I. H. LEVIN.

ELECTROLYTIC APPARATUS.

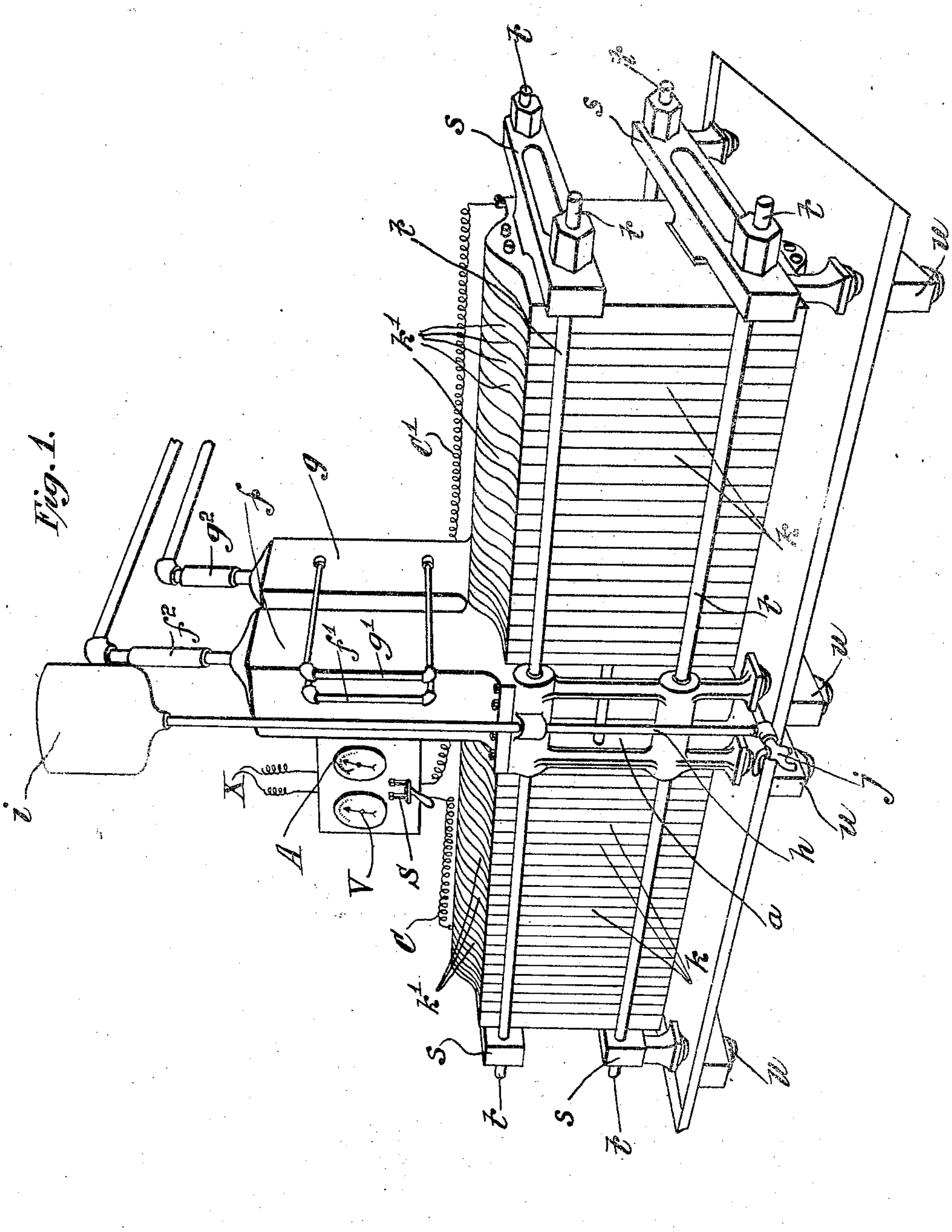
APPLICATION FILED MAY 9, 1913.

1,094,728.

Patented Apr. 28, 1914.

3 SHEETS—SHEET 1.

Fig. 1.



Attest:

D. McIntosh

Eugene Wening.

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by Frank T. Wentworth

his Atty.

