(No Model.)

C. P. NÉZERAUX.

SECONDARY BATTERY.

No. 271,732. Patented Feb. 6, 1883.

FIG. 1

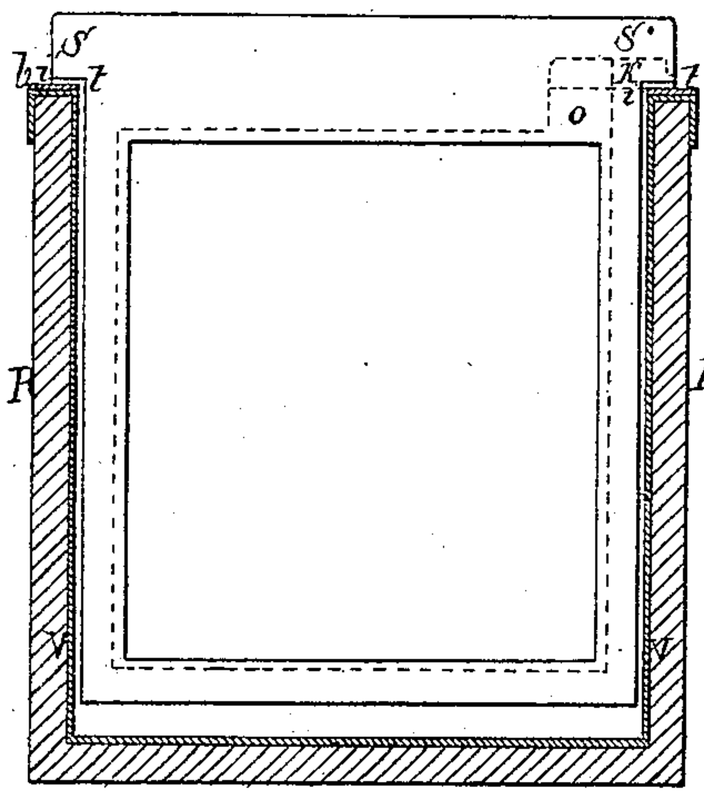


FIG. 2

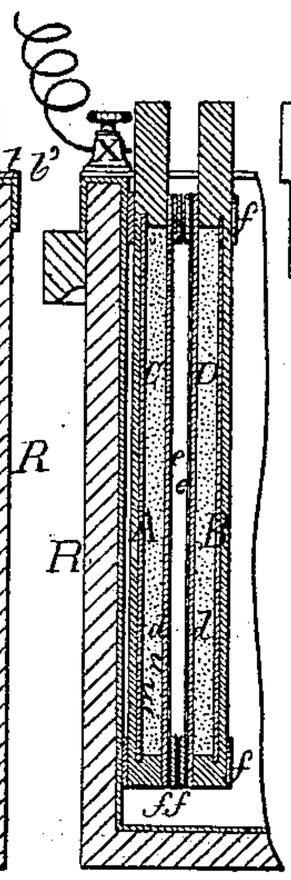


FIG. 5

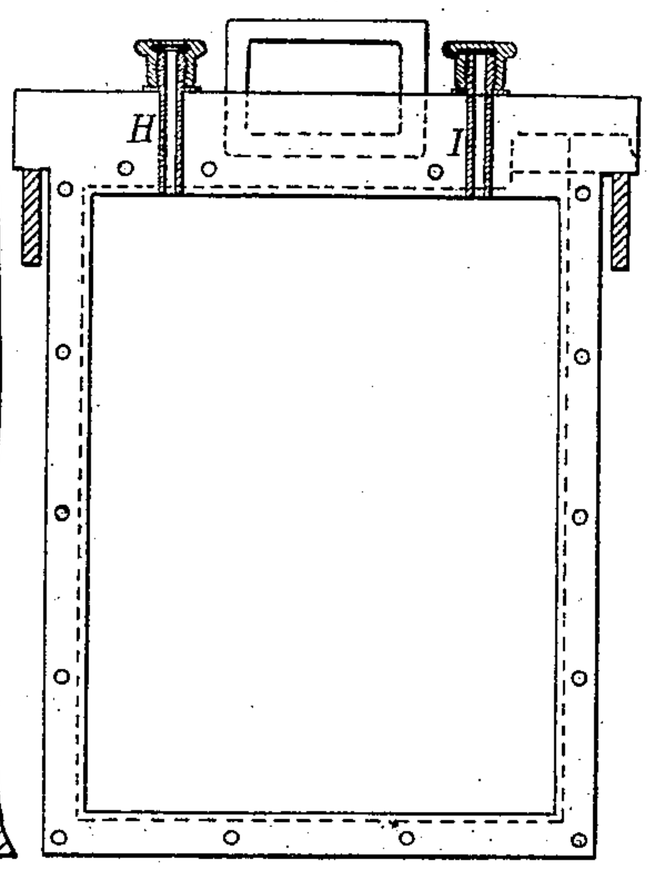


FIG. 6

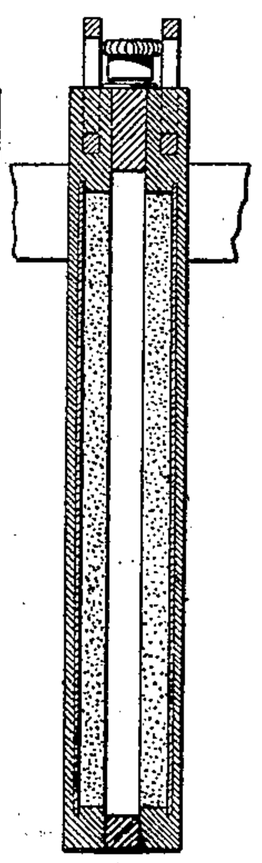


FIG. 7

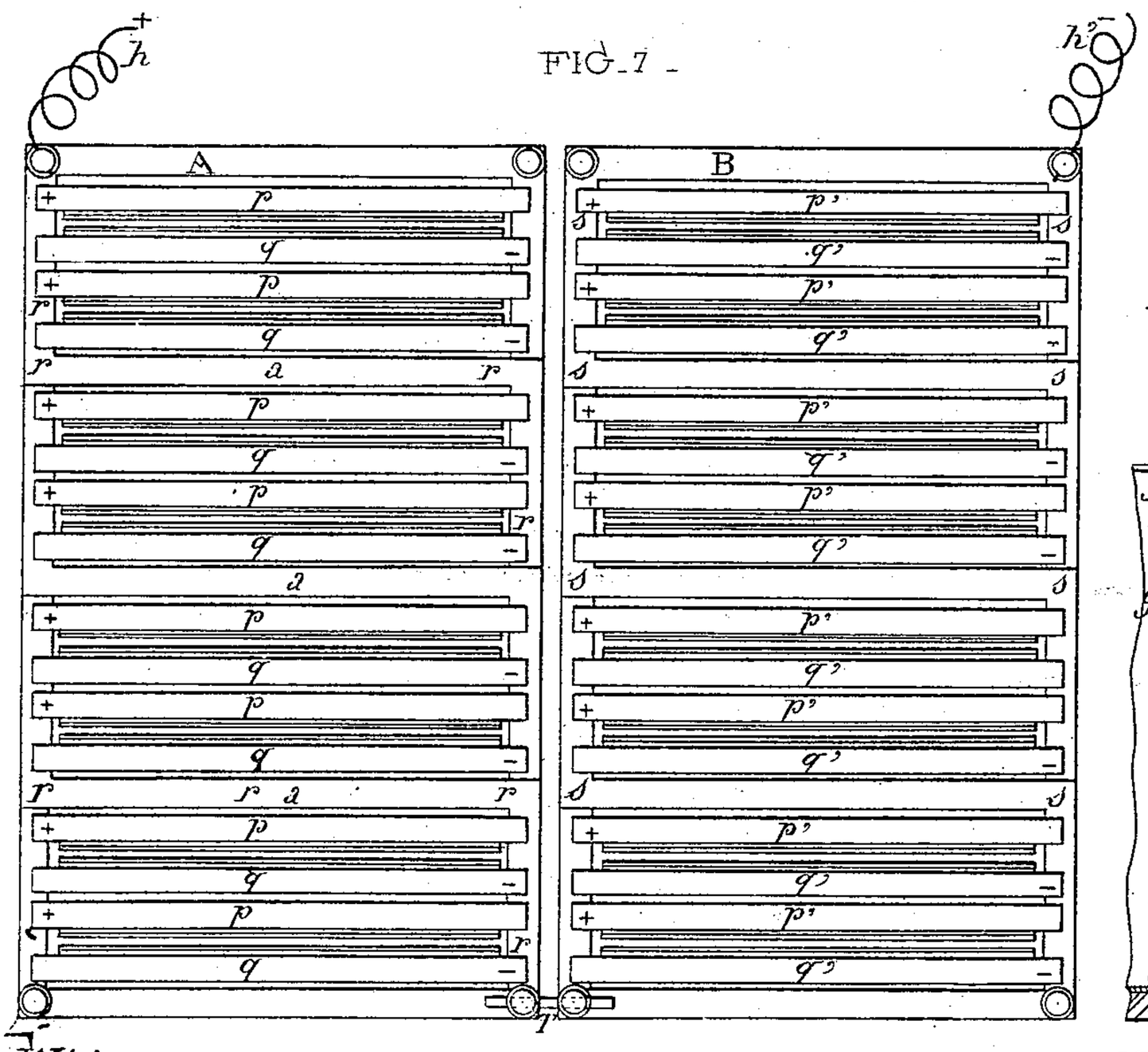


FIG. 3

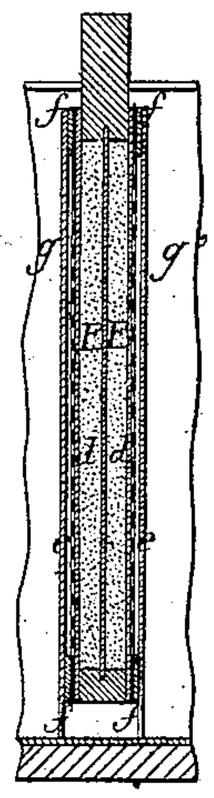
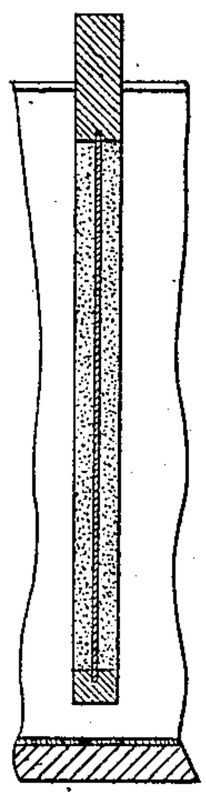


FIG. 4



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UNITED STATES PATENT OFFICE.

CHARLES PLACIDE NÉZERAUX, OF PARIS, FRANCE.

SECONDARY BATTERY.

SPECIFICATION forming part of Letters Patent No. 271,732, dated February 6, 1883.

Application filed September 26, 1882. (No model.) Patented in France June 23, 1882, in Belgium September 2, 1882, and in England June 28, 1882, No. 3,030.

To all whom it may concern:

Be it known that I, CHARLES PLACIDE NÉZERAUX, a citizen of the Republic of France, residing at Paris, France, have invented an Improved Secondary Battery, (for which I have obtained Letters Patent in France, June 23, 1882; Belgium, September 2, 1882; England, June 28, 1882, No. 3,030;) and I do hereby declare that the following is a full, clear, and exact description of the invention, which 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 the letters or figures of reference marked thereon, which form a part of this specification.

