

## **THE SILVER-ZINC BATTERY SYSTEM: A 60 YEAR RETROSPECTIVE, FROM ANDRE, TO SPUTNIK, TO MARS**

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The silver oxide-zinc system was known since the turn of the nineteenth century, when A. Volta experimented with pile batteries of that electrochemistry. However, it was only in the early 1940's that the meticulous work of the French Professor Henri Andre resulted in a commercially viable, truly rechargeable battery. The hallmark of Andre's many contributions was the use of cellophane as a separator to retard the migration of silver species from the positive to the negative electrodes, which caused the early failure of previous versions of the system.

The silver-zinc batteries offer significant technical advantages over other electrochemical systems, which make them irreplaceable for many applications, particularly those that require very high power densities. Additional advantages include:

- High energy density (up to 220 Wh/kg).
- May be used in both the primary and secondary (rechargeable) modes.
- High recharge efficiency.
- May be made with 100% non-magnetic materials.
- Flexible shape factors.
- Low risk of operation.

The main disadvantages are high cost and, for rechargeable batteries, a relatively short cycle life, typically less than 100 cycles.

This retrospective deals with the designs, shapes and the many applications of the system, from the days of Andre to the present. Some of these include:

- The early Andre "copperclad" cells
- The Sputnik battery, designed by Professor Bagotzky.
- The smallest prismatic cell ever built (0.17 Ah, 4.5 grams).
- The largest prismatic cell (22,000 Ah, 420 kilograms).
- The largest rechargeable batteries (256 tons by the USA, 300 tons by the ex Soviet Union), both used in submarines.
- Batteries for underwater applications (submersibles, torpedoes and targets).
- Batteries for orbital space applications, including the Apollo, Space Shuttle, Space Station and equivalent Russian vehicles and satellites.
- Batteries for space exploration, including the Lunar Rover, the Mars Lander and deep space probes.

Also included is a historical description of the work aimed at improving the system, particularly the most recent and promising efforts at increasing cycle life, which could expand the field of applications of silver-zinc, and make it even more attractive for existing ones.