C. W. MARSH.

ELECTROLYTIC CELL.

APPLICATION FILED JULY 14, 1917.

1,302,824.

Patented May 6, 1919.

2 SHEETS—SHEET 1.

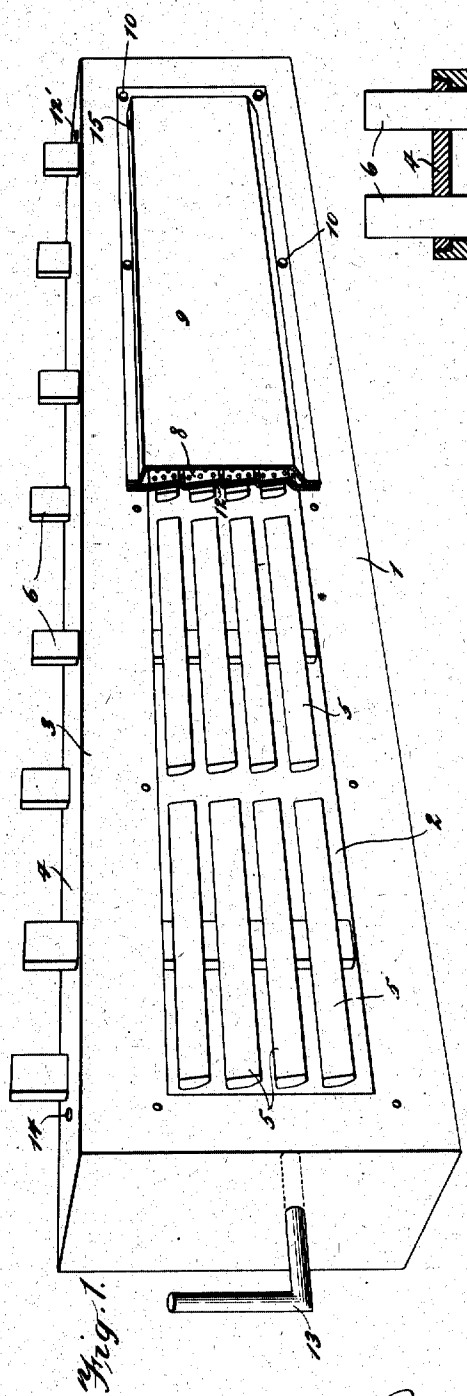

Fig. 1.

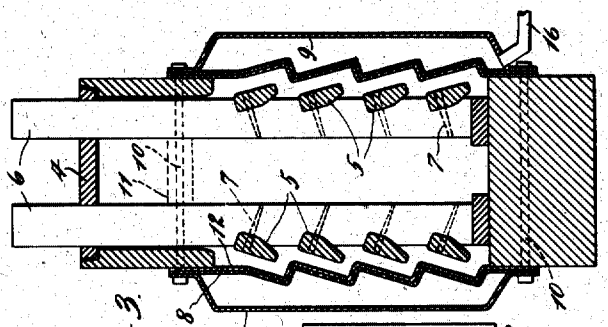

Fig. 3.

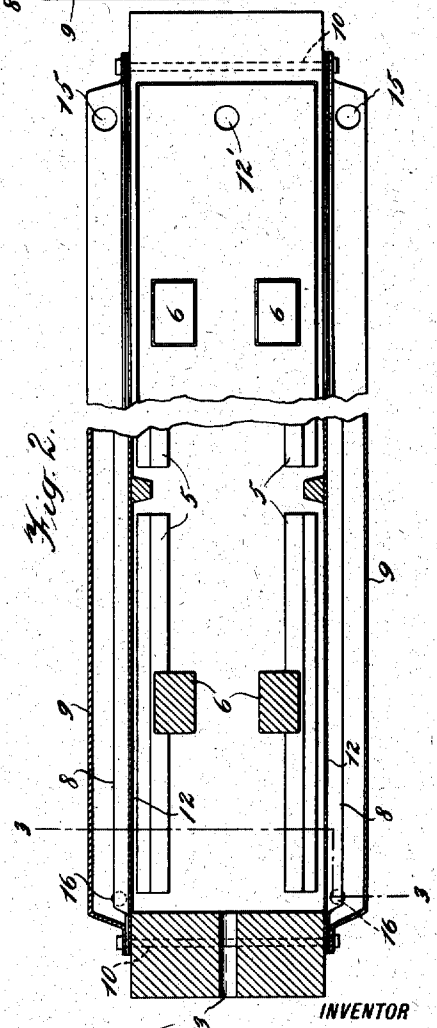

Fig. 2.

