Oct. 22, 1929. F. A. EUSTIS 1,732,797

ELECTROLYTIC CELL

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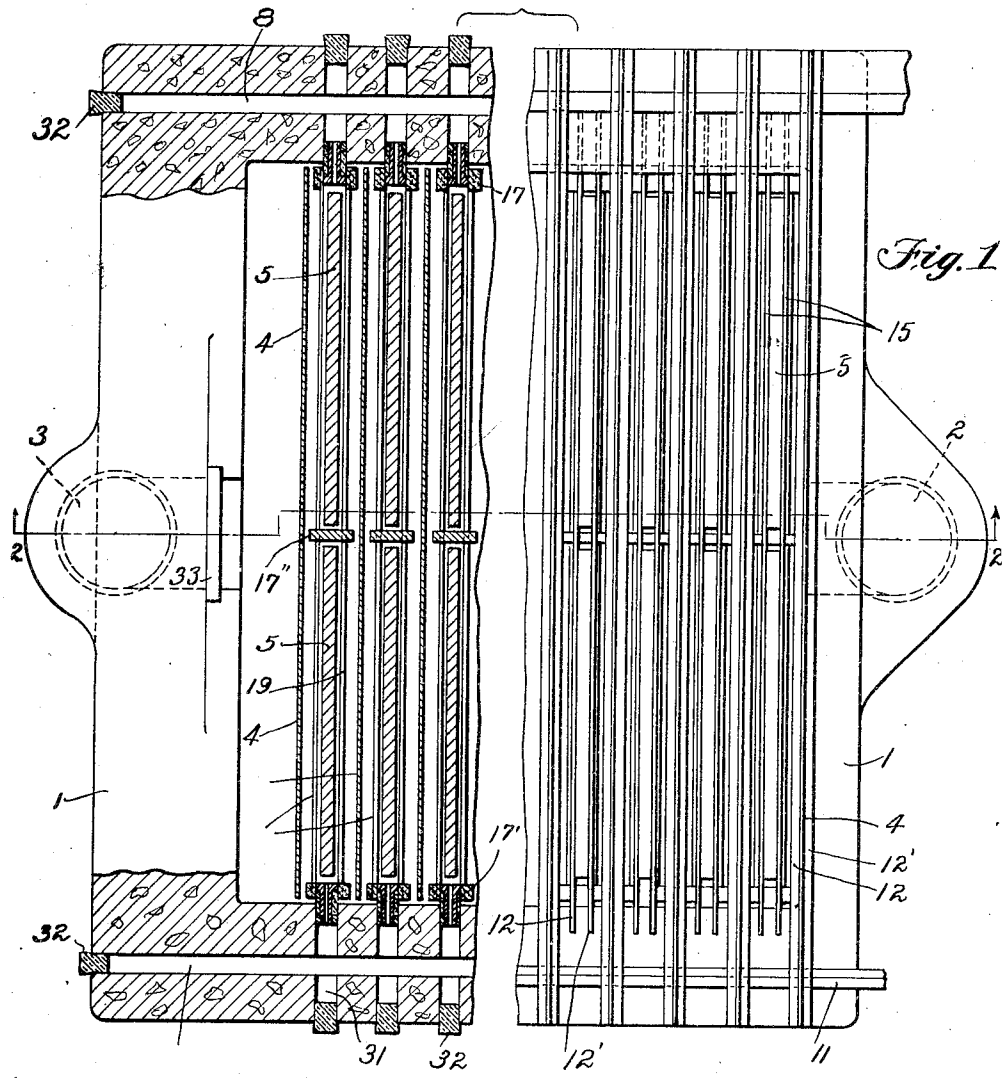
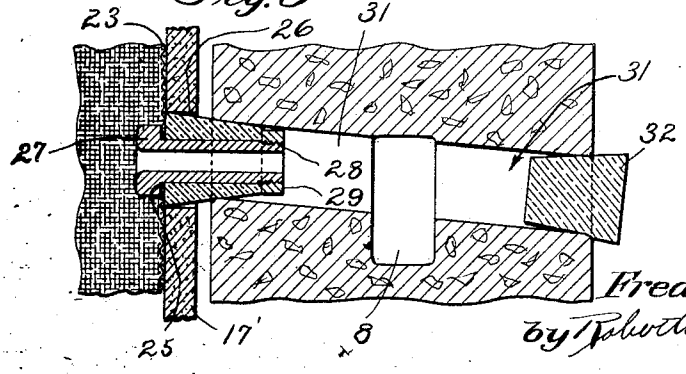


