relationship between the increase rate (%) of the potential difference referred to by the plating electrode replacement period prediction unit 22 (see Fig. 5) and the remaining life (time) of the plating electrode.

[0127] As shown in Fig. 6A, the plating electrode replacement period prediction unit 22 (see Fig. 5) acquires the potential difference between the plating electrode 3 (see Fig. 5) output by the potential difference measurement unit 15 (see Fig. 5) and the reference electrode 14 (see Fig. 5) (see S step 201).

[0128] Next, the plating electrode replacement period prediction unit 22 (see Fig. 5) calculates the increase rate (%) of the acquired potential difference (see S step 202). The increase rate (%) of this potential difference is defined by a relational expression of $100(Pd2 - Pd1)/Pd1$, where Pd1 represents the potential difference between the plating electrode 3 and the reference electrode 14 at the time of initial setting of the plating electrode 3 (see Fig. 5), and Pd2 represents the potential difference acquired from the potential difference measurement unit 15.

[0129] Next, the plating electrode replacement period prediction unit 22 (see Fig. 5) calculates the remaining life of the plating electrode 3 (see Fig. 5) corresponding to the

increase rate (%) of the potential difference based on a preset function (see S step 203).

[0130] The function used for the calculation by the plating electrode replacement period prediction unit 22 (see Fig. 5) represents the relationship between the increase rate (%) of the potential difference and the remaining life (time) of the plating electrode 3.

[0131] Such the relationship between the increase rate (%) of the potential difference and the remaining life (time) of the plating electrode 3 can be expressed by a graph showing a correspondence relationship between the increase rate (%) of the potential difference and the remaining life (time) of the plating electrode 3 as shown in Fig. 6B. Such a correspondence relationship can be determined by simulation performed in advance.

[0132] The ROM of the plating electrode replacement period prediction unit 22 (see Fig. 5) stores a plurality of functions in accordance with the plating solution to be used, the specifications of the plating electrode 3, and the like.

[0133] Returning to Fig. 6A, by using the time at which the potential difference is acquired from the potential difference measurement unit 15 (see Fig. 5), the plating electrode replacement period prediction unit 22 (see Fig. 5) calculates the time at which the plating electrode 3 reaches the end of life (see S step 204).

[0134] Next, the plating electrode replacement period prediction unit 22 (see Fig. 5) outputs a signal indicating the time at which the plating electrode 3 reaches the end of life to the display unit 20 (see Fig. 5) (see S step 205). This ends the series of procedures performed by the plating electrode replacement period prediction unit 22 (see Fig. 5).

[0135] The series of process performed by such the electrode replacement period prediction unit 22 corresponds to the "predicting a replacement period of the plating electrode" in the plating formation method of the present invention.

[0136] The display unit 20 (see Fig. 5) receives a signal from the plating electrode replacement period prediction unit 22 (see Fig. 5), and displays, as a guide for replacement time of the plating electrode 3, the time at which the plating electrode 3 reaches the end of life that is calculated by the plating electrode replacement period prediction unit 22 (see Fig. 5).

<Actions and Effects>

[0137] Next, actions and effects of this plating device E3 of the present embodiment and the plating formation method using this plating device E3 will be described.

[0138] The plating device E3 of the present embodiment includes the reference electrode 14 immersed in the plating solution in the tank 6, the potential difference measurement unit 15 that measures the potential difference between the plating electrode 3 and the reference electrode 14, and the plating electrode replacement period prediction unit 22 that predicts the replacement period

of the plating electrode 3 based on the increase rate of the potential difference.

[0139] The plating formation method further includes a process of predicting a replacement period of the plating electrode 3 in addition to the process of constituting the plating formation method using the plating device E1.

[0140] According to this plating device E3 and the plating formation method using this plating device E3, it is possible to accurately grasp the replacement period of the plating electrode 3.

[0141] While the embodiments of the present invention have been described above, the present invention is not limited to the above embodiments, and can be implemented in various forms.

