(No Model.) 3 Sheets—Sheet 1.

C. E. O'KEENAN.

PRIMARY GALVANIC BATTERY.

No. 354,434. Patented Dec. 14, 1886.

Fig. 1. Fig. 4.

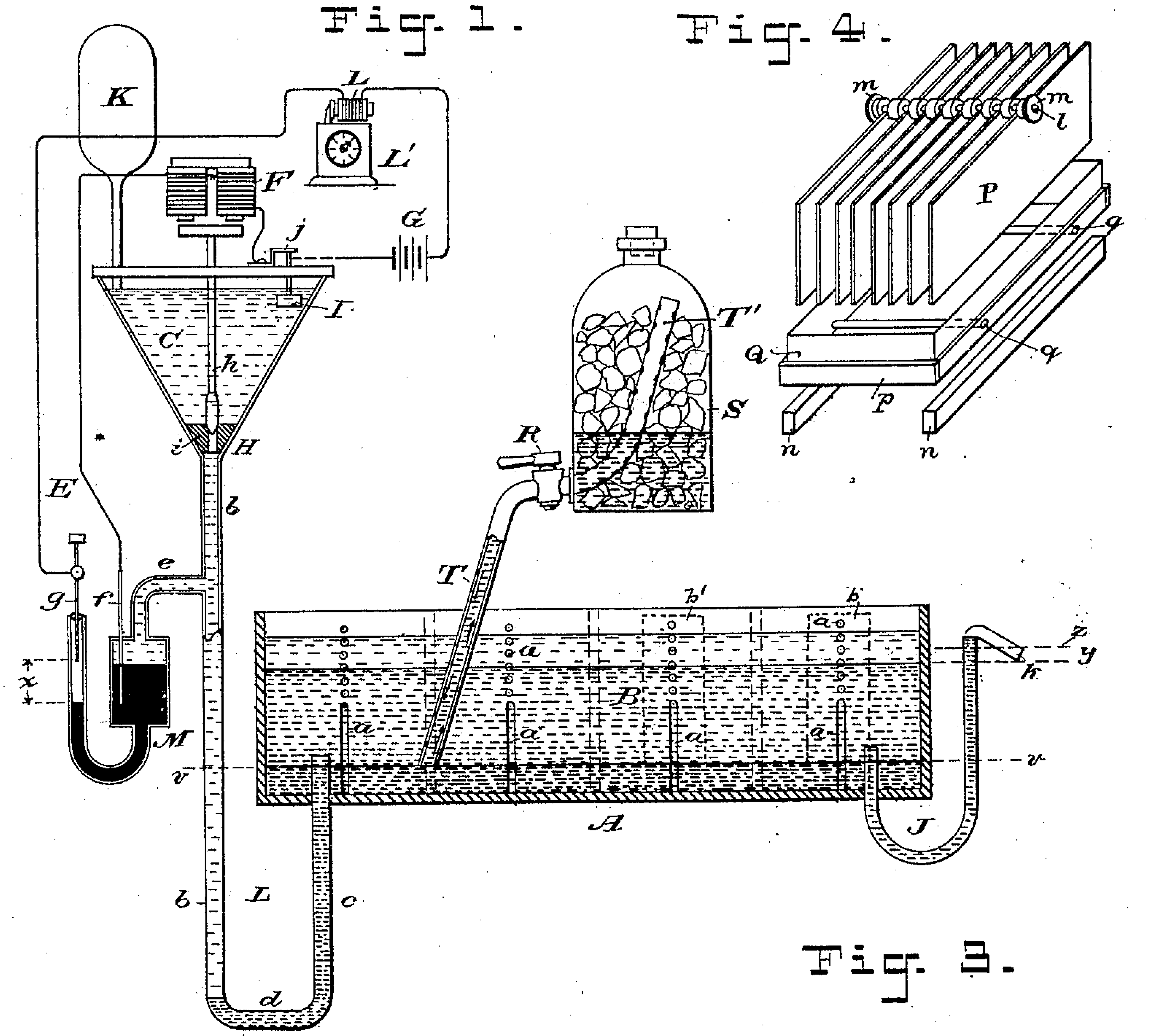
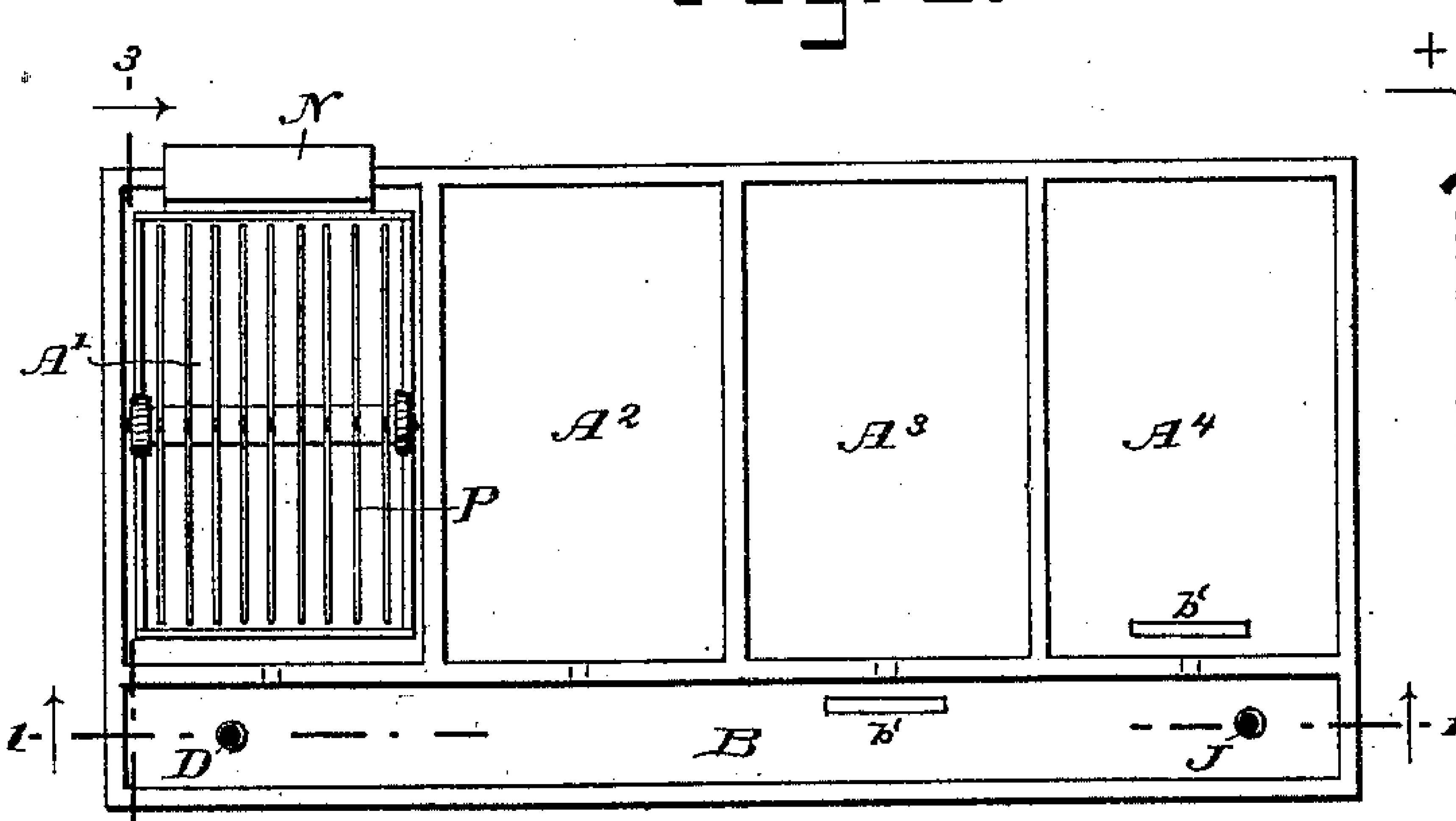
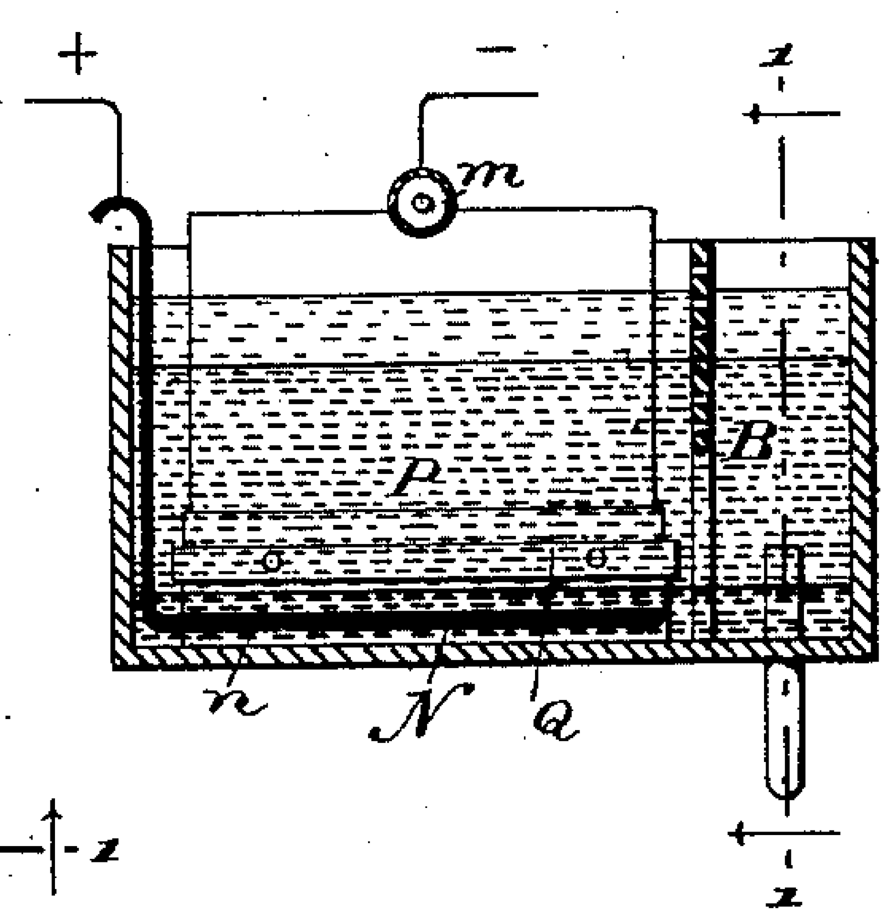


