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(54) BATTERY ASSEMBLY

(71) We, UNION CARBIDE CORPORATION, a corporation organized and existing under the laws of the State of New York, United States of America, whose registered office is, 270 Park Avenue, New York, State of New York 10017, United States of America, (assignee of THEODORE ROBERT BEATTY), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an electrode of a coiled electrode assembly for a sealed galvanic battery.

In the manufacture of a sealed battery employing coiled strips of electrode material it is the conventional practice to affix one or more tabs of conducting material to the strips in order to facilitate electrical contact between such strips of electrode material and the terminal locations on the battery outer housing.

Alkaline MnO_2 and nickel cadium cells are typical of the battery cell types using coiled strips of electrode material. The procedures most commonly used in making strip electrodes include impregnating a sintered electrode metal plaque with the active ingredients and compacting the active ingredients, in powdered form, against an elongated strip of a conductive metal carrier grid. Although the former process it typically used for making both the anode and cathode electrodes the latter process is, at present, generally limited to the fabrication of anode electrodes. A porous separator is placed between the strips of anode and cathode material or alternatively the strips are spaced apart and encapsulated within a sheath of porous separating material.

A necessary step in assembling the battery cell consists in the placement and connection of the electrically conducting tabs to the electrode strips. This may be effected before or after the incorporation of the separator. It is obvious that the joint formed between the tab and the strip may represent a substantial impedance if not adequately established. For this reason a fused joint has heretofore been considered necessary, particularly for high current cell performance. The fused joint is formed by welding, soldering or brazing the parts together. Soldering and brazing are generally less acceptable procedures because of the risk of contamination by the joining metal. To perform an effective welding operation requires some surface preparation including the elimination of some of the active electrode ingredients within the area on the electrode strip to be welded. Such operation, if not carefully performed, may damage the surrounding area of the electrode, remove too much active material, or cause a short circuit upon assembly of the two electrode strips. An alternative to welding which is of low cost and equally effective has long been sought.

Assembly of the battery is completed, after the tabs are joined to the strips of electrode material, by rolling the combined electrode strips and separator into a roll configuration and inserting the coiled structure into the battery housing. The tabs may then be connected in a conventional manner to their corresponding outer housing terminals or alternatively the tab for one of the electrodes, e.g., the positive tab may be welded to the top cover of the battery housing while the negative electrode tab may be bent back so that it mechanically and electrically engages the side wall of the housing under pressure upon insertion of the electrode assembly. An electrolyte of appropriate composition is introduced into the housing in any conventional manner either before or after the insertion of the coiled elctrode strips.

It is the principal object of the present invention to provide an electrode for a sealed galvanic battery, comprising a conducting tab mechanically joined thereto in a manner to provide a joint having an impedance substantially equal to that of a welded joint.

It is a further object of the present invention to provide such an electrode in which the tab connection is mechanically and electrically joined thereto by a multiplicity of projections on the tab engaging on or in a surface of the electrode.

There is provided by the present invention for use in a battery comprising at least one

galvanic cell enclosed within an outer housing having a positive and negative battery terminal and containing a supply of electrolyte, an electrode comprising:—

a strip of positive or negative material, and means for electrically coupling the strip of electrode material to its corresponding housing terminal, said means being in the form of at least one conductive element having a multiplicity of projections mechanically engaging said strip of electrode material and simultaneously establishing electrical contact therewith through the mechanical points of contact provided by said projections.

The present invention will now be described, by way of example with reference to the accompanying drawings in which:—

Figure 1 is an exploded view of the battery assembly using an electrode according to the present invention;

Figure 2 is a perspective view of the uncoiled strips of electrode material for the battery assembly of Figure 1, showing the strips within a sheath of porous separating material, one strip being connected to a tab element in accordance with the present invention;

Figure 3 is a plan view of the preferred tab element of an electrode of the present invention;

Figure 4 is a side view of the preferred tab element of the present invention taken along the lines 4—4 of Figure 3;

Figure 5 is a plan view of a modified conducting tab element of an electrode of the present invention;

Figures 6 (a-c) are graphical presentations which indicate the cell performance of a nickel cadmium Sub C cell using electrodes of the present invention.

Referring to Figures 1—4 inclusive, the battery assembly 10 is shown comprising:— a battery housing 12 of generally cylindrical construction, a coiled electrode structure 14, a compatible electrolyte (not shown) and a cover plate 16. The coiled electrode structure 14 is formed from elongated strips of electrode material wound in combination with a separator into a conventional roll configuration. The electrolyte may be introduced into the housing 12 either before or after insertion of the assembled coiled electrode structure 14. An insulating washer 18 is placed at the bottom end 20 of the housing 12 to insulate the housing bottom from the coiled electrode structure 14. The cover plate 16 seals the assembly 10 and is insulated from the housing 12 by a gasket 21. The battery housing 12 is electrically connected to one electrode strip of the coiled electrode structure 14 to serve as one battery terminal whereas the cover plate 16 is electrically connected to the other electrode strip of the electrode structure 14 to serve as the opposite polarity terminal of the battery.

