

Feb. 20, 1945.

K. E. STUART

2,370,086

ELECTROLYTIC ALKALI HALOGEN CELLS

Filed Sept. 4, 1940

4 Sheets-Sheet 1

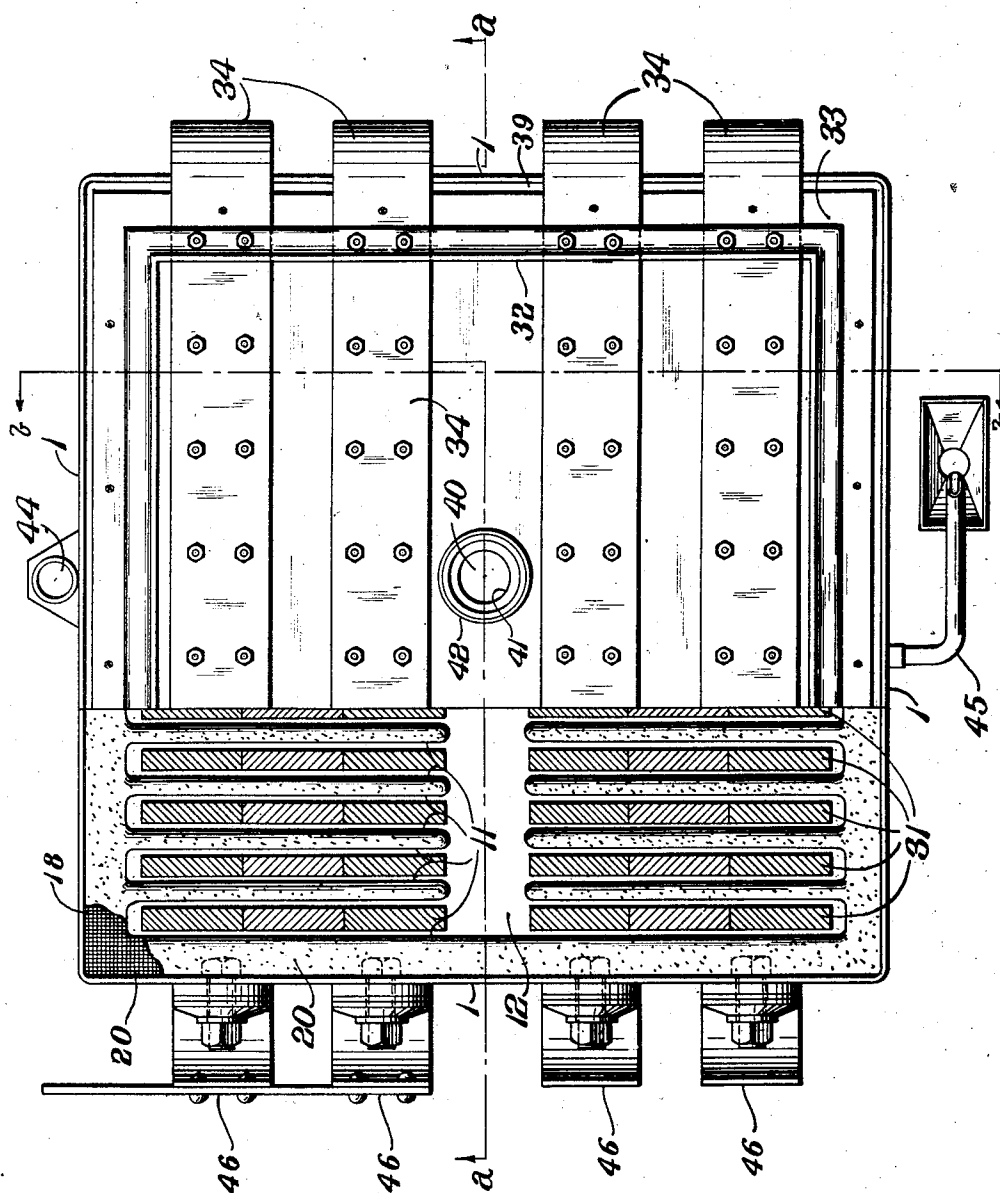


Fig. 1.

INVENTOR

Kenneth E. Stuart

Feb. 20, 1945.

