Chapter 6

DRY BATTERIES, MERCURY TYPE

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LIST OF ILLUSTRATIONS

Introduction

1. Mercury type dry cells are used to provide electrical energy for various types of airborne radio, sonobuoys, air-sea rescue equipment and ground test equipment; in the latter case a particular application is where a reference voltage is required.

2. This type of cell differs both in construction and electrical characteristics from the Leclanche cell described in Chapter 1 of this section. The advantages of the mercury cell are that it will give a higher current at constant voltage; longer shelf life (not prone to local action); capacity unaffected by continuous discharge; hermetically sealed and robust enough to withstand high pressures, accelerations and vibrations; and in addition has a larger electrical capacity for a given case size.

3. There are two types of mercury cell at present in use in the Service: the Kalium and the Mallory. Details of specific types of cells and batteries can be found in A.P.4343A, Vol. 1, Sect. 10.

DESCRIPTION

General

4. The mechanical construction of the Mallory and Kalium cells differ considerably from each other; construction of typical cells of each type is given later in the chapter. The chemical composition of the various components in the cells and the reaction during use is however, the same in both types.

Cathode

5. The cathode is of mercury formed during discharge from the depolarizer. The depolarizer consists of chemically pure mercuric oxide (HgO), to which fine graphite has been added. The graphite is introduced to increase the depolarizer conductivity and thereby reduce the overall internal cell resistance.

Electrolyte

6. This is a concentrated aqueous solution of potassium hydroxide (KOH), to which is added a proportion of zinc oxide (ZnO) in the form of potassium zincate (K_2ZnO_2). The addition of the zinc oxide, whilst increasing the resistance of the electrolyte, reduces the tendency for the anode to be attacked. The electrolyte has a high degree of stability within the cell, and limits the possibility of hydrogen evolution during shelf storage and normal discharge.

Anode

7. The anode takes the form of either granules of amalgamated zinc powder, or a winding of uniformly thin amalgamated zinc strip. The amalgam is employed to counteract the tendency for the cell to gas during discharge and storage. The choice of the type of anode employed depends on the application for which a particular cell is designed.

Kalium cell (*fig.* 1)

8. The cell is contained in a P.V.C. covered zinc canister which is passive; taking no part in the discharge reaction. In this type of cell the anode consists of the zinc granules mounted, with the aid of a starch-like substance, on Whatman paper (a heavy matt, white art paper). The depolarizer cathode is

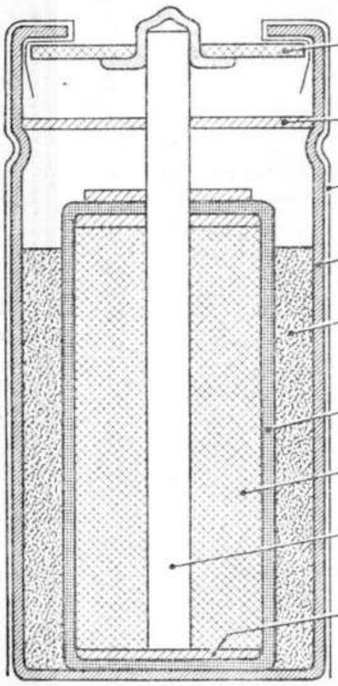

Fig. 1. Sectional view of typical Kalium cell

in the form of cylindrical pellets contained in a wrapping of a porous material. These pellets surround a central carbon rod current collector, insulated from the base of the cell by a washer and supported at the top by the inner sealing washer. A brass contact cap, set in the outer sealing washer, is fixed to the top end of the central rod. The inner sealing washer is made of a resin impregnated board covered with a neoprene based adehsive, and the outer sealing washer is of alkathene to which the zinc canister is swaged securing the P.V.C. outer cover. The electrolyte is contained in the cell by the inner sealing washer.

9. Electrical connection to the Kalium cell is made from the top cap (positive) and the base (negative), i.e. conventional polarity of a dry cell. This cell is mainly used in multi-cell batteries, individual cells being cast in a polyester resin which completely encloses and protects them.

