

W. E. GREENAWALT.
ELECTROLYTIC APPARATUS.

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Patented Sept. 12, 1916.

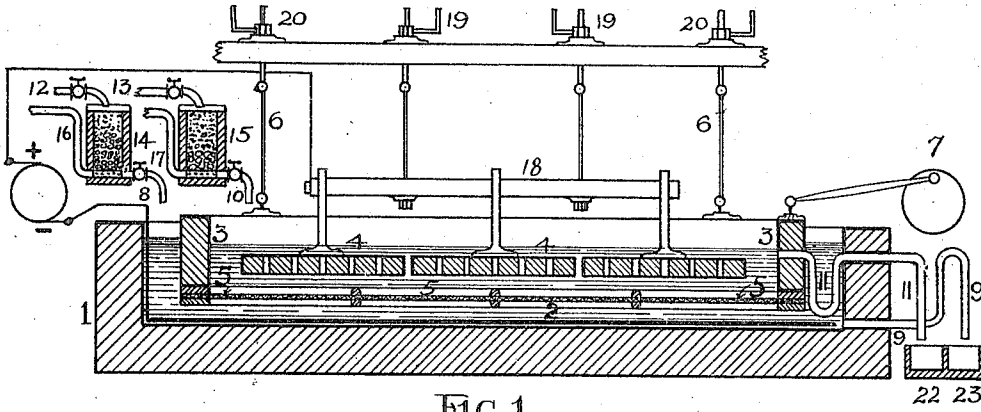


FIG. 1

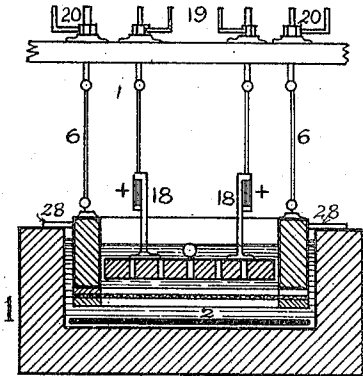


FIG. 2

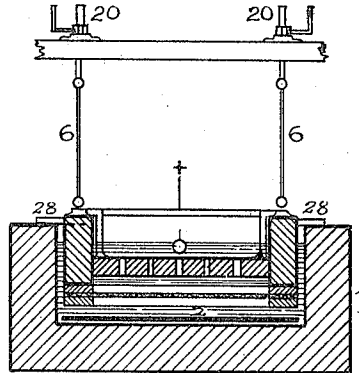


FIG. 3

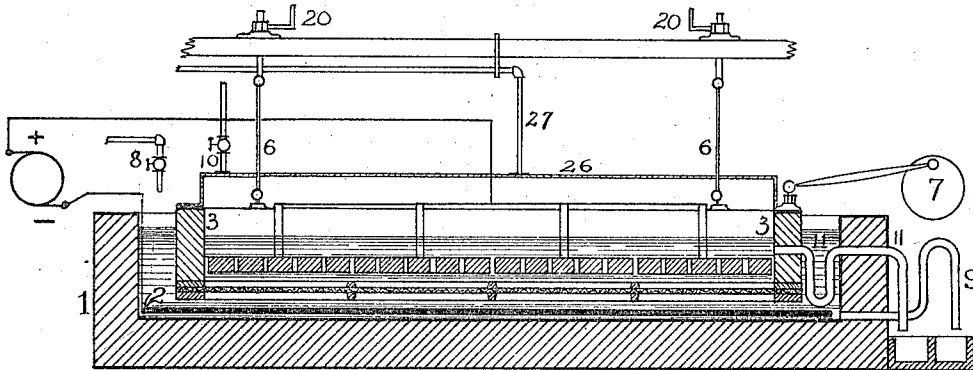


FIG. 4

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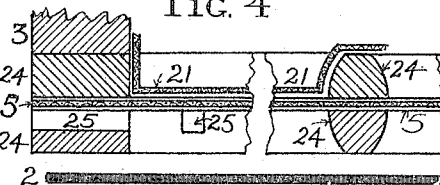


FIG. 5

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ELECTROLYTIC APPARATUS.