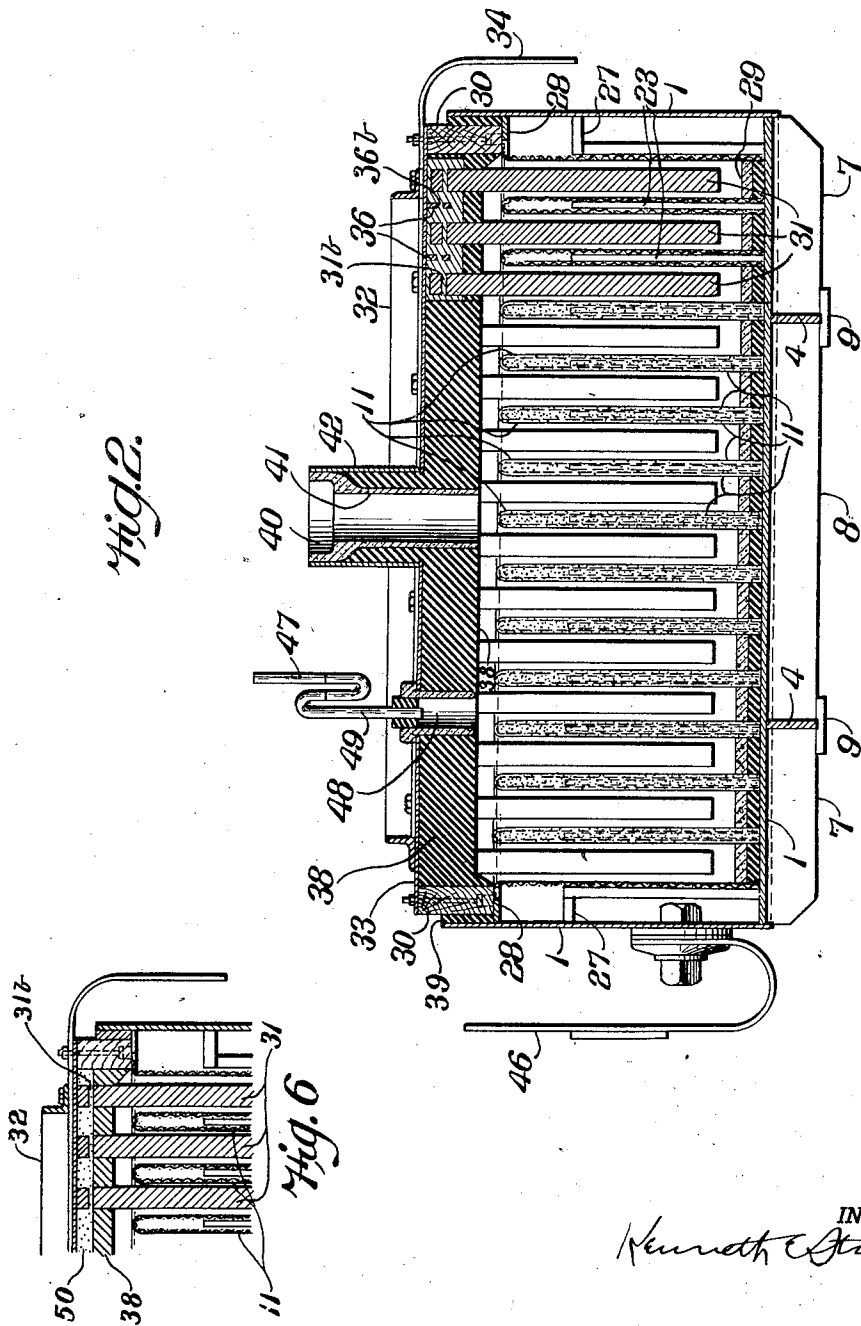
K. E. STUART

2,370,086

ELECTROLYTIC ALKALI HALOGEN CELLS

Filed Sept. 4, 1940

4 Sheets-Sheet 2



INVENTOR

Kenneth E. Stuart

Feb. 20, 1945.

