

Oct. 22, 1946.

K. E. STUART

2,409,912

ELECTROLYTIC ALKALI CHLORINE DIAPHRAGM CELL

Filed May 28, 1942

4 Sheets-Sheet 1

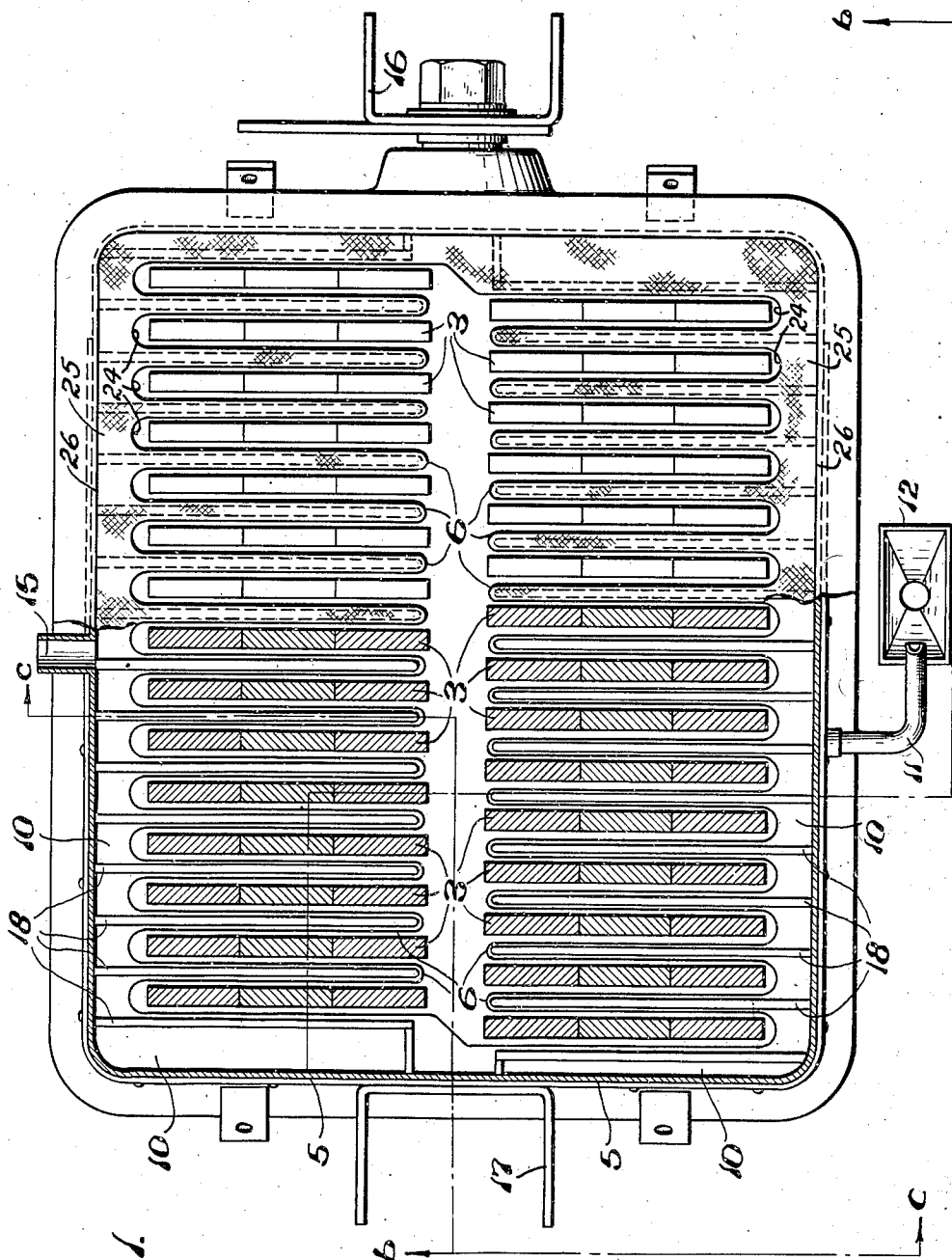


Fig. 1.