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Specification of Letters Patent.

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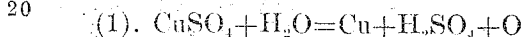
Application filed December 14, 1911, Serial No. 665,742. Renewed May 11, 1916. Serial No. 96,944.

To all whom it may concern:

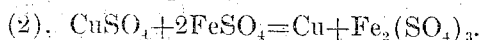
Be it known that I, WILLIAM E. GREENAWALT, a citizen of the United States, residing in Denver, in the county of Denver and State of Colorado, have invented certain new and useful Improvements in Electrolytic Apparatus.

The improvement is particularly adapted to the electrolysis of impure copper sulfate solutions, but it may be used for other purposes.

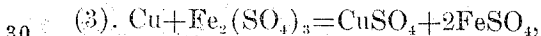
In the electrolysis of impure copper sulfate solutions, as for example those derived from leaching copper ores, iron especially is a deleterious element which injuriously effects the operation. If a solution of copper sulfate, containing ferrous sulfate, is electrolyzed without a diaphragm, then in addition to the reaction:



there will take place,



The ferric sulfate, finding its way back to the cathode, and under the influence of the current, gives rise to the reversible reaction,



thus nullifying the previous reaction, and resulting in a loss of efficiency. This loss will depend largely on the amount of iron in the copper solution. If the iron is excessive, the copper may be dissolved as rapidly as precipitated, and the sum total of the energy expended will be *nil*, so far as any useful effect is concerned.

If a suitable diaphragm is interposed between the electrodes, then both the sulfuric acid and ferric sulfate are regenerated, but the deleterious reactions at the cathode are avoided, and the current efficiency may closely approximate the theoretical. The diaphragm, however, offers other difficulties when inserted in the ordinary way.

In the electrolysis of sulfate solutions no satisfactory insoluble anode has yet been discovered. Lead has given fair results in some cases, but the lead is rapidly disintegrated and becomes a source of annoyance and expense, owing to the accumulation of

peroxid of lead on the face of the anode, which increases the electrical resistance, and as the peroxid drops to the bottom of the electrolyzer, if not removed at frequent intervals may result in short circuiting the current. Its frequent removal presents serious difficulties, delays, and expense.

In all the electrolytic regenerative sulfate processes for extracting copper from its ores, so far as I am aware, the electrolyzed and depleted cathode solution is used to dissolve more copper and hence the iron and other impurities are cumulative, and eventually offer greater difficulties as the operation progresses.

In the present invention it is sought to overcome these difficulties, by a continuous method of removing the disintegrated anode material, by complete replacement of the old electrolyte with a pure one newly regenerated in the anode compartment of the electrolyzer, and by providing for high anode and cathode efficiencies, with an apparatus which is simple, effective, and automatic.

In the accompanying drawings Figure 1 represents a longitudinal section of the electrolytic apparatus, and Fig. 2 the corresponding transverse section. Fig. 4 represents a longitudinal section of a modified apparatus and Fig. 3 the corresponding transverse section. Fig. 5 shows details of diaphragm construction, cloth for retaining the disintegrated anode material, and provision for the escape of gases from the under side of the diaphragm.

Referring to the figures, 1 represents a cathode tank containing the catholyte and substantially horizontal cathodes, 2.

3 represents the anode bell containing the anolyte and substantially horizontal anodes 4, and having a diaphragm 5, stretched over its mouth, thus separating the anolyte from the catholyte. On top of the diaphragm is placed a cloth 21, easily removable, to facilitate removing of the disintegrated anode material and prevent it from getting to the diaphragm and cathode. The anode bell 3, is suspended by hangers 6, so that it oscillates when actuated by the mechanism 7. Faucet 8 serves to introduce the catholyte into the apparatus, and the pipe 9 serves to

withdraw it. Faucet 10 serves to introduce the anolyte into the apparatus and the tubing 11 serves to withdraw it. This tubing is made flexible and is immersed in the catholyte; it is fastened to the anode bell, passes through the catholyte and sides of the cathode tank, so that the anolyte flows out unimpeded while the anode bell oscillates and without mingling with the catholyte.