Fig. 3.

Fig. 2.





WITNESSES:

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C. E. O'KEENAN.

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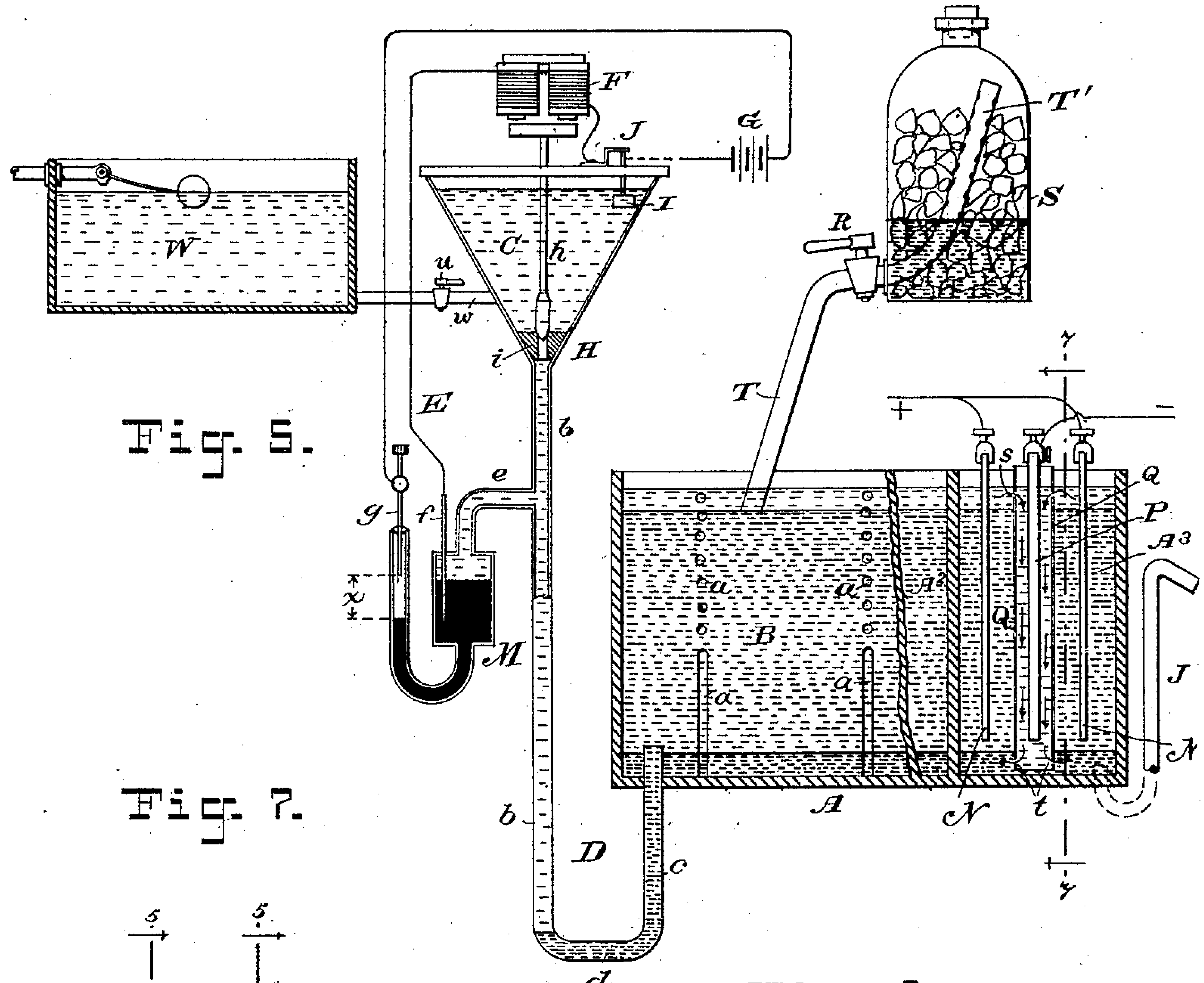


Fig. 5.

Fig. 7.

