No. 745,604. PATENTED DEC. 1, 1903.

G. K. HARTUNG.

SECONDARY BATTERY.

APPLICATION FILED SEPT. 16, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.

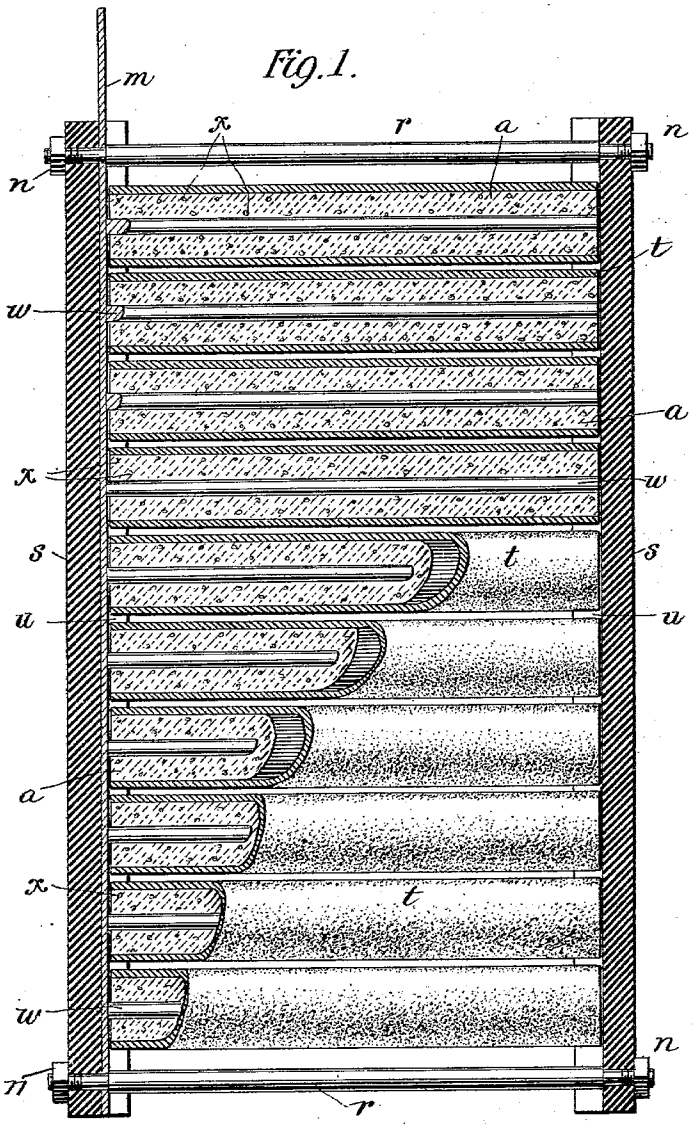


Fig. 2.

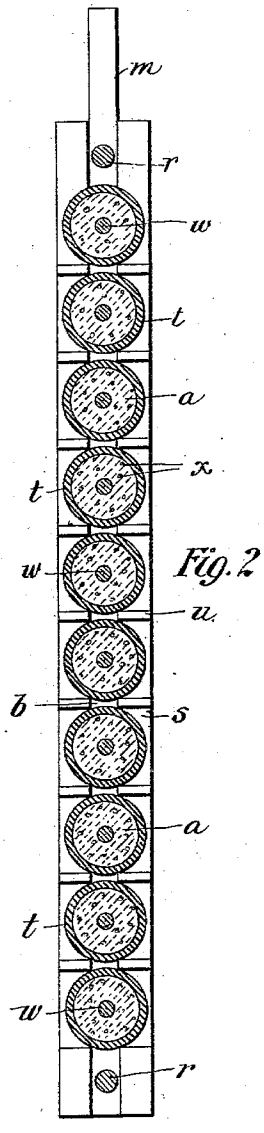
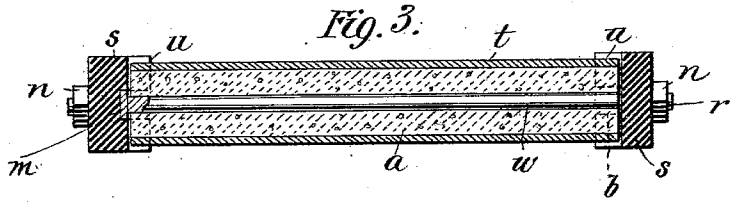


Fig. 3.



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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 5.

