MAGNESIUM COPPER SULPHATE WATER ACTIVATED BATTERIES

By PREM BEHARI MATHUR & NITYANANDAN J. PAUL

Central Electrochemical Research Institute, Karaikudi-3

A number of magnesium cells are known in literature as single shot or reserve type of cells[1]. Recently the authors of this paper discovered and reported a new cell system [2, 3] which comprised of magnesium and copper (or copper deposited over carbon) as electrode materials and copper sulphate as electrolyte. Compactness, non-polarisability, high ampere hour capacity per unit weight, high flash current and simplicity of fabrication were some of the outstanding features of this new cell system. Since 3 grams of anhydrous copper sulphate can deliver an ampere hour, the magnesium copper sulphate system appears to be the lightest and cheapest among the other known single shot cell systems to be operated at ordinary temperatures. The corrosion of magnesium in sulphate solutions is also observed by the authors to be much less than in various chloride electrolytes (fig. 1). The special features possessed by this cell system were reported earlier [2, 3, 4]. In the present paper some of the preliminary work carried out on assembliesand characteristics of 6 volts batteries has been described.

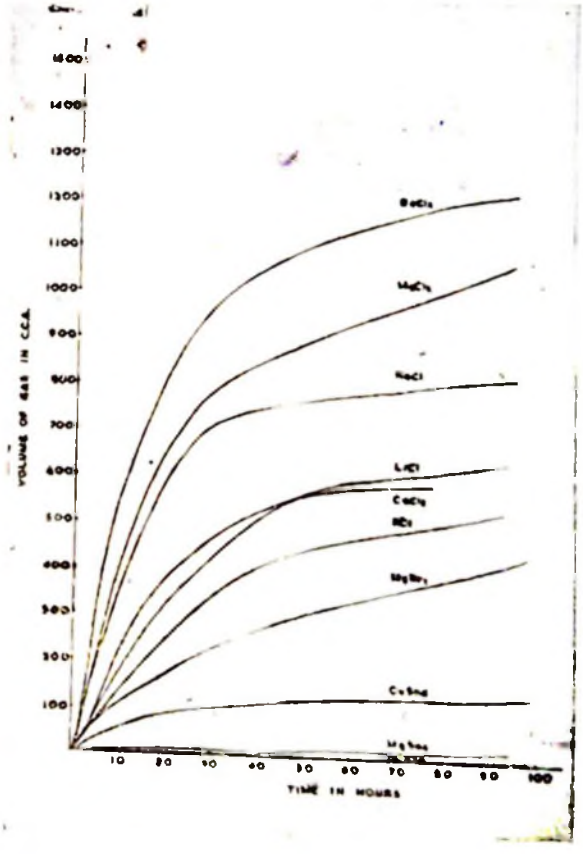
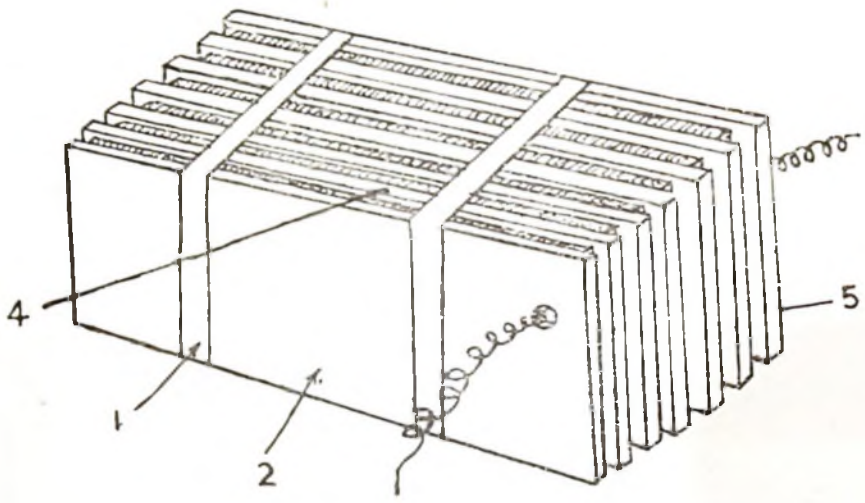


Figure 1. Corrosion of magnesium in various chloride salts.

