K-375-C MINIATURE STANDARD CELL

By E. W. TUCKER

A recent addition to the Muirhead range of cells is the K-375-C miniature unmounted saturated Standard Cell. It is truly hermetically sealed by glass fusion and the special internal construction ensures the provision of a robust reliable 0·01% standard of E.M.F. It has been designed at the request of leading Digital Voltmeter manufacturers who appreciate the reliability, long term stability and simplicity of application with low cost as compared to the Zener diode with its added complexities of current stabilization and costly test procedures. With solid state circuitry the high input impedances of Digital Voltmeters are normally in excess of 10,000 megohms, which means that the current withdrawn from a cell is of very low order. In fact, a cell capacity of one coulomb is more than adequate for this type of application and allows for frequent standardisation over several years. The small dimensions of the cell make it suitable for mounting directly on printed circuit boards or in an adjacent position of minimum temperature variation.

DESCRIPTION

A single tube cell diam. $\frac{11}{32}''$ length $1\text{-}\frac{1}{8}''$ dip coated in red P.V.C. for protection. It is fitted with insulated flying leads 3″ long coloured red and black to denote polarity. Each cell is marked with month and year of manufacture.

SPECIFICATION

E.M.F. 1·01860 V. Abs. $\pm 100\mu V$ at 20°C

Internal Resistance:
2,000 ohms max at 20°C

Temperature coefficient of E.M.F:
As per internationally agreed formula for 0·05 N. acid electrolyte saturated cells. ($-40\mu V/°C$ approx. at normal ambient temperature)

Working temperature range:
0°C to + 43°C

Transport temperature range:
-20°C to + 60°C

Mounting position:
The cell may be used or transported in any position, but for best long term stability an upside down position should be avoided during use.

Current rating:
The maximum current withdrawn or passed through the cell should not exceed $10\mu A$. The cell will remain within the specified E.M.F. tolerance, provided the current drain does not exceed a total of one coulomb during the required life of the cell.

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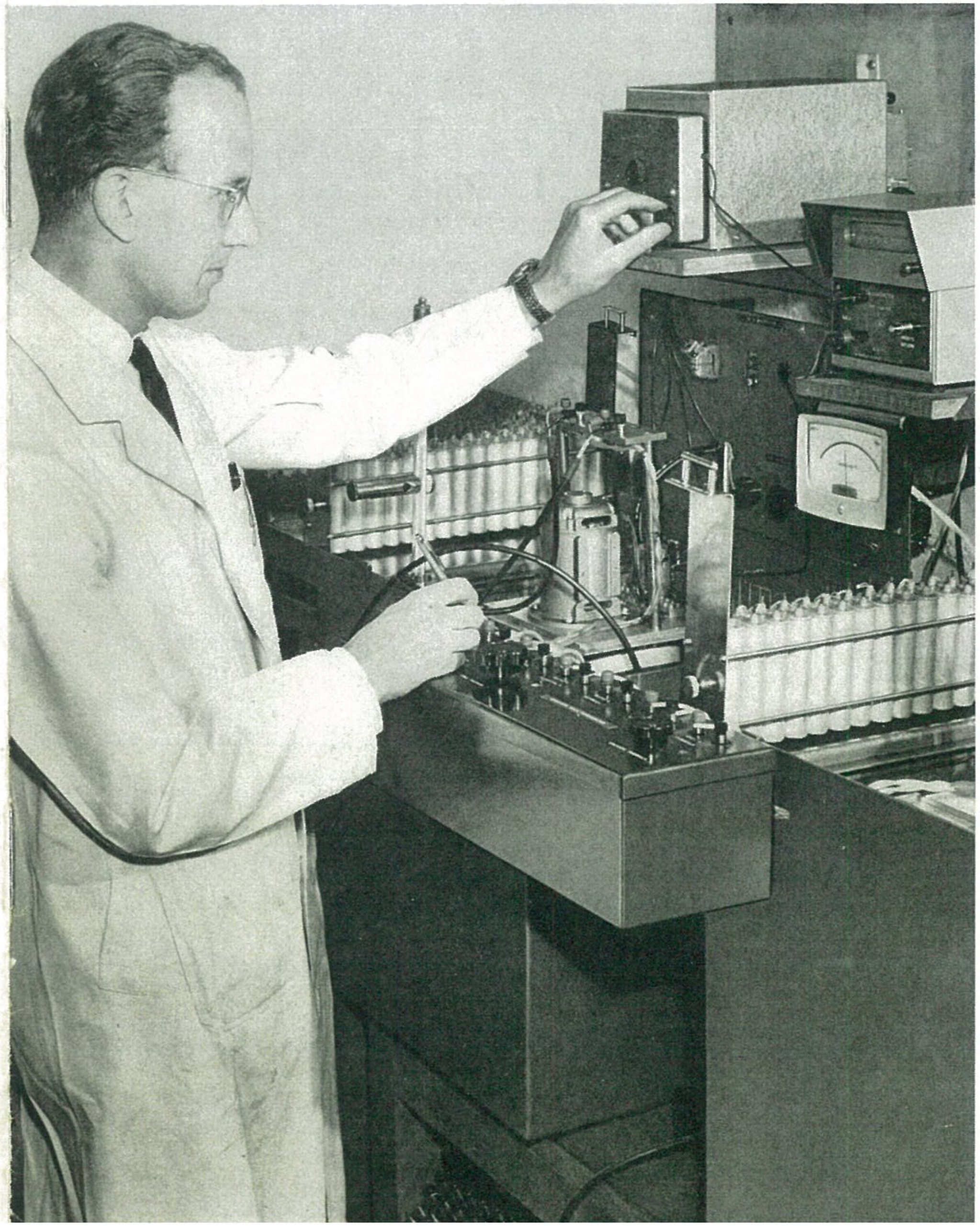

