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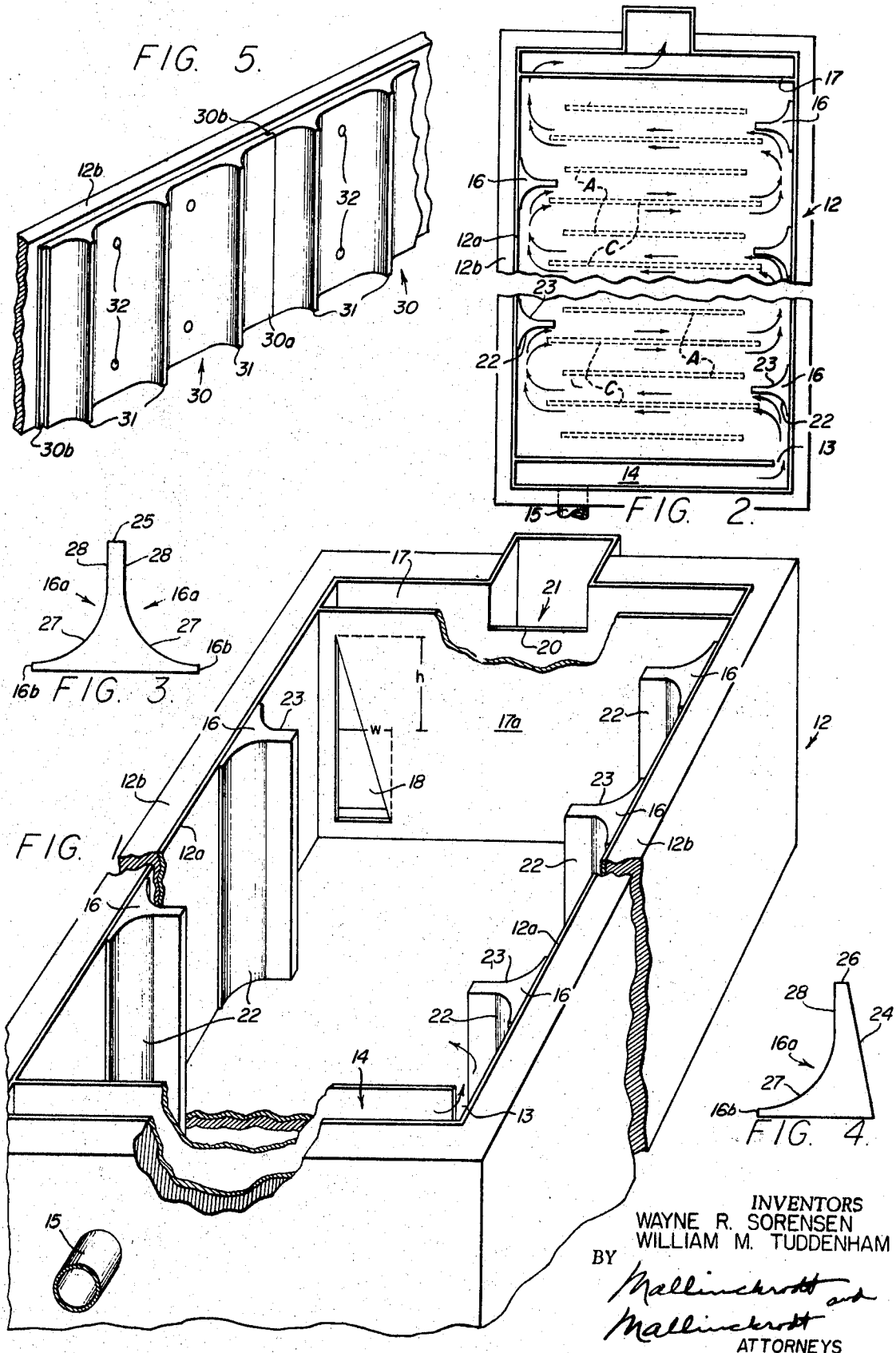
W. R. SORENSEN ETAL

