(No Model.) 2 Sheets—Sheet 1.

A. SINDING-LARSEN.

ELECTROLYTIC APPARATUS.

No. 546,353. Patented Sept. 17, 1895.

Fig. 2.

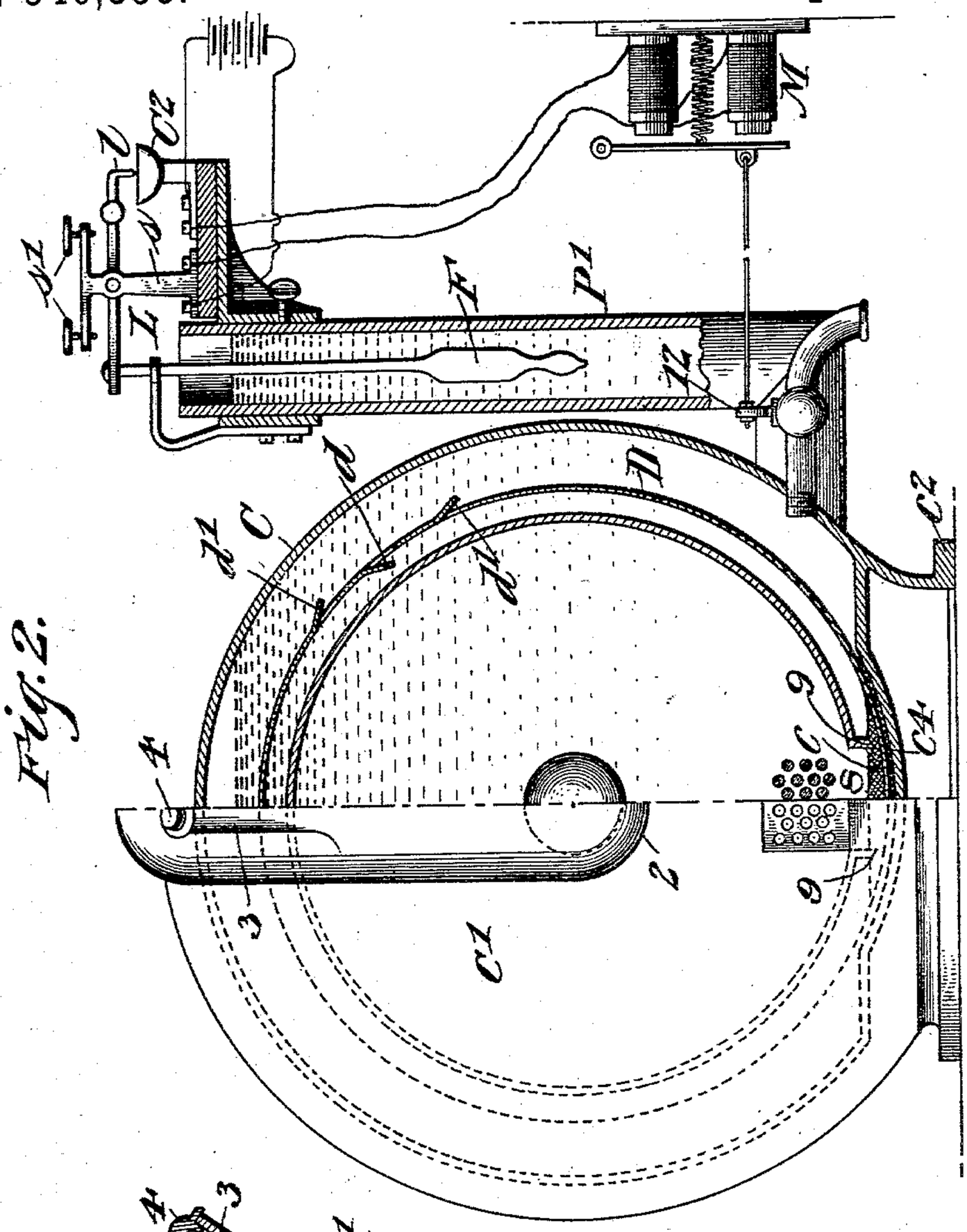
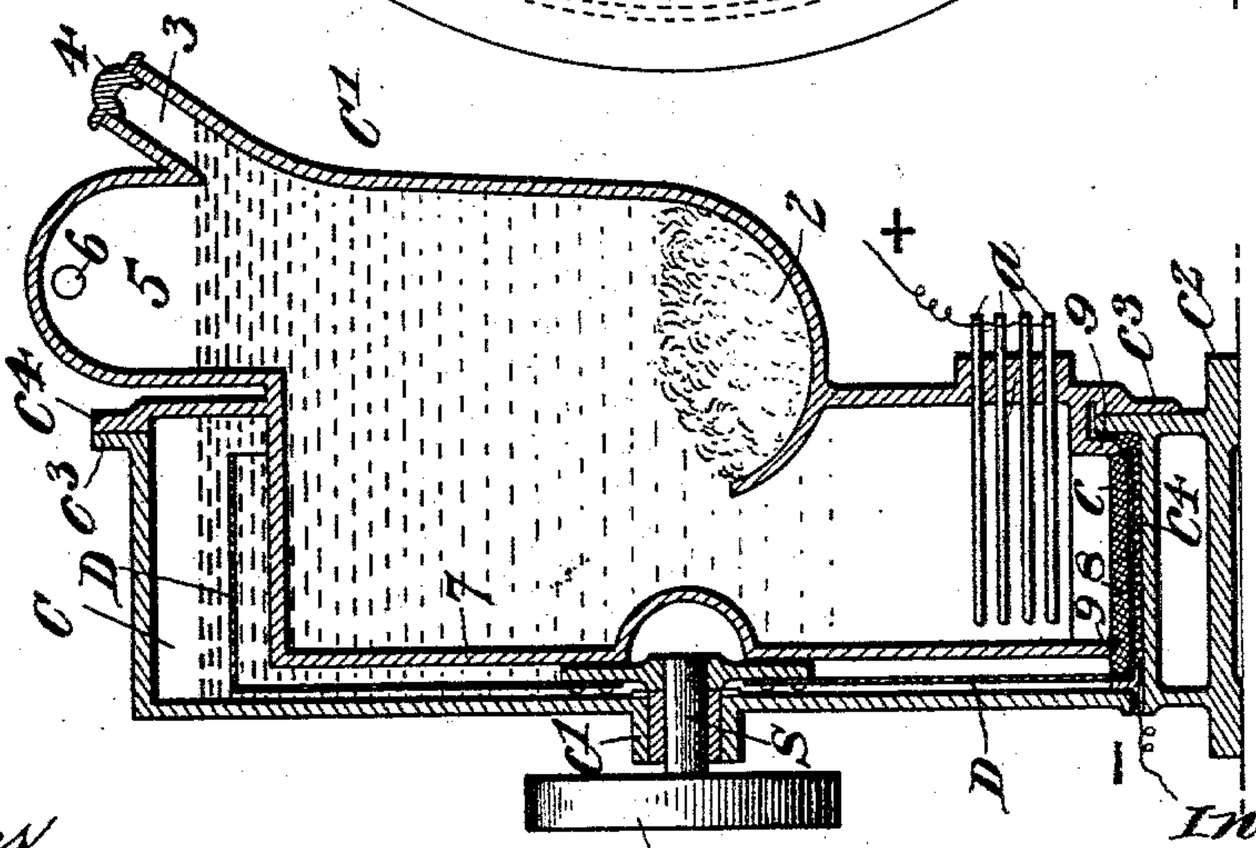


