(No Model.) 2 Sheets—Sheet 1.

A. E. WOOLF.

SECONDARY BATTERY.

No. 418,483. Patented Dec. 31, 1889

Fig. 1.

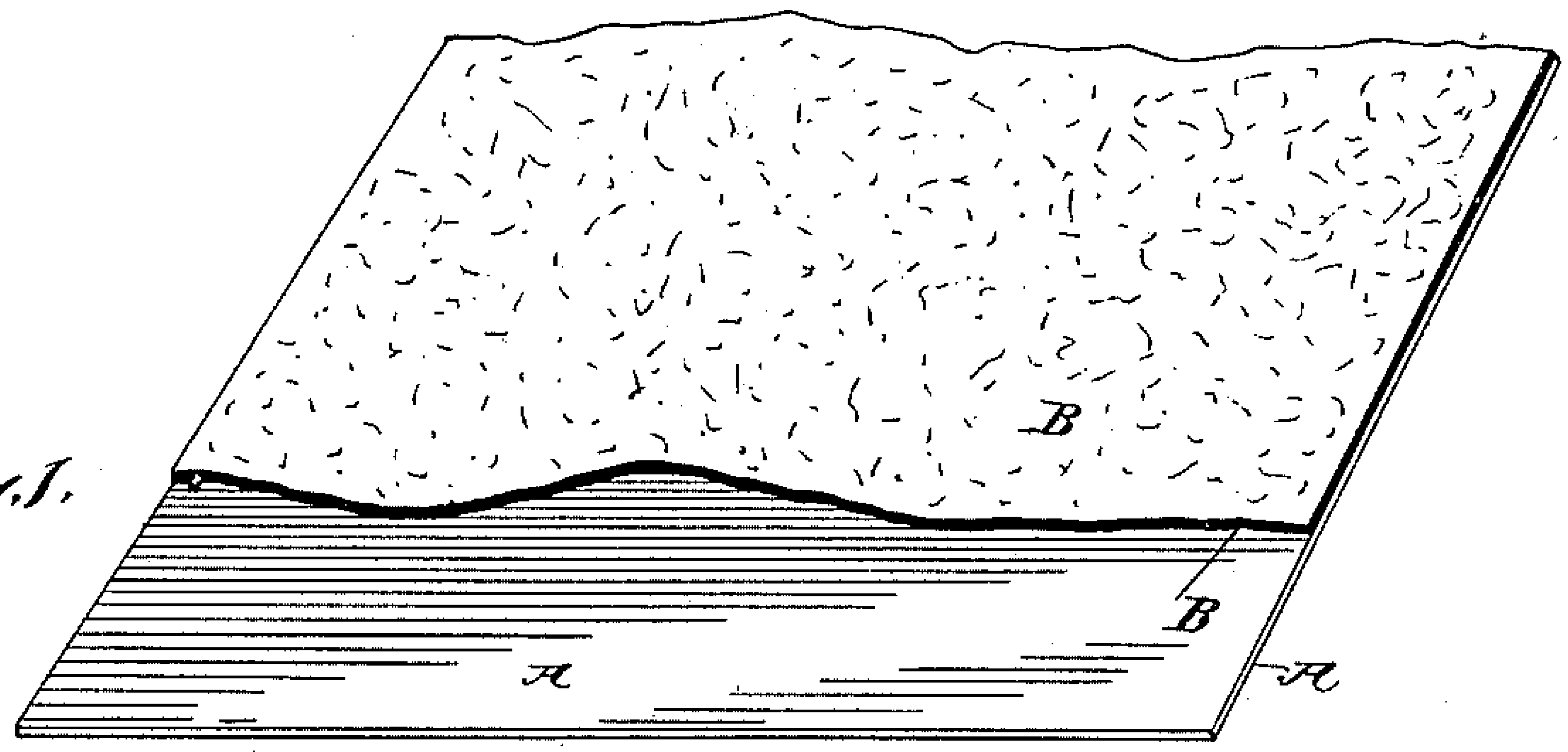


Fig. 2.