I. H. LEVIN.

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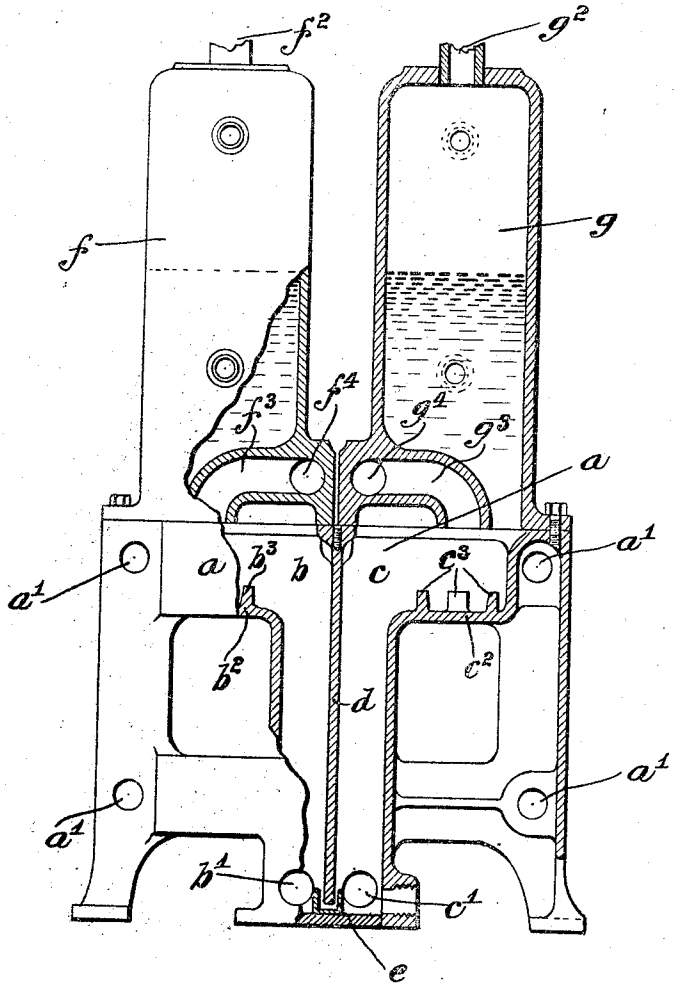
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3 SHEETS—SHEET 2.

Fig. 2.



Witnesses:

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3 SHEETS—SHEET 3.

Fig. 3.

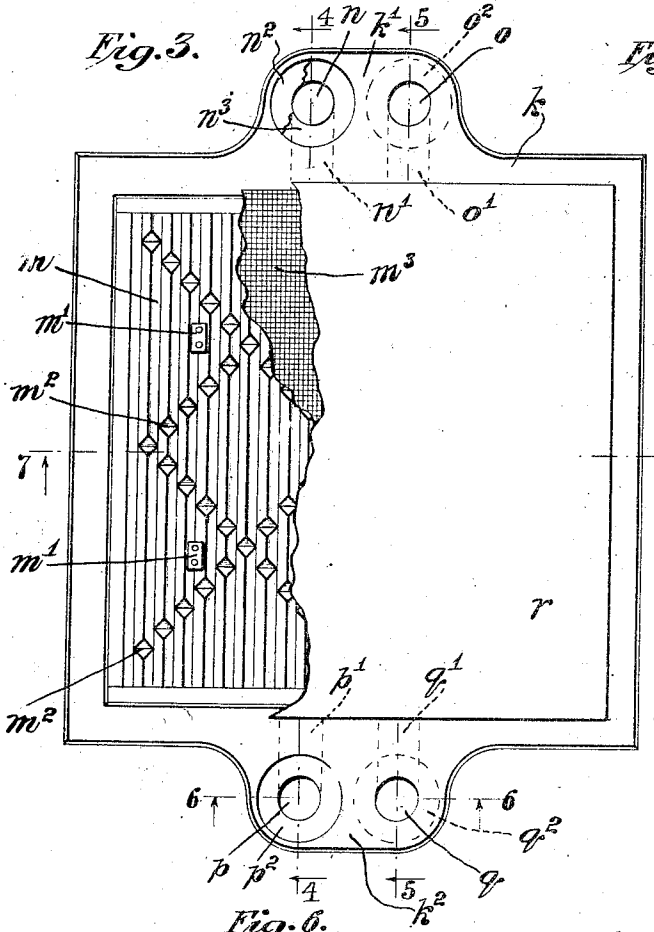


Fig. 4.

