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(54) BIPOLAR ELECTRODE AND METHOD FOR THE PRODUCTION THEREOF

(71) We, CHLORINE ENGINEERS CORP., LTD., of Kasumigaseki Bldg., No. 2-5 Kasumigaseki, 3-chome, Chiyoda-ku, Tokyo, Japan, a Japanese Corporation, do hereby declare the invention, for which we pray that a Patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a bipolar electrode which comprises an anode plate and a cathode plate separated from each other by a partition wall and electrically and structurally connected to each other, and which is suitable for electrolyzing aqueous solutions of, inter-alia, alkali metal chlorides, for the production of alkali metal chlorates or alkali metal hydroxides and chlorine, and to a method for the production of such a bipolar electrode.

A conventional bipolar electrode is disclosed in U.S. Patent 3,859,197 and has the structure shown in Figure 1. In Figure 1, reference numeral 1 represents a composite member obtained by explosion welding of a titanium plate 4 and a mild steel plate 5. The composite member 1 is received in an opening in a partition wall 12 composed of a titanium sheet 2 and a mild steel sheet 3 so that it forms a part of the partition wall 12. The outer edge of the titanium plate 4 of the composite member 1 is welded to the wall of the opening in the titanium sheet 2, and the outer edge portion of the mild steel plate 5 is welded to the wall of the opening in the mild steel sheet 3.

The titanium plate 4 of the composite member 1 is welded to a titanium spacer 6 which in turn is welded to the titanium substrate of an anode plate 7, while the mild steel plate 5 of the composite member 1 is welded to a mild steel spacer 8 which in turn is welded to a cathode plate 9. Further spacers are welded to the partition wall 12 and the plates 7, 9 and hence the anode plate 7 and the cathode plate 9 are connected electrically and structurally to form a bipolar electrode having an anode compartment 10 and a cathode compartment 11.

In conventional bipolar electrodes of this kind, since the spacers are first welded to both surfaces of the partition wall or the composite member and then the anode plate and the cathode plate are welded to the fixed spacers, it is difficult to maintain the anode plate and

the cathode plate in parallel uniform planes. In particular, since the distances from the partition wall to the electrode plates differ between that portion of the partition wall at which the composite member is present and the remaining portion of the partition wall, a difference tends to occur in the interelectrode space between the sites of the spacers on the composite member and the sites of the spacers on the partition wall.

In this way, the anode plate and the cathode plate in conventional bipolar electrodes form non-uniform planes, and the distance between the opposing anode and cathode cannot be maintained constant. Consequently, this causes the defect of a non-uniform distribution of electric current. Another defect is that since the planes of the anode plate and of the cathode plate are non-uniform, the anode and the cathode cannot be brought sufficiently close to each other, and a large loss of voltage occurs in the electrolytic cell. Furthermore, since the distribution of electric current is non-uniform, a uniform reaction does not take place at the anode or cathode, but the reaction occurs vigorously at particular localities to cause localised heating effects. This leads to a shortening of the life of the electrodes.

An object of this invention is to provide a bipolar electrode in which the defects described above are minimised or alleviated.

Accordingly, the invention resides in one aspect in a bipolar electrode comprising:

- a. an electrode frame;
- b. a partition wall welded to the electrode frame and comprising a composite structure of an anode-side sheet and a cathode-side sheet;
- c. an anode plate disposed on the anode-side of the partition wall;
- d. a cathode plate disposed on the cathode-side of the partition wall; and
- d. an electrically conductive spacer welded at its ends respectively to the anode plate and the anode-side sheet of the partition wall, and a further electrically conductive spacer welded at its ends respectively to the cathode plate and the cathode-side sheet of the partition wall, wherein each of the electrically conductive spacers comprises two elements

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which are superimposed between the anode plate or the cathode plate and the partition wall and welded at the superimposed surface so as to support the anode plate and the cathode plate in parallel uniform planes.

5 In a further aspect the invention resides in a method for producing the bipolar electrode described in the preceding paragraph, comprising:

10 (i) welding one element of each of the two electrically conductive spacers to respective predetermined parts of the cathode-side sheet and the anode-side sheet of the partition wall;

(ii) welding the peripheral part of the cathode-side sheet to an intermediate part of the electrode frame;

15 (iii) locating the anode-side sheet on the cathode-side sheet and fixing the peripheral part of the anode-side sheet to the periphery of the electrode frame;

20 (iv) superimposing the other element of each electrically conductive spacer with said one element of the respective spacer and adjusting said other element so that the free end surfaces of the elements are parallel, and welding the superimposed surface; and

25 (v) welding the anode plate and the cathode plate to the free end surfaces of the other elements respectively.