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ELECTROLYTE-CIRCULATING, ELECTROLYTIC CELL

Filed March 4, 1968

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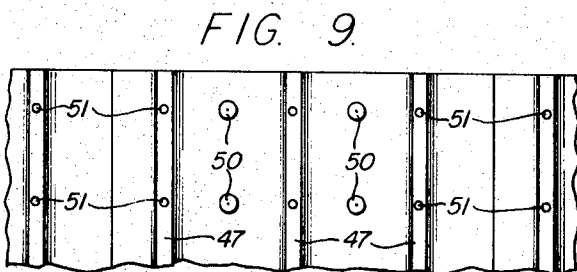
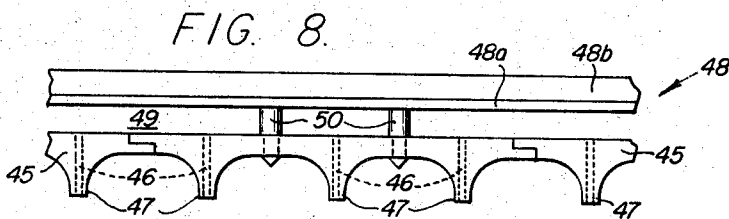
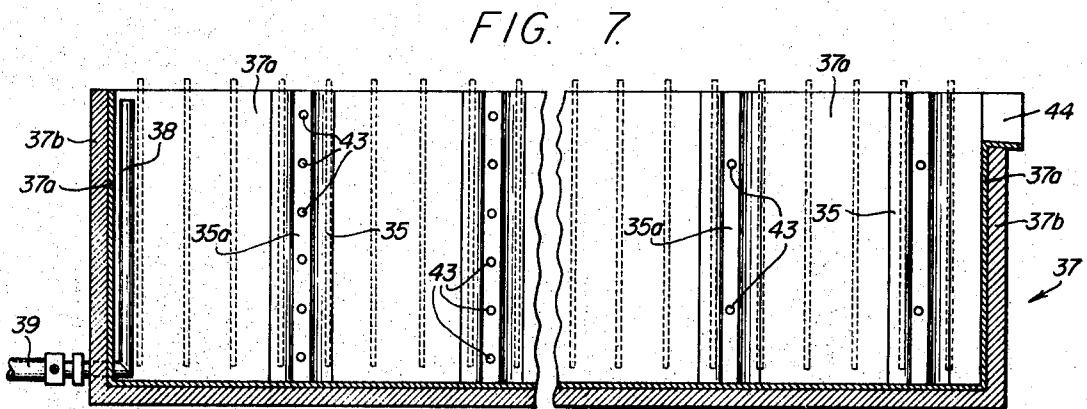
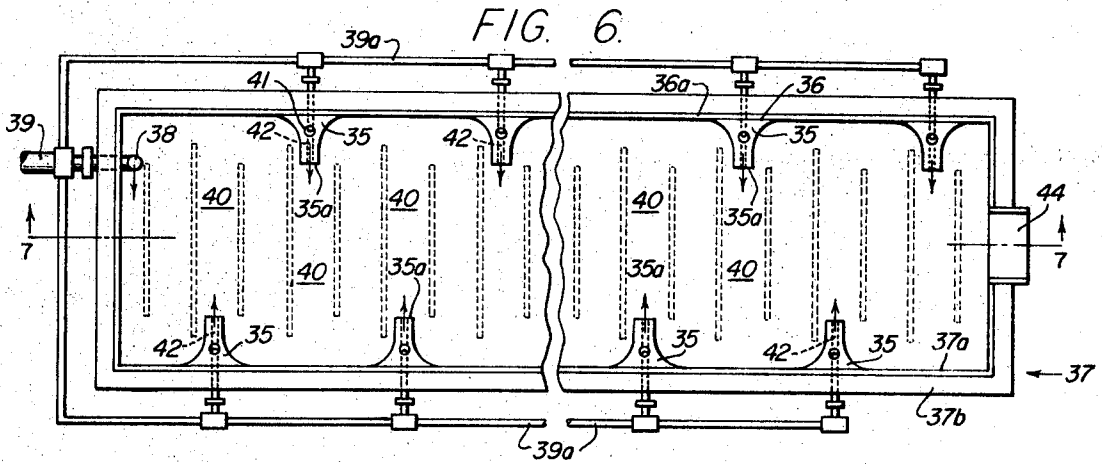
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FIG. 10.