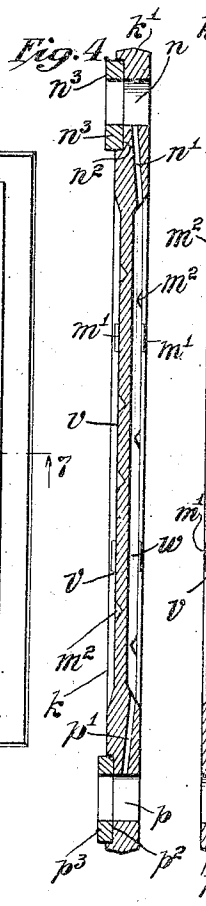


Fig. 5.

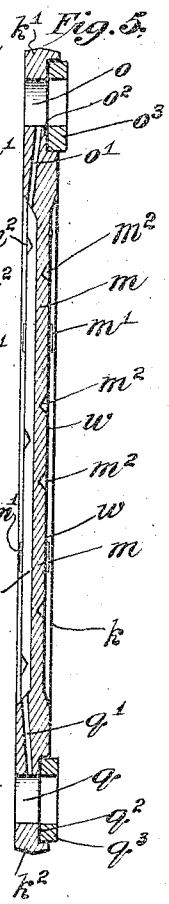


Fig. 6.

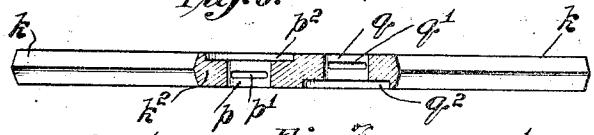
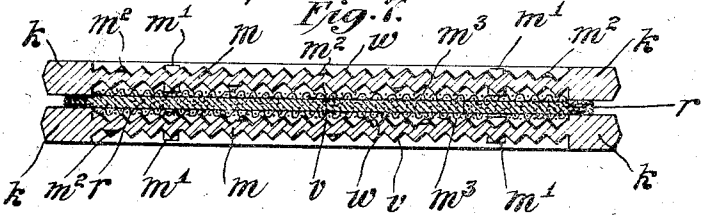


Fig. 7.



Attest:

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Eugene Wening.

Isaac H. Levin Inventor:

by Isaac F. Wentworth

his Atty

UNITED STATES PATENT OFFICE.

ISAAC H. LEVIN, OF NEWARK, NEW JERSEY, ASSIGNOR TO INTERNATIONAL OXYGEN COMPANY, A CORPORATION OF NEW JERSEY.

ELECTROLYTIC APPARATUS.

1,094,728. Specification of Letters Patent. Patented Apr. 28, 1914.

Application filed May 9, 1913. Serial No. 766,469.

To all whom it may concern:

Be it known that I, ISAAC H. LEVIN, a citizen of the United States, residing at Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Electrolytic Apparatus, of which the following is a specification, reference being had therein to the accompanying drawings, which form a part thereof.

My invention relates to electrolytic apparatus, and more particularly to a type of diaphragm apparatus especially adapted for use in dissociating the oxygen and hydrogen entering into an electrolyte.

The main object of the invention is to provide a multiple cell electrolytic apparatus wherein the oxygen and hydrogen produced will be prevented from mixing in the apparatus and wherein the electrolyte adjacent the anode and that adjacent the cathode will be prevented from commingling in a manner to avoid the carrying of gas from adjacent the anode to adjacent the cathode, or vice versa.

A further object is to provide an apparatus of this character wherein an equal pressure of the oxygen and the hydrogen in the device will be automatically maintained.

