

[54] CATHODE FINGER STRUCTURE FOR AN ELECTROLYTIC CELL

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[51] Int. Cl. **B01k 3/04**

[58] Field of Search 204/242, 252, 258, 266, 204/270, 278, 283, 284, 286

[56] **References Cited**

UNITED STATES PATENTS

2,447,547	8/1948	Stuart	204/266
3,342,717	9/1967	Leduc	204/266 X
3,493,487	2/1970	Ruthel et al.	204/284
3,755,108	8/1973	Raetzsch et al.	204/256 X

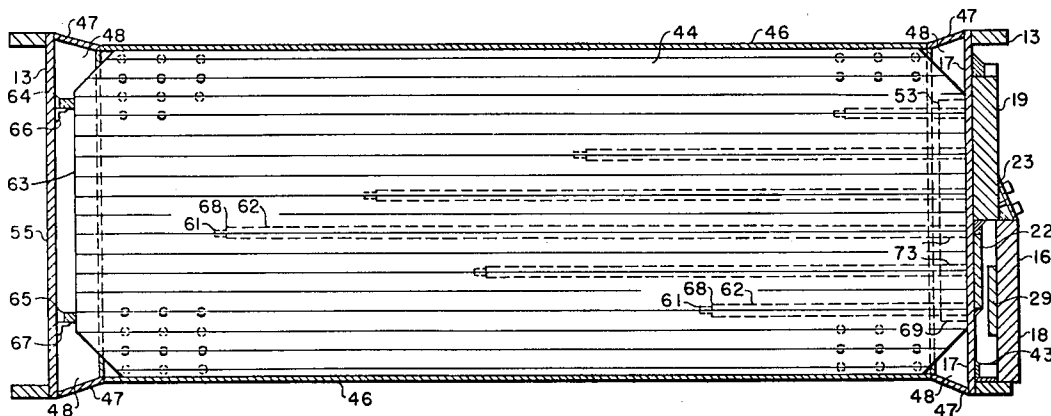
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[57]

ABSTRACT

Novel cathode fingers are provided for an electrolytic cell which can enable the electrolytic cell to be designed to operate as a chlor-alkali diaphragm cell at high current capacities of about 150,000 amperes and upward to about 200,000 amperes while maintaining high operating efficiencies. These high current capacities provide for high production capacities which result in high production rates for given cell room floor areas and reduce capital investment and operating costs. The cathode finger structure comprises a corrugated conductive reinforcing member having protrusions on the outer surfaces of the corrugations, lengths of highly conductive metal, such as copper which can be attached to the reinforcing member, and a foraminous conductive member attached to the protrusions of the reinforcing member and acting as the outer cathode surface.

