No. 659,655. Patented Oct. 16, 1900.

E. EDSER.

APPARATUS FOR ELECTROLYTIC DECOMPOSITION OF ALKALINE SALTS.

(Application filed Mar. 31, 1899.)

(No Model.) 6 Sheets—Sheet 1.

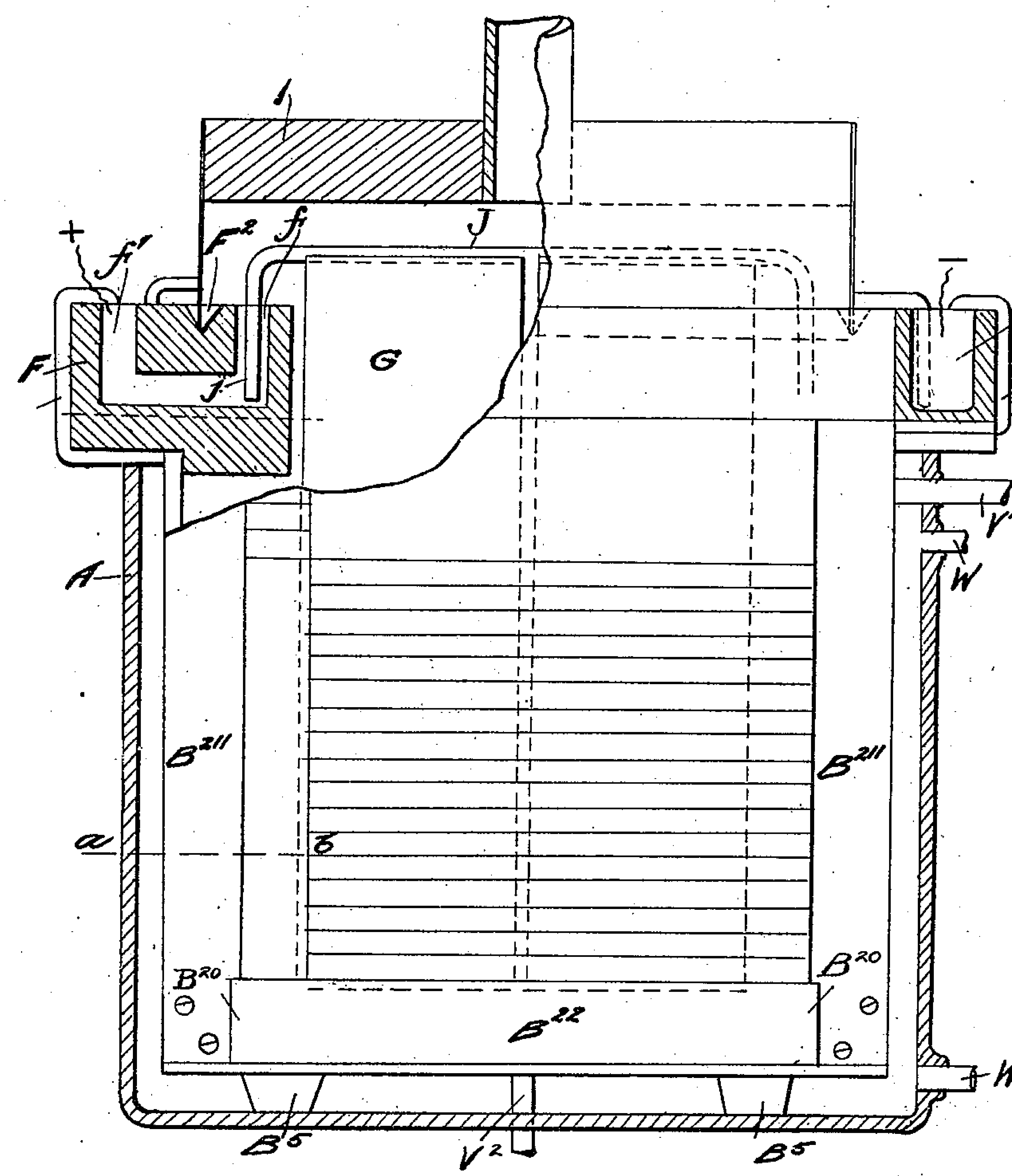

FIG. 1.

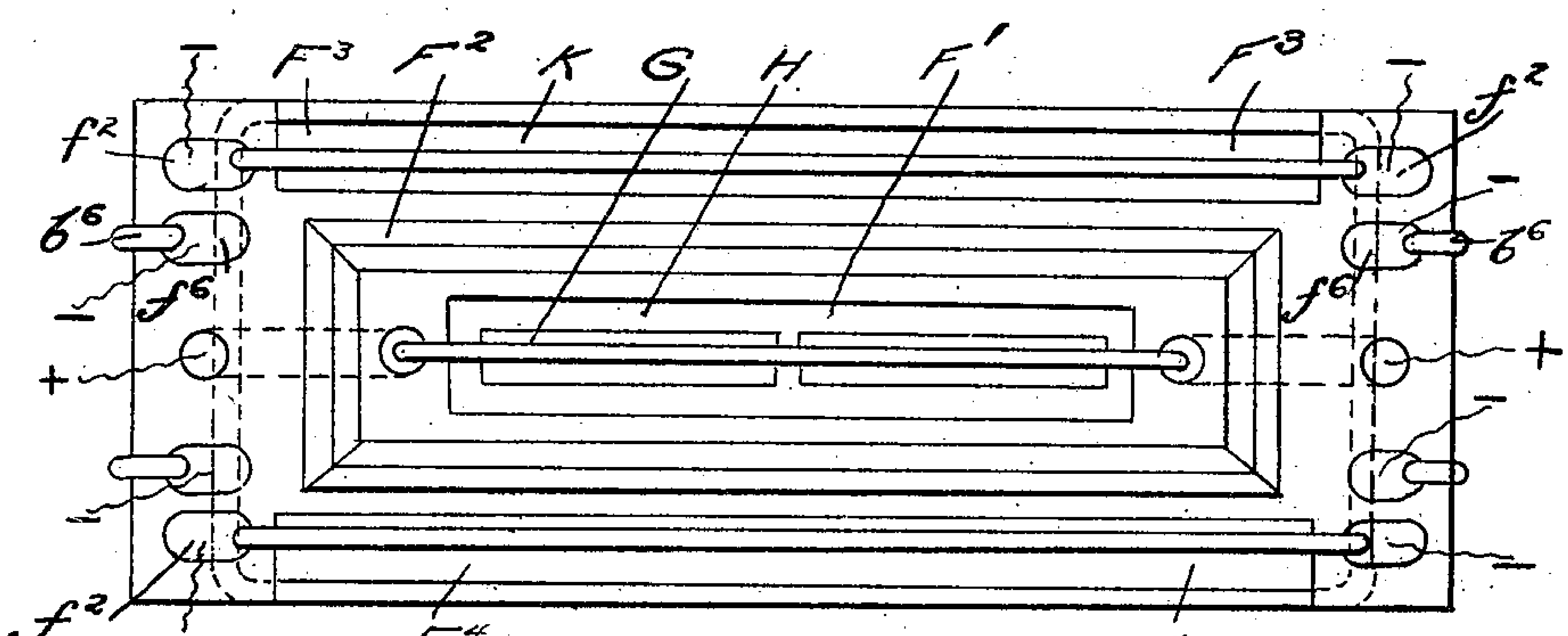

FIG. 2.

