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Cordone et al.

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[54] **MAKING AN ANODE ASSEMBLY**

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Related U.S. Application Data

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[52] **U.S. Cl.** **204/283;** 204/259; 204/260; 204/272; 204/284

[51] **Int. Cl.²**.. **C25D 17/10;** C25D 7/04; C25D 3/12

[58] **Field of Search** 204/259, 272, 284, 260, 204/283

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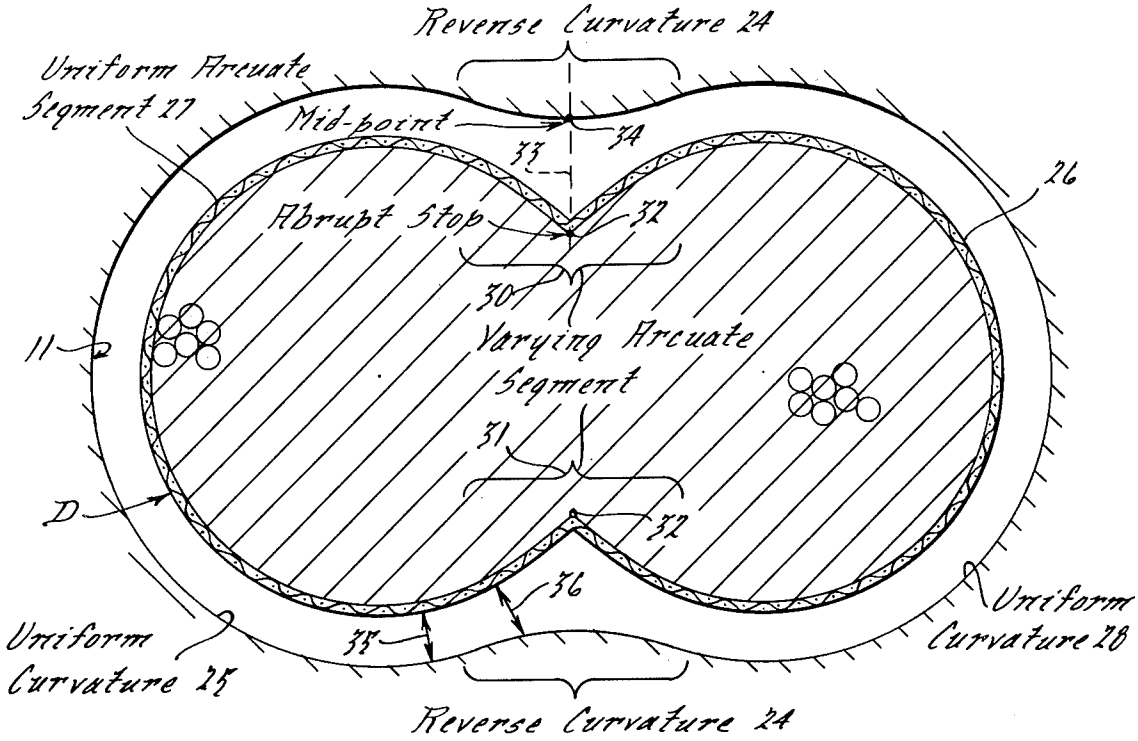
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Attorney, Agent, or Firm—Joseph W. Malleck; Keith L. Zerschling

[57] **ABSTRACT**

An electroplating system for cathodically plating an epitrochoidally shaped internal surface of a rotary engine housing. An anode assembly is provided which is comprised of a perforate walled container of titanium metal or other anodically inert metal to which a voltage potential can be applied; the basket contains anode pieces such as nickel which are shaped to be in intimate contact with each other during the plating operation. The perforate walls of the anode container is shaped from flexible expanded titanium sheet metal interfitted within semi-epitrochoidally aligned grooves respectively machined into titanium plates forming the ends of the anode assembly. The anode walls are thus shaped substantially complimentary to the epitrochoid configuration of the cathode but have a predetermined deviation adjacent the nodes of the trochoid for insuring a uniform but heavy coating thickness under high speed electroplating conditions.