6 Claims, 8 Drawing Figures



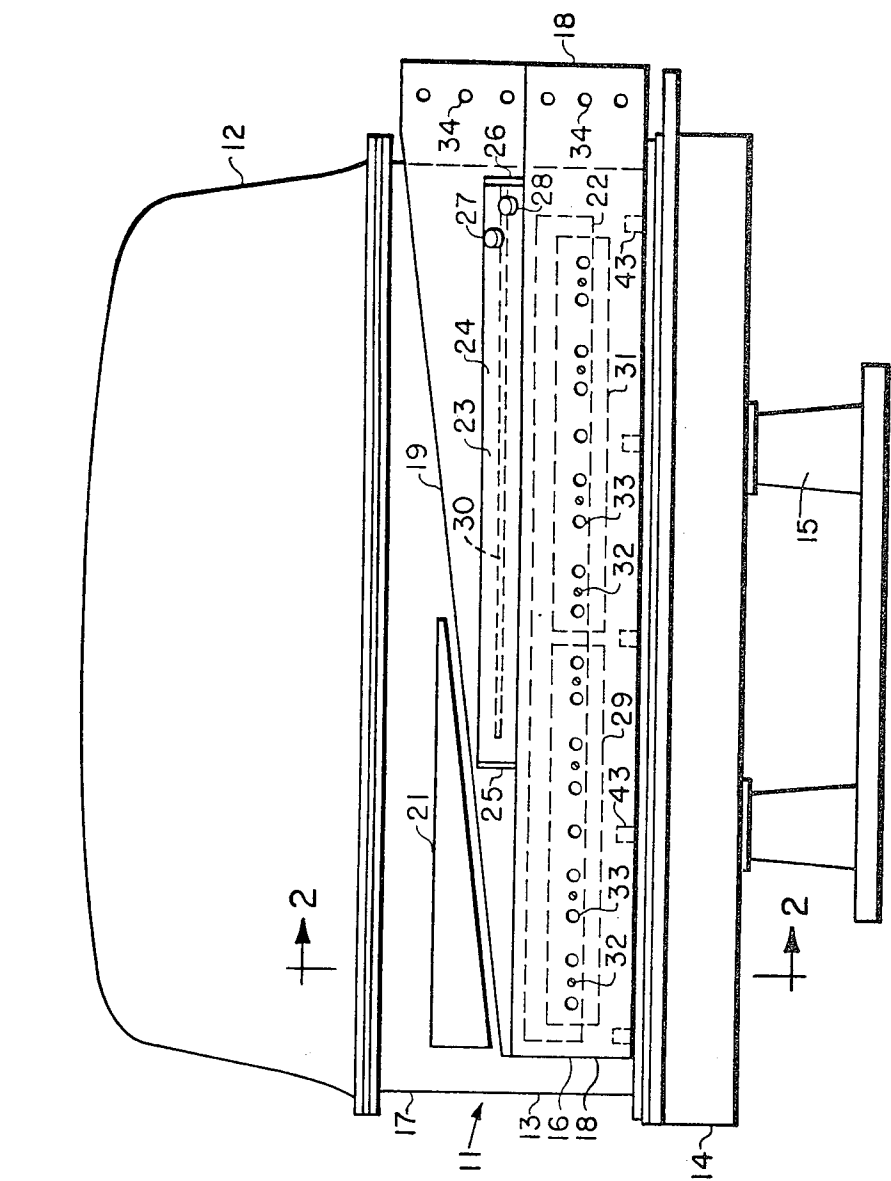


FIG. 1

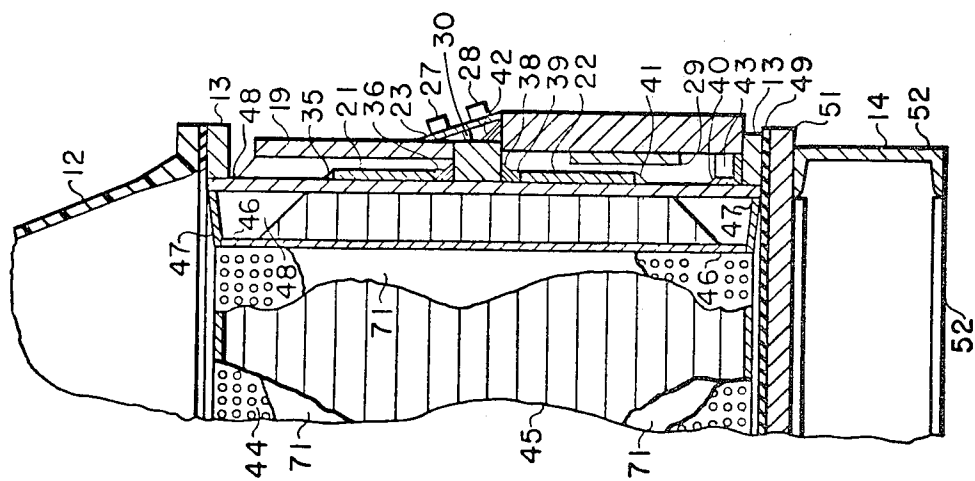


FIG. 2

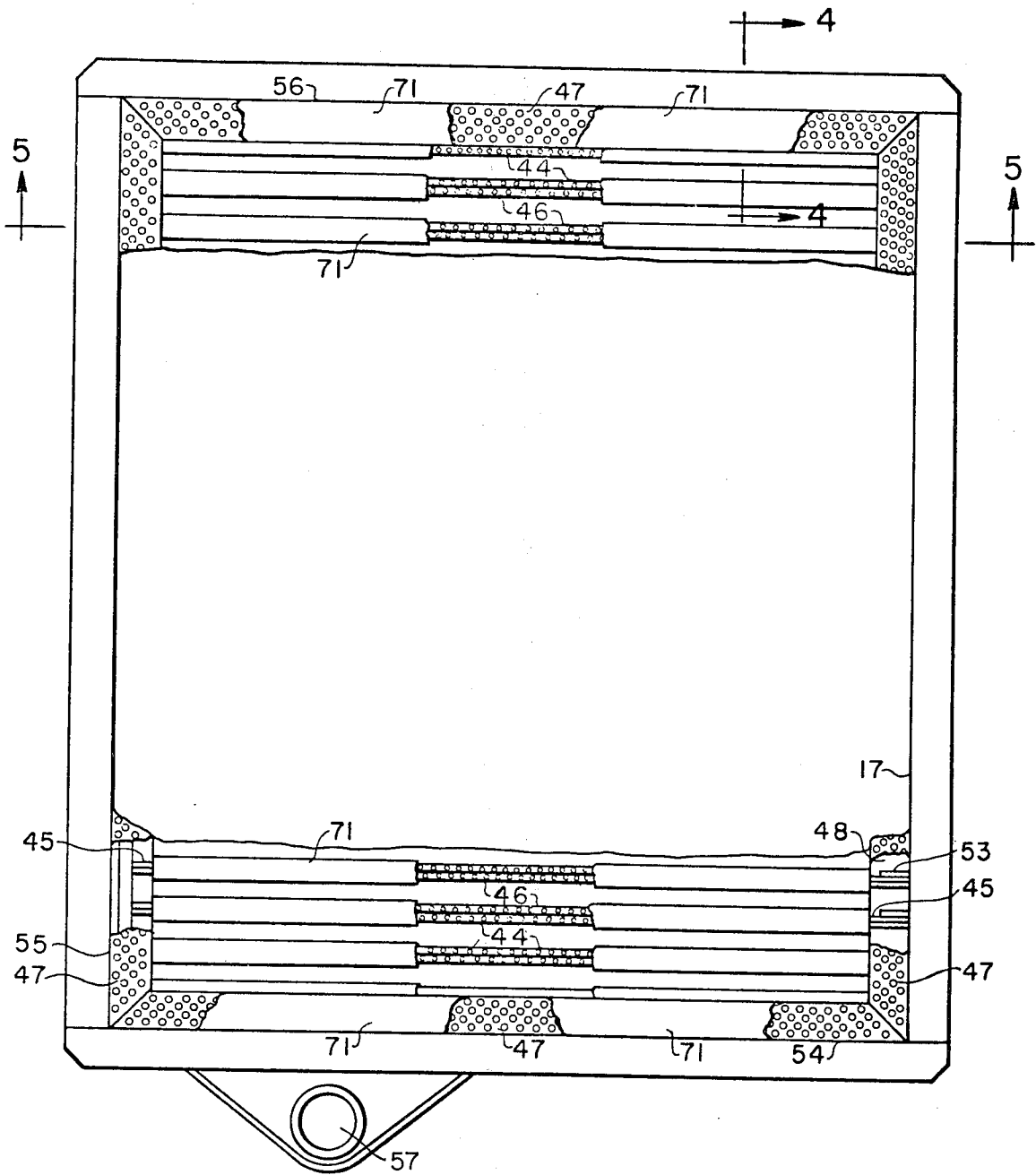


FIG. 3

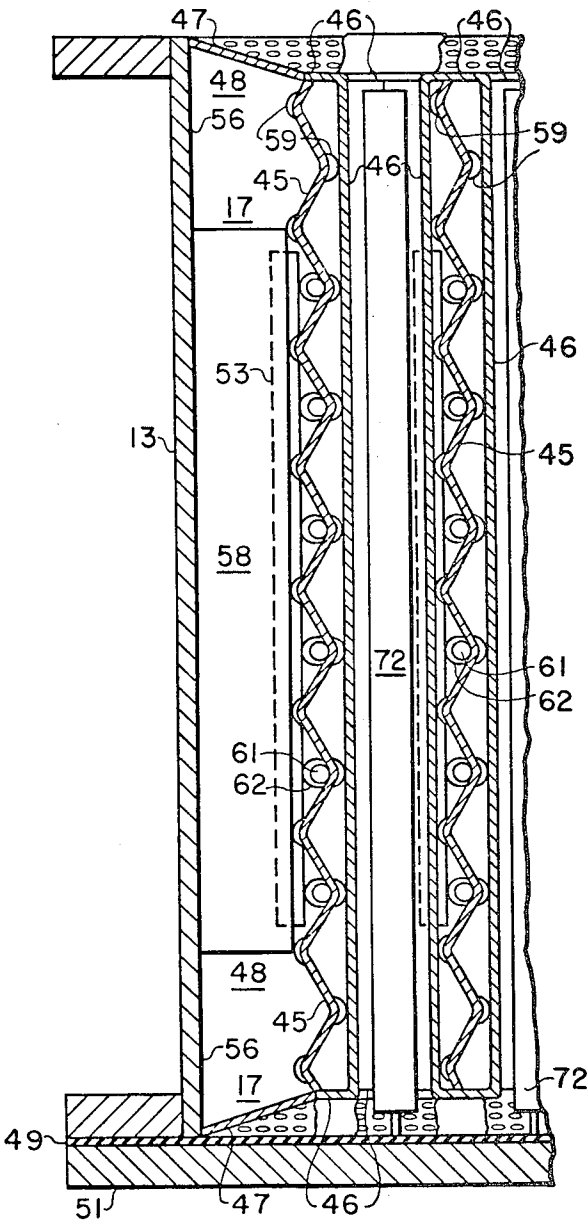


FIG. 4

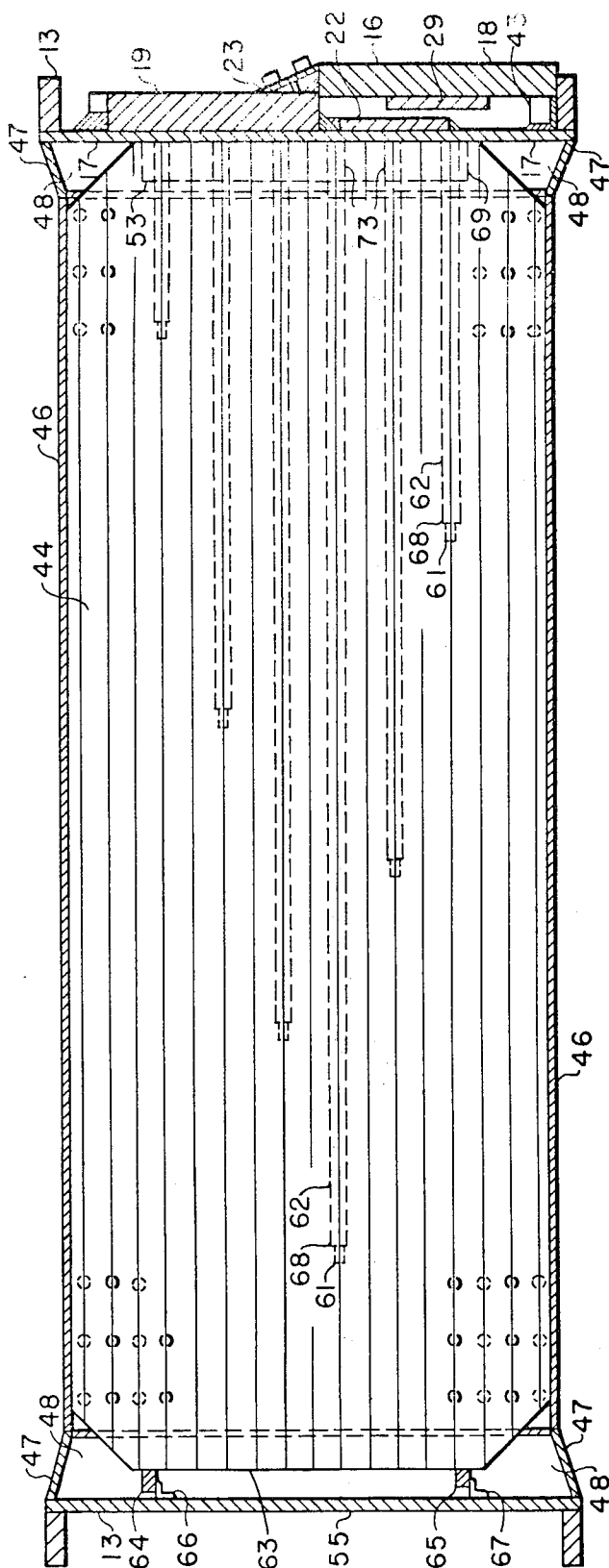


FIG. 5

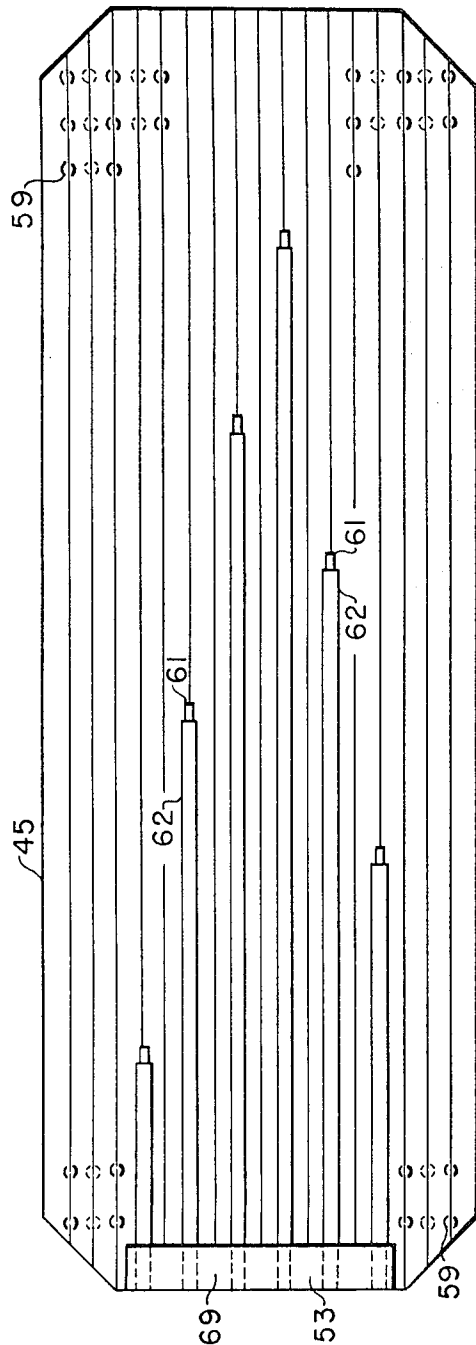


FIG. 6

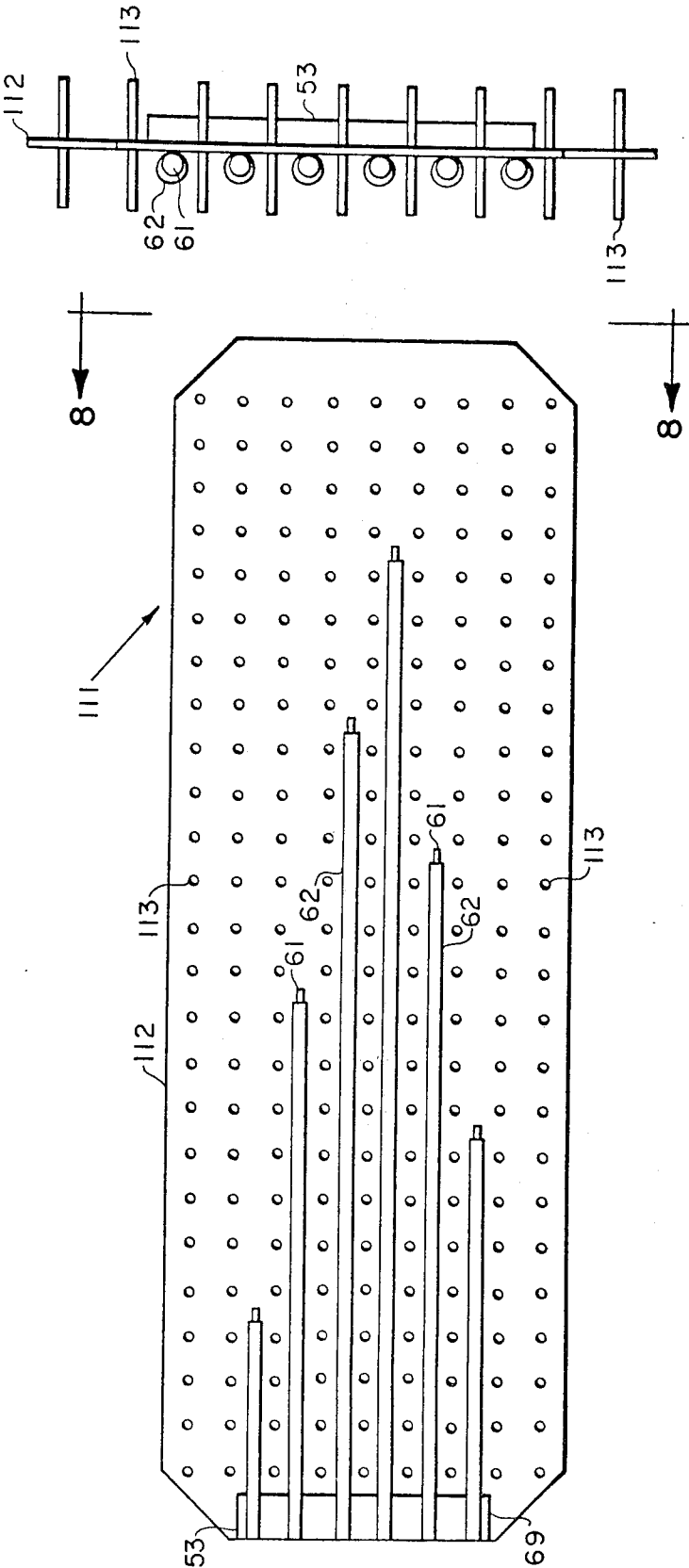


FIG. 7

FIG. 8

CATHODE FINGER STRUCTURE FOR AN ELECTROLYTIC CELL

BACKGROUND OF THE INVENTION

This application is related to U.S. Pat. No. 3,859,196, which discloses an electrolytic cell provided with the cathode fingers claimed in this application.

This invention relates to novel cathode fingers for electrolytic cells suited for the electrolysis of aqueous solutions. More particularly, this invention relates to novel cathode fingers for electrolytic cells suited for the electrolysis of aqueous alkali metal chloride solutions.

Electrolytic cells have been used extensively for many years for the production of chlorine, chlorates, chlorites, hydrochloric acid, caustic, hydrogen and other related chemicals. Over the years, such cells have been developed to a degree whereby high operating efficiencies have been obtained, based on the electricity expended. Operating efficiencies include current, decomposition, energy, power and voltage efficiencies. The most recent developments in electrolytic cells have been in making improvements for increasing the production capacities of the individual cells while maintaining high operating efficiencies. This has been done to a large extent by modifying or redesigning the individual cells and increasing the current capacities at which the individual cells operate. The increased production capacities of the individual cells operating at higher current capacities provide higher production rates for given cell room floor areas and reduce capital investment and operating costs.

In general, the most recent developments in electrolytic cells have been towards larger cells which have high production capacities and which are designed to operate at high current capacities while maintaining high operating efficiencies. Within certain operating parameters, the higher the current capacity at which a cell is designed to operate, the higher is the production capacity of the cell. As the designed current capacity of a cell is increased, however, it is important that high operating efficiencies be maintained. Mere enlargement of the component parts of a cell designed to operate at low current capacity will not provide a cell which can be operated at high current capacity and still maintain high operating efficiencies. Numerous design improvements must be incorporated into a high current capacity cell so that high operating efficiencies can be maintained and high production capacity can be provided.