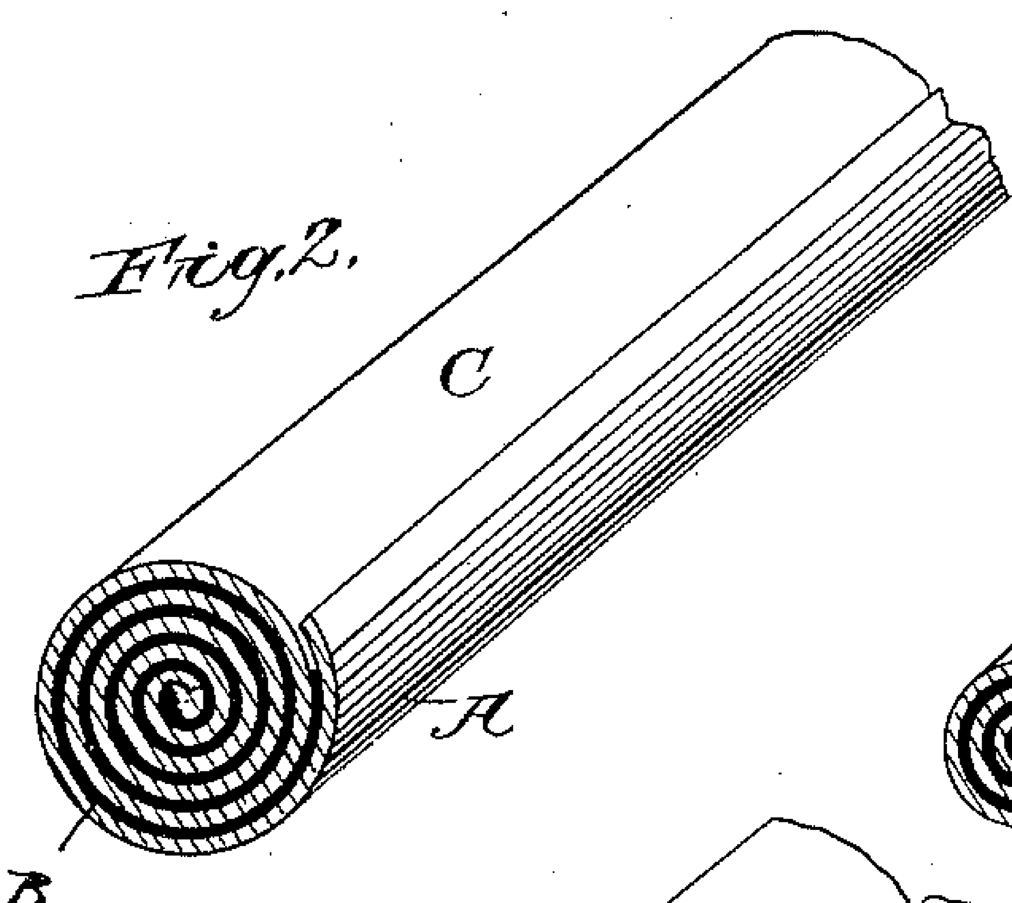


Fig. 3.