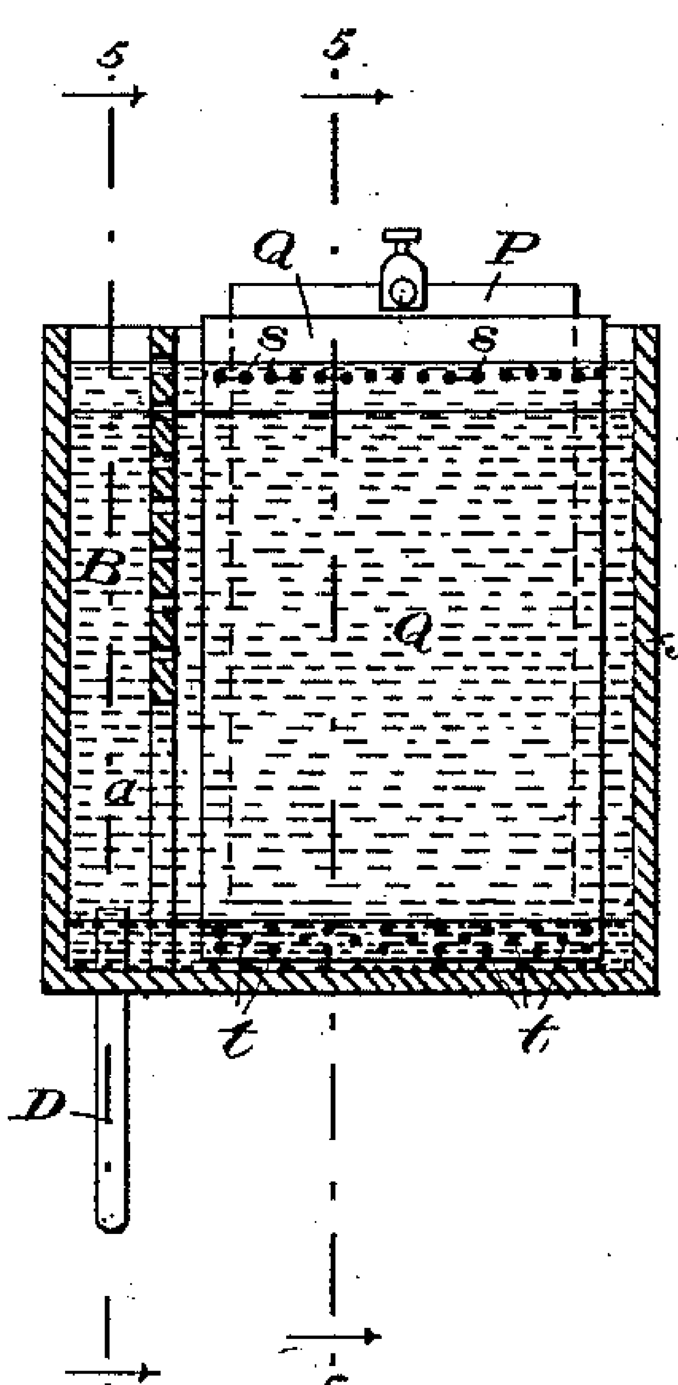
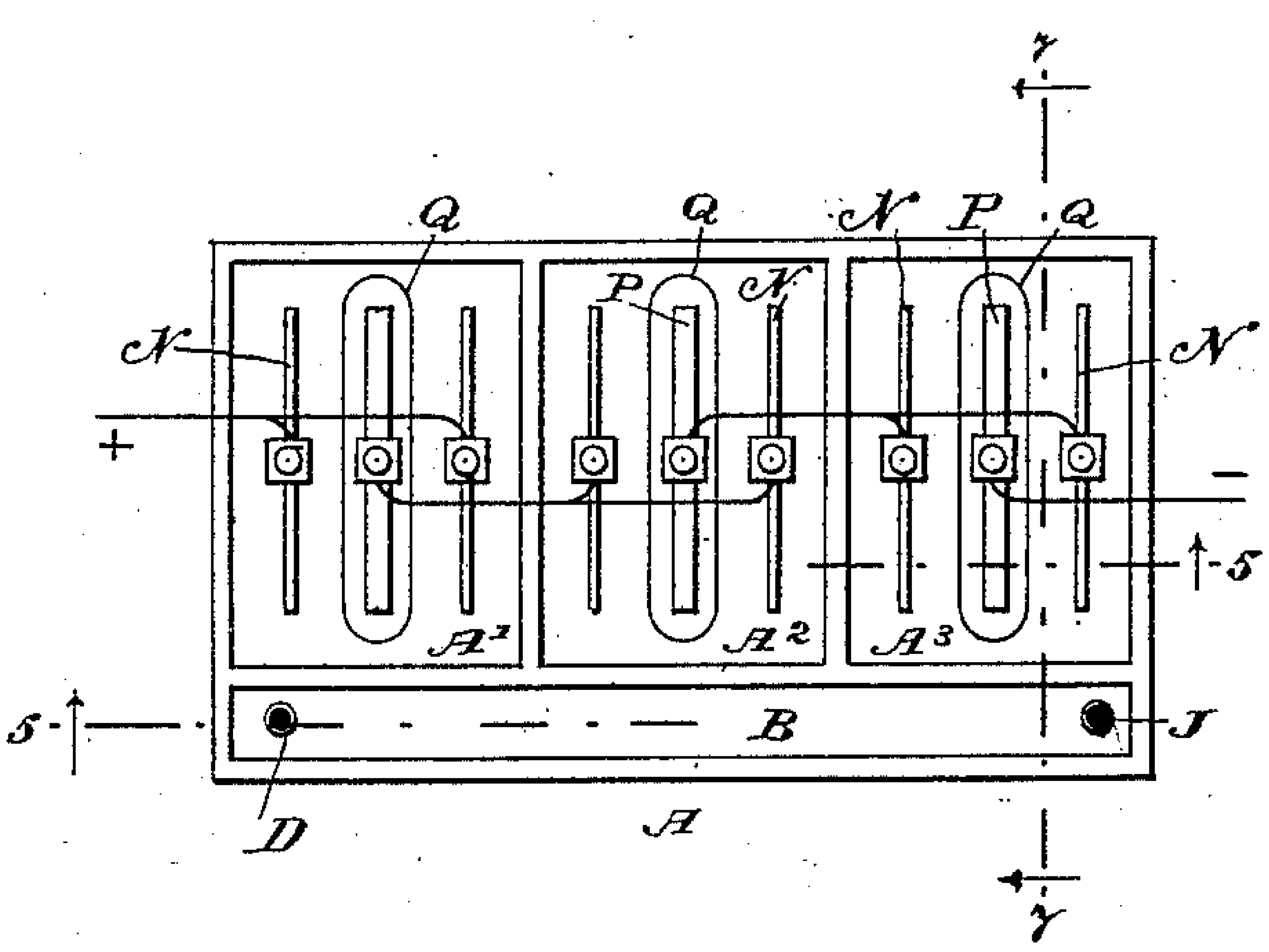


Fig. 8.



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C. E. O'KEENAN.

