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ELECTROLYTIC DECOMPOSITION OF SOLUTIONS.

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972,947. **Patented Oct. 18, 1910.**

Fig. 1.

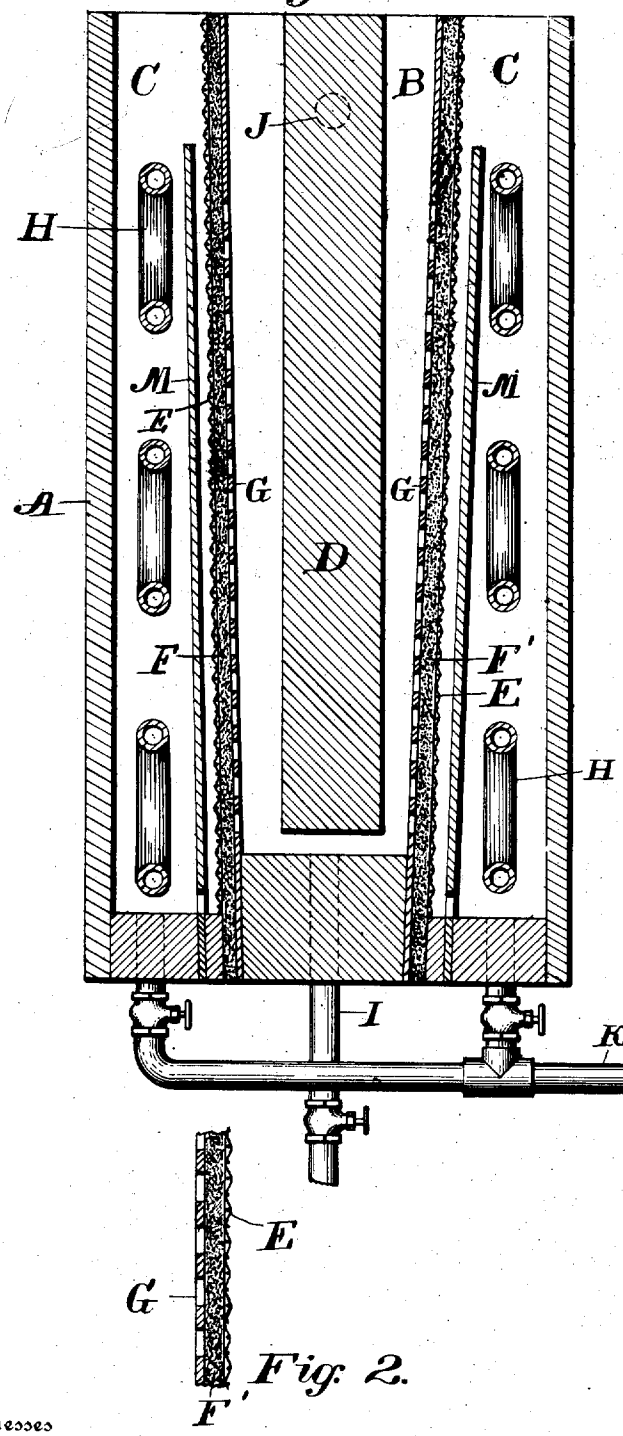

Fig. 3.

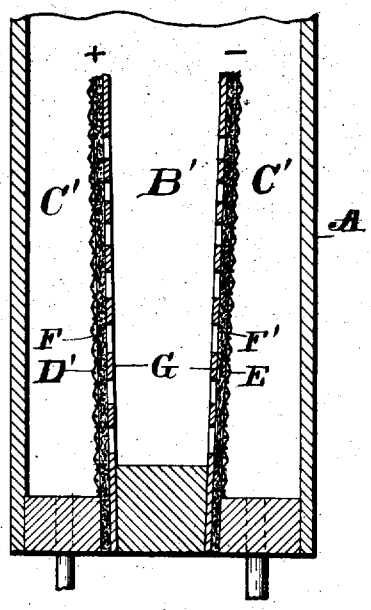

Fig. 2.

Witnesses

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ELECTROLYTIC DECOMPOSITION OF SOLUTIONS.

972,947. Specification of Letters Patent. **Patented Oct. 18, 1910.**

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To all whom it may concern:

Be it known that I, CLINTON P. TOWNSEND, a citizen of the United States, residing at Washington, in the District of Columbia, have invented new and useful Improvements in Electrolytic Decomposition of Solutions, of which the following is a specification.

This invention relates to the electrolytic decomposition of solutions, and particularly to a process of collecting the products of such decomposition.

I will describe the process with reference to the electrolytic decomposition of sodium chlorid solution, it being understood that such solution is a type or illustration only and that the invention is not restricted thereto.

According to my invention, one of the products of the electrolysis, or a secondary product resulting from the action of the primary product upon the electrolyte, or upon the immiscible liquid hereafter mentioned, is collected in, under, or above an immiscible liquid, which serves several important functions.

As a specific example of the process, I will describe the electrolysis of sodium chlorid solution to produce caustic soda and chlorin, referring to the accompanying drawings, wherein:

Figure 1 is a transverse vertical section of one type of cell; Fig. 2 is a sectional detail upon a larger scale, showing one construction of the diaphragm, cathode, and retaining plate; and Fig. 3 is a transverse vertical section of the lower portion of a modified form of cell.