Fig. 1

Fig. 9



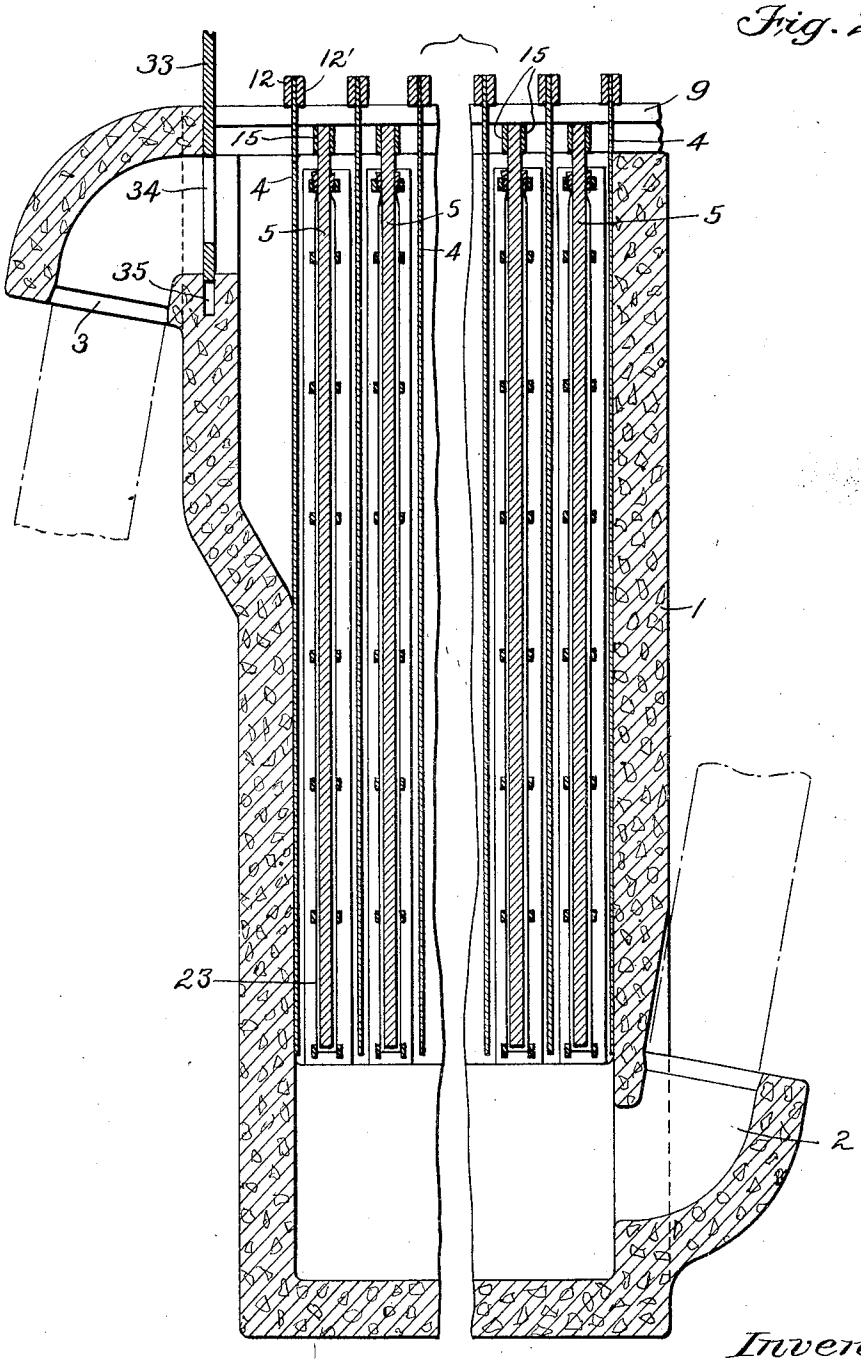
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ELECTROLYTIC CELL