The coiled electrode structure 14 includes a positive electrode strip 22 (Figure 2) and a negative electrode strip 24 separated from one another by a porous separator 26. The porous separator 26 can be of any conventional separator material suitable for alkaline cell systems such as, for example, non-woven nylon fibres. Moreover, the separator 26 can be a single sheet or two or more superimposed sheets interposed between the convolutions of the strips of electrode material 22 and 24 respectively; or preferably, and as is shown in Figure 2, it may consist of two sheets stitched, thermally bonded or tacked together along the opposite longitudinal boundaries, to form a sheath which, before the coil is formed, has the strips of electrode material 22 and 24 inserted therein with the strips longitudinally spaced apart in the sheath. To form the coil, the sheath containing the electrodes is folded about the broken line shown in Figure 2 and then rolled up.

At least one terminal lead or tab is used electrically to couple each strip of electrode material to its corresponding battery terminal. The terminal leads are relatively short conducting tab elements in the form of thin planar strips of any suitable configuration, preferably rectangular, and selected from a material which will be compatible with the particular electrochemical system of the battery assembly, e.g., in a nickel cadmium cell the tabs should be nickel.

As shown in Figure 2, the conducting tab element 28 is connected to the positive strip of electrode material 22 whereas the conducting tab element 30, is connected to the negative strip of electrode material 24. At least one of the conducting tab elements 28 or 30, preferably element 30, includes a multiplicity of projections 32, as is more clearly illustrated in Figure 4, for establishing simultaneous mechanical and electrical engagement of the tab to the strip of electrode material to which it is applied. The other conducting tab 28 may be connected either in the same manner or in the conventional manner to its corresponding strip of electrode material 22.

A particular geometry, curvature and height of the projections 32 and a particular method of formation thereof are not essential in the present invention. However, for any given type of strip electrode, one particular kind of projection may be favoured over another. Moreover, where the tab element is to be connected to the strip of electrode material through the intervening separator this may also favour one kind of projection over another. For example, when the strip of electrode material is the negative electrode in a nickel-cadmium cell and is fabricated using the pressed powder techniques described in U.S. Patent Nos. 3,310,437 and 3,432,351 respectively, it is preferred to use a multi-

plicity of projections 32 constituted by the jagged burrs resulting from perforations 34 pressed out in the tab element 30. The perforations 34 can be made using any suitable conventional tool or punch press, and need only be confined to a predetermined surface section of the tab element to be placed in abutting relationship with the strip of electrode material 24 or against the covering separator 26. Relatively minor pressure is necessary to firmly establish the connection between the tab and the strip of electrode material. This pressure can be directly and immediately applied upon appropriate placement of the projections against the strip or subsequently applied by compression when the rolled electrode structure 14 is inserted, under pressure, into the battery housing 12. Other forms of projections 32 would be metal bristles, teeth, pointed protrusions, etc., extending from one end of the tab surfaces.

The number of projections 32 and their proximity to one another may be varied, although as indicated heretofore there may be a preferred arrangement depending upon the strip electrode manufacturing technique. For example, for the nickel cadmium cell, it is preferred that the negative electrode be made using the pressed powder technique in which the active electrode material is compacted against a metal current carrying grid which is of open mesh construction. For such electrode, the perforated tab projections 32 are preferred and should be of a sufficient number to permit multiple contact with the metal grid in order to assure an electrical conductivity comparable to a welded joint.

Once the tab elements 28 and 30 are in place an adhesive covering 36 of insulating material may be placed over the section of the tab element 30 in which the perforations 34 were made to secure the tab until the electrode is coiled. Covering 36 need only be a piece of self-adhesive plastic film, or a film over a layer of adhesive. The size of the insulating covering 36 should be sufficient to cover the area of the tab 30 containing the perforations with enough overlap to give adhesion to the electrode or separator surface. Covering 36 may be omitted if adhesive is applied between the tab and the electrode or separator surface, or if the projections are pressed firmly into the electrode strip. Lastly, after the tabbed electrode strips are wound to form the electrode assembly 14, the tab elements 28 and 30 are connected to the cover plate 16 and housing 12 of the battery assembly 10 in a conventional manner with the tab element 28 secured to the cover plate 16 and the tab element 30 bent back upon the assembled coiled electrode structure 14 for making a pressure contact with the battery housing 12. In the alternative configuration of Figure 5 the tab element 30 has a double set of projections 32, 32 provided at each opposite end thereof, with one set of projections 32 intended for engaging the electrode strip as explained heretofore and with the opposite set of projections intended to engage the outer wrap of the same electrode strip upon bending the tab 30 under the electrode assembly 14 as shown in Figure 1 with the smooth side of the perforated area pressed against the battery housing. This alternative design will be effective only in limited cases where the electrode strip is on the outer wrap of the coiled electrode structure 14 and where the battery cell container 12 provides an accessible uninsulated region adjacent to the tab.

