

[54] **ELECTROCHEMICAL PROCESSING OF
INNER SURFACES OF LARGE VESSELS**[76] Inventor: **John F. Jumer**, 16 West Timber
Trails Dr., Elmhurst, Ill. 60126[22] Filed: **July 23, 1973**[21] Appl. No.: **381,693****Related U.S. Application Data**[62] Division of Ser. No. 173,581, Aug. 20, 1971, Pat. No.
3,772,163.[52] **U.S. Cl.**..... 204/26, 204/129.6, 204/212[51] **Int. Cl.**..... C23b 5/56, C23b 5/68[58] **Field of Search**..... 204/26, 129.6[56] **References Cited****UNITED STATES PATENTS**

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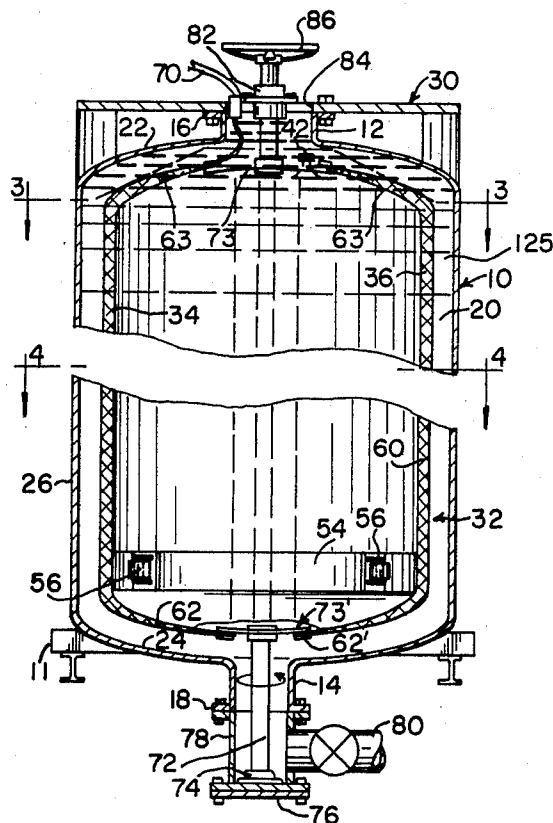
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Primary Examiner—T. M. Tufariello

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& Alex[57] **ABSTRACT**

A portable electrode assembly is disclosed for passage through restricted openings and convenient set-up within relatively large vessels for the purpose of electrochemically processing or treating the inner surface of the vessel without removing the vessel from its associated permanent support structure. In preferred embodiments, high density electrolyte solutions are used with electrode assemblies which include means for displacing substantial quantities of the electrolyte while providing support for the electrode elements.