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Fig. 2



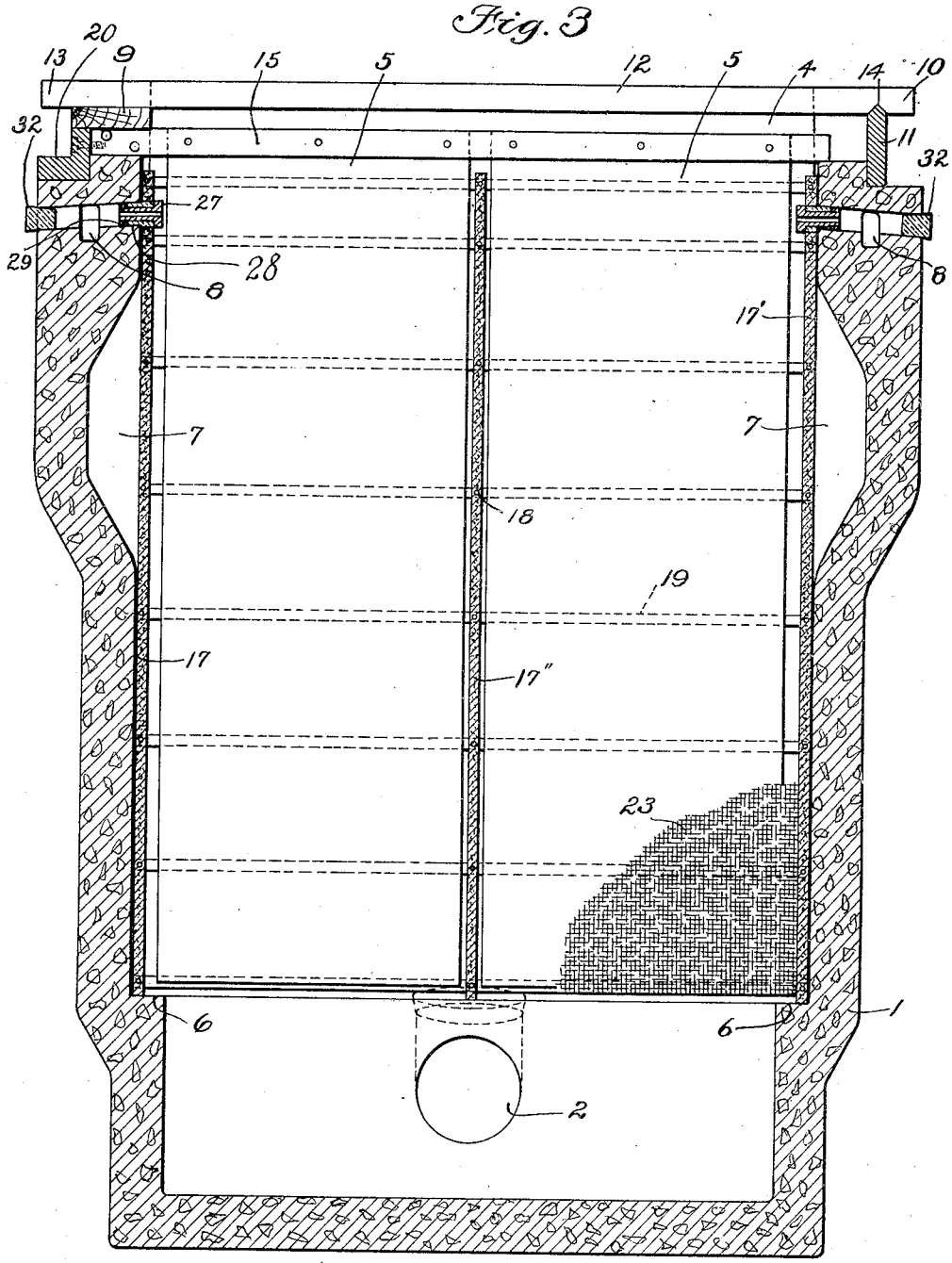
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Fig. 3