A still further object is to provide an apparatus of this character wherein the pressures upon opposite sides of the diaphragm will always be the same and a slow circulation will be maintained, thus avoiding distortion or disruption of the diaphragm which would result from unequal pressures, or too rapid a circulation.

A still further object is to provide an apparatus of this character wherein electrolyte is automatically supplied to the various cells, and a constant level of said electrolyte will be maintained, irrespective of the level in the electrolyte reservoir.

A still further object is to provide an apparatus of this character having electrodes grouped upon opposite sides of the electrolyte chamber or tank and gas domes wherein any electrode may be assembled upon either side of the electrolyte chamber or tank, and wherein the number of electrodes may be increased or diminished as desired, said electrodes being standardized or capable of insertion at any point in the apparatus.

A still further object is to provide an electrolytic apparatus wherein the efficiency of the apparatus will be raised by so constructing and arranging the electrodes as to avoid deterioration thereof through corrosion.

A still further object is to so construct the electrodes as to minimize resistance to the electric current at the anode or cathode, thus increasing the effective decomposition of the electrolyte with a current of low voltage and minimize the necessity for excess voltage over that required in decomposing the electrolyte. And a still further object is to provide an apparatus of this character which is capable of producing practically pure hydrogen and practically pure oxygen, and of being operated continuously without requiring special attention, and without a likelihood of a loss of efficiency or of the apparatus becoming inoperative.

The invention consists in the novel features of construction and combination of parts hereinafter set forth and described, and more particularly pointed out in the claims hereto appended.

Referring to the drawings:—Figure 1 is a perspective view of an electrolytic apparatus embodying my invention, partly broken away; Fig. 2 is a vertical section through the gas domes and the electrolyte chamber; Fig. 3 is an elevation of one of the electrodes; Fig. 4 is a section on the line 4—4 of Fig. 3; Fig. 5 is a section on the line 5—5 of Fig. 3; Fig. 6 is a section on the line 6—6 of Fig. 3; and Fig. 7 is a view of two adjoining electrodes, said electrodes being shown on a section corresponding to the line 7—7 of Fig. 3, the diaphragm and gaskets being shown in place between said electrodes.

Like letters refer to like parts throughout the several views.

In the embodiment of my invention shown in the drawings, I employ a tank or reservoir *a*, divided into two similar compartments *b c* by the partition *d*, the lower end of which projects into an open trough *e* leaving a space below said partition through which one compartment is placed in communication with the other. The projecting walls of the trough *e* extend above the bottom of the partition *d* to an extent sufficient to prevent hydrogen bubbles passing from one compartment or chamber to the other beneath said partition.

Leading from the compartments *b* and *c*

and adjacent the bottom thereof are the outlet openings b' c' through which electrolyte contained in said reservoir or tank is adapted to flow to the various cells. The lower portion of the compartments or chambers b c is constricted as shown, and the upper portion thereof is extended to form the surfaces b^2 c^2 the function of which, as will be more fully described hereinafter, is to retard the flow of, and agitate the electrolyte containing the oxygen and hydrogen bubbles as it enters the upper portion of this chamber, thus aiding in separating these gases from the electrolyte and preventing their being carried toward the outlet openings b' c'. These surfaces b^2 c^2 have thereon respectively baffles b^3 c^3 which may be, and preferably are, used for preventing the formation of a stream of the fluid containing the gas. The compartments b c are open at the top and surmounting the tank or reservoir a are two noncommunicating domes f g having open bottoms or other means of connection with said chambers or compartments b c. Watertight joints are formed between the tank or reservoir and the domes in any desired manner. The domes f g are provided respectively with sight gages f' g' and with gas offtake ducts f^2 g^2 communicating with the upper portion thereof.

Exteriorly of the tank or reservoir a adjacent the bottom thereof, as shown in Fig. 1, is a combined feed and drain pipe h surmounted by a feed tank i, a drain cock j being provided in the length of the pipe h and preferably at the lowest level thereof. This feed tank i has the twofold function of being capable of utilization for filling the tank, a, and the various cells, and in aiding to equalize pressures throughout the apparatus.