Mallory cell (*fig.* 2 *and* 3)

10. This cell is contained in a nickel plated steel case; the depolarizer is situated in the base of the case and the anode in the upper section. With a " wound anode " type cell the foil is interleaved with an absorbent paper to retain the electrolyte at the interface of the anode. The anode pellet of the " pressed powder anode " cell is in contact with layers of cellulose felt which retain the electrolyte. Between the depolariser and the anode is an ion-permeable barrier. The function of the barrier is to prevent migration of particles from the depolariser to the anode, and is usually of parchment paper placed directly on the depolariser surface.

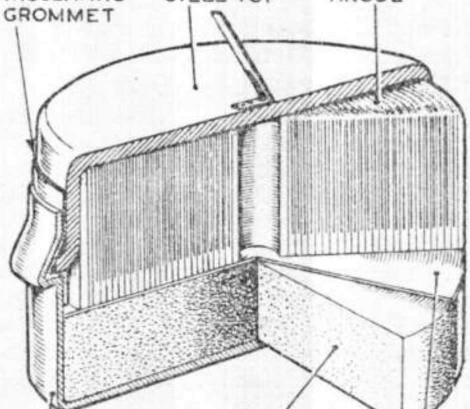

Fig. 2. Constructional details typical " wound anode " Mallory cell

11. The top of the cell, commonly of tinned steel, has the case formed on to it; the two parts being insulated from each other by a sealing gasket of neoprene. To avoid the possibility of cell rupture due to high internal pressures caused by the evolution of hydrogen from such unusual causes as local action at the anode, unbalanced construction, externally applied voltage, etc., a venting arrangement is sometimes incorporated and is shown in fig. 3. With this arrangement, if an abnormal pressure builds up in the cell the top is raised slightly and permits venting into the annular space between the two cases. Any electrolyte vented is retained in the absorbent sleeve in this space and any gas escaping through a hole in the outer cell case.

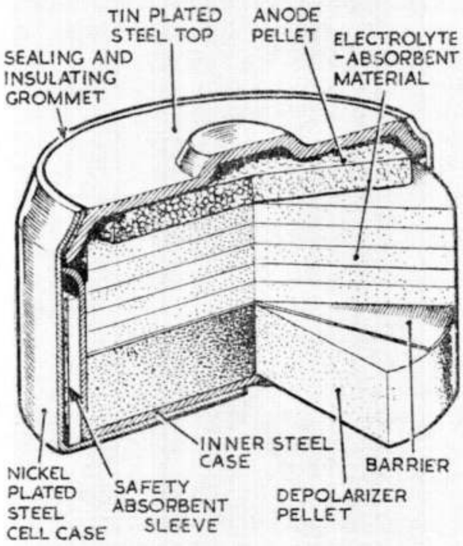

Fig. 3. Constructional details, typical "pressed powder anode" Mallory cell

12. The electrical connections to the Mallory cell are from the case which is positive, i.e., opposite polarity to the conventional dry cell, and from the top which is the negative pole. The negative connection may be effected by either a tag or top cap type contact.

OPERATION

General

13. Until the mercury type cell is connected to an external load, there is no internal cell reaction due to the stable chemical components and passive cell case materials. When connected in a circuit, the cell provides electrical energy by an electro-chemical reaction which occurs at both the anode and depolarizing cathode activated surfaces, aided by the cell electrolyte.

Chemical reaction

14. Zinc ions from the anode dissolve in the electrolyte, and displace hydrogen ions to the depolarizer cathode where they react with the solid mercuric oxide to form mercury (the cathode); the reaction being $HgO + 2H \rightarrow Hg + H_2O$. The electrolyte yields anions, negatively charged ions $ZnO_2^{=}$, which migrate to the anode. There are however, enough zinc ions present in the electrolyte to prevent local action between anode and electrolyte.

Electrical characteristics

15. The open circuit voltage of a single mercury cell is 1·345V and remains virtually constant for its shelf life. The on-load voltage/time discharge curve (*fig.* 4) is nearly horizontal for the cell, this feature makes the cell particularly useful in applications where a constant or reference voltage is essential.