INVENTOR

Kenneth E. Stuart

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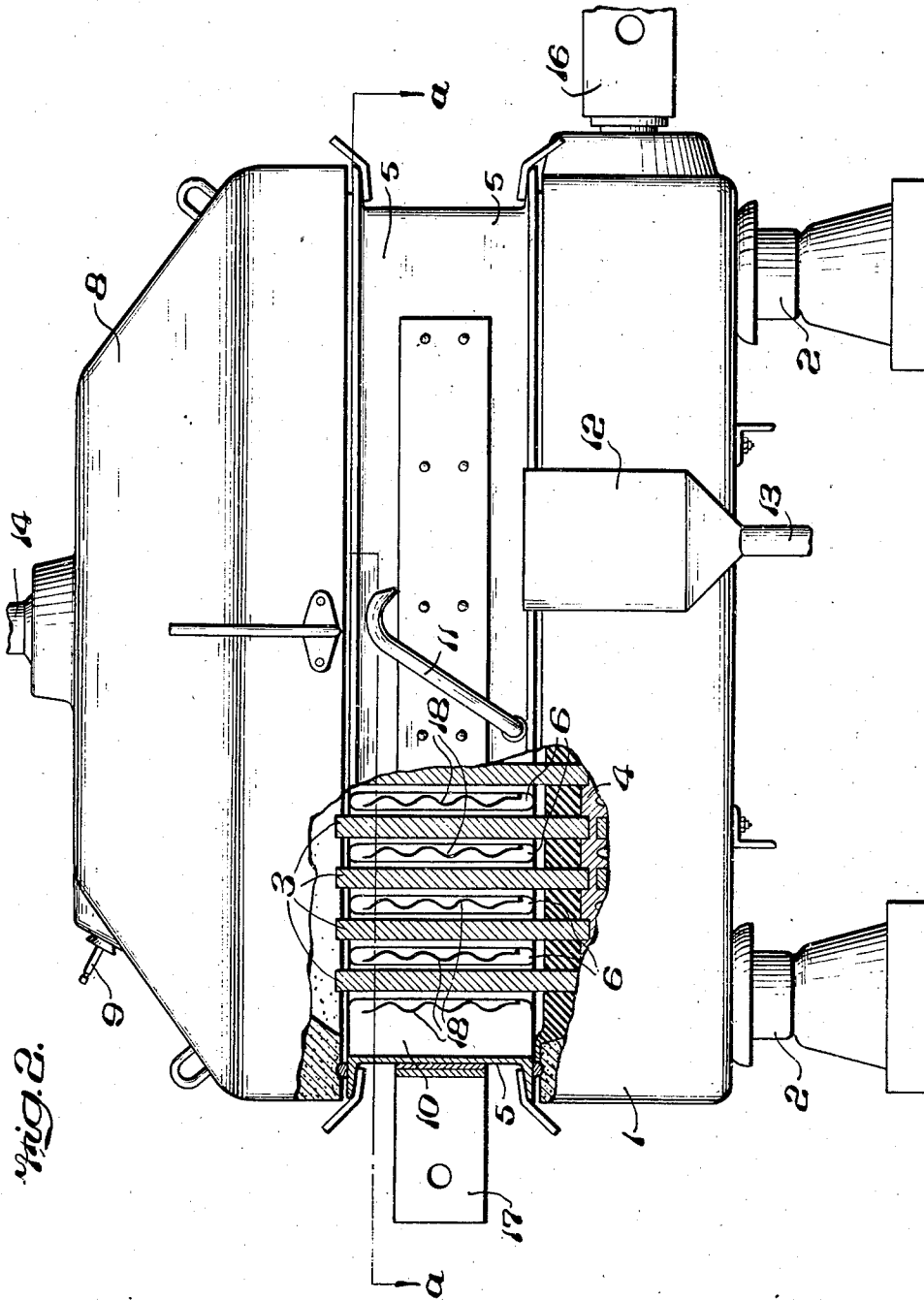
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4 Sheets-Sheet 2



