T. A. EDISON.

METHOD OF MAKING STORAGE BATTERY ELECTRODES.

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Fig. 1

Fig. 2

Witnesses:
Belos Holden
Anna P. Klehn

Inventor
Thomas A. Edison

Attorney

Frank T. Byn
METHOD OF MAKING STORAGE-BATTERY ELECTRODES.

To all whom it may concern:

Be it known that I, THOMAS ALVA EDISON, a citizen of the United States, residing at Llewellyn Park, Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Method of Making Storage-Battery Electrodes, of which the following is a description.

My invention relates to an improved method of making electrode elements for storage batteries of the Edison type. In an application filed on even date herewith I describe the improved electrode element, constructed in accordance with my present method, and have quite elaborately explained the correct condition which should exist in the active material to secure the best results. Assuming the invention to be carried out in connection with the manufacture of the nickel mass and that metallic flakes of cobalt or cobalt-nickel alloy are used therewith, then, the best results are secured in practice when the conducting films or flakes, overlapping and lapping upon one another, constitute a close net-work of metallic conductors, extending in all directions throughout the mass, the active particles being closely compacted in engagement with the conductors so as to make good contact therewith, and proper circulation through the mass being afforded by providing the mass with a net-work of circulating channels extending in all directions and presenting a substantially predetermined proportion of porosity relatively to the entire mass. As I point out in my said application, these peculiar characteristics are secured when the electrode mass is subjected to special treatment before its introduction within the containing tubes, during its introduction therein, and subsequent to such introduction, and this special treatment comprises my present method and will be explained herein. Broadly stated, my improved method comprises:

First: Covering the particles of active material, such as nickel hydroxid, with the conducting films, flakes or scales, preferably cobalt or cobalt-nickel alloy, by a process like that disclosed in my application filed March 30th, 1902, Serial No. 252,931, wherein the particles of active material are first coated with a very sticky substance like glucose, after which the conducting flakes or scales are added and intimately-mixed therewith, so as to adhere with sufficient tenacity to the active particles as to prevent segregation during manufacture. This special treatment presents important advantages in connection with the present invention, as will be explained.

Second: The mass obtained in this way is now introduced within perforated non-deformable pockets of sufficient strength to resist the bulging or disrupting strains encountered in actual use, and due to the tendency of the active material to expand by absorption of the electrolyte, by electrolytic action, and by the pressure of gas generated within the mass. In thus filling the pockets with the mixture of active material and conducting flakes, I introduce the mixture within the pockets in relatively small increments (from fifty to a hundred increments for eight grams of the mixture) and subject each increment to one or more tamping pressures, preferably as much as 20,000 pounds per square inch, each pressure being substantially uniform, so that the mass throughout will be uniformly highly compressed. As a result of this operation, the active particles will be crushed and de- material, greatly extend the area of contact with the conducting flakes and prevent the smaller particles from being isolated or from making imperfect or superficial contact with the conducting flakes, and the conducting flakes will be pressed together to overlap and form a net-work of conducting paths extending in all directions throughout the mass. The mass, as a whole, will furthermore be so closely and tightly consolidated as to prevent relative movement of the active particles with respect to the conducting flakes, and relative movement of the conducting flakes with respect to each other, and I have discovered that if such relative movement takes place the contact condition of the mass will be seriously impaired.

Third: After the mass has been thus packed in increments under high pressure within the perforated non-deformable pockets, and the latter have been compressed at their ends upon small cups or diaphragms engaging the extremities of the mass, the sticky material or binder is removed from the mass by dissolving it out,
preferably in slightly alkaline water to prevent rust. This removal of the binder results in the formation within the mass of a net-work of circulating channels which are important in permitting the electrolyte to readily penetrate the mass and circulate through the same, thereby allowing a large amount of the electrolyte to rapidly reach all parts of the mass to accommodate high discharge rates. These circulating channels also permit the mass to deform internally under swelling pressures, which, if the mass were perfectly consolidated, might burst the containing pockets. By forming a net-work of circulating channels in the active mass, as explained, I am enabled to very perfectly regulate the relative proportion of porosity, merely by regulating the amount of sticky material admixed with the active particles in the first instance.

