Title: WIRE MESH ATTACHMENT STRUCTURE IN AN ANODE AND METHOD OF MAKING SAME

Abstract: An electrode and a method of constructing electrodes including a conductor rod and a conductive mesh structure having a first mesh core material coated with a second material is provided. The rod and mesh are positioned in mutual abutting contact. A first flow of current is passed therethrough for a first predetermined time period sufficient to remove a portion of the second material from the first material in a predetermined area of the mesh structure by the first flow of current without welding the first material in the predetermined area. The first flow of current is suspended for a second predetermined time period after the first period. A second flow of current is established through the rod and mesh for a third time period after the first and second time periods sufficient to weld a portion of the conductive mesh structure with the conductor rod at the predetermined area.
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TECHNICAL FIELD

[0001] The embodiments including the example embodiments described herein relate to electrode apparatus for electrolytic cells and electrolytic processes and, more particularly, to anodes and methods of constructing anodes for use in electrowinning cells such as for example copper electrowinning cells.

BACKGROUND

[0002] Electrowinning processes pass a current through a metal-bearing solution to selectively recover one or more targeted materials from the solution. Typical electrowinning cells include a large fluid vessel configured to contain the material-bearing solution therein and also configured to support a series of electrodes relative to the solution in a manner that top portions of the electrodes span the solution and are supported above the solution by an upper rim or lip of the vessel, while the lower portions or bodies of the electrodes remain submerged in the solution. A power supply is selectively coupled with the electrodes which typically comprise a set of alternately arranged spaced apart anodes and cathodes, each being connected with opposite poles of the power supply, thereby imposing flows of current through the solution between the electrodes.

[0003] Any number of anodes greater than one (1) and any number of cathodes greater than one (1) may be used to extract the target material from the solution. Typical cathodes have a plate-like structure overall including an elongate header bar spanning the fluid containment vessel and a downwardly suspended conductive sheet member. One type of conductive sheet includes a copper starter sheet wherein, in copper electrowinning processes, copper particles extracted from the solution essentially fuse with the copper starter sheet so that the entire sheet with the material accumulated thereon can be removed en toto during the post process reclamation steps. Other cathode sheet member styles include stainless steel or titanium "blanks" providing an active conductive surface upon which the metal value extracted from the material-laden solution may accumulate. In these
cathodes, the accumulant is simply removed from the blank using mechanical means such as scraping, vibrating, or the like.

[0004] Unlike cathodes which primarily function to accumulate the metal value in the electrowinning cell, anodes primarily function to provide a source of electrical current through the material-bearing solution. Agitation or an induced flow of the material relative to the electrodes assists in enhancing the efficiency of the metal value production. Most earlier anodes have a solid overall construction. In this regard, the earlier anodes typically comprise a longitudinal header member and a lead alloy sheet face. Newer anodes recently introduced to the industry have a general overall porous surface. In this regard, the anodes typically comprised a longitudinal header member, a plurality of conductor bars extending from the longitudinal header member, and a pair of conductive mesh members attached with the conductor bars.

[0005] Conductor bars are often formed as a solid elongate copper core portion with an outer thin titanium coating. On the other hand, the conductive mesh members include a woven structure of titanium mesh material bearing an outer thin coating of iridium. The titanium and iridium coatings help defend the anode from the corrosive effects of the material-bearing solution which is often doped with agents such as acids to help maintain and present the metal value in a flowable solution form to the electrodes of the electrowinning cell.

[0006] It is desirable that the entire anode structure maintained good electrical conductivity. A good electrical connection between the outer titanium layer of the conductor bar and the titanium portion of the mesh members is highly desirable. However, it is difficult to attach the conductive mesh members with the conductor rods in this way because the respective protective titanium and iridium coatings impede standard welding techniques and otherwise introduce additional costs and time burdens using grinding or other mechanical fastening techniques.

SUMMARY

[0007] Accordingly, in various embodiments, the example embodiments of the present invention provide a new construction of an anode structure for use in an associated electrowinning cell and, in addition, provide methods of constructing an anode for use in an
associated electrowinning cell for efficient extraction of value metal from a material-laden solution.

