

Electrical
Measurements
& Measuring
Instruments

Golding
& Widdis

Wheeler's Student Edition

ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS

THE LATE

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FIFTH EDITION

wheeler

Fifth Pitman Edition, 1963

© E.W. Golding & F.C. Widdis, 1963

First Indian Edition, 1979

9th Indian Reprint, 1991

For sale only in India and Nepal

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Published by Y.P. Chopra for A.H. Wheeler & Company Limited, 23, L.B. Shastri Marg, Allahabad-211001 by permission of Pitman Publishing Limited, London, and Printed at Wheeler's Offset Unit, Allahabad.
Bound at Agrawal Book Binders, 22, D.N. Marg, Allahabad.

PREFACE TO FIFTH EDITION

It is now thirty years since the first edition of this book was published and I would like to express my deep and sincere appreciation of its acceptance by so many readers in all parts of the English-speaking world. During recent years I have visited many countries in which the book has been used and have been most gratified by the kind remarks made about its value to students and practising engineers. These comments have come from engineers met, sometimes in quite remote places, in East and Central Africa, India, Pakistan, Malaya, Hong Kong and Australia, and they have given me great pleasure.

With the passing of the years, and with the changes which have taken place in my own professional interests, it has become increasingly difficult to keep pace with the rapid advances made in the subject of Electrical Measurements. I have felt it imperative, therefore, to seek assistance in the task of revising the book in a way which, I hope, will prove satisfactory to the present-day reader. In this I have been extremely fortunate in receiving the co-operation of Dr. F. C. Widdis. He has had great experience in both the practical and academic sides of the subject, and he has been mainly responsible for the many changes made in preparing this fifth edition.

We hope that, so far as possible within the confines of a single volume, the latest practice has now been covered adequately and that the book will continue to be as useful as in the past.

Perhaps the most significant single change has been the adoption of the rationalized M.K.S. system of units, which is now increasingly used in teaching the subject. For the benefit of readers who find themselves in the transition stage of conversion from the C.G.S. to the M.K.S. system, a comprehensive comparison between the formulae in the two systems has been made, and we hope that this will be helpful to those who are not yet entirely conversant with the M.K.S. system.

E. W. GOLDING

LONDON,
DECEMBER, 1962

PREFACE TO FIRST EDITION

WHEN this book was first contemplated, it was the author's intention to produce a short text-book covering the syllabuses of the B.Sc. (Eng.), City and Guilds (Final) and I.E.E. examinations. As the work progressed, however, it was realized that the groundwork for these examinations could not be adequately covered in a book of the size originally planned. Extension of the text being thus necessitated, the author felt that the scope and method of treatment could with advantage be modified to suit, also, the requirements of electrical engineers in general, for whom, owing to the rapid advances taking place in the electrical industry and in the inter-connection of power systems, the subject of electrical measurements is assuming an ever-increasing importance. In particular, it was thought that engineers engaged in the standardizing and metering side of the industry could be catered for.

Some of the subjects dealt with—e.g. Transient Phenomena—are essentially mathematical, and cannot well be treated otherwise, but the mathematics throughout the book has been kept as simple as possible and should be followed easily by most readers. The theory of most of the methods of measurement has been given in full, but in many cases smaller type has been used for such theoretical discussions, so that the reader may omit them, if desired, and consider only the resulting expressions.

References and bibliographies are given at the ends of the chapters, their inclusion being both an acknowledgment of the sources of the author's information—in certain cases—and an augmentation of the text, which can, at the best, give only a general outline of so large a subject in the space of a single volume.

A number of worked examples have been given as illustrations, and a selection of examination questions (with answers) is included at the end of the book. In this connection the author's thanks are due to the Senate of the University of London, the City and Guilds of London Institute, and the Institution of Electrical Engineers for permission to use questions from their examination papers.

Most of the illustrations have been specially made for this book, but the author is glad to acknowledge his indebtedness to the many firms and authorities who have very kindly supplied him with information, drawings, and photographs relating to their apparatus. Individual acknowledgments are made in the text. Messrs. Elliott Bros., Ltd., had drawings specially made from photographs of their instruments. The author is indebted also to Messrs. A. T. Dover, B. Hague, and P. Dunsheath for permission to reproduce five illustrations from their books; to B. G. Churcher and C. Dannatt,

Prof. W. M. Thornton, and Prof. S. P. Smith for their co-operation, and to Mr. N. A. Allen for information regarding cable tests with high-voltage direct current.

The author gratefully acknowledges the help which he has received from advanced students in the Electrical Engineering Department of University College, Nottingham, in the shape of proof reading. He would like, also, to tender his sincere thanks to Dr. H. Cotton for his continued and lively interest in the book during its preparation; to Mr. T. M. E. Ward for kindly reading the proofs of Chapters XX and XXI; and to his wife for her unflinching help and consideration while the book was being prepared.

Acknowledgment should also be made to the British Standards Institution for permission to make extracts from several of their instrument specifications. Copies of these specifications can be obtained from the Institution at British Standards House, 2 Park Street, London, W.1.

