

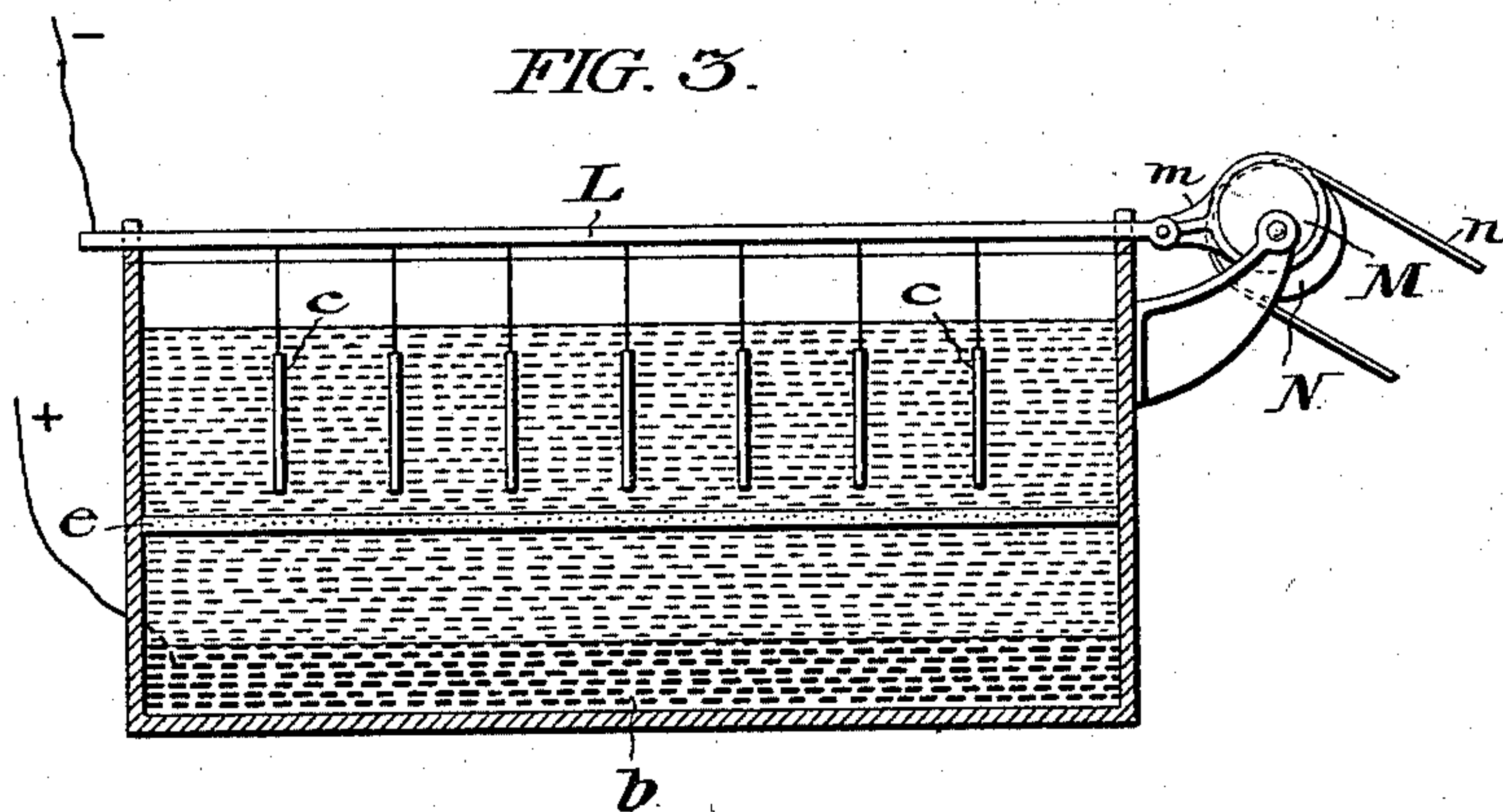
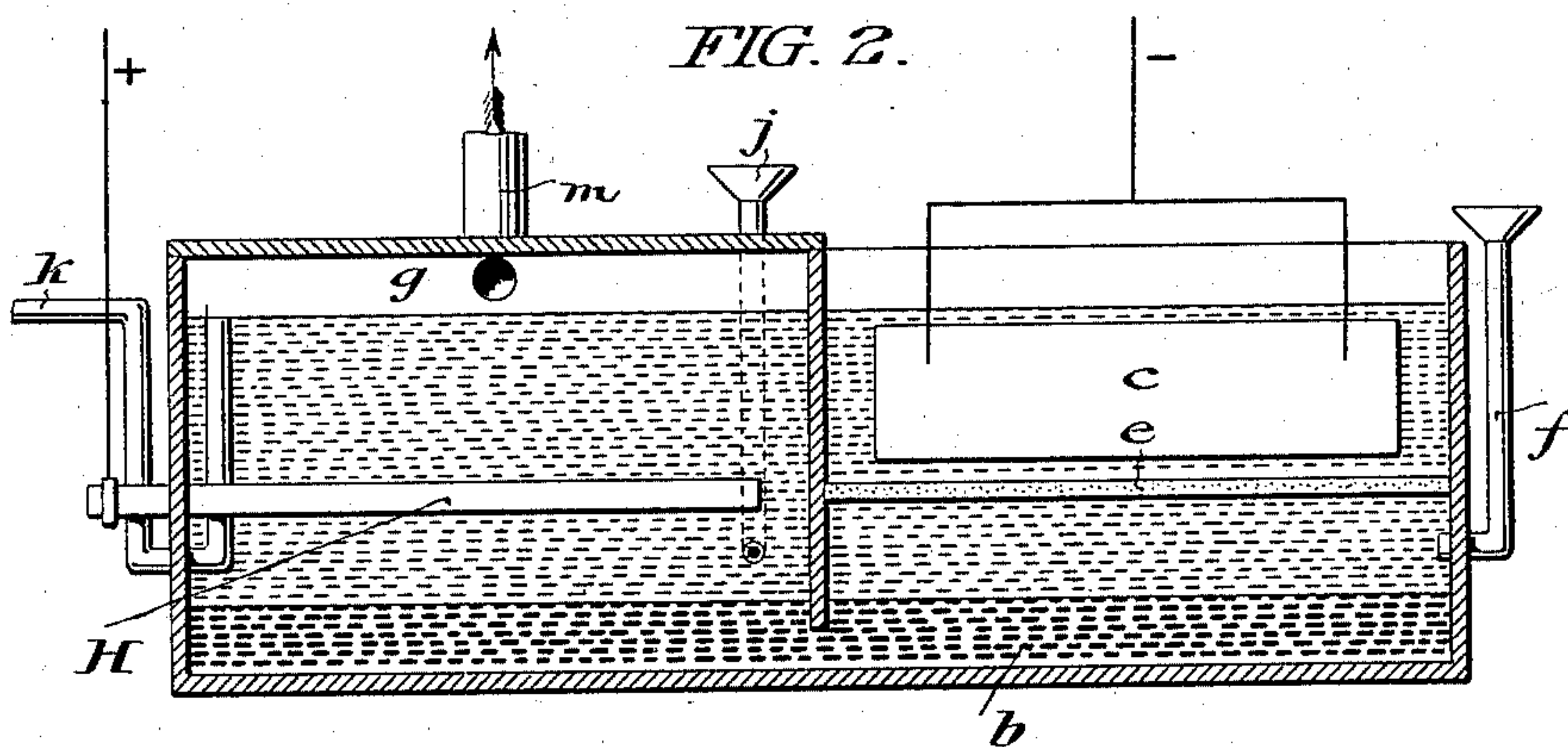