[0008] In an aspect of an exemplary embodiment, there is provided a method of constructing an electrode that comprises establishing first and second flows of current through conductor rods and mesh material of the electrode for predetermined time periods by an associated programmable welding apparatus, wherein the first and second pulses are separated by a gap of time wherein no current is applied by the associated welder to the electrode workpieces.

[0009] In an example embodiment, the positioning includes positioning the conductor rod and a conductive mesh structure comprising a first mesh core material coated with a second material is positioned in mutual abutting contact relative position with a conductor rod. A first flow of current is established through the conductor rod and the conductive mesh structure for a first predetermined time period sufficient to only remove a portion of the second material from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure without welding the first material in the predetermined area. The first flow of current is suspended for a second predetermined time period after the first time period. Thereafter, a second flow of current is established for a third time period sufficient to weld a portion of the conductive mesh structure with the conductor rod at the predetermined area by the second flow of current through the conductor rod and the conductive mesh structure.

[0010] In accordance with a further aspect of an exemplary embodiment, the first pulse delivers power to the anode workpiece sufficient to break through, eradicate, or otherwise remove a portion of the iridium coating of the titanium mesh material at a localized area. Thereafter, power is removed from the anode workpiece for a predetermined time period, and then again resumed to deliver a second pulse of power to the anode workpiece sufficient to form an electrically conductive weld joint between the conductor rod and the mesh material at the localized area.

[0011] In accordance with a further embodiment, a method of constructing an electrode includes positioning a conductor rod and a conductive mesh structure between opposed working elements of an associated welding apparatus. The conductor rod and the conductive mesh structure are clamped against each other in an abutting contact relative
position by the opposed working elements of the associated welding apparatus. A first flow of current is established through the conductor rod and the conductive mesh structure in the abutting contact position by the opposed working elements of the associated welding apparatus for a first predetermined time period. The first flow is suspended and the conductor rod and the conductive mesh structure are held against each other in the abutting contact position by the opposed working elements of the associated welding apparatus for a second predetermined time period after the first time period. A second flow of current is established through the conductor rod and the conductive mesh structure in the abutting contact position by the opposed working elements of the associated welding apparatus for a third predetermined time period after the first and second predetermined time periods.

[0012] In yet a further example embodiment, an anode formed in accordance with any of the methods described herein is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 is an exploded perspective view of a flow-through anode in accordance with an example embodiment;

[0014] Fig. 2 is a perspective view of the flow-through anode of Fig. 1 in accordance with the example embodiment;

[0015] Fig. 3 is a cross-sectional view of a conductor rod of the example flow-through anode taken through line 3-3 of Fig. 1;

[0016] Fig. 4 is a cross-sectional view of a mesh plate of the example flow-through anode taken through line 4-4 of Fig. 1;

[0017] Fig. 5 is a cross-sectional view of the mesh plate connected with a conductor rod of the flow-through anode in accordance with the example embodiment taken through line 5-5 of Fig. 2;

[0018] Fig. 6 is a flow chart illustrating a process for attaching the mesh plate with the conductor rod of the flow-through anode in accordance with the example embodiment;
[0019] Fig. 7a-7f are a set of schematic views illustrating steps in the process for attaching the mesh plate with the conductor rod of the flow-through anode using an associated programmable welding apparatus in accordance with the example embodiment;

[0020] Fig. 8 is a force versus time chart illustrating the clamping steps of the process of Figures 6 and 7a-7e for attaching the mesh plate with the conductor rod of the anode in accordance with the example embodiment;

[0021] Fig. 9 is a voltage versus time chart illustrating the pulse steps of the process of Figures 6 and 7a-7e for attaching the mesh plate with the conductor rod of the anode in accordance with the example embodiment; and

[0022] Fig. 10 is a current versus time chart illustrating the pulse steps of the process of Figures 6 and 7a-7e for attaching the mesh plate with the conductor rod of the anode in accordance with the example embodiment.