4 Claims, 4 Drawing Figures



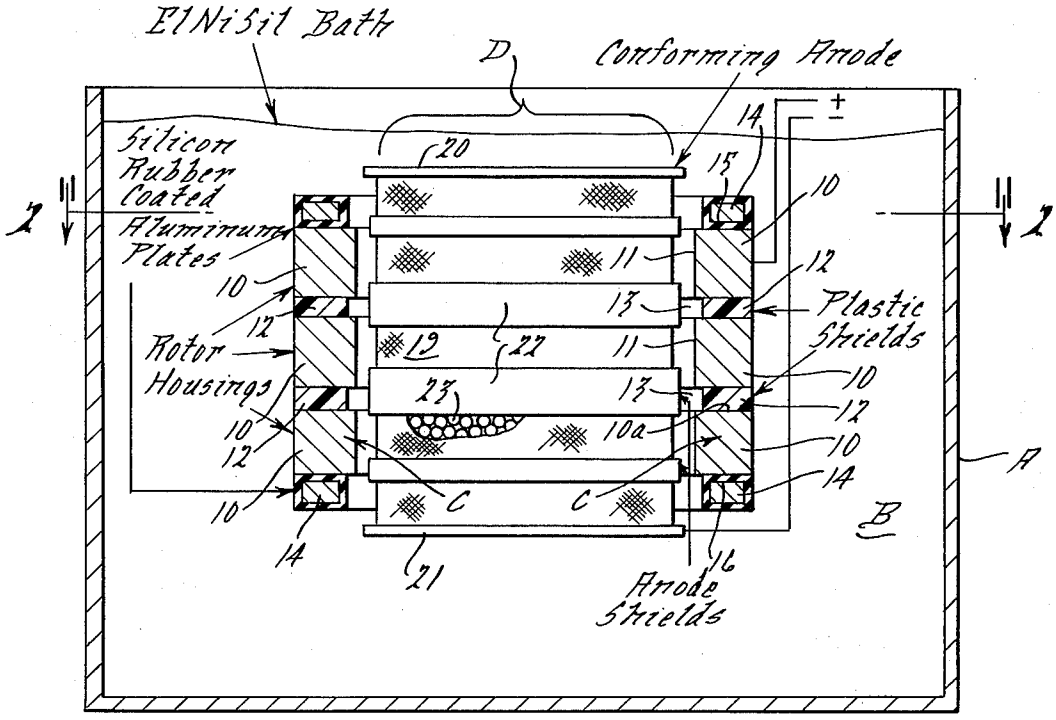

ElNiSil Bath
D
Conforming Anode
Silicon Rubber Coated Aluminum Plates
Rotor Housings
Plastic Shields
Anode Shields
20
14
15
10
11
12
13
22
23
10a
21
16
A
B
C
+
-

Fig. 1.

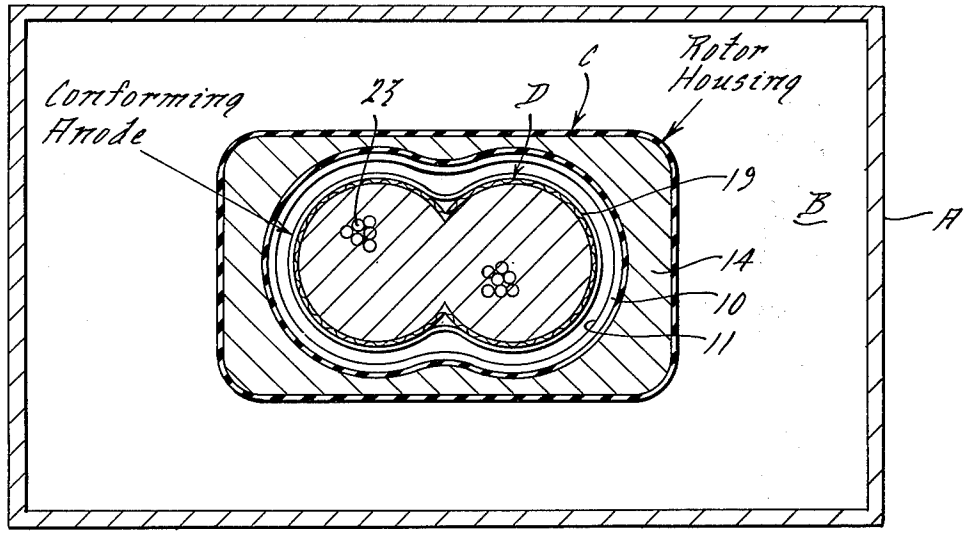

Conforming Anode
23
D
C
Rotor Housing
19
14
10
11
B
A

Fig. 2.

