Chapter 1

PRIMARY BATTERIES

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Primary batteries for modern electrical and instrument equipment are of the " dry " Leclanche type, in which the electrolyte is a paste of consistency, stiff enough not to flow readily but containing sufficient moisture to permit the chemical reaction whereby chemical energy is converted to electrical energy.

DESCRIPTION

2. A typical cell is shown in fig. 1. The central carbon rod is the positive electrode and is fitted with a metal cap to facilitate external connections. This rod is surrounded by a depolarizer consisting of a compressed block of manganese dioxide and carbon (mainly in the form of graphite) moistened with ammonium chloride solution. The depolarizer is usually wrapped in muslin or light canvas and the whole assembly, referred to as the dolly, is surrounded by electrolyte and located centrally within the zinc container which forms the negative electrode of the cell. A washer, interposed between the base of the dolly and the bottom of the container, insulates the dolly from the container.

3. The electrolyte consists mainly of an ammonium chloride and zinc solution, to which gelatinizing agents such as flour and starch are added. It is converted into a paste by controlled cooking. A little mercuric chloride is added to the electrolyte to amalgamate the inner surface of the negative electrode. The cell is sealed with a cardboard " top " washer over which is poured a sealing compound. Most cells have a vent tube which passes through the sealing compound and top washer to the air gap between the washer and the top of the dolly.

Batteries and cells

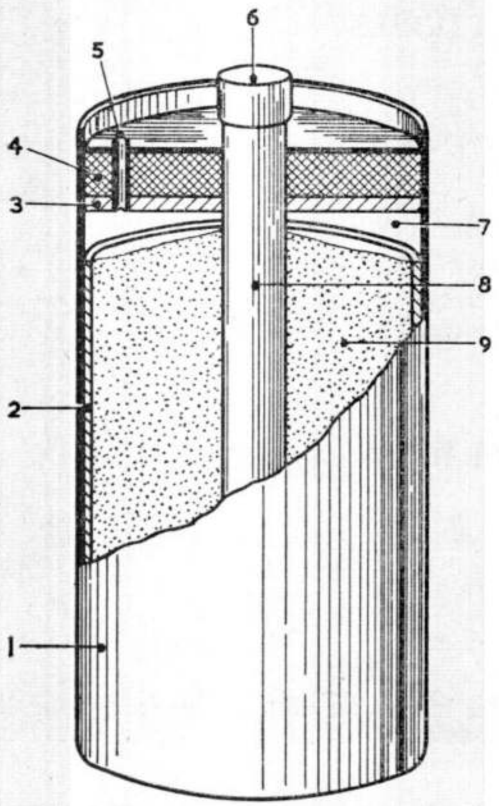
4. A primary battery consists of two or more cells connected in series (i.e. the positive of one cell connected to the negative of the next). Cells and batteries may also be connected in parallel.

5. Cells in series will supply a voltage dependent upon the number of cells, e.g., four 1·5 volt cells will supply 6·0 volts, whilst cells connected in parallel will supply the same voltage as that of an individual cell, but for a period related to the number of cells in the battery (*fig*. 2), i.e., the capacity will be increased. The nominal open circuit voltage of a " dry " cell is 1·5 volts, although it is possible to obtain voltages up to 1·65 volts. This is dependent upon:—

(1) The age of the cell.

(2) The activity of the depolarizer and/or the electrolyte.

(3) The temperature.



1 NEGATIVE ELECTRODE
2 ELECTROLYTE
3 TOP WASHER
4 SEALING COMPOUND
5 VENT
6 METAL CAP
7 AIR GAP
8 POSITIVE ELECTRODE
9 DEPOLARIZER

Fig. 1. Typical dry cell, cut-away view

Reactions in a simple cell

6. When two strips of dissimilar metals (i.e., zinc and copper) are immersed in a dilute solution of sulphuric acid, a potential difference reading of approximately 1 volt will be obtained on a sensitive voltmeter connected to the ends of the metal strips. If a carbon electrode is substituted for the copper, a P.D. of 1·5 volts will be obtained, but this will quickly fall.