DETAILED DESCRIPTION

[0023] With reference now to the drawings wherein the showings are for purposes of illustrating the example embodiments only and not for purposes of limiting same, a flow-through anode 100 in accordance with an example embodiment is illustrated in Fig. 1 in an exploded perspective view and in an assembled view in Fig. 2. As shown, the anode 100 comprises components including an elongate hanger or header bar 102, a set of conductor rods 104, and a set of substrate members 106. The header bar 102 in its preferred form is constructed of copper and includes an elongate cylindrical central portion 110 disposed between curved portions 112 formed on each of the opposite ends 114-116 of the header bar 102. The curved portions 112 provide a convenient interface of the anode with the upper rim or lip of an associated electrowinning cell (not shown) for purposes of supporting the electrode relative to the cell with the header bar above the surface of the material-laden fluid while the body 108 of the anode is submerged relative to the fluid.

[0024] The central portion 110 of the header bar 102 is, in the example embodiment illustrated rectangular cylindrical and, in this regard, is provided with a plurality of equally spaced apart attachment regions 120 corresponding in number to the quantity of conductor
rods comprising the set 104. As illustrated, the attachment regions comprise a set of six (6) or eight (8) equally spaced apart sockets 122, each being configured to receive the upper end of a corresponding conductor rod 130-135 along insertion directions 140-145 in paths toward the header bar and illustrated in dot and dashed lines in Fig. 1. During initial assembly of the anode 100 of the example embodiment, the rods 130-135 are coupled with the header bar 102 and extend there from in parallel in a manner such as shown in Fig. 2 for example. The rods 130-135 may be press-fitted individually or together as a group using any suitable clamping and pressing techniques into place in their respective sockets 122 and attached with the header member by an interference fit or the like.

[0025] Although the conductor rods 130-135 affixed with the header bar 102 such as, for example, in the manner described above, would provide a current path between the header bar and the material-laden solution of the associated electrowinning apparatus, it is highly desirable to enhance the conduction path by providing a set of substrate members 106 in an anode body 108 and attached with the set of rods 104. As illustrated, the set 106 includes first and second mesh-like structures 150, 152 arranged such as shown in Fig 2 in an operative coupled relationship on opposite sides of the conductor rods 104. In an exemplary embodiment, the mesh-like structures 150, 152 comprise thin gage screens formed of woven flattened titanium members stitched together in a desired directional pattern. In a preferred form, the desired directional pattern has a SW dimension of 0.147 inches and a LW dimension of 0.197 inches and a flatness of 1/8th inch. Still further, preferably, the titanium mesh-like structures 150, 152 are provided with an outer protective coating of iridium described in greater detail below.

[0026] It is to be appreciated that other forms of mesh structure are possible in accordance with other embodiments including for example, woven wire screens with about a 100x100 strand density per square inch to about 10x10 strands per square inch, preferably from about 80x80 strands per square inch to about 30x30 strands per square inch, and more preferably about 60x60 strands per square inch to about 40x40 strands per square inch. However, other various rectangular and irregular geometric mesh configurations may be used.

[0027] The set of elongate conductor rods 104 have a generally circular cross-section and in the example embodiment, include an inner core portion 300 surrounded by an outer protective coating portion 302 illustrated best in the cross-sectional view of a representative
rod 135 in Fig. 3. In the example embodiment, preferably, the inner core portion 300 is comprised of an elongate cylindrical copper rod 310 and the outer protective coating portion 302 is comprised of a titanium outer layer 312 having a generally annular shape in cross-section. In one embodiment, the iridium coating is baked onto the titanium substrate comprising the mesh structure. It is to be appreciated that although the inner core portion 300 is comprised of a copper rod 310, other materials may be used as well, such as, for example, aluminum or any other conductive metal or conductive material as necessary or desired. In addition, it is to be further appreciated that although the outer protective portion 302 is comprised of an outer titanium layer 312, other materials may be used as well, such as, for example, stainless steel or other metals or materials having similar properties and characteristics of titanium or stainless steel as necessary, desired or suitable in accordance with the intended application.