Because the present invention may be used in many different electrolytic cells of which chlor-alkali cells are of primary importance, the present invention will be described more particularly with respect to chlor-alkali cells and most particularly with respect to chlor-alkali diaphragm cells. However, such descriptions are not to be understood as limiting the usefulness of the present invention with respect to other electrolytic cells.

In the early prior art, chlor-alkali diaphragm cells were designed to operate at relatively low current capacities of about 10,000 amperes or less and had correspondingly low production capacities. Typical of such cells is the Hooker Type S Cell, developed by the Hooker Chemical Corporation, Niagara Falls, N.Y., U.S.A., which was a major breakthrough in the electrochemical art at its time of development and initial use.

The Hooker Type S Cell was subsequently improved by Hooker in a series of Type S Cells such as the Type S-3, S-3A, S-3B, S-3C, S-3D and S-4, whereby the improved cells were designed to operate at progressively higher current capacities of about 15,000, 20,000, 25,000, 30,000, 40,000 and upward to about 55,000 amperes with correspondingly higher production capacities. The design and performance of these Hooker Type S cells are discussed in Shreve, *Chemical Process Industries*, Third Edition, Pg. 233 (1967), McGraw-Hill; Mantell, *Industrial Electrochemistry*, Third Edition, Pg. 434 (1950), McGraw-Hill; and Sconce, *Chlorine, Its Manufacture, Properties and Uses*, A.C.S. Monograph, Pp. 94-97 (1962), Reinhold. U.S. Pat. No. 2,987,463 by Baker et al. issued June 6, 1961 to Diamond Alkali discloses a chlor-alkali diaphragm cell designed to operate at a current capacity of about 30,000 amperes which is somewhat different than the Hooker Type S series cells. U.S. Pat. No. 3,464,912 by Emery et al. issued Sept. 2, 1969 to Hooker and U.S. Pat. No. 3,493,487 by Currey et al. issued Nov. 2, 1971 to Hooker disclose chlor-alkali diaphragm cells designed to operate at a current capacity of about 60,000 amperes.