Fig. 1.



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By Howard Mott Atty.

(No Model.) 2 Sheets—Sheet 2.

A. SINDING-LARSEN.

ELECTROLYTIC APPARATUS.

No. 546,353. Patented Sept. 17, 1895.

Fig. 5.

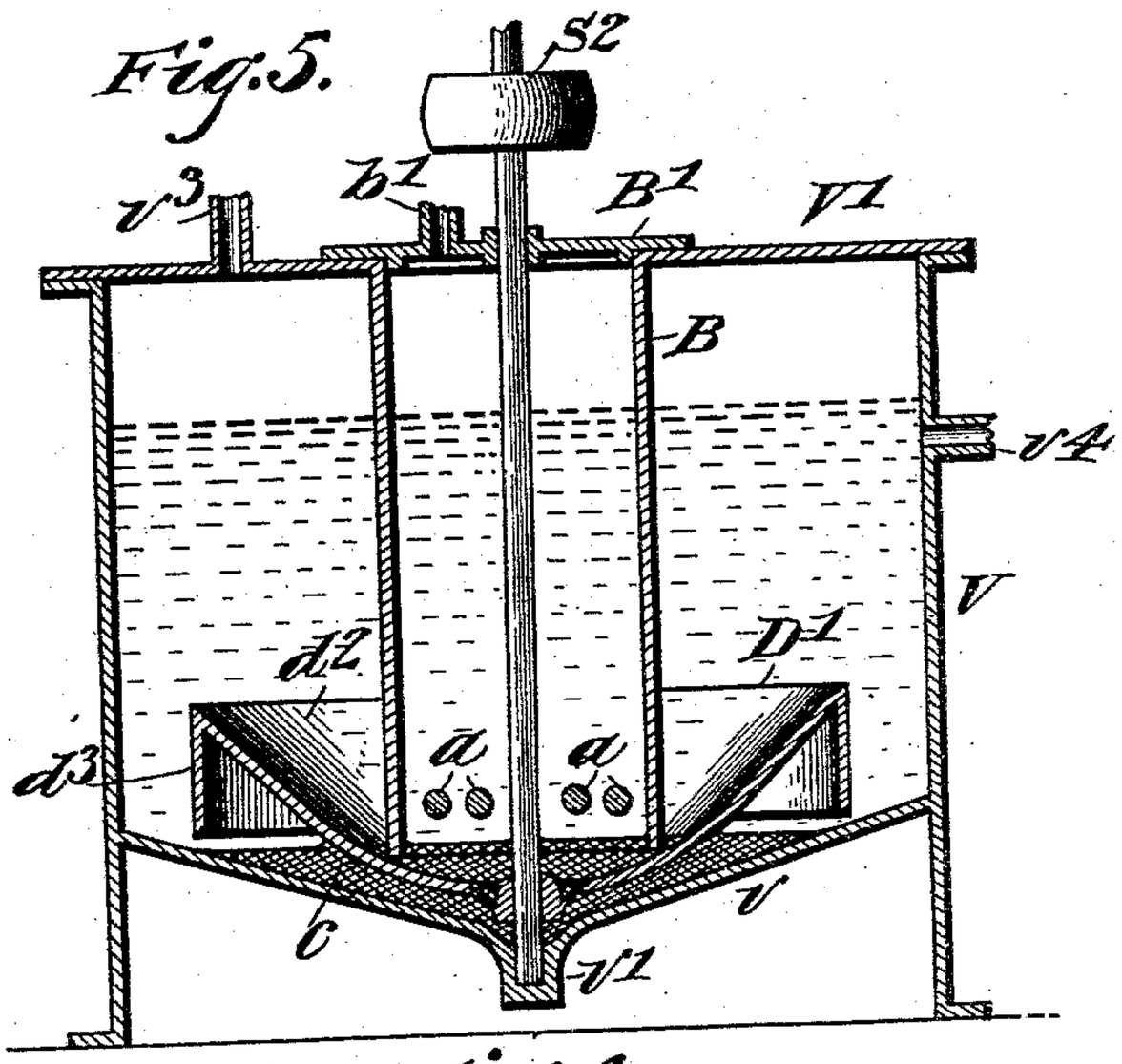


Fig. 4.