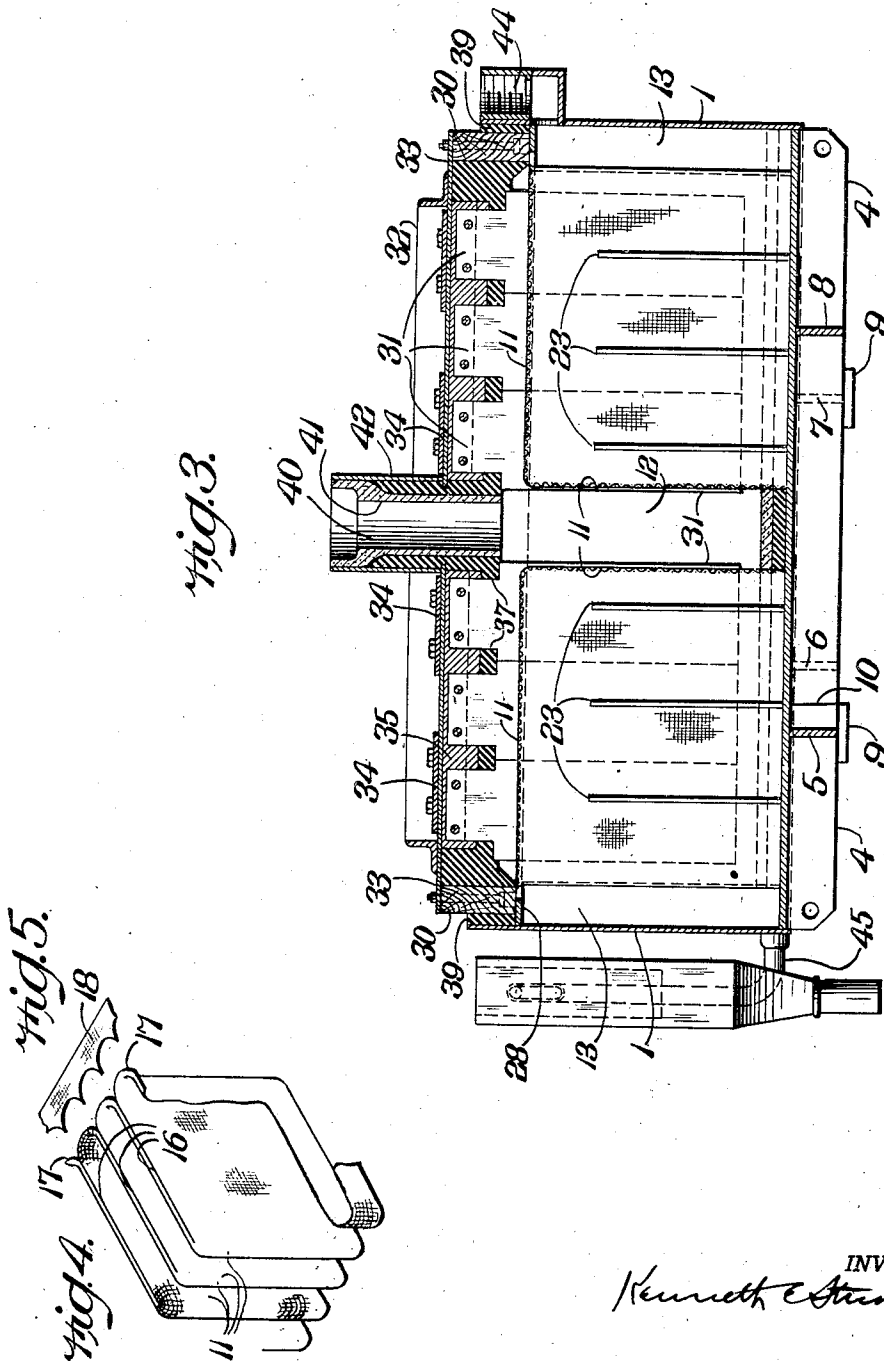
K. E. STUART

2,370,086

ELECTROLYTIC ALKALI HALOGEN CELLS

Filed Sept. 4, 1940

4 Sheets-Sheet 3



INVENTOR
Kenneth E. Stuart

Feb. 20, 1945.