The above description of the prior art shows the development of chlor-alkali diaphragm cell design to provide cells which operate at higher current capacities with correspondingly higher production capacities. Chlor-alkali diaphragm cells have now been developed which operate at high current capacities of about 150,000 amperes and upward to about 200,000 amperes with correspondingly higher production capacities while maintaining high operating efficiencies.

SUMMARY OF THE INVENTION

In accordance with the present invention, there are provided novel cathode fingers for an electrolytic cell. The novel cathode fingers have a novel cathode finger structure.

The novel cathode finger structure comprises a conductive metal cathode finger reinforcing means, lengths of highly conductive metal positioned in the cathode finger structure and foraminous conductive metal means attached to the cathode finger reinforcing means thereby forming the exterior of the cathode finger structure and gas compartment space inside the cathode finger structure. The cathode finger reinforcing means can be provided with a suitable number of pegs, pins or protrusions. The foraminous conductive metal means can be attached to these protrusions and thereby provide additional compartment space for gas, formed at the cathode during electrolysis, to be channeled to a collection chamber.

The highly conductive metal is preferably positioned on the cathode finger reinforcing means in the cathode finger structure and means is provided for attaching the highly conductive metal to the cathode finger reinforcing means. The highly conductive metal is positioned in the cathode finger structure in such a configuration whereby the lengths of highly conductive metal are adapted to carry an electric current and to maintain a substantially uniform current density through the cathode finger structure without any significant voltage drop across the cathode finger structure and with the most economical power consumption in the cathode finger structure.

The novel cathode finger structure provides novel cathode fingers. The cathode walled enclosure contains

a plurality of cathode fingers which extend substantially across the interior of the cathode walled enclosure and the cathode fingers are attached in electrical contact to at least one interior sidewall of the cathode walled enclosure. The cathode busbar structure is attached in electrical contact to the exterior sidewall of the cathode walled enclosure adjacent to the attached cathode fingers.