A Six Cell Battery



1 Rubber bands
2. End Magnesium Plate
3. Electrolyte Cotton Pad
4 Magnesium Copper Bipolar Electrode
5 End copper Plate

Figure 2. Battery Assembly

With a view to minimise the space between adjacent cells of a battery and also to avoid soldering or welding difficulties of copper and magnesium electrodes (for series connection), duplex electrodes were made and used. These are fabricated as follows:

Magnesium is placed over the copper foil (slightly longer than the former) and the edges are folded up and pressed. The four edges are completely insulated by high melting point bees-wax or by Araldite or by any other stop-off laquer. The percolation of electrolytes in between these electrode pairs is thus checked completely. Cotton pads soaked in copper sulphate solution, dried and cut to sizes, are then coated with a paste of copper sulphate powder and then dried. These electrolyte pads and the duplex electrodes are placed one over the other alternately such that the cotton surface is in touch with magnesium surface and the electrolyte surface in touch with the copper surface of the adjacent duplex electrode. The assembly is held in tact by two rubber bands (fig. 2).

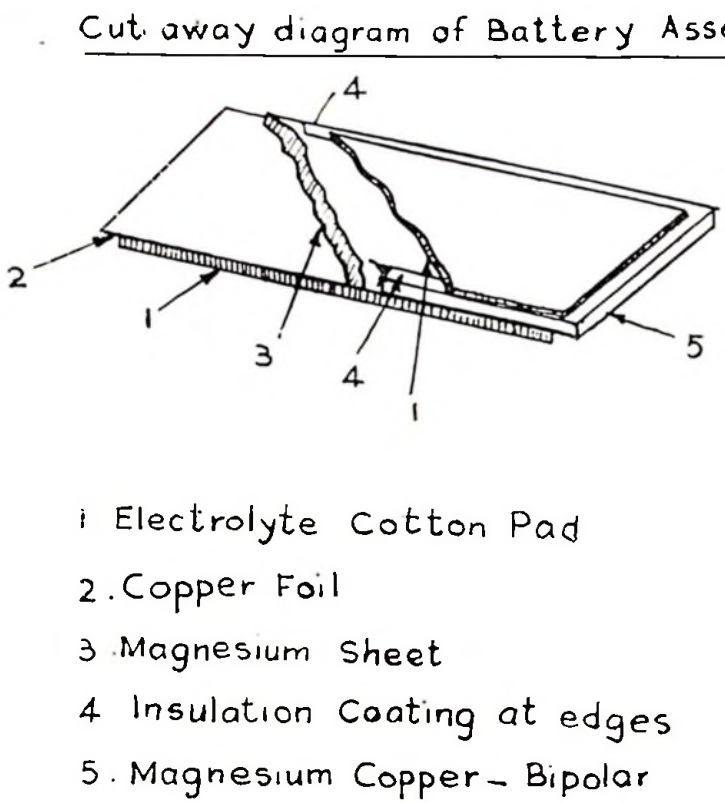


Figure 2. Battery Assembly

Typical data for H.T. low drainage 6 cell battery assembly are given below:

Magnesium: 1.65 mm. thick x 8.75 cm x 2.8 cm.

Copper foil: 0.15 mm. thick x 9.25 cm x 2.8 cm.

Copper sulphate powder: 40 grams.

Amylum paste: 2 to 3 grams.

Cotton separator: 1.65 mm. thick x 8.5 cm x 2.75 cm.

Overall battery dimension: 3.25 cm x 8.75 cm x 2.8 cm.

Total weight of the battery before activation: 110 — 120 grams.

The battery was not enclosed in a container.

The discharge performance of six cell battery under a low external load (22 ohms) and high external load (300 ohms) at R.T. are shown in figures 3 and 4.