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IN THIS ISSUE

This article, by Muirhead's Chief Chemist describes the chemistry, construction and electrical properties of Weston saturated and unsaturated cells, and the relative merits of the two types are discussed.

Muirhead have unrivalled experience in the development and manufacture of standard cells; it is interesting to note that Dr. Alexander Muirhead, the founder of the present firm of Muirhead & Co., Limited, collaborated with Latimer Clark, at the close of the last century in developing the "Clark" standard cell which preceded the improved Weston cell as an accepted standard of e.m.f. Today, we manufacture many thousands of Weston cells whose standards of accuracy and stability are recognized throughout the world.

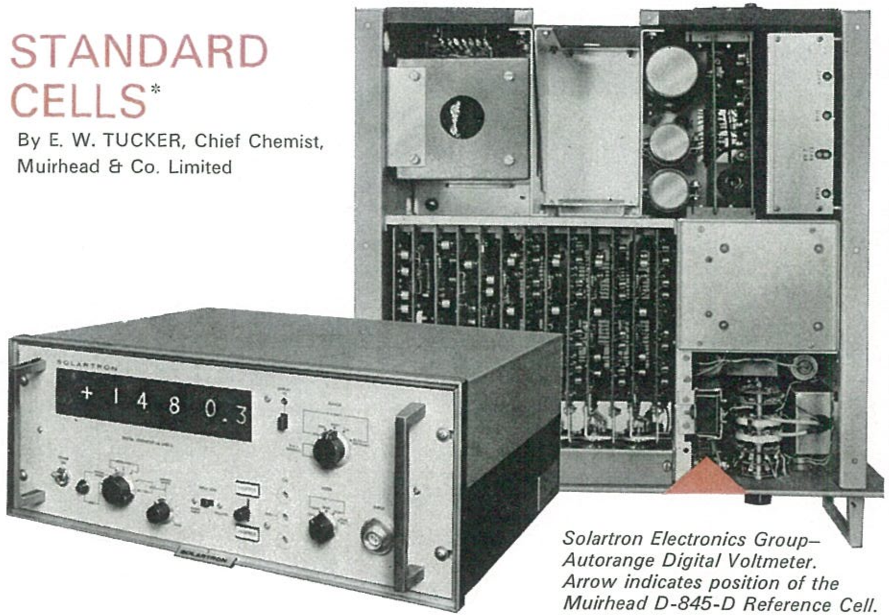
THE FRONT COVER

A corner of our Standard Cell manufacturing department showing a typical temperature controlled oil bath used for precision measurements of E.M.F.