Means are provided for positioning the opposite ends of the cathode fingers adjacent to the interior sidewall of the cathode walled enclosure which is opposite to the interior sidewall where the cathode fingers are attached.

An electrolytic cell provided with the novel cathode fingers of the present invention may be used in many different electrolytic processes. The electrolysis of aqueous alkali metal chloride solutions is of primary importance and the electrolytic cell of the present invention will be described more particularly with respect to this type of process. However, such description is not intended to be understood as limiting the usefulness of the cathode fingers of the present invention or any of the claims covering the cathode fingers of the present invention.

DESCRIPTION OF THE DRAWINGS

The present invention will be more fully described by reference to the drawings in which:

FIG. 1 is an elevation view of an electrolytic cell and shows a cathode busbar structure;

FIG. 2 is an enlarged partial sectional side elevation view of the cell of FIG. 1 along plane 2—2 and shows another view of the cathode busbar structure;

FIG. 3 is an enlarged partial plan view of the cathode walled enclosure of the cell of FIG. 1 and shows the relative position of the cathode fingers.

FIG. 4 is an enlarged partial sectional and elevation view of the cathode fingers and the cathode walled enclosure of the cell of FIG. 3 along plane 4—4 and shows the relative position of the cathode fingers and anode blades as positioned at the end of the cathode walled enclosure;

FIG. 5 is an enlarged sectional side elevation view of a cathode finger and the cathode walled enclosure of the cell of FIG. 3 along plane 5—5 and shows the configuration of the highly conductive metal positioned on the cathode finger reinforcing means;

FIG. 6 is a side elevation view of the opposite side of the cathode finger reinforcing means of FIG. 5 and shows the visible configuration of the highly conductive metal positioned thereon;

FIG. 7 is a side elevation view of another embodiment of a cathode finger reinforcing means and shows the configuration of the highly conductive metal positioned thereon;

FIG. 8 is an end elevation view of the cathode finger reinforcing means of FIG. 7 along plane 8—8 and shows the configuration of the highly conductive metal positioned thereon and the peg or pin means;

FIGS. 3, 4, 5, 6, 7 and 8, when viewed together, show typical embodiments of cathode finger structures.

Two different types of metals are used to fabricate most of the various components or parts which comprise the novel cathode fingers of the present invention. One of these types of metals is a highly conductive metal. The other type of metal is a conductive metal which has good strength and structural properties.

The term highly conductive metal is herein defined as a metal which has a low resistance to the flow of electric current and which is an excellent conductor of electric current. Suitable highly conductive metals include copper, aluminum, silver and the like and alloys thereof. The preferred highly conductive metal is copper or any of its highly conductive alloys and any mention of copper in this application is to be interpreted to mean that any other suitable highly conductive metal can be used in the place of copper or any of its highly conductive alloys where it is feasible or practical.

The term conductive metal is herein defined as a metal which has a moderate resistance to the flow of electric current but which is still a reasonably good conductor of electric current. The conductive metal, in addition, has good strength and structural properties. Suitable conductive metals include iron, steel, nickel and the like and alloys thereof such as stainless steel and other chromium steels, nickel steels and the like. The preferred conductive metal is a relatively inexpensive low-carbon steel, hereinafter referred to simply as steel, and any mention of steel in this application is to be interpreted to mean that any other suitable conductive metal can be used in the place of steel where it is feasible or practical.

The highly conductive metal and the conductive metal should have adequate resistance or have adequate protection from corrosion during operation of the electrolytic cell.

Referring now to FIG. 1, electrolytic cell 11 comprises corrosion resistant plastic top 12, cathode walled enclosure 13 and cell base 14. Top 12 is positioned on cathode walled enclosure 13 and is secured to cathode walled enclosure 13 by fastening means (not shown). A seal is maintained between top 12 and cathode walled enclosure 13 by means of a sealing gasket. Cathode walled enclosure 13 is positioned on cell base 14 and is secured to cell base 14 by fastening means (not shown). A seal is maintained between cathode walled enclosure 13 and cell base 14 by means of an elastomeric sealing pad. Electrolytic cell 11 is positioned on legs 15 which are used as support means for the cell.

Cathode busbar structure 16 is attached in any suitable manner, as by welding, to steel sidewall 17 of steel cathode walled enclosure 13. Cathode busbar structure 16 comprises copper lead-in busbar 18 and a plurality of copper busbar strips 19, 21 and 22 which have different relative dimensions and are positioned in such a configuration wherein lead-in busbar 18 and busbar strips 19, 21 and 22 are adapted to carry an electric current and to maintain a substantially uniform current density through cathode busbar structure 16 to electrical contact points on sidewall 17 of cathode walled enclosure 13.

Cathode busbar structure 16 can be provided with cooling means 23 which comprises steel plates 24, 25, 26 and 30 and steel entrance and exit ports 27 and 28 fabricated in any suitable manner, as by welding, to form the said cooling means. Cooling means 23 is attached in any suitable manner, as by welding, to lead-in busbar 18 and busbar strip 19. Collant, preferably water, is circulated through cooling means 23 by passage through entrance and exit ports 27 and 28. Cooling means 23 is provided primarily for use when an electrolytic cell adjacent to electrolytic cell 11 is jumpered and is removed from the electrical circuit. The use of cooling means 23 permits considerably less copper to

be used in cathode busbar structure 16 which results in a substantial reduction in capital investment costs for cathode copper. While cooling means 23 is provided primarily for use when an electrolytic cell adjacent to electrolytic cell 11 is jumpered, cooling means 23 can be used during routine cell operation either to cool cathode busbar structure 16 during any periodic electric current overloads or to continuously cool cathode busbar structure 16, thereby permitting further reductions in the use of copper in cathode busbar structure 16 with an accompanying reduction in capital investment costs for cathode copper.

Lead-in busbar 18 can be provided with steel contact plates 29 and 31 which serve as contact means. Steel contact plates 29 and 31 are attached to lead-in busbar 18 in any suitable manner, as by means of screws 32. Lead-in busbar 18 and steel contact plates 29 and 31 can be provided with holes 33 which can serve as means for attaching intercell connectors carrying electricity from an adjacent cell or leads carrying electricity from another source to lead-in busbar 18. Lead-in busbar 18 and busbar strip 19 can be used as a cathode jumper busbar when provided with holes 34 which can serve as means for attaching cathode jumper connectors when an adjacent electrolytic cell is jumpered and is removed from the electrical circuit. It is during this jumpering operation that cooling means 23 can provide its greatest utility by preventing the temperatures in cathode busbar structure 16 from rising to levels whereby damage to cathode busbar structure 16 or other components of electrolytic cell 11 occurs.

Referring now to FIG. 2, cathode busbar structure 16 is shown in another view and the description of this figure further describes cathode busbar structure 16 including the configuration and the different relative dimensions of the components or parts comprising cathode busbar structure 16 which were described in FIG. 1.