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Fig. 5

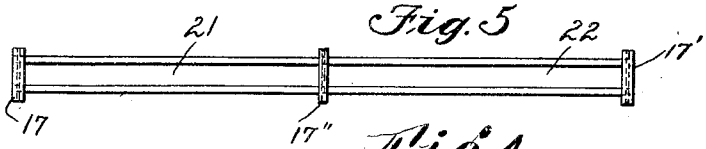


Fig. 4

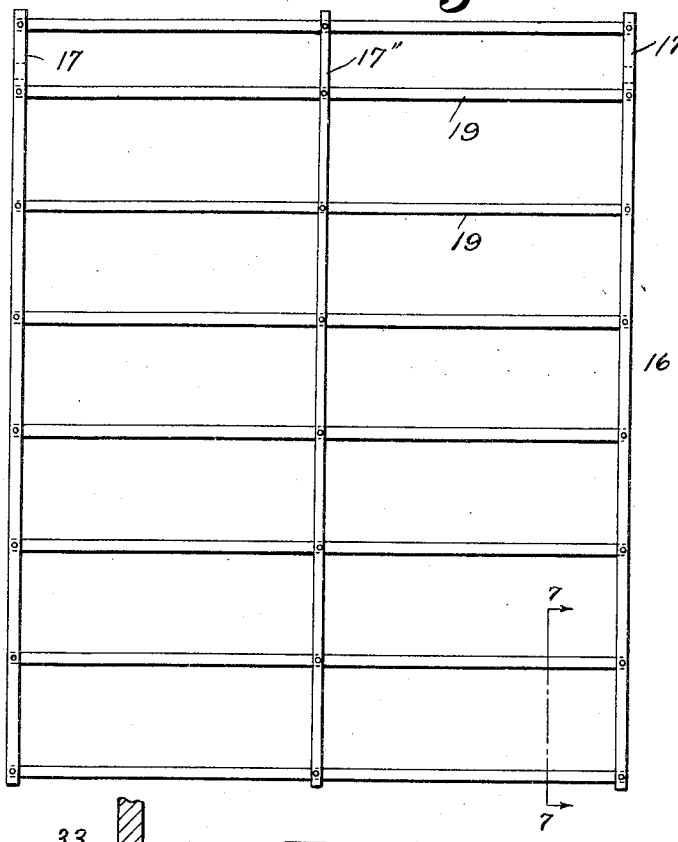


Fig. 6

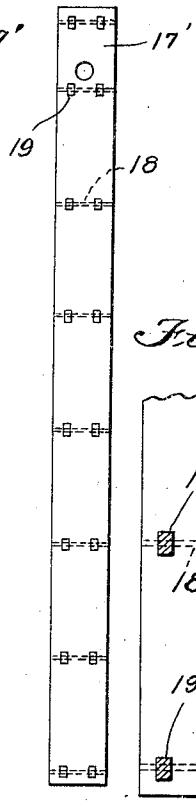
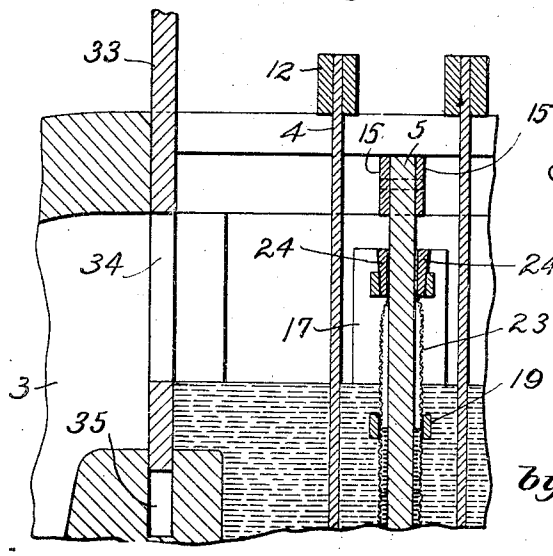


Fig. 7

Fig. 8



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Patented Oct. 22, 1929 1,732,797

UNITED STATES PATENT OFFICE

FREDERIC A. EUSTIS, OF MILTON, MASSACHUSETTS

ELECTROLYTIC CELL

Application filed September 19, 1925. Serial No. 57,354.

This invention relates to electrolysis, and more especially to the construction of electrolytic cells designed for the deposition of a metal or metals from solution, and includes means for effecting the controlled segregation and continued separation of the anode liquors from the cathode, and the remainder of the electrolyte.

It has been demonstrated (as disclosed in my Patent No. 1,456,615, issued May 29, 1923) that the anode liquors or solutions obtained from the operation of electrolytic cells, especially when an insoluble anode is employed, are extremely active solvents and may be conveniently employed for the dissolving of minerals, roasted or crude ores, or other like raw materials.