The connection made by the tab element 30 with a negative pressed powder electrode strip 24 when measured at 1000 Hz, 1 ampere, in a NiCd 1.2 Ah "Sub C" cell, exhibited from approximately .0093 to .0137 ohms total range in impedance. The voltage maintenance during discharge of a cell using a tab element 30 will approximate that of the welded tab connection at 10 and 20 ampere discharges respectively. Figure 6 (a-c) indicates the performance of the foregoing NiCd cell at 10 amperes discharge showing a flat voltage response throughout the cycle life of the cell. Although, the equivalent performance curves using welded tabs are not shown they would essentially overlap the curves of Figure 6. In connection with Figure 6, it is pointed out that the designation "C/1" means that the cell is charged and discharged under a current flow of 1 ampere for one hour; the cell initially being charged at that rate. Thus, the 10 ampere discharge followed repetitive charging and discharging of the cells for the specified number of times at the 1 ampere per hour rate.

Although only one tab element has been shown and described for each strip electrode, it is obvious that multiple tabs can be incorporated and arranged in tandem along the length of the electrode strip to reduce voltage drop normally resulting from longitudinal current flow through the strip.

Conductive metal tabs with projections may be employed essentially as described to make low resistance mechanical and electrical contacts to the electrode strips or plates. The electrodes may be of the pressed powder or pasted type on a conductive grid or screen, or may be of the impregnated porous metal sinter type. The tab may be applied to the bare electrode surface, or it may be applied after the separator has been incorporated, so that the projections penetrate the separator and the electrode beneath. The projections, of course need to be of sufficient depth to insure that they will contact portions of the grid, screen or sinter as well as the active electrode material.

Mechanical stability of the contacts is insured in the coil construction by the tight fit of the coil in the cylindrical housing. Tab contact by means of projections may also be utilized with the flat plate batteries provided end pressure is maintained on the electrode stack.

It should be appreciated that although the invention is directed to a battery assembly incorporating a mechanical-pressure tab connection eqivalent to a welded connection, the same general approach can be utilized but to a lesser degree for applications where current drains are very light, e.g., fewer or smaller projections may be employed, roughened surfaces may be employed to contact the bare electrode surface in place of large projections.

WHAT WE CLAIM IS:—

1. For use in a battery comprising at least one galvanic cell enclosed within an outer housing having a positive and negative battery terminal and containing a supply of electrolyte, an electrode comprising:—

a strip of positive or negative material, and means for electrically coupling the strip of electrode material to its corresponding housing terminal, said means being in the form of at least one conductive element having a multiplicity of projections mechanically engaging said strip of electrode material and simultaneously establishing electrical contact therewith through the mechanical points of contact provided by said projections.

2. An electrode as claimed in claim 1, wherein said conductive element has a planar surface from which said multiplicity of projections extend.

3. An electrode as claimed in claim 1 or 2, wherein the conductive element is in the form of a tab.

4. An electrode as claimed in claim 1, 2 or 3, wherein the conductive element has a multiplicity of perforations formed therein such that the multiplicity of projections is constituted by jagged edges protruding from each of the perforations.

5. An electrode as claimed in any of preceding claims 1 to 4 wherein the conductive element forms a tab and said multiplicity of projections are arranged within a portion of the tab.

6. An electrode as claimed in claim 5, comprising another multiplicity of perforations arranged within a further portion of the tab.

7. An electrode as claimed in any of the preceding claims, wherein the conductive element is used in plurality, with the elements thus provided arranged in tandem along the longitudinal axis of said strip of electrode material.

8. An electrode as claimed in any of the preceding claims, further comprising an insulating layer mounted over at least the portion of the or each conductive element by which the element is joined to the electrode strip.

9. An electrode as claimed in any of the preceding claims, wherein said electrode strip consists of negative electrode material.

10. An electrode as claimed in any of the preceding claims, wherein the or each element is maintained in position in relation to the electrode surface, by an adhesive carried on the face from which the projections extend or by an adhesive strip contacting the opposite face of the element.

11. An electrode according to claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

12. An electrode assembly comprising an electrode as claimed in any of the preceding claims and a porous separating material therefor in the form of a sheath surrounding the strip of electrode material and having the conductive element disposed in abutting relation against the sheath with the mulitplicity of projections extending through the sheath in electrical contact with the strip of electrode material.

