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(54) **ELECTRODE FOR USE IN CATIONIC ELECTRODEPOSITION COATING AND COATING METHOD USING THE SAME.**

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Description

This invention relates to an electrode assembly for cationic electrodeposition and to a method for electrodeposition coating by use of such electrode assembly.

In recent years, increasing importance has come to be attached to the improvement in anti-corrosion protection in the field of coating automobile bodies. The methods used for anti-corrosion protection have been studied in terms of base materials, chemical treatments, types of paints, processes of painting, automobile body designs, etc. from various angles. The technique of electrodeposition coating constitutes one of the most effective and economic methods for corrosion-proofing the inner surfaces of complicated and hollow structures such as automobile bodies, for example, and even those portions thereof which do not readily permit spray coating. Thus, the electrodeposition coating method is extensively used today.

The conventional method of coating by electrodeposition has mainly used anionic electrodepositing paints in consideration of the low cost of such paints, the relatively low temperature for baking the paints, and the relatively low cost of the equipment involved. In accordance with the method for anionic electrodeposition coating, however, the article subjected to coating which is used as an anode is dissolved during the electrodeposition process, whereas the cathode, made e.g. of iron, which is immersed in the paint of the electrodepositing cell is not dissolved. Consequently, the coating process is chemically altered and the thickness of the coat formed on the surface of the related article is small. Accordingly, with the increasing aggravation of the environmental corrosion conditions, it has been proved that the conventional anionic electrodeposition coating is not always satisfactory. For this reason, the technique of cationic electrodeposition coating is now being increasingly used.

To effect cationic electrodeposition, a water-insoluble polyamine resin, R—NH_2 is obtained by adding a primary amine or secondary amine to the glycidyl group of a water-insoluble resin such as, for example, a bisphenol type epoxy resin, thereby effecting ring cleavage thereof, and then an organic acid such as acetic acid or lactic acid is caused to react, as a neutralizing agent (water-solubilizing agent) AH, with the aforementioned water-insoluble polyamine resin to produce an aqueous resin, R—NH_3^+, as shown by the following reaction formula (I)

$$R—NH_2+AH\rightarrow R—NH_3^++A^- \quad (I)$$

In a cationic electrodepositing paint solution including the aforementioned water-soluble resin, and possibly a cross-linking agent and a pigment, an article to be coated is immersed as a negatively charged electrode (hereinafter referred to as "cathode"). Furthermore a positively charged electrode (hereinafter referred to as "anode") such as stainless steel or carbon electrode is immersed in the same solution. Electric current is passed between the cathode (the article under treatment) and the anode.

By the passage of the electric current, the positively charged paint components electrophoretically migrate in the solution and, on arrival at the article (the cathode) coagulate and deposit while emitting the electric charges as shown by the following formula (II), thus giving rise to the formation of a water-insoluble coat on the article.

$$2H_2O+2e^-\rightarrow H_2+2OH^- \quad (II)$$

$$OH^-+R—NH_3^+\rightarrow R—NH_2+H_2O$$

On the anode which is made of a metal such as, for example, stainless steel as indicated in formula (III), dissolution of metal ions and simultaneous generation of oxygen shown by formula (IV) are observed:

$$M\rightarrow M^{n+}+ne^- \quad (III)$$

$$4OH^-\rightarrow O_{2-}+2H_2O+4e^- \quad (IV)$$

In case the anode is made of carbon, since this is not a metal, the dissolution indicated by formula (III) does not occur, but the generation of oxygen through the reaction of formula (IV) does occur. Consequently, the carbon of the anode itself is oxidized. Therefore the anode progressively loses its weight and flaws may develop. Particularly in the case of an anode made of metal, the metal ions dissolved from the anode mix with the solution. When the paint component is coagulated and precipitated or deposited, these metal ions are simultaneously coagulated and precipitated onto the article. The resulting coat consequently has poor anti-corrosion properties or a coarse surface. In the case of an anode made of carbon, the oxidation causes the anode to shed fine carbon particles into the solution. If the electrodeposition process is continued with carbon particles contained in the solution, gritty protrusions extend from the surface of the coated article, with the result that the produced coat suffers from poor appearance and deficient anti-corrosion properties.

As materials for the anode which avoid release of metal ions, the use of high-grade stainless steel of SUS-316 or the like, or a noble metal such as platinum may be considered. Stainless steel, in addition to being expensive, will inevitably release metal ions, if only to a slight extent. The noble metal is too expensive to be feasible for the use contemplated. Carbon and graphite raise a problem in that they have poor processibility.

Electrocoating electrodes have already been described in related prior publications as indicated briefly hereinafter.

Publication US—A—4 231 854 discloses an electrode for cathodic electrocoating which com-

prises a mixture of magnetite (or magnetite/graphite combination) and plastic material. The plastic material acts as a thermoplastic binder for the magnetite which is used in a powderous form. This electrode is produced by compression-moulding such mixture. No particular shape of the electrode is specified in this prior publication.