The domes f and g are each provided with a gas inlet duct f^3 g^3, the discharge end of which is presented downwardly toward and above the surface b^2 c^2 in the compartments b c, and spaced slightly away therefrom. The intake port f^4 g^4 of each said inlet duct is adapted to be connected with the various electrodes in the manner to be hereinafter described. The arrangement of the inlets is such that there will be an automatic equalization of the pressure upon opposite sides of the diaphragm of each cell so as to avoid a too rapid circulation of the electrolytic fluid through said diaphragm, with such a resultant disruption thereof as would permit the gas to pass from adjacent the anode to adjacent the cathode, or the commingling of the gases generated upon opposite sides of said diaphragm.

The outer faces of the end walls of the tank a are machined so as to form a proper facing against which an electrode frame may bear and be attached, and suitable tie rod openings a' are provided in side flanges on said tank by means of which the electrodes may be secured in position relative to said tank.

Grouped upon opposite sides of the tank a is a plurality of electrodes, the abutting frames or rims of which form a series of electrolytic cells, each of which is adapted to receive a supply of electrolyte from the feed tank a.

The number of electrodes used may be increased or diminished as desired, and as all of the electrodes are alike in construction, and each cell is formed in the same manner, a description of but one electrode and of the construction of but one cell will be entered into.

Each electrode comprises a frame k having secured thereto or formed therewith in a manner to prevent the passage of the electrolyte thereabout, a metallic plate m so set within said frame as to cause said plate and the plate of an adjoining electrode to be spaced apart sufficiently to form a chamber or cell therebetween. The frame k is provided with a projection k' at the top thereof, having a plurality of openings n o, communicating by means of the ducts n' o' respectively, with opposite sides of the plate m. The lug or projection k' extends beyond the perimeter or outer edge of the frame k so that any leakage from the openings n o will be into atmosphere and hence readily detected. The openings n o are so arranged that they are adapted to register with similar openings in other frames k to form a continuous duct by means of which communication is established between that portion of each cell adjacent the anode and that portion of each cell adjacent the cathode, or between opposite sides of the plate m, and the ports f^4 g^4 in the domes f and g respectively. About each opening n o the projection or lug k' has formed therein a seat n^2 o^2 for a packing gasket, as n^3 o^3. The bottom of each frame k is provided with a plurality of openings p q preferably arranged in a projection or lug k^2 similar to the lug k', said openings being in communication with opposite sides of the plate m through the ducts p' q'. The openings p q are adapted to register with similar openings in adjoining lugs, and to form therewith a continuous duct adapted to be in communication through the ports b' c' with the compartments or chambers b c respectively so as to convey the electrolyte from said compartments or chambers respectively to adjacent the anode or adjacent the cathode of each cell. By this construction each cell is supplied with the electrolyte from the tank a under conditions which will prevent a commingling of that portion of the electrolyte adjacent the anode with that portion of the electrolyte adjacent the cathode through the supply duct. In other words, that por-

tion of the electrolyte adjacent to the anode will be supplied through a duct communicating only with the space adjacent the various anodes and from a chamber or compartment through which only the oxygen passes, while that portion adjacent the cathode receives its supply of electrolyte through a duct communicating only with the space adjacent the various cathodes and from a chamber wherein the hydrogen is delivered, both ducts drawing their supply of electrolyte from a point of the tank *a* which will preclude the possibility of hydrogen being delivered through one duct to adjacent the anode, and oxygen bubbles being delivered through said other duct to adjacent the cathode.

That portion of the frame *k* adjacent each opening *p q* is provided with at least one countersunk gasket seat p^2 q^2 for the gaskets p^3 q^3 used in forming a continuous water-tight joint between adjoining electrodes.

Seated between each frame *k* and the frame *k* of the adjoining electrode, is a diaphragm *r*, preferably composed of asbestos or any other suitable material permeable to the electrolyte, the edge of which diaphragm insulates and seals the inner edge or perimeter of said frames, forming both a water and gas tight joint. If desired, packing other than the diaphragm may be used for the purpose of forming this joint.

All of the electrodes in a battery are firmly clamped and positioned by means of the insulating clamp bars *s* and tie rod *t* passing through or seated in the openings *a'* in the tank *a*, the entire battery being insulated from ground by suitable supports as *u*.