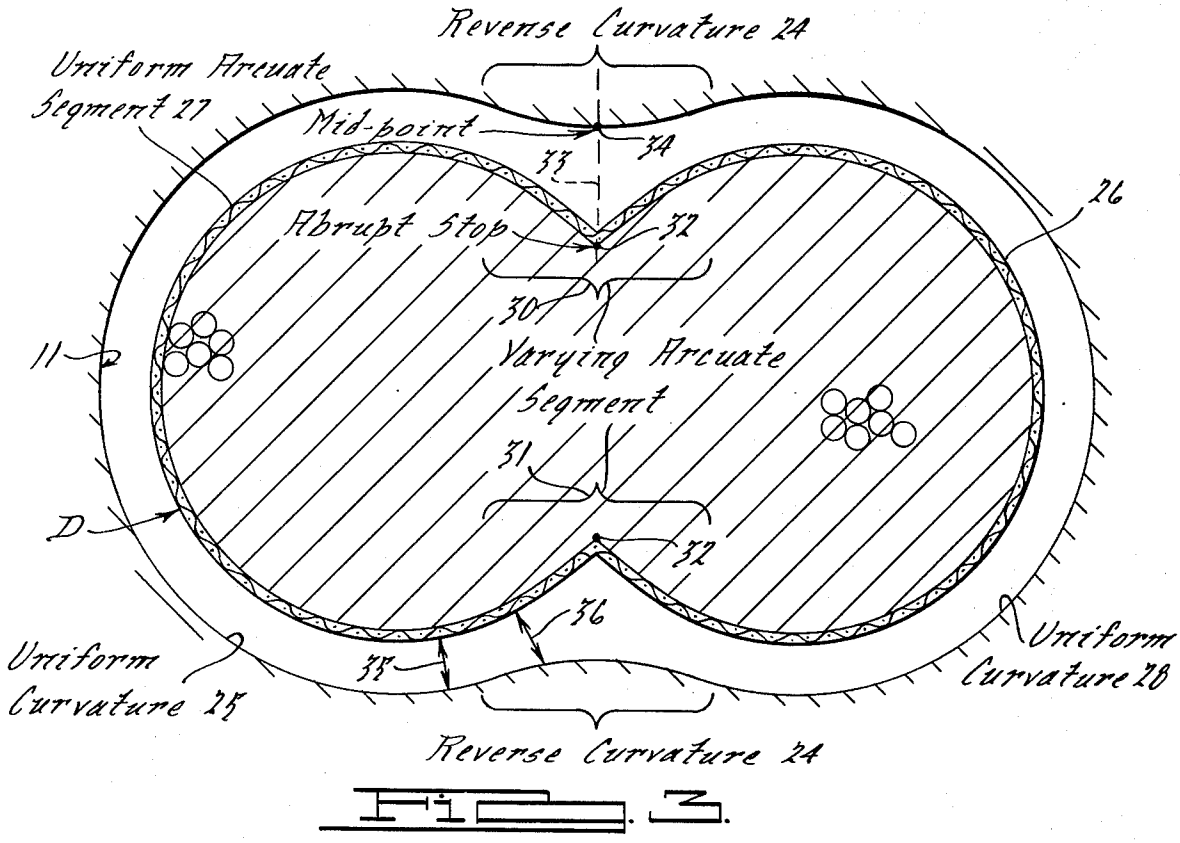

Reverse Curvature 24
Uniform Arcuate Segment 27
Mid-point
34
33
Abrupt Stop
32
26
30
11
Varying Arcuate Segment
31
D
32
36
35
Uniform Curvature 25
Uniform Curvature 28
Reverse Curvature 24

FIG. 3.