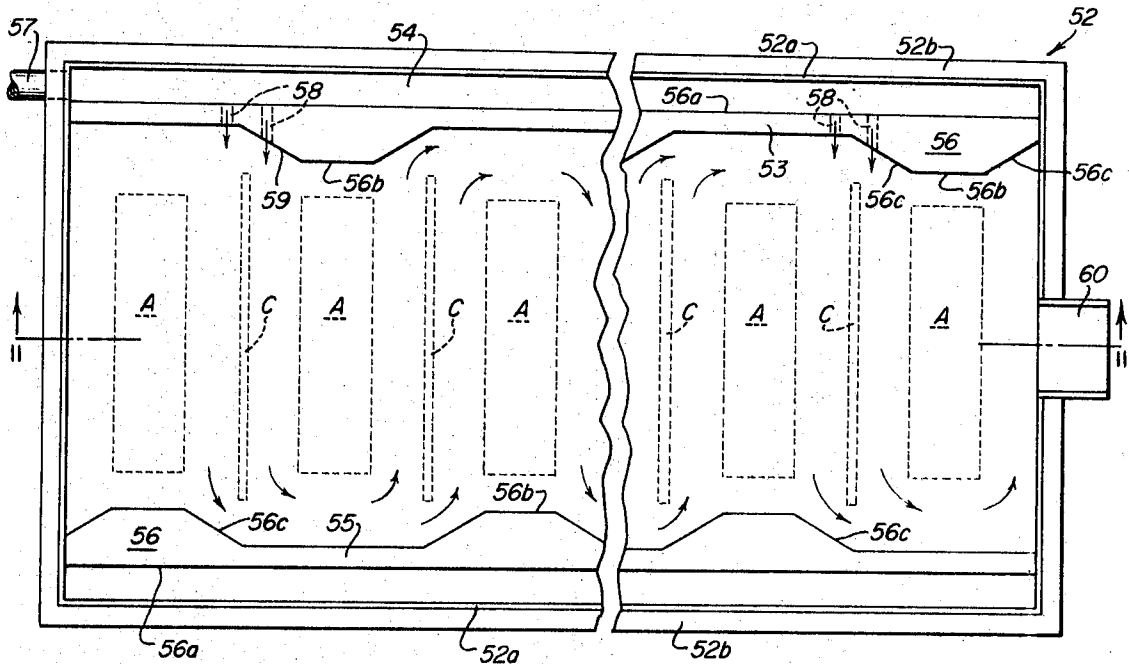
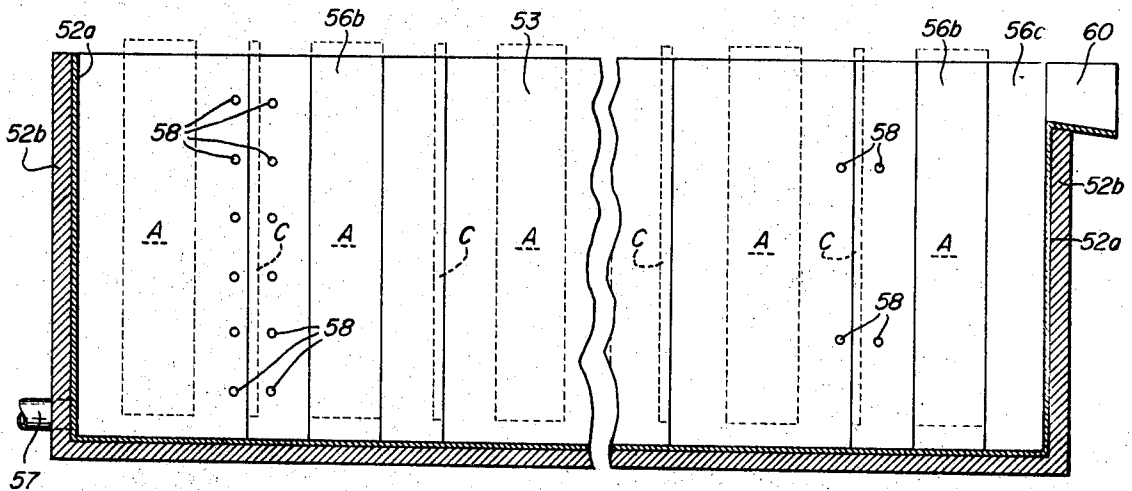


FIG. 11.