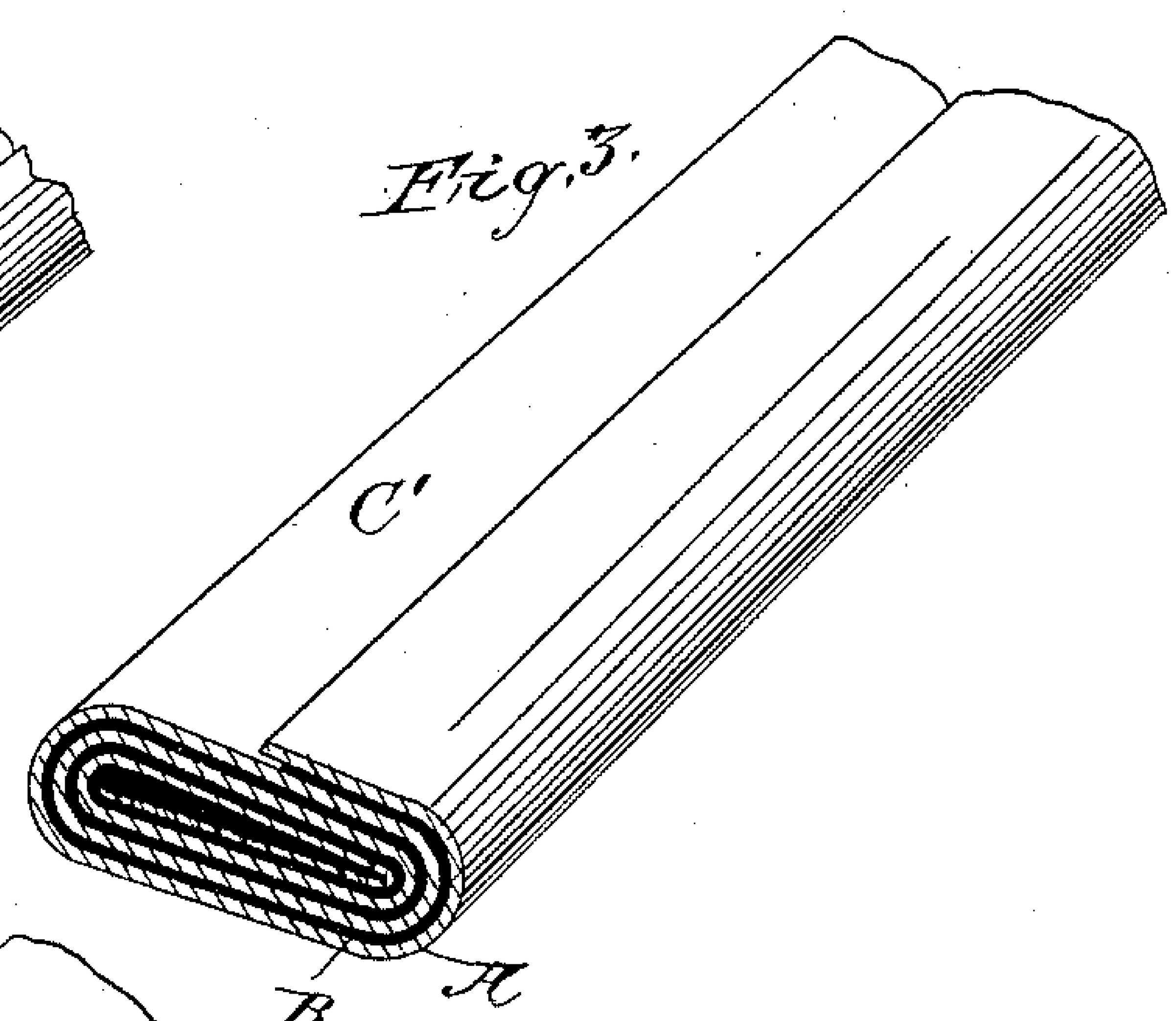


Fig. 4.

