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ELECTROLYTIC CELLS FOR THE DECOMPOSITION OF ALKALI CHLORIDES

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2 Sheets-Sheet 1

FIG. 1

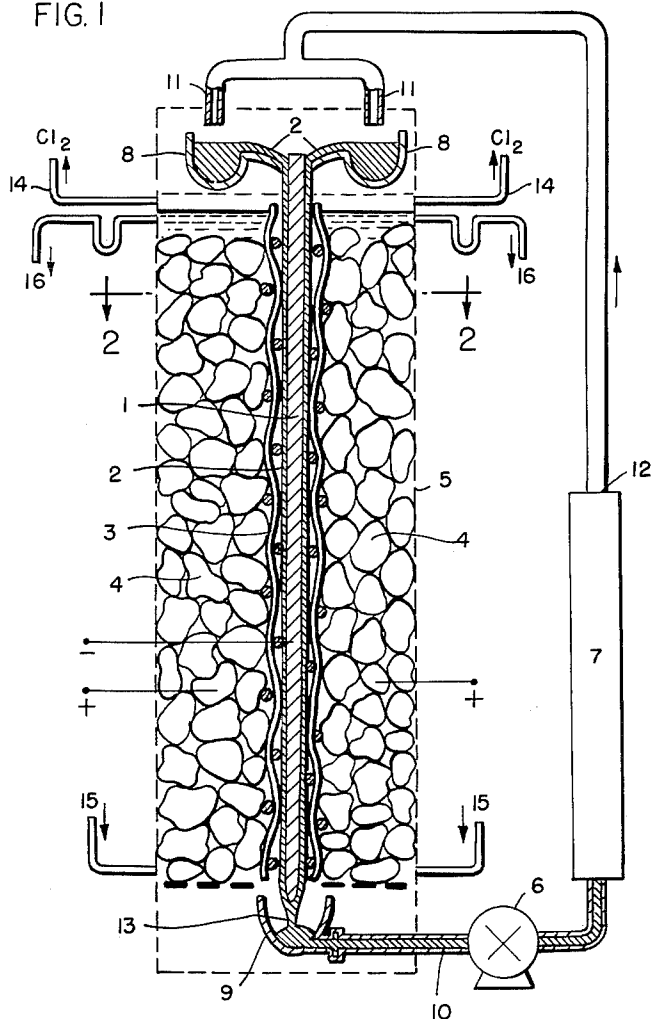
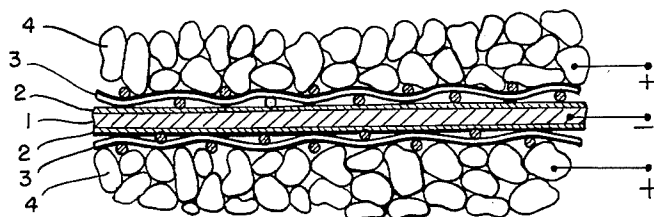


FIG. 2



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FIG. 3

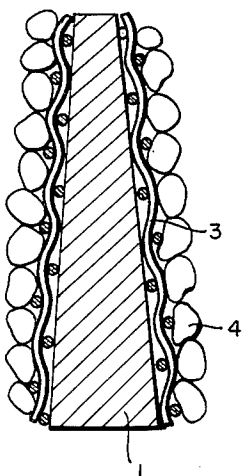


FIG. 4

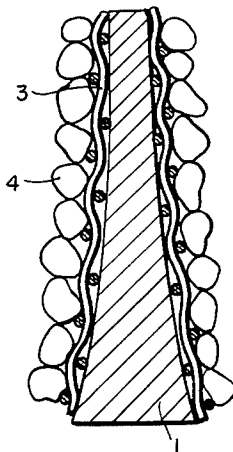
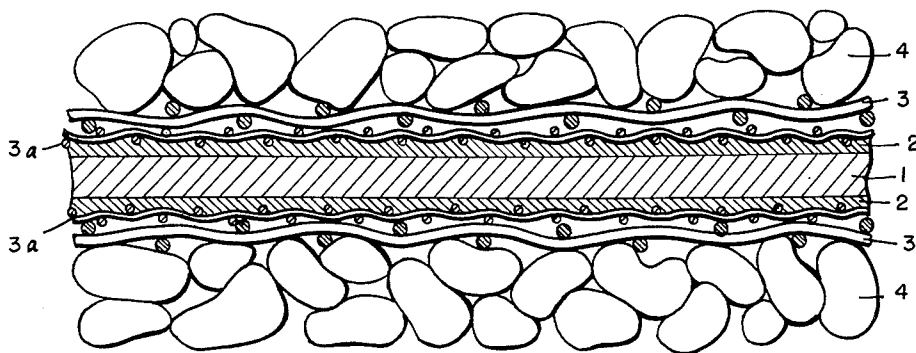