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ELECTROLYTE-CIRCULATING, ELECTROLYTIC CELL

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15 Claims

ABSTRACT OF THE DISCLOSURE

An electrolytic cell constructed for effective circulation of electrolyte relative to the electrodes. Electrolyte-deflecting stub baffles or fins are provided for the respective cathodes at corresponding locations alternating between opposite sides of the cell. Each deflector has a flow-deflecting surface, leading from a side wall of the cell to an area near the adjacent end of a corresponding cell cathode. Such surface preferably comprehends both faces of the cathode in its sweep, with its tip extending to or slightly overlapping the cathode. The electrolyte inlet to and outlet from the cell are advantageously of special formation, as are the deflectors themselves.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to electrolytic cells in general, but is particularly concerned with electrowinning and electrorefining cells such as are commonly employed in the production of copper.

State of the art

Present-day, commercial, electrolytic techniques for either refining blister copper or for winning copper values from solution are largely standardized. Both processes involve depositing copper ions from an electrolyte solution on cathode electrodes in an electrolytic cell. The cathodes are typically thin copper sheets. The anodes of electrorefining cells are blister copper, containing impurities; they dissolve in the electrolyte. The anodes of electrowinning cells are typically constructed from an alloy of lead, antimony, and silver and serve only to conduct electricity. In both types of cells, copper is plated out of the electrolyte bath onto thin copper cathode starter sheets by electrolytic action when an electric current is applied to the electrodes. After sufficient copper has been plated out on the cathode starter sheets, the thus-enlarged cathodes are removed from the cell and are replaced by fresh cathode starter sheets.

Electrolytic cells employed in electrorefining and electrowinning are similar in construction and operation. These cells will often be employed interchangeably as needed in either electrorefining or electrowinning circuits. An electrolytic cell usually comprises a rectangular tank, in which a series of electrodes, alternating anode and cathode sheets or plates, are suspended in mutually spaced, interleaved arrangement to dip deeply into a bath of a suitable electrolyte contained by the tank. The circulated electrolyte is normally fed into the tank at one of its ends and discharged at the opposite end, a predetermined depth of electrolyte being maintained in the tank by a weir or comparable means.

The desirability of improving the circulation pattern for electrolyte in these electrolytic cells has long been recognized. According to certain proposals, baffles have been interposed between the spaced electrodes. Such baffles have, however, resulted in undesirable turbulence and

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consequent etching of the cathodes at flow rates required to maintain deposition of an acceptable degree of uniformity.

SUMMARY OF THE INVENTION

The principal purposes of this invention are to improve the quality of cathodes produced in electrorefining and electrowinning cells by reducing excessive turbulence of the electrolyte passing through such cells, and to make it economical to maintain higher current densities in such cells by improving electrolyte circulation.

Instead of interposing baffle plates between the spaced electrodes to force the electrolyte to closely follow a tortuous path in its passage through the cell, fin-like deflectors, preferably in the form of stub baffles, are provided at opposite walls of the cell in association with respective cathodes.

An electrolytic cell of the invention includes an elongate tank, usually of rectangular configuration, having an outlet for electrolyte at one end, a plurality of interleaved anode and cathode electrodes spaced in conventional manner transversely of the tank, and a plurality of the aforesaid fin-like deflectors located as needed or desired along lateral walls of the tank. Considering the outlet end of the tank to be downstream, each deflector is formed and mounted to project from a lateral wall of the tank to a terminus located downstream of a corresponding cathode and at or slightly overlapping the adjacent end thereof. Thus, electrolyte flowing longitudinally of the tank adjacent to a lateral wall thereof is diverted by the lead faces or surfaces of the deflectors and is caused to flow transversely across the cell, substantially parallel to the electrodes.