3 Claims, 9 Drawing Figures

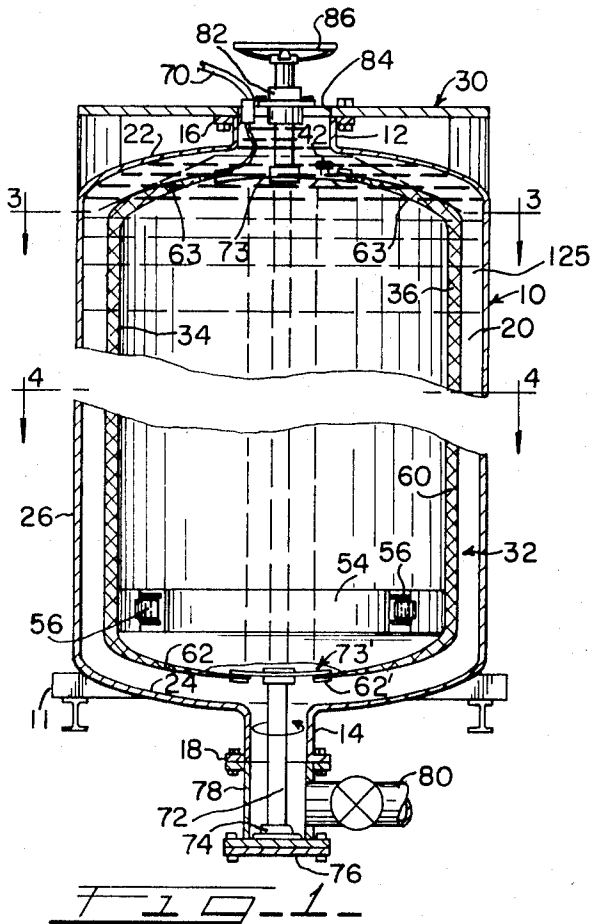


FIG. 2

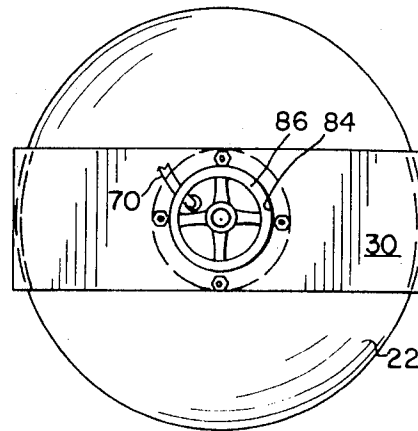


FIG. 3

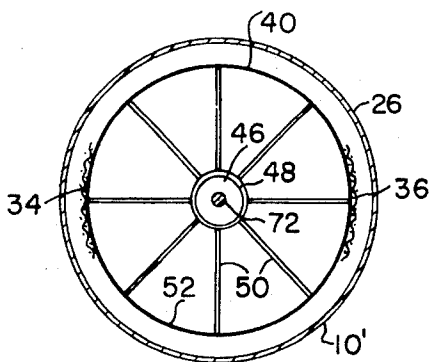
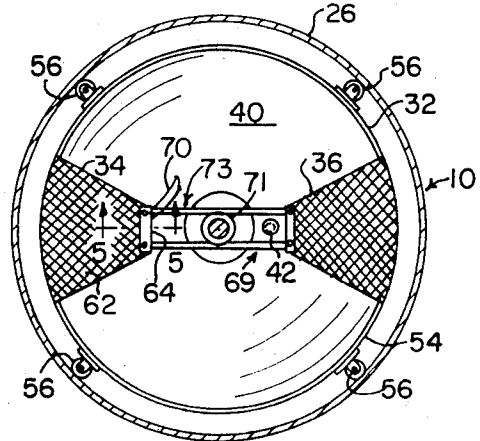
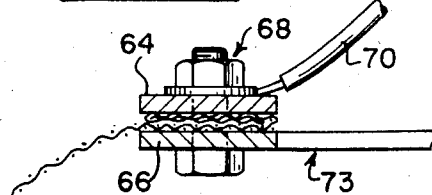
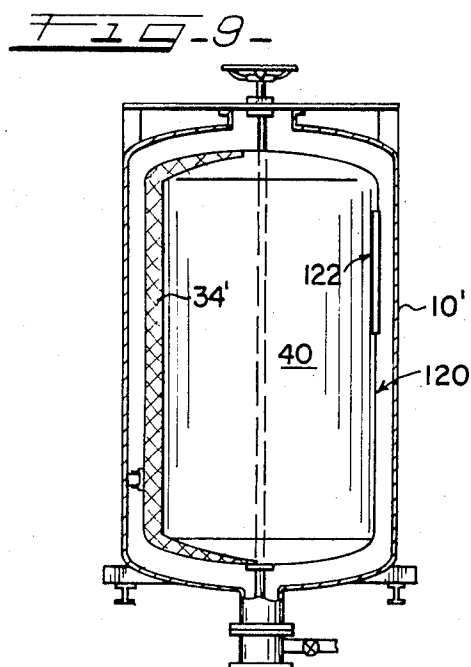