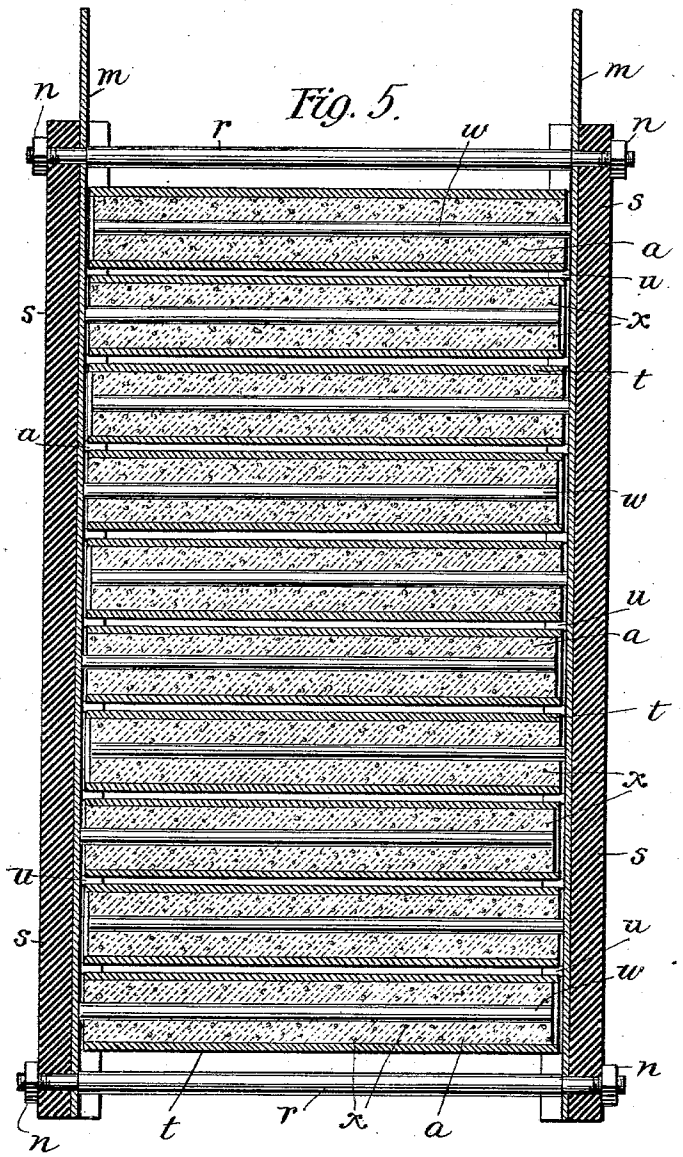


Fig. 4.

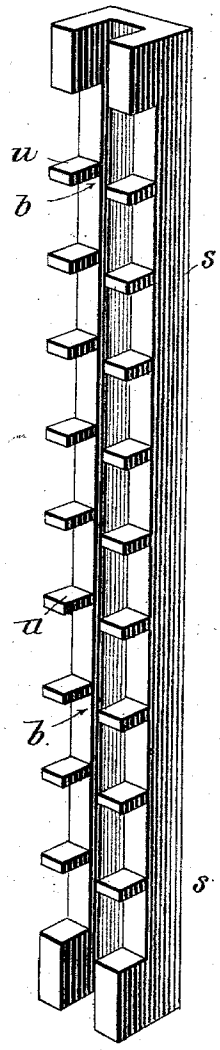
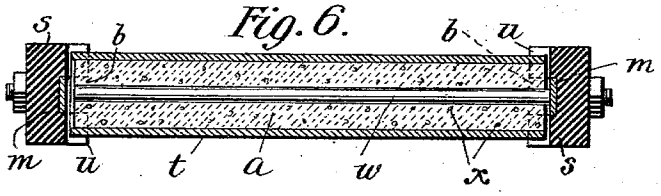


Fig. 6.



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 8.