INVENTOR

Kenneth A. Stuart

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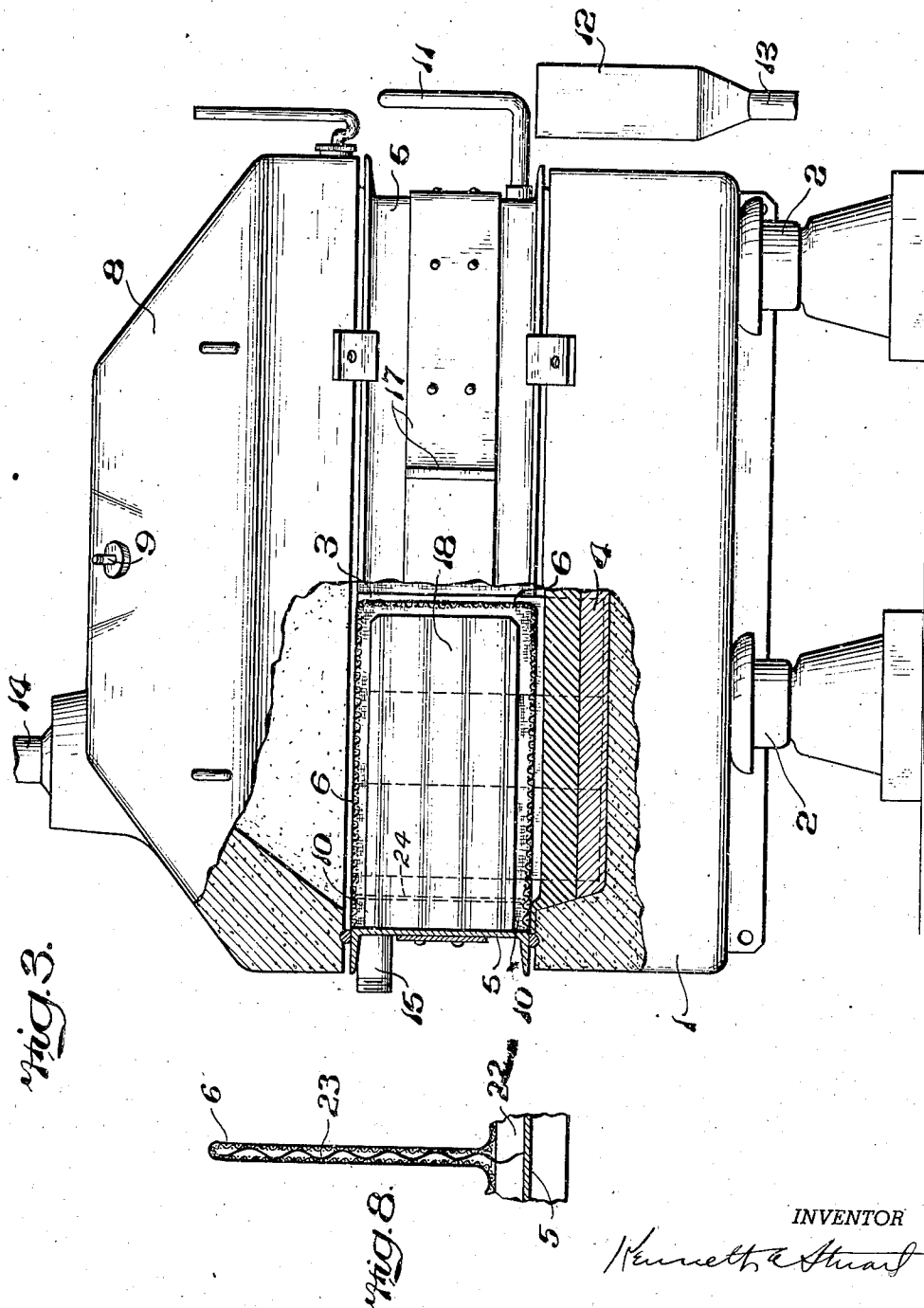
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Fig. 5

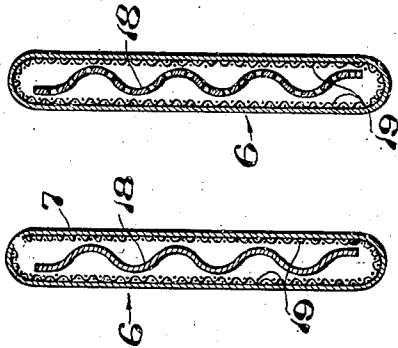


Fig. 4.