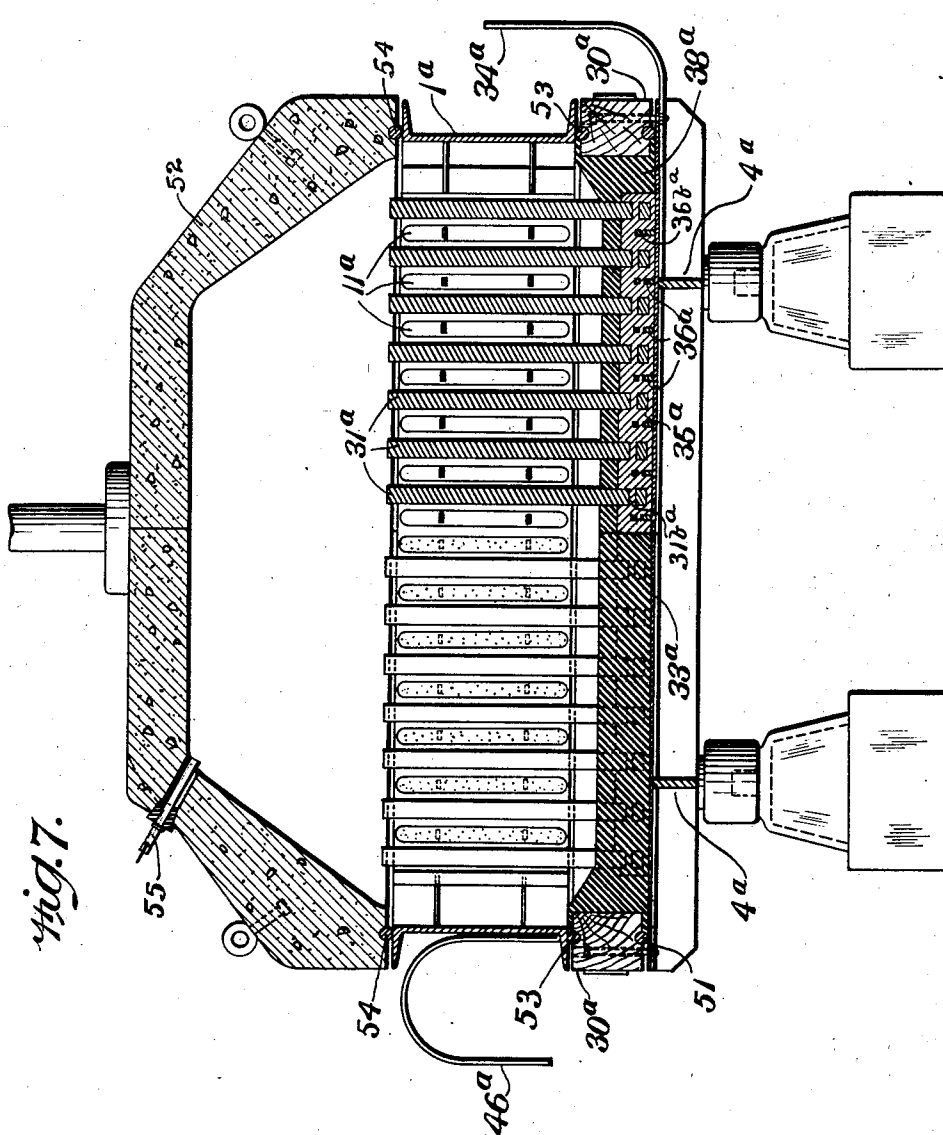
K. E. STUART

2,370,086

ELECTROLYTIC ALKALI HALOGEN CELLS

Filed Sept. 4, 1940

4 Sheets-Sheet 4



INVENTOR.

Kenneth E. Stewart

UNITED STATES PATENT OFFICE

2,370,086

ELECTROLYTIC ALKALI HALOGEN CELLS

Kenneth E. Stuart, Niagara Falls, N. Y., assignor
to Hooker Electrochemical Company, Niagara
Falls, N. Y., a corporation of New York

Application September 4, 1940, Serial No. 355,317

7 Claims. (Cl. 204—266)

My invention relates more particularly to an alkali chlorine cell for production of caustic alkali, chlorine and hydrogen from alkali metal chlorides.

My invention is a modification of the cell disclosed in Patent No. 1,866,065 granted to me July 5, 1932. One object of my invention is to provide a means for securely and conductively affixing elongated graphite anodes to a metal plate by one end with a minimum of sacrifice of graphite. Another object of my invention is conductively to affix foraminous metal cathodic electrode elements to their housing structure so as to afford improved electrical conductivity from the structure to the electrodes.

Referring to the drawings:

Fig. 1 is a plan view of my cell, partly cut away to show the interior construction.

Fig. 2 is a side elevation of my cell in section along line *a-a* of Fig. 1.

Fig. 3 is an end elevation of my cell, in section along line *b-b* of Fig. 1.