[0142] The plating device E2 including the porous body replacement period prediction unit 21 has been described in the second embodiment, and the plating device E3 including the plating electrode replacement period prediction unit 22 has been described in the third embodiment.

[0143] The plating device of the present invention may include both the porous body replacement period prediction unit 21 and the plating electrode replacement period prediction unit 22.

[0144] In the first to third embodiments described above, the plating devices E1, E2, and E3 suitable for repairing the metal component 1 have been described, but the plating devices E1, E2, and E3 can also be used for plating treatment on a new metal component 1.

Claims

1. A plating device comprising

a cell including
a porous body surrounding a metal component and impregnated with a plating solution, and
a plating electrode surrounding the porous body, wherein
a distance between the plating electrode and a surface of the metal component is substantially uniform.

2. The plating device according to claim 1, further comprising a vibration generator that vibrates the cell.

3. The plating device according to claim 1 comprising:

a tank that stores a plating solution to be supplied to the porous body;
a tube that circulates the plating solution between the tank and the cell;
a pump that circulates the plating solution;
a filter that filters the plating solution; and
a plating power source that supplies electric energy to an inside of the cell.

4. The plating device according to claim 1, wherein the plating electrode has a shape formed to surround the metal component, and the porous body is positioned between the plating electrode and the metal component.
5. The plating device according to claim 1, wherein the porous body is formed of one material selected from polyolefin, polyurethane, polyvinyl chloride, polyethylene, and an ethylene copolymer, the porous body has a pore structure of continuous pores, the porous body has a porosity of 70% or more, and the porous body has a thickness of 10 mm or less.
6. The plating device according to claim 1, wherein the plating electrode is an insoluble plating electrode containing one material selected from platinum, iridium oxide, and ruthenium, and has a mesh structure having a thickness of 0.5 mm or less or a wire diameter of 0.5 mm or less.
7. The plating device according to claim 1, further comprising:
- a resistance value measurement unit that measures an electrical resistance value between the plating electrode and the metal component via the porous body; and
 - a porous body replacement period prediction unit that predicts a replacement period of the porous body based on an increase rate of the electrical resistance value.
8. The plating device according to claim 3, further comprising:
- a reference electrode immersed in the plating solution in the tank;
 - a potential difference measurement unit that measures a potential difference between the plating electrode and the reference electrode; and
 - a plating electrode replacement period prediction unit that predicts a replacement period of the plating electrode based on an increase rate of the potential difference.
9. A plating formation method using the plating device according to claim 1, the plating formation method comprising:
- disposing the plating electrode surrounding the metal component via the porous body having a constant thickness disposed so as to surround the metal component; and
 - forming plating on a surface of the metal component by supplying electric energy so as to reduce a metal ion in a plating solution while supplying the plating solution to the porous body.
10. The plating formation method according to claim 9, further comprising predicting a replacement period of the porous body.
11. The plating formation method according to claim 9, further comprising predicting a replacement period of the plating electrode.