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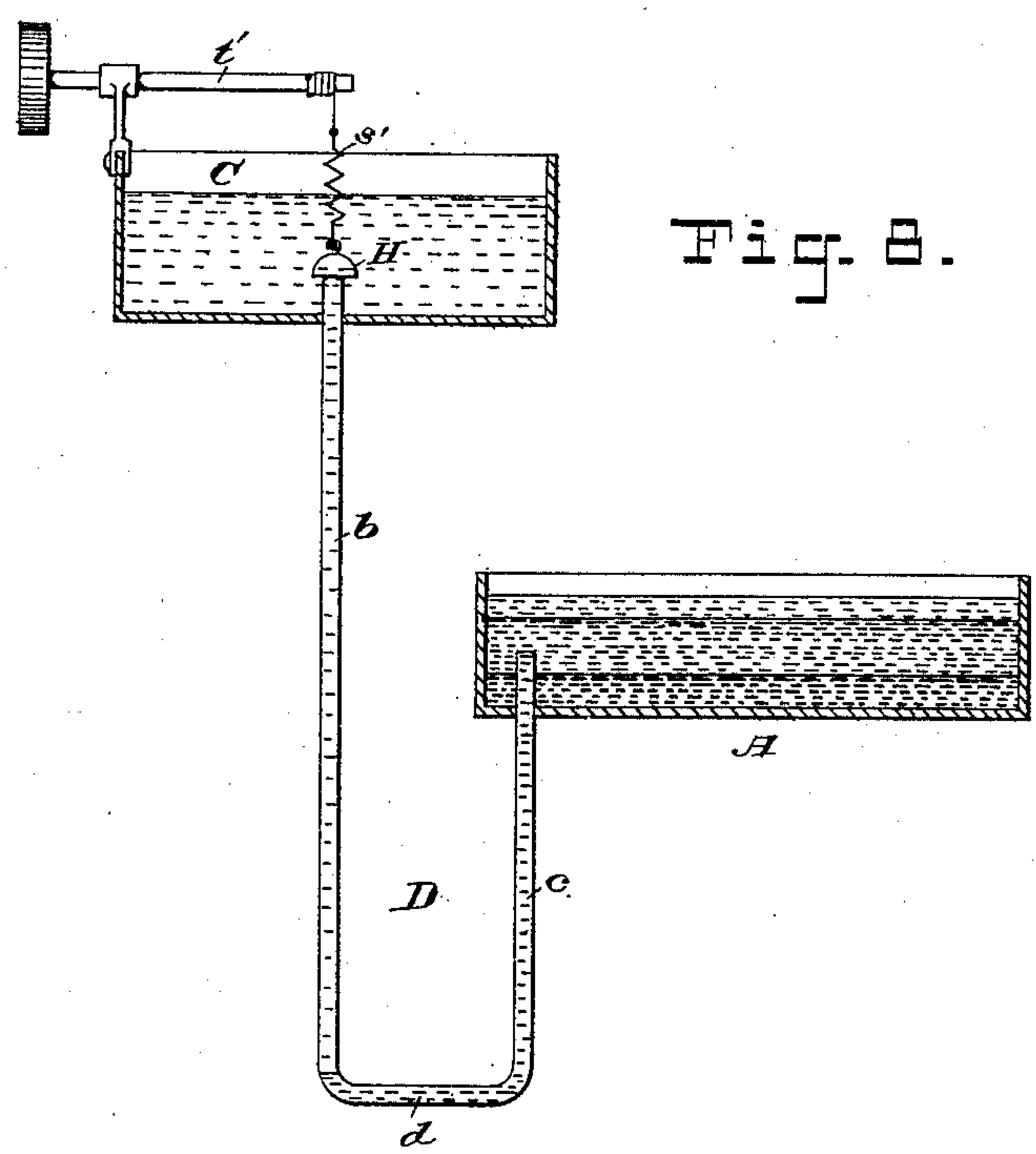

Fig. 8.

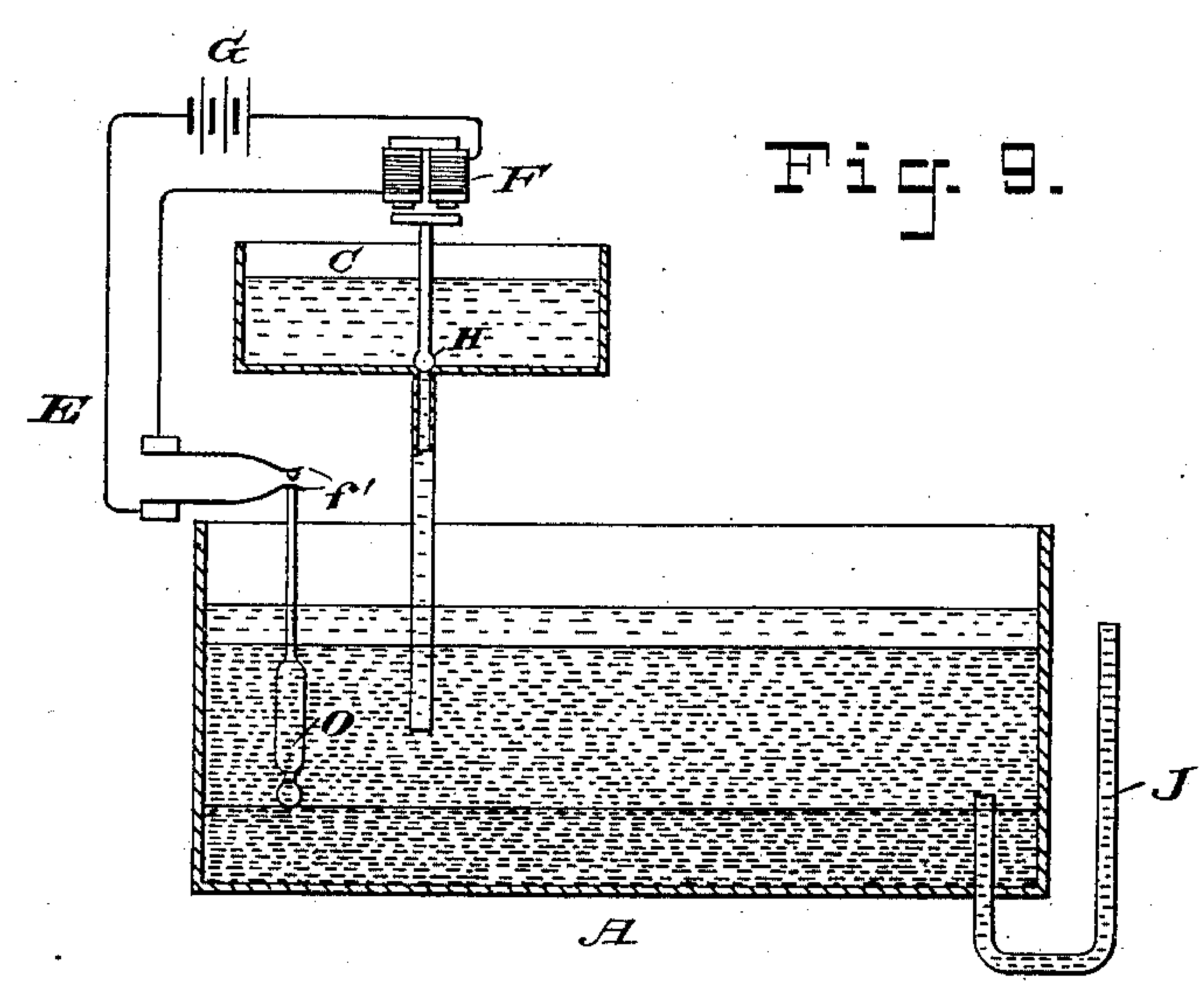

Fig. 9.

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UNITED STATES PATENT OFFICE.

CHARLES EDWARD O'KEENAN, OF ST. CLOUD, NEAR PARIS, FRANCE.

PRIMARY GALVANIC BATTERY.

SPECIFICATION forming part of Letters Patent No. 354,434, dated December 14, 1886.

Application filed October 30, 1886. Serial No. 217,593. (No model.) Patented in France April 23, 1886, No. 175,695, and in England September 17, 1886, No. 11,834.