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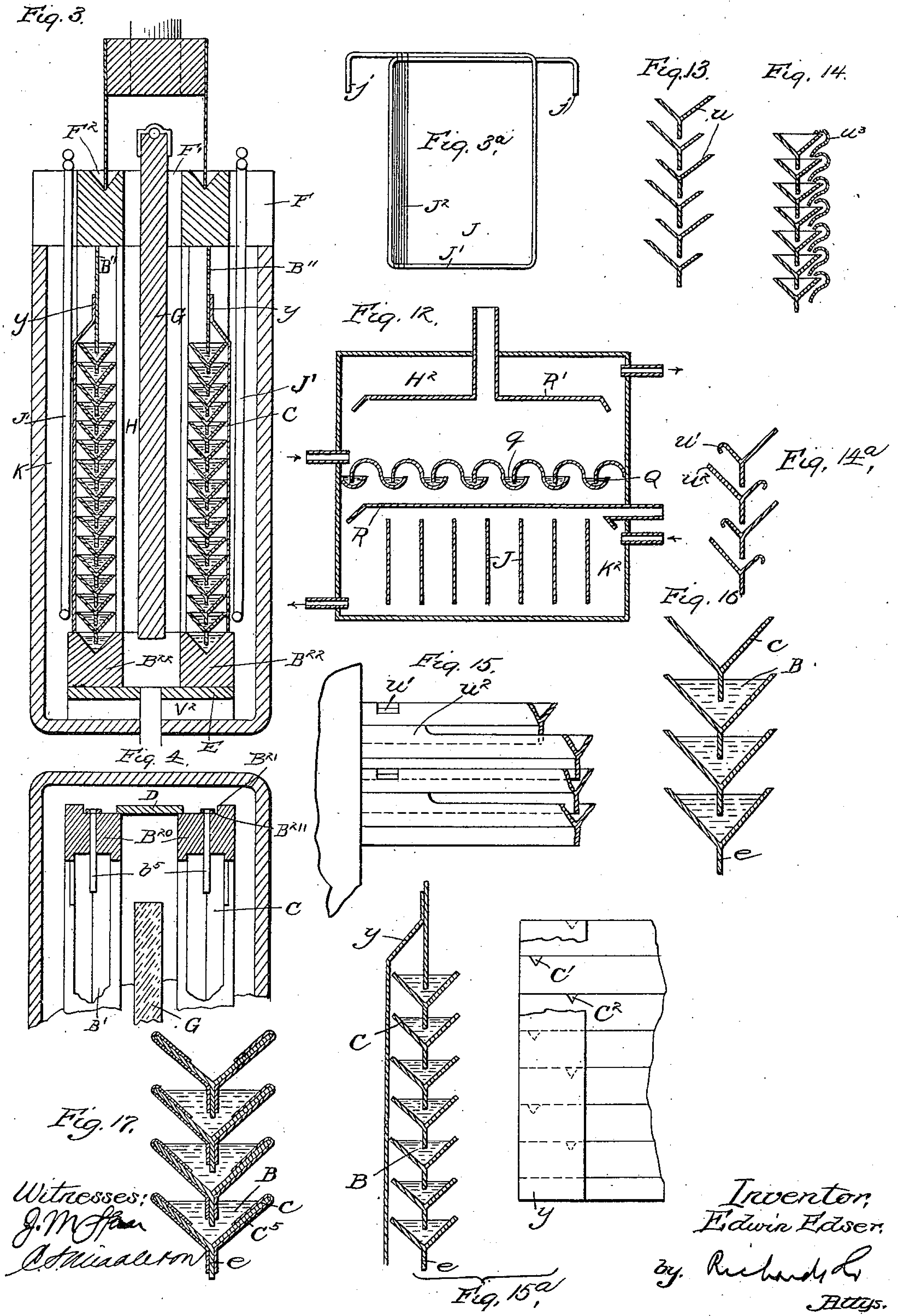
(No Model.) 6 Sheets—Sheet 2.



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No. 659,655. Patented Oct. 16, 1900.

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(Application filed Mar. 31, 1899.)

(No Model.) 6 Sheets—Sheet 3.

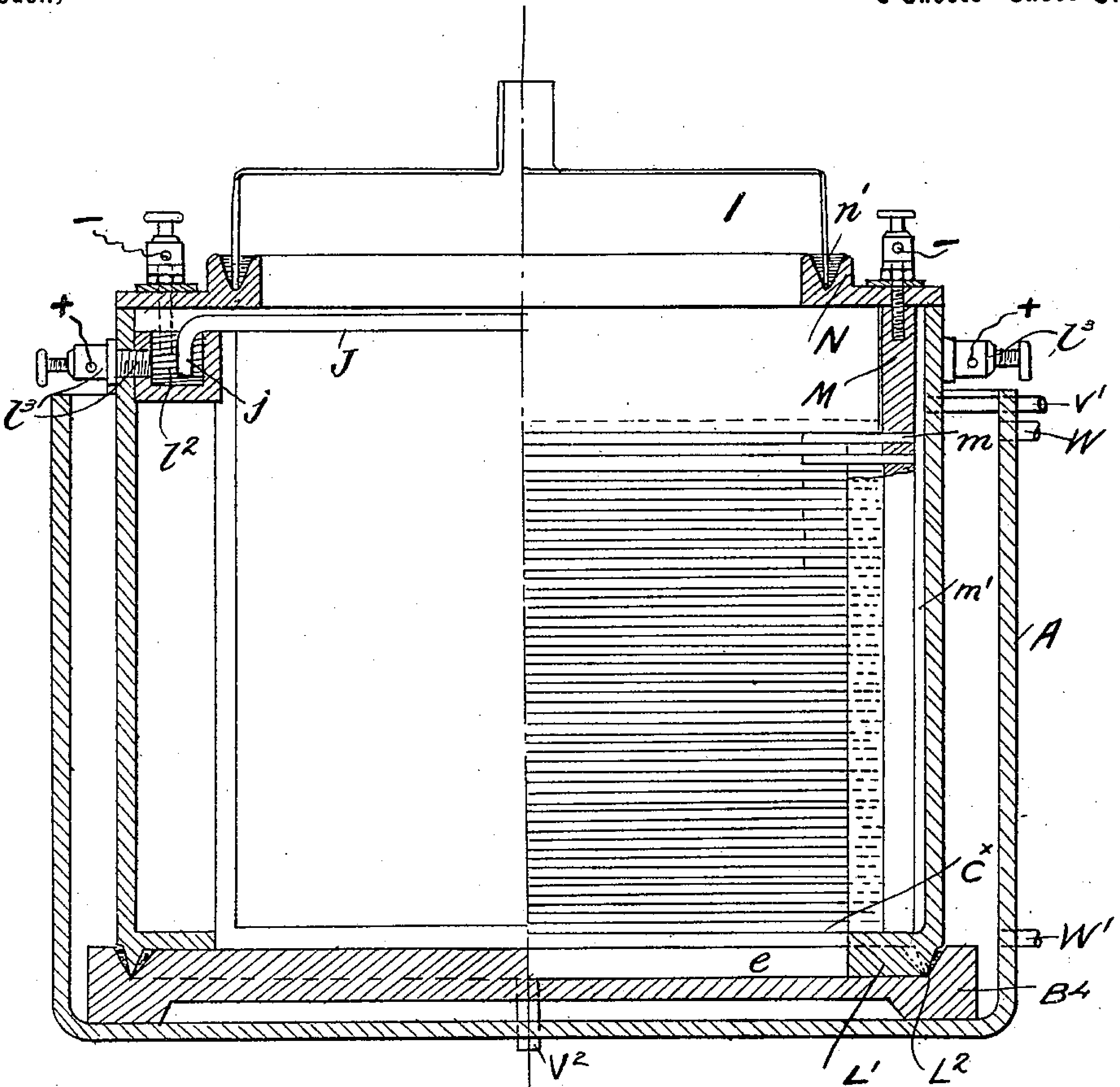

FIG. 5.