It is an object of the present invention to provide a cell for electrolytic purposes, in which the oxidized or oxygenated solution normally formed at the anode, or the anode liquor, may be controllably segregated and removed therefrom and from the remainder of the electrolyte, at the same time being prevented from coming into contact with the cathode or the electrolyte in the immediate vicinity of the cathode, and recovered in a suitable condition to serve effectively as a solvent of the metal to be deposited in the cell, or otherwise.

It is a further object to divise a type of electrolytic cell which shall be reasonably inexpensive to construct and made up of materials sufficiently resistant to withstand the reactive and solvent effects of the anode liquor as ordinarily encountered in such cells and the electrolytic action to be carried on. It is also an object to assure the controlled and constantly unidirectional flow of electrolyte toward the anode, and to prevent irregular deposition of the metal or metals therefrom, other than at or upon the cathode. Another object of the invention is to control the condition and constitution of the electrolyte in the cell and of the anode liquor as withdrawn therefrom. Further objects of the invention will appear from the following disclosure and claims.

Briefly stated, the invention comprises the provision of an electrolytic cell, having one or more cathodes and one or more anodes, in which the electrolyte surrounding the anode is segregated and kept separated thereafter from the remainder of the electrolyte (both by means of a porous diaphragm through which the electrolyte may permeate, continuously, and as a natural result of unidirectional flow, preferably under a controllable hydraulic head) and from which the anode liquor is withdrawn at such rate as to maintain the desired differential pressure,—the diaphragm being positively retained in spaced position relative to the cathode.

The invention will be described with specific reference to an electrolytic cell constructed for the electrolysis of solutions (containing iron, for example in the form of the chloride or sulfate and with appropriate modifications accordingly) as typical and generally representative of its application to the practical purposes and conditions of commercial operations. Such a cell is shown in the accompanying drawings, in which:

Fig. 1 is a horizontal section and plan view of the cell, with the central portion broken out;

Fig. 2 is a longitudinal section of the cell along line 2—2 of Fig. 1 with the central part of the tank and connecting portions of the inlet and outlet broken away;

Fig. 3 is a cross section of the cell and elevation of an anode in operative position therein, enclosed by an anode diaphragm or bag retained in place by a framework or grid, parts of each being broken away;

Fig. 4 is an elevation of the framework or grid employed for receiving and retaining the anode and bag in position;

Fig. 5 is a plan view of the same;

Fig. 6 is a side view of the same;

Fig. 7 is an enlarged detail cross section on line 7—7 of Fig. 4;

Fig. 8 is an enlarged detail cross section along line 2—2 of Fig. 1 showing two cathodes and an intermediate anode adjacent the outlet of the cell; and

Fig. 9 is an enlarged cross section of the outlet and associated connections of one of the anode bags.

Referring to the drawings generally, 1 in-

dicates a substantially rectangular tank or cell, (which may constitute a single unit of a battery of electrolytic cells or may be employed independently) which is fashioned from concrete, rendered acid proof by impregnation with sulfur or like material, having an inlet 2 in one end, at the bottom, and an outlet 3 at the opposite end near the top, and an alternate series of cathodes and insoluble anodes 4, 4, 5, 5, respectively, transversely suspended therein, and spaced with their lower edges at some distance above the bottom of the cell.

The cell preferably is provided with shoulders 6 running longitudinally along the inner face of the side walls of the cell, also longitudinal recesses or channels 7, in the upper part of the wall, and, near the upper edge of the side walls, passageways or conduits 8 running longitudinally through the side-walls, more fully to be described later. Along the top of one side wall there is provided an insulating strip 9, for example, while along the opposite side wall a knife edge strip 11 is provided which serves as a cathode bus bar. Suspended between the parallel strips 9 and 11, a series of spaced cathodes 4, 4, of slightly less width than that of the interior of the cell, are suspended by means of strips or rods 12 12′ which are fastened on opposite sides of the upper edge of the cathode and which extend at both ends beyond the electrodes to which they are attached,—one end 13 resting upon the strip 9, and the other 10 resting upon and engaging the knife edge of the bus bar 11, as by the notch 14 on its under surface.

Placed between the cathodes 4, 4, and alternating therewith, are mounted a corresponding series of vertically positioned anodes 5, 5, severally contained in rectangular frames 16 which may be made of any suitably resistant and dielectric material, such as grayboard impregnated with sulfur, and consisting essentially of a pair of side strips 17, 17′ (Figs. 4, 5 and 6) into which along either edge are mortised and united as with bakelite pins 18, a plurality of cross strips 19. Connecting the cross strips, at the center is a third vertical strip 17″, similar to the side strips 17, 17′ and similarly joined to the cross strips 19 by bakelite pins 18 or the like.