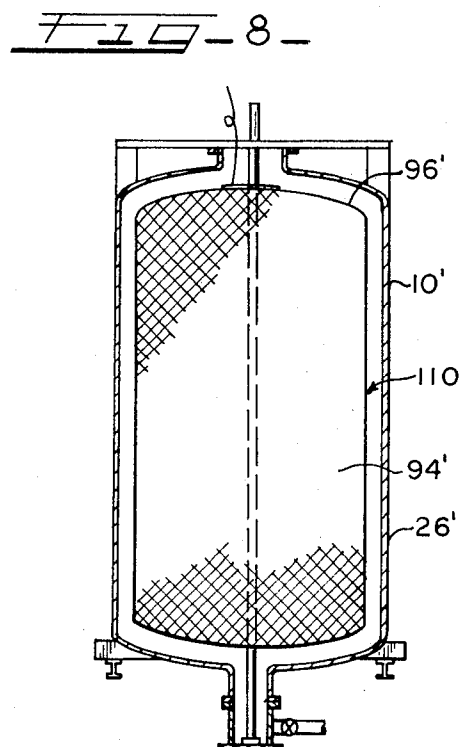
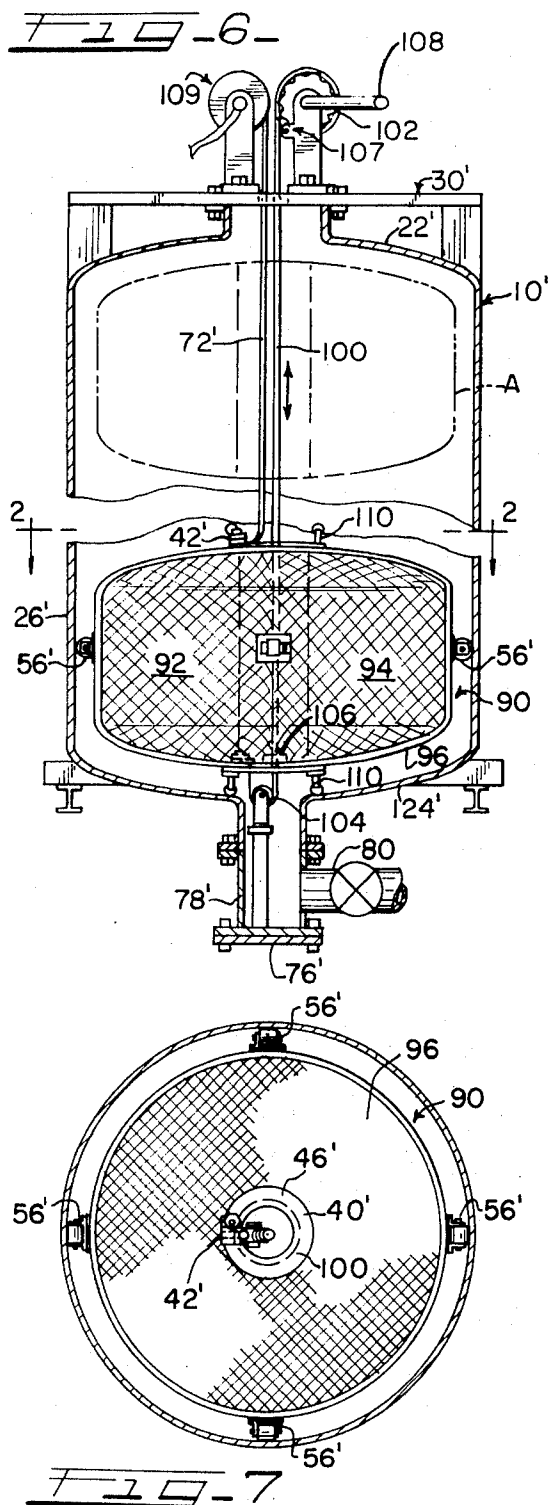


FIG. 5





ELECTROCHEMICAL PROCESSING OF INNER SURFACES OF LARGE VESSELS

This is a division of application Ser. No. 173,581, filed Aug. 20, 1971, now U.S. Pat. No. 3,772,163.