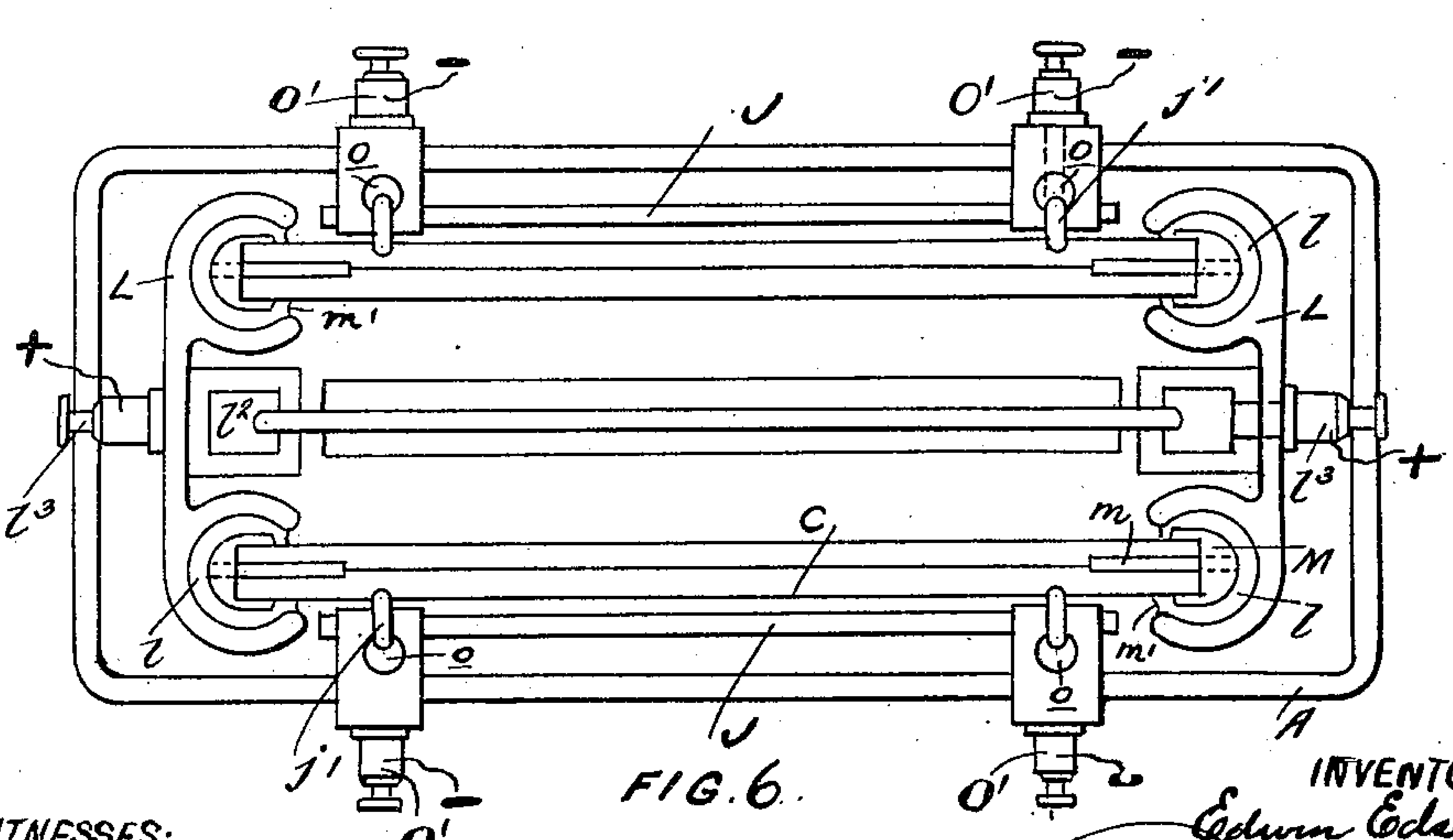

FIG. 6.

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APPARATUS FOR ELECTROLYTIC DECOMPOSITION OF ALKALINE SALTS.

(Application filed Mar. 31, 1899.)

(No Model.) 6 Sheets—Sheet 4.

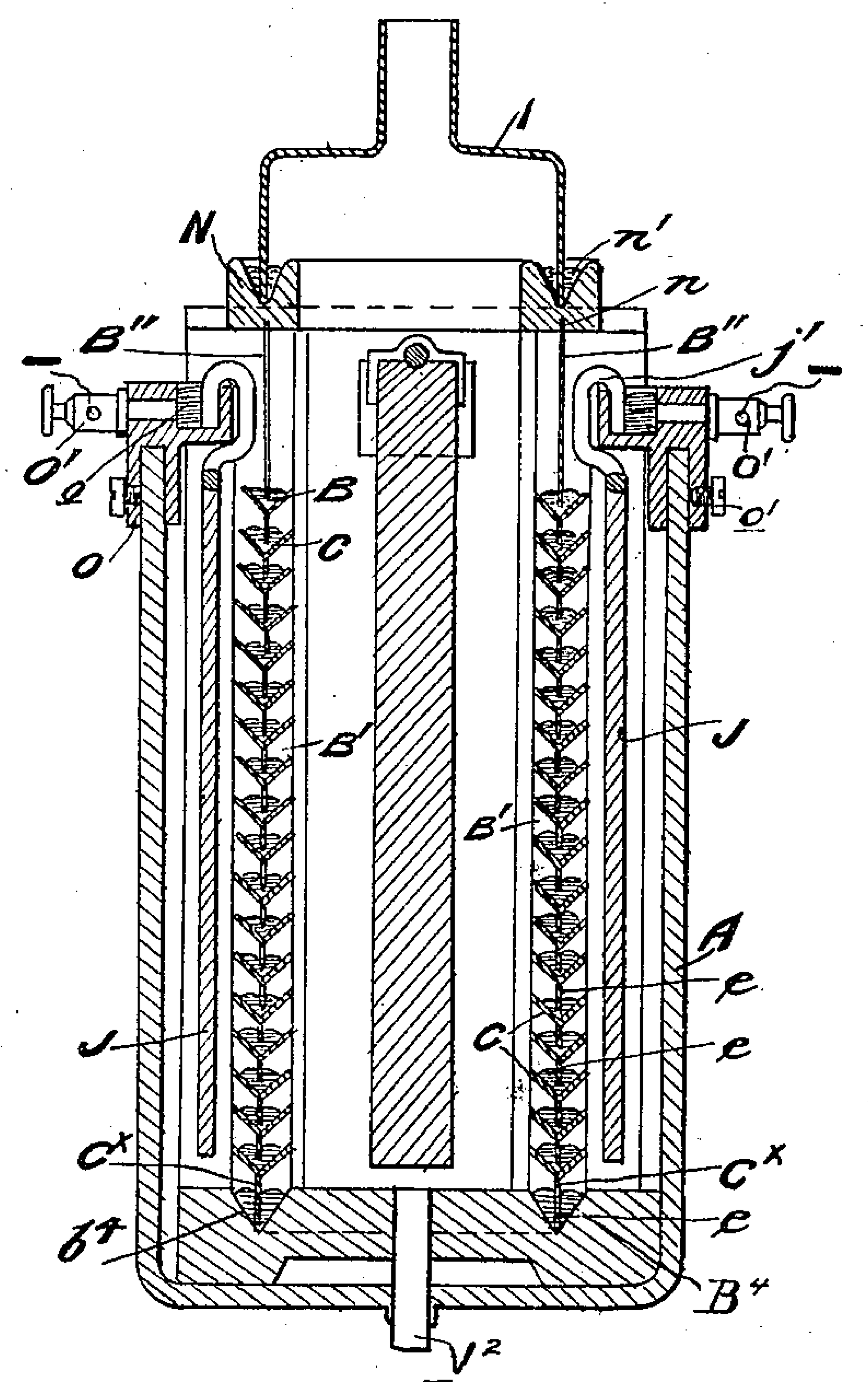

FIG. 7.