FIG. 5



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## ELECTROLYTIC CELLS FOR THE DECOMPOSITION OF ALKALI CHLORIDES

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11 Claims. (Cl. 204—220)

This invention relates to electrolytic cells for the electrolysis of aqueous alkali chloride solutions. In particular it relates to cells in which the cathode is covered with mercury so that a mercury-alkali amalgam is formed in the cell.

In the development of electrolytic cells for the decomposition of alkali chlorides with mercury as the cathode, two different courses have been followed; the mercury cathode has been arranged either horizontally or vertically. At the present time, cells with horizontal cathodes are primarily employed in commercial practice. The advantage of this construction resides in the fact that it is easier to produce a planar surface of mercury having large dimensions. Regulation of the graphite anodes can be more easily accomplished in such horizontal cells. Also, it is more convenient to circulate the mercury by pumping. Opposed to these advantages, however, is the great floor area requirement, i.e. the horizontal space needed to hold a large number of cells. The floor area is a most important feature of electrolytic cells because of the large number of individual cells which have to be combined to make an economic unit. It is desirable that the floor area be small, since with a small floor area the cells can readily be checked during operation and the costs of the electrical installation kept low. Also, the supply and withdrawal of the electrolyte and the electrolysis products are relatively simple.

The alkali chloride solution serving as the electrolyte being usually electrolyzed at elevated temperature, long inlet and outlet pipes for the electrolyte result in the hot solution being cooled to a considerable degree. This may lead to stoppages especially when saturated potassium chloride solution is employed.

In the vertical cells of hitherto known construction, a smaller floor area is possible, but besides the more difficult subsequent regulation of the anodes, it is especially difficult to control the flow of mercury. In particular, the mercury flows downwardly along the cathode at too great a speed so that it does not remain in the cell long enough for reaction during electrolysis to form alkali metal amalgam of the desired concentration. Moreover there is the risk that the mercury, instead of flowing down uniformly over the cathode carrier, will roll off the cathode carrier in drops. Such drops of mercury are in a depolarized condition and will be attacked by chlorine so that loss of mercury occurs. Since the speed of fall of the mercury increases markedly as the height of the cell increases, vertical cells can only be constructed up to a relatively small height. Therefore a cell with a vertical mercury cathode has no real advantage.

One object of this invention is to provide an electrolytic cell which requires only a small floor area. A further object is the provision of an electrolytic cell in which it is not necessary to regulate the distance between the cathode and anode during operation of the cell.

Another object of this invention is to provide an electrolytic cell in which mercury moves vertically downwardly on the cathode without becoming detached from the cathode or forming drops.

A further object of this invention is the provision of an electrolytic cell in which mercury flows as a uniform layer

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vertically downwardly on the cathode and the speed of the downwardly movement of the mercury can be regulated in a simple way.

Further objects and advantages will become more apparent in view of the following detailed description of the invention taken with the accompanying drawings wherein:

FIG. 1 is a vertical cross-section, partly in schematic form, of an electrolytic cell constructed in accordance with the present invention;

FIG. 2 is a horizontal cross-section taken on line 2—2 of FIG. 1;

FIGS. 3 and 4 each illustrate a vertical cross-section of an electrolytic cell corresponding to FIG. 1, but with different embodiments showing a variation in the thickness of the vertical cathode plate; and

FIG. 5 is a horizontal cross-section corresponding to FIG. 2, except that the view has been enlarged to illustrate another embodiment of the electrolytic cell containing both a narrow-meshed and coarse-meshed screening means on either side of the cathode plate.

