Technical Note

Construction of Miniature Silver–Zinc Batteries and the Technology for their Mass Production*

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The construction and production technology of miniature silver–zinc batteries has been developed in the Central Laboratory of Batteries and Cells in Poznań. At the same time a modern assembly line for the mass production of type SR43 and SR 44 batteries, with an output of 2 million units/year has been designed and commissioned. The batteries are for use in miniature electronic devices such as wrist watches, pocket calculators, hearing aids, etc.

A silver oxide battery consists of a can and a cap. The can is stamped from a steel sheet and then nickel plated, or it is stamped directly from steel sheet, nickel plated on each side. The cap is made from chromium–nickel sheet, copper plated on one side. The gasket is made from polyamide subjected to special processing. The anode paste is a mixture of amalgamated zinc powder and electrolyte, gelled with sodium carboxymethylcellulose. The cathode, which consists mainly of monovalent silver oxide, is isolated from the anode by a group of separators.

The accuracy of all operations and compliance of the batteries with specification requirements is assured by on-line measurement and control devices.

A pallet system allows a great number of batteries to be stored in a small area and simplifies inspection.

The construction of miniature silver–zinc batteries and the technology for their production has been developed in the Central Laboratory of Batteries and Cells (CLAiO) in Poznań. A modern automatic assembly line for the mass production of type SR 43 and SR 44 batteries, with an output of 2 million units/year has also been designed and commissioned.

Silver–zinc batteries are used in miniature electronic devices such as wrist watches, minicalculators, hearing aids, etc. The following attributes make them suitable for use in a great many appliances:

— high nominal voltage;
— high specific energy;

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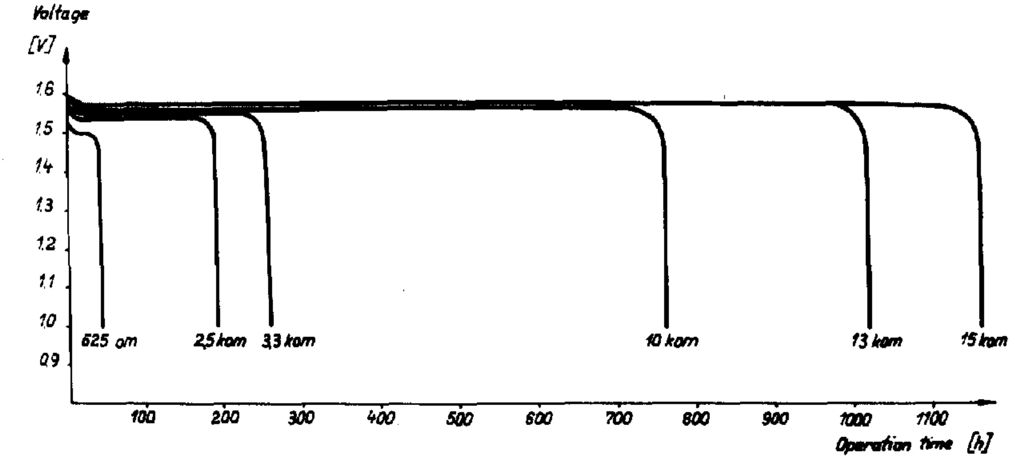

Fig. 1. Characteristics of the type SR43 battery on discharge through loads of 625 ohms, 2.5, 3.3, 10, 13 and 15 kΩ at normal temperature.

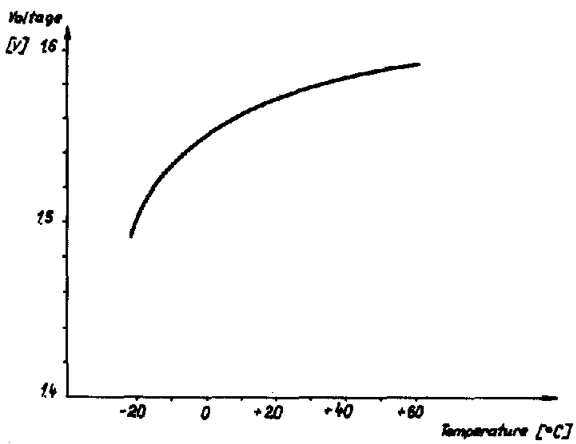

Fig. 2. Dependence of the operating voltage of SR43 and SR44 batteries on temperature on standard discharge loads of 13 and 5.6 kΩ, respectively.