In order that the invention may be better understood, attention is directed to the accompanying drawings, forming part of this specification, and in which—

Figure 1, is a sectional diagrammatic view of a suitable apparatus for filling and tamping the active mass within the non-deformable containing pockets, and Fig. 2, a front elevation partly in section of one of the complete electrode elements. In both of these views corresponding parts are represented by the same numerals of reference.

The pockets-1 are preferably tubular, formed of a perforated strip of steel about .004 of an inch in thickness, first carefully plated with an alloy of cobalt and nickel, after which the strips are subjected to a welding temperature in a hydrogen atmosphere, being then formed into tubes. The tubes in question are preferably about four inches long, and about one-quarter of an inch in internal diameter. Surrounding the tube is a number of seamless nickel rings 2, fitting the tube snugly, and adding very materially to the strength of the tube in resisting bursting strains. The filling of these tubes is preferably performed in a suitable apparatus of the general type disclosed in my application, filed October 14th, 1905, Serial No.282,692, and shown diagrammatically in Fig. 1. One or more of the tubes are placed in a suitable sectional holder 3—3, the sections of which are tightly clamped together and closely engage the tubes, so as to resist the enormous bursting strains encountered during the filling operation. The holder also comprises a base 4, for receiving the sections 3, and provided with an extension 5 extending within the tubes and defining the extent of the tube which is to be turned over upon the compressed material, as will be understood. The sections 3 are provided with recesses 6 for receiving the strengthening rings 2. During the tamping of the material within the tubes, the latter will expand slightly into very close and intimate contact with the strengthening rings, preventing any liability of shifting of the latter. It will be understood that the sectional holder is provided with a series of chambers into which a number of the tubes will be snugly received, so that a plurality of tubes may be simultaneously filled. Leading to each of the tubes is an auxiliary hopper 7, for guiding the successive increments of material therein. These increments are supplied from a main hopper 8, the bottom of which comprises a rotating shaft 9, haying pockets 10—10 therein, the size of the latter depending upon the bulk of each increment. Cooperating with each tube is a tamping plunger 11, formed with a weight 12, of suitable mass and provided with a rack 13, with which engages a toothed cylinder 14. The cylinder 14 is so coordinated with the rotary shaft 9 as to give one or two tamping operations on each increment. There is a substantially greater number of teeth on the rack 13 than on the cylinder 14. As the cylinder 14 rotates the teeth on its periphery engage the rack 13, so as to lift the plunger 11 to an extent depending upon the number of teeth on the cylinder, and when the last tooth on the cylinder leaves the rack 13, the plunger will drop. The rack 13 is of sufficient length to permit the teeth of the cylinder 14 to give at all times a complete lifting movement to the plunger, so that it will be understood that whether the plunger is engaging an increment near the bottom of the tube or an increment when the tube is wholly filled, the first tooth of the cylinder will engage some one tooth on the rack, will then lift the rack through a distance corresponding to the number of the teeth on the cylinder, when the plunger will drop. As the tube is filled up the cylinder teeth will engage with rack teeth which are lower and lower upon the rack, but the rack will always be lifted up until each of the teeth of the cylinder has engaged one of the teeth on the rack and therefore the plunger will always drop the same distance and therefore impart the same tamping blow.