INVENTOR

Clarence W. Marsh

BY

Rosenbaum, Stockbridge & Boss ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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2 SHEETS—SHEET 2.

Fig. 4.

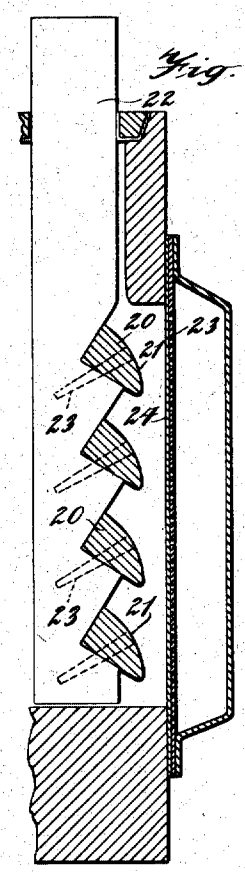


Fig. 5.

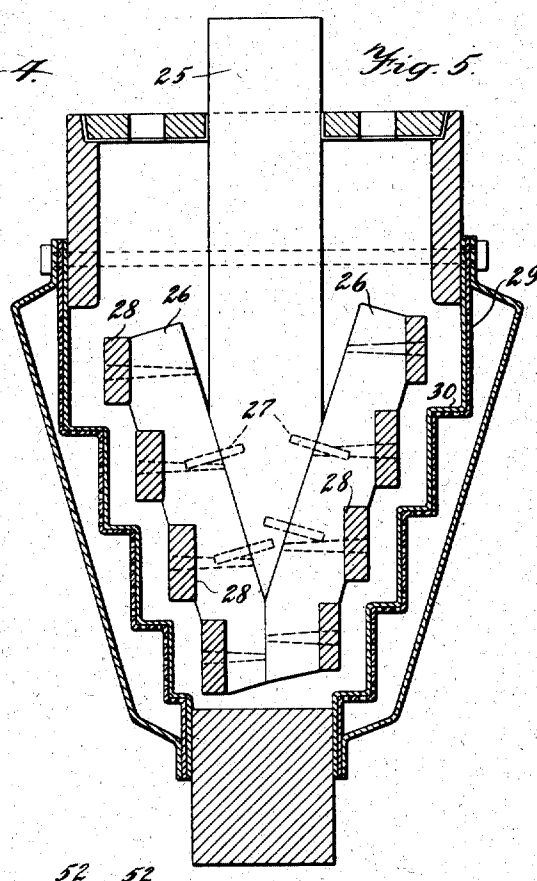


Fig. 6.

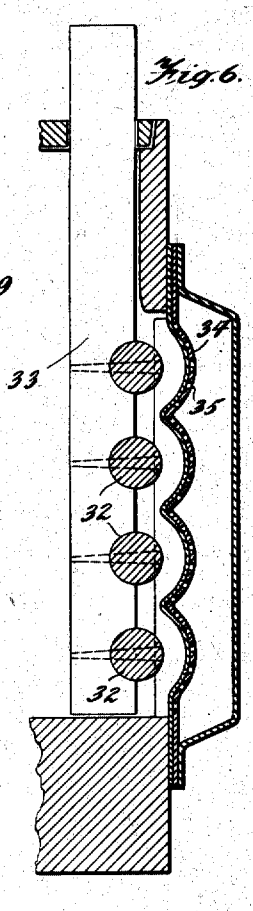


Fig. 7.

