No. 797,110. PATENTED AUG. 15, 1905.

G. K. HARTUNG.

STORAGE BATTERY.

APPLICATION FILED APR. 30, 1904.

4 SHEETS—SHEET 1.

Fig. 1

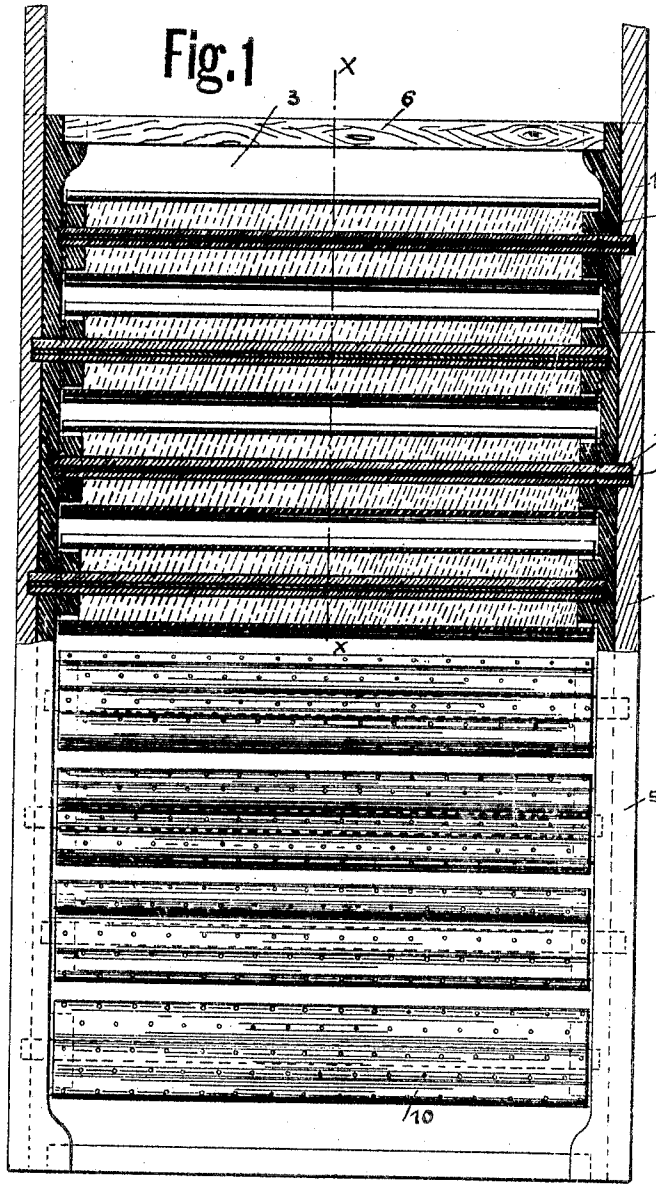
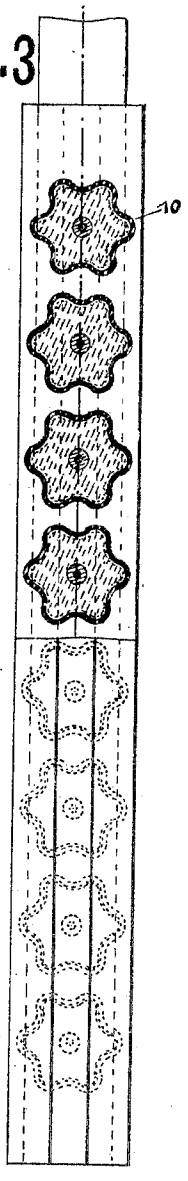



Fig. 3



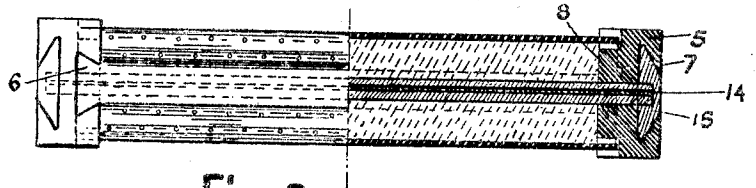




Fig. 2

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By his Attorney C. W. Edwards

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4 SHEETS—SHEET 2.