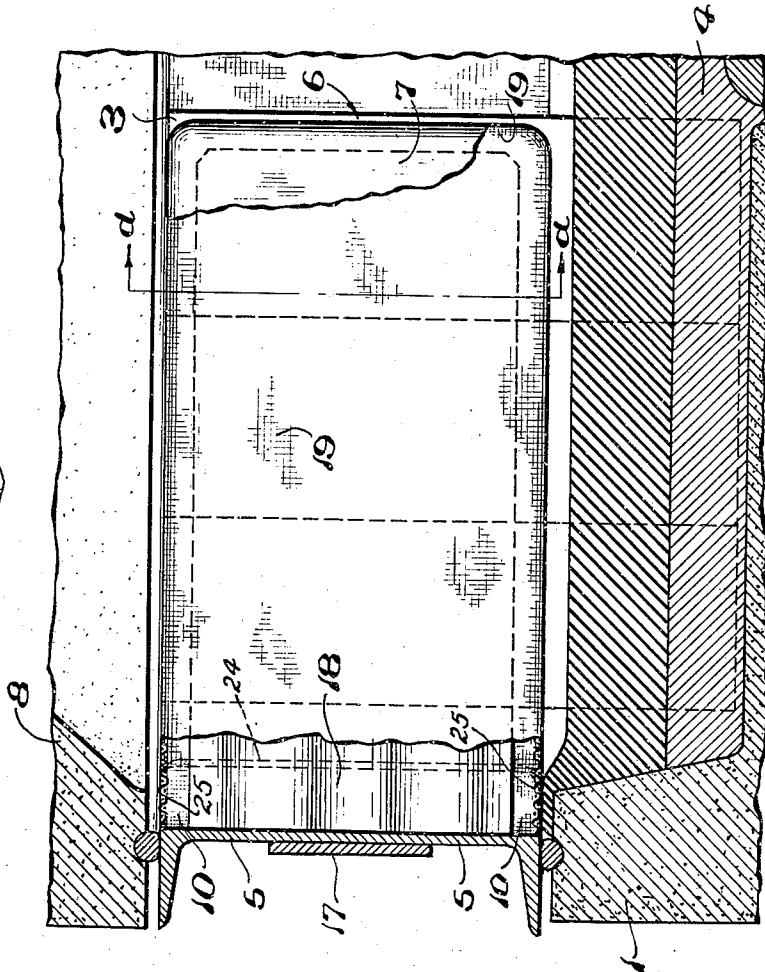
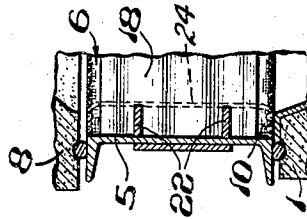


Fig. 7.



INVENTOR

Kenneth E. Stuart

UNITED STATES PATENT OFFICE

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ELECTROLYTIC ALKALI CHLORINE
DIAPHRAGM CELLKenneth E. Stuart, Niagara Falls, N. Y., assignor
to Hooker Electrochemical Company, Niagara
Falls, N. Y., a corporation of New York

Application May 28, 1942, Serial No. 444,770

4 Claims. (Cl. 204—266)

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My invention relates more particularly to an improvement upon the electrolytic cell disclosed in U. S. Patent No. 1,866,065, granted to me July 5, 1932. One object of my invention is to provide a simplified inner supporting structure for the cathodic electrodes. Another object of my invention is to increase the active cathodic electrode surface of the cell without at the same time increasing the diaphragm surface. Still another object of my invention is to reduce the resistance of the current path to the active cathodic electrode faces.