7. It is possible to obtain current from a simple cell such as described in the previous paragraph by connecting the electrodes through some load, such as a small bulb or an electric bell. There will be a comparatively large current to commence with, but this will fall off rapidly after a very short time. Examination of the electrodes would then reveal that the zinc is emitting bubbles of gas and also that the carbon is becoming coated with a fine layer of hydrogen bubbles.

8. The formation of these gas bubbles on the positive electrode is known as polarization. It can be shown, by removal of the bubbles (by wiping down the carbon) that polarization is detrimental to the efficient operation of the cell, because when the carbon has been wiped the cell will again temporarily deliver a comparatively large current.

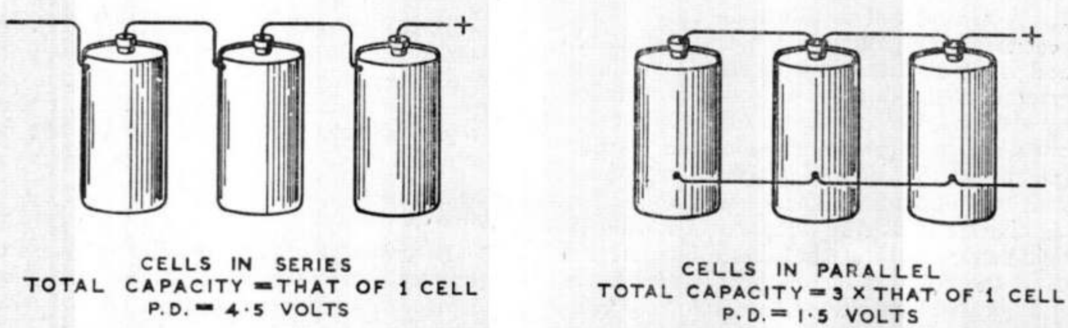


Fig. 2. Series and parallel arrangements

Reactions in a dry cell

9. In the "dry" cell, ammonium chloride (NH_4Cl) ionises into NH_4 ions and Cl ions. The Cl ions go to the zinc or negative electrode, where they combine with the zinc and form zinc chloride ($ZnCl_2$). The NH_4 ions, on the other hand, split up into ammonia gas (NH_3) and hydrogen (H); some ammonia gas is given off and can be detected by smell. The hydrogen goes to the depolarizer, where it is oxidized by the MnO_2 and becomes water, and the NH_3 to the negative electrode, where it reacts with the Cl ions and the zinc chloride ($ZnCl_2$) forming both ammonium chloride (NH_4Cl) and a complex salt known as zinc ammonium chloride. This reaction continues all the time the circuit outside the cell is completed, but as the depolarizing effect of the manganese dioxide (MnO_2) is slow, the dry cell is best suited for intermittent loads.

Local action

10. When a cell or battery is left in storage, or in a piece of equipment without delivering current (i.e., is on open circuit) "local action" takes place continuously. This condition results in loss of capacity depending upon time, humidity, and temperature.

11. Although modern methods of manufacture ensure very nearly pure zinc for the negative electrode, the small amount of impurities present (cadmium, iron, arsenic, etc.), together with the chemical activity of the depolarizer and the electrolyte cause minute short circuits to be formed which slowly and continually discharge the cell. Over a period of time, this local action may considerably reduce the available capacity of the cell.

Storage

12. Local action is always present to a greater or lesser degree in all dry cells or batteries. The shelf life of a cell is therefore, limited and consequently, cells should be issued in strict rotation (i.e., older stocks first), otherwise some cells will deteriorate to such an extent as to become unserviceable. An unused cell is to be considered unserviceable when its P.D. on test load falls below 1.3 volts approximately. The rate of local action increases with the rise in temperature, and cells should always be kept in a cool and dry storage.

SERVICING

13. Before a cell or a battery is inserted in a piece of equipment, it must be examined to ensure that the electrodes are clean and free from mechanical damage or corrosion and that there is no exudation of the electrolyte through the zinc container or the sealing compound. Cells or batteries should not be allowed to remain in any piece of equipment which is not being used for any length of time, for, if local action has occurred, the zinc container may be perforated and the electrolyte may then come into contact with the equipment and cause corrosion.

14. A used dry cell is to be considered unserviceable when its P.D. on load falls below 0.75 volt. It must then be exchanged for a new one.