Fig. 4

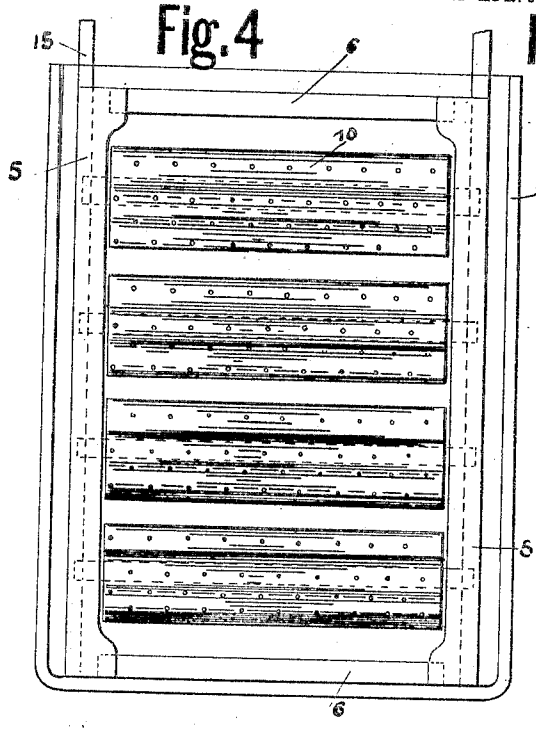



Fig. 6

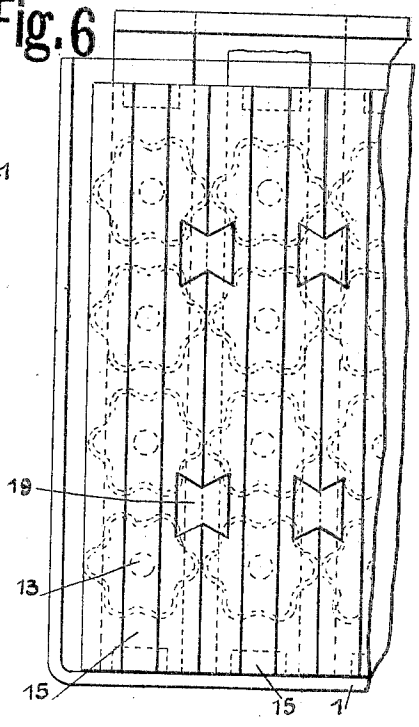



Fig. 5

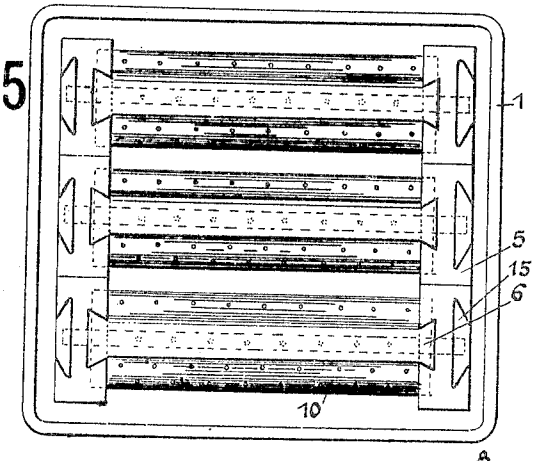



Fig. 7

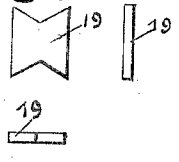



Fig. 8

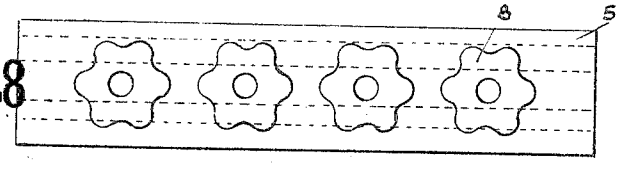
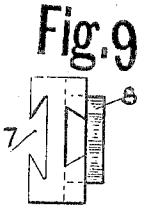



Fig. 9



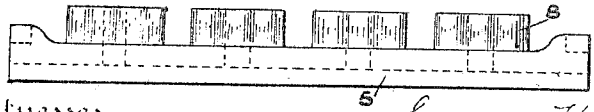




Fig. 10

Witnesses
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4 SHEETS—SHEET 3.