Figs. 4 and 5 are perspective views of a number of cathodic electrode elements, illustrating one method of constructing and assembling them.

Fig. 6 is a sectional elevation of a portion of the cell corresponding to that of Fig. 2, but illustrating a modified detail of construction.

Fig. 7 is a sectional elevation of a modification of the cell of my Patent No. 1,866,065, above referred to, illustrating an application thereto of certain features of my present invention.

Referring to the figures:

My cell comprises a cathode assembly forming a liquid tight base member and an anode assembly resting upon and making a liquid tight joint therewith.

The cathode assembly comprises a rectangular container or tank 1, preferably of steel, housing the cathodic electrode structure. The bottom of tank 1 is reinforced by ribs 4, extending transversely of the cell, and staggered ribs 5, 6 and 7, 8 extending longitudinally of the cell. Pads 9 and web 10 complete three points of support upon which the cell may rest upon insulators (not shown) supported from the floor.

The active surface of the cathode assembly consists of a series of thin, flat, foraminous cathodic electrode members 11, set on edge, and hence with their flat faces vertical. These cathodic electrode members are adapted to alternate with the anodic electrodes, to be described later. In the preferred embodiment of the invention, they are parallel with each other and arranged in groups or banks. The members of

each group are perpendicular to a side wall of tank 1. Between the two banks is a clearance or passage 12, to facilitate circulation of electrolyte (see Figs. 1 and 3). Between each bank of cathodic electrode members and the side wall to which the electrodes are perpendicular is a clearance or passage 13. Each bank of cathodic electrode members is conductively joined to the side wall of tank 1 to which it is adjacent by a strip of foraminous metal similar to that from which the electrodes themselves are formed. Each bank of cathodic electrode members extends downwardly to the bottom of tank 1 and is conductively joined thereto.

The form of these cathodic electrode members will be better understood by reference to Figs. 4 and 5, which illustrate one method of constructing these members. A long sheet of foraminous metal, preferably steel wire screen, having a width slightly greater than the height of the finished electrode members, is first bent into wide corrugations separated by narrow corrugations. The wide corrugations are of a width equal to the distance which is to separate the finished active cathodic electrode surfaces, between which surfaces the anodic electrodes are later to be installed, clearance being provided between the anodic and cathodic electrode surfaces for circulation of the electrolyte. The narrow corrugations are of a sufficient width to provide passages between the active cathodic electrode surfaces for removal of hydrogen and liquid products resulting from the hydrolysis. The edges of the narrow corrugations at one side of the sheet are then peened toward each other, preferably over a semi-circular mandrel, until they meet in seam 16, where they are butted and welded. The screen is also peened outward at the roots of the narrow corrugations as illustrated at 17, Fig. 4. A strip of wire screen is scalloped along one edge, the other edge being left straight. A portion of such a strip is illustrated at 18, Fig. 5. The radii and pitch of these scallops are those of the peened roots 17. These strips are butted and welded along the scallops to roots 17 of the cathodic electrode members 11. The number of cathodic electrode members 11 formed and assembled in this way depends upon the current under which the cell is designed to operate and other practical considerations.

A supporting structure for the cathodic electrode members is then built into tank 1. This support is made up of a number of upright steel bars, 23. These are of a width to slide freely into the clearances between cathodic electrode

members 11, but nevertheless wide enough to support the walls of these clearances against collapsing pressure. Bars 23 are welded by their lower ends to the bottom of tank 1. They are arranged in rows, preferably six, and spaced at exactly the distance which is intended to be the pitch of the electrode members or distance between their corresponding parts. At the ends of the cell bars 23 are supported from the end wall by legs 27. Flat steel bars 28 are also welded around the four sides of the cell near its rim, forming a shelf. Two banks of cathode electrode assemblies, formed as above described, are then inserted in the tank with their lower edges resting on the bottom of the tank, their borders, formed by strips 18, overlapping shelf 28 and their convolutions accurately spaced by upright bars 23. In this position, the borders are welded to the side walls and the lower edges to the bottom of tank 1. Strips 18 are continued around the ends of the tank by strip 20 and the sheets forming the convolutions are brought together, butted and welded at the ends of the cell. There is thus completed a cathode assembly comprising impermeate outer walls and bottom, and a perforate corrugated inner structure.