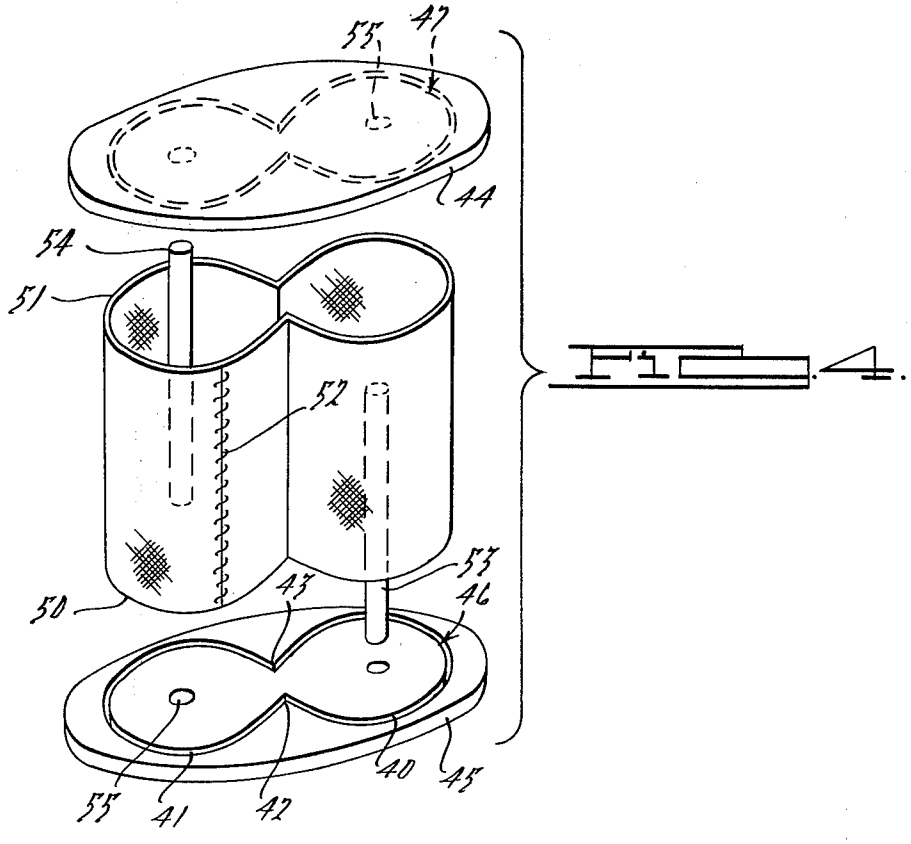

55
47
44
54
51
52
53
43
46
50
40
45
55
41
42

FIG. 4.

MAKING AN ANODE ASSEMBLY

This is a division of application Ser. No. 413,154, filed Nov. 5, 1973, now U.S. Pat. No. 3,891,534.

BACKGROUND OF THE INVENTION

It is generally well known in electroplating that the density of current flow will be uneven at the sharp edges or contour changes on the object to be plated. This phenomenon involves a proposition that there is increased plating resulting from increased current density at any outstanding contour, while the opposite effect will take place at depressions. In the latter case, the density of current flow becomes less than the average density of plating current over the full area being treated. This problem becomes exaggerated when an article to be plated has a compound curvature, such as in an epitrochoid, where the cathode is able to receive current "throw" from two different zones or anode locations due to the reverse or compound curvature. Accordingly, certain areas will be unduly thick because of the throwing power which is multiplied in some areas.

In applications such as a functional coating for a wear surface of an internal combustion engine, i.e. the internal rotor housing surface of a rotary internal combustion engine, the need for uniformity in the coating is extremely severe. The efficient electroplater not only seeks to obtain uniform thickness in such applications, but the plating must be of good sound density throughout; the latter will be degraded as a result of inappropriate bath chemistry, electrode spacing, and change of the anode or cathode area during the plating process.

SUMMARY OF THE INVENTION

A primary object of this invention is to provide an anode assembly useful in an electroplating system for cathodically plating an article having a compound or reverse curvature, the anode assembly being particularly adapted to maintain a proper current throw relationship so that a uniform thickness and density is maintained throughout the plated surface of said article.

Another object of this invention is to provide a semi-conforming anode assembly or apparatus for use in an electroplating system of the type which is adapted to deposit a significantly heavy functional coating on a non-uniformly curved surface.

Features pursuant to the above objects comprise the use of an anode assembly having a foraminous of perforate sheet metal titanium wall shaped in a predetermined unique configuration and varied from the shape of the cathode at selected locations. The wall is retained by end plates formed of the same material, but solid. The cross section of the foraminous wall is defined so that it is semi-conforming with respect to the shape of the cathode; the anode assembly progressively becomes more spaced from any portion of the cathode article which has a reversely curved portion, the progression of spacing increasing to a location intersected by radius of the reversely curved portion passing through the mid-point thereof.