The electrolytic cell of this invention operates according to the following principle:

A cathode carrier 1 in the form of a plate, for example of iron, has mercury 2 flowing down over the surface thereof, and is provided with a screening means 3 of electrically non-conducting material, as for example polyvinyl chloride, polyvinylidene chloride or a copolymer of vinyl chloride and vinylidene chloride. An anode mass 4 in the form of lumps presses the screening means against the cathode carrier.

As may be seen from FIGURE 1, two channels 8 are provided in the upper part of the cell housing 5, and mercury 2 flows from these channels onto the cathode carrier. During its downward path, the mercury reacts to form amalgam of the desired concentration and this amalgam 13 is collected in a channel 9 whence it is supplied through recycle line 10 by means of a pump 6 to the decomposition apparatus 7. The mercury leaving the decomposer 7 at 12 is resupplied to the cell at the points 11. The alkali chloride solution is supplied through inlets 15 and leaves through outlets 16. The chlorine formed during the electrolysis is withdrawn in gaseous form through pipes 14.

FIGURE 2 illustrates a cross-section of an electrolytic cell according to the present invention. In the drawing 1 is the cathode carrier, 2 mercury flowing down the cathode carrier, 3 the screening means provided between the mercury and the anode and 4 one of the graphite particles making up the anode.

FIGURES 3 and 4 are special embodiments of my invention, according to which the cathode carrier widens toward the bottom. In either of these drawings, 1 is the cathode carrier, 3 the screening means and 4 one of the particles making up the anode.

The screening means which separates the mercury from the anode may be either rigid or flexible. It may be arranged either in direct contact with the cathode carrier or at a small distance therefrom so that it can be pressed against the cathode carrier by the anode particles.

FIGURE 5 serves to illustrate an embodiment of the invention in which the coarser-meshed screen 3 is applied to a narrower-meshed screen 3a, both screens acting to regulate the flow of mercury 2 on cathode 1 and to separate the anode particles 4 from the cathode.

It should be noted that my invention as set forth herein is not restricted to the embodiments shown in the accompanying drawings. The drawings merely serve to illustrate some of the preferred embodiments of my invention and any arrangement which may be considered equivalent falls within the scope of my present invention.

In a cell in accordance with the present invention, a vertical cathode carrier plate adapted to receive liquid mercury as a fluid cathode flowing downwardly on a vertical surface of the said plate, has a porous electrically non-conducting screening means adjacent to the said vertical surface. The screening means serves to control the downward flow of the mercury and contains a plurality of openings which are sufficiently large to permit passage of an electrolytic solution. The openings are sufficiently small to hold flowing mercury against the cathode plate. It is advantageous to arrange the cathode carrier plate centrally in the cell housing and to fill the anode mass in on both sides of the cathode carrier.

The cathode carrier plate need not have the same thickness at all points. For example the cathode carrier may widen downwardly in order to ensure a still better adherence of the mercury to the cathode carrier (see FIGURES 3 and 4 of the accompanying drawings).

The cathode carrier plate may consist of any material which is electrically conducting, which has sufficient rigidity and which is not attacked by mercury. The material of the cathode carrier may be especially a metal which is capable of amalgamation and which does not decompose alkali amalgams. Iron is usually used for this purpose but equivalent materials can be substituted. The properties required for the material for the screening means are: (a) mechanical strength, (b) capability of being formed into a screen, web, netting, fabric or the like, (c) insensitivity to mercury, alkali and the products formed during the electrolysis, such as chlorine or chlorine compounds, (d) stability to aqueous alkali chloride solutions and (e) non-conductivity for electric current. It is within the normal ability of the expert to find other suitable materials besides those enumerated above.

I prefer to use polymer materials for the screening means, especially those which are derived from chlorinated hydrocarbons, such as polyvinyl chloride, polyvinylidene chloride, or copolymers thereof.

The material of the anode mass must have a good conductivity for electric current, must be substantially insensitive to chlorine and its compounds and must have sufficient mechanical strength. In most cases carbon or mixtures containing carbon may be used as the anode mass. Often graphite is preferred to other materials.