FIG. 1

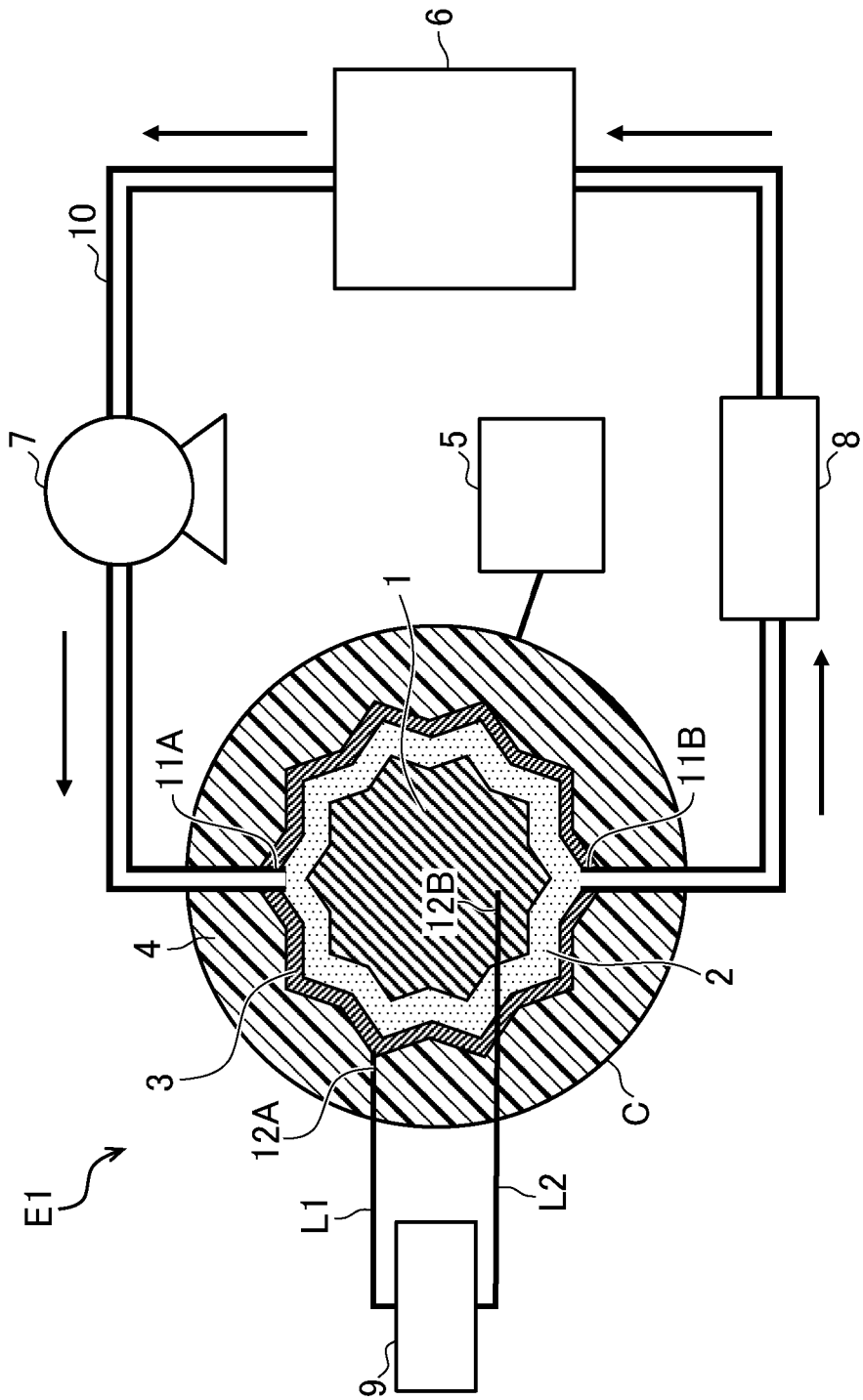


FIG. 2

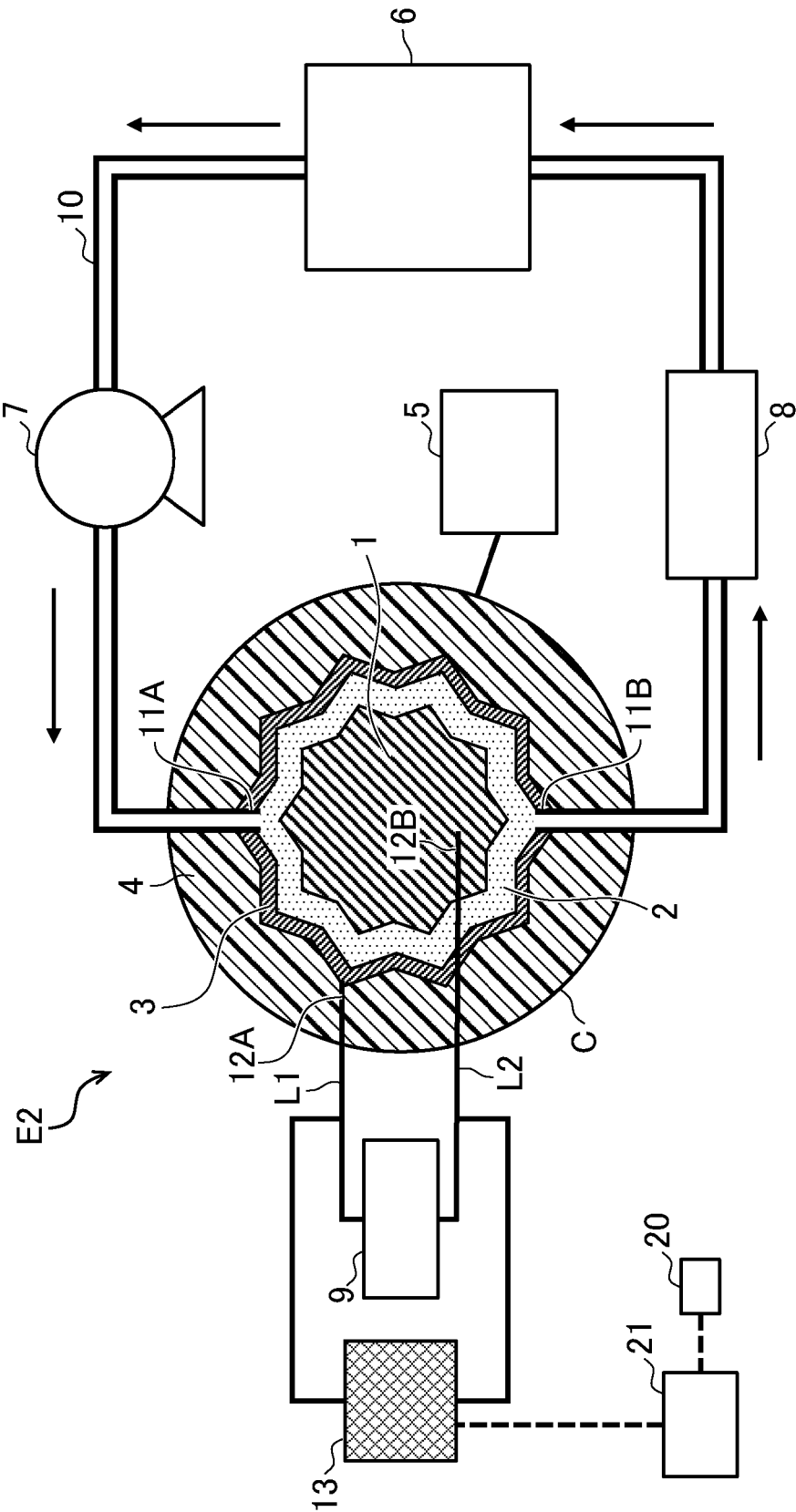


FIG. 3A