Cathode busbar structure 16 comprises copper lead-in busbar 18 and a plurality of copper busbar strips 19, 21 and 22. Busbar strips 19, 21 and 22 are attached to steel sidewall 17 of steel cathode walled enclosure 13 in any suitable manner, as by means of copper to steel welds 35, 37, 38 and 41, and to one another in any suitable manner, as by means of copper to copper welds 36 and 39. The weld metal is preferably of the same metal as the busbar strips, that is, copper. This means of attaching the busbar strips to sidewall 17 greatly decreases the required weld area and forms a lower electrical contact resistance to sidewall 17 or the cathode steel. Lead-in busbar 18 is attached to busbar strip 19 in any suitable manner, as by means of copper to copper weld 42, and lead-in busbar 18 is attached to sidewall 17 in any suitable manner, as by means of steel blocks 43. Lead-in busbar 18 is attached to steel blocks 43 in any suitable manner, as by a combination of screws (not shown), and steel blocks 43 are attached to sidewall 17 of cathode walled enclosure 13 in any suitable manner, as by means of steel to steel welds 40. Steel contact plates 29 and 31 are attached to lead-in busbar 18 in any suitable manner, as by means of screws 32.

The above means of attachment provides a cathode busbar structure wherein lead-in busbar 18 and the plurality of busbar strips 19, 21 and 22 are attached and electrically interconnected by means of welds 36, 37, 38, 39 and 42 and cathode busbar structure 16 is at-

tached in electrical contact to sidewall 17 of cathode walled enclosure 13 by means of welds 35, 37, 38, 40 and 41.

Cathode fingers 44 are attached in electrical contact to sidewall 17 in any suitable manner, as by welding cathode finger reinforcing means 45 to sidewall 17. A typical cathode finger 44 is partially shown. Cathode finger 44 comprises steel cathode finger reinforcing means 45 and perforated steel plates 46 which are attached in any suitable manner, as by welding. Perforated steel plates 47 are attached in any suitable manner, as by welding, to perforated steel plates 46 and sidewall 17, thereby forming peripheral chamber 48.

The height of the plurality of the busbar strips at their points of attachment to sidewall 17 is usually substantially equal to the height of cathode finger reinforcing means 45 at their points of attachment to sidewall 17. This height can be further defined as being of more than about one-half of the height of cathode walled enclosure 13. The thickness of busbar strips 21 and 22 are preferably less than those of lead-in busbar 18 and busbar strip 19.

The cathode finger reinforcing means are preferably corrugated structures fabricated from steel sheet, however, other suitable reinforcing means such as conductive metal bars, plates, reinforced sheets and the like can also be used. The cathode finger reinforcing means serve the dual functions of first, supporting and reinforcing the perforated steel plates, and second, carrying electrical current to all sections of the perforated steel plates with a minimum electrical resistance through the cathode finger reinforcing means.

The foraminous conductive metal means used to form the cathode fingers and the peripheral chamber are preferably perforated steel plates but can be steel screens. Other suitable foraminous conductive metal means which can be used to form the cathode fingers and the peripheral chamber includes conductive metal grids, meshes, screens wire cloths or the like.

Cathode walled enclosure 13 is positioned on cell base 14 and is secured to cell base 14 by fastening means (not shown). Cell base 14 comprises elastomeric sealing pad 49 and conductive anode base 51, and, if needed, structural support means 52. A seal is maintained between cathode walled enclosure 13 and cell base 14 by means of elastomeric sealing pad 49.

In a typical circuit of electrolytic cells, electric current is carried through intercell connectors (not shown) to lead-in busbar 18 of cathode busbar structure 16. Electric current is then carried and a substantially uniform current density is maintained through cathode busbar structure 16 without any significant voltage drop across cathode busbar structure 16 and with the most economical power consumption in cathode busbar structure 16. Electric current is carried and a substantially uniform current density is maintained through cathode busbar structure 16 by means of the configuration and the different relative dimensions of lead-in busbar 18 and busbar strips 19, 21 and 22. Electric current is thus carried through cathode busbar structure 16 to electrical contact points on sidewall 17 of cathode walled enclosure 13 where it is distributed to cathode fingers 44 and, under these conditions, the electric current is readily carried to all sections of perforated steel plates 46 with a minimum electrical resistance through cathode finger reinforcing means 45.

The cathode busbar structure makes the most economic use of invested capital, namely, the amount of copper or other suitable highly conductive metal used in the cathode busbar structure. The configuration and different relative dimensions of the lead-in busbar or busbars and the plurality of busbar strips significantly reduce the amount of copper or other suitable highly conductive metal required in the cathode busbar structure as compared to the prior art. The lead-in busbar or busbars and the plurality of busbar strips by means of their configuration and different relative dimensions are also adapted to carry an electric current and to maintain a substantially uniform current density through the cathode busbar structure.

The configuration and dimensions of the lead-in busbar or busbars and the plurality of busbar strips can vary depending on the designed current capacity of the electrolytic cell and also can vary depending on a number of factors such as the current density, the conductivity of the metal used, the amount of weld area, the fabrication costs and the like.

The cathode busbar structure provides improved electrical conductivity to the immediate area of the cathode fingers, thereby providing a minimum or no significant voltage drop across the cathode busbar structure with a substantial reduction in copper or other suitable highly conductive metal expenditures as compared to the prior art.

The cathode busbar structure can enable an electrolytic cell to be designed to operate as a chlor-alkali diaphragm cell at high current capacities of about 150,000 amperes and upward to about 200,000 amperes while maintaining high operating efficiencies. These high current capacities provide for high production capacities which result in high production rates for given cell room floor areas and reduce capital investment and operating costs. In addition to being capable of operation at high amperages, an electrolytic cell can also efficiently operate at lower amperages, such as about 55,000 amperes using the cathode busbar structure.

Referring now to FIG. 3, cathode fingers 44 are enclosed by steel sidewalls 17, 54, 55 and 56 of steel cathode walled enclosure 13. The plurality of cathode fingers 44 can be any number from about 10 to about 50 or more, preferably the number is about 15 to about 40 and more preferably the number is about 20 to about 30. The anode blades (not shown) are positioned between cathode fingers 44. Perforated steel plates 46 are attached in any suitable manner, as by welding, to steel cathode finger reinforcing means 45. Steel plates 53 are also attached in any suitable manner, as by welding, to cathode finger reinforcing means 45. Cathode fingers 44 are attached to steel sidewall 17 in any suitable manner, as by welding steel plates 53 and cathode finger reinforcing means 45 to sidewall 17. Perforated steel plates 47 are attached to sidewalls 17, 54, 55 and 56 and to perforated steel plates 46 in any suitable manner, as by welding. Perforated steel plates 47 surround the inner sidewalls of cathode walled enclosure 13 and form peripheral chamber 48 which serves as a collection chamber for hydrogen gas formed at the cathode during electrolysis. Hydrogen gas formed at the cathode during electrolysis is channeled across cathode fingers 44 to peripheral chamber 48 from whence it proceeds to gas withdrawal means 57.