In practice I permit the plungers weighing three pounds each to drop a distance of five inches; and the diameter of the plungers is about one-quarter of an inch. In this way I deliver a tamping blow of about one thousand pounds on each increment, since the plungers are brought almost instantaneously to rest. At the same time, by imparting a very great pressure in only a fraction of a second, the plungers although of small diameter, have no opportunity of becoming distorted, or breaking, as would be the case if the same pressure were applied gradually, as in a hydraulic press. Usually provision is made, as disclosed in my said application last referred to, for arresting the operation of
the feeding and tamping mechanism when a
determined number of increments have been introduced in the tubes. In prac-
ticing my method in conjunction with a paratus, having the characteristics described;
I proceed substantially as follows: The active
material, such as particles of granules
of nickel hydroxide, which have been first
screened, for instance, through a thirty-mesh
screen, so as to secure too great a variation in the size thereof, are first coated with
a very sticky material such as molasses or
glucose, preferably the latter, the degree of
viscosity of the sticky material being very
great. I now intimately mix with the sticky
mass, a suitable proportion of conducting
flakes or scales, preferably flakes of met. the
cobalt or cobalt-nickel alloy, and continue
the mixing until the conducting flakes have
effectively covered the surfaces of the active
particles. The best proportion of the mixture
for introduction into the tubes is 60 per
cent. by weight of crushed nickel hydroxide,
screened through a thirty-mesh screen; 20
per cent. of flake cobalt orflake cobalt-nickel
alloy, and 20 per cent. of a very viscous glu-
coses, sufficiently sticky to fasten the flakes to
the nickel granules and prevent their detach-
ment during manufacture. Ordinarily about
eight grams of the mixture will be intro-
duced within the tubular pockets of the di-
ensions stated, the mixture being intro-
duced in relatively small increments, deter-
mined by the size of the pockets. Where
a single tamping operation is performed on
each increment, I find that the best results
are secured when about one-hundred incre-
ments of the active mass are successively in-
troduced within each tube, but where each
increment is tamped twice, fifty increments
may be successively introduced, the latter
substantially being preferable. By applying
an enormous tampering pressure on suc-
cessive small increments, the mass will not
only be closely packed within the tubes, but
the larger active particles will be broken
down and deformed, so as to close up the in-
terstices between the same (so far as will be
permitted by the presence of the sticky ma-
terial) thereby consolidating the mass as a
whole, and bringing all the active particles
in good contact with the conducting paths
formed by the conducting scales or flakes.
At the same time, the pressure forces the ac-
tive particles through the films of sticky ma-
terial into contact with the conducting flakes
and thereby displaces the sticky material,
which accumulates in the many minute in-
terstices presented between the particles of
the active mass. The viscosity of the sticky
material prevents it from being squeezed out
of the active pores, interrupting the pores of the active particles. As thus
formed, the mass presents a very compact,
composite body under great pressure, and
containing minute connected bodies of the
sticky material as displaced by the pressure.
Obviously, as a result of the tampering
pressure, the mass will also be forced into in-
finite contact with the conducting walls of
the tubular pockets, so as to secure good elec-
tric contact with the same. I find that the
consolidation of the mass is materially fa-
cilitated by the presence of the glucose or
other sticky material, which apparently has
a lubricating effect, permitting the particles
under the tamping pressure to more readily
shift into their ultimate positions, and also,
allowing the individual particles to be more
readily compacted or deformed. As a mat-
ter of fact, and notwithstanding the added
bulk of the sticky material, I have observed
that it is possible to tamp a greater mass of
active material into a tube than can be done
under the same pressure when the sticky ma-
terial is not used.

After the proper amount of active material
has been introduced and tamped within the tubular pockets, any excess thereof is re-
moved at the upper end by reaming, and a nickel cup or diaphragm, having a
nickel cup or diaphragm, being forced over the tubes, is forced in upon the
active mass at each end and tightly com-
pressed upon the same, as shown. The ends
of the tubes are now turned over at 180 to
engage the end cup 15, holding the active
mass firmly against longitudinal expansion
within the tubes. The sticky material or
binder is now removed either before or after
the electrode elements have been assembled
in a suitable grid, and this removal is effected
by soaking the tubes in water, slightly alka-
line, so as to dissolve it out. This results
in the formation of the grid-work of minute
connected channels, crevices and pockets,
which are important in permitting the free
escape for gas, and at the same time allow-
ing a rapid circulation of the electrolyte to
accommodate desired high discharge rates.
The open spaces within the mass
which are thus formed, may occupy 25 per
cent, or more of the entire mass. The use of
a sticky material is, therefore, important for
a two-fold purpose (i.e., to cause the con-
ducting flakes to adhere to the active parti-
cles and to result in the formation of cir-
culating channels) and if none were used—or
an insufficient amount were used—the mass
would be too non-porous to permit a suffi-
ciently rapid circulation of the electrolyte to
accommodate desired high discharge rates.
On the other hand, care must be exercised
not to use too much of the sticky material as
to honeycomb the mass to too great an
extent, as thereby the mass would be weak
structurally and there would be liability of
the active particles and conducting flakes
moving relatively to impair the condition of the mass as a whole. After the
sticky material has been removed the active
mass—constitutes a porous coherent body about as hard as soap-stone and cutting with about the same facility. It is, in fact, so hard that it may be polished without crumbling. Under the microscope, the overlapped conducting flakes appear as a delicate tracery of vein-like conductors; extending in all directions throughout the mass, and forming a conducting net-work with which the active particles are in close contact. In use, the absorption of the electrolyte by capillarity and also electrolytic changes, effect a swelling of the active particles, but any deformation is permitted internally by reason of the presence of the net-work of circulating channels, and the pressure on the walls of the container is insufficient to disrupt the same. This swelling is not sufficient to close up the circulating channels and does not, therefore, interfere with the perfect and rapid circulation of the electrolyte, nor with the escape of gas. As a matter of fact, the particles of nickel hydride become themselves quite porous, but not to a sufficient extent, if alone relied upon, to permit the electrolyte to circulate with sufficient rapidity throughout the mass; but by providing the mass with connected passages extending throughout the same, the electrolyte is enabled to readily and rapidly penetrate the mass in all directions, so that the porosity of each particle has only to be relied upon to furnish the necessary supply, of the solution to its own minute mass.