According to Monsieur Gaston Planté, the learned French chemist, when two plates of lead, plunged into a bath acidulated with about one-tenth of sulphuric acid, are submitted to the action of a galvanic current of sufficient strength, oxygen appears almost immediately on one of the plates, which becomes covered with a thin layer of peroxide, while, on the other hand, hydrogen quickly appears on the other plate after having reduced the thin layer of oxide with which the same has been covered by its exposure to the air, and if at the end of a few instants the secondary current produced by the apparatus is tried it is found that this current is already very strong, but of short duration. If the primary current is again passed a certain number of times, the poles being reversed, the layers of oxide alternately formed or reduced become thicker and the secondary effects which result are of longer duration and greater intensity. In any case, however, only a very limited thickness can be given to the said layers, so that in order to store up any considerable quantity of electromotive force it is necessary to give a very large extent of surface to the polar plates, which renders the apparatuses heavy and cumbersome. In order to reduce or obviate this inconvenience, Monsieur Faure deposits upon the polar plates of an analogous couple a thicker layer of oxide, which he afterward submits to the primary current. In this way he accumulates a larger quantity of force; but the resistance of the current increasing with the thickness of the layers of oxide (which layers of oxide are bad conductors) causes a notable loss of useful effect, making it necessary to keep the thickness of these layers tolerably small. The Faure battery, therefore, like that of Planté, is heavy and cumbersome.

The two above-named batteries have, besides these, the following inconveniences, which are still more serious: first, they only receive the charge slowly by reason of the feeble relative development of the polar plates, which, as is the case with condensation-surfaces, cannot receive more than suits their extent; second, the number of piles composing a battery cannot be increased or decreased easily and at pleasure without destroying the galvanic current; third, the putting to work is difficult to manipulate, because each pile carries screw terminals, which serve to connect them together by means of conductors, and as the parts in contact easily oxidize it is necessary to clean or revive them often with care, which necessitates long and minute work, for a single badly-conducting contact is sufficient to reduce or even to prevent completely the action of the current; fourth, a fresh supply of electro-motive force cannot be accumulated after discharge without having recourse, as in the first instance, to a sufficient source of electricity acting upon the apparatuses themselves, which renders it absolutely necessary, if the requisite material is not at hand, to transport the batteries to the place where there is a special and suitable apparatus for effecting the charge, unless, indeed, the charging is effected in place by means of conductors—arrangements which give rise to serious complications and produce inferior results.

It is chiefly to remedy the inconveniences above pointed out that I have invented the system of which the following is a description:

Figures 1 and 2 of the annexed drawings represent a couple, in which A and B are two plates of lead, each entirely covered with an adherent thickness of ebonite (caoutchouc durci) or other material fulfilling the same object. The working-surfaces *m n*, however, are not covered with the ebonite, being merely framed therein, such frames projecting beyond the working-surfaces, as shown.

The perfect adhesion of the caoutchouc to the lead plates is easily obtained by baking the plastic material on the metal at a suitable heat in a metallic mold specially arranged for that

purpose. The plates of lead thus inclosed everywhere in a rigid adherent frame require a solidity they would not otherwise have, and are perfectly insulated at all the parts thus covered. Each element of the couple carries at its head the projections *s s'*, which rest on the small metallic strips *b b'*, fixed to the vessel R, which is lined with gutta-percha or lead V and contains the exciting-liquid. These small conducting-strips serve as collectors of the electricity, and are provided for this purpose with conducting terminals Y. The polar plate of each element carries a lug, *o*, inclosed in the thickness of the frame which contains it, except at the line *i t*, where it comes in contact with the strip *b*. This lug is thickened up with a small plate, *k*, of metal soldered thereto. This plate *k* is preferably made of metal which is not easily oxidized, and which is more resisting than the lead, in order to avoid the too rapid wear of the contact part *i t*. The two elements of the couple being exactly similar and placed parallel to each other in the vessel R, the cavities formed by the frames being opposite one another, it will be understood that by the contact of the lugs *o* they will be in communication, the one with the collector *b* and the other with the collector *b'*. It results from this arrangement that without touching the terminals Y and without destroying the galvanic current one may with the greatest ease put in, take out, or change at pleasure the couples of a battery in order to reduce or increase the electro-motive force, and that by means of independent commutators the couples may be connected in tension or in quantity.