Referring now to FIG. 4, perforated steel plates 46 are attached in any suitable manner, as by welding, to

steel cathode finger reinforcing means 45. Steel plates 53 are attached in any suitable manner, as by welding, to cathode finger reinforcing means 45. Steel support means 58 are attached in any suitable manner, as by welding, to cathode finger reinforcing means 45 and to sidewall 56 of steel cathode walled enclosure 13. Perforated steel plates 47 are attached in any suitable manner, as by welding, to perforated steel plates 46 and to sidewalls 17 and 56 thereby forming peripheral chamber 48. Because of the larger dimensions of this figure, peripheral chamber 48 is more clearly shown. Cathode finger reinforcing means 45 can be provided with protrusions 59 and perforated steel plates 46 can be attached in any suitable manner, as by welding, to protrusions 59 thereby providing additional compartment space for hydrogen gas, formed at the cathode during electrolysis, to be channeled to peripheral chamber 48.

Steel tips 61 and steel plates 53 are attached in any suitable manner, as by welding, to copper rods 62. Steel tips 61 and steel plates 53 are attached in any suitable manner, as by welding, to cathode finger reinforcing means 45 thereby positioning copper rods 62 on cathode finger reinforcing means 45.

Cathode finger reinforcing means 45 are preferably corrugated structures fabricated from sheet steel, however, other suitable reinforcing means such as bars, plates, reinforced sheets and the like can also be used. Cathode finger reinforcing means 45 serve the dual functions of first, supporting and reinforcing perforated steel plates 46, and second, carrying electric current to all sections of perforated steel plates 46 with a minimum electrical resistance through cathode finger reinforcing means 45.

Referring now to FIGS. 2 and 4, cathode walled enclosure 13 is positioned on cell base 14 and is secured to cell base 14 by fastening means (not shown). Cell base 14 comprises conductive anode base 51 and, if needed, suitable structural support means 52. A seal is maintained between cathode walled enclosure 13 and cell base 14 by means of elastomeric sealing pad 49.

Anode blades 72 are preferably metallic anode blades and are attached in electrical contact to conductive anode base 51 in any suitable manner, as by means of nuts and/or bolts, secured projections, studs, welding or the like. Cathode fingers 44 are spaced adjacent to each other at such a distance whereby anode blades 72 are centered between adjacent cathode fingers 44 and the desired alignment distance between anode blades 72 and cathode fingers 44 is provided.

Referring now to FIGS. 2, 3 and 4, electrolytic cell 11 is particularly useful for the electrolysis of alkali metal chloride solutions in general, including not only sodium chloride, but also potassium chloride, lithium chloride, rubidium chloride and cesium chloride. When electrolytic cell 11 is used to electrolyze such solutions, electrolytic cell 11 is provided with diaphragm 71 which serves to form separate anolyte and catholyte compartments so that chlorine is formed at the anode and caustic and hydrogen are formed at the cathode. Diaphragm 71 comprises a fluid-permeable and halogen-resistant material which covers steel plates 46 forming cathode fingers 44 and perforated steel plates 47 forming peripheral chamber 48. Preferably, diaphragm 71 is asbestos fiber deposited in place on the outer surfaces of perforated steel plates 46 and 47. Electrolytic cell 11 is adapted to permit the use of many types of diaphragms, including asbestos fabric,

asbestos paper, asbestos sheet and other suitable materials known to those skilled in the art.

Perforated steel plates 46 forming cathode fingers 44 and perforated steel plates 47 forming peripheral chamber 48 are foraminous conductive metal means. Other suitable foraminous conductive metal means which can be used to form the cathode fingers and the peripheral chamber include conductive metal grids, meshes, screens, wire cloths or the like.

Referring now to FIGS. 3 and 5, some of the details described in the foregoing figures are more clearly shown in these figures. Cathode busbar structure 16 is attached to outer sidewall 17 of cathode walled enclosure 13 and the ends of cathode fingers 44 adjacent thereto are attached to inner sidewall 17 of cathode walled enclosure 13 in the manner or manners described in the foregoing figures.

The other ends of cathode fingers 44 are preferably positioned as follows: Posterior ends 63 of steel cathode finger reinforcing means 45 are positioned adjacent to steel sidewall 55 of steel cathode walled enclosure 13 by means of steel support members 64, 65, 66 and 67. Support members 64 and 65 are attached in any suitable manner, as by welding, to cathode finger reinforcing means 45 and rest upon support members 66 and 67 which are attached in any suitable manner, as by welding, to sidewall 55. Support members 64 and 65 can be attached or fastened to support members 66 and 67, respectively, however, it is preferred that support members 64 and 65 not be attached or fastened so that both linear and horizontal thermal expansion and/or contraction can be provided for cathode fingers 44.

Perforated steel plates 47 are attached in any suitable manner, as by welding, to sidewalls 17, 54, 55 and 56, respectively, and to adjacent perforated steel plates 46 thereby forming peripheral chamber 48.

Copper rods 62 are preferably of different lengths and are preferably positioned on cathode finger reinforcing means 45 as shown in FIG. 5. Steel tips 61 are attached in any suitable manner, as by welding, to ends 68 of copper rods 62 and steel plate 53 is attached in any suitable manner, as by welding, to linear ends 73 of copper rods 62 thereby forming cathode copper assembly 69. Cathode copper assembly 69 is attached to cathode finger reinforcing means 45 in any suitable manner, as by welding steel tips 61 and steel plate 53 to steel cathode finger reinforcing means 45. Copper rods 62 can thus be positioned on cathode finger reinforcing means 45. Copper rods 62 are of sufficient length and preferably are of different lengths to maintain substantially uniform current density through cathode finger 44. Copper rods 62 do not necessarily have to be round or uniform in cross-section and can be square, rectangular, hexagonal, octagonal or the like in cross-section and can vary in cross-section along their lengths. It is important, however, that copper rods 62 be of sufficient length and cross-section to carry an electric current and to maintain a substantially uniform current density through cathode fingers 44 without any significant voltage drop across cathode fingers 44 and with the most economical power consumption in cathode fingers 44.

The use of a suitable highly conductive metal, such as copper, in cathode fingers 44 as shown in FIGS. 4, 5, 6, 7 and 8 is considered to be a novel use of a suitable highly conductive metal in the cathode fingers. The use of copper in the cathode fingers is disclosed in U.S. Pat.

No. 3,464,912 by Emery et al. issued Sept. 2, 1969 to Hooker and U.S. Pat. No. 3,493,487 by Ruthel et al. issued Feb. 3, 1970 to Hooker, however, these disclosed uses of copper in the cathode fingers do not disclose, much less teach, the use of copper in the cathode fingers of an electrolytic cell in the manner as taught herein.

The preferred method of positioning copper rods 62 on cathode finger reinforcing means 45 and in cathode fingers 44 is also novel. Steel tips 61 are welded to ends 68 of copper rods 62 and steel plate 53 is welded to linear ends 73 of copper rods 62 thereby forming cathode copper assembly 69. Any warpage from the welding of steel tips 61 and steel plate 53 to copper rods 62 is corrected or compensated for before cathode copper assembly 69 is attached to cathode finger reinforcing means 45. Cathode copper assembly 69 is attached to cathode finger reinforcing means 45 by welding steel tips 61 and steel plate 53 to steel cathode finger reinforcing means 45. Copper rods 62 are thus positioned on cathode finger reinforcing means 45 and in cathode fingers 44. In this manner, all the copper to steel welds are made prior to the welding of cathode copper assembly 69 to cathode finger reinforcing means 45 and any metal warpage from welding is substantially eliminated.