— high reliability;
— long storage life;
— almost constant voltage during the whole discharge time.

Figure 1 shows the discharge characteristics of the SR43 battery on different resistance loads.

The dependence of the operating voltage of SR43 and SR44 batteries on temperature on standard discharge loads of 13 and 5.6 kΩ, respectively, is shown in Fig. 2.

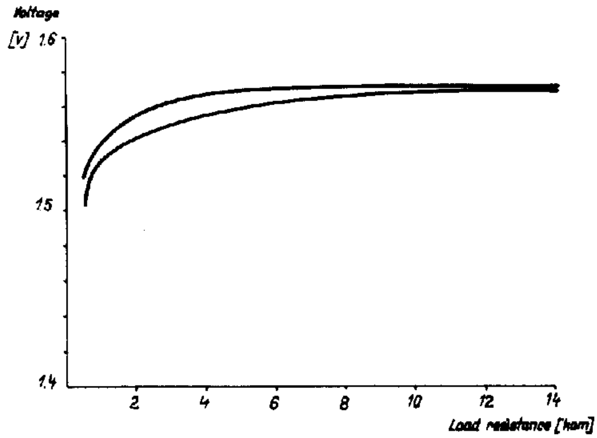

Fig. 3. Dependence of the operating voltage of SR43 (upper curve) and SR44 batteries on the load resistance (kΩ).

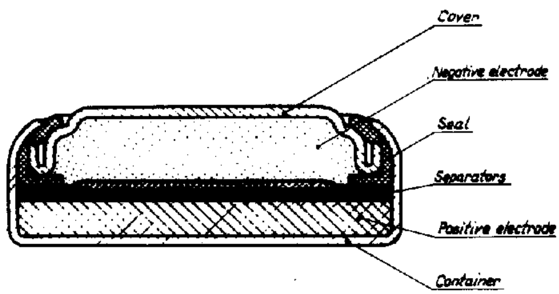

Fig. 4. Construction of the SR43 and SR44 silver–zinc batteries.

Figure 3 shows the dependence of the operating voltage of SR43 and SR44 batteries on the load resistance.

The demands made on these batteries with respect to capacity and hermetic sealing during long duration discharges are particularly severe. These demands considerably influence battery construction and production technology.

Battery design

The silver–zinc battery made in CLAiO and shown in Fig. 4 uses a can stamped from steel sheet which is then nickel plated or from a steel sheet electroplated on each side with a thin layer of nickel. This can is also the battery positive pole.

A cap made from chromium–nickel sheet, electroplated on one side with a thin layer of copper, is the negative pole. The cathode is a mixture of high purity, high surface area, monovalent silver oxide, manganese dioxide, and graphite. It is extruded as a pellet and placed in the can.

The anode paste is a mixture of amalgamated zinc powder and electrolyte. Sodium carboxymethylcellulose is the gelling agent. The anodic material is injected into the cap. The cathode is isolated from the anode by three separators, the first of unwoven polypropylene fabric, the second of tomophane, and the third of unwoven cotton fabric. The electrolyte is an aqueous solution of potassium hydroxide.

A ring gasket is made by injection moulding from a special type of polyamide. It is subjected to an additional treatment to increase its strength.

The gasket prepared in this way with the can and cap accurately constructed guarantee hermetic sealing of the assembled battery during its storage and operational life.

The batteries are widely used because, in addition to such advantages as high capacity and hermetic sealing, they can operate under a wide range of current drains (in wrist watches or calculators: with liquid crystal displays (LCD), 0.1 mA, with light emitting diodes (LED), 70 mA). They also operate effectively in hearing aids, which draw currents of from 1 to 5 mA for ten to twenty hours a day.