This invention relates to innovations and improvements in the electrochemical treatment of interior surfaces of vessels which are permanently mounted and fitted with relatively narrow manways. The invention can be utilized for conveniently and economically electroplating, electropolishing, anodizing, electrocleaning or for other electroprocessing or electrotreating operations on the inner surfaces of vessels.

Large vessels are widely used in industry as reactors or pressure vessels and usually they are installed permanently secured on associated support structures in a vertical or upright position. Many such vessels are enclosed within buildings, and the operations involved in removing such a vessel for processing its inner surface are usually prohibitively expensive. Moreover, many such vessels are installed with mechanical support structure which is only adequate to safely accommodate fluids which have relatively low specific gravities, e.g., 1.0 or less. Hence, it is often unsafe to fill such equipment with a high density electrolyte, e.g., one having a specific gravity of approximately 1.7, such as are commonly used in connection with electropolishing, for example. Furthermore, most tanks, reactors, and pressure vessels of the class described are not provided with large removable lids or ends, and the entrance openings, typically a manway, tend to be quite small, relatively speaking. For example, a small manway with hinged and bolted hatch or cover may serve a vessel of 5,000 gallon capacity.

Moreover, because of the extremely large capacity of many upright reactors, pressure vessels, and other vertical vessels widely used in industry, it would be most undesirable to fill such vessels with electrolyte solution to capacity in order to immerse the electrode therein. After use in electrochemical processing, generally, electrolyte solutions are recovered for salvage of metal values, and in any event, are generally not discharged into sewers because of potentially adverse impact on municipal sewage treatment plants, streams, and the like. The large volume of electrolyte to be recovered and reclaimed, if such large vessels were filled to capacity, would make such an operation undesirable.

It is an object of the present invention to provide a method and an electrode apparatus by which vessels of the class described can be processed in place by electrochemical processing. It is another object of the present invention to provide an electrode assembly or apparatus in which electrodes can be positioned singly or in multiples fixed or movable, and with the active areas of the electrodes juxtaposed and substantially uniformly spaced from the interior surface of the vessel being processed for a period of time necessary to adequately process the inside surface. Moreover it is an object of the present invention to provide such an electrode system for electrochemical processing of the inside of a relatively large vessel using high density electrolyte solution even though the vessel be designed for use in connection with relatively low density fluid.

It is another object of the present invention to provide an apparatus and a method for electrochemical processing of inner surfaces of large vessels which achieve effective electrochemical processing of the in-

terior surface of said vessel without requiring that the vessel be filled to capacity with high density electrolyte solution.

Many upright tanks or pressure vessels have a domed bottom and a domed top which can be referred to as heads, with central openings or ports in the bottom for emptying, etc. and with central ports and/or nozzles in the top. It is an object of the present invention to utilize central top and bottom ports for the introduction and operation of an electrode system which can be introduced through a manway for the purpose of electrochemically processing the inside surface of the vessel. It is a further object of the present invention to provide an electrode system which can be adapted for use to electrochemically treat only a portion of the total inside area of the vessel at any one time, whereby power equipment and conductor size is reduced to a conveniently practical level, and also the problem of gas accumulation in the underside of the top head is reduced or eliminated. It is a further object of the present invention to provide an electrode system which can be shaped to conform to standard top and bottom head configurations whereby the top and bottom head of the vessels can be electrochemically treated simultaneously with the substantially cylindrical side walls of the vessel.

These and other objects are achieved in accordance with the present invention, which is described in connection with preferred embodiments, as well as in general terms in the following description with the aid of the accompanying drawings in which:

FIG. 1 is a vertical sectional view with certain parts shown in elevation, of a preferred embodiment of the invention as applied to a large vertical permanently mounted vessel;

FIG. 2 is a top plan view of the structure illustrated in FIG. 1;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is a reduced scale cross-sectional view taken approximately along the line 4—4 of FIG. 1;

FIG. 5 is an enlarged fragmentary detail sectional view taken on line 5—5 of FIG. 3 showing the upper electrical connection with one electrode element;

FIG. 6 is a fragmentary partially cross-sectional elevational view of another embodiment of this invention in a large vertical permanently mounted vessel;

FIG. 7 is a sectional view taken on line 7—7 of FIG. 6;

FIG. 8 is a partially sectional view of an alternative embodiment of this invention; and

FIG. 9 is a partially sectional view of another alternative embodiment of the present invention.