Each frame as thus constructed has its smallest dimension in a direction longitudinally of the cell and is of such width as to set transversely of the cell and rest upon the longitudinal shoulders 6. In assembly, such a frame is placed between successive cathodes 4, 4, (Figs. 1 and 2) the edges of the vertical members 17, 17′ and 17″ holding the cathodes apart and maintaining the latter in fixed spaced relationship. By providing the central partition 17″ each frame constitutes two compartments 21, 22. Each compartment is adapted to receive therein an anode plate 5, preferably leaving a space therebetween on all sides and at the bottom, but with the top projecting an appreciable distance above the upper cross piece of the frame (Figs. 2—3) and fastened to an anode bar 15 which passes across the top of the cell and from which the anode is suspended. The anode bar is, in turn, joined to an anode bus bar 20. Before thus inserting the anodes into the corresponding compartments of their several frames, they are slipped into thin rectangular bags 23 of substantially the same size and shape, and made of a chemically resistant permeable diaphragm or porous fabric such as woven asbestos cloth. The anodes, as thus enclosed, are then suspended in the several compartments 21, 22 of the frames, and reaching almost to the bottom of the frame but preferably without touching the same (Figs. 2, 8). The anodes are retained in this position by their bus bars as already described, and wedges or strips 24 are next inserted along either side of the upper edges of the anodes, between the upper cross bars of the frame and the anode, thereby gripping the bag at its upper edge and holding the same in this position.

At the outer edge of each anode bag, near the top, there is provided an opening 25 adapted to register with the hole in a rubber stopper 26 (and a hole in the side panel 17 or 17′,) and to be firmly held there against by the expanded head 27 of a tube 28, passing through the stopper and screw threaded into the ring nut 29 at the outer end of the stopper. The stopper, as thus arranged and protruding from the side of the bag is adapted to fit into a corresponding transverse opening 31, which is provided in the wall of the cell adjacent thereto and leads into the longitudinal conduit 8 and thence to the outside of the cell wall where it is normally closed by a solid stopper 32.

In operation of the cell, either independently or as a unit of a series or battery in assembly with other electrolytic apparatus, the electrolyte is introduced through the inlet 2, fills the entire bottom portion of the cell, and rises between the anode and cathode plates, penetrating the anode bags and finally tending to establish a substantially constant surface, level with the outlet 3. The required electric current is then passed through the cell, suitable connections being made between the electrodes and a source of current, as by the anode bus bars and cathode connections, which may be severally enclosed by a chemically resistant dielectric substance as by applying a mass of cement thereon, (not shown), if necessary. By the electrolytic action induced in the electrolyte by the passage of the electric current through the cell, the metallic element or elements of the electrolyte are deposited upon or adjacent to the cathodes, while the electrolyte in the imme-

diate vicinity of the anodes assumes an oxygenated condition, concomitantly therewith,—and it may be that actual liberation of oxygen gas will also take place.

The resulting oxygenated portion of the electrolyte, or anode liquor, accumulates substantially entirely adjacent the anode and hence within the diaphragm bag which retains it and prevents subsequent admixture of the same with the remainder of the electrolyte in the cell. Upon exceeding the level of the opening in stopper 26, the anode liquor in each bag overflows through passageway 31 and into the common conduit 8 which carries it away to a suitable receiver, or treating tank,—not shown. In order to maintain such flow continuously into and through the bag surrounding the anode, the height at which the surface of the electrolyte in the cell stands, outside of the bag is maintained sufficiently above that of the outlets in the anode compartments to create an appreciable hydrostatic head between the opposite sides of the diaphragm. This is effectuated at the outlet 3 by means of a dam or adjustable slide 33 having an opening 34 therein, and which may be raised or lowered as desired, in slot 35. The differential pressure and the rate at which the electrolyte will permeate through the diaphragm into the anode compartment and hence the amount,—and correspondingly the effective concentration,—of the anode liquor produced will thus be controlled.