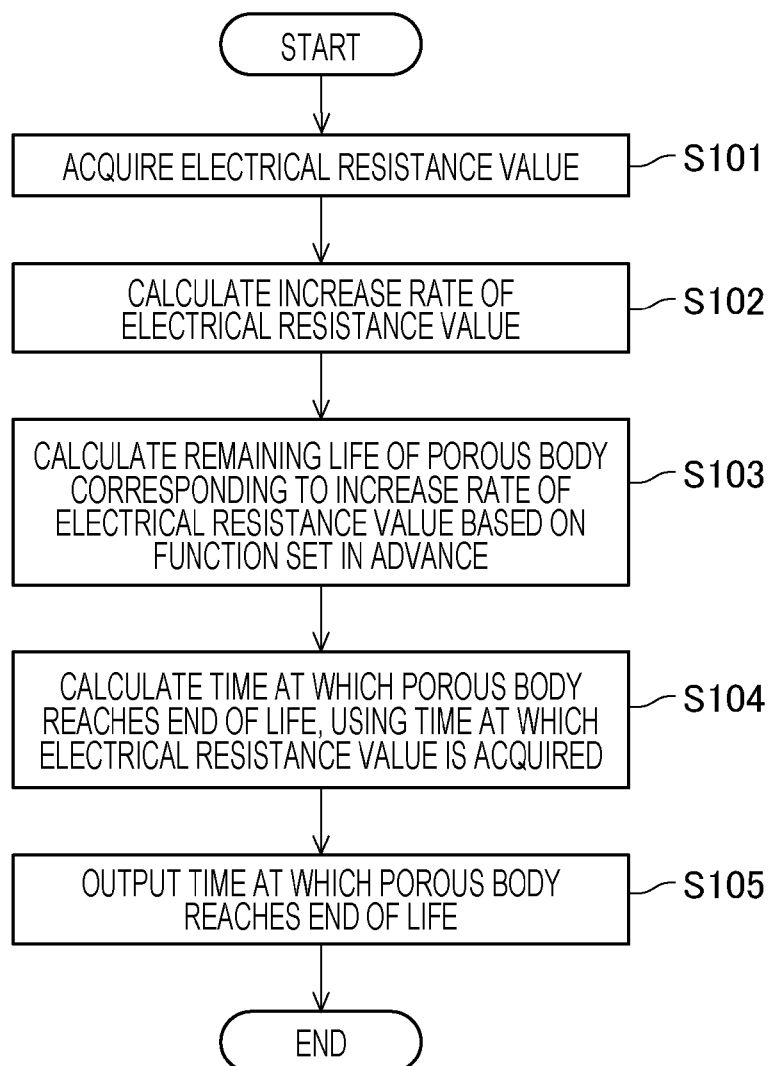


FIG. 3B

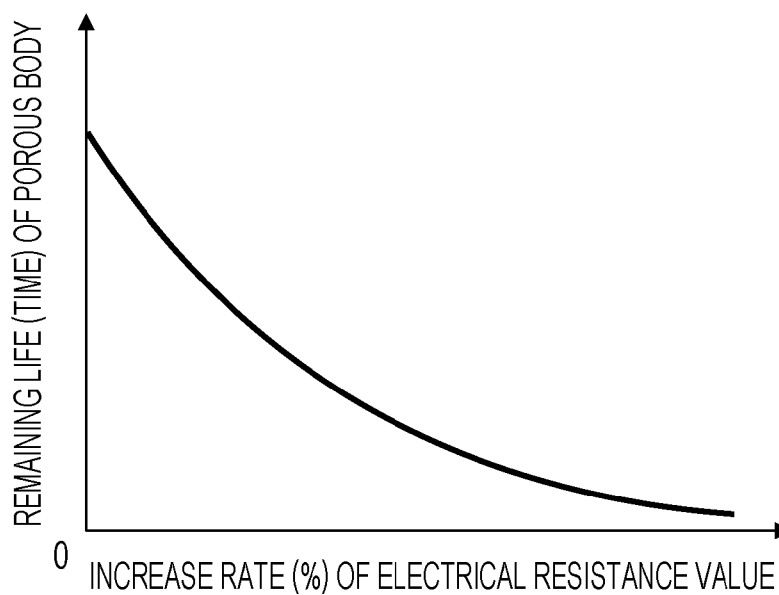


FIG. 4

20

POROUS BODY
REPLACEMENT PERIOD

POROUS BODY CURRENTLY IN
USE REACHES END OF LIFE
XX:YY ON AA (MONTH)/BB (DAY).

WILL YOU MAKE
ADVANCE REPLACEMENT
OF POROUS BODY?