Desirably, there is provided one deflector for each cathode in the cell. The deflectors are mounted alternately on respectively opposite lateral sides of the tank, with one deflector advantageously disposed directly in front of the electrolyte inlet when such inlet is located at the end of the tank opposite the discharge end. Inlets for the electrolyte, however, are advantageously distributed along at least one lateral wall of the tank in accordance with the general concepts taught by the copending application of Lebrizzi et al., Ser. No. 710,040, filed Mar. 4, 1968, entitled "Electrolytic Cell." Here, however, the inlets for electrolyte are advantageously closely associated with the several deflectors such that the electrolyte is most effectively directed in parallel flow relationship with the electrodes.

In their presently most preferred form the deflectors are each of generally prismatic formation, with two of the three sides concavely curved uniformly along their lengths from the third side around a quarter segment of a circle, such third side serving as a base for attachment to the cell wall. The concavely curved sides continue rectilinearly to form a stub end, which preferably projects inwardly of the tank to or beyond the corresponding cathode. Each deflector is preferably symmetrically formed at opposite sides of a center reference plane passing through its stub end and along its height.

The outlet for electrolyte from the cell is preferably of right-triangular configuration, extending from the normal level of electrolyte near the open top of the cell tank to the bottom of the cathodes. As so provided and as illustrated, such outlet is a vertically extending, upwardly tapering, triangular opening. From a processing standpoint, its triangular shape is preferably correlated to the specific gravity of the electrolyte such that the width w of the triangle at any given depth h below the electrolyte surface is calculated by the expression $w = h/s$ where s is the specific gravity of the electrolyte.

Although the specified curvature for the concave surfaces of this preferred form of deflector is much preferred,

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merely making the lead surfaces of the deflectors concavely curved is an advantage for this type of deflector. As will appear hereinafter, however, there are instances in which planar lead surfaces for the deflectors are entirely acceptable.

In some embodiments, instead of being unitarily formed, a plurality of the deflectors may be formed as, or supported from, a single panel adapted for mounting on the cell wall to extend therealong and provide proper placement of each deflector relative to the corresponding cathode. If desired, several such panels, formed as wall liner sections, may be arranged to interlock to form a lateral wall or wall liner for the cell tank.

THE DRAWINGS

There are illustrated in the accompanying drawings constructions representing the best modes presently contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a fragmentary pictorial view of a preferred form of cell tank for electrowinning operations, looking from above the inlet end and with intermediate and other portions broken out for convenience of illustration;

FIG. 2, a corresponding top plan view drawn to a reduced scale, the electrodes being indicated by broken lines;

FIG. 3, an enlarged top plan view of one of the deflectors shown in the preceding views;

FIG. 4, a top plan view of another form of deflector of this type;

FIG. 5, a fragmentary perspective view of two interlocking panel sections mounted on a lateral wall of a cell tank, each panel section providing a plurality of deflectors;

FIG. 6, a view corresponding to that of FIG. 2, but illustrating a form of the invention with respect to an electrowinning cell wherein the inlet for electrolyte is at one end and distributed along both lateral sides of the cell tank directly through the stub baffle deflectors;

FIG. 7, a longitudinal vertical section taken along the line 7—7 of FIG. 6;

FIG. 8, a fragmentary top plan view showing a portion of a lateral wall of a different form of the invention having a lateral side inlet for the electrolyte, wherein a panel similar to that of FIG. 5 is spaced from the cell tank wall as a false wall to provide an electrolyte supply header;

FIG. 9, a corresponding view in front elevation, i.e. looking from inside the cell tank;

FIG. 10, a view corresponding to that of FIG. 6, but illustrating a form of the invention with respect to an electrorefining cell, having stub baffle deflectors of different formation and a lateral side inlet for electrolyte corresponding in general with that of FIG. 8; and

FIG. 11, a longitudinal vertical section taken on the line 11—11 of FIG. 10.

DETAILED DESCRIPTION OF ILLUSTRATED EMBODIMENTS

In the electrowinning cell of FIGS. 1 and 2, an open tank 12 of rectangular formation contains electrodes in the form of plate anodes "A" and cathodes "C" with the usual vertical, suspension mounting and interleaved arrangement thereof and with standard electrical connections (not indicated). Electrolyte delivery to the cell is from the upstream end of tank 12 through an inlet slot 13 at one end of distributor box 14, which receives electrolyte from any suitable source by way of pipe 15. Slot 13 desirably runs the full depth of the cell, and, in this embodiment, is the only inlet for flow of electrolyte into the cell. It serves as a distributor for electrolyte being recirculated into the cell. Both it and feedbox 14 could be replaced by a vertically positioned length of perforated pipe, if desired, connected directly to supply pipe 15.