Production technology

The production process and its automation required the solution of a number of problems which included:

the development of a precise means of cathodic material batching and of checking and segregating the pellets;

the determination of the properties of the anodic material which must be stable over a prolonged operational time. The anodic material must have a consistency suitable for automatic batching;

the development of equipment for the accurate and automatic batching of the anodic material.

Patents are pending for many of the technical developments involved in the design of the batteries and the plant used for their production. This latter process consists of two basic stages

— preparation of semi-finished products and assembly.

Preparation of semi-finished products

Can. This is produced on a single-stroke die stamping machine, usually from deep-drawing steel strip. In order to protect against corrosion and provide an aesthetic appearance the can is nickel-plated. The nickel coat must be pore free, bright, adhere well to the substrate and be malleable. Special baths and brightening additives are used to ensure these properties.

Cap. This is stamped from chromium–nickel sheet. It is difficult to stamp accurately from a hard, chromium–nickel sheet coated on one side with a soft layer of electrolytic copper and damage to the copper often results.

Gasket. This is made on a precision automatic worm injection moulding machine. A multiseat mould is used and the temperature is controlled by a thermostat. In production the gaskets are checked for strength and dimensional accuracy. Coating the gaskets with a layer of binder, recommended by some manufacturers, did not appreciably improve the sealing properties, and therefore a coating is not used.

Cathode mix

The cathode mix is made by thoroughly mixing silver oxide, manganese dioxide and graphite in the correct proportions. The mix is then prepared in pellet form using a precision pelleting machine.

Anode mix

The anode paste is prepared by thoroughly mixing amalgamated zinc powder with carboxymethylcellulose and electrolyte in mixers. The paste is of a consistency which allows it to be mechanically batched.

Assembly

The batteries are produced on a monitored automatic assembly line which is supplied with the necessary materials.

There are three stages in the assembly:

— assembly of the cathodic semi-cell;
— assembly of the anodic semi-cell;
— battery assembly.

Assembly of the cathodic semi-cell

The cathodic semi-cell assembly begins with the cathodic pellet being pressed on a precision pelleting machine.

The precise weight of the pellet is ensured by batching the cathode mix to an accuracy of 0.01 g and using a segregating device which controls the batch. At constant pressure and uniform density of the pressed powders, the pellet height is a function of its weight.

Vibrating feeders supply pellets to the device inserting them into the cans. The next stage involves the cutting of separators and placing them in the cans. This can be difficult, because some separators tend to curl after cutting. Therefore, immediately after cutting and inserting into the can, the separators are pressed down with a gasket.

The gaskets are supplied to the holder by a vibrating feeder which places them in the cans. Precision gasket preparation ensures that it is positioned accurately.

Electrolyte is added to the gasket compressed separators by small precision pumps. These pumps, together with a specially shaped injection nozzle ensure electrolyte metering to an accuracy of 1 mm^3.

Assembly of the anodic semi-cell

Caps are supplied to the grab by a vibrating feeder. The grab places them into seats on the machine batching the anode mix. The batching device, which can be used for the precise metering of different pastes in the range 100 - 500 mm^3, adds the anode mix with an accuracy of 0.005 g.

Battery assembly

When the anode paste is batched the two semi-cells are combined and the batteries are transferred to the sealing department, following which they are washed, placed on pallets and stored for ageing. On-line control automatically checks the accuracy of all operations and signals any irregularities.

The ageing lasts for 8 - 12 weeks, after which the batteries are subjected to magnified visual inspection to check for possible leakage and external appearance. The batteries are transferred to the despatch department, after the voltage, e.m.f. and height have been checked.

Conclusions

(1) The design of silver–zinc batteries and their mass production, based on technical developments at the Central Laboratory of Batteries and Cells in Poznań, result in highly reproducible, high quality batteries.

(2) The trial assembly line has proved to be successful for the automation of miniature battery production. The measuring-and-control devices used ensure high accuracy in effecting certain operations.

(3) The assembly line and its auxilliary devices can be rapidly adapted to other types of button cells.