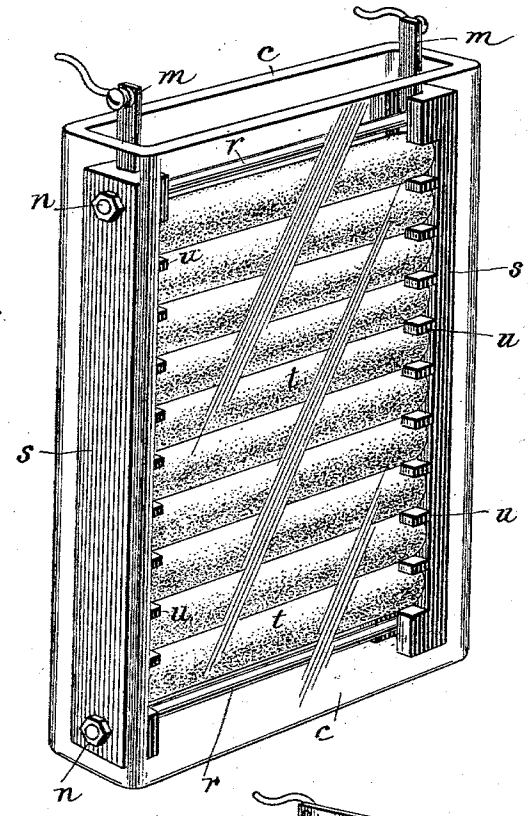
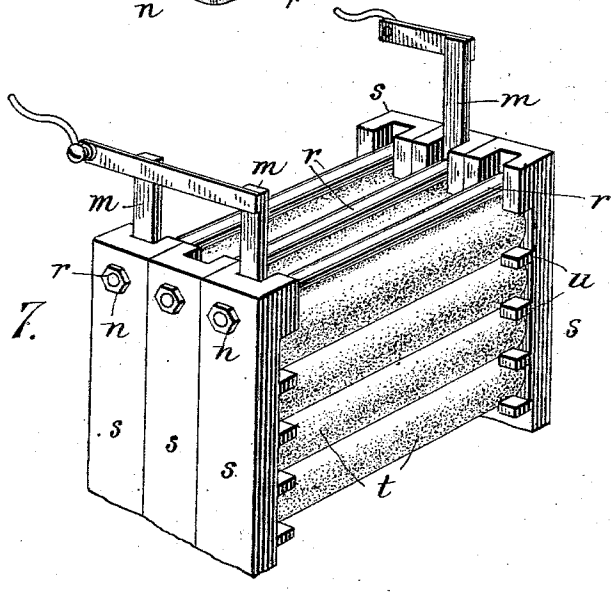


Fig. 7.



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No. 745,604. Patented December 1, 1903.

UNITED STATES PATENT OFFICE.

GUSTAVE K. HARTUNG, OF NEW YORK, N. Y., ASSIGNOR TO JOHN KNOBLOCH, OF NEW YORK, N. Y.

SECONDARY BATTERY.

SPECIFICATION forming part of Letters Patent No. 745,604, dated December 1, 1903.

Application filed September 16, 1903. Serial No. 173,360. (No model.)

To all whom it may concern:

Be it known that I, GUSTAVE K. HARTUNG, a subject of the Emperor of Germany, residing in the city of New York, county and State of New York, have made certain new and useful Improvements in Secondary Batteries, of which the following is a specification.

My invention is an improvement in the structure of the secondary or storage battery or "accumulator," as it is called.

The object of my invention is to increase the durability of the battery, to minimize the cost, and to provide a battery that is adapted for transportation or mobile operation.

The battery element or plate devised by me is composed of a series of tube-sections of porous earthenware, held in the same plane, every tube being parallel and equidistant from every other tube, thus equalizing the work and activity of each. Each tube contains the material to become active, usually an oxid of lead, mixed with resilient subdivided inactive material, like finely-divided cork or pure rubber. This obviates the difficulty due to the expansion of the material to become active, which would otherwise result in splitting the tubes, and the resilience of this novel inactive material tends to maintain good contact between the material to become active and the section of bare conductor embedded therein. These sections of conductor are electrically united and grouped as may be desired to form the elements. The tubes to form an element are supported in a frame consisting of two strips of greater breadth or width than the diameter of a tube. These strips are clamped to the ends of a number of tubes by bolting the strips together, thus holding the tubes in a plane, usually vertical, equidistant and parallel. The excess in width of the strips over the diameter of a tube fits the strips to act as separators between adjacent elements and avoids the use of independently-movable separators.

I provide an improved form of cell for mobile or movable use by arranging a number of the described tubular elements in a plane, fixed in a frame, and connecting alternate elements together in two series to form the positive and negative elements, respectively, I inclose these elements in a cell arranged vertically. By means of the described structure and arrangement the displacement of the active material and the "wash" of the electrolyte is absolutely avoided and the durability and efficiency of the battery for locomotive power purposes is greatly increased.

The accompanying drawings illustrate my invention.

Figure 1 is a vertical elevation, partly in section and partly broken away to clearly show the structure. Fig. 2 is a central vertical cross-section. Fig. 3 is a horizontal cross-section through one of the tubular elements. Fig. 4 shows one member of the supporting-frame. Fig. 5 is a vertical cross-section showing alternate tubular elements electrically united in two series. Fig. 6 is a cross-section showing the last-named electrical connection. Fig. 7 shows three elements assembled to form a complete cell, the frame serving the purpose of separator and frame combined; and Fig. 8 shows a complete cell, including electrolyte and inclosing cell, the tubular elements arranged in two series of opposite polarity.