Publication DE—A—2 320 883 discloses an electrocoating electrode comprising a body made of sintered metal oxides.

The present invention is aimed at providing an electrode or electrode assembly of the above described type which overcomes the aforementioned drawbacks of the known electrodes, while preserving the advantages thereof.

More particularly, the invention is aimed at providing such an electrode assembly, which can be entirely immersed in an electrolytic bath in any desired position.

Furthermore, the invention is aimed at providing an electrode assembly of the above-defined type, which can be manufactured in any desired large size, so as to allow particular electrocoating problems to be solved easily, as opposed to electrodes having a comparatively small size.

With these and other aims in view, the invention provides an electrode assembly for cationic electrodeposition entirely immersible in the electrolytic bath, comprising an electrode including at least one tube which is made of a sintered mass of an electroconductive metal oxide, such as magnetite or ferrite and which is closed at an outermost end of said electrode; a metallic core placed within said tube and bonded thereto by a tubular layer of an electroconductive material interposed between the inner wall of the tube and the outer wall of said core; a rigid resin tubular bridging member concentrically surrounding the other end of said tube; and a mass of cured resin interposed between the inner surface of said bridging member and said tube.

According to a first embodiment of the invention, the said assembly comprises at least two coaxial tubes of sintered mass, one of said tubes being closed at said outermost end, a rigid resin tubular bridging member, concentrically surrounding the adjacent end portions of said tubes and a mass of cured resin, interposed between the inner surface of said bridging member and said tubes.

According to another embodiment of the invention, the said assembly comprises an electrode including at least one tube of sintered mass being closed at on outermost end; and a sheathed lead wire including an insulating sheath; and a conductor electrically connected to said electrode; a rigid resin tubular bridging member concentrically surrounding the other end of said tube and an adjacent end portion of said sheathed lead wire; and a mass of cured resin interposed between the inner surface of said bridging member and those respective outer surface portions of said sheathed lead wire and said tube.

The sintered mass of metal oxide which is used for the associated or "paired" electrode, i.e. the anode, in the present invention is highly electroconductive. Typical examples of the sintered mass are a magnetic iron oxide represented by $FeO—Fe_2O_3$ which is generally called magnetite and a magnetic metal oxide such as $MO \cdot nFe_2O_3$ which is called ferrite. In the formula, M denotes a divalent metal ion such as of Mn, Ni, Cu, Mg, Co, or Zn.

Because of the intended purpose, the sintered metal mass to be used in this invention is required to possess electric conductivity.

In the case of the aforementioned magnetite, since the specific resistance is sufficiently low, the electric conductivity does not raise any serious problem. In the case of the ferrite, the specific resistance is fairly variable with the composition. Generally, ferrites possess ferromagnetic properties.

The ferrites of the type which are now used in the electronic industry as various transformers, permanent magnets, memory elements, and magnetic elements in television receivers, radio sets, audio devices, and telecommunication devices possess varying specific resistance within a wide range of 100 Ωcm to 100 MΩcm. Among ferrites, some of those having a high specific resistance may suffer from decline of current and generation of heat and, consequently, prove to be unfit for use as anodes. The ferrite to be used as the material for the anode in the present invention is required to possess a low degree of specific resistance. In the ferrite, the electric conduction is preponderantly caused by the hopping of electrons between Fe^{2+} and Fe^{3+}. For making the ferrite possess a low degree of specific resistance, therefore, the composition of the ferrite must be excessively rich in Fe_2O_3.

For the purpose of giving a large surface area to the anode and avoiding the non-uniform current distribution originating in the electrode based on the volume specific resistance of the sintered mass of metal oxide itself possibly induced when a large amount of electric current flows and further for the purpose of avoiding possible breakage of the anode such as due to mechanical impacts, the anode of the present invention is constituted such that the sintered mass of metal oxide is molded into a cylindrical tube with one end thereof closed and the cavity is filled by a metal member such as an aluminum core, iron core, stainless steel core, copper core, or twisted strands of copper, particularly stainless steel material inserted into the cylindrical body and connected thereto through an electroconductive material such as lead, solder, or conductive resin (e.g., an epoxy resin containing silver or graphite, commercially available under the trademark designation of "Dotite").

When stainless steel is employed as a core material in the above-mentioned construction, it is possible to preclude rise of temperature or non-uniformity of current distribution when a large amount of electric current is passed. Owing to the characteristic properties of stainless steel, the metal ions will dissolve only to a slight extent even when the sintered mass is broken.

When the article to be coated by electrodeposition by a known process has a large, complicated structure, and even the inner surface of a box-like structure is required to be thoroughly and uniformly coated as in the case of an automobile body, the electrodepositing tank itself becomes bulky and the anode to be used therein also becomes large. In case the installation of the anode only in a lateral portion of the electrodepositing cell or tank fails to yield high throwing power and to produce sufficient coating thickness, it is thus necessary to have another anode installed near the bottom surface of the electrodepositing cell.