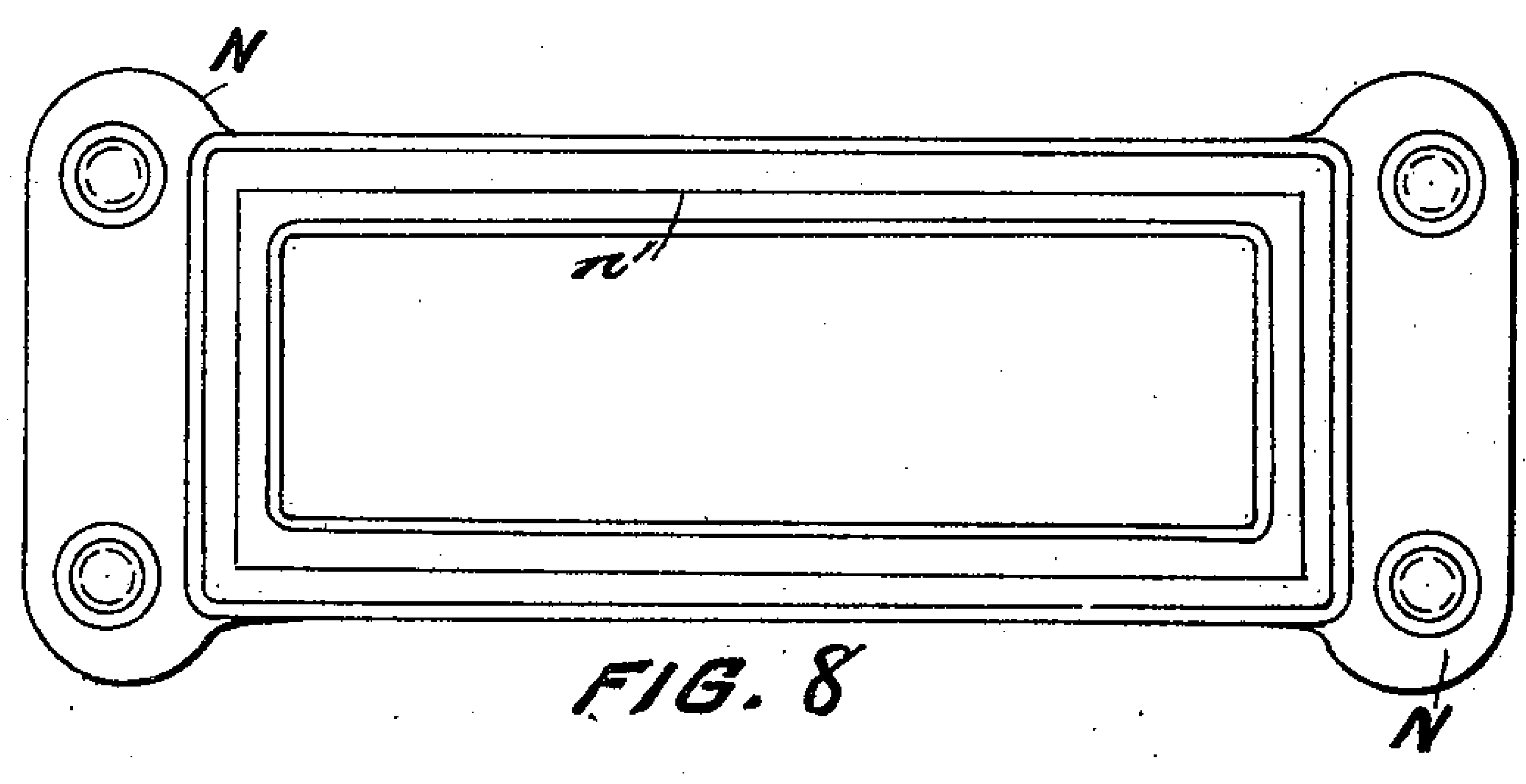

FIG. 8

WITNESSES:

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APPARATUS FOR ELECTROLYTIC DECOMPOSITION OF ALKALINE SALTS.

(Application filed Mar. 31, 1899.)

(No Model.) 6 Sheets—Sheet 5.

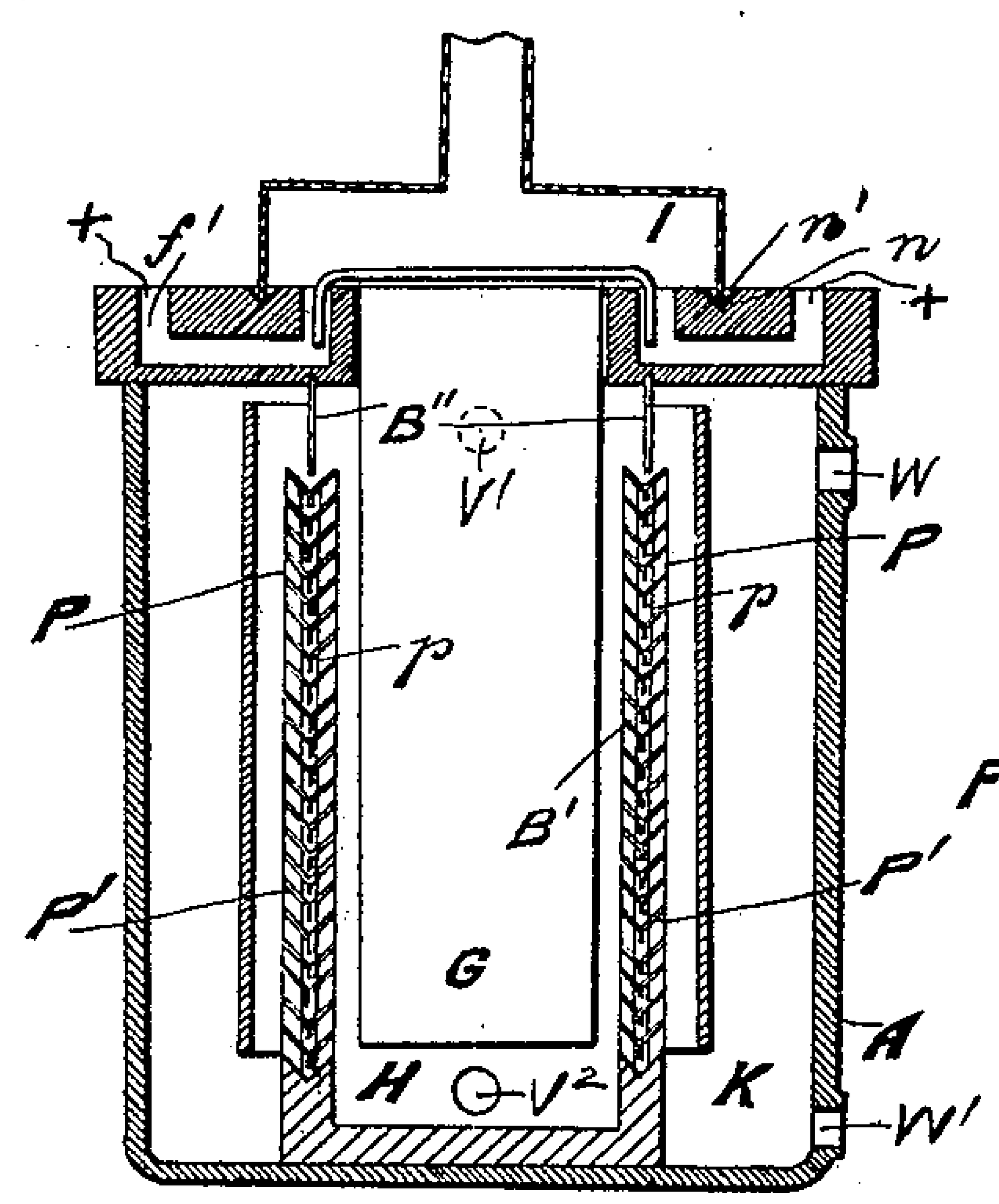

FIG. 9.