To all whom it may concern:

Be it known that I, CHARLES EDWARD O'KEENAN, a subject of the Queen of England, residing in St. Cloud, near Paris, France, have invented certain new and useful Improvements in Primary Batteries, of which the following is a specification.

This invention is the subject of French Patent No. 175,695, dated April 23, 1886, and of a patent in England, No. 11,834, dated September 17, 1886.

My invention relates to primary electric batteries of that class known as "circulating" batteries, so-called by reason of a circulation of the exciting or depolarizing liquid being provided for, so that the battery is continually renewed.

The object of my invention is to render the circulation entirely automatic, so that it will adjust itself to the varying conditions of use to which the battery is subjected.

All practical hydro-electric batteries consume a metal and require a depolarizer. The consumption of the metal causes the saturation of the liquid with the salt of said metal in a short time. To avoid this is the purpose of circulating the liquid, fresh liquid being admitted to dilute the solution, and a portion of the saturated solution being run off. This circulation has been effected by hand by opening cocks at intervals; but this is very troublesome, and in no case can the circulation be exactly proportioned to the varying work of the battery. If a uniform stream be admitted, properly adjusted to supply the average need, then when the battery is inactive there is too large a flow, and when the consumption of current is at its maximum the flow of liquid is insufficient and the current which the battery should furnish is not maintained. The battery of d'Arsonval is, I believe, the only one in which the circulation is at all automatic, and in that the flow of liquid is governed by the force of the current, so that the circulation is proportioned to the electro-motive force of the battery, which in its turn depends chiefly upon the condition of saturation of the liquids.

In my present invention I make use of the saline solution itself to control by its varying density the inflow of new liquid, (generally water,) which I will call "desaturating" liquid in contradistinction to "depolarizing" liquid, and which is to dilute the solution and reduce it to the proper density.

My invention may be readily understood in its application to the gravity-battery. In the Callaud battery and others there is a dense solution of sulphate of copper at the bottom of the cell, and a solution of sulphate of zinc of less specific gravity floating upon the denser copper solution. The positive element (zinc) is suspended in the solution of sulphate of zinc, and the negative element (copper, &c.) is immersed in the solution of sulphate of copper. As the battery operates the positive or zinc plate is dissolved, and the solution of sulphate of zinc grows continually denser until, if not corrected, it will equal the density of the sulphate of copper, whereupon it will no longer be superposed. To prevent this result, I arrange for introducing a quantity of fresh water as soon as the zinc solution reaches a predetermined density, in order that its concentration shall be arrested at that density.

The density of a saturated solution of sulphate of copper, according to Ewing and Macgregor, is 1.2051, (at 10° centigrade.) The density of the zinc solution must not be permitted to become nearly as great. Let us assume 1.16 as its maximum density. Now, one of the simplest ways to carry out my invention would be to place an areometer (or density-meter) in the zinc solution, and arrange it so that when the density rises to 1.16 the areometer in ascending shall touch an electric contact and close a circuit in which is an electro-magnet controlling a valve. As long as the circuit remained closed water would continue to flow into the zinc solution until it was diluted to below 1.16, whereupon (a uniform level being maintained) the areometer would sink, the contact would be broken, and the flow would cease; but in preference to this areometer device I employ what I call a "differential tube" as a means of regulating the flow of desaturating-liquid according to the varying density of the solution. This differential tube is of U shape, with its two legs of unequal length. The shorter leg enters the battery cup or cell and terminates in the zinc solution, while the longer leg extends to a higher level and is connected to an elevated reservoir of desaturating-liquid, (water.) A valve controls the flow of water from this reservoir into the tube. This valve is operated either electrically or mechanically, being opened as soon as the density of the zinc solution rises, say, to 1.16, and after admitting a definite quantity of water being again closed. This operation is due to the shorter leg of the differential tube, which becomes filled with the zinc solution, gradually acquiring sufficient density to disturb the equilibrium of the two legs, so that, to illustrate, if the longer leg were open at its top the level of water therein would rise above a predetermined point.

Whenever the desaturating-liquid is introduced it is necessary to get rid of an equal bulk of the solution in order that its level may be maintained uniform. To effect this, I apply a siphon discharge-pipe, which extends from the zinc solution outside of the cell, and thence upward. When the introduction of desaturating-liquid raises the level sufficiently to start the flow through this siphon, the zinc solution will flow out through it until the original level is restored, whereupon the flow will cease.

My invention also provides means for maintaining the reservoir of desaturating-liquid at a uniform level, for maintaining the lower solution (as sulphate of copper) at a maximum saturation and uniform level, and for registering the number of admissions of desaturating-liquid, and consequently the number of watts of energy consumed.

My invention is by no means confined to batteries of the Callaud type, wherein the plates have a horizontal arrangement at different levels, but is equally applicable to batteries wherein the plates are placed vertically. One part of my invention relates to certain improvements in the construction of batteries having upright plates. Nor is my invention confined in its application to batteries using sulphate of zinc and sulphate of copper as its exciting-liquids, as it is equally adapted to batteries using any liquid or liquids the variations in the specific gravity of which will suffice to control the admission of a desaturating liquid or diluent.

I will now proceed to describe my invention in detail, with reference to the accompanying drawings, wherein—

Figure 1 is a vertical section on line *l l* in Fig. 2 of a gravity-battery constructed according to my invention and provided with my improved means of supplying the desaturating-liquid, wherein the differential tube and manometer above referred to are used. Fig. 2 is a plan of the case or vessel of this battery, illustrating its division into compartments, whereby I construct a compound battery of several cells, all replenished by one supply apparatus. Fig. 3 is a vertical transverse section of the vessel, cut on the line 3 3 in Fig. 2. Fig. 4 is a perspective view of the compound zinc element removed from one of the compartments, and of the porous box in which it is placed. Fig. 5 is a vertical section on line 5 5 in Fig. 6 of a battery having upright elements constructed according to my invention. This construction embodies my entire invention. Fig. 6 is a plan of the vessel of the battery shown in Fig. 5, illustrating its division into compartments and the arrangement of the elements therein. Fig. 7 is a vertical section on the plane of the line 7 7 in Fig. 6. Fig. 8 is a vertical section illustrating the simplest adaptation of my differential tube as a means of regulating the inflow of liquid, and Fig. 9 is a similar section illustrating the operation of a battery according to my invention by means of an areometer.

I will first describe the construction shown in Figs. 1 to 4.

The vessel A is constructed in compartments A′ A^2, &c., Fig. 2, up to any desired number. Each compartment constitutes one distinct battery-cell. All the compartments communicate with a chamber, B, which I call the "distributing-canal," by means of holes or slits *a a*, Fig. 1. These holes or slits allow the liquids to flow from the distributing-canal into all the compartments, so that they stand at the same levels in each, and are of uniform density throughout. This construction enables me to avoid the complication of pipes in previous batteries for supplying separately the different cells. In this instance a saturated solution of sulphate of copper is employed, as denoted by the symbols SO^4Cu. The density is about 1.20, and it reposes at the bottom of the vessel. Above this is a lighter solution of sulphate of zinc, (SO^4Zn,) which is not permitted to exceed a density of, say, 1.16 specific gravity, and on top of this is a layer of pure water (H^2O) of density 1.00.