[0028] As shown, the cylindrical copper rod 310 comprises a major portion of the conductor rod 135 and, to that end, in the example embodiment illustrated, the cylindrical copper rod 310 has a circular cross-section having a nominal outer diameter of about 0.410 inches (10.4 mm). Also, the titanium cladding forming the outer layer 312 has a nominal thickness of about 0.028 inches (0.7 mm). Preferably, the rods 130-135 are cold drawn titanium cladded copper rods. However, the rods may be cold drawn aluminum cladded copper rods.

[0029] The set of substrate members 106 have a generally woven screen structure in the example embodiment and, as shown best in the cross-sectional view in Fig. 4 of a representative portion of the mesh structure 152 (Figs. 1 and 2) comprise an inner core portion 400 surrounded by an outer protective coating portion 402. In the example embodiment, preferably, the inner core portion 400 is comprised of elongate titanium strand members 410 and the outer protective portion 402 is comprised of a baked-on layer 412 of iridium. It is to be appreciated, however, that other types of materials may be used, such as, for example, stainless steel or other metals or materials having similar properties and characteristics of titanium or iridium as necessary, desired or suitable in accordance with the intended application. As shown, the titanium strand 410 comprises a major portion of the mesh structure 152 and to that end, in the example embodiment illustrated as a cross-sectional area of about 0.022 inches (0.56 mm). Also, the iridium coating layer 412 has, in
the example embodiment, a nominal thickness of about 1-1.5 microns. Preferably, the iridium coating is baked onto the titanium mesh structure.

[0030] With reference next to Fig. 5, a novel wire mesh attachment structure 500 of the anode 100 (Figs. 1 and 2) in accordance with an example embodiment is illustrated in cross-sectional form. It is to be appreciated that the structure 500 is formed with accordance with a novel method 600 (Fig. 6) of a further example embodiment in a manner to be described in greater detail below. As shown in Fig. 5, the structure comprises the first and second mesh structures 150, 152 electro-mechanically attached with a conductor rod 135. Although only a single rod 135 is shown by way of example, it is contemplated within the scope of this disclosure that each of the other conductor rods 130-134 are similarly electro-mechanically attached with corresponding regions of the mesh structures 150, 152. Only a single attachment structure 500 is shown for clarity of illustration, however. As described above, the exemplary conductor rod 135 comprises an inner core portion 300 comprising a copper rod 310 surrounded by an outer cover portion 302 comprising a titanium outer layer 312. The first mesh structure 150 comprises woven titanium strands 510-516 each having an iridium coating layer 520-526 and, similarly, the second mesh structure 152 comprises woven titanium strands 530-536 each having an iridium coating layer 540-546.

[0031] In its preferred form, the attachment structure 500 by way of example comprises the conductor rod 135 and the first and second mesh-like structures wherein the titanium strands 510-516 of the first structure 150 are directly affixed with the outer titanium layer 312 of the conductor rod 135, and wherein the titanium strands 530-536 of the second structure 152 are directly affixed with the outer titanium layer 312 of the conductor rod 135, as shown. Preferably, the affixed members are affixed by a welding method in accordance with a further example embodiment described herein whereby a plurality of weld joints 550-566 are created at the interfaces between the conductor rod and the set of substrate members insuring a good electro-mechanical connection therebetween. In addition, as seen in the cross-sectional view of Fig. 5, none of the titanium strands 510-516 or 530-536 of either the first of second mesh structures are directly exposed to the material-laden fluid surrounding the anode 100 during use in an electrowinning process. More particularly, as shown, the strands are covered by the iridium outer layer. Significantly, the titanium components of the anode structure are fused directly together without exposing any of the copper rod 310 comprising the inner core portion of the conductor rod 135 shown in Fig. 5 by way of
example. It is to be appreciated that each of the conductor rods comprising the anode structure shown in Figs. 1 and 2 illustrated in Fig. 5 showed in single form for purposes of helping to clarify the description of the example embodiment.