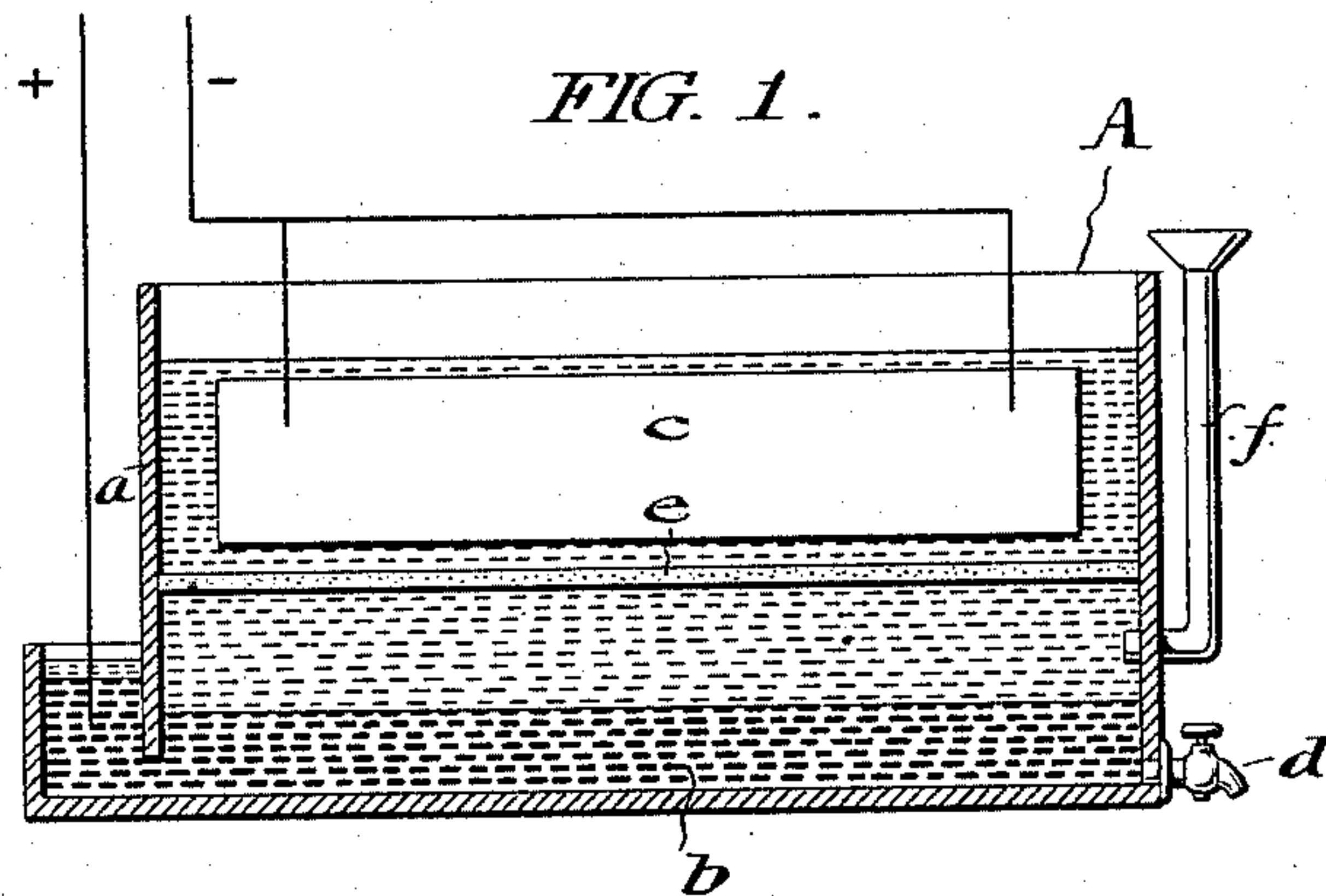
(No Model.)