Referring to the drawings:

Fig. 1 is a plan view of a cell embodying my invention, with the chlorine gas collecting cover removed to reveal the electrodes, and some of the cathodic electrodes in section, along line *a—b* of Fig. 2, to reveal the supporting structure within them, the foraminous walls of the cathodic electrodes and diaphragm covering them being indicated conventionally by single lines.

Fig. 2 is a side elevation of my cell, partly in section, the section being taken partly through the electrodes, along line *b—b* of Fig. 1, to show the supporting structure with the cathodic electrodes, the foraminous walls of the cathodic electrodes being indicated conventionally as before.

Fig. 3 is an end elevation of my cell, partly in section, the plane of the section extending along line *c—c* of Fig. 1, through one of the cathodic electrodes, to show the supporting structure within it, which is not in section.

Fig. 4 is a longitudinal elevation of a portion of my cell to an enlarged scale, partly in section, showing one of the cathodic electrodes and supporting structure within it, which is not in section.

Fig. 5 is a cross sectional elevation of one of the cathodic electrodes of my cell along the line *d—d* of Fig. 4, the inner supporting structure being likewise in section. The scale of vertical dimensions in Fig. 5 is the same as that of Fig. 4, but the scale of some of the horizontal dimensions is somewhat exaggerated, in order to show the details more clearly.

Fig. 6 is a sectional detail of a modified form of a portion of the inner supporting structure, to the scale of Fig. 5.

Fig. 7 is a sectional detail of a portion of the inner supporting structure, illustrating a modified method of assembling the same and affixing it in position, to the scale of Figs. 1 to 3.

Fig. 8 is a sectional detail of one of the cathodic electrodes in plan, to the scale of Fig. 1, showing

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another modifier form of a portion of the inner supporting structure.

Referring to Figs. 1, 2 and 3, 1 is a bottom member, which in this case is shown as rectangular and constructed of concrete. Bottom member 1 rests upon non-conducting members 2, 2 and houses the anode assembly, comprising rows of upright, elongated, graphite anodic electrodes 3, 3 in the form of flat-sided blades, and having their lower ends conductively affixed to a metallic plate 4, preferably of lead.

Resting upon bottom member 1 is the cathode assembly, comprising a normally level, liquid-retaining enclosing frame including walls 5, of metal plate, in this case of channel section, adapted to carry the cell current and conforming in plan to bottom member 1, and, projecting perpendicularly with respect to walls 5, and with their outer ends conductively affixed thereto in a manner to be hereinafter described, two banks of thin, parallel, flat-sided, elongated, horizontally aligned, foraminous cathodic electrodes 6, 6, alternating with anodic electrodes 3, 3, and adapted to be covered by permeable, chlorine-resistant diaphragm 7 (Fig. 5). This diaphragm is preferably of asbestos fiber and formed in accordance with the process of U. S. Patent No. 1,865,152 granted to me June 28, 1932, and therefore seamless over the entire foraminous cathodic structure of the cell.

The cathodic electrodes are part of a foraminous structure, housed in enclosing walls 5. This structure is preferably of woven wire screen, as clearly illustrated in Figs. 4 to 8. The side walls or active faces 19 of adjacent cathodic electrodes are joined at their butt ends by walls 24, which are preferably arcuate, thus presenting in plan view the appearance of fillets, as illustrated in Fig. 1. Walls 24 are spaced from walls 5, leaving corridors 10 between, for the reception of liquid and gaseous products issuing from the open butt ends of the cathodic electrodes. Corridors 10 are closed at top and bottom by walls 25, which are scalloped to fit the fillets formed by walls 24. The outer edges of walls 25 are conductively affixed to the inner faces of walls 5, flush with their upper and lower edges, along seams 26, preferably by welding. The current flow from walls 5 to the active faces of the cathodic electrodes is therefore inward and edgewise through walls 25, thence edgewise through walls 24 and thence inward and edgewise through active faces 19 of the cathodic electrodes. The vertical wires of the active faces, indicated by the corrugated lines in Figs. 5 and 6, form closed flat-