[0032] As shown in the figures, an electrode is provided, particularly, an anode 100. The anode comprises a header bar 102, a plurality of elongate conductor bars 130-135 extending from the header bar, a conductive mesh structure 150, 152 comprising a first mesh core material 400 coated with a second material 402; and, an attachment portion 551 configured to attach the conductive mesh structure with the plurality of elongate conductor bars, the attachment portion being formed by a two-pulse weld connection, wherein details of example embodiments of the two-pulse weld connection will be described below.

[0033] Fig. 6 is a flow chart illustrating a method 600 of constructing an electrode 100 in accordance with a further example embodiment. With reference to Figs. 6 and 7a, the method comprises the step 602 of positioning a conductor rod and a conductive mesh structure between opposed working elements 720, 722 of an associated welding apparatus 730. In a further step 604 of the method 600, the conductor rod and the conductive mesh structure is clamped such as shown at 704 of Fig. 7b against each other by the opposed working elements 720, 722 of the associated welding apparatus 730. Preferably, as shown in Fig. 8, the clamp force is about 1350 lbs. In method step 606, a first flow of current 750 is established through the conductor rod and the conductive mesh structure by the working elements 720, 722 of the associated welding apparatus for a first predetermined time period. In an example embodiment, a first pulse having a voltage component 902 and a current component 1002 are shown in Figs. 9 and 10, respectively. Preferably, as shown in Figs. 9 and 10 the first pulse is about 700 volts at about 10,000 amps for about 0.125 seconds. It has been found that this combination of potential, current and time generates a sufficient amount of energy to remove a portion of the iridium coating from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure without welding the mesh structure with the conductor rod. However, it is to be appreciated that other voltage, current, and time values or parameters may be used as necessary or desired to effect the ultimate weld integrity and, in particular, to remove the outer iridium mater without initiating a weld formation.
In step 608, the current 750 is removed from the workpiece held between the associated opposed working elements 720, 722 of the associated welding apparatus 730 such as shown in Fig. 7d, for example. In this way, a gap time period 910, 1010 shown in Figs. 9 and 10, respectively, is established wherein no power if applied between the conductor rod and the conductive mesh structure. Preferably, the gap period is about 0.083 seconds. The gap time is selected to allow for cooling of the parts prior to the second pulse being applied. Other time gaps wherein no energy is applied to the conductor rod and the conductive mesh structure can be used as necessary or desired in accordance with the characteristics of the workpiece.

In step 610, a second current pulse 760 is established through the rod and mesh structures such as shown for example in Fig. 7e. In the example embodiment illustrated, a voltage component 904 and a current component 1004 of the second pulse 760 is illustrated in Figs. 9 and 10, respectively. Preferably, as shown in Figs. 9 and 10 the second pulse is about 700 volts at about 10,000 amps for about 0.125 seconds. It has been found that this combination of potential, current and time generates a sufficient amount of energy to weld the conductor rod with the conductive mesh structure at the predetermined area of the conductive mesh structure. However, it is to be appreciated that other voltage, current, and time values or parameters may be used as necessary or desired to effect the ultimate weld integrity and, in particular, to form a weld connection.

It is to be appreciated that the positioning includes positioning the conductor rod and the conductive mesh structure comprising a first mesh core material coded with an iridium coating between the opposed working elements of the associated welding apparatus. Further, the first time period is selected to remove a portion of the iridium coating from the first material in a predetermined area of the conductive mesh structure by the first flow of current 750 through the conductor rod and the conductive mesh structure. Further, the second predetermined time period is selected to weld portions of the conductive mesh structure with the conductor rod at the predetermined areas by the second flow of current 760 through the conductor rod and the conductive mesh structure.

Still further in accordance with the example embodiment, the first flow of current 750 including the voltage component 904 and the current component 1002 is established between the conductor rod and the conductive mesh structure by the associated welding
apparatus for a first predetermined time period sufficient to remove a portion of the iridium coating from the mesh structure in the predetermined areas of the conductive mesh structure by the first flow of current therethrough. For a second period sufficient to weld portions of the conductive mesh structure with the conductor rod at the predetermined areas by the second flow of current 760 through the rod and mesh structures.