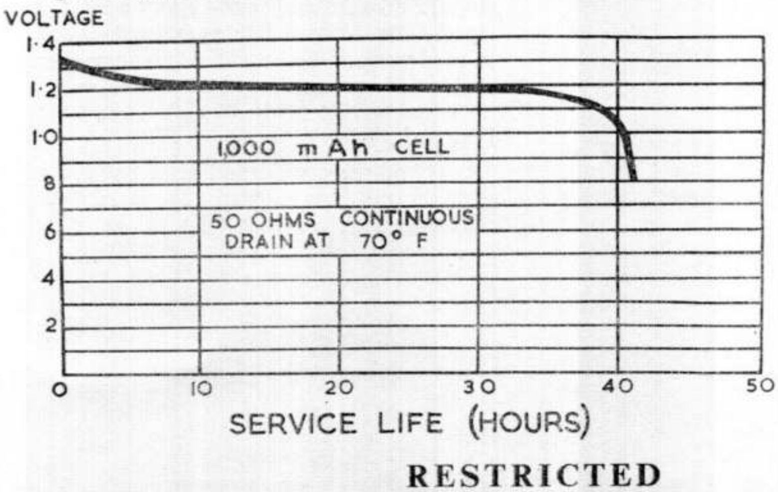

Fig. 4. Typical discharge characteristic

16. The internal resistance of the cells is high compared with the Leclanche type cell, due to a temporary state of the electrodes there is in effect an increase of this resistance with age—a three fold increase being typical. Although the open circuit voltage of a cell that has aged in this manner will remain constant, the load voltage will be less. In a serviceable cell the load current will restore the condition of the cell, and the terminal p.d. will rise to its normal on-load value within a short period. This phenomenon is sometimes referred to as "sleepiness" and is less apparent in the "Mallory" cell, usually being detected only with a heavy current drain.

17. The operating temperature of a cell will affect its performance. Except where a cell has been specially designed for use in sub- or abnormal temperatures, the voltage of a cell at a normal working temperature of 17 to 40°C remains virtually constant. Below this temperature there will be a decrease in voltage; at 0°C and below there is a rapid deterioration in efficiency.

SERVICING

18. When handling mercury cells care should be taken to ensure that they are not shorted out (particularly when in the unused state), or subjected to undue shock. The cells should never be heated and no attempt must be made to open cells or batteries or to charge them as a secondary cell.

Testing

19. Before testing a mercury cell or battery refer to the Air Publication for the equipment to which the cell or battery is to be fitted, or to A.P.4343A, Vol. 1, Sect. 10, and service test in accordance with the appropriate instructions. When no specific instructions have been issued the following general tests may be applied.

Kalium

20. Off- and on-load voltage tests should be conducted on these cells. The off-load voltage, when measured with a high resistance voltmeter or by comparative method, should not be less than 1·340V per cell. The on-load voltage reading must be continued for a period of some ten to fifteen seconds, and is characterised by an initial fall for one or two seconds, followed by a gradual rise to a steady reading. The final steady reading may take between 30 seconds and one minute before it is attained in a new cell; as cells age or at low temperatures this time may show a considerable increase. The magnitude of the test load should be of the order of 20 ohm per square inch of curved surface area of the cell; the steady on-load reading must be greater than 1·15V per cell.

Mallory

21. With Mallory type cells an open circuit voltage test using a 20,000 ohm per volt instrument (Multimeter type 1, Ref. No. 10S/17411,) is required only. A voltage of 1·3V per cell should be obtained within 2 minutes. If at any time during the test the voltage be observed to fall, then the cell or battery is suspect and should be considered unserviceable. A white encrustation may form on the base of the cells; this is due to venting and should it occur in new cells they should be considered unserviceable. If however, it is known that the cell has had a long storage life, the encrustation may be removed using dilute acetic acid (vinegar) before conducting the electrical test.

Note . . .

Extreme care should be exercised during this operation as the product from the cell is corrosive.

STORAGE

22. Mercury type dry cells and batteries should not be stored in temperatures below 0 deg. C. or above 40 deg. C.; the preferred temperature is 20±5 deg. C. Unprotected cells and batteries should not be stored in humid or corrosive atmospheres. The maximum shelf life when stored in the specified temperature range is for Kalium cells 12 months and for Mallory cells 2 years; should the storage temperature over prolonged periods be outside the range then the shelf life is reduced.

Disposal

23. Used mercury cells have a salvage value and should be returned to stores. Where circumstances are such that the cells cannot be disposed of in this manner they should be buried in the earth.

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