In the accompanying drawings:

30 Figure 1 is a cross-sectional view of a bipolar electrode of the prior art;

Figure 2 is a partial cross-sectional view showing a bipolar electrode according to one example of the invention;

35 Figure 3 shows one example of a method for producing the bipolar electrode in accordance with this invention.

Referring to Figure 2, reference numeral 17 is a picture frame-like electrode frame which is made of, for example, mild steel. Titanium can also be used as the electrode frame. A partition wall 12 comprises a composite structure of an anode-side sheet 2 and a cathode-side sheet 3. The partition wall 12 is welded to the electrode frame 17 and at a portion 2', the anode-side sheet 2 is fixed to the electrode frame 17. The members 2 and 2' may be formed as a single continuous sheet.

40 Sandwiched between the sheets 2, 3 is a composite member 13 in the form of a triple layered material. Thus the member 13 is composed of a portion 14 made of the same type of metal or metal alloy used as the anode-side sheet, e.g., a metal such as titanium or a titanium alloy, a portion 15 is made of an electrically conductive material resistant to atomic hydrogen migration, such as copper, gold, tin, lead, nickel, cobalt, chromium, tungsten, molybdenum and alloys of these metals and a portion 16 made of the same type of metal or metal alloy used as the cathode-side sheet, e.g., mild steel.

60 In the bipolar electrode of this invention, the structure of the composite member or the method of forming the composite member is

not critical, and the invention can be applied also to the structure shown in Figure 1 in which the composite member is connected to the partition wall by insertion. Since, however, the difference in interelectrode distance is large between that portion of the partition wall where the composite member is present and the other portion of the partition wall in the structure shown in Figure 2, the structure in accordance with this example is especially effective.

70 An anode plate 7 and a cathode plate 9 are disposed with the partition wall 12 therebetween. The anode plate 7 and the anode-side sheet 2 of the partition wall are connected to each other through an electrically conductive spacer 18, which can be made of the same type of metal or metal alloy as used for the anode-side sheet or the anode plate substrate, and which is welded at its ends to the plate 7 and sheet 2 respectively. Similarly, the cathode plate 9 and the cathode-side sheet 3 of the partition wall 12 are connected to each other through an electrically conductive spacer 21, which can be made of the same type of metal or metal alloy as used for the cathode-side sheet or the cathode plate, and which at its ends is welded to the plate 9 and sheet 3 respectively. In order that the anode plate 7 and the cathode plate 9 may form horizontal uniform planes, the electrically conductive anode-side sheet 2 and an element 20 to be welded to the spacer 18 is divided into an element 19 to be welded to the anode plate 7, the elements 19, 20 being superimposed and welded at their superimposed surfaces. Likewise, the electrically conductive spacer 21 is divided into an element 22 to be welded to the cathode-side sheet 3 and an element 23 to be welded to the cathode plate 9, the elements 21, 22 being superimposed and welded at their superimposed surfaces. By dividing each spacer and welding the superimposed separate spacer elements while adjusting the position of the part to be welded of the divided spacers, the anode plate and the cathode plate can be formed as horizontal uniform planes.

105 The divided spacers may have various shapes. From the standpoint of mechanical strength, as shown in Figure 2, it is preferred that the spacer elements 19 and 22 to be welded to the anode-side sheet 2 and the cathode-side sheet 3 respectively be L-shaped, and that the other spacer elements 20 and 23 be plate-shaped.

120 The substrate of the anode plate 7, the anode-side sheets 2 and 2' and the electrically conductive spacer 18 on the anode side are made of a material which is corrosion resistant to the anolyte solution, such as titanium. Since a portion of the anode-side sheet 2' in contact with the electrode frame 17 tends to corrode if there are any small interstices in the sheet, it is desirable to make the anode-side sheet 2' from a palladium-containing titanium

alloy or titanium whose surface has been diffusion treated with palladium, for example. The cathode plate 9, the cathode-side sheet 3 and the electrically conductive spacer 21 on the cathode side are made of a material such as mild steel which is corrosion resistant to the catholyte solution.

The anode plate comprises a substrate made of an anti-corrosive metal or metal alloy and an electrically conductive coating formed on the surface thereof. As previously stated, a suitable substrate metal or metal alloy for the substrate of the plate 7, as well as the anode side sheets 2, 2' and the spacer 18, is titanium, but tantalum, niobium, hafnium, and zirconium and alloys where one or more of these metals predominate can also be used. Similarly, other materials than mild steel can be used for the cathode plate 9, the cathode side sheet 3 and the spacer 21, examples being iron, aluminium, nickel, lead, tin and zinc, alloys of these metals and alloys such as stainless steel, bronze, brass, monel and cast iron, with mild steel being preferred.