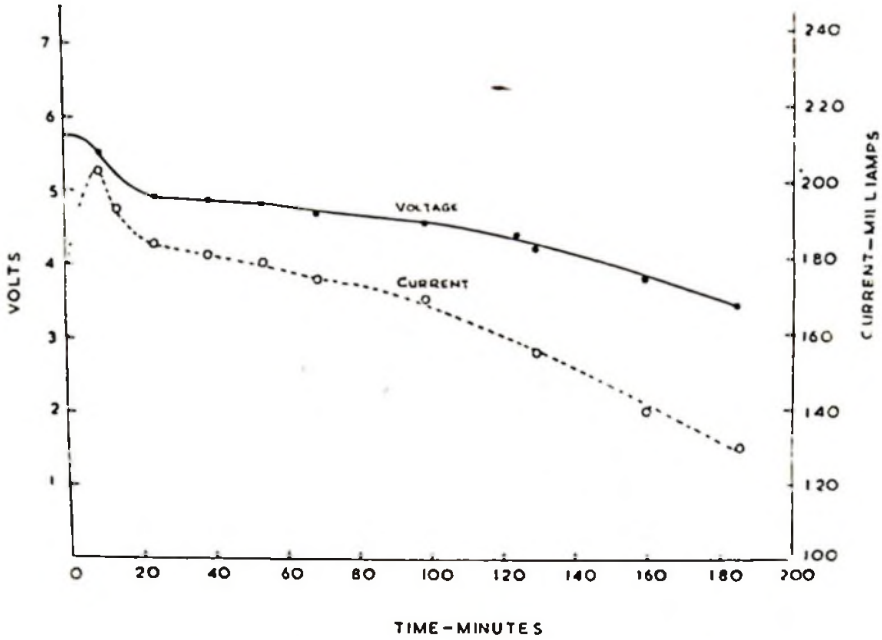


FIGURE 3 CHARACTERISTICS OF SIX CELLS BATTERY DISCHARGED THROUGH 22 OHMS RESISTANCE.

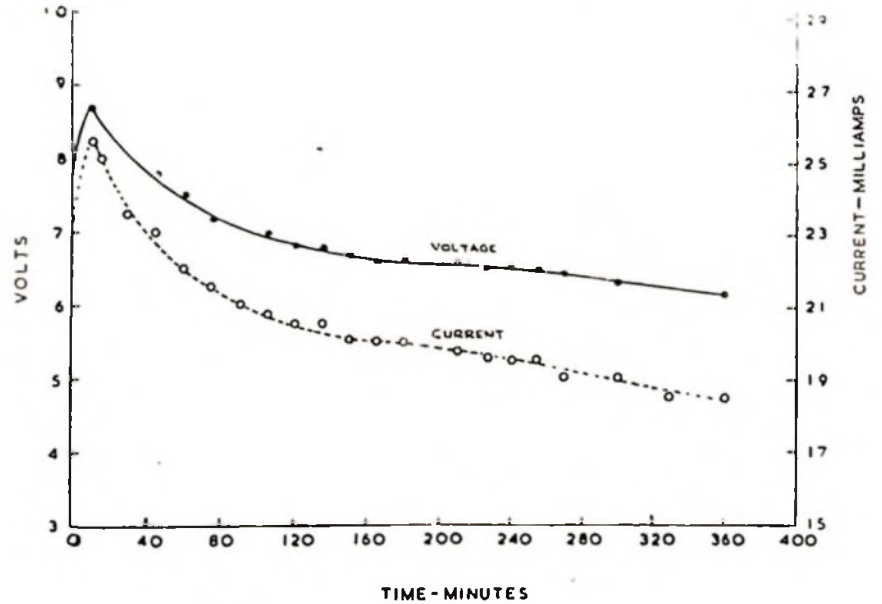


FIGURE 4 CHARACTERISTICS OF SIX CELLS BATTERY DISCHARGED THROUGH 300 OHMS RESISTANCE.

The voltage characteristics at constant current (220 mA) drain of the six cell battery represented in figure 5.