Referring to Fig. 1, the cell comprises a central compartment B, containing an anode D and one or more lateral or cathode compartments C, shown as two in number, said lateral compartments being separated from the central compartment by the cathodes and diaphragms preferably constructed as shown in detail in Fig. 2.

F F′, are diaphragms of asbestos or other suitable pervious material supported between the perforated sheet or wire gauze E, and the perforated or pervious plate G. As shown, E E, are of metal and constitute the cathodes of the cell. The plates G, which may be of hard rubber or of earthenware, hardened asbestos or any suitable material, are preferably nonconducting and serve to support the diaphragm proper; they may, of course, be dispensed with, if the diaphragm be so treated as to be capable of supporting itself. They are shown as imperforate in their upper portions. It will be noted that the cathodes are shown as inclined slightly from the vertical, but such inclination is not essential.

M represents a sheet of metal, as iron, adjacent and approximately parallel to the cathode. This plate terminates a slight distance above the bottom of the cathode compartment and below its top, for a purpose hereinafter described.

H is a coil suitably connected and employed for heating or cooling the liquid in the cell to maintain its temperature at any desired point.

As illustrated, the cathode compartments C are somewhat deeper than the central or anode compartment, and are provided with valve-regulated drain pipes communicating with a main conduit K leading to the tank L, from which the solution may be withdrawn as desired.

In operation, the central compartment is filled with sodium chlorid solution, and a continuous flow is preferably maintained through this compartment from below upward, the inlet I and the outlet J being provided to this end. The lateral compartments are filled to a higher or lower level with a liquid which is substantially immiscible with water or aqueous solutions and inert toward the products of electrolysis liberated in contact therewith, or the secondary products resulting from the oxidation or other chemical modification of said products. Of such liquids, the non-saponifying oils may be taken as an example. Upon the passage of the current chlorin is liberated at the anode and sodium at the cathode. The chlorin escapes from the cell and may be collected and used as desired. The sodium is set free at the cathode and is in part or entirely oxidized by the solution in the diaphragm or percolating through the diaphragm. The caustic solution so formed under the oil, detaches itself freely from the cathode and is withdrawn from the

cell through the pipe K. The hydrogen which results from the reaction escapes upward through the narrow space between the cathode and the plates M, thereby inducing a strong circulation of the oil, which further aids in detaching the globules of caustic solution, thereby removing them quickly from the field of the electrolytic action.

The chief advantages due to the use of a liquid immiscible with the electrolyte for the purpose of collecting a product of the electrolytic decomposition thereof may be stated as follows:

(1) The product is formed and collected under a seal of said immiscible liquid and is thereby protected from all effects due to the contact of atmospheric gases. In the case of caustic soda, for instance, the sealing liquid prevents the production of sodium carbonate; it also prevents the production of carbonates of such metals as calcium and magnesium which may be present in an unpurified brine and which would act to obstruct the diaphragm and gradually to reduce its porosity; it also prevents evaporation of the liquid which carries the product in solution and consequent deposition therefrom in the diaphragm or on the cathode of the less soluble constituents.

(2) It effects the positive removal of the product from the electrode, an effect probably due in part at least to the difference in the adhesive power of the two liquids, (as, for instance, the caustic solution and the mineral oil), for the material of the electrode. For instance, oil adheres closely to such surfaces, and it follows that the caustic solution, being unable to displace the oil, assumes at once the form of a globule and freely detaches itself from the surface. Since the amount of diffusion of one liquid into another is dependent upon the time during which they remain in contact, this rapid removal of the caustic through the agency of the oil is most effective in preventing diffusion of the caustic into the liquid in the anode compartment.

(3) This removal of the caustic from the cathode is further aided by the fact that the hydrogen, which is a product of the reaction between the sodium and the water of the brine, and which is set free concurrently with the production of the caustic, is liberated under the hydrostatic pressure of the oil instead of merely expanding into an atmosphere. The hydrogen is compressed into bubbles which acquire a positive energy and direction of movement and greatly assist in detaching globules of caustic.

(4) The hydrogen, moving rapidly upward between the cathode and the plate M as before mentioned, imparts a rapid movement of circulation to the oil, which causes the oil effectively and positively to strip from the cathode the particles or globules of caustic solution. This rapid and useful movement of circulation is effected automatically, and without extraneous assistance, by the escaping hydrogen. The immiscible liquid therefore, operating through its own adhesion to the cathode surface, through the direction which it gives to the bubbles of hydrogen, and through its rapid movement of circulation, effects a practically instantaneous removal of the caustic from the surface of the cathode and from the field of electrolysis.

(5) The removal of the caustic from the cathode being effected in part by the hydrogen bubbles escaping under the oil and in part by the stripping action of the circulating oil thereby induced, as above described, it follows that an increase of current density, by which both of these favorable effects are increased, will operate advantageously within certain limits. In practice I find that I am enabled to utilize current densities equal to or exceeding one ampere per square inch of cathode area with a high degree of efficiency, thus giving to the apparatus a very large capacity.