Still another object of this invention is to provide a novel and unique method for fabricating an anode assembly which will have a defined cross sectional configuration with a semi-conforming relationship to the cathode, a continuous wall of the assembly being fabricated of perforate sheet metal, such as titanium.

BRIEF SUMMARY OF THE DRAWINGS

FIG. **1** is a schematic illustration of an electroplating apparatus having a stacked series of cathodically consituted articles for plating, and an anode assembly disposed within the interior of said series of cathode articles;

FIG. **2** is a plan view of the apparatus of FIG. **1**, shown similarly in a somewhat schematic manner;

FIG. **3** is a highly enlarged schematic layout of the cross sectional configuration of the anode assembly and the inner wall of the cathodic article to be plated;

FIG. **4** is an exploded view of the basic elements which interfit to form the cathode assembly according to the method of this invention.

DETAILED DESCRIPTION

Turning now to the drawings and particularly FIGS. **1** and **2**, there is schematically illustrated a preferred mode for an anode assembly and plating system according to this invention. An electroplating tank A is provided to contain an electrolyte B, such as an aqueous solution of nickel sulfamate containing inert particles of silicon carbide. Typically the bath may contain about 600 grams/liter of nickel sulfamate, about 120 grams/liter of silicon carbide with a mesh size no greater than 400, about 2.5 grams/liter of a stress reliever such as saccharin, about 19 grams/liter of nickel chloride, and about 45 grams/liter of boric acid (H_3Bo_3).

A cathode assembly C is disposed in the electrolyte consisting of several cathodic articles **10** each constituting a cast aluminum rotor housing useful as an element of a rotary internal combustion engine. The rotor housings are annular and must have a highly wear-resistant epitrochoid surface **11** on the interior thereof and against which apex seals or other moving parts of a rotary engine must bear. The housings are separated, one from the other, by spacers **12** which may act as shields and prevent plating on the side faces **10***a* of the rotor housings. Such spacers can be formed as polypropylene or nylon sheets and have an inner edge **13** which is recessed from the interior surface **11** of each rotor housing. Alternatively, the spacers may be arranged as cathode elements which fit tightly between the housings and which draw current around the edges of the housings to overcome the problem of exaggerated thickness at such edges; again the spacers would be recessed as illustrated.

At the upper and lower ends of the stack of housings and spacers, there is employed a rigid annular shield **14** for the top and bottom faces **15** and **16** respectively. Each shield should be a plate comprised of aluminum coated with silicon rubber which stays clean and does not draw plating. Plates are supported by a harness (not shown) which facilitates the lowering and the raising of the entire cathode assembly from the electrolyte. The harness should similarly be coated so as to have an inert outer surface.

An anode assembly D is employed which is of a semi-conforming type wherein only a portion of the anode **12** is adapted to be proportioned identical to the cathode surface **11** to be plated; other portions are designed to progressively deviate from such configuration. The anode assembly, here, is a basket made from expanded titanium sheet metal (or may be woven from titanium wire). The walls **19** are foraminous and the bottom and top walls **20** and **21** are each a solid titanium plate. Re-

silient or elastic neoprene bands **22** may be mounted about the anode wall **19** to mask off or block the current throw in certain predetermined elevation zones along the anode assembly, particularly those areas where the edges of the cathode article would promote an uneven distribution. The masking also blocks off current throw to the spacing between the housings. Such masking is unnecessary if cathodic spacers are utilized as mentioned earlier. Active anode pieces **23,** such as nickel, are collected and stacked in the basket for intimate interengagement with each other and with the basket.

An anodic film is formed on the titanium basket which affords corrosion resistance and electrical insulation, the basket thereby being rendered anodically inert. The titanium acquires a thin-dense inert oxide film which is chemically resistant to acidic electrolytes and has a high electrical resistance. The current density, of course, is controlled by the configuration of the titanium basket even though the nickel anode pieces therein are the active anode metal. Current will pass between the basket and pieces at a contact point between the anodic film and the nickel pieces; this is so even though the film on the titanium is an electrical insulation.