Fig. 11

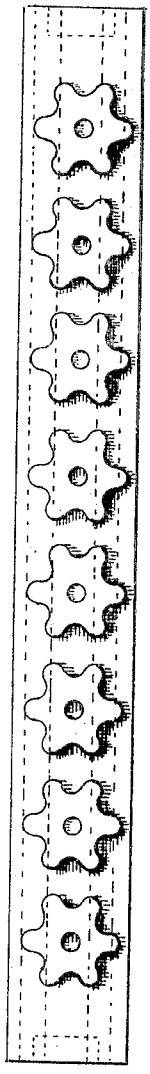

Fig. 12

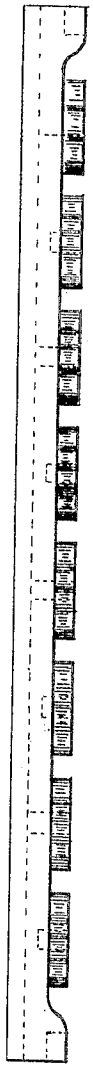

Fig. 13

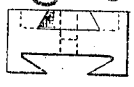

Fig. 14

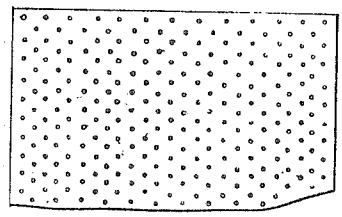

Fig. 15

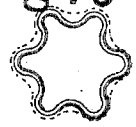

Fig. 16

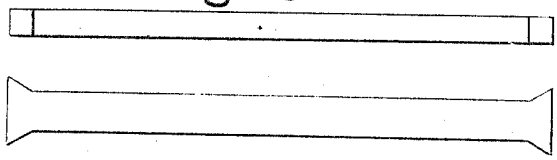

Fig. 17

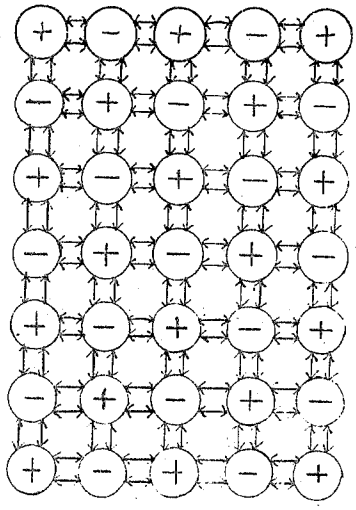

Fig. 18

Witnesses
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4 SHEETS—SHEET 4.

Fig. 19

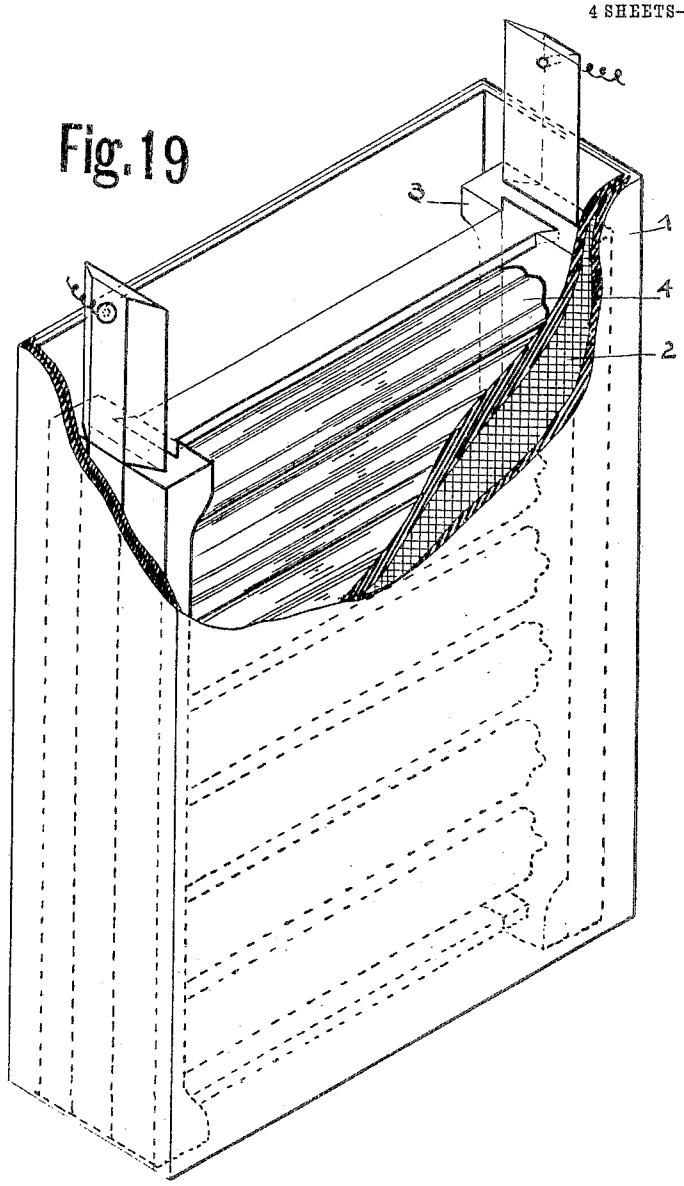
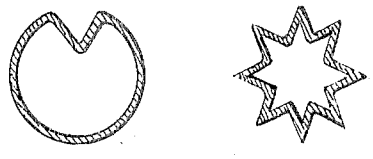