J. W. RICHARDS.

PROCESS OF AND APPARATUS FOR ELECTROLYTIC EXTRACTION OF
METALS FROM THEIR SOLUTIONS.

No. 591,141.

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PROCESS OF AND APPARATUS FOR ELECTROLYTIC EXTRACTION OF METALS FROM THEIR SOLUTIONS.

SPECIFICATION forming part of Letters Patent No. 591,141, dated October 5, 1897.

Application filed March 6, 1897. Serial No. 626,305. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH W. RICHARDS, a subject of the Queen of Great Britain, residing at Bethlehem, in the State of Pennsylvania, have invented certain new and useful Improvements in Processes of and Apparatus for the Electrolytic Extraction of Metals from Their Solutions, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to those metallurgical processes in which a metal is recovered from solution by means of electrolysis, and the main feature of my improvement lies in the composition, preparation, disposal, and treatment of the positive pole or anode which is to be employed in conducting the electrolysis.

Briefly stated, it consists in employing as the anode an amalgam of such composition that the attack of the electrolyte shall be substantially limited to the non-mercurial ingredient of such physical character as to be substantially liquid and so disposed as to permit the renewal of the anode as the consumption thereof occurs. In this composition and disposal of the anode the mercury acts as a vehicle for the continual supply of the electro-positive ingredient to the attack of the electrolyte. I contemplate the use of a great variety of amalgams, such as those of sodium, potassium, aluminium, zinc, or ammonia, the proportion of mercury being always, however, kept sufficiently great to preserve the fluidity of the compound.