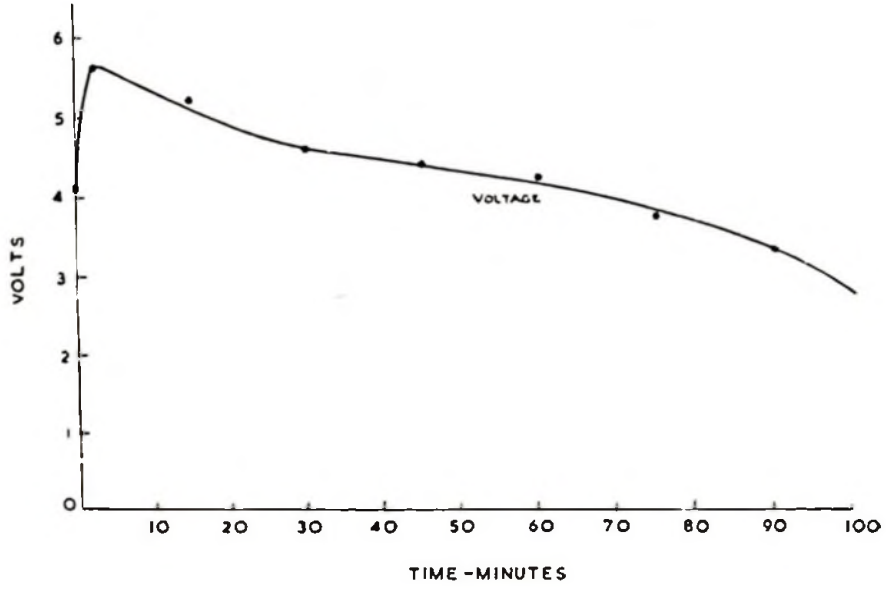


FIGURE 5 CONSTANT CURRENT (22 mA) DISCHARGE OF SIX CELL BATTERY

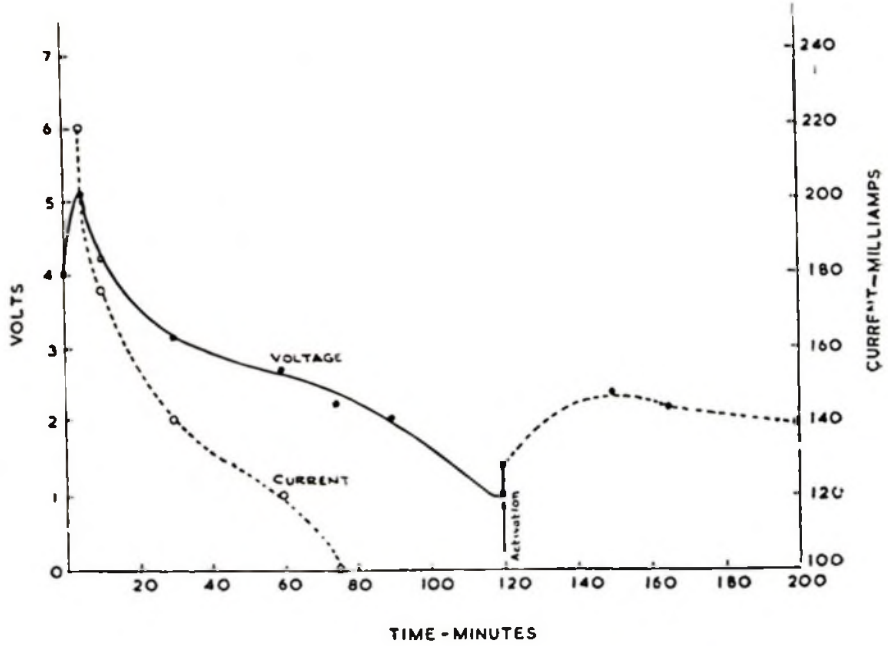


FIGURE 6 CHARACTERISTICS OF SIX CELLS BATTERY ACTIVATED BY SALT WATER AND DISCHARGED THROUGH 22 OHMS.