For directing flow of electrolyte into the spaces between adjoining electrodes, fin-like deflectors—here

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shown in the form of stub baffles 16—are fastened to the protective lining 12a, e.g. lead, polyvinylchloride plastic, etc., of the lateral walls 12b, e.g. reinforced concrete, of the tank 12 vertically and at strategic locations along the lengths of such lateral walls. As illustrated, the stub baffles 16 extend either the full depth or approximately the full depth of the tank and are located immediately downstream of each cathode "C," alternately at opposite ends of successive cathodes, whereby electrolyte flowing from the inlet to the outlet end of the cell is deflected so as to traverse both of the broad faces of each cathode in substantially parallel flow relationship therewith.

The first deflector 16, located farthest upstream in the cell, is positioned to present its lead face 16a in direct opposition to flow of electrolyte through slot 13, so as to intercept the flow and direct it substantially at right angles transversely across tank 12. The next deflector 16 is located farther downstream at the opposite lateral side of the tank in juxtaposition to the next cathode of the series, and similarly for the remainder of the deflectors.

Outflow from cell tank 12 into a weir box 17 is through an opening 18 formed in tank end wall 17a diagonally opposite inflow slot 11. Spent electrolyte flows from the interior of the cell tank through opening 18 into weir box 17 and over weir 20 into a discharge channel 21. Opening 18 is advantageously of right triangular formation. The width w at any given electrolytic depth h , i.e., at any depth h below the surface of electrolyte in the cell, is calculated by the formula $w=h/s$, where s is the specific gravity of the electrolyte.

Each of the stub baffle deflectors 16 is preferably of prismatic formation, as shown in FIG. 3, so that the several deflectors can be cut to length from stock lengths of material, such as extruded plastic material, and used at either side of the tank, either one or the other of the concavely curved faces 16a being the lead or upstream face 22 when installed in the tank. Although having the opposite or downstream face 23 of the deflector similarly concavely curved is advantageous from the standpoint of the total circulation pattern in the tank, this is important primarily from the standpoint of convenience and cost of manufacture, such opposite or downstream surface may be as shown at 24, FIG. 4, for example, where the deflector is not of symmetrical formation.

The opposite faces 16a and 16a, respectively, FIG. 3, or 16a and 24, respectively, FIG. 4, preferably terminate in a stub tip face 25 or 26, FIGS. 3 and 4, respectively, and each concavely curved face 16a preferably has its base portion concavely curved on a radius along a quarter segment of a circle, as at 27, merging into a rectilinear portion 28. This directs the flow of electrolyte in the most expeditious manner with respect to the corresponding cathode and with the least turbulence. Although the base of each of the stub baffle deflectors 16 and 24 here shown has stub thickness at its ends, see 16b, to provide structural strength, such ends can terminate in knife edges, see FIG. 6, depending upon the material employed, which further decreases turbulence.

Typical dimensions for the stub baffle deflector 16 are five inches from base to tip, a three inch radius for the concavely curved face portion 27 and a length of two inches for the rectilinear face portion 28. The stub tip face 25 or 26, is typically one-half inch wide and the stub ends 16b of the base portion are each typically one-quarter inch wide if not tapered to a knife edge as in FIG. 6.

As shown in FIG. 2, it is preferred that each of the stub baffle deflectors 16 be located with the concavely curved face portion 27 of its lead face 22 comprehending both the upstream and downstream faces of its corresponding cathode "C" and with the rectilinear extension 28 thereof projecting far enough to overlap the downstream face of such cathode. As previously indicated, additional deflectors are provided adjacent each cathode but on alternate sides of the cell to direct electrolyte back and forth across the

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cell parallel to the cathodes. The flow pattern of electrolyte is illustrated in FIG. 2 by arrows.

