Electrical Measurements in Theory and Application

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PREFACE

This book is written for students who have had one year of college physics and desire further knowledge of electrical and magnetic matters. It can be used as a guide in laboratory work, but it is more than a laboratory manual. The principles involved are fully treated; the student is led to reason out the relationships rather than to memorize formulas; and he is urged to learn the facts from his own observations. To this end direct information is often replaced by suggestions as to how the knowledge can be obtained.

The time has certainly come when the electron theory of electrical phenomena should be presented to all students of physics and electrical engineering. Regarding the electron tubes used in radio communication, for instance, there is no doubt that the stream of electrons through the tube continues as an electron current through the connecting wires. Since this point of view has been taken throughout the book, the drifting of electrons along the circuit is called "an electron current," or simply "the current." It is hoped that this concept, which is in accordance with the ideas of modern physics, will add a concreteness to the subject that will prove helpful in the classroom. Where the direction of this current must be indicated, an arrow is placed alongside the circuit, pointing *up* the potential gradient, *i.e.*, from $-$ to $+$ potentials. This direction is also the direction of the electron current.

As in the previous editions, the simpler and more fundamental subjects are treated in the first chapters, and in the first part of each chapter; more difficult measurements and methods requiring more extended knowledge are reserved until the student has attained greater proficiency. The simple experiments in Chap. I on measuring current, resistance, electromotive force, and power by ammeter and voltmeter methods are intended to bring out the fundamental relations of electrical measurements with a minimum of apparatus to distract the student. It is hoped that students with little laboratory experience will build a correct and useful foundation in the use of electrical instruments, while those with college laboratory training can pass on to the advanced subjects and more complicated methods.

In revising the book for the fourth edition, the author has carefully

examined each page and diagram in the light of classroom experience and has rewritten much of the text to make the subject clearer to the student reader and to bring it up to date. The author has relied on comments made by users of earlier editions in retaining topics that have proved most useful in their classes; he has omitted obsolete topics and has made many additions where teaching experience has indicated better methods and clearer explanations.

The meter-kilogram-second system is used in giving the definitions of the electrical and magnetic units. Since the unit of power in this system is the watt, the practical units of electrical quantities—ohm, volt, henry, etc.—fall naturally into the same system, thus making the definitions of the practical electrical units much simpler and more direct than heretofore.

The symbol for a voltaic cell has always been a long thin line drawn alongside a short thick line. A careful examination of the books published during the past half century shows that 50 years ago over 90 per cent of those using this symbol intended the long thin line to represent the negative side of the cell, perhaps because it looked like the long thin zinc rods that were then commonly used in primary batteries. Since then, decade by decade, there has been a steady shifting of the meaning ascribed to this symbol until now barely 10 per cent cling to the former use, and 90 per cent indicate the negative side of the battery by the short thick line, perhaps because it looks more like the − sign. For this reason the negative side of a battery is represented in the diagrams in this edition by the short thick line.

The measurement of capacitance and of inductance is usually made with alternating current. The methods are fully described and are illustrated with vector diagrams of the bridge networks. The bridge diagrams show telephone receivers used with 1,000-cycle-per-second current from electron-tube a-c generators, which is a satisfactory and inexpensive combination available to any laboratory. The methods are the same when more elaborate apparatus is used. With the advent of new forms of instruments, especially in the field of electronics, it is now comparatively easy for students to make accurate measurements of inductance and capacitance.

With the use of a newly developed triple-bladed switch, which is fully described, the difficult measurements of the hysteresis of steel are made as easily as other measurements with a ballistic galvanometer.

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CONTENTS

*Laboratory Exercises Are Indicated By **

CHAPTER II

Ballistic-galvanometer and Condenser Methods

CHAPTER III

The Current Galvanometer

CHAPTER IV

The Wheatstone Bridge

CHAPTER V

The Wheatstone Bridge (*Continued*)

CHAPTER VI

Potentiometer and Standard-cell Methods

CHAPTER VII

Measurement of Current

CHAPTER VIII

Measurement of Power

CHAPTER IX

Electron Tubes

CHAPTER X

The Magnetic Circuit

CHAPTER XI

Measurement of Magnetic Flux and Mmf

CHAPTER XII

Magnetic Tests of Iron and Steel

CHAPTER XIII

Alternating Currents

CHAPTER XIV

Measurement of Capacitance

CHAPTER XV

Inductance

CHAPTER XVI

Measurement of Inductance