Referring to FIG. 1, a large vessel is generally indicated at 10. For the purpose of simplifying and clarifying the illustration of the invention, FIG. 1 does not show all of the conventional support elements 11 for supporting vessel 10. It is to be understood that vessel 10 is intended to illustrate any one of many well known reactor or pressure vessels. These vessels commonly are enclosed within a building, and may extend through one, two or more stories of the building. Typically the vessels such as 10 are provided with at least a manway in the top 12 and a bottom drain opening 14. The manway 12 and drain opening 14 typically have flanges 16, 18, respectively. It is to be understood that in a specific installation vessel 10 may have one or more conven-

tional inlet or outlet connections which communicate with the interior 20 either through domed top 22, domed bottom 24 or the side wall 26.

Typically manway 12 is accessible from a catwalk generally indicated at 30 which is supported on vessel 10 or on other conventional structural elements.

A preferred electrotreating apparatus for vessel 10 in accordance with this invention is indicated generally at 32. The electrode apparatus includes a pair of copper mesh electrodes 34, 36 supported on a large inflatable plastic liquid displacing bag 40 having a capped stem 42. Bag 40 is toroidal in horizontal section and in exterior shape conforms generally to the interior of the vessel 10. The bag 40 has a centrally located cylindrical passageway 46, cylindrical inner wall 48, a number of reinforcing dividers 50 connecting inner wall 48 and outer wall 52. Band 54 formed of stiffly resilient dielectric material passes around bag 40 near the lower end thereof and serves to reinforce the bag 40 in the regions of insulated spacing rollers 56 and also provide support for the rollers. It will be appreciated that three or more of rollers 56 should be used around the circumference of band 54 to maintain proper clearance between side walls 26 and electrodes 34, 36.

In the embodiment illustrated in FIGS. 1 through 5, electrodes 34, 36 include elongated curved wall portions 60, 61 respectively, which conform to the inside lateral face 26, and two sector shaped portions 62, 63 conforming to bottom 24, and top 22, respectively. Referring to FIGS. 3 and 5, the respective radially innermost or terminal ends of electrode 34, 36 are clamped between respective clamping bars 64, 66 by nuts and bolts generally indicated at 68. Clamping bars 64, 66 are electrically connected to each other by means of electrically conductive cross bars 69. Electric lead 70 is bolted to clamping bar 64 and provides uniform distribution of current to both electrodes 34, 36. Cross bars 69 are clamped between tightenable sections of a two-part collar 71, one part of which is fixed to rod 72. Clamping bars 64, 66, and cross bars 69, and collar 71 can be considered an electrode support assembly 73, and an identical assembly 73' fastens the other ends of the electrodes 34, 36. Collar 71 is formed of dielectric material so as to insulate rod 72 from cross bars 69.

In assembling the apparatus 32 shown in FIG. 1, electrodes 34, 36 are passed through manway 12, and bag 40 is passed through manway 12 in collapsed condition. One or more bands 54 are passed through manway 12 in open condition and ends are joined to provide resilient annular structures 54. Rod 72 is then passed through manway 12, and seated in socket 74. Collar 71 can be fastened to rod 72 before its entry into vessel 10, and clamping bars 64, 66 and frame assemblies 73, 73', generally, can be attached, as described hereinbefore, while inside vessel 10. Electrodes 34, 36, are fastened to bands 54, and to clamping bars 64, 66. Bag 40 is fastened to bands 54, while unfilled, and the assembler leaves the vessel before spider 84 is secured.