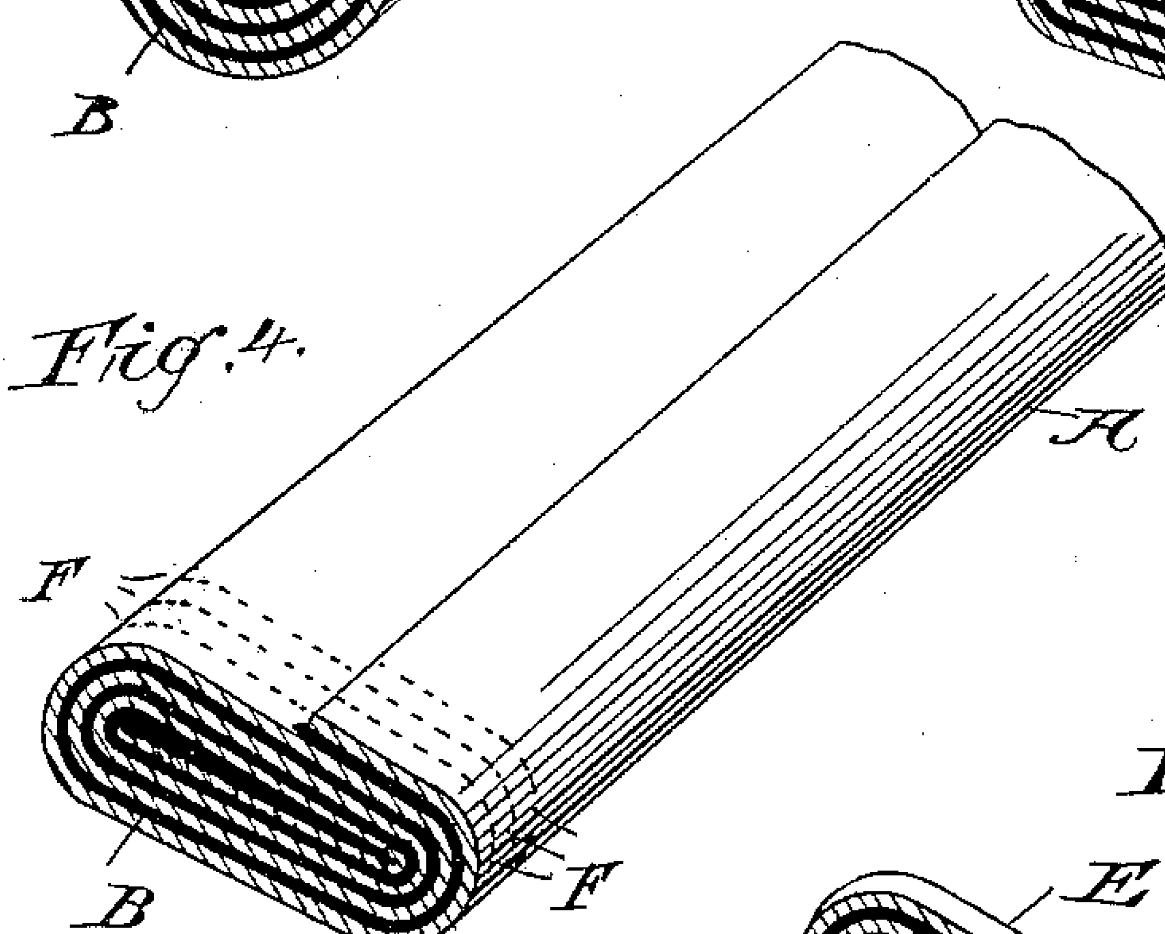


Fig. 4.a

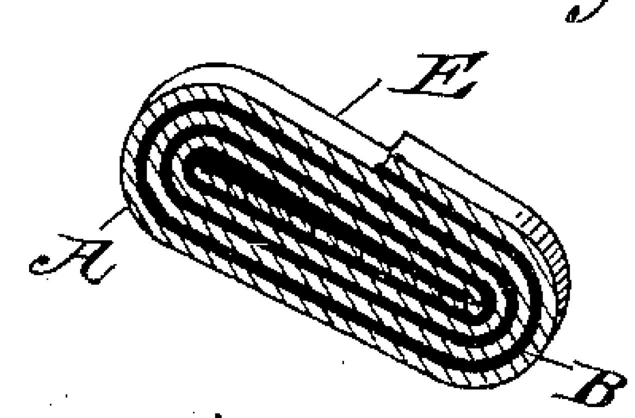


Fig 5

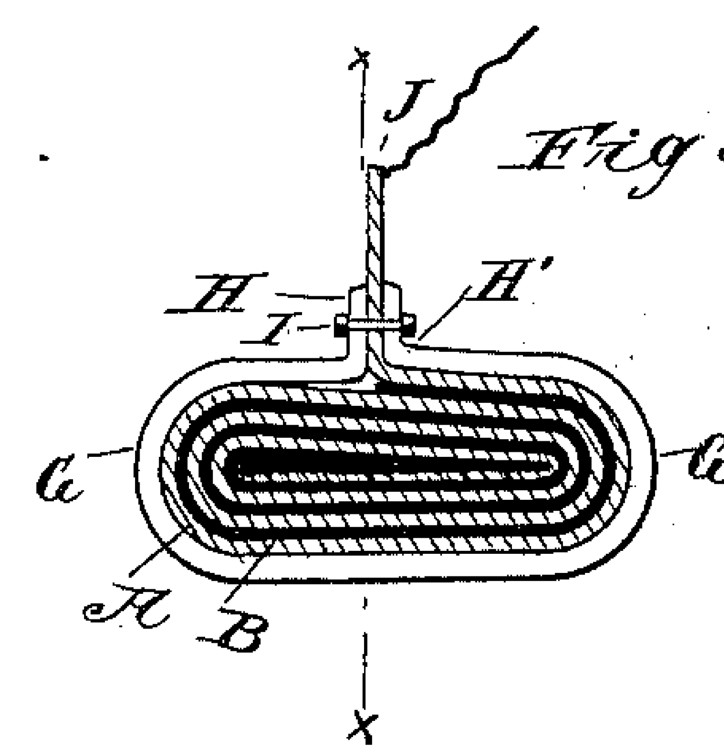
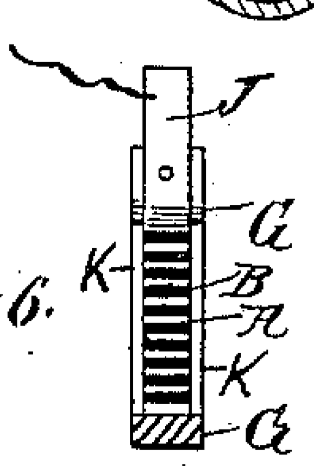


Fig. 6.



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(No Model.) 2 Sheets—Sheet 2.

A. E. WOOLF.

SECONDARY BATTERY.

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Fig. 7.