[0038] Still further in accordance with the example embodiment, an anode 100 formed in accordance with any of the methods described comprises a header bar 102, a plurality of elongate conductor bars 130-135 extending from the header bar, and a conductive mesh structure 150, 152 comprising a first mesh core material 400 coated with a second material 402, the conductive mesh structure being attached with the plurality of elongate conductor bars by an attachment portion 551 configured to attach the conductive mesh structure with the plurality of elongate conductor bars, the attachment portion being formed, preferably, by a two-pulse weld connection 553. In accordance with one form of anode, the two-pulse weld connection 553 is formed by establishing a first flow of current through the conductor rods and the conductive mesh structure for a first predetermined time period sufficient to only remove portions of the second material from the first material in predetermined areas of the conductive mesh structure by the first flow of current through the conductor rods and the conductive mesh structure without welding the first material in the predetermined areas; suspending the first flow of current for a second predetermined time period after the first time period; and, establishing a second flow of current for a third time period sufficient to weld portions of the conductive mesh structure with the conductor rods at the predetermined areas by the second flow of current through the conductor rods and the conductive mesh structure.

[0039] In accordance with another form of anode, the two-pulse weld connection 553 is formed by establishing a first flow of current through the conductor rod and the conductive mesh structure by an associated welding apparatus for a first predetermined time period sufficient to remove a portion of the second material from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure; suspending the first flow of current for a second predetermined time period after the first time period; and, establishing the second flow of current for a third predetermined time period sufficient to weld a portion of the
conductive mesh structure with the conductor rod at the predetermined area by the second flow of current through the conductor rod and the conductive mesh structure.
Claims:

1. A method of constructing an electrode, the method comprising:
   positioning a conductor rod and a conductive mesh structure between opposed working elements of an associated welding apparatus;
   clamping the conductor rod and the conductive mesh structure against each other in an abutting contact relative position by the opposed working elements of the associated welding apparatus;
   establishing a first flow of current through the conductor rod and the conductive mesh structure in the abutting contact position by the opposed working elements of the associated welding apparatus for a first predetermined time period;
   holding the conductor rod and the conductive mesh structure against each other in the abutting contact position by the opposed working elements of the associated welding apparatus for a second predetermined time period after the first time period; and,
   establishing a second flow of current through the conductor rod and the conductive mesh structure in the abutting contact position by the opposed working elements of the associated welding apparatus for a third predetermined time period after the first and second time periods.

2. The method according to claim 1 wherein:
   the positioning includes positioning the conductor rod and a conductive mesh structure comprising a first mesh core material coated with a second material between the opposed working elements of the associated welding apparatus;
   the establishing the first flow of current comprises removing, by the first flow of current, a portion of the second material from the first material in a predetermined area of the conductive mesh; and,
   the establishing the second flow of current comprises welding, by the second flow of current, a portion of the conductive mesh structure with the conductor rod at the predetermined area.

3. The method according to claim 2 wherein:
the positioning comprises positioning the conductor rod and a conductive mesh structure comprising a titanium core material with an iridium coating thereon between the opposed working elements of the associated welding apparatus.

4. The method according to claim 3 wherein the positioning comprises positioning the conductor rod and a conductive mesh structure having a titanium core material and an iridium coating of about 1-1.5 microns thick between the opposed working elements of the associated welding apparatus.

5. The method according to claim 2 wherein:

the clamping comprises clamping the conductor rod and the conductive mesh structure against each other by a force of about 1200-1400 pounds per square inch (PSI) between the working elements of the associated welding apparatus.

6. The method according to claim 2 wherein:

the establishing the first flow of current comprises establishing a first flow of about 10000-12000 amps of current through the conductor rod and the conductive mesh structure by the associated welding apparatus for a first time period of about 125 milliseconds;

the holding comprises removing the first flow of current from the conductor rod and the conductive mesh structure for a second time period of about 83 milliseconds; and,

the establishing the second flow of current comprises establishing a second flow of current of about 10000-12000 amps for a third time period of about 125 milliseconds.