To secure the maximum surface in the plates *m*, I use corrugated sheets of rolled or cast metal as shown, and the thickness of these plates relative to that of the frames *k* is such as to bring them as close together as possible to reduce the internal resistance of each cell. The peaks of the corrugations will tend to prevent such a distortion of the diaphragm as would bring it in contact with the surface of the plate, but to insure against any possibility of such distortion, I provide the surface of each plate with a plurality of projections *m'*. To insure the circulation of the electrolyte about all portions of the faces of each plate, I cut away each corrugation, which cut away portions are indicated at m^2, in a manner to permit the electrolyte to pass from one side of each corrugation to the other side thereof. If desired, the entire face of each plate *m* on both sides thereof may have a wire mesh extended over same, which mesh is indicated at m^3 in the drawings. This mesh while increasing the efficiency of each cell may be dispensed with if desired as the apparatus is highly efficient without the use of such.

In operating an electrolytic apparatus of the character herein described, it has been found that the voltage of the current used must always be in excess of the theoretical resistance of the cell, this excess voltage being probably required because of surface resistance at the electrodes. While with electrodes of similar metal, high efficiency can be secured in any apparatus constructed as herein described, I have found that by using an anode and a cathode of dissimilar metals, or having dissimilar metalized surfaces, I can secure greater economy in the operation of the apparatus, or higher capacity with a given voltage. In actual practice, I have found that a nickel surface for the anode and an iron surface for the cathode produce the best results, and so far as experiments have been able to determine, an iron plate *m* having one surface thereof electro-plated with nickel is quite as efficient as a laminated plate *m*, consisting of an iron sheet and a nickel sheet associated in the frame *k*. Hence I prefer to use a bi-polar electrode wherein that portion forming the anode indicated at *v* in the drawings presents a nickel surface, and that portion forming the cathode indicated at *w* presents an iron surface. It is not my intention to claim in this application the specific construction of the electrode as to the dissimilar metals employed, such being the subject matter of a separate application filed by me February 26, 1914, Serial No. 821,126.

In the accompanying drawings, I have indicated the leads from the mains at *x*, the ammeter at A, the voltmeter at V, the switch at S and the conductors in electrical connection with the terminals of the battery at C C'.

The operation of the herein described electrolytic apparatus is substantially as follows:—A battery of cells having been assembled in the manner shown in the drawing, the electric current is passed through said cells, the electrolyte being decomposed in the usual and well-known manner to free the oxygen and hydrogen, the former accumulating in the form of bubbles on the surface of the anode, and the latter accumulating in the form of bubbles on the surface of the cathode, these bubbles ultimately rising to the top of each cell, passing through the outlets *n o* and through the intake ports f^4, g^4, being finally discharged into the domes *f g* respectively through the ducts f^3 g^3. The close proximity of the anode and the cathode, and the conductivity of the diaphragm due to the absorption thereby of the electrolyte, reduces the internal resistance of the cell without reducing the efficiency of the apparatus. As I heretofore stated, by using an anode and cathode having exposed surfaces of dissimilar metals, this resistance may be still further reduced.

The various cells in the apparatus are

filled with electrolyte through the ducts formed by the alinement of the openings p and q in the various electrode frames or rims, the supply of electrolyte being led from the compartment or chamber b by the duct formed by the openings p, and from the compartment or chamber c by the duct formed by the openings q. For convenience of expression, the ducts formed of the openings p q will be referred to hereafter simply as the ducts p q. The duct p being in communication with each cell upon one side of the diaphragm therein, and the duct q being in communication with said cell upon the other side of said diaphragm, the electrolyte adjacent the anode cannot circulate through the supply pipe and be mixed with that adjacent the cathode, or vice versa. The arrangement of the ducts formed by the openings n o and the means by which gas flows thereto from the various cells are such that no admixture of the gases can occur either in the cell or in delivering from the various cells to the domes. The domes f g being noncommunicating, none of the gas stored therein or passing therethrough can pass from one to the other as the sole means of communication between said domes is through the trough e which is located at a point where the electrolyte will be substantially free of gas bubbles. The arrangement of the gas inlets f^3 g^3 is such that the gas in passing to the domes f g must pass upwardly from said ducts, the surfaces b^2 c^2 preventing the development of currents in the electrolyte in the chambers b c which would tend to carry the gas bubbles downwardly therewith. The baffles b^3 c^3 will also aid in breaking up this current to assist in freeing the gas bubbles from the electrolyte, although these baffles are not essential, merely insuring a more rapid separation of the gas and electrolyte. The level of the discharge end of said ducts f^2 g^2 defines the level of the eletrolyte in the various cells, and also maintains a uniform pressure within each cell upon both sides of the diaphragm, thus preventing a sufficiently rapid circulation of the electrolyte to deform or break the diaphragm.