The cathodic electrode members 11 and, in fact, all of the foraminous cathode structures, are covered with a permeable diaphragm, as indicated by the speckled surfaces, dividing the cell into anode and cathode compartments. This is preferably of asbestos fiber. It will be noted that the cathodic electrode members comprise surfaces that could not be covered by a sheet of paper. The diaphragm can therefore best be applied by the method disclosed in my U. S. Patents Nos. 1,855,497; 1,862,244 and 1,865,152. The diaphragm formed in this way will cover strips 18 and 20, extending along the sides and ends of the cell respectively, and will therefore have its outer edges overlapped and sealed by the anode assembly, to be described later, which forms a cover to the cell. The impermeate bottom of tank 1 will however, remain uncovered and this must be insulated, otherwise caustic alkali would be formed here and as this would be on the anode side of the diaphragm it would come into contact with chlorine and be converted to the corresponding chlorate, with consequent loss of efficiency. Ordinarily it is very difficult to insulate impermeate metal and to protect diaphragm edges within such a cell. In the present case, however, this becomes a very simple matter. Since all the impermeate metal is in the bottom of tank 1 and the lower diaphragm edges are contiguous thereto, all that is necessary is to pour in grout or molten bituminous material, or both, as illustrated at 29, Fig. 2. This will spread uniformly over the surface to be protected and will be firmly anchored by the screen and its convolutions.

The anode assembly comprises a rectangular frame 30 and cover plate 33, supporting a series of graphite anodic electrodes 31. The proportion and dimensions of frame 30 conform to the rim of tank 1, so that this frame is adapted to rest upon shelf 28. Frame 30 is of non-conducting material, such as wood, slate, composition of cement and asbestos, etc. Cover 33 is bolted to frame 30 as shown. On the under surface of cover 33 are a number of flat steel fins 36, Fig. 2. These are welded by their edges to cover 33 and are spaced so that one fin 36 comes midway between each pair of rows of anodic electrodes 31. Holes 31b are drilled at intervals through

5 fins 36. Holes 31b are likewise drilled through graphite anode blades 31 near their upper ends. The upper ends of these blades are also notched, as shown at 37. With the plate inverted and the graphite blades held in position in a jig, a slab 35 of low melting metal or alloy, preferably lead, is formed, embedding not only fins 36, but the ends of graphite blades 31. This is done by introducing the metal while molten. The molten metal flows through the holes in fins 36 and through the holes and notches in graphite blades 31, thus anchoring the latter firmly to the former. Before pouring in the molten metal the under surface of cover 33 is tinned. The lead bonds with the tinned surface, thus ensuring good electrical contact.

The inner surfaces of cover 33 and lead slab 35 are protected against electrolysis by a layer 38, preferably of bitumen or asphalt. This is likewise poured in while molten and flows through the notches between contiguous blades. When the anode assembly is in place and frame 30 resting upon shelf 28 the joint between it and the cathode assembly is sealed by pouring in bitumen 39.

Cover 33 may be reinforced by steel frame 32 of angle section, to stiffen it against warping when the molten lead is poured in contact with its opposite side.

At a point above passage 12, preferably above the geometrical center of the cell, an exit 40 is provided for chlorine. This comprises a section of ceramic pipe 41 in an envelop 42 of steel, the bitumen of non-conducting layer 38 being allowed to fill the space between. Between the upper edges of cathodic electrode members 11 and the lower surface of non-conducting layer 38 sufficient clearance is provided for circulation of electrolyte and to permit the chlorine liberated on anodic electrodes 31 to find its way to passages 12 and thence to exit 40.

Hydrogen liberated on the cathodic side of the diaphragm finds its way through passage 13 to exit 44.

The liquid products of electrolysis, together with undecomposed electrolyte, are discharged from the cathode compartment through pipe 45 which, although connected to tank 1 near its bottom, is preferably formed with a high point slightly below the level of the upper edge of cathodic electrodes 11, so that the cathode compartment of the cell is normally nearly filled with liquid.

Electrolyte may be supplied to the cell in the form of a jet (not shown) directed downwardly into chlorine exit 40. The level of the electrolyte within the cell above the lower surface of layer 38 is indicated by liquid column 47 in manometer 48 in response to gas pressure built up in chamber 49 by chlorine evolved upon the anodes beneath chamber 48 and trapped therein under the hydrostatic head corresponding to the depth of submergence of the mouth of the chamber, as described in co-pending application Serial No. 304,813, filed by me November 16, 1939.