Having now described my invention, what I claim as new therein and desire to secure by Letters Patent is as follows:

1. The method of making electrode elements which consists in introducing a mixture of particles of active material and flake-like conducting material within non-deformable insulating pockets, and in applying a pressure to such material sufficient to crush or deform the active particles and cause them to substantially follow the contour of the conducting flakes, as and for the purposes set forth.

2. The method of making electrode elements, which consists in introducing within a non-deformable insulating pocket in successive small increments, a mixture of particles of active material and flake-like conducting material, and in applying to each increment after its introduction sufficient pressure to deform or crush the active particles and cause them to substantially follow the contour of the conducting flakes, as and for the purposes set forth.

3. The method of making electrode elements, which includes adding a sticky binder to the active particles, so as to substantially coat the surfaces of the latter, in then adding to the sticky mass flake-like conducting material, whereby the conducting flakes will be caused to adhere to the active particles, in introducing the mixture so obtained within non-deformable insulating pockets, and in applying to the mixture sufficient pressure to force the active particles through the films formed by the binder, displacing the latter into the minute interstices formed within the mass and spreading the active particles with respect to and upon the surfaces presented by the conducting flakes, as and for the purposes set forth.

4. The method of making electrode elements, which includes adding a sticky binder to the active particles, so as to substantially coat the surfaces of the latter, in then adding to the sticky mass flake-like conducting material, whereby the conducting flakes will be caused to adhere to the active particles, in introducing the mixture so obtained within non-deformable insulating pockets, and in applying to each increment sufficient pressure to force the active particles through the films formed by the binder, displacing the latter into the minute interstices formed within the mass and spreading the active particles with respect to and upon the surfaces by the conducting flakes, as and for the purposes set forth.

5. The method of making electrode elements, which consists in adding a sticky binder to the active particles, so as to substantially coat the surfaces of the latter, in then adding to the sticky mass flake-like conducting material, whereby the conducting flakes will be caused to adhere to the active particles, in introducing the mixture so obtained within non-deformable insulating pockets, and in applying to the mixture sufficient pressure to force the active particles through the films formed by the binder, displacing the latter into the minute interstices formed within the mass and spreading the active particles with respect to and upon the surfaces by the conducting flakes, as and for the purposes set forth.

6. The method of making electrode elements, which consists in adding a sticky binder to the active particles, so as to substantially coat the surfaces of the latter, in then adding to the sticky mass flake-like conducting material, whereby the conducting flakes will be caused to adhere to the active particles, in introducing the mixture so obtained within non-deformable insulating pockets, and in applying to each increment sufficient pressure to force the active particles through the films formed by the binder, displacing the latter into the minute interstices formed within the mass and spreading the active particles with respect to and upon the surfaces by the conducting flakes, as and for the purposes set forth.
7. The method of determining the porosity to be present in the active mass of a storage battery electrode, which consists in adding to the active particles a predetermined amount of a soluble viscous material, then in adding a flake-like conducting material thereto, then in introducing the mixture within a suitable inclosing pocket, then in applying pressure to the mass, and finally, in removing the viscous material, whereby the spaces previously occupied by the same will exist as a net-work of circulating channels extending in all directions throughout the mass, as and for the purposes set forth.

8. The method of making storage battery electrodes, which consists in introducing in successive and very small increments, active material within a non-deformable inclosing pocket, and in subjecting each increment to one or more tamping blows delivered by a weight falling always from the same height above each increment, as and for the purposes set forth.

This specification signed and witnessed this 31st day of October 1905.

THOMAS A. EDISON.

Witnesses:

FRANK L. DYER,

ANNA R. KLEIM.