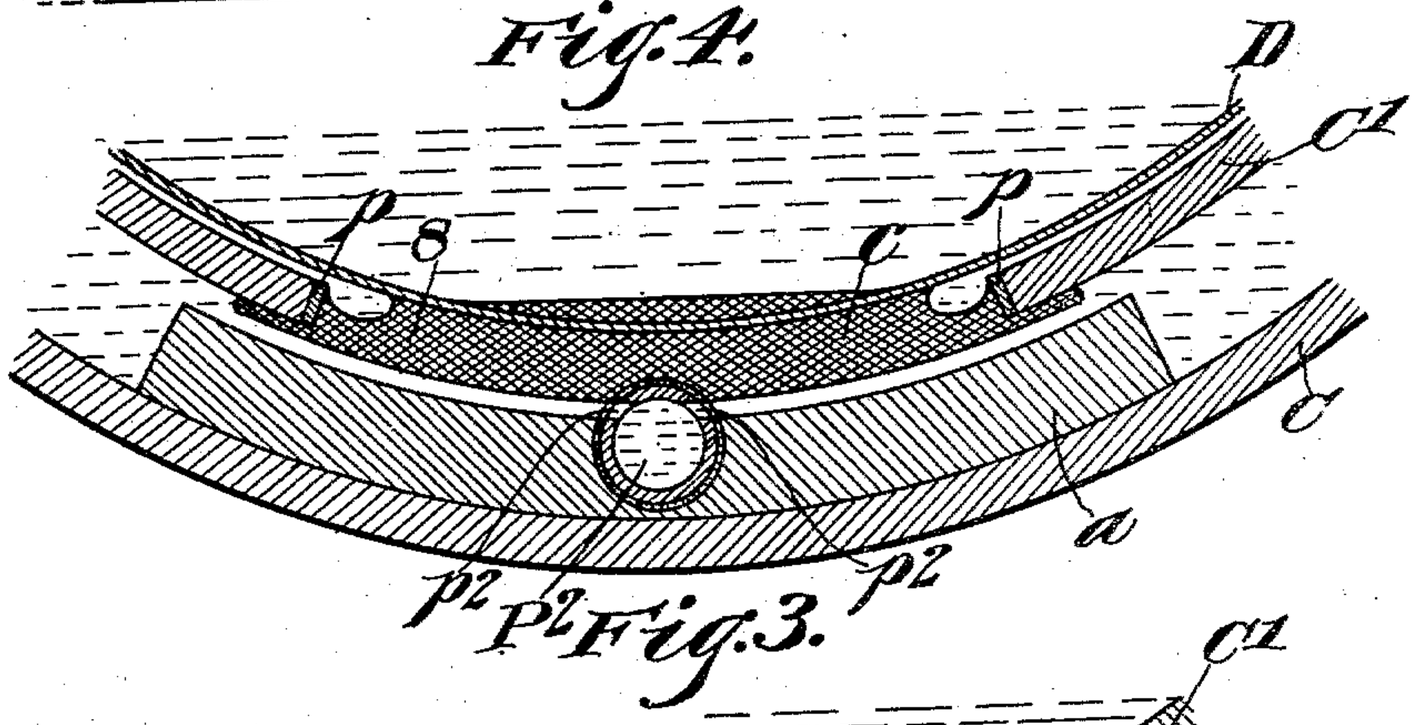
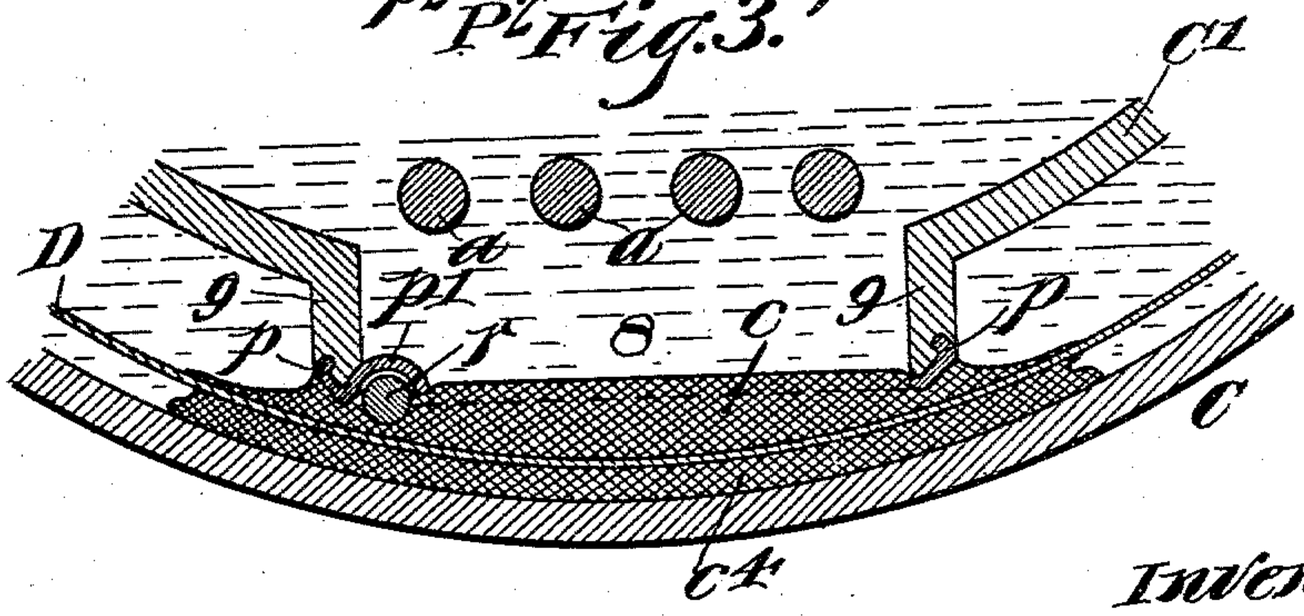