In order to place the couples above described in a condition to furnish a certain electro-motive force, I proceed either in a direct or in an indirect manner, according to circumstances. I shall first explain the indirect case, because it is the most interesting from an industrial point of view, and because the direct process will come out as a consequence in the course of the description. Assuming, first of all, that a special manufactory, operating on a large scale and economically, supplies to industrial or other persons who employ my couples powders of lead peroxidized and reduced a certain number of times by a galvanic current—one part finally reduced or metallized and the other part finally peroxidized—I then operate as follows: I fill the cavities C and D in the plates A B, one with reduced or metallized powders mixed with water containing an alkaline salt—such as potassic cyanide, for example—and the other with the peroxidized powders mixed simply with water. I level the pulverulent layers to the frames with a straight-edge, and I place the elements on an inclined plane to facilitate the draining away of the excess of liquid. After an hour or more of draining the layers have acquired a consistence which allows of turning them over. I then put over each layer of powder a woolen cloth, a piece of felt, or other spongy and unattackable material, *d*, and over all a rigid plate, *e e*, perforated with a multitude of small holes, which plate I connect to each element with india-rubber bands *f f*. A couple thus prepared and plunged into a bath acidulated with about one-tenth of sulphuric acid is capable of furnishing during several days a supply of electricity powerful in tension and in intensity. If it is desired to reconstitute this couple when exhausted more or less completely of chemical work, it is sufficient to remove the pulverulent layers from the lead plates with a scraper or other means and to replace them by fresh powders kept carefully in reserve, operating with them as I have just described. The exhausted powders removed as above from the lead plates are taken to the special manufactory, where they are revivified and put into a condition to serve again, and so on indefinitely. It will be understood that this manner of operating removes certain difficulties in practical working.

In order to obtain the powders which are to serve in the formation of my couples, I employ chiefly the three following means:

The first consists in melting the required quantity of lead in an iron vessel, and in adding thereto, after fusion, one or two equivalents of mercury, so that the amalgam remains in a pasty condition after cooling. After having carefully amalgamated the surface of the polar plates of the elements of one or more couples analogous to that already described, I fill the cavities C and D with this amalgam, which I level to the frames with the straight-edge. After the superabundant mercury has drained away, the metallic layers thus obtained are very solid and adhere strongly to the polar plates, whereby any porous devices whatever for holding such layers in place are dispensed with. These couples, being plunged into an acidulated bath and submitted to the action of a galvanic current of sufficient strength, will act as follows: The positive layers will soon become covered with peroxide, beginning on the visible surface, and afterward penetrating the mass in proportion to the galvanic action and driving out the mercury, which falls to the bottom of the vessel. This goes on until the polar plates are reached. At that moment the mercury will have disappeared completely from the peroxidized layers, which will then form a spongy net-work solidly agglomerated. If the electric current is reversed, the amalgamated layers of the other elements will be peroxidized in their turn, while those already peroxidized will be reduced to the metallic state. By reversing the direction of the current a number of times the peroxidized and reduced powders will acquire the maximum of their electro-motive force, which is very great if the discharge is effected with the same couples which have served for storing up the primary work. In order to utilize these agglomerated powders in the couples, the action of which is indirect, they are carefully removed from the frames and lightly ground separately in water to render them

more uniform, and they are afterward delivered for industrial consumption. In order to preserve the reduced powders from oxidation, if they are not used immediately, they are immersed in water containing an alkaline salt—such as potassic cyanide, for example. The peroxidized powders may be simply dried.

The second means consist in melting the required quantity of lead and adding thereto only a third of its weight of mercury. This amalgam, after cooling, is dry and friable, and is ground and sifted. The powder thus obtained is dry to the touch, very permeable, and a good conductor of electricity. Placed in the cavities of the above-mentioned couples, it peroxidizes well, driving off the mercury contained in it, and renders an excellent useful effect, whether the discharge is effected directly or the powders are used in other couples.

The third means consist in rasping pure lead, either by milling in water or by means of a circular rasp having tolerably fine teeth acting on plates of from one to two millimeters thickness, to facilitate the work and to prevent the choking of the teeth of the rasp. The powders thus obtained, placed in my couples, also give good results, but inferior to those of the amalgamated powders.