Assuming the "Sir William Thompson" type of battery, the positive plate P is of zinc, and is suspended in the zinc solution, and the negative plate N is of lead, and is placed in the copper solution. The layer of copper solution can have a depth of ten to fifteen millimeters. The bottom of the zinc plates should be about ten to fifteen millimeters from the top of the copper solution, and the zinc solution should be deep enough to cover the zinc plates to a depth of a few millimeters.

C is the elevated reservoir of desaturating liquid or diluent, (in this case water,) and D is the differential tube. The long leg *b* of this tube extends up to the reservoir, while its short leg *c* extends into the vessel A, and terminates therein at a height above the copper solution and beneath the zinc plate where it shall always communicate with the zinc solution. The bend *d* is considerably beneath the vessel A.

M is an open mercury-manometer, (or a Bourdon or other system,) the larger area of which communicates with the long leg *b* by a branch, *e*. A platinum wire, *f*, enters the larger area, and another wire, *g*, is set with its end at a distance, *x*, above the level of the smaller area of mercury. An electric circuit, E, terminates at the wires *f* and *g* and includes a magnet, F, and battery G. This latter may be the battery which is being regulated, or a shunt therefrom, or I may provide a separate Leclanche cell.

The reservoir C communicates with the tube D through a valve, H, which is opened or closed by the magnet F. The armature of the magnet is fixed to a glass tube, *h*, the lower end of which is drawn to a point, and when lowered enters and closes a hole in a plug or stopper, *i*, of india-rubber or cork. Let it be supposed that the tube D is full of water. The sulphate of zinc in the battery being heavier than the water, flows down the leg *c*, the water which it displaces therefrom flowing up into the solution. This phenomenon of the double flow of the two liquids in one tube I have called "unitubulary siphonism." The sulphate of zinc descends to *d*, and cannot ascend through the leg *b*. Thus the leg *c* contains a column of sulphate of zinc, which maintains the same density as that in the battery. As the density increases the weight of this column becomes greater, and its consequent pressure on the column of water in the leg *b* increases, and the mercury in the manometer is displaced; and when the density of the zinc solution reaches 1.16 the mercury is so much displaced as to touch the wire *g* and close the circuit, thereby exciting the magnet F and opening the valve H. Water then flows from the reservoir C down the leg *b* of the differential tube under sufficient head to overcome the pressure of the column of zinc solution in the leg *c*, and the flow of water forces the solution out of the leg *c* and into the battery, and, in addition, sufficient water enters the battery to dilute the solution to, say, 1.15 specific gravity. The water which enters the battery, or a portion of it, rises to the surface because of its impetus and its lesser gravity, and forms a layer of pure water at the top of the liquids of the battery, the function of which is to prevent the creeping up of any salts and to keep the contacts clean. This layer of water should be maintained at a thickness of two to three centimeters. The opening of the valve H increases the pressure on the manometer M, thus holding the circuit closed and thus keeping the valve open. When the desired quantity of water has run out of the reservoir C, it is necessary to stop the flow. This I do by means of a float, I, in the reservoir, which, when the level falls to a predetermined point, breaks the circuit by separating two contacts, *j*, thus causing the magnet F to let go its armature, and hence closing the valve H. Other equivalent means for closing the valve at the proper time may be substituted.

By the arrangement just described a predetermined volume of water is injected into the battery each time the apparatus works. This quantity raises the level of the liquids in the battery from the normal level *y*, Fig. 1, to the level *z*, for instance. An equal volume of concentrated zinc solution is discharged from the battery to each admission of water. To accomplish this I provide the outlet-siphon J. (Shown best in Fig. 1.) This is a bent tube which leads from the zinc solution downward, and then upward, and has its end *k* turned down a distance proportional to the difference between the levels *y z*. When the level rises to or nearly to *z*, the column of sulphate of zinc in this tube is displaced far enough to overflow at the end, thus starting the siphon, which continues to flow until the level *y* is restored. After each injection of water the level in the reservoir C is drawn down to a point where the float I breaks the circuit at *j*. Before another admission can take place some more water must be added, in order to restore the former level and again close the circuit. This can be accomplished in many different ways, the one illustrated in Fig. 1 being by means of a "Mariotte flask," K, filled with water and having its mouth placed at the level desired for the water in the reservoir. When the level falls, the mouth of the flask is unsealed, air enters it and water runs out until the level rises and again seals its mouth; but the admission from the flask must be at a much slower rate than the outflow through the valve H, as otherwise the float I would not descend and the outflow would not be stopped. The admission of desaturating-liquid to the battery is intermittent, the admissions occuring with greater or less frequency, according as the battery is doing much or little work. There may, for instance, be one or two or more admissions a day, or one every second or third day, or less often.

I contemplate registering the work done by the battery by means of the number of admissions of depolarizing-liquid. Since the work realized by the battery depends upon the consumption of zinc, and since we know the amount of zinc dissolved in the solution of a given density, and since at each admission a given quantity of the zinc solution is discharged at a known density of, say, 1.16 specific gravity, it is easy to calculate the number of watts or of ampère hours which is represented by each discharge of sulphate of zinc, and by multiplying this number by the number of admissions of desaturating-liquid we may ascertain the work performed by the battery in a given time. To accomplish this I may attach any suitable registering or integrating mechanism to record automatically the number of admissions of desaturating-liquid. The dial of this instrument may be divided so as to be read in ampère hours, if desired, or by other electrical standard. As an instance of one method of operating such a registering mechanism, I have shown in Fig. 1 an electrically-operated counter. An electro-magnet, L, is installed in the circuit E, and its armature actuates a mechanical counting device, L'.

The layer of sulphate of copper is maintained concentrated and at a given level by the following means: A large bottle, S, Fig. 1, with two openings hermetically closed, is filled with crystals of sulphate of copper, and with one-fourth of its capacity of water. This water communicates with the tap R, and thence by the tube T with the liquid of the battery. The concentrated solution of sulphate of copper descends to the bottom part of the large bottle, and flows out through the tap R and tube T to the battery, while the water containing sulphate of zinc (density 1.15 to 1.16) ascends the same tubes to the bottle S. This phenomenon is the unitubulary siphonism before referred to, the action being similar to that produced in the differential tube. The concentrated layer of solution of sulphate of copper spreads itself over the bottom of the battery, and consequently over the lead plates, and finally reaches the level *v* of the mouth of the tube T, which it cannot rise above. Whenever, while the battery is at work, the level of the sulphate of copper gets lower than *v*, the mouth of the tube T is placed in communication with the sulphate of zinc, which, being less dense than the sulphate of copper, can ascend, while a fresh quantity of sulphate of copper descends and re-establishes the level *v* to the mouth of the tube T. By raising or lowering the tube T the depth of the sulphate of copper may be varied at will. The large bottle of sulphate of copper can be placed at any distance from the battery, provided it remains in communication with it by a tube which shall always have an inclination varying between zero and ninety degrees. The tube T is continued inside the bottle S by a rubber tube, T′, which extends to the top of the bottle, and is pierced with holes in two rows along its upper and lower sides. This enables the ascending sulphate of zinc to escape to the upper part of the bottle without becoming mixed with the sulphate of copper.

The form of the zinc plates can be varied. Plain flat horizontal plates (cast or not) can be used; but it is better to make use of what I call "accumulator-shaped" zincs, on account of their apparent similarity to accumulator-plates. These are made of rectangular zinc plates of moderate thickness (one-half millimeter) set vertically side by side, as shown in Fig. 4, and kept together by a metal rod, *l*, with metallic washers inserted between the plates. At the ends of the rod *l* are two screw-nuts, *m m*, which permit the whole contrivance to be well tightened up, thus insuring a perfect metallic contact between all the zinc plates and washers.