Fig. 20



Witnesses
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# UNITED STATES PATENT OFFICE.

GUSTAVE K. HARTUNG, OF NEW YORK, N. Y.

## STORAGE BATTERY.

No. 797,110. Specification of Letters Patent. Patented Aug. 15, 1905.

Application filed April 30, 1904. Serial No. 205,764.

*To all whom it may concern:*

Be it known that I, GUSTAVE K. HARTUNG, a subject of the Emperor of Germany, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Storage Batteries, of which the following is a full, clear, and exact specification.

This invention relates to storage batteries of the Faure type, and more particularly to improvements in the construction of the grid or supporting structure for the active material, whereby a lighter battery is secured having increased output and durability. Batteries of this system are objectionable because of the tendency of the active material to become detached from the supporting structure or grid by expansion and contraction in charging and discharging, and also because the grid itself, being usually made of lead, is disintegrated by electrolytic action and gradually disintegrates with continued use. These lead plates or grids are furthermore objectionable because of their low conductivity, which necessitates a large increase in weight. These objections render this type of battery unreliable and open to serious objection in commercial service and their economic life uncertain.

The objects of this invention are to provide means for overcoming the aforesaid objections and to provide an improved supporting-frame for the battery elements in which the parts subject to renewal shall be reduced to a minimum. To accomplish these objects, I propose to do away with the use of metallic grids for supporting the active material and instead to place the active material in expansible tubes suitably mounted in frames and electrically connected to the terminals of the battery. Preferably the tubes will be composed of non-conducting acid-proof material, and carbon rods will be embedded in the active material to conduct the current to and from the elements. The use of carbon in this connection is especially advantageous, as it is a good conductor and is not attacked by the electrolytic action. The frame is composed of non-conducting acid-proof material and supports the tubes containing the active material. The ends of the carbon rods project through the sides of the frame and are electrically connected together by conductors carried by the frame which are led to the battery-terminals. In this manner a battery is provided which contains little or no metal and which is light in proportion to its output and which can be charged and discharged at a high rate without injury.

The invention will be more fully described in connection with the accompanying drawings, in which—

Figure 1 is a composite view of my improved storage battery, partly in section. Fig. 2 is a top plan view of Fig. 1, partly in section. Fig. 3 is a side view of Fig. 1, partly in section, as indicated by line X in Fig. 1. Fig. 4 is a side view of a complete battery wherein three grids are employed, it also shows each tubular element connected to charging and discharging mains. Fig. 5 is a top plan view of Fig. 4. Fig. 6 is a fragmentary transverse view of Fig. 4, showing the method employed in securing the grids to each other. Fig. 7 shows coupling-keys employed to unite the separate grids in one structure. Fig. 8 shows one of the side bars of the frame. Fig. 9 is an end view of Fig. 8. Fig. 10 is a side view of Fig. 8 and shows the projections which carry the tubular elements. Figs. 11, 12, 13 are also views of side bars of the frame, showing method employed to connect each alternate tubular element to conducting-main when positive and negative elements are employed in a single frame or grid. Fig. 14 is a part of the flexible material of which tube is made showing perforations. Fig. 15 is an end view of a perforated form of tube, the broken lines indicating how the tube can expand if internal pressure is applied. Figs. 16 and 17 shows cross-bars employed in the grid-frame. Fig. 18 is a diagrammatic view of a five-grid battery wherein negative and positive electrodes are carried in each frame or grid. Fig. 19 is a perspective view of a complete battery containing a single grid, and showing the preferred form of jar partly in section. Fig. 20 shows cross-sections of modified tubes which may be used.