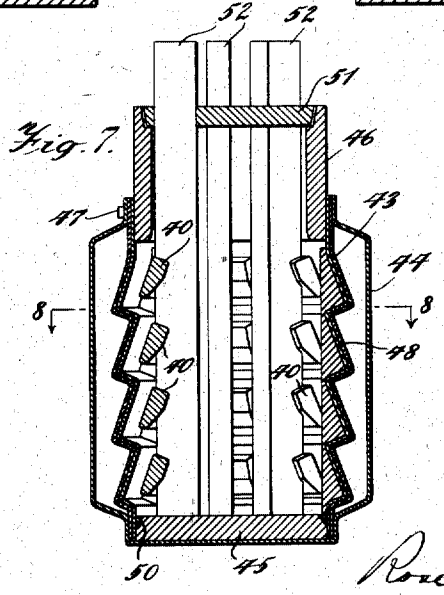
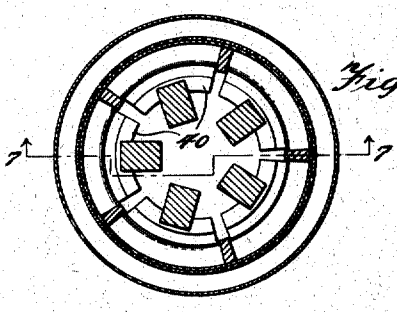


Fig. 8.



INVENTOR

Clarence W. Marsh

BY

Rosenbaum, Stachenger & Boyd ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

CLARENCE W. MARSH, OF GREENWICH, CONNECTICUT.

ELECTROLYTIC CELL.

1,302,824. Specification of Letters Patent. Patented May 6, 1919.

Application filed July 14, 1917. Serial No. 180,494.

To all whom it may concern:

Be it known that I, CLARENCE W. MARSH, a citizen of the United States, residing at Greenwich, in the county of Fairfield and State of Connecticut, have invented certain new and useful Improvements in Electrolytic Cells, of which the following is a full, clear, and exact description.

This invention relates to electrolytic cells and has for its primary object the provision of means for increasing their efficiency. The invention is particularly applicable to cells of the vertical type, that is, in which the anode and cathode are both vertically disposed with an intervening space between them for the electrolyte.

More specifically stated, one of the objects of the invention is to provide means for removing the gas which is formed at the anode from the electrolyte between the anode and cathode before the gas rises to the top of the cell. As is well known, the presence of gas bubbles in the electrolyte between the anode and cathode increases materially the resistance of the electrolyte and hence the voltage required for the operation of the cell. These bubbles are formed at the surface of the anode for its entire height, and will, if not diverted, rise in the electrolyte between the anode and cathode so that the quantity of bubbles in the upper portion of the cell is materially greater than in the lower portion. By removing these bubbles at frequent intervals throughout the entire height of the cell the electrolyte at the upper portion of the cell is maintained practically as free from bubbles as the electrolyte in the lower portion of the cell and hence the voltage required for the operation of the cell is materially decreased.

Another object of the invention is to promote or increase the local circulation of the electrolyte to maintain a freshly saturated electrolyte between the anode and cathode, which will also increase the efficiency of the cell. The circulation of the electrolyte is also of importance since it will further tend to carry away the bubbles of gas which are formed at the anode and prevent deposits upon the cell diaphragm.

A further object of the invention is to provide a type of cathode which will serve as a support for the diaphragm which permits the thickness of the diaphragm to be materially diminished, thereby decreasing the resistance of the cell.

A still further object of the invention is to provide a cathode in which the cathode liquor which passes through the cathode, will be continuously removed at frequent intervals for the entire height of the exterior face thereof to prevent secondary reactions and thus decrease the efficiency of the primary reaction.

It is also an object of the invention to increase the area of the active surface of both the anode and cathode without increasing the size of the cell.

Further objects of the invention will be apparent from the detailed description hereinafter to follow when taken in connection with the accompanying drawings.

In the drawings there are disclosed several types of electrolytic cells, each of which shows a structure constituting one embodiment of the invention, but it is intended that the invention be not limited to the specific embodiments shown but only by the scope of the claims appended hereto.

Figure 1 shows in perspective, a cell constructed in accordance with the principles of the invention.

Fig. 2 is a plan of Fig. 1.

Fig. 3 is a transverse vertical section through Fig. 1;

Fig. 4 is a sectional detail showing a slightly modified construction in which the cathode is not corrugated;

Fig. 5 is a transverse sectional view through a cell having a series of anode members inclined from the vertical and the cathode similarly inclined;

Fig. 6 is a sectional detail of another modification;

Fig. 7 is a central vertical section through a circular cell; and

Fig. 8 is a plan of Fig. 7.