In order to keep the zincs at an invariable distance from the leads, they are put into a box or tray, Q, having its bottom part and sides made of parchment-paper, and stiffened by a wooden frame, *p*, Fig. 4. In order that the zinc may not touch the parchment-paper, two small rods, *q q*, covered with insulating matter, (such as gutta-percha, caoutchouc, &c.,) are inserted between two sides of the box Q, so that the bottoms of the zinc plates will stand vertically on said rods, and when the plates become worn by the action of the electrical current their own weight makes them descend and keeps them always at the same distance from the lead. The small box or frame Q is maintained at a small distance (two and one-half millimeters) from the bottom of the battery-vessel A by small pieces of paraffined wood, *n n*. In Fig. 2 only one compartment, A′, is shown with the zincs in place, the others being empty. The box or tray Q has also the advantage that the dirt or precipitate which falls from the zinc plates will fall on its bottom and be arrested thereby, thus preventing its mixing with the electrolytic copper. The parchment-paper box also forms a porous partition, dividing the sulphate of zinc immediately over the sulphate of copper from that in which the zinc plates are immersed, and hence reduces to almost nothing the consumption of zinc in open circuit.

The above-described elements are specially suitable to the charging of accumulators and to uses which do not require great energy. If a very important application should be required—such as the lighting up of a great number of lamps, &c.—these elements might be found rather cumbersome. It would, therefore, be found advisable to use the construction shown in Figs. 5, 6, and 7, which I will now describe. In this battery the elements are vertical instead of horizontal. There are two negative plates, N N, of lead, arranged on opposite sides of the positive or zinc plate P. The liquids are disposed oppositely to those in the battery first described. The sulphate of zinc, of maximum density, rests at the bottom of the vessel. The sulphate of copper is inferior in density to the zinc solution, is superposed upon the latter, and above the copper solution is a layer of pure water, all as shown in Figs. 5 and 7. Thus there is at the top a layer of water at specific gravity 1.00. Beneath that is the layer of copper sulphate solution, which, if saturated, is at 1.20 specific gravity, (but which may be more or less diluted, and consequently at lighter gravity,) and at the bottom is a layer of zinc-sulphate solution, which may have its maximum density or any lesser density which is greater than that of the copper solution—for instance, about 1.30 specific gravity.

The zinc plate is separated from the copper solution by being inclosed in a porous vase, or, preferably, a porous bag, Q, which surrounds it at a little distance for nearly its entire height. This bag is made of parchment-paper cemented with a glue of gum-lac dissolved in methylic alcohol or with other suitable cement. The bag Q has free communication at its top with the layer of pure water through small pin-holes *s s* or over the top of the bag, and at its bottom with the layer of dense sulphate of zinc through pin-holes *t t* or under the bottom of the bag. There is no sulphate of copper within the bag, but pure (acidulated) water flows in at the top, attacks the zinc, which gradually acquires greater density, and consequently descends, until, finally, when its density exceeds that of sulphate of copper, (1.20,) it flows out at the bottom holes and joins the dense solution of zinc sulphate on the bottom of the vessel. This latter solution thus gradually accumulates, and when its level rises above the open end of the differential tube D it flows down the short leg *c* of that tube, displacing the lighter sulphate of copper, which ascends through the tube at the same time, according to the unitubulary siphonism before mentioned. Thus the short leg becomes filled with a heavier liquid than the sulphate of copper which it before contained, and the pressure thus exerted on the manometer causes the circuit to be closed, and a quantity of desaturating-liquid (water) to be injected into the solution of sulphate of copper, as before described with reference to Fig. 1. This water or part of it rises to the top, whence it may enter the top of the porous bag. The raising of the levels caused by this injection starts the outflow-siphon J, the inner end of which opens at the bottom of the vessel, and which consequently discharges some of the denser solution of sulphate of zinc. If one liter of water has been admitted, the siphon will draw out one liter of zinc sulphate, thus drawing down the level of the latter below the end of the differential tube, and leaving the latter immersed in the copper-sulphate solution. The short leg *c* will presently fill with the copper solution, but the manometer is so adjusted that this will not close the circuit.

It may be remarked that in this construction of battery the sulphate of zinc may be discharged at as great a density as 1.3, so that each quantity of water introduced dissolves more zinc than in the horizontal battery, and hence less water is required for a given generation of energy. The progressive descent of the liquid in the porous bag is continuous, although the admission of fresh water to the battery is intermittent; hence there is no variation in the composition of the liquid in contact with the zinc plate, and no fluctuation in the force of the current. By means of this treble superposition of liquids—sulphate of zinc, sulphate of copper, and water—it is possible to get water to enter the porous bag without being obliged to use an arrangement of complicated tubes. It is therefore possible and convenient to put several zinc and lead plates in each element, and thus have sulphate-of-copper batteries of an exceedingly small resistance, such as have not yet been produced, and be able to light a great number of lamps or do any other kind of work generally expected only from accumulators. The saturation of the copper solution is maintained in this construction of battery in the same way as the other, by means of the Mariotte flask S and tube T, with only this difference, that when some sulphate of copper flows down the lighter liquid which rises to take its place is in this instance water instead of sulphate of zinc. The ascending water when it enters the flask dissolves more of the sulphate of copper crystals, so that the solution of sulphate of copper in the flask and in the battery is maintained saturated, or nearly so, until all the crystals are dissolved.

The manometer M, circuit E, reservoir C, and valve H are the same as in the construction already described. The level in the reservoir C, however, is not replenished by a Mariotte flask, as before, but by water introduced through the pipes by which the building is supplied from the city water-works, which in most cases is preferable. A uniform level is maintained by means of a float-valve or "ball-cock," but I prefer to locate this in a separate tank, W, from which the reservoir C is supplied through a tube, *w*, the flow through which is regulated by a cock, *u*. The flow is reduced to a slower rate than the outflow through the valve H, as before explained. It may be advantageous to use two porous bags, Q, one inside of the other, to effect a more complete separation of the zinc solution from the sulphate of copper.

The distributing-canal B, in connection with two or more, preferably several, cells, constitutes an important feature of my invention, since it avoids the necessity of duplicating the hydraulic supply apparatus for each cell, thereby conducing greatly to simplicity.

In order to prevent any small electrical leakage from one cell to another that might occur through the holes or slits *a a* and the canal, I may arrange shades or screens *b′ b′*, of glass or other suitable material, opposite the holes or slits, either outside or inside of the cells, as shown in Fig. 2, and in dotted lines in Fig. 1.

Fig. 8 shows what I believe to be the simplest construction of supply apparatus on the principle of the differential tube. The operation is wholly mechanical. The valve H, which rests upon the upper end of the leg *b*, is pulled upward by a compensating-spring, *s′*, adjusted by a regulating-spindle, *t′*. The valve is held closed by the pressure of water in the reservoir above it and by the suction of the water in the leg *b*, and against these is the counterpressure of the weight of the column of liquid in the leg *b* and the tension of the spring *s′*, both tending to open the valve. The valve remains closed until the column of liquid in the leg *b* reaches the maximum density—say 1.16—whereupon the pressure beneath it, added to the tension of the spring, becomes sufficient to open it. The liquid then runs out from the reservoir to replenish the battery. The valve may be reseated by its own weight when all the liquid has run out.