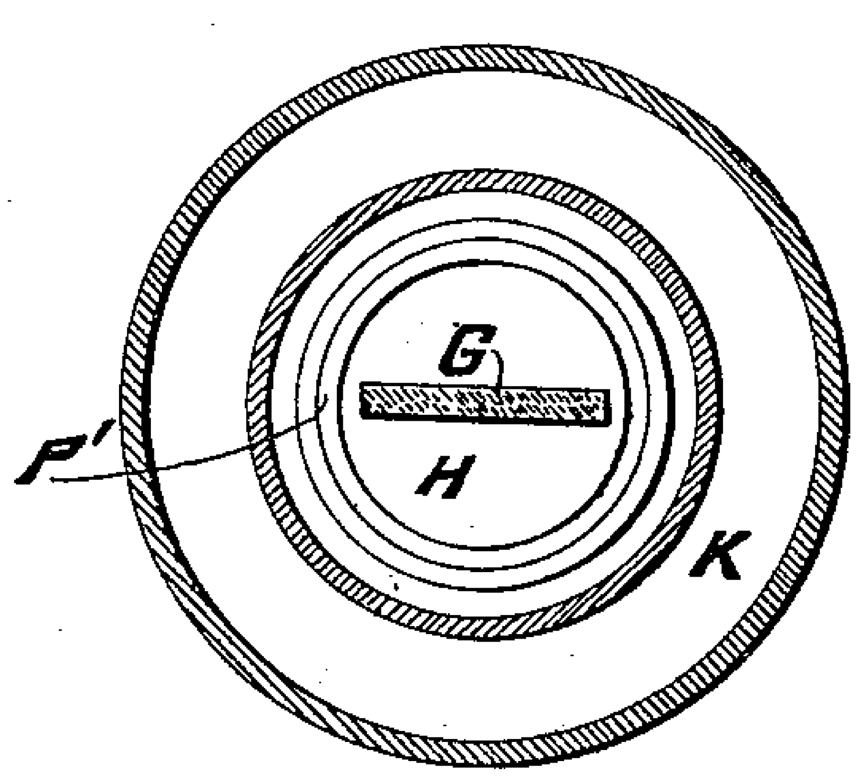

FIG. 10.

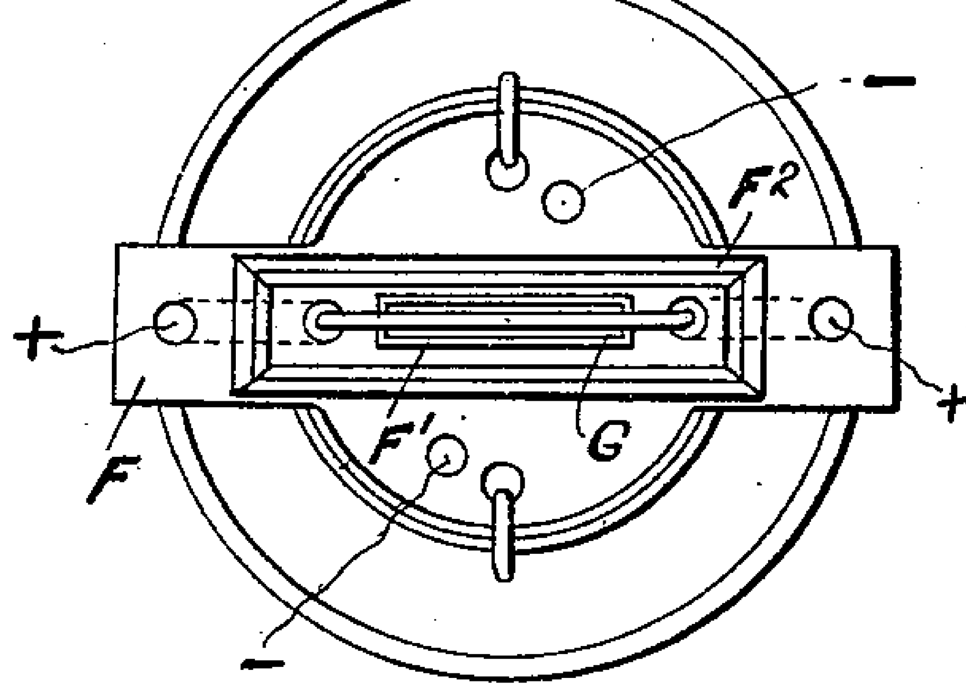

FIG. 11.

WITNESSES:
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No. 659,655. Patented Oct. 16, 1900.

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APPARATUS FOR ELECTROLYTIC DECOMPOSITION OF ALKALINE SALTS.

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(No Model.) 6 Sheets—Sheet 6.

Fig. 18.

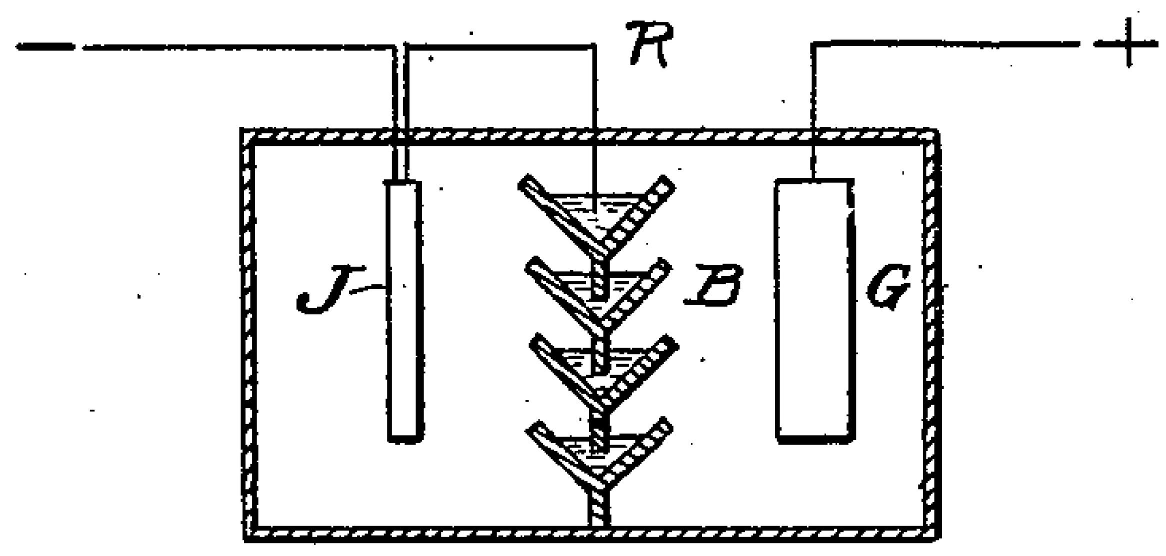


Fig. 19.