The novel cathode fingers can enable an electrolytic cell to be designed to operate as a chlor-alkali diaphragm cell at high current capacities of about 150,000 amperes and upward to about 200,000 amperes while maintaining high operating efficiencies. These high current capacities provide for high production capacities which result in high production rates for given cell room floor areas and reduce capital investment and operating costs. In addition to being capable of operation at high amperages, an electrolytic cell can also efficiently operate at lower amperages, such as about 55,000 amperes using the novel cathode fingers.

Referring now to FIG. 6, the opposite side of cathode finger reinforcing means 45 shown in FIG. 5 is shown and the visible configuration of copper rods 62 positioned thereon is also shown. Cathode copper assembly 69 which comprises copper rods 62, steel plate 53 and steel tips 61 is shown positioned on cathode finger reinforcing means 45. Cathode finger reinforcing means 45 can be provided with protrusions 59 and perforated steel plates 46 can be attached in any suitable manner, as by welding, to protrusions 59 thereby providing additional compartment space for hydrogen gas, formed at the cathode during electrolysis, to be channeled to peripheral chamber 48. Protrusions 59 are positioned at spaced intervals on cathode finger reinforcing means 45 and only a representative portion are shown in this figure.

Referring now to FIGS. 7 and 8, another embodiment of a cathode finger reinforcing means is shown and a configuration of copper rods positioned thereon is also shown. In this embodiment, cathode finger reinforcing means 111 comprises steel plate 112 having steel peg or pin means 113 extending therefrom. Cathode copper assembly 69 which comprises copper rods 62, steel plate 53 and steel tips 61 is shown positioned on steel plate 112 of cathode finger reinforcing means 111 with a portion of steel plate 112 removed to accommodate steel plate 53. Cathode copper assembly 69 is attached to cathode finger reinforcing means 111 in any suitable manner, as by welding steel plate 53 and steel tips 61 to steel plate 112. Perforated steel plates 46 can be at-

tached in any suitable manner, as by welding, to steel
peg means 113 thereby providing compartment space
for hydrogen gas, formed at the cathode during elec-
trolysis, to be channeled to peripheral chamber 48.

PREFERRED EMBODIMENTS

The following Example illustrates the practice of the
present invention and a mode of utilizing the present
invention.

EXAMPLE

The following data is typical of the performance of an
electrolytic cell provided with the novel cathode fin-
gers of the present invention operating at a current ca-
pacity of 150,000 amperes. The performance is com-
pared with the performance of a smaller electrolytic
cell of the prior art, also equipped with metal anode
blades, operating at a current capacity of 84,000 am-
peres. Both electrolytic cells are chlor-alkali diaphragm
cells.

	84,000 Ampere Cell of the Prior Art	150,000 Ampere Cell Provided with the Novel Cathode Fingers of the Present Invention
Current Efficiency	96.4	96.4
Average Cell Voltage (including busbars)	3.84	3.83
Power - KWHDC/Ton Cl ₂	2735	2725
Cell Liquor Temperature - °C	100.5	100.7
Anolyte Temperature - °C	94.5	94.7
Percent NaOH in Cell Liquor	11.5*	11.5*
Chlorine Production - Tons/Day	2.83	5.06
NaOH Production - Tons/Day	3.20	5.71
Brine Feed - Grams/Liter	325	325
Current Density - Amperes/sq.in.	1.5	1.5

*The cells can be operated at lower caustic content in the cell liquor. This will result in greater current
efficiencies.

The above data show that the electrolytic cell pro-
vided with the novel cathode fingers of the present in-
vention operates at essentially the same current effi-
ciency, voltage and operating conditions as the smaller
electrolytic cell of the prior art at the same anode cur-
rent density. The electrolytic cell provided with the
novel cathode fingers of the present invention has a
higher production rate for a given cell room floor area,
uses less operating labor and also has a lower capital
investment per ton of chlorine produced.

This example shows that an electrolytic cell can be
designed to operate at a high current capacity to pro-
vide a high production capacity and a high production
rate while maintaining high operating efficiencies.

An electrolytic cell provided with the novel cathode
fingers of the present invention can have many other
uses. For example, alkali metal chlorates can be pro-
duced using the electrolytic cell by further reacting the
formed caustic and chlorine outside of the cell. In this
instance, solutions containing both alkali metal chlo-
rate and alkali metal chloride can be recirculated to the
electrolytic cell for further electrolysis. The electrolytic
cell can be utilized for the electrolysis of hydrochloric
acid by electrolyzing hydrochloric acid alone or in
combination with an alkali metal chloride. Thus, the
electrolytic cell is highly useful in these and many other
aqueous processes.

While there have been described various embodi-
ments of the present invention, the apparatus described
is not intended to be understood as limiting the scope
of the present invention. It is realized that changes

therein are possible. It is further intended that each
component recited in any of the following claims is to
be understood as referring to all equivalent compo-
nents for accomplishing the same results in substan-
tially the same or an equivalent manner. The following
claims are intended to cover the present invention
broadly in whatever form the principles thereof may be
utilized.

What is claimed is:

1. A cathode finger, suitable for use in an electrolytic
cell, wherein said cathode finger has a cathode finger
structure which comprises a corrugated conductive
metal reinforcing means, lengths of highly conductive
metal positioned in the cathode finger structure, and
foraminous conductive metal means attached to said
cathode finger reinforcing means thereby forming the
exterior of the cathode finger structure and providing
a gas compartment space inside the cathode finger
structure, said corrugated conductive metal structure
having protrusions positioned on the outer surfaces of
its ridges to which said foraminous conductive metal
means is attached to provide additional compartment

space for gas, said lengths of highly conductive metal
are positioned in the cathode finger structure in such
a configuration wherein the lengths of highly conduc-
tive metal are adapted to carry an electric current and
to maintain a substantially uniform current density
through the cathode finger without any significant volt-
age drop across the cathode finger and with the most
economical power consumption in the cathode finger.

2. The cathode finger structure of claim 1 wherein
said foraminous conductive metal means is perforated
metal plate.

3. The cathode finger structure of claim 1 wherein
the foraminous conductive metal means is screen.

4. The cathode finger structure of claim 1 wherein
the lengths of highly conductive metal are of different
lengths and are positioned on the cathode finger rein-
forcing means in the cathode finger structure and the
highly conductive metal is attached to the cathode fin-
ger reinforcing means.

5. The cathode finger structure of claim 1 wherein
the lengths of highly conductive metal have different
cross-sections and are positioned on the cathode finger
reinforcing means in the cathode finger structure and
the highly conductive metal is attached to the cathode
finger reinforcing means.

6. The cathode finger structure of claim 1 wherein
the lengths of highly conductive metal ahve different
lengths and different cross-sections and are positioned
on the cathode finger reinforcing means in the cathode
finger structure and the highly conductive metal is at-
tached to the cathode finger reinforcing means.

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