For example, if a ferrous chloride solution is to be employed as the electrolyte, for the purpose of recovering electrolytic iron therefrom, metallic iron will be deposited in the form of a coating upon the surface of the cathodes and the electrolyte at and in the vicinity of the anodes, severally, will acquire an increased concentration of chlorine, manifesting itself, e. g., by addition to the ferrous chloride in the solution to form ferric chloride. (Other ferric salts may be so formed corresponding to the acid or iron salt employed.) The thus oxidized portion of the solution is effectively confined within the asbestos bag surrounding the anodes, and, by continuously withdrawing the liquor, therefrom, (as well as any gases that may be evolved) by overflow through stopper 26 and thence into the longitudinal draw-off conduit 8, the level of anode liquor therein is brought to and maintained appreciably below the level of the electrolyte outside of the anode bag. Still further to insure the constancy of this condition with continued operation of the cell, the level of the liquid electrolyte in the cell may be adjustably controlled by raising or lowering the slide 33, as before mentioned.

The electrolyte withdrawn from the outlet 3 may be passed to another cell for further electrolysis or re-circulated through the same cell, depending upon the operating arrangements desired. The iron deposited upon the cathodes may be removed in the usual manner. The anode liquor containing ferric and ferrous chlorides in varying proportions, depending upon the degree of completion to which the electrolysis has been carried, the relative rates of withdrawal of the electrolyte and of the anode liquor, etc., is returned to leaching vats or the like for effecting the solution of fresh raw material, for which it is an especially potent reagent.

It will be readily understood and appreciated by those skilled in the art that various modifications and adaptations of this invention may be made in its application to industrial requirements, both with respect to the raw materials and the solutions to be electrolyzed and to the specific types of electrolytic apparatus with which it may be desirable or necessary to assemble it. Such modifications and adaptations are to be considered as comprehended in the disclosure above and by the terms of the following claims.

I claim:

1. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable diaphragm surrounding the anode, and means retaining the surface of said diaphragm in spaced relationship with respect to the cathode.

2. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable bag surrounding the anode and a grid holding the surface of the bag in spaced relationship with respect to the cathode.

3. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable bag surrounding the anode, and an outlet for the anolyte through the bag, said outlet being capable of tight connection with an opening in the wall of the container.

4. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable bag surrounding the anode, a frame adapted to receive the anode and bag therein and means for suspending said bag between the frame and the anode.

5. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable diaphragm surrounding the anode, and inlet and outlet means for controlling the flow of electrolyte through the cell.

6. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable diaphragm surrounding the anode, and inlet and outlet means for controlling the flow of electrolyte through the cell, and outlet means in the diaphragm for the withdrawal of anode liquor away from the anode.

7. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable bag surrounding the anode, inlet and outlet means for controlling the flow of electrolyte through the cell, and outlet means in the bag for the withdrawal of anode liquor therefrom, and disposed at a lower level than the outlet from the cell proper.

8. An electrolytic cell, comprising a container for the electrolyte, a cathode, an insoluble anode, a liquid-permeable bag surrounding the anode, inlet and outlet means for controlling the flow of electrolyte through the cell, and outlet means in the bag for the withdrawal of anode liquor therefrom, and disposed at a lower level than the outlet from the cell proper, and means for controlling the effective height of the outlet from the cell proper, thereby to determine the level of the electrolyte in the cell with respect to the height of the anode liquor in the anode compartment.

9. In combination with an electrolytic cell, an insoluble anode, and a chemically resistant, liquid-permeable bag substantially enclosing the same, and a grid, adapted to retain the bag in position and away from the cathode.

10. In combination with an electrolytic cell, an insoluble anode, and a chemically resistant, liquid-permeable bag substantially enclosing the same, and a grid, said grid being impregnated with a dielectric substance such as sulfur, and adapted to retain the bag in position and away from the cathode.

11. In combination with an electrolytic cell, an insoluble anode, a chemically resistant, liquid-permeable bag substantially enclosing the same, a frame adapted to receive the bag therein and to maintain the bag out of contact with the cathode, and means for retaining said bag uniformly disposed between the anode and the frame.

12. In combination with an electrolytic cell having a plurality of electrodes, a framework, having an impregnating coating of a dielectric, chemically resistant material thereover, and comprising members adapted to retain the cathode elements of said cell at spaced intervals and a compartment adapted to receive the anode elements therein.

13. In an electrolytic cell, a container for the electrolyte characterized by being impregnated with elementary sulfur in those portions of its surface which contact with said electrolyte.

Signed by me at Boston, Massachusetts, this fourteenth day of September, 1925.

FREDERIC A. EUSTIS.