In general aspects the battery of this application resembles that described in Letters Patent No. 745,604, issued to me December 1, 1903. In the battery of this patent the active material is contained in tubes composed of porous earthenware mounted in a frame and suitably connected together. In order to provide for the expansion of the active material, it is mixed with a yielding substance which would contract with the expansion of the active material. In the battery of this invention the tube is constructed of material which will yield to the internal pressure of

the active material and is preferably corrugated for this purpose.

In the several figures similar characters of reference are employed to designate identical parts.

5 5 and 6 6 represent the frames, composed, preferably, of incombustible insulating material, such as impregnated wood or other insulating material. The conductors 15, which connect the elements, are preferably made of lead or its alloys. The corrugated and perforated tubes 10 are preferably constructed of hard vulcanized rubber or celluloid of such thickness as to yield with the pressure of the material. The active material contained within the tubes may be peroxid of lead. The inclosing medium or casing 1 may be of any acid-proof material—such as glass, celluloid, or vulcanized rubber—and the electrolyte may be composed of dilute sulfuric acid. These constitute the principal parts of a storage battery embodying my invention.

1 represents a battery-jar composed of two layers of hard rubber or other material with a layer of textile fabric 2 between in order to prevent breakage. In batteries used for traction purposes this construction is especially advantageous.

3 represents a frame carrying the elements 4. Each frame 3 comprises the side bars 5 5 and end bars 6 6, composed of porcelain or other inert material. As may be seen in Fig. 1, the end bars are dovetailed into a corresponding socket in the ends of the side bars. Each side bar 5 has a groove 7 in its back face and carries lugs or projections 8 on its front or inside face. The lugs 8 may be shaped to correspond with the cross-section of the tubes 9, so as to center the tubes and form a support to prevent lateral movement. Each element comprises an outer corrugated tube 10, which is held in position by the lugs 8 and the side bars 5 5. It will be seen that the tube is closed in such a manner that it is free to expand and contract without permitting the active material to escape. This end closure at the same time may form a support for the tube, as herein shown. These tubes are so constructed as to be expansible when the active material contained therein expands and to contract to its original form when the internal stress is removed. To this end I propose to construct the tubes of thin celluloid, rubber, or other material not attacked by the electrolyte which will yield to the internal stresses in the active material occurring in charging and discharging. In case celluloid or similar impervious material is used it will of course be perforated, as shown in Fig. 14, so as to bring the electrolyte into contact with the active material, the essential feature being that the tube act merely as a retaining means for the active material and interfere with the access of the electrolyte thereto as little as possible. By corrugating the tube, as herein shown, a considerable degree of expansion can be secured, depending upon the number and depth of the corrugations and also a constant area of surface. It will be obvious that an expansible tube may be constructed in other ways than by corrugating it, and Fig. 20 shows modifications of tubes which may be used. Another feature of advantage resulting from the use of corrugated tubes resides in the fact that a large increase in surface is secured which enables this battery to have a very high charging and discharging rate as there will be no danger of injuring the electrodes on account of too large input or output, and the distortion is taken up in such a manner as not to affect the elements.

Each of the lugs 8 is centrally bored in order to receive a conducting-rod 13. This rod is preferably made of carbon because of its greater conductivity for a given weight than lead or other metals which could be used.

14 is a lead or alloy wire which may be placed in the carbon-core, so that in case of breakage of the core the circuit will not be interrupted. The lead wire is protected from corrosion by the carbon rod. As has been before stated, each of the side frames has a groove 7, preferably dovetailed, as shown, into which the ends of the rods 13 project.

15 is a conductor which connects all of the rods 13 of like polarity. The conductor 15 is preferably molded or melted into the groove 7, so as to form close contacts with the rods 13. The conductor may be molded in paste form, composed of powdered carbon and a binding material, the latter being afterward electrically carbonized, or a fusible metal may be run in the groove and afterward covered with insulation where exposed to the acid. In this manner a good contact is formed between the rods and the conductor 15, and it is not subject to deterioration or attack by the electrolyte or electrolytic action. The frames may all contain elements of like polarity, in which case only one side frame need carry the conductor 15, or the elements may alternate in polarity, in which case the opposite conductors 15 will have opposite polarities and connect alternate elements.