Fig. 3.



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UNITED STATES PATENT OFFICE.

ALF SINDING-LARSEN, OF CHRISTIANIA, NORWAY.

ELECTROLYTIC APPARATUS.

SPECIFICATION forming part of Letters Patent No. 546,353, dated September 17, 1895.

Application filed July 9, 1894. Serial No. 516,965. (No model.)

To all whom it may concern:

Be it known that I, ALF SINDING-LARSEN, a subject of the King of Sweden and Norway, residing in the city of Christiania, in the Kingdom of Norway, have invented certain new and useful Improvements in Electrolytic Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

My invention has relation to the art of electrolysis, and more particularly to the electrolytic treatment or decomposition of the salts of metals of the alkalies wherein mercury is employed as one of the electrodes, and as a carrier or vehicle for one of the ions, whereby the latter may readily be brought into contact with a suitable solvent.

One of the difficulties encountered in apparatus as heretofore constructed for the electrolytical decomposition of the salts referred to—as, for instance, sodium chlorid—lies in the requirement of large quantities of mercury as compared with the results or quantity of the final product obtained—*i. e.*, as compared with the capacity of the apparatus. This is due to the fact that the surfaces of contact of the amalgamated mercury and the solvent must be very extensive as compared with the surface of mercury acted upon by the electric current.

This invention is chiefly designed to overcome the difficulty or disadvantage referred to, and has for its object the provision of means whereby the amalgam resulting from the electrolytical action upon the salt solution is spread out or converted into a thin sheet, or more properly a film, in which condition it is exposed to the action of the solvent, so that but a comparatively small body of mercury substantially proportionate to the electric action can be used, and whereby the quantity of mercury exposed to said electric action may be very great—in fact, much greater than the quantity of amalgam exposed to the action of the solvent.

To these ends my invention consists in an improved method of electrolytically decomposing the salts of the metals of the alkalies, and in apparatus therefor, as will now be fully described, reference being had to the accompanying drawings, in which—

Figure 1 is a vertical axial section of one form of apparatus suitable for carrying out my improved method. Fig. 2 is a half front elevation and half section thereof. Figs. 3 and 4 are detail views, the latter showing a modification in the arrangement of certain elements of the apparatus; and Fig. 5 is a vertical axial section of a modified construction of apparatus.