Referring first to Figs. 1, 2 and 3, the body of the cell which is indicated 1, may be of concrete or any other suitable material

and may be cast monolithic to provide a box-like construction having an open top and long rectangular-shaped openings 2 in its side walls, which openings extend substantially the entire length of the structure providing a side web or strip 3 at the upper portion of the cell. The open top of the cell is closed by a cover 4 which may also be of concrete. This cell body is suitable for a double cell, which will be described in conjunction therewith, but a single cell construction may also be used if desired. In the double cell, the anode comprises anode members which are designated 5, each of which consists of a bar or slat of graphite or other suitable material which is fastened in suitable recesses in graphite posts or standards 6 by means of graphite pins 7. These anodes, in the construction shown in Fig. 3, are arranged similar to the arrangement of the slats or louvers of a blind, the louvers being in vertical alinement but each louver being inclined to the vertical position so that the upper edge of one louver or anode member is out of vertical alinement with the lower edge of the anode member above it, whereby there is formed between each pair of anode members an inwardly and upwardly inclined passage which is directed away from the space between the anode and the cathode.

The gas bubbles which form at the surface of each anode member rise and strike the lower wall of the anode member immediately above it, which will deflect and divert the bubbles from the space between the anode and the cathode, the bubbles passing through the passages provided between the anode members and rising to the top of the cell in the central portion thereof. This is an important feature of the invention since it is a well known fact that the resistance of the cell is dependent, among other things, upon the quantity of bubbles present in the electrolyte between the anode and cathode and where short or shallow cells of the vertical type have been used it has been found that the efficiency of such a cell is much greater than in the tall cells which, while economizing in floor space, have heretofore been open to the objection that the gas bubbles formed at the anode can not escape otherwise than up through the passage between the active surfaces of the anode and cathode. The construction described, however, dividing as it does the anode into a plurality of superimposed anode members, provides a cell which is in fact a plurality of shallow cells superimposed upon each other with the corresponding increase in the efficiency which is thereby produced.

The cathode consists of a sheet of perforated or foraminous sheet material 8, which is fitted over the openings 2 in the side walls of the cell, the exterior surface of the cathode being covered by a metal casing 9. The casing 9 and the perforated diaphragm are secured over the openings 2 in the side wall, as described, by bolts 10 which pass through the bottom of the cell and also through the webs 3. The bolts 10 which pass through the webs 3 are preferably covered by a sleeve 11 of concrete or other suitable non-conducting material.

Resting against the inner face of the cathode 8 is a diaphragm 12 of asbestos paper, cloth or other suitable material. The marginal edges of this diaphragm are secured between the concrete side walls and the metal cathode 8 which is held clamped against the side walls by the bolts 10. The inlet for the electrolyte, which may be sodium chlorid where the cell is utilized for the production of caustic liquor, is provided by an opening 12′ at one end of the cover 4 of the cell. The outlet pipe for the electrolyte is indicated 13, which pipe may be angular, as shown in Fig. 1, to constitute an overflow pipe which will maintain the electrolyte at the proper level within the cell. The gases formed at the anode pass out of the cell through the opening 14 in the cover, which opening is preferably piped to any suitable receiver wherein the gas is to be collected, as for example, where chlorin is formed by the electrolysis of sodium chlorid.

Openings 15 are also provided in the walls of the casing 9 forming the cathode chamber for the escape of the gases formed at the cathode, which may be hydrogen or any other gas, depending upon the electrolyte. The cathode liquor which collects within the cathode chamber is drawn off in any suitable manner, as for example, by means of a pipe 16.

In the preferred construction as shown in Fig. 3, the cathode 8 is crimped or corrugated longitudinally and horizontally providing walls which are substantially parallel to the louver-like anode members 5. In this manner the distance between the respective anode members 5 and the cathode is maintained substantially constant, although the anode members are slanted upwardly and inwardly, as described. An important consequence of this construction is that the resistance of the electrolyte will be substantially constant throughout the height of the cell, since the resistance is proportional to the distance between the anode and the cathode.