Interlocking deflector panels 30, FIG. 5, may be utilized, if desired, as inner liners for the outer lateral walls 12b of the cell tank. Each of such deflector panels 30 is formed with a plurality of stub baffle type of fin-like deflectors 31 appropriately spaced with respect to the electrode spacing of the cell with which it is intended for use. Thus, when the panels are mounted in the cell, with an end lip 30a of one panel butted against and overlapping a mating end lip 30b of an adjacent panel, the several deflectors 31 are aligned adjacent to the respective cathodes. The panels may be bonded to the inside faces of the outside lateral walls 12b of the cell tank by suitable bonding agents, or they may be fastened by screws, clips, bolts or equivalent means indicated 32.

The foregoing embodiments of the invention are not applicable in instances involving electrolytic cells of great length and/or relatively low velocity input of the electrolyte, for the deflectors introduce a flow-retarding factor that must be considered in cell design to maintain optimum rate of flow of the electrolyte relative to the electrodes throughout the length of the cell.

For such instances, electrolyte is introduced along one or both lateral walls of the cell tank in accordance with the general concept taught by the aforementioned co-pending patent application of Lebrizzi et al., Ser. No. 710,040.

In the embodiment of FIGS. 6 and 7, which corresponds in general with the embodiment of FIGS. 1 and 2, stub baffle type deflectors 35 have their bases 36 fastened to the protective lining 37a of lateral walls 37b of an electrowinning cell tank 37 in appropriate relationship with the cathodes "C" and anodes "A" as previously explained.

As illustrated, the base 36 of each deflector 35 has its opposite ends 36a tapered to a knife edge to eliminate turbulence, although the configuration of deflector 16 of the embodiment of FIGS. 1 and 2 could be used if manufacturing factors should outweigh the advantage gained by eliminating turbulence at the base.

There is an inlet 38 at one end of the tank for a portion of the electrolyte circulated through the tank from supply piping 39, but most of the electrolyte is introduced through the stub ends 35a of the deflectors 35 in direct flow relationship with the spaces 40 between mutually adjacent anodes and cathodes. For this purpose, each of the stub baffle deflectors 35 has a header passage 41 extending lengthwise therethrough centrally thereof and a series of relatively short inlet passages 42, FIG. 6, extending therefrom transversely of the length of the deflector to respective outlet ports 43, FIG. 7, along the longitudinal axis of the stub tip face. A system of branch piping 39a connects supply piping 39 with the header passages 41 of the respective deflectors.

Outflow of electrolyte from the cell tank 37 is by way of an overflow weir 44 in the usual manner.

It should be noted that the volume of electrolyte flowing into the cell tank by way of the deflectors 35 is distributed along the length and the height of the tank according to the number of inlet passages 42 and port 43 either supplied to the individual deflectors or kept open for flow of electrolyte from the header passages. For simplicity of manufacture, it is desirable to supply a predetermined number of such passages 42 and ports 43 spaced uniformly along the length of each of the deflectors, but to plug those not required considering the decreased volume requirements as the outlet end of the cell tank is approached.

In the embodiment of FIGS. 8 and 9, which corresponds in general with that of FIG. 5, interlocked deflector panels 45 having transverse inlet passages 46 extending through the individual deflector portions 47 thereof are spaced from the protective lining 48a of the lateral wall 48b of the cell tank 48 to provide a header passage 49 commensurate in length and breadth with the lateral walls of the tank. Headed spacer-fasteners 50, formed

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integrally with or otherwise provided on the liner sheets 48a, serve to hold the deflector panels in place. The inlet passages extend from flow communication with the header passage 49 to respective outlet ports 51.

In the electrorefining cell of FIGS. 10 and 11, a cell tank 52 is constructed for introduction of electrolyte along only one of its lateral walls. A deflector panel 53 is spaced from the protective liner 52a of a lateral wall 52b to provide a header passage 54 corresponding to the header passage 49 of the embodiment of FIGS. 8 and 9. For the sake of symmetry, the deflector panel 55 along the opposite lateral wall of the cell tank is also spaced from such wall, but the space therebetween is closed off and serves no useful purpose.

The deflector panels 53 and 55 in this instance are formed with stub baffle type of deflectors 56, which are each of prismatic formation having a base 56a, a stub tip face 56b, and symmetrical upstream and downstream sloping faces 56c of plane configuration. As in the foregoing embodiments, these baffles are strategically positioned relative to the electrodes of the cell, i.e. the anodes "A" and the cathodes "C."