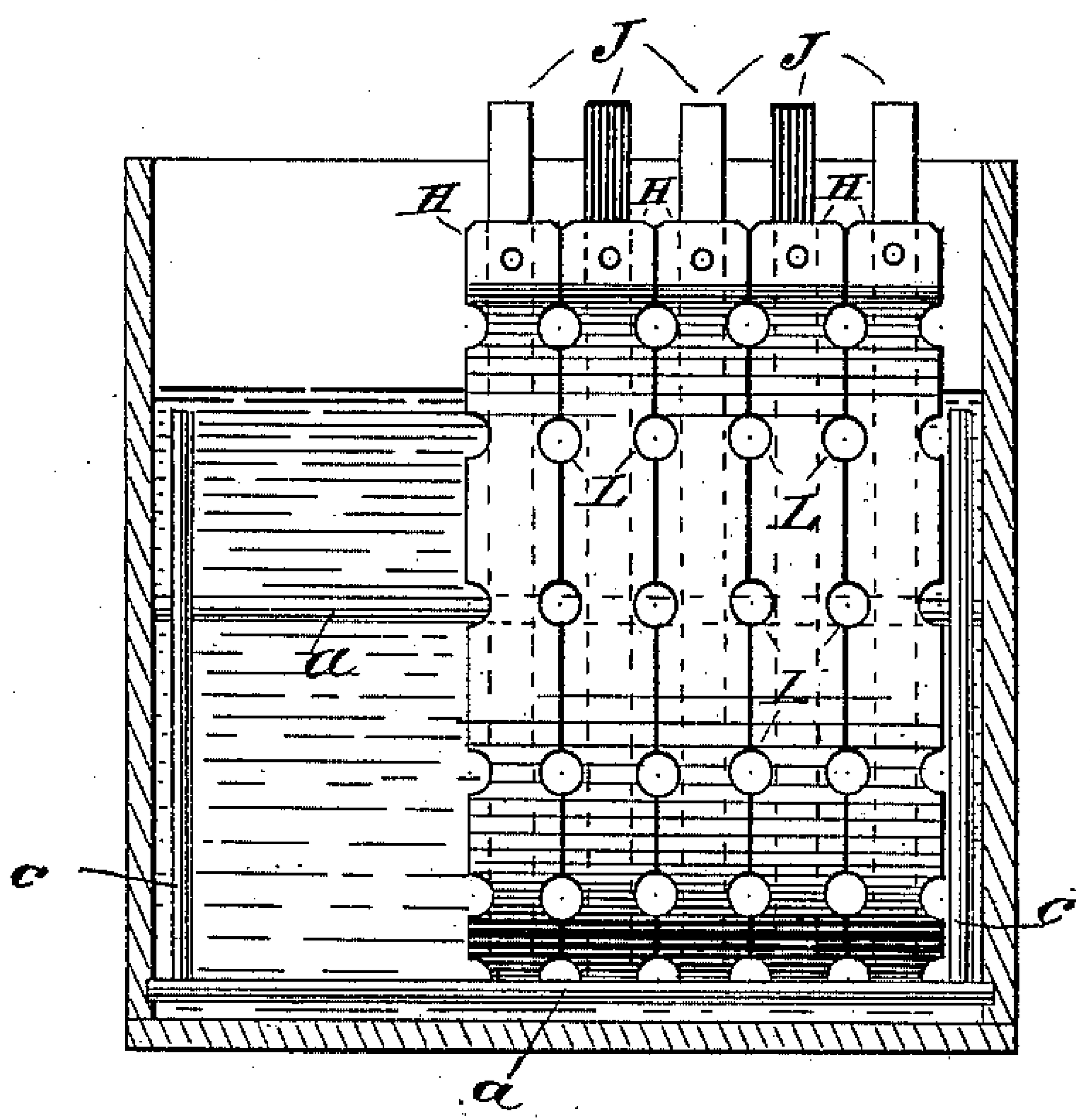