Referring to Figs. 1 to 4, the apparatus is composed of two cells C and C′, separated from each other by a mercury cathode *c*. The cell C may be constructed of any suitable material—as iron, for instance. It is cylindrical in cross-section and provided with an axial bearing c', with a supporting-base c^2, and with a circular bolt-flange c^3. The cell C′ is constructed of a non-conducting and non-porous material, as porcelain, and its general form is also cylindrical. It is provided with a circular bolt-flange c^4 for connection with the like flange c^3 of cell C, with bearings or openings in its front wall for the insertion of the carbon anode *a*, which I prefer to construct in the form of rods, as shown, for the purpose of increasing the surface thereof exposed to the salt solution. Said cell C′ is further provided in its front wall above the anodes with a pocket 2, adapted to hold a quantity of the salt to be decomposed, as sodium chlorid, with a charging-duct 3, through which the salt and salt solution are introduced, said duct being normally closed by a suitable cap or cover 4, and with a dome 5 at its upper portion for the collection of gas generated during the electrolytical decomposition, said dome having a suitable outlet 6 for such gases connected with a suitable valved exhaust-pipe. (Not shown.)

From an inspection of Fig. 1 it will be observed that the front wall of cell C′, in which is formed the pocket 2, is curved outwardly, and the charging-duct 3 lies at an angle to said wall, so as to direct the salt introduced into the said pocket. It will further be observed that the said cell C′ is of such horizontal diameter that the rear wall 7 thereof will lie close to the outer vertical wall of cell C′, while the vertical diameter of the latter cell

within cell C is considerably less than the like diameter of said cell C, whereby a chamber is formed between the two cells for the reception of the solvent—as water, for instance. A portion of the bottom of cell C is made concave, thereby forming a pocket or well c^5 for the reception of the mercury cathode, and in bearing c' of said cell is mounted a short shaft S, that carries a driving-pulley P at its outer end, and at its inner end within the cell C a sheet-metal cylinder or drum D, that projects over and encompasses that portion of cell C′ within cell C.

The major diameter of the drum D is such as to dip into the pocket c^5 containing the mercury cathode. It is constructed of sheet metal, preferably tinned sheet-iron, and both its inner and outer surfaces are coated or covered with an amalgam, as tin and mercury. The porcelain cell C′ has an opening 8 in its lower portion immediately above the pocket c^4, said opening having a downwardly-projecting encompassing-flange 9, Figs. 1, 2, and 3, that dips into the cathode *c* for the purpose of separating the two cells from each other and preventing the admixture of the salt solution with the solvent or cathion solution without interfering with the direct contact of said salt solution with the cathode and the amalgamation of the cathion with the latter.

As more clearly shown in Fig. 3, the lower edge of the flange 9, encompassing the opening 8, is shod with a metal plate *p*, the surface of which is coated with an amalgam, to which the mercury adheres, thereby providing a more perfect seal or luting around the said flange for the purpose of more effectually preventing the admixture of the contents of the two cells. I also provide a metal roller *r*, coated with an amalgam and arranged to revolve in cup c^5 in such manner as to be partly immersed in the mercury, the exposed portion of the roller *r* being protected by a shield or guard-plate *p′*, extending over such roller and dipping into the cathode *c*. The function of this roller is that of a feeding device. Its surface being amalgamated, the lighter amalgam on the surface of the cathode will collect thereon and be carried down in proximity to the drum A, to be taken up thereby and carried into contact with the solvent in cell C.

In practice I prefer to provide means for automatically discharging the cathion solution whenever its specific gravity or density has reached a given degree, and to this end I connect a vertical pipe P′, Fig. 2, with the cell C, as near as possible to the cup c^5, in which I suspend a suitably-weighted float F, adapted to close an electric circuit and open a discharge valve or cock either in said pipe near its lower end or in the wall of cell C through the medium of the armature of an electromagnet in said circuit. To this end the float is suspended from one arm of a two-armed lever L, the other arm of which has a balance-weight and a downwardly-bent contact *l*, adapted to make contact with mercury in a cup C^2, which latter and the post or standard *s*, on which the lever has its fulcrum, are included in an electric circuit, in which is also included an electromagnet M, that, when energized, will attract its armature and thereby open a discharge cock or valve 12 in a well-known manner. The vibrations of the lever L are limited by suitable screws *s′ s′*, extending through and working in the arms of a cross-head on said standard *s*, as shown.