It may be found desirable to introduce a reducing agent into either the anolyte, the catholyte, or both. In such a case the solution from the faucets 12 and 13, connecting with the source of supply, is preferably sprayed into the towers 14 and 15, while the reducing agent, as for example sulfur dioxide, is forced through the pipes 16 and 17, into the bottom of the tower. In this way the solution may be saturated with the reagent and flowed into the electrolyzer, or the reagent may be introduced direct into the apparatus. The first method is preferred.

The anodes 4, are suspended from conducting bars 18, which in turn are suspended by an adjustable device 19, whereby the anode may be raised or lowered at will, even when the apparatus is in operation. Similarly the anode bell may be raised or lowered by the adjusting device 20.

In Figs. 1 and 2 the anodes are shown stationary, and the anode bell, with the attached diaphragm, oscillated independently of the anode. This is the preferred arrangement.

In Figs. 4 and 3 the anodes are attached to the bell and are oscillated with it, but the results so obtained are inferior to the arrangement shown in Figs. 1 and 2. It is evident, also, that the suspended anode in the alternative arrangement, may have considerable weight, especially if the anode is lead, and this adds somewhat to the difficulty of oscillation.

In Fig. 5 is shown a detail section of the anode bell and diaphragm. The diaphragm is preferably made by sandwiching a layer of asbestos paper between two thicknesses of asbestos cloth, and the whole fastened between two mullioned frames. The frame is then fastened to the anode bell, preferably with copper screws. The mullions 24, serve to support the diaphragm and act as an agitator for both the anolyte and catholyte, and this is an important function, because it reduces the necessary voltage required in the operation, and increases both the anode and cathode efficiencies, and assists in continuously removing the disintegrated anode material from the cell. These mullions, or cross strips, are not absolutely necessary though desirable. Good results have been obtained without them, especially in the smaller sized apparatus. Instead of asbestos cloth, ducking may be used; while

in some respects ducking performs the function of a diaphragm better than asbestos cloth, it is not so durable.

Unless suitable provision is made, air, hydrogen, or other gases may become entrained under the diaphragm, and thus reduce the efficiency of the apparatus. This may happen with hydrogen released at the cathode when the deposition is not going on smoothly or when the catholyte becomes impoverished in copper. To overcome this difficulty, means are provided for the escape of the gas as rapidly as formed. This is preferably done by saw cuts or auger holes, as shown at 25 Fig. 5, which prevents the trapping of the gases, and the motion of the anode bell facilities their expulsion. On the top of the diaphragm proper, is a cloth 21, Fig. 5, fastened to the anode bell to keep it in position, but easily removable. This cloth keeps the disintegrated anode material from getting on the diaphragm, and in case the material becomes lodged, or in case of a clean-up, the cloth may be easily removed with the disintegrated anode material, thus facilitating the work and saving wear on the diaphragm. In the event of its not being necessary to make an absolute separation between the anolyte and catholyte, a single cloth of asbestos or cotton may be used to function both as diaphragm and means of catching the disintegrated anode material. In case a diaphragm is not necessary, a cloth is still interposed between the electrodes which permits of free diffusion of the electrolyte but sufficiently dense to intercept the disintegrated anode material from getting on the cathode until it can be expelled with the electrolyzed solution. In such a case, the diaphragm and cloth for intercepting the disintegrated anode material are considered the same for the purpose of this specification. In addition to the saw cuts in the diaphragm frame, the diaphragm may be given a slight tilt to throw the gases toward the outside and thus prevent their lodgment. This may be done by making the mullions slightly thicker at the middle than at the ends.

In the operation of the apparatus, the anolyte and catholyte are introduced into the electrolyzer, the current turned on, and the anode bell oscillated by the mechanism 7. In the deposition of copper from sulfate solutions, lead anodes are preferably used. It is well known that these anodes disintegrate, the metallic lead being converted into the peroxid of lead by the liberated oxygen, but the disintegration is greatly reduced by oscillating the anode bell, whereby the anode reactions are greatly facilitated. The resistance is also largely decreased, because the oscillation of the anode bell prevents undue impoverishment of both the anolyte and catholyte in immediate contact with the electrodes. It is well known that agitation of

the electrolyte increases the electrode efficiency. A higher current density can be used than would otherwise be possible, and the deposited copper is pure and reguline.