Referring to Figure 3, there is shown therein one example of a method for producing a bipolar electrode in accordance with this invention. In Figure 3, a partition wall 12 is composed of an anode-side sheet 2 and a cathode-side sheet 3 in a composite structure. Reference numeral 19 represents an L-shaped electrically conductive spacer element which is welded to a predetermined part of the anode-side sheet 2. Although not shown in Figure 3, an L-shaped electrically conductive spacer element is also welded to a predetermined part of the cathode-side sheet 3. Then, the peripheral part of an electrode frame 17, and the anode-side sheet 2 is lined on the cathode-side sheet 3 and the peripheral part of the anode-side sheet 2' is fixed to the peripheral part of the electrode frame 17.

Then, another plate-like electrically conductive spacer element 20 is held by a fixing jig 24 to keep the end surface thereof horizontal, and superimposed on the electrically conductive spacer element 19, after which the superimposed surface is welded. Although not shown in Figure 3, a plate-like electrically conductive spacer element for the cathode side is fixed in the same way.

Subsequently, the anode plate and the cathode plate are welded to one end surface of the respective plate-like electrically conductive spacer elements.

Since in the bipolar electrode produced in accordance with this invention, the anode plate and the cathode plate can be formed as horizontal uniform planes, the distance between the opposing anode and cathode can be maintained constant, and a uniform distribution of electric current can be obtained. Furthermore, since the opposing anode and cathode can be brought closer to each other, a sufficient decrease in voltage can be achieved.

Furthermore, since a uniform distribution of electric current can be obtained, a uniform electrode reaction takes place over the entire surface of the electrode, and no localized heating effect is produced, thus making it possible to prolong the life of the electrode.

WHAT WE CLAIM IS:-

1. A bipolar electrode comprising
 - a. an electrode frame;
 - b. a partition wall welded to the electrode frame and comprising a composite structure of an anode-side sheet and a cathode-side sheet;
 - c. an anode plate disposed on the anode-side of the partition wall;
 - d. a cathode plate disposed on the cathode-side of the partition wall; and
 - e. an electrically conductive spacer welded at its ends respectively to the anode plate and the anode-side sheet of the partition wall, and a further electrically conductive spacer welded at its ends respectively to the cathode plate and the cathode-side sheet of the partition wall, wherein each of the electrically conductive spacers comprises two elements which are superimposed between the anode plate or the cathode plate and the partition wall and welded at the superimposed surface so as to support the anode plate and the cathode plate in parallel uniform planes.
2. A bipolar electrode as claimed in Claim 1, wherein the electrically conductive spacer element welded to the anode-side sheet or the cathode-side sheet is generally L-shaped, and the other element of each electrically conductive spacer is generally plate-shaped.
3. A bipolar electrode as claimed in Claim 1, or Claim 2, wherein the substrate of the anode plate, the anode-side sheet, and the electrically conductive spacer on the anode side are each made of titanium, and the cathode plate, the cathode-side sheet and the electrically conductive spacer on the cathode side are each made of mild steel.
4. A bipolar electrode as claimed in any preceding Claim, wherein that portion of the anode-side sheet which contacts the electrode frame is made of a palladium-containing titanium alloy or titanium whose surface has been diffusion-treated with palladium.
5. A method for producing a bipolar electrode as claimed in Claim 1, which comprises:
 - (i) welding one element of each of the two electrically conductive spacers to respective predetermined parts of the cathode-side sheet and the anode-side sheet of the partition wall;
 - (ii) welding the peripheral part of the cathode-side sheet to an intermediate part of the electrode frame;
 - (iii) locating the anode-side sheet on the cathode-side sheet and fixing the peripheral part of the anode-side sheet to the periphery



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alloy or titanium whose surface has been diffusion treated with palladium, for example. The cathode plate 9, the cathode-side sheet 3 and the electrically conductive spacer 21 on the cathode side are made of a material such as mild steel which is corrosion resistant to the catholyte solution.

The anode plate comprises a substrate made of an anti-corrosive metal or metal alloy and an electrically conductive coating formed on the surface thereof. As previously stated, a suitable substrate metal or metal alloy for the substrate of the plate 7, as well as the anode side sheets 2, 2' and the spacer 18, is titanium, but tantalum, niobium, hafnium, and zirconium and alloys where one or more of these metals predominate can also be used. Similarly, other materials than mild steel can be used for the cathode plate 9, the cathode side sheet 3 and the spacer 21, examples being iron, aluminium, nickel, lead, tin and zinc, alloys of these metals and alloys such as stainless steel, bronze, brass, monel and cast iron, with mild steel being preferred.