Another advantage of the longitudinal crimping of the cathode, as described, is that the diaphragm which fits against this cathode is supported by the angularly disposed walls of the cathode, which permits the use of a thinner and weaker diaphragm. In order to maintain the diaphragm against

the corrugated cathode, strips of non-conducting material 17 of asbestos cement or other suitable material may be utilized, which strips are vertically disposed at suitable intervals along the length of the cathode between the sets of anode members. In practice the diaphragm is fastened to the cathode by these strips of cement prior to the assembling of the cathodes 8 and their casings 9 to the side walls of the concrete body of the cell. By the use of a weaker diaphragm, as described, the resistance between the anode and cathode is materially reduced, which will give a corresponding decrease in the voltage required to operate the cell.

Another advantage of the use of the corrugated cathode described is that the cathode liquor will not flow from the top of the cathode down the entire outer face to the bottom thereof and thus decrease the efficiency. Instead the cathode liquor will flow down one wall of a corrugation of the cathode until it reaches the lower edge of this corrugation when it will drip or drop to the bottom of the cathode chamber instead of flowing down the remainder of the cathode.

It will also be noted that by crimping or corrugating the cathode, as described, so that its walls and the walls of the louver-like anode members 5 are substantially parallel and are directed in an upward and inward direction, passages are formed which will tend to cause a local circulation of the electrolyte around each of the anode members. This local circulation will cause fresh electrolyte to be constantly brought into the space between the anode members and the cathode so that a saturated electrolyte is always present, which will increase the efficiency of the cell. The local circulation will also cause the gas which is formed at the anode members and which would otherwise rise up in the space between the anode members and the cathode to the top of the cell to be carried away by this local current or circulatory action of the electrolyte to the central portion of the cell where it can rise to the top of the cell and flow out through the outlet 14 without increasing the resistance of the cell.

Referring to the modification disclosed in Fig. 4, the anode members 20 are shown here of a slightly different shape, having curved outer surfaces 21 to increase the area of the active surface of the anode. These anode members 20 are secured to a graphite standard or post 22 by pins 23, similar to the construction shown in the preferred form. The cathode 23 shown in this view is not corrugated but forms a straight plate against which the diaphragm 24 rests. It is not believed that this construction is as efficient as that disclosed in the preferred form, but the use of the separate louver-like anode members 20 so that they are inclined upwardly and inwardly will to a certain extent increase the efficiency of the cell, since the gas bubbles which are formed in the space between the anode members and the cathode will be diverted into the central portion of the cell instead of rising directly upwardly in the space between the anode and the cathode. There will also be to a certain extent a local circulation of the electrolyte which circulation will not, however, be as pronounced as where the cathode is corrugated or crimped, as shown in Fig. 3, since the walls of the anode members and cathode are not parallel to each other and both inclined in such a direction as to set up the local current.

In Fig. 5 a still further modification is shown. In this view a central graphite holder or standard 25 is employed, to which are secured auxiliary holders 26 by means of pins 27 arranged to form a V. Secured to the holders 26 are the anode members 28 each of which may have its active surface vertically disposed, the anode members forming a V so that the lower anode member is closest to the center of the cell and the anode members above it are at increasingly greater distances from the center of the cell. The cathode 29 can be crimped or corrugated, as shown in this view, to provide a substantially stepped cathode which supports a diaphragm 30. It will be noted that by crimping the cathode to correspond to the shape and position of the anode members a local circulation of the electrolyte will be set up in the cell, as in the construction shown in Fig. 3. It will also be apparent that the gases which form upon the face of the anode in rising upwardly will pass to the rear of the anode member immediately above it instead of into the space between it and the corresponding portion of the cathode.

In Fig. 6 a further modification is shown in which the anode members 32 are cylindrical bars which are secured to a holder 33, as before described. The cathode member 34 is preferably crimped or corrugated so as to form substantially semi-cylindrical depressions therein, which depressions support a diaphragm 35, as in the construction shown in Figs. 3 and 5. In this form, the anode members 32 are shown directly above each other, but since the substantially semi-cylindrical passages are formed between each anode member and the respective portion of the cathode surface with which it coöperates, the local circulation of the electrolyte around each cathode member will be increased materially and this local circulation will to a great extent carry away the bubbles of gas which are formed at the surface of the anode member. It is believed that this local circu-

lation will be sufficient to carry the bubbles of gas away, but should this not be the case the anode members 32 may be arranged in an inclined plane, as shown in Fig. 5.