As indicated hereinbefore, the present invention provides an electrode assembly which allows this problem to be solved.

Brief explanation of the drawing:

Figure 1 is a cross-sectional side view illustrating a system for carrying out the method for cationic electrodeposition coating;

Figure 2 is a cross-sectional side view illustrating another system for carrying out the method for cationic electrodeposition coating;

Figure 3 is a longitudinal cross-sectional view of yet another system for carrying out the method for cationic electrodeposition coating;

Figure 4 is a cross-sectional view illustrating an electrode of this invention, wherein sintered masses of metal oxide are joined to each other;

Figure 5 is a cross-sectional view of the essential part of the electrode of figure 4;

Figure 6 is a front view illustrating an electrode having a lead wire connected thereto;

Figure 7 is a cross-sectional view of the essential portion of the electrode of figure 6;

Figures 8 and 9 are cross-sectional views illustrating electrodes as the one shown in figure 6, as laid out for actual service.

There will be first explained Examples 1 and 2 which set forth commonly known electrodeposition coating aspects.

Example 1

(A) Preparation of anodes

Anodes were prepared through sintering magnetic iron oxide and ferrites having different values of volume specific resistance.

(B) Electrodeposition coating method

As illustrated in Figure 1, a container comprising a vinyl chloride resin lining 2 on a tank 1 of steel plate measuring 200 mm in length, 110 mm in width, and 150 mm in depth was filled with the paint solution 3. Then the sintered ferrite electrodes 4, were fixed in the bath while their portions 10 mm downward from the respective upper ends protruded from the surface of the bath, whereas an article 5 to be coated was immersed in the aforementioned bath. The two electrodes 4, 4 where disposed symmetrically with respect to the article 5 under treatment so that a coat would be uniformly formed on the article 5. These electrodes 4, 4 were interconnected by a lead wire 6. Further, the article 5 was electrically connected via a contact or switch 8 to a power supply 7 which in turn was connected to the aforementioned lead wire 6. With the bath kept in the state described above, electric current was passed under the following conditions. The electrodes 4, 4 were positively charged and used as anodes, the article 5 being used as a cathode, with the result that the cationic paint was deposited on the surface of the article 5.

Example 2

In a field electrodeposition coating process, as illustrated in Figure 2, a container in which a lining 2 such as of vinyl chloride is provided on the inner surface of a tank 1 of steel plate was filled with a paint solution 3. In the paint solution 3, the anodes 4, 4' and an article 5 to be coated were immersed, with the anodes 4, 4' connected to the anode of a DC power supply 7 by means of a lead wire 6, the article 5 being connected to the cathode of the power supply via a contact or switch 8. In the present example, the anodes were used as a bare electrode construction illustrated in Figure 1 and as a diaphragm electrode construction, respectively. Specifically, the latter construction was obtained by setting up a diaphragm box 9 round the anode 4', disposing an ion-exchange resin membrane 10 in the plane of the diaphragm box 9 interposed between the anode 4' and the article 5 under treatment, and pouring diaphragm water 12 into the box 9. If the anode is formed in such a diaphragm-electrode construction as described above, the coat or electrodeposit produced has improved quality because even if the material of the anode dissolves slightly, the dissolved material is prevented from mixing with the paint solution.

Figure 3 illustrates the location of anodes in the longitudinal direction of an electrodepositing cell. In the figure, 4 denotes an anode in a bare construction and 4' an anode in a diaphragm-electrode construction.

Electrodeposition coating was carried out by following the procedure described in Example 1(B).

Typical constructions of the anode according to this invention will now be described.

Figure 4 represents the electrode formed by joining end to end tubes or tube sections made of sintered mass of metal oxide in its entirety. Figure 5 represents the essential portion of this electrode.

A bar-shaped metal member 11 is made of copper, iron, or stainless steel. The outer periphery of one end of this metal member 11 is covered by an electroconductive member 13 made e.g. of lead, solder, or electroconductive adhesive, surrounded by a sintered mass of metal oxide 4a, one end of which is closed and has a U-shaped cross section, another tube of sintered mass of metal oxide 4b being provided and spaced from tube 4a. Surrounding the mutually facing portions of the upper and lower sintered masses 4a, 4b, there is provided a connecting member 16 made of resin, which forms a sheath.