To facilitate the taking up of the cathion amalgam the periphery of the drum D may be slitted, and the edge along one side of the slit bent inwardly, as shown at *d*, Fig. 2, the opposite edge of the next succeeding slit being bent outwardly, as shown at *d′* in said Fig. 2, whereby said amalgam is more readily taken up and evenly distributed over the drum-surfaces.

The use of the cells C and C′, as described in reference to Figs. 1 to 3, may be reversed. The cell C′ may contain the solvent and the cell C the salt solution, the carbon anode *a* being arranged between the two cells below the opening 8 in said cell C′. A pipe P^2, slotted longitudinally, is interposed between the anode *a* and the aforesaid opening 8, and preferably partly embedded in the said anode, said pipe being of a conductive material, and above the same is the mercury cathode *c*, luting or closing the opening 8, as shown in Fig. 4. The downwardly-projecting flange 9 around the opening 8 is here unnecessary, though the inner face of said opening is shod with a metal plate *p*, covered with an amalgam for purposes hereinbefore explained. To prevent contact between the anode and cathode the slots *p′* in conductor-pipe P are made very narrow, and the salt solution is supplied to the pipe under a sufficient pressure to prevent such contact, whereby said salt solution is exposed to the action of the electric current between the electrodes in a comparatively thin film.

In order to more effectually prevent contact between the electrodes, and also to prevent the mercury from flowing into pipe P^2, the latter may be covered with a thin cloth, or the cloth may be drawn through the diametrically opposite slots or slits p^2 in said pipe. By means of this arrangement the decomposition of the salt solution proceeds very rapidly. Of course it will be understood that in the construction shown in Fig. 4 both the dome 5 and pocket 2 of cell C′ are dispensed with, and the cell C is provided with a suitable gas-escape, while the drum D is caused to revolve in said cell C′ in such manner as to dip in the mercury cathode *c*, as shown.

The operation of the apparatus is as follows: Cell C′ being supplied with a solution of sodium chlorid, cell C with water, and pocket c^5 with mercury, (of which but a comparatively small quantity will be required,) the current is turned on and the shaft S is revolved. As the decomposition of the salt solution and the amalgamation of the cathion

with the murcury proceeds, the sodium amalgam will be taken up by the amalgamated surfaces of the roller *r* and carried to the drum D, a portion of such amalgam being taken up by the drum itself, and as said drum revolves will spread over the surface thereof in a thin film, and as the drum revolves in the solvent the cathion is rapidly dissolved out of the mercury, which latter flows back to the pocket c^5.

It will readily be understood that the capacity of an apparatus of the construction described is greatly increased relatively to the quantity of mercury required, so that caustic soda, for instance, can be obtained on a commercial scale at a comparatively low cost.

The hydrogen evolved in cell C′ rises through the salt solution and collects in the dome 5, and may be drawn off and used for any desired purpose.

In Fig. 5 I have shown a further modification in the construction of the apparatus, which consists of a cylindrical vessel V, provided with a conical button *v*, so as to form a pocket for the cathode *c*, said vessel having a central bearing *v′* in its said bottom for one end of a vertical spindle S^2, to which is secured a carrier or drum D′, whose web d^2 is dished in the form of an inverted cone, or substantially so, the periphery of the drum forming a downwardly projecting or overhanging flange d^3. The conical web d^2 of drum D′ has an opening about its smaller end, and is constructed of sheet metal coated with an amalgam, its lower open end dipping into the cathode *c*. An open-ended cylinder B, arranged concentrically with the spindle S^2, is suspended from the cover V′ of vessel V, the upper open end of said cylinder B being closed by a cover B′, provided with a bearing for the upper portion of spindle S^2 and with a feed-pipe *b′* for supplying the salt solution to the cylinder B, which serves the purpose of cell C′, the outer vessel serving the purpose of cell C, described in reference to Figs. 1 to 3. The cover B′ is further provided with a gas-escape pipe. (Not shown.) The lower end of cylinder B dips into the cathode *c*, and in suitable proximity to said cathode are arranged the carbon anodes *a*, also constructed in the form of rods secured in suitable openings or bearings in said cylinder. When the spindle S^2 is revolved, the amalgam formed by the electrical action upon the salt solution in contact with the cathode is carried by centrifugal action up along the web d^2 of the drum D′ into contact with the solvent in vessel V. The mercury freed from sodium flowing along said web is arrested by the periphery d^3 of said drum and flows back to the bottom of vessel V. In this construction the amalgam is also exposed to the action of the solvent in the condition of a thin film, so that the separation of the cathion from the cathode takes place very rapidly.