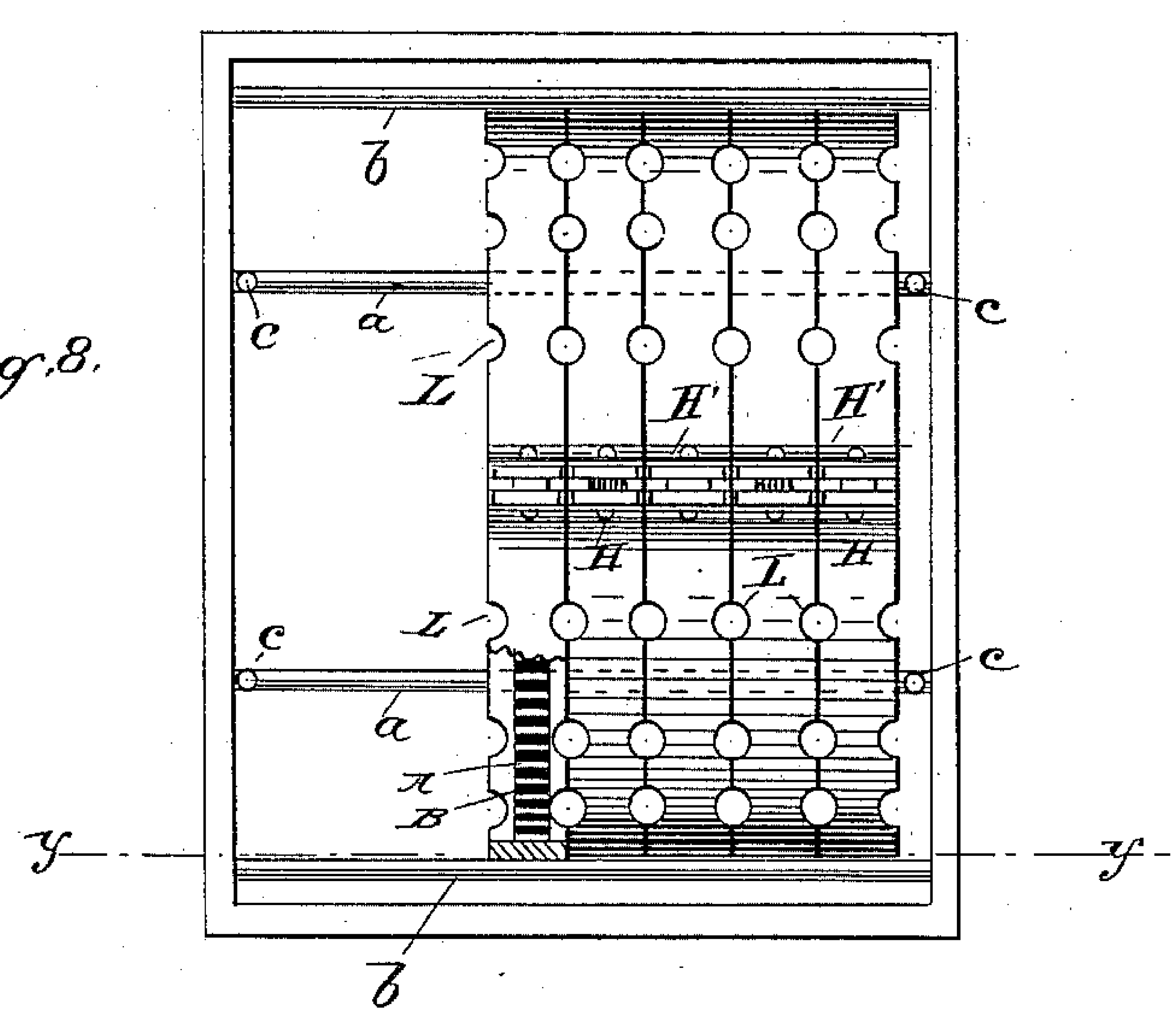