This connecting member 16 comprises a tubular member 17 made of rigid resin such as fluorine resin (such as a resin marketed under trademark "Teflon"), polyvinyl chloride or nylon® covering the outer peripheries of the facing or opposed portions of the sintered masses 4a, 4b, while O-rings 18 of Teflon, leather or rubber, placed on stepped portions 17a, 17a are provided at opposite locations on the inner wall of the tubular member 17 and interposed between said member 17 and the sintered mass of metal oxide and ring member 19, 19a of rigid resin, such as Teflon or polyvinyl chloride, having outer peripheral male threads 19a, 19a to be screwed into female threads 17b, 17b formed at the inside of the mutually facing end portions of the rigid resin tubular member 17. Because of the screw attachment of the rigid resin members 19, 19a, the O-rings 18 have their leading end pressed down to establish tight contact between the rigid resin member 17 and the sintered masses 4a, 4b. After the connecting member has been positioned in the construction described above, liquid hardenable resin 20 such as, for example, two-pack hardenable type epoxy resin, polyester resin, or hardenable polyvinyl chloride sol is inserted into the void space formed between the sintered masses of metal oxide 4a, 4b and the rigid resin members 19, 19a and is caused to harden at room temperature or at elevated temperature. The liquid resin 20 is inserted into the empty space defined by the opposed edge surfaces of the sintered masses 4a, 4b, the outer periphery of the metal member 11, and the rigid resin member 17 prior to screwing-on the rigid resin members 19, 19a. This resin 20 may be of any nature, provided it does not dissolve in the paint.

Owing to such a covering structure comprising the resin, all the voids within the connecting member 16 are filled, so that no paint solution is allowed to enter the inner space of the connecting member. The resin itself is not dissolved in the paint solution. The connecting member 16 has a high bending strength etc. because the adhesive strength of the hardenable resin 20 and the mechanical strength of the rigid resin members 17, 19, 19a are added.

Figure 6 represents a side view of the electrode with a lead wire formed by joining an electrode and Figure 7 shows a cross section of the essential part thereof.

Reference numeral 4 designates an electrode in which the outer circumference of a bar-shaped metal member 11 of copper, iron, stainless steel or the like, forming a core, is covered with an electroconductive material 13 such as lead, solder, or electroconductive adhesive, and a sintered mass 4a of metal oxide. To the upper end of the electrode, a sheathed lead wire 22 such as, for example, a 600-V cable having a vinyl sheath insulated by crosslinked polyethylene or a vinyl sheath insulated by vinyl is connected through a connecting part 21.

The aforementioned connecting member 21 will be described more specifically. The metal member 11 is provided at the upper end thereof with a male thread 11a, to which a pressure connector 24 for connecting the lead wire is fastened by nuts 23, 23. To the pressing portion 24a of the pressure connector 24, a conductor 26 such as, for example, stranded copper wire of lead wire 22 exposed by the removal of a portion of sheath 25 is attached under pressure such as by caulking. Thus, the electrode 4 and the sheathed lead wire 22 are connected to each other.

A rigid resin tubular bridging member 27 made of Teflon, polyvinyl chloride or the like is mounted round the outer peripheries of the electrode 4 and the sheathed lead wire 22 so as to bridge them. On that side of the tubular rigid resin member 27 which faces electrode 4, an O-ring 28 such as of Teflon, leather, rubber or the like is inserted round a stepped portion 27 formed on the inside of the member 27, and is held in contact with the outer periphery of the sintered mass 4a of metal oxide. Furthermore, a rigid resin member 29 formed of Teflon or polyvinyl chloride in the shape of a hollow cap and provided on its outer periphery with a male thread 29a is screwed into a female thread 27b formed at the end of the inside of member 27. When screwing-on this rigid resin member 29, the O-rings 28 are pressed by its tip to establish tight contact between the outer rigid resin member 27 and the sintered mass 4a of metal oxide. Facing the sheathed lead wire 22, a rigid resin member 30 formed of Teflon or polyvinyl chloride in the shape of a hollow cap is provided, and the outer periphery of member 30 has a male thread 30a that is screwed into the female thread 27b formed similarly at the inside end of member 27.

After the connecting member has been mounted in the construction described above, liquid hardenable resin 31 such as, for example, two-pack hardenable type epoxy resin, polyester resin, or hardenable polyvinyl chloride sol is filled into the empty space between the sintered mass 4a of metal oxid and the rigid resin members 29, 27 and into the empty space formed by the sheath 25 and the conductor 26 of the sheathed lead wire 22, the pressure connector 24, the nuts 23, the male thread 11a of the metal member 11, and the rigid resin members 30, 27 and is then caused to harden at room temperature or at an elevated temperature. This resin 31 may be of any nature, provided that it is in liquid or sol form and that it will not dissolve in the paint solution after hardening.

All the voids around the connecting member 21 are filled up due to using resin as mentioned above. Thus, there is absolutely no possibility of internal parts being exposed directly to the solution used. Efficient electrical insulating and reliable liquid-tightness can be ensured. When the connecting member 21 is immersed into the paint solution from the sheathed lead wire 22, it is only through the intered mass 4a of metal oxide that electrical current is passed to the paint solution.