Bus bar 34 is bolted and soldered to the upper surface of cover 33 (passing through an opening in frame 32). Bus bar 46 is similarly bolted and soldered to the end of tank 1. These two bus bars serve to complete the electrical connections to the cell.

Fig. 6 illustrates a modified construction in which lead slab 35 is dispensed with. In this case, the ends of the anode blades are coated, as with copper, zinc or tin, by electroplating or

dipping, and under surface of plate 33 is tinned or galvanized as before, and the anode blades are butted against and bonded directly to plate 33. A layer of grout 50 may then be applied, to increase the mechanical strength of the support. This may be protected by a layer of bitumen 38. In this way the proportion of inactive graphite may be reduced to an absolute minimum.

In the construction of Fig. 2, obviously the layer of lead between the ends of the anode blade and plate 33 could be dispensed with and the blade butted directly against the plate as in Fig. 6.

Fig. 7 is a sectional elevation of a modification of the cell illustrated and described in my U. S. Patent No. 1,866,065 above referred to. In this case the anode assembly is similar to that above described, but inverted, plate 33a serving as a bottom closure, instead of as a cover, for the cell, analogous parts being indicated by the same reference figures, followed by the suffix "a." Thus, this assembly comprises anodes 31a, provided with holes 31ba an insulating frame 30a, steel plate 33a, lead slab 35a, fins 36a, provided with holes 36ba and bitumen layer 38a. A gasket 51 is interposed between frame 30a and plate 33a. A cathode assembly 1a, provided with cathodic electrodes 11a, rests upon frame 30a, with gasket 53 between, and a concrete cover 52 rests upon the cathode assembly, with gasket 54 between. Bus bars 34a and 46a serve to complete the electrical connections to the anode and cathode assembly respectively. 55 is a tube through which a jet of electrolyte is supplied to the cell.

While I have illustrated and described one method of forming the cathodic electrodes and two methods of affixing the graphite anode blades to the steel cover of the cell I do not wish to be limited thereto, as other equivalent methods of accomplishing these objectives will suggest themselves to persons skilled in the art.

I claim as my invention:

1. In an electrolytic alkali chlorine cell, a cathode assembly comprising a normally level, liquid-retaining metal plate structure adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising cathodic electrodes adapted to co-operate with chlorine-resistant anodic electrodes and to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, said cathodic electrodes having edges butted directly against and conductively affixed to the inner surface of said metal plate structure, covering local areas thereof; impervious, non-conducting, chlorine-resistant material covering and protecting the inner surface of said plate structure between areas covered by said foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from within said foraminous structure.

2. In an electrolytic alkali chlorine cell, a cathode assembly comprising a normally level, liquid-retaining metal plate structure adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising a plurality of spaced, horizontally-aligned, cathodic electrodes, having flat side walls adapted to co-operate with flat-faced, upright, chlorine-resistant anodic electrodes, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, said cathodic electrodes having edges butted directly against and conductively affixed to the inner sur-

face of said metal plate structure, covering local areas thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said plate structure between areas covered by foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from within said foraminous structure.

3. In an electrolytic alkali chlorine cell, a cathode assembly comprising a normally level, liquid-retaining metal plate structure adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising a plurality of spaced, horizontally-aligned, cathodic electrodes, having flat side walls adapted to co-operate with flat-faced, upright, chlorine-resistant anodic electrodes, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, and having edges, including those of the side walls of said cathodic electrodes, butted directly against and conductively affixed to the inner surface of said metal plate structure, covering local areas thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said plate structure between areas covered by foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from within said foraminous structure.

4. In an electrolytic alkali chlorine cell, a cathode assembly comprising an open, liquid-tight, rectangular metal tank adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising two banks of thin, elongated, parallel, spaced, horizontally-aligned, cathodic electrodes extending from opposite sides of said tank perpendicularly with respect thereto and with respect to the bottom of said tank and adapted to alternate and co-operate with flat-faced, upright, chlorine-resistant, anodic electrodes extending downwardly from above, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, each of said cathodic electrodes comprising a top wall, an inner end wall, and two side walls and being open at its outer end, the spaces between adjacent cathodic electrodes being bridged at their outer ends to form discontinuous inner walls paralleling the side walls of said tank, with corridors between into which the cathodic electrodes may freely deliver products of electrolysis through their open outer ends, the outer edges of said top walls and upper edges of said bridge walls being conductively joined to the rim of said tank, the lower edges of said bridge walls and cathodic electrode side walls and inner end walls being butted directly against and conductively joined to the bottom of the tank, covering local areas thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said tank between areas covered by said foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from said corridors.