The means of communication between the chambers b c and the domes f g, as exemplified by the trough e, permits such a flow of the electrolyte from one chamber to the other as to cause the hydrostatic pressure throughout the apparatus to be uniform. By using an auxiliary feed tank, this pressure may be made constant. The hydrostatic pressure throughout the apparatus being uniform, the pressure at the discharge end of the ducts f^3 g^3 will be the same, thus maintaining uniform and constant gas pressure throughout all of the cells. Hence the pressures upon opposite sides of the diaphragm, both hydrostatic and gas, will be equal, and the circulation of electrolyte throughout the apparatus will be slow, as determined by the rate of decomposition.

It is not my intention to limit myself to the precise details of construction shown in the accompanying drawings, it being apparent that such may be varied without departing from the spirit and scope of the invention.

Having described my invention, what I claim as new and desire to have protected by Letters Patent, is:—

1. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, separate sources of electrolytic supply, independent, non-communicating means delivering electrolyte from said sources of supply respectively to opposite sides of said diaphragm, and means controlling the hydrostatic pressure on both sides of the diaphragm.

2. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank having separate compartments or chambers for the electrolyte, and independent, noncommunicating means delivering electrolyte from one of said compartments or chambers to adjacent the anode, and from the other of said compartments or chambers to adjacent the cathode.

3. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, separate sources of electrolytic supply, noncommunicating gas domes, independent, noncommunicating means delivering electrolyte from said sources of supply respectively to opposite sides of said diaphragm, and noncommunicating offtake ducts communicating with opposite sides of said diaphragm and discharging into said gas domes respectively.

4. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank having separate compartments or chambers for the electrolyte, a dome surmounting each said compartment or chamber and communicating therewith, independent, noncommunicating means delivering electrolyte from one of said compartments or chambers to adjacent the anode, and from the other of said compartments or chambers to adjacent the cathode, and noncommunicating offtake ducts communicating with opposite sides of said diaphragm and discharging into said gas domes respectively.

5. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank containing separate compartments or chambers for the electrolyte, a dome surmounting each said compartment or chamber and communicating therewith, each of said domes having an intake port and an inlet duct

leading therefrom and having its discharge presented downwardly into its compartment or chamber, means whereby said intake ports are respectively placed in communication with said cell adjacent the anode and adjacent the cathode, and means delivering electrolyte from said tank to opposite sides of said diaphragm.

6. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank having separate compartments or chambers for the electrolyte, means adjacent the bottom of said tank whereby said chambers or compartments are placed in communication with each other to permit the equalization of the pressures in said chambers, and independent, noncommunicating means delivering electrolyte from one of said compartments or chambers to adjacent the anode, and from the other of said compartments or chambers to adjacent the cathode.

7. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank, a pendant partition therein forming separate compartments or chambers for the electrolyte, a trough open at the top and inclosing the lower edge of said partition, and independent, noncommunicating means delivering electrolyte from one of said compartments or chambers to adjacent the anode, and from the other of said compartments or chambers to adjacent the cathode.

8. An electrolytic apparatus embodying therein a battery composed of a plurality of cells coupled in series, each said cell containing an anode, a cathode and an interposed diaphragm, separate sources of electrolytic supply common to all of said cells, and independent, noncommunicating means delivering electrolyte from said sources of supply respectively to adjacent the anode of each cell and to adjacent the cathode of each cell.