Figs. 4, 5, and 6 show elements of like polarity connected on both sides, thereby securing more even distribution of the current. In this case the wire in the carbon rod may be dispensed with. It will be noticed that where a frame carries elements of opposite polarities only those rods of like polarity project through on the same side of the frame. Where it is desired to group a number of frames together to form large units, it is desirable to couple the frames together, and this can be done by means of dovetail keys 19, which can be set into suitable recesses in the side bars (see Fig. 14) to lock as many as may be desired together.

From the foregoing description it will be seen that I have devised a battery which will contain a minimum of metal and be light in weight. I have also described a battery which will be capable of a high charging and discharging rate, because of the expansible tubes, with consequent increased durability, without danger of injuring the electrodes. The destructible parts are also reduced to a minimum, and in rebuilding the battery but few new parts, aside from the active material, would have to be supplied.

The invention is capable of modifications and changes without departing from its scope, and I do not, therefore, limit myself to the exact construction I have shown and described.

Having thus described my invention, I declare that what I claim as new, and desire to secure by Letters Patent, is—

1. In a secondary battery, an electrode comprising an expansible tube and a conducting-rod of non-metallic material having a metallic core, embedded in said material, substantially as described.

2. In a secondary battery, the combination with a non-conducting frame, of electrodes mounted therein and having conducting portions projecting through one side of the frame, a conductor molded around said projecting ends, said frame having means for holding said conductor in position, substantially as described.

3. In a secondary battery, the combination of a plurality of frames having electrically-connected elements mounted therein, and dovetail keys for coupling said frames side by side, substantially as described.

4. In a secondary battery, the combination of a non-conducting frame having inwardly-projecting lugs on opposite sides, a tube into which said lugs are inserted to hold it against lateral movement, and active material carried in said tube, substantially as described.

5. In a secondary battery, the combination of a frame having inwardly-projecting lugs on opposite sides, a tube mounted on said lugs and held thereby against lateral movement, active material contained in said tube, and a conducting-rod embedded in said active material and having its ends held by said lugs, substantially as described.

6. In a secondary battery, the combination of a frame having inwardly-projecting corrugated lugs on opposite sides, a corrugated tube mounted on said lugs and held thereby against lateral movement, and active material contained in said tube, substantially as described.

7. In a secondary battery, the combination of a frame having inwardly-projecting lugs on opposite sides, an expansible tube mounted on said lugs and held thereby against lateral movement, and active material contained in said tube, substantially as described.

8. In a secondary battery, the combination of a frame having inwardly-projecting lugs on opposite sides, an expansible tube mounted on said lugs and held thereby against lateral movement, active material contained in said tube, and a conducting-rod embedded in said active material, substantially as described.

9. In a secondary battery, the combination of a frame, tubes mounted in said frame and containing active material, composition conducting-rods composed of metallic and non-metallic material embedded in said active material, and means carried by the frame connecting the conducting-rods of like polarity with the terminals of the battery, substantially as described.

10. In a secondary battery, the combination of a non-conducting frame, tubes mounted in said frame and containing active material, conductors embedded in said material and projecting into the side of the frame, and a conductor molded around said conductors and connecting the elements, substantially as described.

11. In a secondary battery, an electrode comprising an expansible tube, active material inclosed in said tube, and a conducting-rod composed of carbon and a lead wire embedded in said material, substantially as described.

12. In a secondary battery, the combination with oppositely-disposed side bars, of a series of elements carried thereby, a conducting-rod in each element having its ends projecting into said side bars, and conductors carried in said side bars, adapted to electrically connect the conducting-rods, and mechanically hold the same in the side bars, substantially as described.

13. A battery element comprising a non-conducting frame, a plurality of corrugated resilient tubes mounted therein, each tube containing active material and a conducting-rod, and a conductor carried by the frame and connected with said conducting-rods in the tubes, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

GUSTAVE K. HARTUNG.

Witnesses:
JULIAN S. WOOSTER,
GEORGE N. KERR.