For using electrodes constructed as described above in the electrocoating by cationic electrodeposition, they are immersed in an electrodepositing cell as illustrated in Figure 8 or Figure 9.

When the article 5 subjected to coating was an automobile body, throwing power was satisfactory even on the inner surface of a box-shaped body such as floor member. Comparing the case where one electrode of the same construction as described above was additionally used at the bottom of the cell as illustrated in Figure 8 to the case where such an additional electrode was omitted, the coat obtained on the inner surface such as of the floor member under the same conditions had a greater thickness and better quality in the former case.

Although the working examples and the construction assembling given above are explained with reference to electrodes for cationic electrodeposition coating, the electrodes according to the present invention are not limited thereto, but may be used for power electrodeposition coating or other forms of coating.

Claims

1. An electrode assembly for cationic electrodeposition entirely immersible in the electrolytic bath, comprising an electrode (4) including at least one tube (4a) which is made of a sintered mass of an electroconductive metal oxide, such as magnetite or ferrite and which is closed at an outermost end of said electrode; a metallic core (11) placed within said tube (4a) and bonded thereto by a tubular layer of an electroconductive material (13) interposed between the inner wall of the tube (4a) and the outer wall of said core (11); a rigid resin tubular bridging member (17, 27) concentrically surrounding the other end of said tube (4a); and a mass of cured resin (20, 31) interposed between the inner surface of said bridging member (17, 27) and said tube (4a).

2. An electrode assembly according to claim 1, characterized in that it comprises at least two coaxial tubes (4a, 4b) of sintered mass, one of said tubes (4a) being closed at said outermost end, and a rigid resin tubular bridging member (17) concentrically surrounding the adjacent end portions of said tubes (4a, 4b) and a mass of cured resin (20) interposed between the inner surface of said bridging member (17) and said tubes (4a, 4b).

3. An electrode assembly according to claim 1, characterized in that it comprises an electrode (4) including at least one tube (4a) of sintered mass being closed at an outermost end; and a sheathed lead wire (22) including an insulating sheath (25); and a conductor (26) electrically connected to said electrode (4); a rigid resin tubular bridging member (27) concentrically surrounding the other end of said tube (4a); and an adjacent end portion of said sheathed lead wire (22); and a mass of cured resin (31) interposed between the inner surface of said bridging member (27) and those respective outer surface portions of said sheathed lead wire (22) and said tube (4a).

4. An electrode assembly according to any of claim 1 to 3, characterized in that said metallic core is a bar (11) of stainless steel.

5. An electrode assembly according to any of claims 1 to 4, characterized in that the ends of said tubular bridging member (17, 27) are provided with screwed-on insulating caps (19, 29, 30).

6. A method of coating by cationic electrodeposition, which comprises using anodes constituted each by an electrode assembly as claimed in any of claims 1 to 5.

Patentansprüche

1. Gänzlich in ein Elektrolysebad eintauchbare Elektrodeneinheit zum kationischen Galvanisieren, mit einer Elektrode (4), die wenigstens ein aus elektrisch lietendet Metalloxydsintermasse, wie Magnetit bzw. Ferrit bestehendes, an einem äusseren Ende der Elektrode geschlossenes Rohr (4a) umfasst, sowie einen metallischen Kern (11), der im Rohr (4a) angeordnet und mit demselben durch eine zwischen der Innenwandung des Rohrs (4a) und der Aussenwandung des Kerns (11) angeordnete rohrförmige Schicht aus elektrisch leitendem Material (13) verbunden ist, ferner umfassend ein steifes rohrförmiges Zwischenglied (17, 27) aus Harz, das das andere Ende des Rohrs (4a) konzentrisch umgibt, und eine erhärtete Harzmasse (20, 31), die zwischen der Innenfläche des Zwischenglieds (17, 27) und dem Rohr (4a) angeordnet ist.

2. Elektrodeneinheit nach Anspruch 1, dadurch gekennzeichnet, dass sie wenigstens zwei koaxiale Rohre (4a, 4b) aus Sintermasse aufweist, wobei eines der Rohre (4a) an seinem äusseren Ende geschlossen ist, und wobei die benachbarten Endabschnitte der Rohre (4a, 4b) von einem steifen rohrförmigen Harz-Zwischenglied (17) konzentrisch umgeben sind, während eine erhärtete Harzmasse (20) zwischen der Innenfläche des Zwischenglieds (17) und den Rohren (4a, 4b) angeordnet ist.