7. The method according to claim 1 wherein:

the positioning includes positioning the conductor rod and a conductive mesh structure comprising a first mesh core material coated with a second material between the opposed working elements of the associated welding apparatus;

the establishing the first flow of current comprises establishing a first flow of current through the conductor rod and the conductive mesh structure by the associated welding apparatus for a first predetermined time period sufficient to remove a portion of the second material from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure; and,
the establishing the second flow of current comprises establishing the second flow of
current for a third time period sufficient to weld a portion of the conductive mesh structure
with the conductor rod at the predetermined area by the second flow of current through the
conductor rod and the conductive mesh structure.

8. The method according to claim 7 wherein:
   the positioning comprises positioning the conductor rod and a conductive mesh
structure comprising a titanium core material with an iridium coating thereon between the
opposed working elements of the associated welding apparatus.

9. The method according to claim 8 wherein the positioning comprises positioning the
conductor rod and a conductive mesh structure having a titanium core material and an
iridium coating of about 1-1.5 microns thick between the opposed working elements of the
associated welding apparatus.

10. The method according to claim 7 wherein:
    the clamping comprises clamping the conductor rod and the conductive mesh
structure against each other by a force of about 1200-1400 pounds per square inch (PSI)
between the working elements of the associated welding apparatus.

11. The method according to claim 7 wherein:
    the establishing the first flow of current comprises establishing a first flow of about
10000-12000 amps of current through the conductor rod and the conductive mesh structure
by the associated welding apparatus for a first time period of about 125 milliseconds;
    the holding comprises removing the first flow of current from the conductor rod and
the conductive mesh structure for a second time period of about 83 milliseconds; and,
    the establishing the second flow of current comprises establishing a second flow of
current of about 10000-12000 amps for a third time period of about 125 milliseconds.

12. The method according to claim 1 wherein:
    the positioning includes positioning the conductor rod and a conductive mesh
structure comprising a first mesh core material coated with a second material between the
opposed working elements of the associated welding apparatus;
the establishing the first flow of current comprises establishing a first flow of current through the conductor rod and the conductive mesh structure by the associated welding apparatus for a first predetermined time period sufficient to only remove a portion of the second material from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure without welding the first material in the predetermined area; and,

the establishing the second flow of current comprises establishing the second flow of current for a third time period sufficient to weld a portion of the conductive mesh structure with the conductor rod at the predetermined area by the second flow of current through the conductor rod and the conductive mesh structure.

13. A method of constructing an electrode, the method comprising:
positioning a conductor rod and a conductive mesh structure against each other in an abutting contact relative position;

establishing a first flow of current through the conductor rod and the conductive mesh structure in the abutting contact position for a first predetermined time period;
suspending the first flow of current for a second predetermined time period after the first time period; and,

establishing a second flow of current through the conductor rod and the conductive mesh structure in the abutting contact position for a third predetermined time period after the first and second time periods.

14. The method according to claim 13 wherein:
the positioning includes positioning a conductive mesh structure comprising a first mesh core material coated with a second material and the conductor rod against each other in the abutting contact relative position;

the establishing the first flow of current comprises removing, by the first flow of current, a portion of the second material from the first material in a predetermined area of the conductive mesh; and,

the establishing the second flow of current comprises welding, by the second flow of current, a portion of the conductive mesh structure with the conductor rod at the predetermined area.
15. The method according to claim 14 wherein:
   the positioning comprises positioning a conductive mesh structure comprising a
titanium core material with an iridium coating thereon and the conductor rod against each
other in the abutting contact relative position.

16. The method according to claim 15 wherein the positioning comprises positioning a
conductive mesh structure having a titanium core material and an iridium coating of about
1-1.5 microns thick and the conductor rod against each other in the abutting contact relative
position.

17. The method according to claim 14 further comprising:
   clamping the conductor rod and the conductive mesh structure against each other by
   a force of about 1200-1400 pounds per square inch (PSI).

18. The method according to claim 14 wherein:
   the establishing the first flow of current comprises establishing a first flow of about
10000-12000 amps of current through the conductor rod and the conductive mesh structure
for a first time period of about 125 milliseconds;
   the suspending comprises removing the first flow of current from the conductor rod
   and the conductive mesh structure for a second time period of about 83 milliseconds; and,
   the establishing the second flow of current comprises establishing a second flow of
current of about 10000-12000 amps for a third time period of about 125 milliseconds.