9. An electrolytic apparatus embodying therein a battery composed of a plurality of cells coupled in series, each said cell containing an anode, a cathode and an interposed diaphragm, separate sources of electrolytic supply common to all of said cells, independent, noncommunicating means delivering electrolyte from said sources of supply respectively to adjacent the anode of each cell and to adjacent the cathode of each cell, and means maintaining equal hydrostatic pressure on both sides of the diaphragm of all of said cells.

10. An electrolytic apparatus embodying therein a battery composed of a plurality of cells coupled in series, each said cell containing an anode, a cathode and an interposed diaphragm, separate sources of electrolytic supply common to all of said cells, independent, noncommunicating means delivering electrolyte from said sources of supply respectively to adjacent the anode of each cell and to adjacent the cathode of each cell, means maintaining equal hydrostatic pressure on both sides of the diaphragm in each of said cells, noncommunicating offtake ducts communicating with the side of said diaphragm adjacent the anode, and with the side of said diaphragm adjacent the cathode, respectively, and independent, noncommunicating storage means into which said offtake ducts discharge.

11. An electrolytic apparatus embodying therein a battery composed of a plurality of electrodes, each consisting of an imperforate plate adapted to form the anode of one cell of said battery and the cathode of the contiguous cell, and a metallic frame inclosing said plate, having at the top thereof two noncommunicating openings therethrough adapted to form, with similar openings in contiguous frames, continuous offtake ducts, and channels leading from said openings and terminating within said frame on opposite sides of said plate, said frame at the bottom thereof also having two noncommunicating openings therethrough adapted to form, with similar openings in contiguous frames, continuous electrolyte supply ducts, and channels leading from said last named openings and terminating within said frame on opposite sides of said plate, a tank, means dividing said tank into separate compartments or chambers each having an outlet port adapted to communicate with one of said electrolyte supply ducts, noncommunicating gas domes, each having an intake port adapted to communicate with one of said offtake ducts, said domes respectively being in communication with a compartment or chamber in said tank, a diaphragm between each pair of frames, and means securing all of said frames in position relatively to said tank and said domes, said frames being insulated from each other so that said cells are coupled in series.

12. An electrolytic apparatus embodying therein a cell containing an anode, a cathode and an interposed diaphragm, a tank having separate compartments or chambers for the electrolyte, means adjacent the bottom of said tank whereby said chambers or compartments are placed in communication with each other to permit the equalization of the pressures in said chambers, independent, noncommunicating means delivering electrolyte from one of said compartments or chambers to adjacent the anode, and from the other of said compartments or chambers to adjacent the cathode, and auxiliary electrolyte supply means discharging into either of said compartments or chambers.

13. An electrolytic apparatus embodying therein an electrode comprising a frame having an extension at the top thereof projecting beyond said frame whereby any leak-

age of gas will be into atmosphere, said extension being provided with two openings extending therethrough, and a channel leading from each of said openings and discharging inwardly within said frame, and an extension at the bottom thereof provided with two openings extending therethrough and a channel leading from each of said openings and discharging inwardly within said frame, and an imperforate plate set within said frame between said upper and said lower channels respectively, whereby one of said upper and one of said lower channels communicate with one side of said plate and the other of said upper and said lower channels communicate with the other side of said plate.

14. An electrolytic apparatus embodying therein an electrode comprising a frame having an extension at the top thereof provided with two openings extending therethrough, and a channel leading from each of said openings and discharging inwardly within said frame, and an extension at the bottom thereof provided with two openings extending therethrough and a channel leading from each of said openings and discharging inwardly within said frame, an imperforate plate set within said frame between said upper and said lower channels respectively, whereby one of said upper and one of said lower channels communicate with one side of said plate and the other of said upper and said lower channels communicate with the other side of said plate, and means whereby contact of the diaphragm with said plate through the distortion of the former is prevented.

In witness whereof, I have hereunto affixed my signature in the presence of two subscribing witnesses, this 14th day of April, 1913.

ISAAC H. LEVIN.

Witnesses:
D. J. TONKONOGY,
F. T. WENTWORTH.