(6) During the relatively slow downward movement of the oil in the large compartment between the plate M and the wall A, the caustic carried by the oil is permitted to separate therefrom and is deposited in the lower portion of the cell and in the drainage system, whence it is withdrawn as desired. The caustic is thus automatically deposited as formed out of the circulating path of the oil and out of the field of electrolytic action, and is positively insulated from the electrolytic field.

(7) The oil further acts in a marked degree to protect the diaphragm from the products of the electrolysis. I find that a fibrous material of vegetable or animal origin may be employed and that the film of oil which covers or coats the fiber serves to a large extent to prevent contact therewith of the products of electrolysis, and hence to prevent their corrosive action.

(8) The oil affords a convenient means for regulating the rate of flow of the electrolyte through the diaphragm and hence the concentration of caustic solutions produced at any particular current density. By raising or lowering the oil level the amount of percolating liquid may be decreased or increased at will, and this effect may be supplemented by a variation in the level of the liquid in the anode compartment. If the rate of flow through the diaphragm be greatly diminished the caustic is seen to be detached from the cathode in the form of flakes or flocculent masses or particles.

(9) The oil serves to positively support the diaphragm and particularly those portions of the same which lie between the meshes of the cathode and which do not

therefore derive support therefrom; the tendency of the diaphragm to yield to the pressure of the liquid in the anode compartment and to become perforated is thereby obviated.

(10) The hydrostatic pressure of the anode liquor varies from top to bottom of the diaphragm, and hence the percolation through portions of the diaphragm at different levels would vary through wide limits in the absence of a balancing hydrostatic pressure. The effect of the balancing or partially balancing hydrostatic pressure of the oil is to compensate in part for such differences and to equalize the flow through different portions of the diaphragm.

(11) The heating or cooling means for varying the temperature of the oil and hence of the electrolyte afford a convenient means for control in this respect.

It is to be understood that the foregoing statement of advantages is merely illustrative, and is not to be construed as in any way limiting the scope of the process as set forth in the claims.

In Fig. 3 I have indicated a construction wherein both anode D′ and cathode E, are placed in contact with an immiscible liquid and the anode as well as the cathode products are collected in, under, or above such liquid.

In operating the cell I have noted a very marked storage effect, the yield at first being low but rising rapidly to figures closely approximating those required by theory. On ceasing to pass current through the cell, a strong secondary current appears, apparently due to the oxidation of sodium which had been deposited upon the cathode and protected from oxidation. This secondary current persists for some time and caustic soda solution is delivered from the cell during the whole of such period. In case it is desired to interrupt the passage of current through the cell the electrical connections may be so changed as to cause this secondary current from two or more cells to pass through other cells, whereby such current is employed to produce a useful effect. Such procedure should not be permitted to continue too long however as some oxidation or solution of the cathode may occur.

I claim:—

1. The process of electrolyzing solutions, which consists in passing an electric current through the solution to an electrode, and recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, as set forth.

2. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, and recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, as set forth.

3. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode and recovering a product of electrolysis by means of a non-saponifying oil, as set forth.

4. The process of electrolyzing solutions, which consists in interposing a diaphragm and a pervious electrode between a body of the solution and a body of a liquid which is substantially immiscible with water or an aqueous solution and inert toward a product of the electrolysis, and passing an electric current through said solution and diaphragm to said electrode, whereby said product is removed from the field of electrolysis, as set forth.

5. The process of electrolyzing solutions, which consists in interposing a diaphragm and a pervious electrode between a body of the solution and a body of a non-saponifying oil, and passing an electric current through said solution and diaphragm to said electrode, whereby a product is removed from the field of electrolysis, as set forth.

6. The process of electrolyzing solutions, which consists in passing an electric current through the solution to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid in contact with said electrode, as set forth.

7. The process of electrolyzing solutions, which consists in passing an electric current through the solution to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid in contact with said electrode by means of a gaseous product of the electrolysis, as set forth.

8. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid in contact with said electrode, as set forth.

9. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and

circulating said liquid in contact with said electrode by means of a gaseous product of the electrolysis, as set forth.

10. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid rapidly upward along said electrode and slowly downward at a distance from said electrode, as set forth.

11. The process of electrolyzing solutions, which consists in passing an electric current through the solution and a diaphragm to an electrode, recovering a product of electrolysis by means of a liquid which is substantially immiscible with water or an aqueous solution and inert toward said product, and circulating said liquid rapidly upward along said electrode and slowly downward at a distance from said electrode by means of a gaseous product of the electrolysis, as set forth.

12. The process of electrolyzing solutions, which consists in interposing a diaphragm and a pervious electrode between a body of the solution and the body of a liquid which is substantially immiscible with water or an aqueous solution and inert toward a product of the electrolysis, passing an electric current through said solution and diaphragm to said electrode, whereby said product is removed from the field of electrolysis, and controlling the temperature of the electrolyte by suitably varying the temperature of said liquid, as set forth.

In testimony whereof I affix my signature in presence of two witnesses.

CLINTON P. TOWNSEND.

Witnesses:

EUGENE A. BYRNES,

CLAUDE I. PARKER.