tened loops. These vertical wires receive current from the horizontal wires of the active faces, indicated by the dots in Figs. 5 and 6, by pressure contact therewith. These horizontal wires mostly receive current in the same way, i. e., by pressure contact from the vertical wires of walls 24, which are conductively connected to horizontal wires in walls 25, preferably by welding. Hence a large proportion of the wires constituting the active faces of the cathodic electrodes receive current through a considerable length of intervening or intermediate wire made up of two or three separate sections electrically connected by pressure contact only. There is an appreciable voltage drop in these wires and contacts, and it is desirable to minimize this drop.

Surmounting the cathode assembly, conforming therewith and resting upon enclosing walls 5, is the chlorine gas collecting cover or cell top 8, which may be of concrete as shown. The joints between bottom member 1 and walls 5, and between the latter and cover member 8, may be rendered liquid tight by the gasket means illustrated in U. S. Patent No. 2,208,778, granted to me July 23, 1940. Brine is fed into the interior of the cell to serve as electrolyte therein through tubular controlling restriction 9, preferably in accordance with U. S. Patent No. 2,183,299, granted to me Dec. 12, 1939. The electrolyzed brine, after percolating through the diaphragm, is received into the hollow cathodic electrodes and delivered by them at their outer ends into corridors 10, as above stated, whence it issues through effluent pipe 11, to be caught in funnel 12 and carried away to a header (not shown) through pipe 13. Chlorine gas is carried away from cover 8 through exit 14 to a header, not shown. Hydrogen gas is carried away from the upper part of the corridors 10 through pipe 15 to a header, not shown. Direct electric current is passed through the electrolyte between the anodic and cathodic electrodes from a generating source (not shown) by means of bus bars 16 and 17.

In the course of forming the diaphragm, in accordance with the process of the above mentioned patents, vacuum is applied to the interior of the cathodic electrodes, and there results a considerable pressure upon the outer surface thereof. In order to prevent collapse of the cathodic electrodes under this pressure, it has heretofore been the practice to build into them a skeleton structure, comprising upper and lower frames, consisting each of horizontal members extending longitudinally along opposite enclosing walls 5, and welded thereto and elongated members extending within the cathodic electrodes perpendicularly with respect to the members just described and welded thereto at their intersections therewith. These latter members are of a width to support the cathodic electrodes against collapsing pressure. A series of vertical members, one to each cathodic electrode, is then welded to the upper and lower frames thus formed, at the points where these members intersect, to join the upper and lower frames into a single skeleton structure. This structure is fully illustrated and described in Patent No. 1,866,065.

I have now found that this structure may be advantageously replaced by a series of plates, preferably one to each cathodic electrode, welded by one end directly to the interior surface of the walls of retaining structure 5, at opposite sides thereof, and extending horizontally within the cathodic electrodes. These plates are illustrated

at 18 in the figures. They are preferably formed with corrugations, the corrugations having an amplitude sufficient to support the foraminous walls 19 (Fig. 5) of the cathodic electrodes against collapse. These corrugations may extend horizontally, or longitudinally with respect to the greatest dimension of the cathodic electrodes, as illustrated in Figs. 3 to 7. In that form the plate permits of a more rigid connection with the walls of the retaining structure and is more resistant to bending in a direction transverse to the cathodic electrodes. One of these corrugated plates is illustrated in side elevation in Fig. 4 and in cross section in Fig. 5. The liquid and gaseous cathodic products of electrolysis may find their way along the corrugations to corridor 10 and thence to effluent pipe 11 or hydrogen pipe 15 respectively. However, in Figs. 1 to 7 the amplitude of the corrugations is shown as slightly less than the distance between the foraminous walls 19 of the cathodic electrodes, providing clearance through which the hydrogen may rise directly to the upper part of the cathodic electrode, whence it may find its way to corridor 10. The upward flow of hydrogen may, if desired, be facilitated by perforating the sheet metal of which the plate is to be formed, before corrugating it, producing a perforated plate, as illustrated in Fig. 6. I have found however that standard corrugated steel roofing, which is normally plentiful and cheap, is very well adapted to my purpose. For reasons of symmetry, the corrugated plate is preferably cut so that its upper and lower edges are in opposite phase with respect to the corrugations.