Fig. 8.



WITNESSES:

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Edwin Dusenbury

INVENTOR

Albert Edward Woolf

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his ATTORNEY

UNITED STATES PATENT OFFICE.

ALBERT EDWARD WOOLF, OF NEW YORK, N. Y., ASSIGNOR TO BENNO LOEWY, OF SAME PLACE.

SECONDARY BATTERY.

SPECIFICATION forming part of Letters Patent No. 418,483, dated December 31, 1889.

Application filed June 20, 1889. Serial No. 314,991. (No model.)

To all whom it may concern:

Be it known that I, ALBERT EDWARD WOOLF, a citizen of the United States, and a resident of New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Secondary Batteries, of which the following is a specification.

My invention relates to improvements in plates for secondary batteries; and it consists in the construction of the plates hereinafter described, and illustrated in the drawings, in which the same reference-letters indicate the same parts in all the figures.

Figure 1 illustrates a perspective view of a sheet of lead covered with the "active material" in a flat state, from which sheet so covered I make my improved plates. Fig. 2 illustrates a perspective view of the sheet of lead covered, as shown in Fig. 1, after having been rolled up into substantially cylindrical form. Fig. 3 illustrates a perspective view of the rolled sheet shown in Fig. 2 after it has been subjected to a flattening operation. Fig. 4 illustrates the flattened sheet shown in Fig. 3, from which one of my improved plates has been cut or sawed, as shown at Fig. 4ª. Fig. 5 illustrates an elevation of one of my improved plates having a re-enforcing band of hard rubber or equivalent material placed around it. Fig. 6 illustrates a vertical transverse section of the plates shown in Fig. 5, taken on the line *x x* of that figure. Fig. 7 illustrates a side view of a battery-cell the side whereof has been removed, showing the construction of the cell and the relative position and arrangement of my improved plates when in the cell, some of the plates being omitted. Fig. 8 illustrates a top view of the cell and a few of the plates shown in Fig. 7, partly in section.

The best forms of plates for secondary batteries known prior to my invention, so far as I am aware, are the Julian and the Faure plates. These plates, owing to their peculiar construction, are subject to the following serious objections:

First. The chemical action induced by the current during the operation of "forming" the plates, so called—in other words, the getting them into condition for useful service by repeatedly charging and discharging them electrically—and even after the plates have been "formed," induces a lateral warping or bending of the plates, which is technically called "buckling." This buckling frequently brings contiguous plates into contact with each other, which of course results in short-circuiting the battery.

Second. The buckling of the plates loosens the active material in the "grids," which sooner or later becomes displaced. Thus the plates are injured, if not rendered practically valueless.

Third. When these prior plates have become thoroughly formed and in their most valuable condition for service, because then being specially capable of receiving a large quantity of current, they become exceedingly "foraminated" throughout, so much so that they disintegrate and ultimately fall to pieces of their own weight, and frequently they are destroyed during the period of their greatest value because of jars or like disturbing causes, which break them up.

Fourth. The weight of the plates heretofore in use is much greater than can be conveniently used for practical purposes under many conditions—such, for instance, as a motive power for surface roads or as lighting medium on moving structures—and is greater than is theoretically necessary for giving the desired storage capacity.

Fifth. The expense of the plates heretofore known, owing to their insufficient durability, is relatively much greater than that of my improved plates.

In the manufacture of my plates I proceed as follows:

A is a sheet or plate of lead of the desired thickness, and large enough to be rolled up and then cut into a number of separate plates, as hereinafter set forth.

B is a coating of the active material, preferably litharge, although other equivalent material may be used. It is made into a plastic mass, so that it may be evenly and readily spread upon the lead by admixing it with any suitable liquid substance. I prefer to employ sulphuric acid for this purpose, because there will then be nothing present requiring subsequent elimination. The litharge or its equivalent is spread on the lead to a thickness preferably about equal to the thickness of the lead itself. Then either before or after the litharge has dried, as may be preferred, the sheet of lead is carefully rolled up into the form of a scroll C, (shown in Fig. 2,) the litharge being rolled in, leaving the lead exposed outwardly. It is preferably rolled as tightly as may be, so that the lead on both sides touches the active material. The scroll-like roll is then preferably placed under a suitable press and is squeezed into a somewhat flattened shape, as seen at C′ in Fig. 3. The roll may, if preferred, be put into a suitable former or die during the pressing operation, whereby it will be given such form, square or otherwise, as desired. The application of the pressure to the roll has the effect of bringing all parts of both surfaces of the lead into intimate contact with the active material. The pressed roll is then cut across transversely, preferably with a circular saw, into slices or pieces, which are to form the battery-plates, one of which I illustrate at E, Fig. 4[a], and the lines on which subsequent ones may be cut I also illustrate by dotted lines F. The first and last slices or plates severed from the ends of each roll are not always perfect, owing to the partial displacement of the active material during the rolling and pressing operations. The action of the circular saw is such as to draw down a burr from each layer of the lead throughout the saw-kerf, which, overlapping the active material adjacent to it, holds it more firmly in its place. After the separate plates have been formed as above stated the exposed end of the sheet of lead may be fastened in any preferred manner, as by soldering it, and they may be used as battery-plates in their then condition, if desired; but I prefer to strengthen the plates, thereby very greatly adding to their durability, as follows: G is a hard-rubber band or clasp, which is made of such size as to fit snugly around the outer edge of each plate. The ends of the bands are provided with means whereby they may be drawn together, and preferably the end of the lead clamped between them. I show laterally-projecting ends H H and a cross screw or rivet I, also preferably of hard rubber, for this purpose. The end of the strip of lead shown at J is freed from the active material, and, being bent at substantially right angles from the plate, is held firmly in place between the terminals H H′ of the rubber band or clasp, projecting somewhat beyond them, thus affording a good means whereby the wire connections can be made. The rubber clasp is preferably made somewhat wider than the thickness of the plate. Thus there are laterally-projecting edges K K (see Fig. 6) at each side of the plate. Thus, when the several plates are put in the cell, as seen in Figs. 7 and 8, the rubber bands or clasps may be arranged to touch each other at their edges, whereby movement of the plates in the cell will be avoided, thus reducing liability of fracture. The rubber band or clasp of course insulates each plate from the plates adjacent to it, and in order that the solution may have free access to and circulation among the several plates I form a series of openings L in the edges of the rubber bands, through which the solution can readily circulate. The plates should preferably be supported within the cell upon rubber or equivalent bars *a a* at the bottom and similar bars *b* at the sides, running horizontally, and vertical bars *c* at the ends, running vertically. They may, however, rest on the bottom of the cell, or be otherwise supported.