In order to provide for accurate location and operation of the apparatus 10 of this invention, rod 72 extends through passageway 46 and is secured at its bottom end in thrust bearing 74 of known type capable of absorbing downward thrust resulting from the weight of the electrodes 34, and 36, and liquid-displacing container or bag 40. Thrust bearing assembly 74 is secured to end plate 76 which, in turn, is bolted to "T" 78 having valved side outlet 80. The upper portion of rod 72

is supported in suitable thrust bearing assembly 82 which is maintained centered in manway 12 supported in the center of a spider 84. The thrust bearing 82 should be capable of absorbing the upward thrust due to buoyancy of the liquid-displacing container or bag 40. Handle wheel 86, and top and bottom frame members 73, 73' are fixed with respect to rod 72. Hence rotation of handle 86 causes rotation of rod 72 and, with it, frame elements 73, 73' and the rest of the electrode assembly 32. It will be appreciated from a consideration of FIG. 3 that the electrodes 34, 36 cover a relatively small portion of the surface area of the inflated bag 40. For example in the embodiment illustrated in FIGS. 1 through 5 electrodes 34, 36 are each approximately 50 inches wide and together cover approximately 28 percent of the total exterior of displacer 40.

Thus in the embodiment illustrated in FIGS. 1 through 5, electrodes 34, 36 can be considered to be axially extending elongated strips and the entire surface of the vessel 10 can be electrochemically treated by rotated electrode assembly 32 around its elongated vertical axis.

In operation of the invention a conventional electrolyte is pumped into vessel 10, and a liquid-displacer such as water is charged to bag 40 until vessel 10 and bag 40 are filled. Thus only a relatively small amount of electrolyte is required.

During operation of the apparatus of the present invention, vessel 10 is electrically grounded and an electrical potential is applied at electrical lead 72. Whether the lead 72 is made positive or negative depends on whether electroplating, electropolishing, etc. is to be performed. Handle 86 is turned as desired to rotate assembly 32 to uniformly process the entire inner surface of the tank.

An alternative embodiment is shown in FIGS. 6 and 7 in which an electrode extends 360° horizontally but extends along a relatively short portion of the vertical length of the side wall of the vessel the interior of which is to be electroprocessed. In this alternative embodiment portions of the vessel and associated structures correspond to those shown in FIGS. 1-5, and are identified in FIGS. 6 and 7 by primed numbers.

The alternative electrode assembly is generally indicated by the numeral 90 in FIGS. 6 and 7 and includes electrode 92. A substantially toroidal bag 40' is positioned within closely adjacent screen electrode 92 and, in the illustrated embodiment, electrode 92 has relatively short laterally facing portions 94 and end walls 96. Laterally facing portions 94 are maintained spaced apart from inside lateral face 26' of vessel 10' by insulated rollers 56' whose axles run horizontally, rather than vertically. Bag 40' is equipped with a stem 42' for filling and emptying and is toroidally shaped to provide vertically extending inner passageway 46'. A rope or cable 100 passes around drum 102, through passageway 46', around bottom pulley 104 and is fastened at connector 106 to bag 40'. Bottom pulley 104 is fixed to plate 76' which, in turn, is bolted to "T" 78'. The drum 102 is fitted with conventional ratchet mechanism generally indicated at 107 whereby rotation of drum 102 can be controlled by applying forces to drum handle 108 to raise or lower electrode mechanism 90, and the broken line silhouette marked "A" in FIG. 6 is intended to indicate the top or upper position of electrode assembly 90. It is noted that the end walls 96 of assembly 90 are shaped to have approximately the