3. Elektrodeneinheit nach Anspruch 1, dadurch gekennzeichnet, dass sie eine wenigstens ein aus Sintermasse gefertigtes, an seinem äusseren Ende geschlossenes Rohr (4a) umfassende Elektrode aufweist, sowie einen von einer isolierenden Hülle umhüllten Stromleiter (22), einen mit der Elektrode (4) leitend verbundenen Leiter (26), ein rohrförmiges, steifes Harz-Zwischenglied (27), das das andere Ende des Rohrs (4a), sowie einen benachbarten Endabschnitt des umhüllten Stromleiters (22) konzentrisch umgibt, und eine erhärtete Harzmasse (31), die zwischen den Innenfläche des Zwischenglieds (27) und den entsprechenden Aussenflächenteilen des umhüllten Stromleiters (22) und des Rohrs (4a) angeordnet ist.

4. Elektrodeneinheit nach einem der Ansprü-

che 1 bis 3, dadurch gekennzeichnet, dass der metallische Kern durch eine Stange (11) aus nichtrostendem Stahl gebildet ist.

5. Elektrodeneinheit nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die Enden des rohrförmigen Zwischenglieds (17, 27) mit aufgeschraubten Isolierkappen (19, 29, 30) versehen sind.

6. Verfahren zum kationischen Galvanisieren, unter Verwendung von Anoden, deren jede durch eine Elektrodeneinheit nach einem der Ansprüche 1 bis 5 gebildet ist.

Revendications

1. Un ensemble d'électrode pour électrodéposition cationique, susceptible d'être entièrement immergée dans un bain électrolytique, comportant une électrode (4) qui comprend au moins un tube (4a) formé d'une masse frittée d'un oxyde métallique électriquement conducteur, tel que magnétite ou ferrite, ledit tube étant fermé à une extrémité extérieure de ladite électrode; un noyau métallique (11) placé à l'intérieur dudit tube (4a) et lié à celui-ci par une couche tubulaire d'un matériau électro conducteur (13) interposée entre la paroi intérieure du tube (4a) et la paroi extérieure dudit noyau (11); un élément intercalaire (17, 27) rigide entourant concentriquement l'autre extrémité dudit tube (4a); et une masse de résine durcie (20) interposée entre la surface intérieure dudit élément intercalaire (17, 27) et ledit tube (4a).

2. Un ensemble d'électrode selon la revendication 1, caractérisé en ce qu'il comporte au moins deux tubes coaxiaux (4a, 4b) formés d'une masse frittée, l'un desdits tubes (4a) étant fermé à ladite extrémité extérieure, cet ensemble comportant en outre un élément intercalaire rigide tubulaire (17) entourant concentriquement les parties terminales adjacentes desdits tubes (4a, 4b), ainsi qu'une masse de résine durcie (20) interposée entre la surface intérieure dudit élément intercalaire (17) et lesdits tubes (4a, 4b).

3. Un ensemble d'électrode selon la revendication 1, caractérisé en ce qu'il comporte une électrode (4) comprenant au moins un tube (4a) formé d'une masse frittée et fermé à une extrémité extérieure; et un fil conducteur (22) gaîné d'une gaîne isolante (25); et un conducteur (26) relié électriquement à ladite électrode (4); un élément intercalaire tubulaire (27) rigide en résine qui entoure concentriquement l'autre extrémité dudit tube (4a) et une partie terminale adjacente dudit fil conducteur gaîne (22); et une masse de résine durcie (31) interposée entre la surface intérieure dudit élément intercalaire (27) et les parties respectives de la surface extérieure dudit conducteur gaîné (22) et dudit tube (4a).

4. Un ensemble d'électrode selon l'une quelconque des revendications 1 à 3, caractérisé en ce que ledit noyau métallique est constitué par une barre (11) d'acier inoxydable.

5. Un ensemble d'électrode selon l'une quelconque des revendications 1 à 4, caractérisé en ce que les extrémités dudit élément intercalaire tubulaire (17, 27) sont pourvues de capuchons isolants (19, 29, 30) mis en place par vissage.

6. Un procédé pour fabriquer un revêtement par électro-déposition cationique, dans lequel on utilise des anodes constituées chacune par un ensemble d'électrode tel que défini dans une quelconque des revendications 1 à 5.