For the purposes of my invention it is immaterial what may be the source of the electric current by means of which the electrolysis is conducted. It is also immaterial what may be the nature of the cathode or receiving plate upon which the metal in solution is to be deposited. When convenient, this plate may be formed of the same metal as that which is to be deposited. If this is not convenient, any other substance which is capable of receiving the metal as it is deposited and from which it can be removed will answer the purpose. In order to practice my invention, however, it is necessary that the anode should consist of a combination of mercury and one or more of the metals (or ammonia) with which mercury is capable of forming an amalgam. It is, furthermore,

necessary that the proportion of mercury shall be sufficiently great to preserve the mobility of the amalgam. Within these limits the nature of the metal in the amalgam may vary as the character of the solution from which the metal is to be extracted or the convenience of the operation may dictate.

For the purpose of explaining a convenient method of practicing my invention I have shown in the accompanying drawings alternative forms of suitable apparatus.

Figures 1 and 2 are cross-sections of such apparatus, while Fig. 3 is a longitudinal section of either apparatus when fitted with means for obtaining constant motion of the cathode-plates. Fig. 2 differs from Fig. 1 in that it shows combined with the electrolytic tank a receptacle and apparatus by means of which the same current which conducts the electrolysis of the metal-containing solution may also be rendered effective for the purpose of producing continuously and electrolytically the required amalgam.

My invention is entirely independent of the nature of the metal which is to be recovered. In many well-known metallurgical processes the desired metal is obtained first in the solution stage, from which solution it must be extracted. For the purpose of describing my invention it will, however, be convenient to assume, by way of example, the extraction of gold from its cyanid solution. I will therefore describe the apparatus, using this solution as a typical example.

In Fig. 1, A represents the tank, which may be of any convenient size and shape. One of the sides *a* of the tank fails by a short distance of reaching the bottom of the tank, the bottom being extended and turned up beyond this side, so as to form an external supply passage-way isolated from the main body of the tank. The entire bottom of the tank is filled with a liquid amalgam *b*—as, for instance, sodium amalgam—the height of the amalgam being well above the space left at the bottom of the side *a*. Above the amalgam is hung a series of receiving-plates *c*, which may either be of gold or of any substance capable of receiving a deposit of gold upon it and also of acting as an electrode. By means of electrical connections these plates are constituted cathodes and the amal-

gam an anode. A porous plate or diaphragm *e* is interposed between these electrodes, dividing the tank horizontally into two compartments. Through the upper of these compartments flows the cyanid solution carrying the gold. The lower compartment is filled from the surface of the amalgam to the plate with any suitable electrolyte—as, for example, a simple solution of cyanid of sodium. The rate of flow of the cyanid solution should depend upon the rapidity of the electrolysis, due precaution being taken to keep either the solution or the cathode-plates in constant motion, so as to minimize deleterious secondary reactions and insure full efficiency of deposition by the current passing. If the rate of flow of the solution through the tank is sufficiently great, this flow in itself supplies the requisite motion; otherwise motion of the cathode-plates may be resorted to, which motion may be obtained by mounting the entire series of plates upon a slowly-reciprocating frame, as shown in Fig. 3, where I have illustrated in transverse section an apparatus provided with convenient means for effecting this motion of the cathode-plates. The plates *c* are supported by means of a horizontal frame *L*, which rests upon the sides of the tank *A*. Said frame is connected by means of a pitman *m* with an eccentric *M*, whose shaft is provided with a driving-pulley *N*, actuated by means of a belt *n*. By the rotation of the eccentric *M* at any desired speed a reciprocating movement of the entire system of the cathode-plates *c* is effected.

In order to prevent any passage of the gold-containing solution through the porous diaphragm to the lower solution, a slight hydrostatic pressure may be maintained in the lower solution by means of the stand-pipe *f*.

The action of the electrolytic current causes the decomposition of the double cyanid salt, the gold being deposited on the plate *c* and being replaced in the solution by a proportionate quantity of sodium set free from the amalgam. As the process proceeds the amalgam, constantly losing its sodium, is replaced by fresh amalgam supplied from an external source through the isolated passage-way, that which is exhausted being drawn off by means of the spigot *d* upon the other side of the tank. For the greater protection of the amalgam, which is exposed in the external passage-way, its surface may be covered by a layer of naphtha. The liquid-amalgam anode may thus be maintained at any desired level and its mercurial ingredient may be drawn off, the two operations being entirely independent of one another.