By choosing a suitable mesh width of the screening means the speed of the downwardly flowing mercury can be regulated so that the amalgam has the desired concentration when it leaves the cell. When the mesh width of the screening means is small, the mercury is strongly braked in its downward movement and it becomes laden with a large amount of alkali metal so that a high percentage alkali amalgam collects in the channel 9. When the mesh width is large, the converse effect results. Accordingly, by choosing an appropriate mesh width, the operating conditions of the electrolytic cell, in so far as they relate to mercury, can be adjusted to the optimum. The present invention however does not lie in the discovery of certain especially advantageous mesh widths. Details such as these can readily be determined by an expert by experiment and depend on the operational requirements in a given case. It is not possible to state beforehand which mesh widths will be most suitable in a given case. Moreover, the mesh width of the screening means is dependent on the particle size of the anode material. The mesh width is preferably between about 1 and 5 millimeters. These values do not however constitute critical magnitudes because in certain cases other mesh widths, i.e. larger or smaller mesh widths, may also be useful. The thickness, i.e. the diameter, of the filament or thread used for the production of the fabric forming the screening means bears a certain relationship to the mesh width in so far as filaments or threads with a greater diameter are normally used for the screens, webs, fabrics, etc., with larger mesh widths. Since however the mesh width of the screening means must be

adapted to the prevailing operating conditions, the same holds good for the choice of the thickness of the filament or thread.

Screening of polyvinylidene chloride with 40 meshes per square centimeter and a filament thickness of 0.35 millimeter has proved especially suitable in the apparatus according to this invention. Contrary to expectation, it has been found that such a narrow screen is suitable for preventing electrical contact between the downwardly flowing mercury and the anode mass, which preferably consists of granules or particles of graphite. The subsequent regulation of the anode, which hitherto has been attended by difficulties, does not arise here because the graphite particles which have been consumed can easily be replenished by introducing fresh particles of graphite. At the same time, the minimum electrode spacing is achieved because the distance between the electrodes corresponds to the thickness of the screening used, i.e. usually about 1.5 to 3 times the filament thickness.

The most advantageous electrode spacing cannot be given but is in the discretion of the expert using the electrolytic cell according to this invention and can readily be ascertained by him by simple tests.

When, in order to reduce as much as possible the speed of flow of the mercury, there is used a screening means having such small meshes that it does not ensure a sufficient separation of the cathode from the anode (because the screen becomes clogged or permeated with mercury or amalgam as the meshes become narrower), it is recommended that there be applied to this narrow-meshed screen, a coarse-meshed screen which ensures an electrical insulation between cathode and anode. Thus, as shown in FIG. 5, the narrow meshed screen 3a serves to reduce the flow rate of the mercury 2, while the coarse-meshed screen 3 electrically insulates the anode particles 4 from the cathode. In any case, the material used is not a woven cloth of the type which serves as a diaphragm and is suitable for example for the separation of different gases from each other, but is a relatively coarse netting which is quite unsuitable for separating gases. In other words, the screening means should be gas-permeable by comparison with a diaphragm.

The following example will further illustrate this invention but the invention is not restricted to this example.

#### Example

A horizontal cell of conventional design, which is operated with about 6000 amperes, requires a floor area of  $1.1 \times 6.3 = 6.9$  square meters. A cell of vertical construction according to this invention which is operated with the same amperage requires an area of  $1.0 \times 1.2 = 1.2$  square meters. The electrolytic cell according to this invention therefore requires only about 17.4% of the area required by a cell of conventional design. The cathode carrier plate of the cell according to this invention has the dimensions  $0.7 \times 1.7$ , i.e. the cell has a total cathode surface of 2.4 square meters. The size of the graphite particles present in the cell according to this invention is preferably between 0.5 and 5 centimeters. Particles of about 5 centimeters in diameter are introduced into the cell and these become smaller in operation by reason of wear. The screen applied to the cathode carrier plate has a mesh width of about 1.5 to 2 mm. (internal width). The cell can be operated for long periods without short circuits because the screen adjacent to the cathode carrier plate normally assures a satisfactory separation of the cathode from the anode. At 6000 amperes, the consumption of sodium chloride of the cell according to this invention is equal to the consumption of a cell of conventional design. The amount of mercury to be pumped through the cell and the speed of the circulatory pumping are regulated so that an about 0.1 to 0.15% sodium amalgam is withdrawn from the cell.