Fig. 1

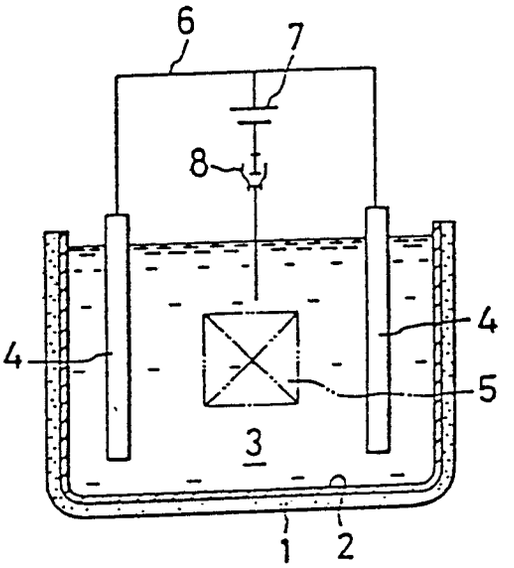


Fig. 2

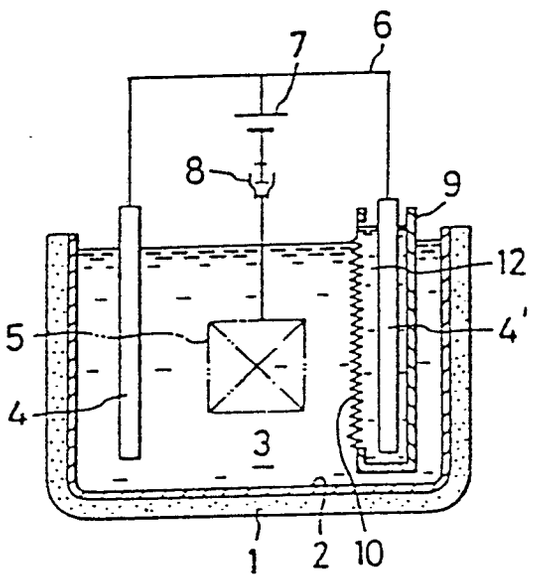


Fig. 3

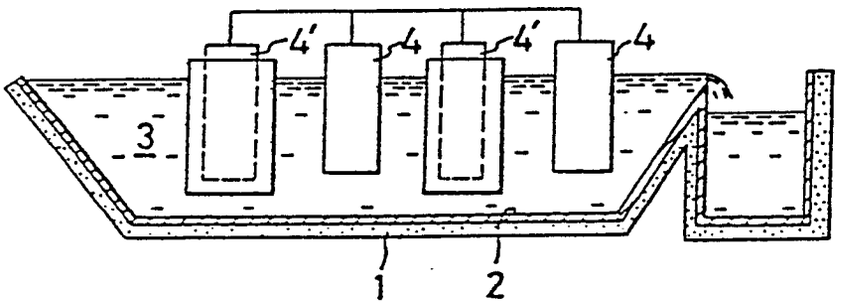


Fig. 4

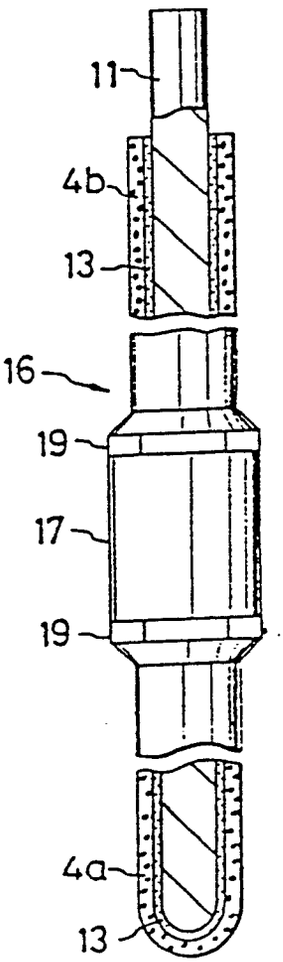

11
4b
13
16
19
17
19
4a
13

Fig. 5

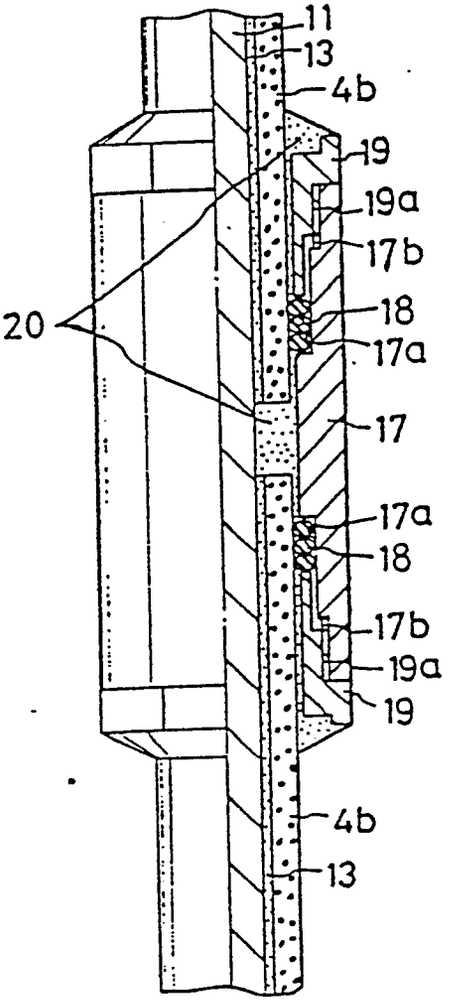

11
13
4b