5. In an electrolytic alkali chlorine cell, a cathode assembly comprising an open, liquid-tight, rectangular metal tank adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising two banks of thin, parallel, spaced, horizontally-aligned, cathodic electrodes extending from opposite sides of said tank perpendicularly with respect thereto and with respect to the bottom of said tank and adapted to alternate and co-

operate with flat-faced, upright, chlorine-resistant, anodic electrodes extending downwardly from above, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, each of said cathodic electrodes comprising a top wall, an inner end wall and two side walls and being open at its outer end, the spaces between adjacent cathodic electrodes being bridged at their outer ends to form discontinuous inner walls paralleling the side walls of said tank, with corridors between into which the cathodic electrodes may freely deliver products of electrolysis through their open outer ends, walls paralleling the end walls of said tank with corridors between, the spaces between cathodic electrodes at the extremities of said banks and said walls paralleling the ends of said tank being bridged at the outer ends of said cathodic electrodes, the outer edges of said top walls and upper edges of said bridge walls and inner walls paralleling the end walls of said tank being conductively joined to the rim of said tank, the lower edges of said bridge walls and walls paralleling the end walls of said tank and cathodic electrode side walls and inner end walls being butted directly against and conductively joined to the bottom of the tank, covering local areas thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said tank between areas covered by said foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from said corridors.

6. In an electrolytic alkali chlorine cell, a cathode assembly comprising an open, liquid-tight, rectangular metal tank, provided with an inwardly extending shelf around its rim, said tank being adapted to carry the cell current and housing an inner, foraminous, caustic alkali-resistant, metal structure comprising two banks of thin, parallel, spaced, horizontally-aligned, cathodic electrodes extending from opposite sides of said tank perpendicularly with respect thereto and with respect to the bottom of said tank and adapted to alternate and co-operate with flat-faced, upright, chlorine-resistant, anodic electrodes, extending downwardly from above, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable, chlorine-resistant diaphragm material, each of said cathodic electrodes comprising a top wall, an inner end wall, and two side walls and being open at its outer end, the spaces between adjacent cathodic electrodes being bridged at their outer ends to form discontinuous walls paralleling the

side walls of said tank, with corridors between into which the cathodic electrodes may freely deliver products of electrolysis through their open outer ends, the outer edges of said top walls and upper edges of said bridge walls being conductively joined to the rim of said tank, the lower edges of said bridge walls and cathodic electrode side walls and inner end walls being butted directly against and conductively joined to the bottom of the tank, covering local areas thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said tank between areas covered by said foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from said corridors.

7. In an electrolytic alkali chlorine cell, a cathode assembly comprising an open, liquid-tight, rectangular metal tank adapted to carry the cell current and housing an inner foraminous, caustic alkali-resistant, metal structure comprising two banks of thin, elongated, parallel, spaced, horizontally-aligned, cathodic electrodes extending from opposite sides of said tank perpendicularly with respect thereto and with respect to the bottom of said tank and adapted to alternate and co-operate with flat-faced, upright, chlorine-resistant, anodic electrodes extending downwardly from above, said foraminous structure being adapted to be covered on its anode facing surfaces with permeable chlorine-resistant diaphragm material, said cathodic electrodes comprising elongated sheets of foraminous metal flexed into convolutions having straight sides, constituting the active faces of the cathodic electrodes, joined by fillets, constituting the ends and roots of the cathodic electrodes, the top edges of said sheets being peened to form filleted flanges continued around the roots of the cathodic electrodes, said flanges being joined to form the top walls of the cathodic electrodes, the scalloped edges thus left free along the upper outer edge of each of the resulting structures being conductively joined through a fitted filler strip to the rim of said tank, constituting a bank of electrodes, the lower edges of each of said resulting structures being butted directly against and conductively joined to the bottom of the tank, covering a local area thereof; impervious, non-conducting, chlorine-resistant material protecting the inner surface of said tank between areas covered by said foraminous structure; and means for withdrawing gaseous and liquid products of electrolysis from said corridors.

KENNETH E. STUART.