Temperature control is of the order of $\pm 0{\cdot}001\,^\circ C$ and long term stability of E.M.F. to better than one part in a million are continuously maintained.

STANDARD CELLS*

By E. W. TUCKER, Chief Chemist, Muirhead & Co. Limited



Solartron Electronics Group–Autorange Digital Voltmeter. Arrow indicates position of the Muirhead D-845-D Reference Cell.

History. A Standard cell may be defined as a specialized form of chemical primary cell so constructed as to produce a stable electromotive force of known and reproducible potential, which is relatively unaffected by external influences. The particular chemical system of the Standard cell in use today was due to an Anglo-American inventor, named Weston, in 1893. In 1911 it was internationally agreed to adopt it as the ultimate Standard of E.M.F. to be used in all electrical measurements. From this date further developments of the Standard cell was painstakingly slow. Many valuable theoretical contributions came from academic workers but there was little opportunity to prove or apply their findings on a commercial scale. A new era started after the end of the last war. Industry, compelled by the growing demands of automation and instrumentation requiring ever increasing accuracies, had to find an increasing number of standard references. It is in these new functions and processes that many tens of thousands of cells annually are becoming an integral component.

Chemistry. Two basic types of cell are in regular use.

1. The Saturated Cell.

This is usually referred to as a "Standard Cell". The positive electrode is mercury and mercurous sulphate, the negative electrode is a cadmium/mercury amalgam and the electrolyte a Saturated solution of cadmium sulphate. Excess crystals of cadmium sulphate possessing the formula $3CdSO_4 - 8H_2O$ are also present to ensure the electrolyte is fully saturated at all working temperatures.

2. The Unsaturated Cell.

In this country this is usually given the distinguishing title of "Reference Cell". The electrodes are the same as in the Standard Cell but the electrolyte is of fixed concentration and no excess crystals of cadmium sulphate are present. When current is drawn from a cell it may be represented by the following equations:—

At the negative electrode

$$Cd + SO_4 \rightarrow CdSO_4 + 2e$$

At the positive electrode

$$Hg_2SO_4 + 2e \rightarrow 2Hg + SO_4$$

These reactions produce two definite e.m.f.s and additively equal the total e.m.f. of the whole cell. The overall reaction may be expressed as a combination of the two separate reactions:—

Cd (from the amalgam) +

$$Hg_2SO_4 \rightarrow CdSO_4 + 2Hg$$

In the case of the saturated cell the reaction is truly reversible as the electrolyte remains saturated at all temperatures. This type of cell has a great stability over many years. When using saturated cells there is an extremely important transition temperature to note. If cadmium sulphate solution crystallises out of solution above $43{\cdot}4\,^\circ C$ it does so as the monohydrate $CdSO_4 - H_2O$ instead of the stable salt $3CdCO_4 - 8H_2O$. This can lead to serious instability; $43{\cdot}4\,^\circ C$ is therefore the absolute maximum temperature saturated cells should ever encounter. If the foregoing equations are studied it is evident that in the case of a cell with unsaturated electrolyte the cell is not truly reversible. When current is taken the concentration of cadmium sulphate slowly increases in the electrolyte and in time the result is a saturated cell. This is not as serious as it first appears for in well chosen circuitry many years elapse before the e.m.f. is changed significantly. It does, however, rule out its use as a fundamental standard of e.m.f. Since the e.m.f. of the cell depends on the concentration of the cadmium sul-

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