HOW TO USE METERS

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Revised

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PREFACE

This revision of the second edition of *How to Use Meters* is twofold: (1) the original text has been brought up to date, and (2) new material has been added on modern advances in the rapidly growing field of meter use. Every effort has been made to retain the original point of view which proved so successful in the first edition, i.e., satisfying the practical interest of those concerned with measuring devices and their basic principles. As the electronic art expands in breadth and depth of applications, it becomes increasingly important to preserve this most effective approach by placing the accent on fundamental meter function.

This approach has been kept in mind in introducing such new developments as transistorized voltmeters, refined laboratory instruments providing greatly increased sensitivities, and advanced indication features in meters providing long-arc (250°) meter scales and digital displays. Careful attention has been given to the important extension of measurement capability in the new chapters on specialized measurements (Chap. 14) and advanced meter features (Chap. 15). Circuits are discussed to illustrate the use of electrometer-type voltmeters having extremely high input impedances, and of chopper-type stabilized galvanometers capable of measuring minute d-c currents. Summary tables have been added to allow at-a-glance comparisons of the numerous meter types. Attention has also been paid to the fast-growing areas in industrial electronics where transducers are widely used to display and control physical quantities after they have been converted into electrical values.

It is recognized that the inclusion of too many specialized details and complexities could easily tend to obscure the picture of the fundamental functioning of the measuring devices with which this text is primarily concerned. To avoid this tendency, a reference reading list of specialized texts is given in Chap. 14, to direct further study in the more special fields of electronic instruments.

Grateful acknowledgment is made, as before, to the many manufacturers who supplied information and illustrations, as indicated by the credit lines that accompany their very helpful material.

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PRINCIPLE AND CONSTRUCTION OF D-C MOVING COIL METERS

1-1. Introduction

Electric meters are devices which *measure* electric current and other electrical quantities and *indicate* the quantity measured. The heart of an electric meter is the *meter movement.* The movement translates electrical energy into mechanical energy which causes visual indication. The indicator usually is a pointer moving across a calibrated scale.

A number of different types of meter movements have been designed and are in use. The most important of these is the *moving-coil* movement, which in its original form was developed by the French scientist *D'Arsonval.* The modern moving-coil movement is the result of the work of *Dr. Edward Weston,* who considerably improved on *D'Arsonval's* original version. In its present-day form moving-coil movement is referred to as either a *Weston-type* or a *D'Arsonval* movement. A majority of the meters discussed in this book use this type of mechanism.

1-2. Principles of the Moving-Coil Meter Movement

This type of meter depends for its operation on the reaction between a direct current-carrying coil and a stationary magnetic field. The magnetic lines of force generated by the current in the wire interact with the unvarying lines of force of the magnetic field in which the coil is located, and the coil is forced to *move* with respect to the stationary field. By virtue of its physical design, the coil rotates. In order that there be useful interaction, the current in the coil must be unidirectional, hence the instrument is a d-c meter.

Suppose a *loop* of wire is located in a magnetic field (Fig. 1-1A) in which the poles of the magnet are concave, so that the loop of wire