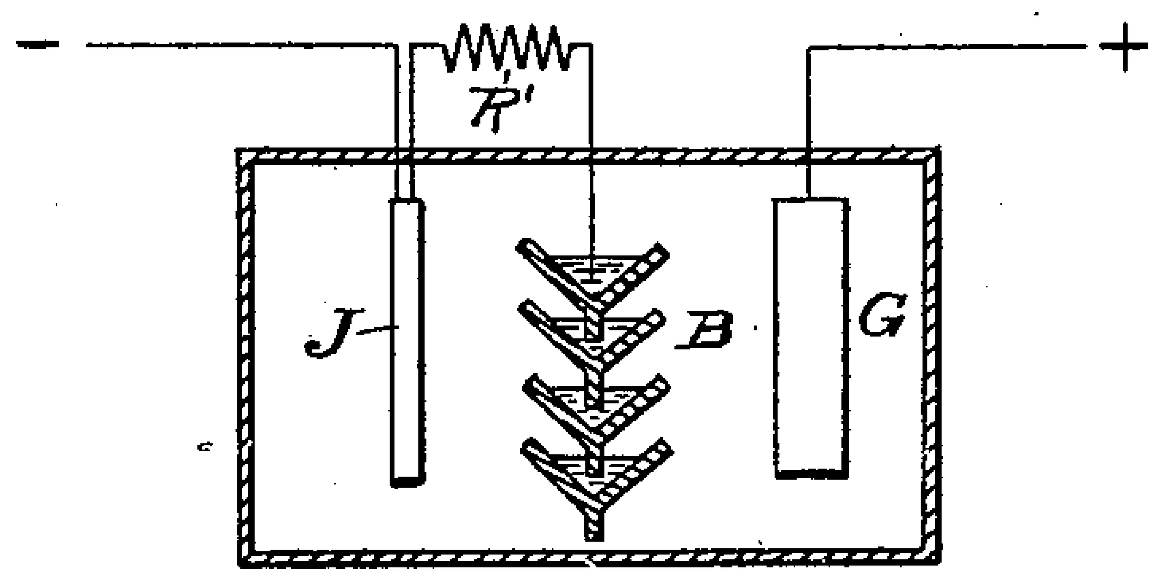


Fig. 16a.

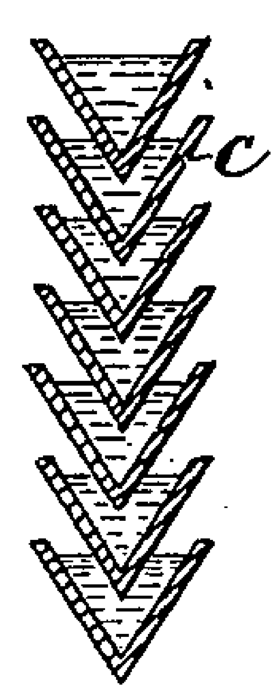
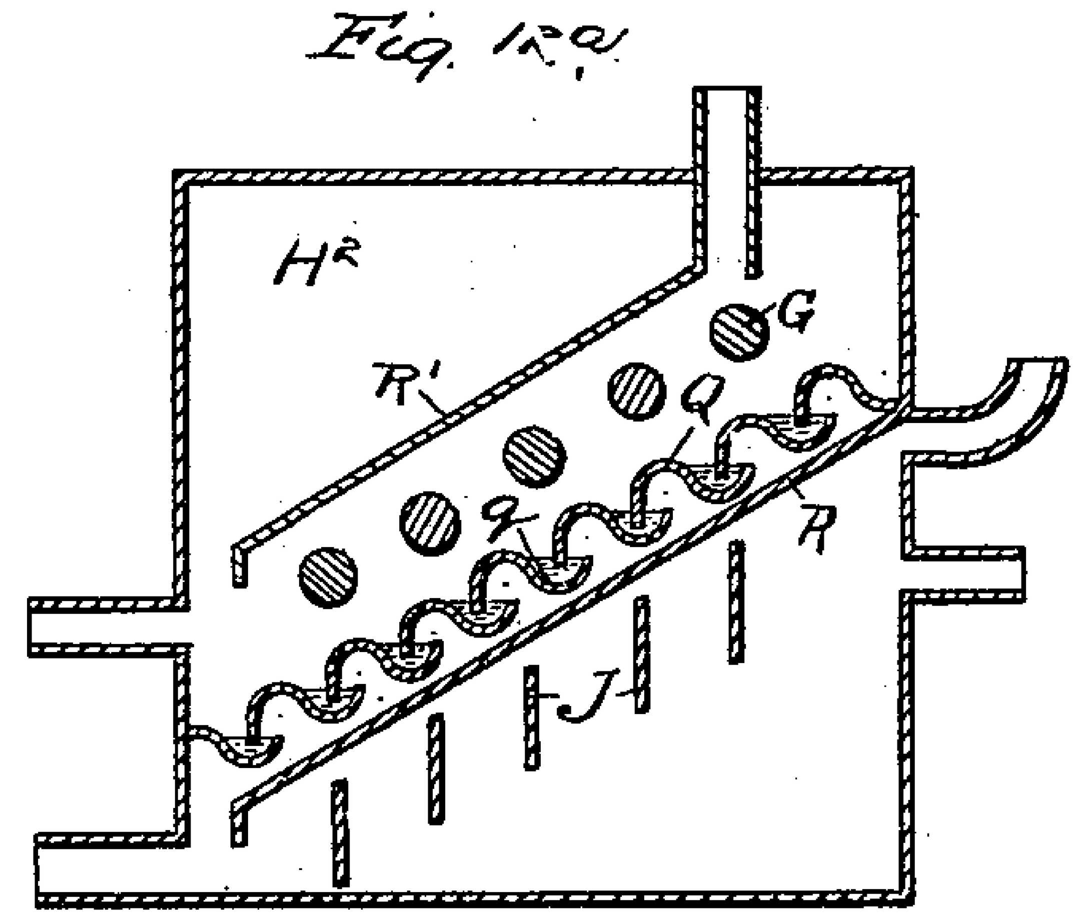


Fig. 12a.



Witnesses;
J. McGuire
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Inventor,
Edwin Edser
By- Richards & Co
Attys.

UNITED STATES PATENT OFFICE.

EDWIN EDSER, OF LONDON, ENGLAND.

APPARATUS FOR THE ELECTROLYTIC DECOMPOSITION OF ALKALINE SALTS.

SPECIFICATION forming part of Letters Patent No. 659,655, dated October 16, 1900.

Application filed March 31, 1899. Serial No. 711,242. (No model.)

To all whom it may concern:

Be it known that I, EDWIN EDSER, gentleman, a subject of the Queen of Great Britain and Ireland, and a resident of 34 Mexfield road, Putney, London, S. W., England, have invented certain new and useful Improvements Relating to Apparatus for the Electrolytic Decomposition of Alkaline Salts, (for which I have made application for Letters Patent in Great Britain, No. 18,958, bearing date September 5, 1898,) of which the following is a specification.

This invention relates to apparatus designed for the electrolytic decomposition of alkaline salts, and more especially for the production of alkaline hydrates, in which process an amalgam of the alkaline metal is formed as an intermediate product.

The invention has for its object to provide an electrolytic cell that shall be simple in construction, efficient in operation, and in which there shall be a minimum of electric resistance, a minimum amount of mercury employed, and perfect purity of the resulting products.

The invention consists in the provision within an electrolytic cell of a partition composed of a series of troughs, so shaped and disposed as to contain a quantity of mercury, which seals the interstices between the troughs, and so effectually prevents the mixture of the respective liquids contained in the compartments separated by such partition, while permitting by means of the mercury thorough electric communication between the compartments. In action an amalgam is formed upon one side of the partition by the deposit of the alkaline metal upon the mercury, while upon the other caustic alkali is produced by the action of the diffused sodium upon the water.

The invention further consists in detail features of construction and arrangement, which are hereinafter described.