The above example shows that the results obtainable with an electrolytic cell according to this invention are

just as satisfactory as with a cell of conventional design, the new type of cell requiring considerably less floor area.

The present invention provides an excellent solution to the problem of arranging and operating on a small floor area a large number of high-capacity electrolytic cells which are safely operated even over long periods of time.

I claim:

1. In an electrolytic cell containing a vertical electrically conducting cathode carrier plate adapted to receive liquid mercury as a fluid cathode flowing downwardly on a vertical surface of said plate, the improvement which comprises a porous electrically non-conducting screening means adjacent to said vertical surface of said plate for controlling the downward flow of mercury, said screening means being permeable to gas and having a plurality of openings sufficiently large to permit passage therethrough of an electrolytic solution but sufficiently small to hold flowing mercury against said plate, said cell containing particles of anodic material in a space opposite said vertical surfaces of said plate, whereby said particles press said screening means against said plate.

2. An electrolytic cell as claimed in claim 1, wherein the cathode carrier plate is arranged in the central part of the cell with vertical surfaces on each side of said plate and screening means for each of said vertical surfaces.

3. An electrolytic cell as claimed in claim 1, wherein the screening means consists of a narrow-meshed screen adapted to retain said mercury against said plate and a coarser-meshed screen applied to said narrow-meshed screen and adapted to prevent a granular anodic material from containing said mercury.

4. In an electrolytic cell containing a vertically electrically conducting cathode carrier plate adapted to receive liquid mercury as a fluid cathode flowing downwardly on a substantially vertical surface of said plate, the improvement which comprises a carrier plate in which the thickness of said plate widens toward the bottom and a gas-permeable electrically non-conducting screening means adjacent to said vertical surface of said plate for controlling the downward flow of mercury, said screening means having a plurality of openings sufficiently large to permit passage therethrough of an electrolytic solution but sufficiently small to hold flow mercury against said plate, said cell containing particles of anodic material in a space opposite said vertical surfaces of said plate, whereby said particles press said screening means against said plate.

5. An electrolytic cell as claimed in claim 4, wherein the screening means consists of a narrow-meshed screen adapted to retain said mercury against said plate and a

coarser-meshed screen applied to said narrow-meshed screen and adapted to prevent a granular anodic material from contacting said mercury.

6. An electrolytic cell as claimed in claim 1 wherein the screening means is made of a material selected from the group consisting of polyvinyl chloride, polyvinylidene chloride and copolymers of vinyl chloride and vinylidene chloride.

7. In an electrolytic cell which contains a liquid electrolytic solution in contact with a cathode and an anode, the improvement which comprises: a vertical electrically conducting cathode carrier plate adapted to receive mercury as a fluid cathode flowing downwardly on a substantially vertical surface of said plate; particles of anode material occupying a space in side cell opposite said vertical surface of said plate; and a gas-permeable electrically non-conducting screening means located between said vertical plate and said particles of anode material such that said particles press said screening means against said plate, said screening means having a plurality of openings sufficiently large to permit passage therethrough of the electrolytic solution but sufficiently small to hold flowing mercury against said plate and said screening means being so constructed and arranged as to prevent deleterious electrical contact between said mercury and said anode particles.

8. An electrolytic cell as claimed in claim 7 wherein said anode material consists essentially of graphite particles.

9. An electrolytic cell as claimed in claim 7 wherein said screening means is made of a material selected from the group consisting of polyvinyl chloride, polyvinylidene chloride and copolymers of vinyl chloride and vinylidene chloride.

10. An electrolytic cell as claimed in claim 7 wherein said plate is separated from said anode material by approximately the thickness of said screening means.

11. An electrolytic cell as claimed in claim 7 wherein said screening means has a mesh width of between about 1 and 5 millimeters.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,065,163

November 20, 1962

Werner Honsberg

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 72, for "with" read -- within --; column 6, line 12, for "carier" read -- carrier --.

Signed and sealed this 24th day of September 1963.

(SEAL)

Attest:

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Attesting Officer

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