same contour as top wall 22' and bottom wall 24' of container 10'. A number of end spacers 110 are provided to keep the distance between respective end portions 96 and top wall 22' and bottom wall 24' a suitable distance for electrochemically processing the inner faces of end walls 22', 24'. Thus, the embodiment shown in FIGS. 5 and 7 is similar to the embodiment illustrated in FIGS. 1-5 inasmuch as only a small portion of the inner face of the vessel 10, 10' is in operating association with the respective electrodes 24, 26, 92, 96 at any one time. The embodiment shown in FIG. 6, however, differs from the embodiment shown in FIGS. 1-5 inasmuch as the entire circumference of electrode assembly 90 is covered with electrode 92, and electrode 92 extends in an axial direction for only a relatively small fraction of the axial dimension of side wall 26' of vessel 10'. In the embodiment shown in FIG. 6 the electrode assembly 90 is permitted to float upwardly, and is moved downwardly by controlling cable 100. Thus line 100 is payed out to raise the electrode assembly 90, and reeled in to lower it. A suitable biased take-up reel generally indicated at 109 keeps electrical lead 72' taut as electrode assembly 90 moves up and down within vessel 10'.

In the alternative embodiment illustrated in FIG. 8 an electrode assembly is generally indicated at 110 and the details of its construction are substantially identical to the construction described in connection with FIGS. 1-5. However, inner lateral face 94' extends substantially the entire length of side wall 26' and ends 96' are closely spaced apart from the top and bottom of vessel 10' which is identical to the vessels described in connection with the other embodiments herein. In the latter embodiment it is unnecessary to provide means for raising and lowering or for rotating about a vertical axis since the entire inner surface of the walls of vessel 10' have an electrode mesh closely adjacent thereto, and in operating association therewith.

Although electrode 92 is shown with an integral electrode grid around its entire circumference, it is contemplated that electrode grid 92 can be assembled from a plurality of axially extending strips, each similar to electrode 34, 36, placed side by side to provide a complete 360° electrode grid. In such an embodiment the respective electrode strips, e.g., 34, 36, are passed through manway 12 in a slightly folded condition and displacement medium container 40 is positioned within the electrode strip circle. Thereafter the upper portions of the respective electrode strips 34, 36 are fastened, as illustrated in FIG. 5 herein, to a suitable framing element, e.g., 63, with appropriate electrical connections being made thereto. As electrolyte 125 is introduced into vessel 10, for example through valve line 80, a suitable electrolyte displacing material is charged to container 40. If vessel 10 and its associated supporting structures (not shown because conventional) have been designed to accommodate a high density fluid, water or a relatively high density displacing fluid can be added to container 10 to fill it out and provide a suitable configuration for supporting the electrode grid, e.g., 34, 36. However, if vessel 10 and its associated supporting structure has been designed for use solely in connection with relatively low density fluid, it is preferred that container 40 be filled with a relatively low density material, and a particulate plastic capable of being pneumatically conveyed, and capable of removal by conventional vacuum conveyor, is preferred.

In another alternative embodiment, which is shown in FIG. 9, elongated vertical electrode 34' is used along only one side of container 40, and a counter weight 122 is suspended from the opposite side of frame 63. This embodiment corresponds to that shown in FIGS. 1-5, except that electrode 36 is replaced by counterweight 122. In operation it is necessary to rotate the electrode assembly 120, in order to electro-treat the entire inner surface of vessel 10'.

In the operation of the invention, container 40 is filled with an electrolyte displacing material, and the preferred density of the material utilized within bag 40 will depend, to a great extent, on the engineering details of the supporting structures of the particular vessel 10 and on the safety factor used in designing vessel 10. For example, in the case of a vessel which was designed, along with its supporting structure, to contain and process a relatively low density liquid, e.g., 0.8, it may well be advisable to avoid filling such a vessel with a high density electrolyte, e.g. one having a specific gravity of 1.7. In this instance, it would be highly desirable and probably advisable to displace most of the electrolyte with a relatively low density displacing material for reasons of safety. It is contemplated that container 40 can be filled with a gas such as air, with a relatively low density liquid such as water, or oil, etc., or with a solid, such as discrete particles of low density plastic which can be charged to container 40 and withdrawn therefrom by means of appropriate conventional vacuum or gas stream conveying systems.