The tubular element is composed of a tube or cylinder *t* of porous unglazed earthenware. Material to become active—an oxid of lead *a*—is placed inside this tube *t* and is mixed or mingled with a yielding resilient inactive material, such as finely-divided cork or pure rubber *x*. This yields when the material to become active expands and prevents cracking or fracturing the tubes *t* during the process of charge or chemical change in the material incident to immersion in the electrolyte. Within the tubes *t*, preferably in the center, in the line of the major axis is a rod or wire of conducting material *w*. I prefer lead or an alloy of lead and antimony. A series of these tubes *t*, filled as described, are fixed in a vertical plane by means of a frame composed of two strips *s*, having shelves *u* arranged equidistantly and divided, as at *b*, to receive the connecting strip or lug *m* and support the tubes *t*. These strips are of greater width or breadth than the diameter of a tube *t*, (see Fig. 2,) being thus fitted to act as separators and hold the parallel series of tubular elements in a plane.

r is a bolt, and *n* is a nut, preferably of non-

conducting material, such as hard rubber. These bolts *r* (in pairs) and nuts *n* unite the strips *s* and clamp them firmly against the opposite ends of the tubular elements.

In Fig. 1, *m* is a lug which is electrically connected at one side to the series of bare conductor-sections *w*. With this arrangement all the tubular elements would be of the same polarity. As shown in Fig. 5, there are two lugs *m*, and the tubular elements are divided in two series, one series alternating with the other. One series of these tubular elements is electrically connected to one lug *m*, and the other alternate series is connected to the other lug *m*. In this latter arrangement alternating tubular sections would be of opposite polarity.

In Fig. 7 I have shown three elements assembled. It is to be noticed that the strips *s* act as separators. The assembled elements closely fit the inclosing cell and are thus held in a fixed position, or they may be clamped together in any well-known manner.

In Fig. 8 a single compound element is shown, the mechanical construction being the same; but the tubular elements are divided in two series to form the positive and negative elements. Each series is electrically united to its own lug *m*. The compound element is immersed in an electrolyte, such as sulfuric acid and water, and placed in the inclosing cell *c*.

What I claim, and desire to secure by Letters Patent, is—

1. In a secondary battery, an element consisting of a series of porous earthenware tubes, a section of conductor within each tube, material to become active within the tubes, surrounding said conductor-sections, a frame of insulating strips or sections in width greater than the diameter of a tube, mechanically uniting the tubes in a vertical plane and electrical connections uniting said conductor-sections with the battery-terminal.

2. In a secondary battery a plate or element consisting of a series of porous earthenware tubes, a frame composed of separable strips or sections in which said tubes are supported equidistantly in a vertical plane, material to become active in the tubes, a bare conductor-section in each tube embedded in said material, and a separable, electrical connection uniting the series of conductor-sections.

3. In a secondary battery an element including one or more porous tubes of insulating material, active material mixed with a resilient, subdivided, inactive material in said tubes, conductor-sections embedded in the material in each tube and means for electrically uniting said conductor-sections.

4. In a secondary battery, an element containing a conductor, embedded in active material mixed with resilient subdivided inactive material.

5. In a secondary battery an element containing a conductor embedded in active material mixed with resilient subdivided inactive material held in position by a porous inclosing medium.

6. In a secondary battery element a conductor embedded in active material mixed with resilient, subdivided, inactive material and enveloped in a case or covering of porous earthenware.

7. In a secondary battery element a conductor embedded in active material mixed with numerous small sections of cork and held in position by a porous inclosing medium.

8. In a secondary battery the combination of a series of porous tubes each containing active material and a section of bare conductor, means for electrically uniting said conductor-sections with the battery-terminal, a frame including two strips of insulating material having a width greater than the diameter of a tube with receptacles for the tube-terminals and means for clamping said strips together and to said tubes.

9. In a secondary battery an element including a series of porous tubes each containing material to become active and a section of bare conductor combined with a frame consisting of two strips of insulating material in width greater than the diameter of a tube and means for clamping said tubes in a vertical plane.

10. In a secondary battery the combination of two or more elements including a series of porous tubes containing material to become active and a section of bare conductor; a frame for each element consisting of two strips of insulating material of greater width than the diameter of a tube, shelves to receive the ends of the tubes and means for clamping said strips upon opposite ends of a number of tubes whereby said tubes are held in a vertical plane, equidistant from adjacent similar elements.

11. In a secondary battery a series of porous tubes each containing material to become active and a section of bare conductor, a frame in the form of separable strips or sections for clamping or holding said tubes in a vertical plane, and means for separably, electrically connecting said tubes and conductor-sections in two series whereby such positive and negative elemental parts alternate.

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