To the cover V′ of vessel V is connected a feed-pipe v^3, and suitable means, as a pipe v^4, is provided for drawing off the cathion solution from time to time.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. An electrolytic apparatus, comprising a decomposing cell, a suitable anode therein, a solution cell, a passage leading from one cell into the other, a mercury cathode adapted to form a seal for said passage, and a revoluble cylindrical amalgam coated conveyer within the solution cell adapted to take up the electrolytically formed amalgam and convey the same from the decomposing cell into the solution cell without breaking the aforesaid seal, for the purpose set forth.

2. An electrolytic apparatus, comprising a decomposing cell, a suitable anode therein, a solution cell, a passage leading from one cell into the other, a mercury cathode adapted to form a seal for said passage, and a drum revoluble in the solution cell, said drum open at one end and having its exterior and interior surfaces coated with an amalgam, said drum adapted to take up the electrolytically formed amalgam and convey the same in the form of a thin sheet or film from the decomposing cell into the solution cell without breaking the aforesaid seal, for the puspose set forth.

3. An electrolytic apparatus comprising a decomposing cell, a suitable anode therein, a solution cell, a passage leading from one cell into the other, a mercury cathode adapted to form a seal for said passage, and an amalgam coated conveyer arranged within the solution cell and adapted to take up the electrolytically formed amalgam and convey the same from the decomposing cell into the solution cell without breaking the aforesaid seal, and means for conveying the said electrolytically formed amalgam to the amalgam coated conveyer, for the purpose set forth.

4. The combination with the cell C, the shaft S, and the drum D on said shaft, of the cell C′ fitting into said drum and opening into cell C at the lowest point thereof, a mercury cathode at said point luting or sealing the said opening, and the anodes *a* arranged in cell C′ above the opening, for the purpose set forth.

5. The combination with the cell C, the shaft S and the drum D on said shaft, of the cell C′ fitting into said drum and opening into cell C at the lowest point thereof, a mercury cathode at said point luting or sealing said opening, said cell C′ provided with a dome, as 5, a pocket, as 2, and a feed duct, as 3, adapted to discharge into said pocket, and the anodes *a* arranged in cell C′ above the aforesaid opening, for the purpose set forth.

6. The combination with the cell C and the drum D revoluble therein, of the cell C′ fitting into said drum and having an opening at its lowest point provided with a downwardly projecting encompassing flange, a metal lining for said flange coated with an

amalgam, a mercury cathode contained in cell C and luting or sealing said opening, a revoluble metal roller, as *r*, partly immersed in the cathode above the drum D, said metal roller also coated with an amalgam, a metal amalgam-coated shield covering the roller and dipping into the cathode, and an anode arranged in cell C′ in proximity to the cathode, for the purpose set forth.

7. The combination with the cell C, a mercury cathode therein, and the drum D revoluble in said cell and dipping into the cathode, said drum having peripheral slots, one of the edges of alternate slots being turned inwardly and outwardly respectively; of the cell C′, the anode therein, said cell C′ projecting into the drum D and having an opening in its bottom luted by the cathode in cell C′, substantially as and for the purpose set forth.

8. The combination with the cathode cell of an electrolytic apparatus, its valved discharge pipe, and a stand pipe in communication with said cell near the bottom thereof, a two-armed lever, a float in said pipe suspended from one of the arms of said lever the other arm thereof being weighted to balance the float and provided with a conductive contact, of a second contact within range of the lever contact, an electric circuit including said contacts and an electro-magnet, and a connection between the valve of the aforesaid discharge pipe and the armature of the electro-magnet, for the purpose set forth.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

ALF SINDING-LARSEN.

Witnesses:

OSCAR WINGE,

O. SIG V. SORINSEN.