If preferred, the horizontal members previously described as extending horizontally along opposite sides of retaining structure 5, in accordance with previous practice, may be retained, as illustrated as 22 in Fig. 7. The corrugated plates are then notched at their ends for passage therethrough of members 22 and welded to these members. This construction permits the plates 18 and members 22 to be assembled, and the foraminous structure to be slipped over the supporting structure thus formed, while outside of retaining walls 5. The entire assembly is then placed within walls 5 in its proper position, as a unit, and members 22 welded thereto.

Also, if preferred, the corrugations may extend vertically, or transversely with respect to the greatest dimension of the cathodic electrodes, as illustrated at 23 in Fig. 8, which is a sectional plan view through one of the cathodic electrodes. In this figure the corrugations are shown as contacting the foraminous walls. This is an advantage, as it facilitates flow of current from the corrugated plate to the walls and thus reduces the resistance of the current path to the active faces of the cathodic electrodes. In order to ensure good contact between the corrugations and wires, the amplitude of the corrugations may be made greater than that of the desired distance between the walls and the whole structure brought to the desired dimensions by flattening between heavy clamping plates, in obvious manner. The corrugations are thus reduced in amplitude and increased in pitch and considerable pressure caused between them and the wires, insuring good conductive contact between these two conductive elements. Thus the conductivity of the current path through the wires from walls 5 is supplemented by the more ample conductivity of the corrugated plates 18, and the voltage drop therein appreciably reduced. When the corru-

gations are vertical the use of members 22 (Fig. 7) becomes rather important, for reasons of mechanical strength as well as of electrical conductivity.

Hitherto nothing has been said about the effect upon the operating characteristics of the electrolytic cell, resulting from the introduction of the inner corrugated plate within the cathodic electrodes. However, this is of great importance, and one of the leading objects of my invention. It will be noted that effluent pipe 11, although connected to corridor 10 near its lower-most portion, rises therefrom and has its outer end bent over and terminating in a downwardly directed spout. The high point of this pipe determines the liquid level within corridor 10. Pipe 11 is normally set so that the liquid within corridor 10, and hence within cathodic electrodes 6, is slightly below the ceiling thereof, leaving a passage above the liquid through which the hydrogen may flow freely to exit 15. It will be observed therefore that the inner plates extending within the cathodic electrodes are immersed in liquid that has percolated through the diaphragm. This liquid contains caustic alkali produced upon the surface of the foraminous walls, but it also normally contains approximately one half of the original quantity of alkali metal chloride, since that proportion of the chloride normally goes through the diaphragm undecomposed. These inner plates are therefore immersed in electrolyte and constitute inner cathodic electrodes. The inner plate is farther from the anodic electrode than the outer foraminous wall, but on the other hand has a more direct connection with adjacent wall 5, through which current is supplied to the cathodic electrodes. The inner plate therefore acts to some extent through the mesh of the outer wall and its effect is to diminish the mean current density upon the cathodic electrode surfaces, as a whole. It is well known that the voltage that must be impressed upon the cell to cause a given current to flow through it is a function of the current density at the electrodes. However, relatively low current density means not only correspondingly low output, but also relatively low operating temperature. These conditions favor mingling of chlorine with caustic soda, hence production of the undesired by-product sodium chlorate, with corresponding loss of current efficiency. Cells operated at relatively low current density therefore show correspondingly low current efficiency. On the other hand, cells operated at relatively high current density show correspondingly low power efficiency. For a given anodic current density, the cell of my invention operates at a lower voltage than those of the prior art, without a corresponding loss of current efficiency. Conversely, when operated at the same voltage as cells of the prior art having equivalent anodic electrode and radiating surfaces, it yields a greater output of product.