19
19a
17b
18
17a
20
17
17a
18
17b
19a
19
4b
13

Fig. 6

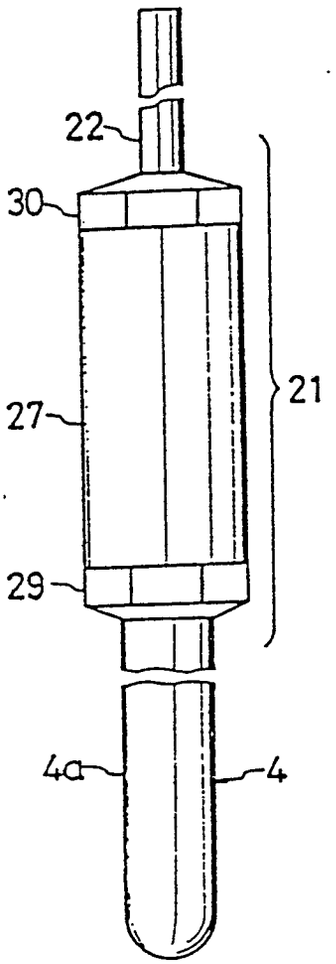


Fig. 7

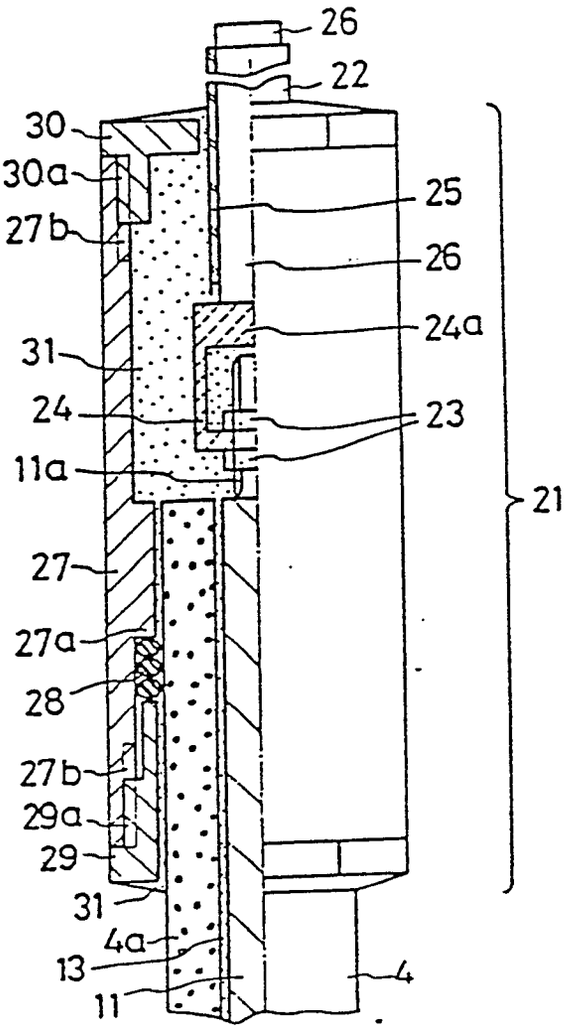

26
22
30
30a
27b
25
26
24a
31
24
23
11a
21
27
27a
28
27b
29a
29
31
4a
13
4
11

Fig. 8

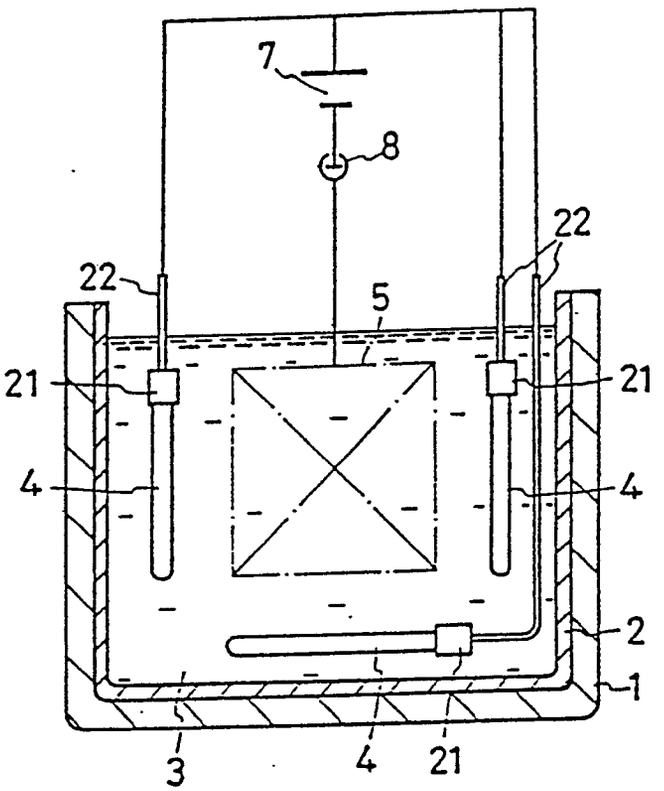


Fig. 9