5 Under the action of the current, copper is deposited at the cathode, sulfuric acid and ferric sulfate formed at the anode, and the anode lead is oxidized to the peroxid of lead, PbO_2 , and thus disintegrated. Under
10 ordinary conditions this peroxid of lead accumulates on the anode in quite a considerable layer, and thus increases the resistance of the current, finally dropping off in large scales to the bottom of the tank, and thus
15 causes short circuiting of the current, if not removed at frequent intervals. Under the action of the oscillating diaphragm or anode bell, the peroxid of lead is removed from the anode about as rapidly as formed and if
20 it were not for the diaphragm or cloth between the electrodes, the peroxid would settle on the cathode and destroy the purity of the deposited copper and cause other irregularities. The action of the oscillation is to
25 remove the peroxid from the lead about as rapidly as formed and confine it to the anode bell until it is removed in suspension with the regenerated anolyte, passing through the flexible tube 11. The oscillating
30 movement keeps the disintegrated anode material stirred up and facilitates its expulsion. The operation is entirely automatic, both as to the removal of the peroxid from the anode and its expulsion from the
35 cell. A jerky motion facilitates the expulsion, but this is a detail easily adjusted by well known mechanical appliances.

The regenerated electrolyte, containing the disintegrated anode material in suspension, flows from the electrolyzer, through
40 the flexible tubing 11, into launder 22, and from there into a settling tank (not shown), where the disintegrated anode material settles to the bottom. The clear supernatant regenerated electrolyte may then be returned to the ore to repeat another cycle. The peroxid of lead, after sufficient accumulation, is again reduced with carbon to
45 metallic lead and recast into anodes to again pass through the same cycle. From this it will be seen that the removal of the disintegrated anode material and its expulsion from the cell is practically continuous and automatic, and very little loss or expense is
50 incurred in reducing the peroxid to metallic lead. The large expense of continually supplying new anode material, is almost entirely obviated. Theoretically at least, the anode lead, once purchased, will last indefinitely, by simply reducing the peroxid
55 formed at the anode and recasting into new lead anodes.

It was noted in the experimental work that the amount of disintegrated anode material is greatly diminished under the action

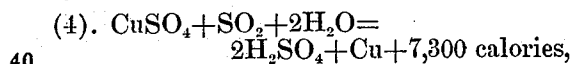
of the apparatus. In actual tests made with stationary electrodes under ordinary conditions, the peroxidation of the lead anode amounted to 0.85 pound of peroxid per pound of copper deposited; under the conditions of the improvement herein described, the oxidation amounted to only one tenth ounce of lead per 1.25 pound of copper, and practically all the peroxid was automatically removed with the regenerated anolyte.

With a suitable diaphragm, like the one described, the anolyte may be kept almost totally separated from the catholyte. Suppose that the catholyte consists of a very impure neutral solution of copper sulfate, such as might be obtained from leaching copper ores in a cyclic process, and the anolyte consists of slightly acidulated water, as for example washwater obtained in treating copper ores with an acid sulfate solution. As the copper is deposited on the cathode, sulfuric acid is liberated at the anode, and when the operation is completed, the copper is removed from the catholyte, and all the available acid transferred to the anolyte. It is evident that under these conditions, the practically pure anolyte contains all the available acid, and the catholyte, now deprived of its copper and containing no available acid, may be wasted without loss. In this way fouling of solutions cannot occur, and that difficulty, so troublesome in the past, is entirely overcome. It may not be necessary to waste the catholyte at every cycle of the operation; in which case the density of the diaphragm is not of so much importance, until the solution has sufficiently fouled to make its rejection necessary or desirable. The apparatus has flexibility enough to adapt it to all the varying conditions, and it would be useless to discuss all these conditions in detail.