13. An electrode assembly as claimed in claim 12 comprising two strips of the electrode material, one comprising negative electrode material and the other comprising positive electrode material, with both enclosed within said sheath longitudinally spaced apart therein.

14. An electrode assembly, as claimed in claim 13 wherein the sheath is folded transversely of the electrodes in the portion between the two electrodes and the folded assembly rolled up to form an electrode coil.

15. An electrode assembly comprising an electrode as claimed in any of the preceding claims 1 to 11, employed in plurality to provide two of the electrodes with one being formed of negative electrode material and the other of positive electrode material, and a porous separating material therefor to separate the two electrodes.

16. An electrode assembly as claimed in claim 15 wherein the two electrodes and the porous separating material are rolled up to form an electrode coil with each two adjacent convulations of the electrodes spaced apart by the porous separating material.

17. An electrode assembly as claimed in claim 15 or 16, wherein the porous separating material is in the form of a single sheet of material or a plurality of superimposed sheets.

18. An electrode assembly substantially as hereinbefore described with reference to the accompanying drawings.

19. A battery having at least one galvanic cell enclosed within an outer housing having positive and negative battery terminals, and containing a supply of electrolyte wherein the galvanic cell comprises an electrode as claimed in any of the preceding claims 1 to 10 or an

electrode assembly as claimed in any of preceding claims 11 to 17.

20. A battery substantially as hereinbefore described with reference to the accompanying drawings.

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1568544 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

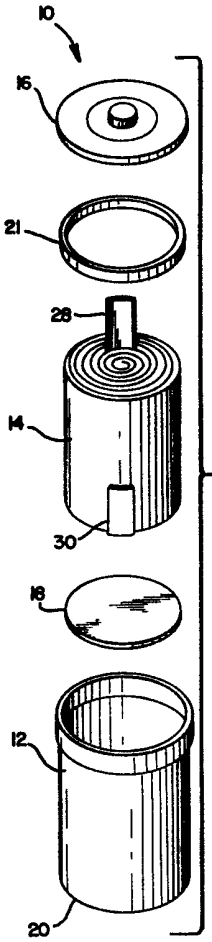

FIG. 1

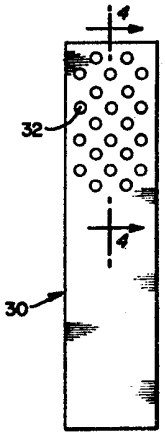

FIG. 3

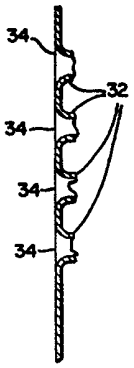

FIG. 4

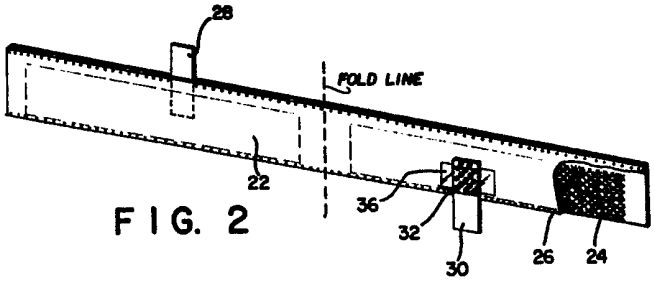

FIG. 2

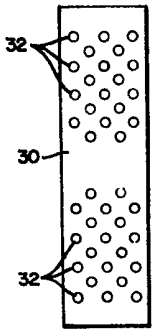

FIG. 5

FIG. 6a

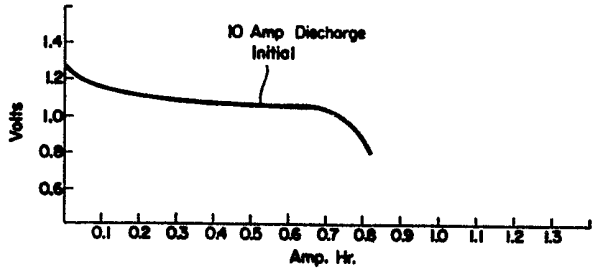

FIG. 6b

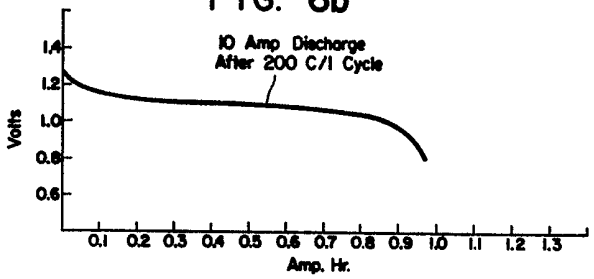

FIG. 6c