Referring to Figure 3, there is shown therein one example of a method for producing a bipolar electrode in accordance with this invention. In Figure 3, a partition wall 12 is composed of an anode-side sheet 2 and a cathode-side sheet 3 in a composite structure. Reference numeral 19 represents an L-shaped electrically conductive spacer element which is welded to a predetermined part of the anode-side sheet 2. Although not shown in Figure 3, an L-shaped electrically conductive spacer element is also welded to a predetermined part of the cathode-side sheet 3. Then, the peripheral part of an electrode frame 17, and the anode-side sheet 2 is lined on the cathode-side sheet 3 and the peripheral part of the anode-side sheet 2' is fixed to the peripheral part of the electrode frame 17.

Then, another plate-like electrically conductive spacer element 20 is held by a fixing jig 24 to keep the end surface thereof horizontal, and superimposed on the electrically conductive spacer element 19, after which the superimposed surface is welded. Although not shown in Figure 3, a plate-like electrically conductive spacer element for the cathode side is fixed in the same way.

Subsequently, the anode plate and the cathode plate are welded to one end surface of the respective plate-like electrically conductive spacer elements.

Since in the bipolar electrode produced in accordance with this invention, the anode plate and the cathode plate can be formed as horizontal uniform planes, the distance between the opposing anode and cathode can be maintained constant, and a uniform distribution of electric current can be obtained. Furthermore, since the opposing anode and cathode can be brought closer to each other, a sufficient decrease in voltage can be achieved.

Furthermore, since a uniform distribution of electric current can be obtained, a uniform electrode reaction takes place over the entire surface of the electrode, and no localized heating effect is produced, thus making it possible to prolong the life of the electrode.

WHAT WE CLAIM IS:-

1. A bipolar electrode comprising
 - a. an electrode frame;
 - b. a partition wall welded to the electrode frame and comprising a composite structure of an anode-side sheet and a cathode-side sheet;
 - c. an anode plate disposed on the anode-side of the partition wall;
 - d. a cathode plate disposed on the cathode-side of the partition wall; and
 - e. an electrically conductive spacer welded at its ends respectively to the anode plate and the anode-side sheet of the partition wall, and a further electrically conductive spacer welded at its ends respectively to the cathode plate and the cathode-side sheet of the partition wall, wherein each of the electrically conductive spacers comprises two elements which are superimposed between the anode plate or the cathode plate and the partition wall and welded at the superimposed surface so as to support the anode plate and the cathode plate in parallel uniform planes.
2. A bipolar electrode as claimed in Claim 1, wherein the electrically conductive spacer element welded to the anode-side sheet or the cathode-side sheet is generally L-shaped, and the other element of each electrically conductive spacer is generally plate-shaped.
3. A bipolar electrode as claimed in Claim 1, or Claim 2, wherein the substrate of the anode plate, the anode-side sheet, and the electrically conductive spacer on the anode side are each made of titanium, and the cathode plate, the cathode-side sheet and the electrically conductive spacer on the cathode side are each made of mild steel.
4. A bipolar electrode as claimed in any preceding Claim, wherein that portion of the anode-side sheet which contacts the electrode frame is made of a palladium-containing titanium alloy or titanium whose surface has been diffusion-treated with palladium.
5. A method for producing a bipolar electrode as claimed in Claim 1, which comprises:
 - (i) welding one element of each of the two electrically conductive spacers to respective predetermined parts of the cathode-side sheet and the anode-side sheet of the partition wall;
 - (ii) welding the peripheral part of the cathode-side sheet to an intermediate part of the electrode frame;
 - (iii) locating the anode-side sheet on the cathode-side sheet and fixing the peripheral part of the anode-side sheet to the periphery

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- of the electrode frame;
(iv) superimposing the other element of each electrically conductive spacer with said one element of the respective spacer and adjusting
5 said other element so that the free end surfaces of the elements are parallel and welding the superimposed surface; and
(v) welding the anode plate and the cathode plate to the free end surfaces of the other
10 elements respectively.
6. A method of producing a bipolar electrode as claimed in Claim 5, substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.
7. A bipolar electrode produced by a method as claimed in Claim 5 or Claim 6. 15
8. A bipolar electrode as claimed in Claim 1, comprising the combination and arrangement of parts substantially as hereinbefore described with reference to Figure 2 of the
20 accompanying drawings.
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Agents for the Applicants