Referring now to Figs. 7 and 8, a circular cell is shown to which the invention is equally applicable. In this form, the anode members 40 are similar to the anode members 5 of Fig. 3, with the exception that they are curved longitudinally to constitute segments of a circle. A series of these segmental-shaped anode members are carried by holders 52 and are arranged in circular form with an intervening space between each superimposed set of anode members.

The cathode 43 is also cylindrical in form and may be corrugated or crimped, as in the form shown in Fig. 3. This cathode is surrounded by a cylindrical casing 44, which forms substantially a barrel and constitutes the body of the cell. The bottom of this cell may be filled with a circular disk of cement 45, which is of slightly less diameter than the bottom of the barrel 44. A cylindrical ring 46 of concrete or other suitable material forms the upper portion of the cell, which ring is secured to the barrel by a clamp 47, which clamp also serves to support the upper end of the diaphragm 48. The lower edge of the cathode 43 and the diaphragm 48 is secured in place by a layer of cement 50, which fills a recess formed between the upper portion of the concrete slab 45 and the lower portion of the barrel casing 44. The cell is closed by a cover 51 through which the holders 52 pass and are supported in vertical position. The advantages derived from this construction are similar to those described in connection with the other forms.

By the term louver-like as used herein, I aim to describe any arrangement of the individual anode members, whether inclined as in Fig. 3 or vertical as in Fig. 5, in which the line where the bubbles leave one anode is vertically so related to the bottom surface of the anode above that the bubbles formed at the lower anode will rise and be conveyed away by the anode above.

I claim:

1. In an electrolytic cell, a vertical anode and cathode disposed in spaced relation, the anode being divided by horizontal passages into a plurality of anode members and the anode members being so shaped and arranged that their lower wall extends toward the cathode beyond the vertical plane of the line from which the bubbles formed at the anode leave the active surface of the anode member immediately below it.

2. In an electrolytic cell, a vertical anode and cathode disposed in spaced relation, the anode being composed of a plurality of horizontal anode members arranged so that each member overhangs the one immediately below it, whereby the bubbles arising from the members are conducted away from the space between the anode and cathode.

3. In an electrolytic cell, a vertical anode and cathode disposed in spaced relation, the anode being composed of a plurality of horizontal anode members arranged one above the other in a plane somewhat inclined outwardly to the vertical, whereby the bubbles arising from the active face of one anode member pass to the rear of the member above it.

4. In an electrolytic cell, a vertical anode and cathode disposed in spaced relation, the anode being composed of a plurality of horizontal anode members arranged one above the other in a plane somewhat inclined outwardly to the vertical, whereby the bubbles arising from the active face of one anode member pass to the rear of the member above it, and the cathode being inclined to the vertical and horizontally stepped in conformity with the arrangement of the anode members.

5. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said cathode comprising a perforated sheet of material having continuous horizontal corrugations therein.

6. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said cathode comprising a perforated sheet of material having continuous horizontal corrugations therein, and a flexible diaphragm fitting against said corrugated cathode.

7. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said cathode having continuous horizontal ridges formed on its exterior face.

8. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said cathode comprising a perforated sheet of material having longitudinal corrugations therein, a flexible diaphragm fitting against said cathode, and means for holding said flexible diaphragm against said cathode.

9. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said anode comprising a plurality of horizontally disposed louver-like members, and said cathode comprising a perforated sheet of material having longitudinal corrugations therein.

10. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said anode comprising a plurality of horizontally disposed louver-like members and said cathode comprising a perforated sheet of material having horizontal corrugations therein, said corrugations corresponding in shape to the shape of the louver-like members and each of said louver-

like members being positioned opposite one of said corrugations.

11. In an electrolytic cell, a vertically disposed anode and cathode mounted in spaced relation, said anode comprising a plurality of horizontally-disposed louver-like members, said cathode comprising a perforated sheet of material having horizontal corrugations therein, each of said anode members being positioned opposite one of said corrugations and forming therewith a tortuous passage to cause a local circulation of the electrolyte.

In witness whereof, I subscribe my signature.

CLARENCE W. MARSH.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."