The invention is illustrated in the accompanying drawings, in which—

Figure 1 is a sectional elevation of an electrolytic cell made according to the invention. Fig. 2 is a plan corresponding thereto, but with the gas-collecting hood removed. Fig. 3 is a sectional end elevation corresponding to Fig. 1, and Fig. 4 is a part sectional plan on the line *a b*, Fig. 1. Fig. 3[a] is a detail view of the preferred form of cathode-plate. Figs. 5, 6, and 7 are respectively a part sectional elevation, a plan, and a sectional elevation of a modification in construction. Fig. 8 is a detail plan of the lid or cover to the inner compartment of the cell illustrated in Figs. 5, 6, and 7. Figs. 9, 10, and 11 are respectively a sectional elevation, a sectional plan, and a plan of a further constructional modification. Figs. 12 and 12[a] are constructional modifications, wherein horizontal and inclined partitions instead of vertical partitions, respectively, are employed, consisting of series of troughs containing mercury, having its surface exposed to the upper and lower compartments formed by such partitions. Figs. 13, 14, 14[a], 15, and 15[a] illustrate means that may be employed for filling a vertical series of troughs, Figs. 13 and 14 being diagrammatic views. Figs. 16, 16[a], and 17 are sectional detail views of the troughs employed according to the invention to form a separating-partition. Figs. 18 and 19 are diagrammatic elevations illustrating the electric connections in the working of the cell.

In carrying the invention into effect as illustrated in Figs. 1 to 4 of the accompanying drawings a vessel A, of suitable non-conducting material, preferably glass or earthenware, is provided which is divided into two compartments by means of two partitions B′ B′, consisting of vertical series of longitudinally-extending troughs C, of **V** or similar section, made of any convenient electrically non-conducting substance or of any other suitable material, preferably glass. These troughs C are held within frames B^{20}, consisting of lateral vertical members B^{21} and lower longitudinal members B^{22}, and the extremities of the troughs are retained within the frames. The frames B^{20} are connected together by means of the lateral walls D on each side and a bottom plate E, by means of which the space between the partitions B′ B′ is completely inclosed to form a central compartment. Plates B″ effect the inclosure of the central compartment at its upper part. The troughs C are so shaped and disposed one above the other that when nearly filled with mercury the spaces between the troughs shall be filled and sealed, and the partitions B B' will thereby effectually separate the compartments which they divide, so that no mixture of the liquids contained in the respective compartments can take place. The frames B^{20} are integrally formed with a cross-frame F, which is carried upon base-supports B^5. The cross-frame F has a central aperture F', through which the carbon rods or plates G are introduced into the central inner compartment H. The carbon plates G are suspended upon a rod whose extremities are downwardly diverted into troughs *f*, formed in the cross-frame F and filled with mercury. The wire-terminals are placed in the exterior openings *f'* of the troughs *f*, and by means of the mercury the current is led into the cell. A channel F^2 is formed in the cross-frame F around the aperture F', into which mercury is poured to form a gas-tight seal for a gas-collecting hood I, by means of which the gas forming in the inner compartment is led away. The mercury-surfaces are protected from the action of the chlorin by a layer of vaseline or other suitable oil. The cathodes J of the exterior compartment are preferably formed of metallic frames J', upon which iron wire j^2 is stretched, as indicated in Fig. 4^a. The frames J' are suspended from the cross-frame F, which is recessed at F^3 and F^4 for the purpose, and the extremities *j* of the frames J' are downwardly diverted into small troughs f^2, provided in the cross-frame. These troughs f^2 are filled with mercury and serve to receive the wire-terminals, by means of which the current is led away. The recesses F^3 F^4 permit of the free egress from the cell of the gas generated in the exterior compartment K. A copper or other metallic strip B^{211} is fitted within recesses provided in the lateral members B^{21} of the frames B^2, and copper or other metallic pins b^5 are driven or inserted transversely, so as to connect such strip with the frame and serve for supporting the trough C and for the electric connection of the strip with the mercury contained in the several troughs C of the series. The strips B^{211} are provided with an upper hooked extremity b^6, passing within troughs f^6, formed in the cross-frame F and filled with mercury. By such means the current may be led out through the mercury, as hereinafter described.

As illustrated in Fig. 17, the trough C instead of being made of insulating material, as in Fig. 16, may preferably be of metal, covered by means of mica c^5 or other such insulating material upon the surfaces in contact with the liquids in the respective compartments, while the ribs or flanges *e* are preferably amalgamated, so that thereby a better contact will be effected with the mercury in the troughs, and thereby leakage of liquid from one compartment to the other may be prevented.

The inner compartment H is nearly filled with a solution of alkaline salt—say, chlorid of sodium (NaCl)—that is to be electrolized, while the outer compartment K is nearly filled with a strong solution of caustic alkali, (NaOH.) On the connection of the cell with a dynamo or other source of electric current the sodium-chlorid solution is electrolized in the inner compartment H, and sodium as a cation is deposited upon the mercury in the several troughs C, and chlorin as an anion is set free, passing upward into the hood I and away to be utilized in production of bleaching-powder or for other purpose, while the sodium amalgam thus formed with the mercury diffuses through to the free surfaces of the mercury in the outer chamber K, and there the sodium becomes chemically and electrolytically dissolved on contact with water, so that sodium hydrate is formed and hydrogen gas as a cation is evolved at the cathode J, which may, if desired, be collected for use.

In Figs. 5, 6, 7, and 8 a constructional modification is illustrated, wherein an exterior containing vessel A, preferably of porcelain or other suitable non-conducting material, is employed and a base part B^4, which may likewise be of porcelain, serves to support the partitions B' and their containing-frames. In this case two end plates L are provided also preferably of porcelain and have both two circular vertical recesses *l* on each side for retaining the extremities of the troughs C. The troughs are firmly fitted to the end plates L by means of copper or other metal rods M, which are provided in the recesses *l* and are each fitted with transverse supporting wires or strips of metal *m*, upon which the edges of the troughs C rest, and the whole is fitted together by letting in a luting *m'* of paraffin wax or other suitable cement. The respective lowermost troughs $C^{\times}$ have their extremities resting upon the respective bases L' of the end plates L L, while their downwardly-projecting edges or flanges *e* protrude into a channel b^4, provided in the base part B^4, which is filled with mercury, so that an effective seal may be formed thereby. The channel b^4 extends around and near the edge of the base B^4, and the seal is completed at the respective ends by a flange L^2, provided upon the base L' of the respective end plates in continuation of the flanges *e* upon the lowermost trough of each series. Each of the end plates L is provided centrally at its upper extremity with a small trough l^2 for the reception of mercury, a contact-screw l^3 in each case projecting from the exterior into the trough to which the terminals of a dynamo may be connected for leading the current into the cell. A cover-plate N is fitted upon and connects the tops of the end plates L. The upper parts of the partitions B', as in the former case, are provided with plates B'', whose upper edges engage with grooves *n*, provided on the under side of the cover-plate N, so as to form a gas-tight joint. The cover-plate N is secured in position by means of screws passing into the copper rods M, the screws at the same time serving as terminals, by means of which current may be led out of the mercury-partition, the current thereby being utilized in the decomposition of the salt, but not in the solution of the metal. The cover-plate N is provided with a channel n', which is filled with mercury and effects a seal on the insertion therein of the edges of the collecting-hood I, by means of which the chlorin gas evolved in the inner compartment is led away. Iron cathodes J are suspended in the outer compartment upon each side, the hooked extremities j' of such cathodes entering within small troughs o, provided in terminal connections O, secured by means of screws o' to the sides of the outer vessel, screws O' serving as a metallic connection with the mercury in the respective troughs o and for connecting the return-wires of the dynamo. The electrolytic action in this cell is the same as that of the modification illustrated in Figs. 1, 2, 3, and 4, while in each case the process may be rendered continuous by supplying brine solution at V^2 to the lower part of the inner compartment and drawing off the weakened solution near the surface at V' in the same compartment, while water may be supplied to the outer compartment at W, near the surface, and the strong alkaline solution may be withdrawn at W', near the bottom of the same compartment.