The advantage of the interposed diaphragm is that the gold solution and the amalgam do not come in physical contact, thus preventing the possibility of any chemical action between them. There is also the further advantage that any gold which may fall off the receiving-plate will be caught by the diaphragm instead of falling into the amalgam.

In the apparatus illustrated in Fig. 1 it is necessary as the amalgam gives up its non-mercurial ingredient to draw off the mercury by means of the spigot *d* and replace it by fresh amalgam, which amalgam may be manufactured by means of any well-known process.

An alternative form of apparatus is illustrated in Fig. 2, by means of which the continuous formation of amalgam may be effected electrolytically by the same current which effects the electrolytic deposition of the gold. In this figure of the drawings the right-hand portion corresponds in all details to the apparatus which is shown in Fig. 1, *b* representing the amalgam at the bottom of the tank, *e* the diaphragm, and *c* the suspended cathodes. As above, hydrostatic pressure may be obtained by the stand-pipe *f*. Instead, however, of the external passage-way for the supply of the amalgam a second electrolytic cell is provided, which cell occupies the left-hand portion of the drawings, communicating at the bottom with the right-hand portion in precisely the same manner as does the external passage-way shown in Fig. 1. This left-hand compartment *g* has a covered top. It is filled with a suitable electrolyte, as hereinafter explained, within which is suspended a positive electrode *H*, say, of carbon. The bottom of this compartment is also filled with amalgam and means are to be assumed for maintaining its free circulation from one compartment to the other beneath the partition, but as such means are well known they are not shown.

Let it be supposed that the compartment *g* is kept filled (by means of the intake and outlet openings *j k*) with a strong solution of chlorid of sodium. The course of the current is from the positive electrode *H* through the brine to the amalgam, and thence under the partition through the cyanid solution, the diaphragm, and the gold solution to the negative receiving-plate *c*. At the anode the chlorid of sodium is decomposed, the chlorine being released and collected through the discharge-tube *m*, (whence it may be employed as a useful by-product,) while the sodium enters into the amalgam, continually renewing that which is lost by reason of the action of the cathode, which has been explained. The electrolytic action in the right-hand compartment proceeds as before. Both processes are thus continuous, simultaneous, and correlative to each other.

The following advantages of my invention may be especially pointed out:

First. The anode being in a liquid form it is capable of being continuously renewed, (by means of the simple apparatus which I have described,) from which it results that all of the disadvantages ordinarily incident to solid but soluble anodes are obviated. In the ordinary practice of the electrolytic deposition of metals from their solutions the anode, whatever be its constitution, is more or less rapidly destroyed and must be replaced. Such replacement requires time and trouble and

causes an interruption of the continuity of the process.

Second. Not only is the regeneration of the anode continuous, but whatever be the salt used as a solvent to bring the metal into solution the use of mercury as a vehicle makes it possible to choose the amalgam so that it shall contain a metallic base of that salt, and in such case the salt is regenerated by the electrolysis. Thus, as has been explained, for cyanid solutions, whether of sodium or of potassium, sodium or potassium amalgam may be employed. For a solution of zinc in an ammonium salt ammonium amalgam may be employed, &c., and it must be particularly emphasized that the metals which most commonly form the base of those salts which are employed in metallurgical-solution processes are the alkaline and earthy metals and those allied to them, which metals, by reason of their nature, it is either impossible or very difficult to employ as anodes in any other form but amalgams.

Third. These amalgams are easily prepared electrolytically, (either by the process which I have described or any known process,) and the active precipitating agent can thus in many instances be cheaply prepared from its cheapest salt, thus costing far less than if it were bought or prepared and used in its metallic state without being in an amalgam.

Fourth. The salt from which the amalgam is to be formed can frequently be chosen so that its other ingredients are of immediate value. Thus in the process which has been outlined as an example the by-product resulting from the decomposition of the chlorid of sodium, which results in the formation of sodium amalgam, is chlorine gas, which in very many gold processes is of the highest utility in the treatment by chlorination of certain portions of the gold ore which are not amenable to the cyanid process.

Fifth. The process lends itself readily to such a combination as has been outlined in connection with the description of Fig. 2, by which the amalgam-producing apparatus is combined with the apparatus for the decomposition of the metal-carrying solution, so as to render it possible to employ not only the same source of electricity but the same electric circuit to do both the work of producing electrolytically the amalgam and of effecting the electrolytic decomposition of the metal-carrying solution.