Although I have described and illustrated my inner plates as corrugated, I do not wish to be limited to that construction, as any inner plate of equivalent construction comes within the scope of my invention. Also, although I have illustrated and described my invention as applied to the cell of Patent No. 1,866,065, I do not wish to be limited thereto, as my invention is equally applicable to the cells of co-pending applications Serial Nos. 355,317, 355,346 and 356,388, filed Sept. 4, 1940, Sept. 4, 1940, and Sept. 11, 1940, respectively, or electrolytic cells of any other construction which use perforated or foraminous cathodic electrodes.

In other words, my invention includes, broadly, any cathodic electrode comprising a perforate outer wall backed by a perforate or imperforate inner plate electrolytically associated therewith, i. e., forming therewith, for electrolytic purposes, substantially a unitary cathodic electrode.

I claim as my invention:

1. An electrolytic alkali-chlorine cell cathode structure comprising a liquid-retaining wall carrying the cell current and a thin, elongated, hollow, foraminous cathodic electrode projecting therefrom and cooperating with a pair of electrically interconnected anodic electrodes on each side thereof; said cathodic electrode having a top wall and flat, parallel, spaced side walls, of woven wire screen, in edgewise electrical communication with said retaining wall, the wires of the screen composing said side walls communicating with said retaining wall by pressure contact with intermediate wires welded thereto; in combination with means for improving the conductivity of the electrical path to portions of said side walls remote from said retaining wall comprising an electrically continuous metal plate between said side walls, butted against, welded to and projecting from said retaining wall, said plate being corrugated and the crests of its corrugations being in electrical contact with the inner surfaces of said side walls.

2. An electrolytic alkali-chlorine cell cathode structure comprising a liquid-retaining wall carrying the cell current and a thin, elongated, hollow foraminous cathodic electrode projecting therefrom and cooperating with a pair of electrically interconnected anodic electrodes on each side thereof; said cathodic electrode having a top wall and flat, parallel, spaced side walls, of woven wire screen, in edgewise electrical communication with said retaining wall, the wires of the screen composing said side walls communicating with said retaining wall by pressure contact with intermediate wires welded thereto; in combination with means serving as a supplementary unipolar cathodic electrode acting through the meshes of said side walls, comprising an electrically continuous metal plate, between said side walls, butted against, welded to and projecting from said retaining wall.

3. An electrolytic alkali-chlorine cell cathode structure comprising a liquid-retaining wall carrying the cell current and a thin, elongated, hollow, foraminous cathodic electrode projecting therefrom and cooperating with a pair of electrically interconnected anodic electrodes on each side thereof; said cathodic electrode having a top wall and flat, parallel, spaced side walls, of woven wire screen, in edgewise electrical communication with said retaining wall, the wires of the screen composing said side walls communicating with said retaining wall by pressure contact with intermediate wires welded thereto; in combination with means for improving the conductivity of the electrical path to portions of said side walls remote from said retaining wall comprising an electrically continuous metal plate between said side walls, butted against, welded to and projecting from said retaining wall, said plate being corrugated and the crests of its corrugations being in elastic pressure electrical contact with the inner surfaces of said side walls.

4. An electrolytic alkali-chlorine cell cathode structure comprising a liquid-retaining wall carrying the cell current and a thin, elongated, hollow, foraminous cathodic electrode projecting

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therefrom and cooperating with a pair of electrically interconnected anodic electrodes on each side thereof; said cathodic electrode having a top wall and flat, parallel, spaced side walls, of woven wire screen, in edgewise electrical communication with said retaining wall, the wires of the screen composing said side walls communicating with said retaining wall by pressure contact with intermediate wires welded thereto; in combination with means for improving the conductivity of the

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electrical path to portions of said side walls remote from said retaining wall comprising an electrically continuous metal plate between said side walls, butted against, welded to and projecting from said retaining wall, said plate having vertical corrugations and the crests of said corrugations being in electrical contact with the inner surfaces of said side walls, said plate extending to a level short of said top wall.

KENNETH E. STUART.