In the employment of the cells for the production of chlorin and caustic soda the current may be first run through from the carbon anode to the mercury cathode, thence out of the cell. By such means the mercury is charged with sodium, and the current may be then run from the carbon anode out of the cell by way of the iron cathode immersed in the alkali solution. Owing to a want of perfect efficiency in the electrolytic action in the brine-compartment insufficient sodium amalgam is produced to render the formation of the alkali continuous and care is necessary in regulation, for on the one hand a scarcity of sodium in the mercury may lead to the oxidation of the mercury-surface in the alkali-compartment, while too great a quantity would lead to the recombination of the sodium with the chlorin and the formation of other products, as well as the hardening of the amalgam, by which the efficiency of the cell would be impaired. The current could, however, be conducted from the carbon anode to the mercury cathode, and the mercury cathode could be connected with the iron cathode by a conductor of negligible resistance, as shown diagrammatically in Fig. 18, J G B representing the iron cathode, carbon anode, and mercury-partition, respectively, and R the conductor of negligible resistance. The current flowing through the alkaline solution would then be due merely to the chemical combination of the sodium and the water.

A high efficiency can be obtained by providing a greater current passing through the brine solution than through the alkaline solution by providing a wire R', Fig. 19, of suitable resistance between the mercury cathode B and iron cathode J and connecting the carbon anode G and iron cathode J with the dynamo or with the supply-mains.

As illustrated in Figs. 9, 10, and 11, a circular wall or partition P may be provided instead of a longitudinal partition, such circular wall or partition dividing the cell into an inner central compartment H and an outer annular compartment K, in which, respectively, the brine solution may be supplied and the alkaline solution produced. These circular troughs P' are spaced apart and supported by means of distance-pieces p, placed at intervals.

Further, in another manner of carrying the invention into effect, as illustrated in Fig. 12, a horizontal partition Q may be provided, composed of a number of elements q of substantially ⁀‿ section, such elements being arranged side by side and each providing a channel for the reception of the mercury upon one side and a flange for dipping into the channel of the next element, so that when sufficient mercury is poured into each of the elements previously laid in horizontal series in connection one with the other the vessel is divided into two compartments H^2 K^2, effectually separated by the mercury seals, for when once the lower or cathode compartment K^2 has been completely filled with weak alkaline solution the upper or anode compartment H^2 may be filled with a brine solution without any fear of the two liquids mixing. Electrodes G and J are placed in the respective compartments. Strong brine solution is continuously fed into the upper compartment near the partition and withdrawn from near the top of that compartment, while water is fed into the upper part and alkali solution withdrawn from the lower part of the lower compartment. A hood R is provided in the lower compartment by means of which the hydrogen gas evolved may be withdrawn, and similarly a hood R' may be provided for the withdrawal of the chlorin gas evolved in the upper compartment. In order to procure the maximum amount of surface of mercury exposed upon each side of the partition to the salt and alkaline solutions, the troughs are preferably provided of a shallow **V**-section with downwardly-extending ribs e, as illustrated in the figures, which latter alone dip into the mercury provided in the adjacent trough. No limitation, however, is placed to such a construction of the partition, as instead the troughs may be provided so as to fit one within the other, thereby providing an interstitial space between of constant depth, as shown in Fig. 16ᵃ, or any other suitable shape and disposition of the troughs may be made without departing from the essential feature of the invention. Again, no limitation is placed to the vertical disposition of the troughs forming the partition when provided to extend horizontally in the cell, as the partition may obviously be disposed in an inclined position, as shown diagrammatically in Fig. 12ª, wherein similar parts are similarly lettered to the modification illustrated in Fig. 15.

Mercury may be poured into the series of troughs C by filling the uppermost and permitting overflow into the trough immediately beneath, and so on until the whole series of troughs are filled with mercury.

For convenience in filling the troughs and to preclude spilling of the mercury, while also to insure that each trough shall be filled, the troughs may be provided, as illustrated in Fig. 13, with one of their walls u upwardly extending beyond the other, the alternate edges of the troughs upon each side being extended, so that the downward flow of mercury shall be over the lower edge of one trough and the overflow received by the extended side u of the trough next beneath; or instead of providing a continuous extension of the alternate sides of the troughs a partial extension or lip u' alone may be alternately provided, as illustrated in Fig. 15, and arranging that the overflow shall be limited to a particular part u^2 of the edge of each trough; or, as illustrated in Fig. 14, the mercury may be guided by capillary action by means of a hook and stem u^3, made from amalgamated copper wire. The filling of the troughs may, however, be effected by the means illustrated in Fig. 15ª, which are shown as applied in the cell illustrated in Figs. 1 to 5. This consists of a strip y, which is connected in each case to a plate B″ and preferably connected also to the contiguous edges of the troughs. The troughs are nicked at their edges, as indicated at c' and c^2, the alternate nicks not being in the same vertical line, so that the mercury flowing through a nick or recess in the edge of the one trough shall be guided by the strip y to fall into the next trough. It is obvious that no limitation is placed to the particular shape or disposition of the troughs forming the partition nor to the shape and disposition of the partition. By the provision of such a cell the use of moving parts for the agitation or movement of the mercury is obviated, while a thoroughly-efficient cell is simply and economically provided according to this invention.

In the use of a cell such as hereinbefore described it has been found that sodium completely and rapidly diffuses through the mercury-cells, so as thereby not to necessitate any agitation whatever, and this constitutes a distinguishing advantage of the invention.

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

1. An electric cell having a partition formed of a series of troughs dividing said cell into decomposing and combining compartments, said troughs containing mercury which has its surface exposed to each compartment, each of said troughs having a portion dipping into and below the level of the mercury in the adjoining trough, and electrodes in said compartments, substantially as described.

2. An electric cell having a vertical partition formed of a series of troughs dividing said cell into decomposing and combining compartments, said troughs containing mercury which has its surface exposed to each compartment, each of said troughs dipping below the level of the mercury in the trough below, and electrodes in said compartments, substantially as described.

3. A cell having a partition dividing the same into decomposing and combining compartments and formed of a series of superposed mercury-containing troughs of insulating material of substantially **V**-shaped cross-section, the apex of each trough dipping below the level of mercury in the trough below, and electrodes in said compartments, substantially as described.

4. A cell having a partition dividing the same into decomposing and combining compartments and formed of a series of superposed mercury-containing troughs of substantially **V**-shaped cross-section, the apex of each trough dipping below the level of mercury in the trough below, said troughs having alternate edges on each side extended to permit overflow of mercury into the trough beneath, and electrodes in said compartments, substantially as described.

5. For the electrolytic decomposition of alkaline salts, a cell or vessel having a partition comprising a plurality of superposed troughs of substantially **V**-shaped cross-section having the alternate edges on each side provided respectively with a spout and lip, mercury in said troughs and electrodes in the compartments formed by said partition.

6. An electrolytic cell having a vertical partition dividing the same into decomposing and combining compartments and comprising a series of superposed troughs, mercury located in said troughs, each upper trough dipping below the mercury-level in the trough below, means for filling said troughs, and electrodes in said compartments, substantially as described.

7. In an electrolytic cell, a vessel, a vertical partition therein comprising a plurality of superposed troughs having metal ribs or flanges depending from the bottom of each trough into the trough below, said ribs or flanges being amalgamated, mercury in said troughs, and electrodes in the compartments formed by said partition, substantially as described.

8. In an electrolytic cell, a vessel, a vertical

partition therein comprising a plurality of superposed troughs, an insulating-covering for the exposed surfaces of said troughs, mercury in the troughs and electrodes in the compartments formed by said partition, substantially as described.

In witness whereof I have hereunto set my hand, this 22d day of March, 1899, in the presence of two witnesses.

EDWIN EDSER.

Witnesses:
ALBERT E. PARKER,
F. J. BIGNELL.