In the electrolysis of copper sulfate solutions, oxygen is released at the anode as set forth in equation (1). To provide for the removal of this oxygen from the under side of the anode as rapidly as formed, the lead anodes are cast with perforations. The oxygen or other gases readily escape through these perforations, and their escape is greatly facilitated by the oscillating motion of the anode bell or diaphragm. As the electrolysis progresses, the cathode builds up with deposited copper so that it becomes necessary to correspondingly elevate the anode and anode bell. This is readily accomplished by the adjusters 19 and 20, and the adjustment may be made while the apparatus is in operation. In this way the cathode may be built up to any desired thickness, and the cell need only be stopped at considerable intervals to remove the copper. In depositing the copper it is best to deposit it in sections to facilitate its re-

moval. This may be done by insulating strips of paint or paraffin or by thin strips of wood, or by sectionalizing the original cathode sheets. The size of the sections are regulated so as to be conveniently lifted or removed from the tank. Ordinarily, in operating the apparatus, it will be desirable to have the tendency of flow be from the cathode to the anode to overcome diffusion toward the cathode; this is facilitated by keeping the catholyte at a slightly higher level than the anolyte, and its height may be adjusted by the outlet pipe 9.

When it is desired to stop the operation of the apparatus and remove the copper, the anodes are elevated, preferably as a whole, the anode bell gradually elevated and the anolyte allowed to drain out through the tubing 11 so as not to bring undue strain on the diaphragm. If there is any accumulation of disintegrated anode material in the anode bell, the removable cloth is taken out with the material on it; after being washed, it may be replaced. The catholyte is drained from the cell and the copper taken out, after which the original order of things may be established, and the cycle repeated. Ordinarily the regeneration of acid in the anolyte will not be sufficient to make up the loss consumed by the gangue of the ore. To overcome this difficulty and also to reduce the voltage necessary for the electrolytic decomposition of the copper sulfate, a depolarizer, such as sulfur dioxide, is introduced into the anolyte, which acts both as a depolarizer and acid generator, as shown by the following reaction:



which amounts to about 0.16 volt, acting with the current. Ordinarily it is difficult to realize any benefit from this reaction, because the SO_2 cannot be brought into sufficiently intimate contact with the liberated SO_4 as the anion, at a practicable current density. With the present invention, the anolyte is agitated by the anode bell and diaphragm as well as the catholyte, and the oscillating anode bell acts both as a suction and a pressure on the anolyte in connection with the perforated anodes, to suck the solution through the perforations and again expel it, and in this way bringing the depolarizer in intimate contact with the anode so that a good anodic efficiency may be realized at a practicable working current density. It may also be desirable to introduce a reducing agent into the catholyte to prevent the action of ferric salts in dissolving the copper and reduce the metallic compounds in the catholyte to their lowest valency, and thus make them unable to act on the deposited metal. Where oxidation, instead of reduction, is desired at the anode, the oxi-

dizing agent may be introduced through the same means as described for the reducing agent.

The description given in this specification is for the preferred arrangement, and as particularly applicable to the deposition of copper from sulfate solutions derived from leaching ores. It is evident that the apparatus may be used for other purposes with equally good results, as for example, in leaching ore with ferric sulfate solution; in which case, during electrolysis, ferric sulfate is regenerated at the anode from ferrous sulfate, and the regenerated ferric sulfate solution again applied to the ore. It may be used in the deposition of zinc, in which a neutral or slightly acid electrolyte is easily maintained. It may be used for refining of copper and other metals, etc. If the released anion is a gas which it is desired to use, it may be collected and withdrawn by placing a hood 26 over the anode bell, in which case a flexible inlet pipe, 10, and a flexible outlet pipe 27 for the gas, are provided.

28 are guides to keep the anode bell in proper alinement during oscillation.

Having thus described my invention, I claim:

1. In electrolytic apparatus the combination of a cathode tank containing the catholyte; anode bell suspended within the cathode tank and containing the anolyte; diaphragm interposed between the anode and cathode; means of oscillating the anode bell, and means of introducing and withdrawing the anolyte and maintaining it distinct from the catholyte.