In order to revivify the powders which have been used, the same process is employed as for the other powders. They are put into special couples and are submitted to the primary current, whereby one part is peroxidized and the other part metallized, after which they are removed and delivered for fresh use. It may be observed that if the work of revivification is effected in heated baths a more economical result is obtained.

From what precedes it will be seen that the more economical the primary source of power is the less will be the cost of the electro-motive force furnished by my couples. Hydraulic machines and steam-engines of great power, working expansively and with condensation, driving dynamo-electric machines, are, I believe, the best adapted for practically resolving in many cases, and in an economical manner, the important problem of power and light by electricity.

Fig. 3 of the drawings represents a double element, the cavities E F of which are filled with powders held in place by the felts *d d*, the perforated plates *e e*, and the india-rubber bands *f f*. *g g'* are plates of porous earthenware, placed between the elements of the couples to prevent polarization by hydrogen.

Fig. 4 represents also a double element, but without felts and perforated plates. Its cavities are furnished with lead powders amalgamated to saturation.

Figs. 5 and 6 represent a couple for direct discharge, in which the vessel which usually contains the exciting-liquid is suppressed. The two elements in this case are connected to another frame, with which they make a tight joint. The object of this other frame is to leave between the porous layers a free space, which is filled with fine sand or other substance. H I are small tubes, each closed with a screw-plug. They serve for filling the hollow space and for saturating the powders with acidulated water. Apparatuses thus arranged are easily handled and occupy little space.

Fig. 7 represents a battery formed of two series of piles, each composed of the same number of couples, *p q* and *p' q'*, separated by the partitions *a a a a* of the vessels A and B. The couples *p q* of the series A are connected in tension by means of the conductors *r r r*, and those of the series B are connected in quantity by means of the conductors *s s s*, the two series being in communication by the conductor T. If the circuit is closed with a dynamo-electric machine, for example, by the conductors *h h'*, a very energetic galvanic current will be produced, which will set the machine in motion, and in proportion as the couples *p q*, connected in tension, accomplish their discharge, the couples *p' q'*, connected in quantity, will receive in return and by accumulation a certain remunerative work. If by means of commutators, and after more or less complete discharge of the couples *p q*, these latter couples, *p q*, are connected in quantity and the couples *p' q'* in tension, an inverse current will be produced in the battery, and the dynamo-electric machine will continue its motion. The result of this combination is that the smaller the loss of useful effect in each discharge the more frequently the galvanic current can be reversed. After exhaustion of these couples they may be reconstituted, either by means of a galvanic current acting directly on the couples themselves or by changing the powders. There may also be added to the piles in tension any number of other piles capable of restoring as it is produced the loss of useful effect of the electro-motive force. The maintenance in this case will only amount to that of the additional piles.

In order to charge my couples by means of a galvanic current, it is not indispensable to soak them in water containing sulphuric acid, as a good result can also be obtained with a solution of sulphate of copper, potash, and certain other acid or alkaline baths.

The form of the apparatuses may be varied according to the purposes for which they are intended. The nature of the materials employed in making the frames may also be varied, according to whether the baths in which the couples are to work are acid, alkaline, heated, or not heated.

The reduced and peroxidized powders employed in my couples for indirect discharge can also be obtained by means of an oxide of lead submitted to the action of the primary current in the revivifying apparatuses, but with less advantage than with the powders in the metallic state.

The small metallic strips serving as collectors may be replaced by mercury-cups, which complete the contact of the couples by means of lugs arranged to dip therein for that purpose.

The arrangements above described are applicable wherever electricity is susceptible of being usefully employed, especially for the production of power or light, or for chemical decomposition, &c.

I claim—

1. The combination of the vessel R and its lining V and metal strips *b b'* with the plate A, having lug *o*, projections *s s'*, and with the plate K and terminal X, substantially as herein shown and described.

2. The hollow plate A, having a filling of metallized lead powder and alkaline salt, and the porous covering *d e*, in combination with hollow plate B, having a filling of peroxidized lead, and a porous covering, *d e*, substantially as herein shown and described.

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ROBT. M. HOOPER.