Yes No

FIG. 5

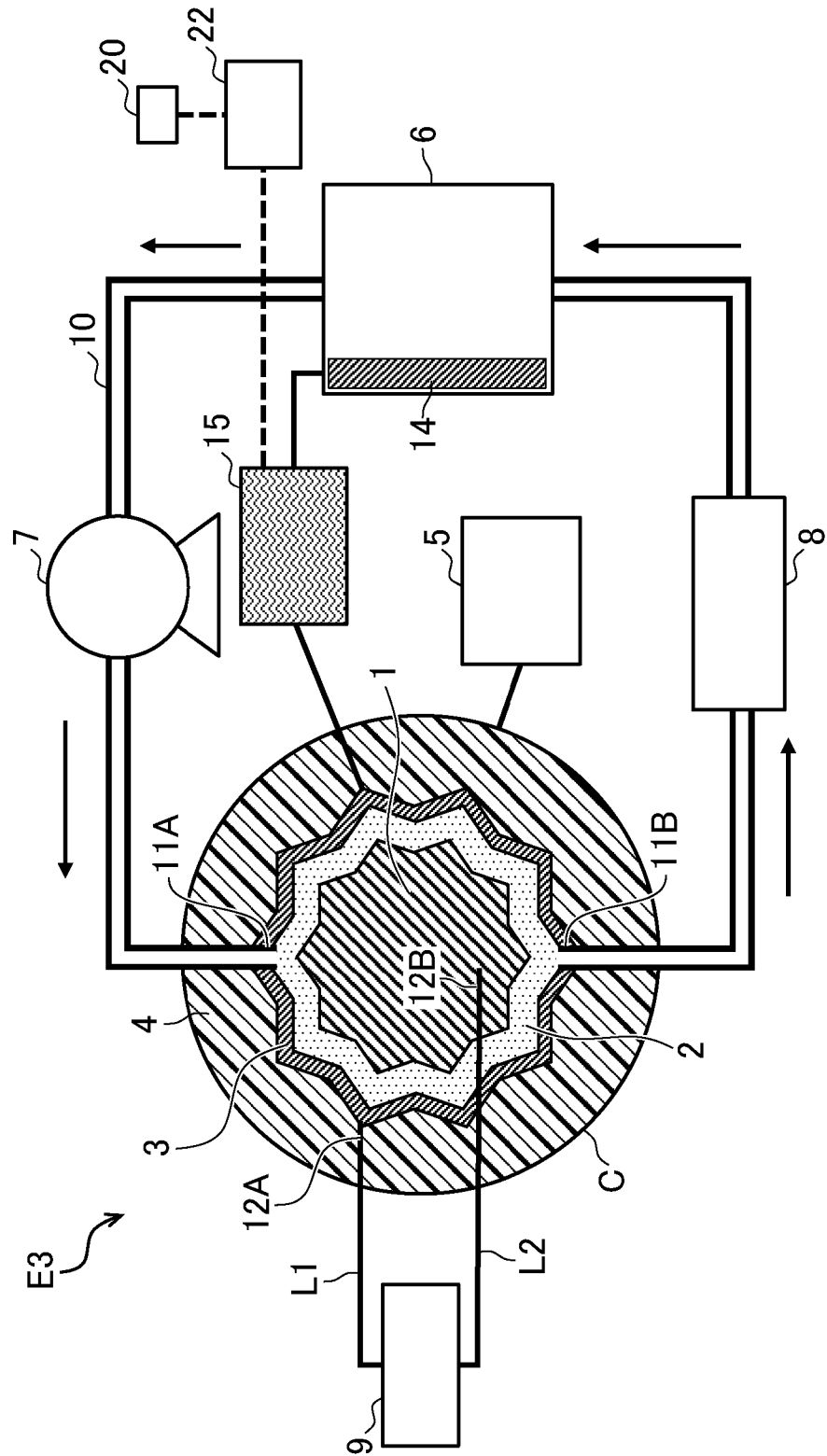


FIG. 6A

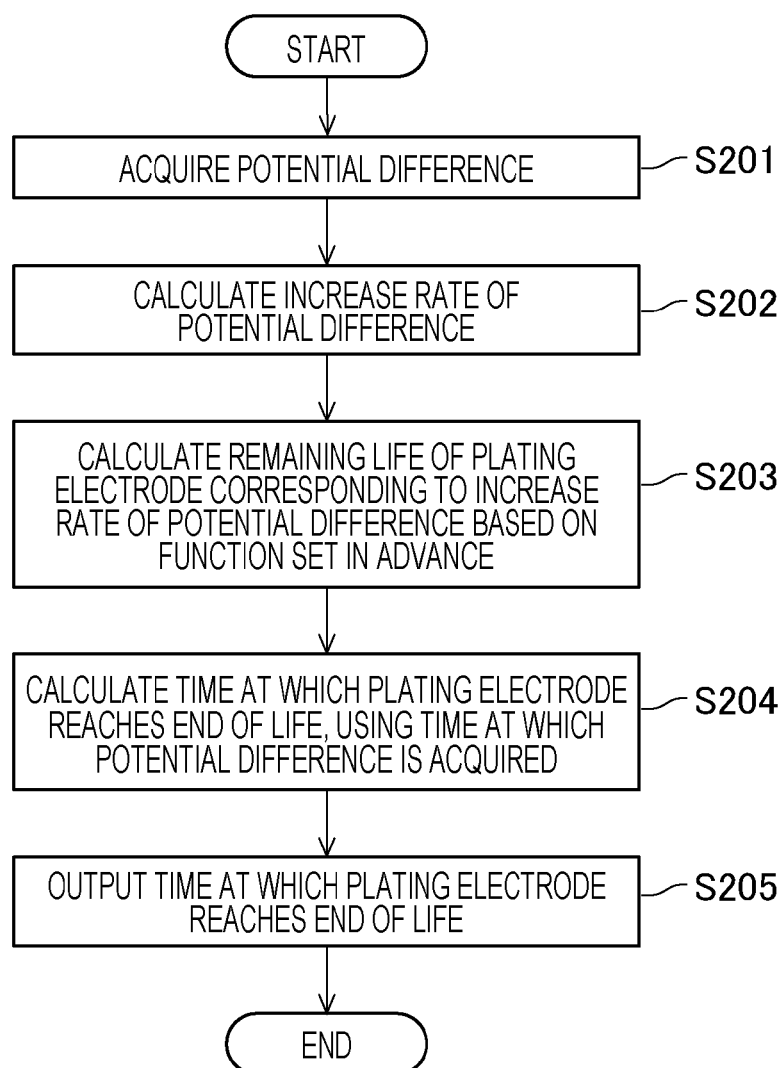
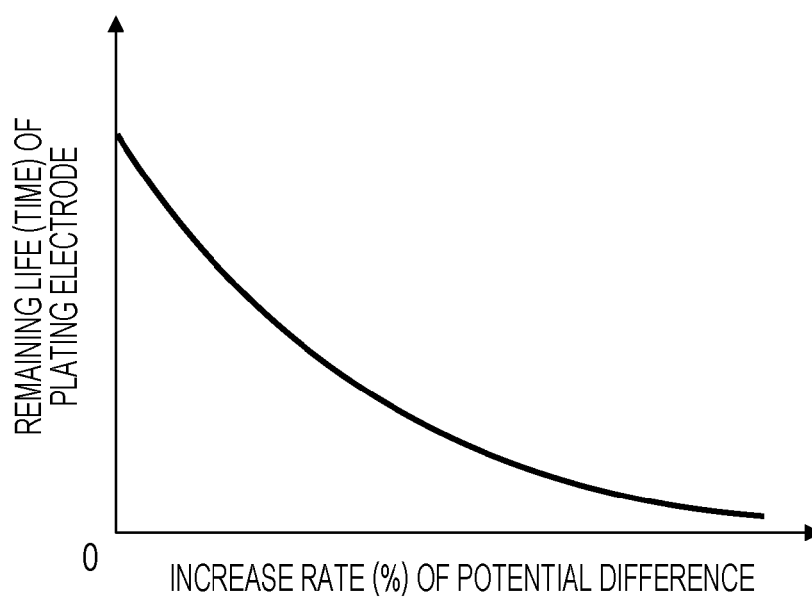


FIG. 6B



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005213596 A [0004] [0005] [0006]
- JP 2016169399 A [0005] [0006]