Fig. 9 illustrates the areometer-regulator, first herein described. O is the areometer, which, when it is raised by the increasing density of the liquid, brings together two light contact-springs, *f′ f′*, and closes the circuit E, thereby causing the magnet F to lift the valve H. The outflow-tube J is not a siphon, but is arranged to preserve a uniform level of liquid in the battery.

My automatic means of supplying liquid is applicable to all hydro-electric batteries known. I have described it herein as applied to batteries of the Daniels type, but the same essential features may be adapted, with slight modification, to the bichromate, Bunsen, hydrochlorate-of-ammonia, the newly-invented "upward" battery, and many others.

I am aware that the supply of liquids in batteries has been maintained by means of a Mariotte flask having its neck or tube extending down vertically into the battery-vessel. I am also aware that in such batteries the opening of an outlet-valve, in order to discharge a quantity of the liquid, has been effected upon the density of the liquid reaching its maximum by means of an immersed float controlling the outlet-valve. The operation of such a battery is precisely the reverse of mine, since upon the liquid attaining its maximum density a quantity thereof is first discharged, and subsequently enough fresh liquid is supplied to restore the original level. In a battery thus constructed the discharge of liquid will be almost continuous, the outlet-valve being continually either on the point of opening or very slightly opened, whereas according to my invention the replenishing of the liquids is effected only at intervals and in predetermined quantities—a method which is attended with many practical advantages.

I claim as my invention—

1. The combination, with a galvanic battery, of an automatic supply apparatus for injecting desaturating-liquid, consisting of a reservoir of said liquid, with its outlet communicating with the solution in the battery, a valve closing said outlet and shutting off communication between said reservoir and battery, and means dependent on the density of the solution for opening said valve and establishing an outflow from the reservoir, whereby when the solution acquires a predetermined density it is diluted by the injection of fresh liquid.

2. The combination, with a galvanic battery, of an automatic supply apparatus for injecting desaturating-liquid, consisting of a reservoir of said liquid, an outlet therefrom communicating with the solution in the battery, a valve closing said outlet and shutting communication between said reservoir and battery, and means dependent on the density of the solution for opening said valve and establishing an outflow from said reservoir, whereby a quantity of desaturating-liquid is injected into the battery, and an overflow adapted to discharge from the battery a quantity of the dense solution proportional to the quantity of desaturating-liquid added.

3. The combination, with a galvanic battery, of automatic means for diluting the solution therein upon its reaching a predetermined density by the injection of a quantity of desaturating-liquid, and an overflow consisting of a tube leading from the portion of the battery containing the denser part of the solution, extending upwardly and opening outside the battery at a higher level, whereby upon each injection the overflow discharges from the battery a quantity of the dense solution proportional to the quantity of desaturating-liquid added.

4. The combination, with a galvanic battery, of an automatic supply apparatus consisting of a reservoir, its valve, and a differential tube, its longer leg extending downwardly from said reservoir and normally not in connection therewith, and the shorter leg extending upward to the battery and opening therein, and means dependent on the density of the solution in the battery for establishing communication between the reservoir and said tube.

5. The combination, with a galvanic battery, of an automatic supply apparatus for injecting desaturating-liquid, consisting of a reservoir of said liquid, a valved outlet therefrom, a tube extending from said outlet and terminating in the solution in the battery, and electro-magnetic means governed by the varying density of the solution for opening said valve.

6. The combination, with a galvanic battery, of an elevated reservoir, a differential tube communicating therewith and with the battery, a manometer connected with said tube and adapted upon the increase of the pressure to a predetermined point to manipulate an electric circuit, the said circuit, and an outlet-valve from said reservoir controlled thereby.

7. The combination, with a galvanic battery, of an elevated reservoir, an outlet-valve therefor, a tube leading thence to the battery, electro-magnetic means for opening said valve, operated by the density of the solution rising to a predetermined point, and a float in said reservoir adapted to effect the closure of said valve upon the discharge of a predetermined quantity of liquid.

8. The combination, with a galvanic battery, of an elevated reservoir of water, automatic means governed by the varying density of the solution in said battery for discharging water from said reservoir into said battery, a supplementary supply-tank, a float-valve for admitting water from a service-pipe into said tank, and a contracted duct for passing water from said tank to said reservoir.

9. The combination, with a galvanic battery wherein there are two or more liquids relatively superposed by reason of their different gravity, and with the positive and negative plates thereof, of a device for replenishing a denser liquid, consisting of an elevated reservoir containing such liquid, hermetically sealed, and a tube extending thence at an inclination down through the lighter liquid and terminating at the level at which it is desired to maintain the denser liquid, whereby when the latter gets below that level it unseals the mouth of said tube, the lighter liquid is drawn up to the reservoir, and the denser liquid descends therefrom.

10. In a galvanic battery, an automatic supply apparatus for injecting desaturating-liquid,

consisting of a reservoir of said liquid, a closed outlet therefrom communicating with the solution in the battery, and means dependent on the density of the solution for establishing an outflow from said reservoir, whereby when the solution acquires a predetermined density it is diluted by the injection of a quantity of fresh liquid, which raises the level of the liquid in the battery, in combination with an outflow-siphon leading from the battery, which is started by said rise of level and discharges some of the spent solution until the original levels are restored.

11. The combination, with a galvanic battery, of an automatic supply apparatus adapted to admit to the battery a fixed quantity of desaturating-liquid whenever the solution in the battery rises to a predetermined density, and a recording mechanism constructed to register the number of such admissions, whereby the energy developed by the battery may be ascertained.

12. A galvanic battery consisting of a vessel divided into compartments and constructed with a distributing-canal on the same level with the compartments, and with openings between said canal and said compartments, adapted to establish communication between the respective superposed solutions in the compartments and canal, whereby the solutions shall be of the same densities and stand at the same levels in each of the compartments and in the canal, and positive and negative elements in each compartment, combined with an automatic supply apparatus communicating with a distributing-canal, and adapted to maintain the respective solutions at approximately uniform densities.

13. A galvanic battery consisting of a vessel divided into compartments and constructed with a distributing-canal communicating with the compartments, and the positive and negative elements in each compartment, in combination with an automatic supply apparatus communicating with the distributing-canal, adapted to inject the liquid thereinto whenever the solution in the battery reaches a predetermined density, and an outflow-tube communicating with said canal and adapted to discharge therefrom the spent solution.

14. A galvanic battery consisting of a vessel with upright positive and negative plates, and a porous bag (or equivalent) inclosing the positive plates and communicating at its top and bottom with the external liquids in the vessel, combined with automatic means for supplying fresh liquid to the top of said vessel and for discharging spent liquid from the bottom thereof, whereby the fresh liquid enters said bag at the top, attacks the positive plate, and in becoming charged with metallic salt descends through said bag and flows out therefrom at the bottom.

15. A galvanic battery consisting of a vessel with upright positive and negative plates, and three superposed layers of liquid—viz., a dense solution of salt of the positive plate at the bottom, the solution for immersing the negative plate superposed thereover, and the lighter fresh liquid at the top—and a porous bag (or equivalent) inclosing the positive plate and communicating at its top with the layer of fresh liquid and at its bottom with the layer of dense saline solution, in combination with automatic means for supplying fresh liquid to said vessel by a tube entering the intermediate layer of solution, and operating whenever the lower layer of denser solution rises above the mouth of said tube and flows down the same, and an outflow-tube leading from the bottom of the vessel and adapted to discharge only said dense solution.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

CHARLES EDWARD O'KEENAN.

Witnesses:
ROBT. M. HOOPER,
AMAND RITTER.