As illustrated, all the electrolyte is introduced through the deflector panel 53 from supply pipe 57 by way of inlet passages 58 extending transversely through the panel at the lead faces 59 of the individual deflectors 56 thereof; however, if desired part may be introduced at one end of the cell tank as in the embodiment of FIGS. 6 and 7.

Outflow of electrolyte from the cell tank is at one end of the tank by way of a conventional weir 60.

Reference herein and in certain of the claims to inventive details of specific embodiments is not intended to limit the scope of the generic claims, which particularly point out and distinctly claim the broader subject matter regarded as the essence of the invention. Thus, the present disclosure will suggest many modifications which do not essentially depart from the invention described and claimed hereby.

We claim:

1. An electrolytic cell, comprising an elongate tank adapted to hold electrolyte and a plurality of vertically and transversely disposed, mutually spaced, interleaved anodes and cathodes; means for introducing electrolyte into said tank; outlet means for electrolyte at one end of said tank and constructed to maintain a predetermined electrolyte depth in the tank during operation of the cell; and vertically disposed, fin-like deflectors spaced alternately along mutually opposite lateral walls of said tank and projecting inwardly of said tank and toward said anodes and cathodes, each deflector having a sloping lead surface facing away from said outlet but directed toward the space between a cathode and the anode next downstream toward said outlet.

2. An electrolytic cell according to claim 1, wherein the outlet means extends vertically at one lateral side of the tank; and the means for introducing electrolyte into the tank extends vertically at the opposite end and lateral side of the tank and is directed toward the lead face of the deflector located farthest upstream in the tank.

3. An electrolytic cell according to claim 2, wherein the outlet means is a vertically extending, upwardly tapering, triangular opening.

4. A process for operating the electrolytic cell of claim 3, wherein the width of the triangular outlet opening at a given depth in the cell is determined by the formula $w=h/s$, wherein w is the width of the opening at a depth h , and s is the specific gravity of the electrolyte.

5. An electrolytic cell according to claim 1, wherein there is a deflector for each cathode, alternating in placement at opposite lateral sides of the tank.

6. An electrolytic cell according to claim 1, wherein the lead faces of individual deflectors are concavely curved.

7. An electrolytic cell according to claim 1, wherein the lead faces of individual deflectors are concavely curved

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at deflector base portions and merge into rectilinear tip portions.

8. An electrolytic cell according to claim 7, wherein the base portions are concavely curved on a radius about a quarter segment of a circle.

9. An electrolytic cell according to claim 1, wherein individual deflectors are of prismatic formation, with symmetrical faces converging from a relatively wide base to a relatively narrow tip.

10. An electrolytic cell according to claim 1, wherein the deflectors are provided in multiple by panels arranged in end-to-end formation as an inside wall of the cell tank.

11. An electrolytic cell according to claim 1, wherein the means for introducing electrolyte into the cell comprise inlet passages extending through at least some of the deflectors transversely thereof and directed toward spaces between mutually adjacent cathodes and anodes; and means for supplying said inlet passages with electrolyte.

12. An electrolytic cell according to claim 11, wherein individual deflectors are of prismatic formation, with symmetrical faces converging from a relatively wide base to a relatively narrow tip; wherein the inlet passages are arranged in series along the longitudinal axes of the deflectors concerned; and wherein the electrolyte supplying means includes header passages extending longitudinally through the said deflectors concerned.

13. An electrolytic cell according to claim 11, wherein

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individual deflectors are of prismatic formation with symmetrical faces converging from a relatively wide base to a relatively narrow tip; and wherein inlet passages are arranged in series along the height of the lead faces of the deflectors concerned.

14. An electrolytic cell according to claim 13, wherein the electrolyte supplying means includes an inner panel wall spaced from a lateral wall of the tank to form a header passage for electrolyte, and means for supplying electrolyte to said header passage; and wherein deflectors are formed integrally with said panel wall, the inlet passages communicating with said header passage.

15. An electrolytic cell according to claim 1, wherein the fin-like deflectors extend approximately the full depth of the tank.

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