The performance of a six cell battery when activated with salt solution instead of tap water is represented in figure 6. The salt water used for activation in this experiment was a solution of 3% NaCl 0.5% $MgCl_2$. Tremendous amount of heat developed during activation and naturally the output current and voltage decreased to some extent.

In all these cases it was found that the batteries could be made to discharge for some more time provided more water is available. This is evident from the regain of capacity to some extent when the batteries were reactivated with water at the end of discharge (fig. 6). In such cases where output is required for long time, the use of somewhat thicker absorbant cotton pads is recommended[5].

A battery for heavy current drain and low voltage requirements was also fabricated and tested. A five cell battery specimen of overall dimensions 10 cm x 6 cm x 1.8 cm. weighing 120 grams before activation was fabricated. The electrodes were connected in parallel and the cells separated by partitions in the container. One of these batteries was activated with water and the other with the strong solution of copper sulphate. The battery performance at 1 amp. constant current drain is shown in figure 7.

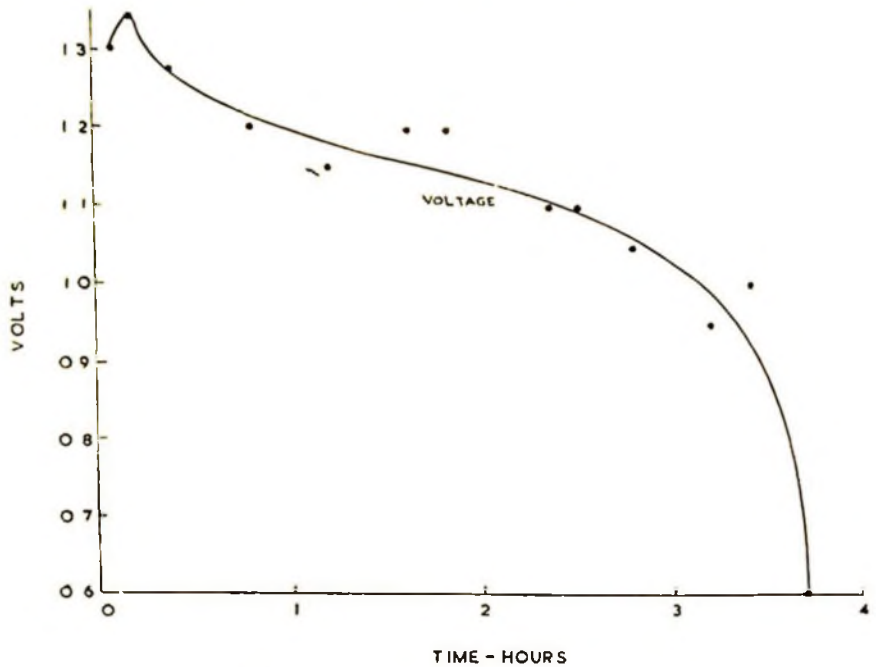


FIGURE 7 VOLTAGE VERSUS TIME CURVE FOR FIVE CELL HEAVY DUTY BATTERY DISCHARGED AT 1 AMPERE.

ACKNOWLEDGEMENT

Thanks are due to Professor K. S. G. Doss, Director, Central Electrochemical Research Institute, for his kind interest and suggestions in this work.

REFERENCES

1. Development in magnesium batteries, Mathur, P.B., and Paul, N. J., Jour. of Sci. & Industr. Res., **19A**, (1960), 597—602.
2. An activated and unpolarised type of magnesium primary cell system, Mathur, P. B., and Paul, N. J., Ind. J. Appl. Chem., **25**, (1962), 1 — 6.
3. Magnesium cell for demonstration, Mathur P. B., and Paul, N. J., Chem. Edn., **40**, (1963), 43.
4. Indian Patent. 83365 (1962).
5. Silver chloride — magnesium reserve battery, Ivan C., Blake, J., Electrochem. Soc., **99**, (1952), 202 c.