Also, it is contemplated that the displacing means used in this invention could also be provided in the form of a self-contained material such as one or more large, preferably elongated pieces of relatively light weight solid material which are fastened to the electrode assembly in place of container or bag 40. Elongated blocks having the cross section of a truncated sector of a circle, can be used, for example, to form a cylindrical body similar to bag 40 as shown in FIG. 4. Blocks of styrofoam, or polyurethane can also be used.

It will be apparent that modifications and changes can be made with respect to the specifically described illustrations herein without departing from the spirit or the scope of the invention. For example, although container 40 is described in connection with the illustrated preferred embodiment has been referred to as a plastic, it is contemplated that non-plastic, or even porous materials such as screens or mesh can be used to confine larger low density plastic spheres, for example, providing that the material which is used for the container, and the electrolyte-displacement material are both compatible with the electrical and chemical environment.

As indicated above, it is most preferred that the respective electrodes utilized in the invention be cooperatively associated with a relatively small portion of the total interior surface of the vessel 10. The main reason for this is the fact that such an apparatus can provide the relatively high ampere per square foot surface throughput, while requiring a total current supply which is conveniently manageable. In a preferred method of operating, utilizing the embodiment described in FIGS. 1-5 herein, it is preferred that the rotation of the electrode assembly 32 around its vertical axis is constant, and in the same direction. Constant rotation in the same direction better assures uniform treatment of the vessel. However it is not essential that

the electrode assembly 32 be rotated only in a given direction, and back and forth rotation is entirely satisfactory.

With respect to the other details of operation, e.g. the current levels, etc. the operation of the present invention is governed by well known electrochemical processing techniques and principles.

The invention has been described in general terms, and in connection with several preferred embodiments. However, the specific examples provided herein are for illustrative purposes only, and changes can be made without departing from the spirit or scope of the invention. Hence, the invention is not limited to the specific illustrations herein, and has the scope of the claims appended hereto.

I claim:

1. A method of electroprocessing the electrically conductive interior surface of a stationary large capacity upright vessel of uniform cross section having at least one top and one bottom opening therein which openings are relatively small compared to the girth of said vessel, comprising: securing anchor means in said bottom opening; attaching to said anchor means inflatable buoyant electrolyte displacer means having a uniform cross-sectional shape when inflated corresponding generally to that of the interior side wall of said vessel but having a height when inflated that is substantially shorter than the height of said vessel and inflating said displacer means until the exterior side wall surface thereof is adjacent to said interior side wall surface with approximately uniform space therebetween; covering the exterior side wall surface of said inflated electrolyte displacer means with an endless electrode, operatively connecting position control means with said inflated electrolyte displacer means so as to permit raising and/or lowering thereof through at least one said top open-

ing; introducing and maintaining an electrolyte in substantially the entire space separating said exterior surface of said electrolyte displacer means from said interior surface of said vessel, the actual amount of electrolyte in said vessel being substantially less than the capacity thereof, and the combined volumes of said electrolyte and said submerged electrolyte displacer means being substantially equal to said vessel capacity; passing an electrical current through said electrolyte between said electrode and said interior surface; and, raising and/or lowering said inflated electrolyte displacer means to electroprocess all of said interior side wall surface.

2. The method called for in claim 1 wherein the shape of the exterior bottom surface of said electrolyte displacer means when inflated is substantially the same as that of the inner surface of the bottom of said vessel, covering said bottom surface of said inflated displacer means with an electrode, and passing an electrical current through said electrolyte between said bottom electrode and said inner bottom surface of said vessel when said inflated electrolyte displacer means is in its lowermost operating position so as to also electroprocess said inner bottom surface.

3. The method called for in claim 2 wherein the shape of the exterior top surface of said electrolyte displacer means when inflated is substantially the same as that of the inner surface of the top of said vessel, covering said top surface of said inflated displacer means with an electrode, and passing an electrical current through said electrolyte between said top electrode and said inner top surface of said vessel when said inflated electrolyte displacer means is in its uppermost operating position so as to also electroprocess said inner top surface.

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