2. In electrolytic apparatus the combination of a cathode tank containing the catholyte; anode bell suspended within the cathode tank and containing the anolyte; means of oscillating the anode bell; diaphragm attached to the anode bell and oscillating with it; flexible outlet for the anolyte passing through the cathode tank, and means of introducing and withdrawing separately both the anolyte and catholyte.

3. In electrolytic apparatus the combination of a cathode tank containing the catholyte; anode bell suspended within the cathode tank and containing the anolyte; means of oscillating the anode bell; diaphragm attached to the anode bell and oscillating with it; flexible outlet attached to the anode bell for the withdrawal of the anolyte without mingling with the catholyte, and means of introducing a reagent into the anode bell which will combine with the released anions.

4. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm inter-

posed between the electrodes: means of catching and removing the disintegrated anode material; means of oscillating the anode bell, and flexible means of withdrawing the anolyte with the disintegrated anode material in suspension from the anode bell without mingling with the catholyte.

5. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm interposed between the electrodes; means of oscillating the anode bell; means of introducing a reagent capable of combining with the released anions, and means of withdrawing the regenerated anolyte from the anode bell passing through the catholyte and sides of the cathode tank.

6. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell containing the anolyte and substantially horizontal anodes; a diaphragm attached to the mouth of the anode bell and provided with means for the escape of gases from the under side of the diaphragm.

7. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm interposed between the electrodes; means with said diaphragm of providing for the escape of gases which may have a tendency to become entrained by the diaphragm; means of oscillating the anode bell and means of withdrawing the anolyte without mingling with the catholyte.

8. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal and perforated anodes; diaphragm attached to the mouth of the anode bell; means of catching and removing the disintegrated anode material, and means of oscillating the anode bell horizontally.

9. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm interposed between the electrodes; means of horizontally oscillating the anode bell; means of introducing the anolyte at one end of the anode bell and withdrawing it from the other side while the bell is oscillating, and means of withdrawing the anolyte without mingling with the catholyte.

10. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm over the mouth of the anode bell supported by frame attached to the anode bell, and means in said frame of providing for the escape of gases from the under side of the diaphragm.

11. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; means of oscillating the anode bell; means of adjusting the vertical distance between the electrodes; and independent means of adjusting the vertical distance of the diaphragm between the electrodes.

12. In electrolytic apparatus the combination of a cathode tank containing the catholyte and substantially horizontal cathodes; anode bell suspended within the cathode tank containing the anolyte and substantially horizontal anodes; diaphragm interposed between the electrodes; means of introducing a reagent into the anolyte to combine with the released anions; means of introducing a reagent into the catholyte to reduce the bivalent compounds to the univalent condition and retaining them so; and means of separately introducing and withdrawing both the anolyte and catholyte, and means of oscillating the anode bell thereby bringing the reagents into intimate contact with the electrodes.

13. In electrolytic apparatus the combination of a cathode tank containing the catholyte and stationary cathode; anode bell suspended within the cathode tank by flexible supports and containing the anolyte and stationary anode; a diaphragm attached to the anode bell and interposed between the electrodes; means of oscillating the diaphragm and anode bell, and means of introducing and withdrawing the anolyte and maintaining it substantially distinct from the catholyte.

14. In electrolytic apparatus having horizontal electrodes a horizontal diaphragm interposed between the electrodes, frames supporting said diaphragm, and apertures in connection with the outside rim of the under frame for the escape of gases from the under side of the diaphragm.

15. In electrolytic apparatus having horizontal electrodes a diaphragm interposed between the electrodes supported by an upper and lower frame; means in connection with the lower frame of providing for the escape of gases from the under side of the diaphragm, and means of oscillating the diaphragm between the electrodes.