To realize the objects of this invention, the anode walls **19** are defined with a predetermined variation from the nodes **24** of the epitrochoid configuration of cathode wall **11.** Such nodes or segments have a reverse curvature relative to the uniform curvature of the remaining portions **25** and **28** of the epitrochoid; in cross section, the portions **25** may substantially be arcs of circles. The cross sectional configuration of wall **19** has a pair of uniform arcuate segments **26** and **27** which are directly proportional and aligned with the segments **25** and **28** respectively of wall **11.** At stations on wall **19,** substantially adjacent the extremities of the reverse curvature segments **24,** varying arcuate segments **30** and **31,** each of which may have a different radius from that of the uniform segments, are employed. Each of these varying arcuate segments substantially continue or extend the curvature from each of the uniformly curved segments until they meet at a juncture **32** which is on the minor axis of the epitrochoid, or in other terms, has a radius **33** of the reverse curvature segment **24** passing therethrough and through a midpoint **34** of the reverse curvature. In this manner the total segment **30** or **31** is each comprised of two arcs meeting at an abrupt juncture and thereby rendering the combination as varying in curvature.

As shown in FIG. **3,** the uniform segments **27** and **26** are formed from cricles which overlap. It is possible that for some types of epitrochoids or compound cathode surfaces, the circles should be made tangent. In any event, the deviation (distance **36** - distance **35**) should be progressively varied according to the relationship whereby the deviation is inversely proportional to $\sqrt{\text{C.D.}}$, where C.D. is current density, provided such factors as the conductivity of the solution and temperature are constant.

METHOD OF MAKING ANODE ASSEMBLY

A preferred method mode according to this invention with respect to FIG. **4,** comprises:

1. Prepare solid titanium end plates **44** and **45** with identical continuous groove **46** and **47** respectively, each groove defining a semi-conforming configuration to that of the cathode surface. In this case, the semi-conforming configuration comprises two uniform arcs **40** and **41** connected by varying segments **42** and **43.** The varying segments are adapted to render a predetermined deviation away from the cathode surface at these areas to promote uniform plating thickness.

2. Assemble a flexible web of titanium expanded sheet metal (having a mesh size no greater than **150**) with the longitudinal edges **50** and **51** of the web in the grooves **46** and **47** respectively. The web is overlapped upon itself at a seam **52** to define a sleeve-like wall with a uniform cross section reflecting the uniformity and deviations of said grooves.

3. Locate the ends of posts **53** and **54** in mating seats **55** in the end plates to effect a strong stable joint between said plates.

4. Stitch the seam **52** with titanium wire, and fill the assembly with a collection of nickel anode pieces.

5. Provide suitable electrical means for applying a potential to the web.

We claim as our invention:

1. A method for fabricating an anode assembly for an electroplating process, comprising:

a. preparing a pair of flat impervious titanium end plates with a continuous groove in each defining an epitrochoid configuration except adjacent the minor axis of said configuration whereat said groove is progressively displaced toward the major axis of the configuration to define a pair of inwardly directed apices,

b. provide a flat flexible perforate wall of titanium sheet metal and assemble said flexible wall with the edges thereof in the grooves of said end plates, the seam of said wall being secured by titanium stitching, and

c. locating a pair of spaced posts between said end walls to maintain a predetermined spacing therebetween independent of said flexible wall and for securing said flexible wall in said grooves so that any section of said flexible wall is maintained as a straight line between grooves in the opposing end walls.

2. The method as in claim **1,** in which the flexible perforate wall is assembled from a wire mesh fabric having a mesh size no greater than 150.

3. The method as in claim **1,** in which pieces of nickel are deposited in said enclosure defined by said plates and perforate wall, said nickel pieces being in contact with each other, with said perforate wall, and with at least one of said plates, said nickel pieces providing an active anode portion and the configuration defined by said plates and perforate wall providing a passive anode portion, said anode portions being complete upon application of current thereto, whereby a thin dense anodic inert oxide film is formed on the surfaces of said plates and perforate end wall thereby affording electrical insulation and assisting in the control of current density.

4. The method as in claim **1,** wherein continuous elastic bands of inert material are mounted snugly around the exterior of said flexible wall stationed between said end plates and in said grooves, said bands being located along a predetermined elevation to further assist in controlling current density.

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