Also, an important feature of my improvement is, that the several plates which are to constitute the double electrode for the cell may be clamped all together, so as to form one structure, which can be slipped into the battery cell or reservoir and otherwise manipulated, transported, and handled much more conveniently than the separate plates can be.

It will be seen that in addition to the foregoing the employment of the rubber band or clasp greatly increases the durability of the plates, because the rubber, being unaffected by the solution, will remain intact permanently, and will hold or sustain the lead and the active material in their proper place for a long time, irrespective of the degree of their foramination or partial disintegration. It will also be observed that the metal of the strip of lead is in several convolutions throughout the plate, and also that it is presented edgewise to the strain of the buckling action. Thus it is enabled to overcome that action, and even without the strength-giving rubber band the plates are not deflected materially from their proper flat condition. It will of course be obvious that the separate plates may be sawed or otherwise separated from the roll, as shown in Fig. 2, without being flattened or otherwise compressed. I prefer to subject them to pressure, however.

My plates may be made separately by coiling a strip of metal of the desired width into the form of a flat volute, as seen in Fig. 2, at the forward end thereof, and then crowding the active material in place between the several convolutions of the metal. Also, the lead plate, having the active material upon it, as shown in Fig. 1, may be slit into strips of the desired width, and then these strips coiled into flat volute forms, thus forming the plates.

Having described my invention, I claim—

1. An electrode for storage-batteries, comprising, essentially, a strip of metal coated with active material and coiled upon itself in such manner that the active material fills all the space between contiguous layers of the metal, substantially as set forth.

2. An electrode for storage-batteries, comprising, essentially, a strip of flat metal coated

with active material and coiled upon itself flatwise and in such manner that the active material fills all the space between contiguous layers of the metal, substantially as set forth.

3. An electrode for storage-batteries, comprising, essentially, flat metal coated with active material and coiled upon itself in such manner that the width of the metal extends across the plane of the plate, and also so that the active material fills all the space between contiguous layers of the metal, substantially as set forth.

4. An electrode for storage-batteries, comprising, essentially, flat metal coated with active material, coiled upon itself flatwise, and having all the space between contiguous layers of the metal filled with active material and pressed into oblong form, substantially as set forth.

5. An electrode for storage-batteries, comprising, essentially, metallic parts separated by interposed layers of active material, and an exterior sustaining band or clasp, substantially as and for the purposes set forth.

6. An electrode for storage-batteries, comprising, essentially, flat metallic parts disposed in such manner that the width of the metal extends across the plane of the plate, active material between adjacent surfaces of the metal, and an exterior sustaining band or clasp of rubber or other material not acted upon by the solution, substantially as set forth.

7. An electrode for storage-batteries, comprising, essentially, metallic parts separated by interposed layers of active material, and an exterior band or clasp of rubber or other material not acted upon by the solution, and means for drawing the ends of the band together, substantially as set forth.

8. An electrode for storage-batteries, comprising, essentially, metallic parts separated by interposed layers of active material, and an exterior band or clasp of rubber or other material not acted upon by the solution, the band being wider than the metal or the active material, or provided with projections which extend laterally beyond the face of the plate, substantially as set forth.

9. As a new manufacture, a roll from which electrodes for storage-batteries may be cut, consisting, essentially, of a sheet metal coated with active material and rolled up upon itself, so that the active material fills all the space between contiguous layers of the metal, substantially as set forth.

Signed at New York, in the county of New York and State of New York, this 17th day of June, A. D. 1889.

ALBERT EDWARD WOOLF.

Witnesses:
PHILLIPS ABBOTT,
EDWIN C. DUSENBURY.