16. In electrolytic apparatus the combination of an electrolyte tank; a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes, and means of oscillating said diaphragm independently of the electrodes. 5
17. In electrolytic apparatus a stationary electrolyte tank; a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes and suspended from fixed pivotal points, and means of oscillating said diaphragm. 10
18. In electrolytic apparatus the combination of an electrolyte tank containing one electrode; an electrolyte bell suspended within the electrolyte tank and containing the opposite electrode; a diaphragm interposed between the electrodes, and means of moving said diaphragm from fixed pivotal points as the center of oscillation. 15
19. In electrolytic apparatus the combination of an electrolyte tank containing one electrode; an electrode bell suspended within the electrolyte tank and containing the opposite electrode; a diaphragm interposed between the electrodes and suspended from fixed pivotal points; means of oscillating said diaphragm, and means of withdrawing the electrolyte from the electrode bell without mingling with the electrolyte in the electrolyte tank. 20
20. In electrolytic apparatus the combination of an electrolyte tank containing a stationary electrode; an electrolyte bell suspended within the electrolyte tank; a stationary electrode suspended within the electrolyte bell and independently of it; a diaphragm interposed between the electrodes, and means of oscillating said diaphragm independently of the electrodes. 25
21. In electrolytic apparatus the combination of an electrolyte tank containing a stationary electrode; an electrolyte bell suspended within the electrolyte tank; a stationary electrode suspended within the electrolyte bell and independently of it; a diaphragm interposed between the electrodes; means of oscillating said diaphragm independently of the electrodes, and means of withdrawing the electrolyte from one electrolyte compartment without mingling with the electrolyte in the other compartment. 30
22. In electrolytic apparatus the combination of an electrolyte tank containing horizontal and stationary electrodes; means of agitating the electrolyte interposed between the electrodes and suspended from fixed pivotal points, and means of oscillating said agitator from the fixed pivotal points independently of the electrolytic tank. 35
23. In electrolytic apparatus the combination of an electrolyte tank containing the electrolyte and horizontal electrodes; a diaphragm interposed between the electrodes; means of oscillating said diaphragm; means 40
- of adjusting the vertical distance between the diaphragm and cathode, and means of adjusting the vertical distance between the diaphragm and anode. 70
24. In electrolytic apparatus having stationary electrodes, a diaphragm oscillating from fixed pivotal points. 70
25. In electrolytic apparatus a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes, and means of oscillating said diaphragm between the stationary electrodes. 75
26. In electrolytic apparatus an oscillating diaphragm interposed between stationary electrodes and a space arranged for the free circulation of the electrolyte between the diaphragm and both electrodes. 80
27. In electrolytic apparatus the combination of a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes; means of oscillating said diaphragm, and means of withdrawing the anolyte from the electrolyzer without mingling with the catholyte. 85
28. In electrolytic apparatus the combination of a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes; means of oscillating said diaphragm; means of escape for the gases from the underside of the diaphragm; and means of withdrawing the anolyte from the electrolyzer without mingling with the catholyte. 90
29. In electrolytic apparatus the combination of an electrolyte tank; a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes; means of oscillating said diaphragm; means of providing for the escape for the gases from the underside of the diaphragm; means of withdrawing the anolyte from the electrolyzer without mingling with the catholyte, and means of adjusting the vertical distance between the diaphragm and both electrodes. 95
30. In electrolytic apparatus the combination of an electrolyte tank; a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes; means of oscillating said diaphragm; means of withdrawing the anolyte from the electrolyzer without mingling with the catholyte; means of adjusting the vertical distance between the diaphragm and cathode, and means of adjusting the vertical distance between the diaphragm and anode. 100
31. In electrolytic apparatus the combination of an electrolyte tank; a stationary anode; a stationary cathode; a diaphragm interposed between the electrodes; means of oscillating said diaphragm; means of adjusting the vertical distance between the diaphragm and electrodes; means of withdrawing the electrolyte from one compartment of the electrolyzer without mingling with the other, and means of adding to the electrolyte 105
- 110
- 115
- 120
- 125
- 130

a reagent capable of combining with the released ions.

32. In electrolytic apparatus a stationary anode; a stationary cathode; a diaphragm dividing the apparatus into anode and cathode compartments; means of oscillating said diaphragm between the electrodes, and means of withdrawing the electrolyte from

the anode compartment without mingling with the electrolyte in the cathode compartment. 10

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