19. The method according to claim 13 wherein:
   the positioning includes positioning the conductor rod and a conductive mesh
structure comprising a first mesh core material coated with a second material in the abutting
contact relative position;
   the establishing the first flow of current comprises establishing a first flow of current
through the conductor rod and the conductive mesh structure for a first predetermined time
period sufficient to only remove a portion of the second material from the first material in a
predetermined area of the conductive mesh structure by the first flow of current through the
conductor rod and the conductive mesh structure without welding the first material in the
predetermined area; and,
the establishing the second flow of current comprises establishing the second flow of current for a third time period sufficient to weld a portion of the conductive mesh structure with the conductor rod at the predetermined area by the second flow of current through the conductor rod and the conductive mesh structure.

20. An anode comprising:
   a header bar;
   a plurality of elongate conductor bars extending from the header bar;
   a conductive mesh structure comprising a first mesh core material coated with a second material; and,
   an attachment portion configured to attach the conductive mesh structure with the plurality of elongate conductor bars, the attachment portion being formed by a two-pulse weld connection.

21. The anode according to claim 20 wherein the conductive mesh structure is attached with the plurality of elongate conductor bars by the two-pulse weld connection formed by:
   establishing a first flow of current through the conductor rods and the conductive mesh structure for a first predetermined time period sufficient to only remove portions of the second material from the first material in predetermined areas of the conductive mesh structure by the first flow of current through the conductor rods and the conductive mesh structure without welding the first material in the predetermined areas;
   suspending the first flow of current for a second predetermined time period after the first time period; and,
   establishing a second flow of current for a third time period sufficient to weld portions of the conductive mesh structure with the conductor rods at the predetermined areas by the second flow of current through the conductor rods and the conductive mesh structure.

22. The anode according to claim 20 wherein the conductive mesh structure is attached with the plurality of elongate conductor bars by the two-pulse weld connection formed by:
   establishing a first flow of current through the conductor rod and the conductive mesh structure by an associated welding apparatus for a first
predetermined time period sufficient to remove a portion of the second material from the first material in a predetermined area of the conductive mesh structure by the first flow of current through the conductor rod and the conductive mesh structure:

suspending the first flow of current for a second predetermined time period after the first time period; and,

establishing the second flow of current for a third predetermined time period sufficient to weld a portion of the conductive mesh structure with the conductor rod at the predetermined area by the second flow of current through the conductor rod and the conductive mesh structure.
FIG. 5
FIG. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPCI(8) - H01M 4/02 (2011.01)
USPC - 429/523

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 429/523

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 429/523, 60, 81, 128, 137, 208, 209, 502/101; 427/58, 59 (keyword limited - see search terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (PGPB, USPT, USOC, EPAB, JPAB); GOOGLE; Google Scholar
Terms: electrowinning, electrode, conductor, electrolysis, rod, mesh, currents, time, period, clamp, pulse, titanium, coating, iridium.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 2010/0276281 A1 (Sandoval et al.) 04 November 2010 (04.11.2010), entire document, especially abstract, para [0001], [0023], [0058], [0059], [0061], [0063], [0072], [0076].</td>
<td>1:22</td>
</tr>
<tr>
<td>Y</td>
<td>US 2004/0108200 A1 (Des Jardins et al.) 10 June 2004 (10.06.2004), entire document, especially abstract, para [0013], [0014], [0015], [0074], [0077], [0108], [0113].</td>
<td>1:22</td>
</tr>
<tr>
<td>A</td>
<td>US 2009/0152124 A1 (Ashford et al.) 18 June 2009 (18.06.2009), entire document, especially abstract, para [0003], [0022], [0024], [0030], [0031], [0034], [0039], [0046], [0050], [0053], [0056].</td>
<td>1:22</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
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  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search: 19 October 2011 (19.10.2011)
Date of mailing of the international search report: 1 NOV 2011

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