I desire it to be distinctly borne in mind that in my process neither the amalgam nor either of its constituents has any independent chemical action upon the solution apart from that which is incident to the electrolytic action.

I am aware that it has hitherto been proposed to use an amalgam—as, for example, sodium amalgam—for the purpose of chemically decomposing gold solutions. Such processes have nothing in common with my process, not only by reason of the fact that

in my process the decomposition of the solution is electrolytic rather than chemical, but because the practical result of the chemical precipitation is inevitably the combination of the mercury with the metal which it is desired to obtain, resulting in the formation of a second amalgam, while in my process the metal to be obtained cannot possibly associate itself with the amalgam, but is driven away from it and deposited upon the receiving-surface which is constituted the cathode.

I am also aware that it is not new, broadly speaking, to employ a body of mercury in such relation to an electric circuit as that it shall act as an anode, and I do not broadly claim the same.

My invention is based upon the peculiar availability of a liquid amalgam as an anode under specified conditions and in a specific process for which it has a peculiar and definite value, and in which I believe myself to be the first to so organize its employment as to render it commercially practicable.

In using the word "liquid" in this specification and in the following claims to designate the physical condition of the anode, I do not desire to limit myself to an amalgam which is liquid in the more restricted sense, but mean to comprehend thereunder any amalgam which has a mobility approximating that of a liquid, even though it be somewhat viscous or pasty.

Having thus described my invention, I claim—

1. The process of extracting metals from their solutions, which consists in subjecting such solutions to the electrolytic action of an electric current passing into the solution by a liquid-amalgam anode, and separating said anode from its cathode by a porous partition, substantially as described.

2. The process of extracting metals from their solutions, which consists in subjecting such solutions to the electrolytic action of a pair of electrodes, of which the anode is composed of a liquid amalgam, with a porous plate interposed between the electrodes, the solution from which the metal is to be extracted passing through the cathode-compartment, substantially as described.

3. The process of extracting metals from their solutions, which consists in subjecting them to electrolytic action by means of a liquid-amalgam anode situated in one of two compartments separated by a porous partition, the cathode-compartment being filled with the solution from which the metal is to be extracted, and the anode-compartment being filled with a suitable electrolyte maintained at a slightly-increased pressure, substantially as described.

4. An apparatus for electrolytically separating metals from their solutions, which consists in the combination of a cell with means for electrolytically producing an amalgam therein; a second cell to which the amalgam

formed in the first cell is conveyed; a cathode in said second cell as to which the amalgam therein is constituted an anode; a porous partition between said anode and cathode; 5 and means for subjecting the metal-containing solution to electrolytic action between the anode and cathode in the second cell, substantially as described.

5. An apparatus for electrolytically separating metals from their solutions, which consists in the combination of a cell, having means substantially as set forth for electrolytically producing an amalgam therein; a second cell; means substantially as set forth by which the 15 amalgam formed in the first cell is conveyed to the second cell; a cathode in said second cell, as to which the amalgam therein is constituted an anode; a porous partition between said anode and cathode; and electrical connections whereby said first and second cells 20 are maintained in series in the same electric circuit, substantially as described.

6. An apparatus for electrolytically separating metals from their solutions, which consists in the combination of a cell with means for electrolytically producing an amalgam therein; a second cell to which the amalgam 25 formed in the first cell is conveyed; a cathode in said second cell as to which the amalgam therein is constituted an anode; a porous

partition between said anode and cathode; means for passing the metal-containing solution through the cathode-compartment thus formed; and means for subjecting the liquid in the anode-compartment to a pressure 35 greater than that existing in the cathode-compartment, substantially as described.

7. An apparatus for electrolytically separating metals from their solutions, which consists in the combination, with a tank containing a liquid-amalgam anode in its bottom region, and an electrolyte in the region above said anode, and having a cathode-plate arranged in the region of the electrolyte; of a porous partition arranged above said anode 45 and dividing the region of the electrolyte horizontally into two compartments; and means, substantially as set forth, (as a stand-pipe,) communicating with the lower of said two compartments, whereby a body of liquid electrolyte may be maintained in said lower compartment at a pressure in excess of the pressure of the body of liquid electrolyte in the upper compartment, substantially as and for the purposes specified. 50

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Witnesses:

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