E. W. GOLDING

UNIVERSITY COLLEGE,
NOTTINGHAM, 1933

CONTENTS

	PAGE
PREFACE TO FIFTH EDITION	v
PREFACE TO FIRST EDITION	vii
AUTHORS' NOTE	xv
CHAPTER I	
ELECTROSTATIC AND ELECTROMAGNETIC THEORY	1
Coulomb's Law—Electric fields in the neighbourhood of various systems of charged conductors—Gauss and Coulomb theorems—Potential—Capacitance—Energy stored in electric field—Magnetism—Intensity of magnetization—Magnetizing force and magnetic potential—Permeability—Magnetic fields in the neighbourhood of current-carrying conductors—Generation of e.m.f.—Energy stored in magnetic field—Hysteresis and hysteresis loss—Permanent-magnet theory—Formulae in C.G.S. form	
CHAPTER II	
UNITS, DIMENSIONS, AND STANDARDS	52
C.G.S. electrostatic and electromagnetic systems of units—The connections between such systems—Practical and legal units and their relationship to the absolute units—Dimensions of electrical quantities—Dimensional equations—The M.K.S. (Giorgi) system of units—Rationalized systems of units—Determination of "c"—International and absolute units and standards—Absolute measurements—Concrete representation of units—Construction of standard cells and standard resistors—Resistance materials—Kelvin current balance—Primary and secondary standards of self- and mutual-inductance—Capacitance standards	
CHAPTER III	
CIRCUIT ANALYSIS	106
General rules—The various methods of symbolic representation—Applications of such methods to circuit calculations—Symmetrical components—Network theorems	
CHAPTER IV	
CAPACITORS, CAPACITANCE, AND DIELECTRICS	135
Calculation of the capacitances of various systems of charged conductors—Electrical images—Capacitors in series and in parallel—Capacitances of multi-core cables—Self-capacitance of solenoids—Guard rings and screening—Dielectrics and their properties—Dielectric strength—Potential gradient—Graded cables and condenser bushings—Permittivity—Dielectric absorption—Dielectric losses and power-factor of capacitors—The measurement of dielectric losses—The Schering bridge—Dielectric loss measurements by cathode-ray oscillograph	
CHAPTER V	
INDUCTANCE	180
Self- and mutual-inductance—The relations between them—Calculation of the inductances of various systems of conductors—Design of inductance coils—Skin effect	

	PAGE
CHAPTER VI	
MEASUREMENT OF INDUCTANCE AND CAPACITANCE	208
Elementary methods—A.C. bridge methods—Sources of error in bridge measurements—Screening of bridges—The Wagner earth—Apparatus for use in a.c. bridge methods—Supplies for bridge networks—Variable standards of resistance, inductance, and capacitance—Detectors—Vibration galvanometers—Sensitivity	
CHAPTER VII	
MEASUREMENT OF RESISTANCE	286
Classification of resistances and methods of measurement—Measurement of low resistance—Voltage-drop method—Potentiometer method—Kelvin double bridge—Precautions necessary for precision measurements—Measurement of medium resistance—Substitution, and Wheatstone bridge methods—Precision forms of Wheatstone bridge—Applications of resistance measurements by Wheatstone bridge—Measurement of high resistance—Surface and volume resistivity—Insulation resistance—Meggers and ohmmeters—Measurement of resistance of electrolytes—Measurement of water purity—Galvanometers and other apparatus used in connection with resistance measurements—Theory of the D'Arsonval galvanometer	
CHAPTER VIII	
POTENTIOMETERS	342
General principles—Modern forms of d.c. potentiometers—Potentiometers for special purposes—Thermo-electric potentiometers—Diesselhorst and Brooks deflectional forms—Use for the measurement of resistance, current, and voltage—Volt ratio boxes and other auxiliary apparatus—pH meters—A.C. potentiometers and their applications	
CHAPTER IX	
MAGNETIC MEASUREMENTS	371
Classification of magnetic measurements—Magnetometer measurements—The ballistic galvanometer, fluxmeter, and other auxiliary apparatus—Methods of calibrating ballistic galvanometers—Magnetic potentiometer—Hall effect devices— <i>B-H</i> curves and permeability measurements on bars and ring specimens—Leakage factor—Hysteresis measurements—Bar and yoke methods—Permeameters—Testing at very high and very low inductions—Testing of permanent magnets—A.C. magnetic tests—Power loss in sheet steel—Separation of losses—Wattmeter measurements—Iron powders—Bridge and a.c. potentiometer methods	
CHAPTER X	
ILLUMINATION	435
General considerations—Definitions—Laws of illumination—Standards of luminous intensity—Sub-standards of luminous intensity—Measurement of luminous intensity—Photometer bench and heads—Flicker photometers—Distribution of luminous intensity—M.S.I.—Rousseau construction—The integrating sphere—Illumination photometers—Physical photometry	
CHAPTER XI	
HIGH-VOLTAGE MEASUREMENTS AND TESTING	460
General classification and purpose of testing methods—Testing apparatus—High-voltage transformers and voltage regulation—Control gear and connections—Apparatus for voltage measurement—Sphere gap—Potential dividers—Measurement of peak voltage—Rectified capacitor-charging-current method—Peak voltmeters—High-voltage voltmeters—Special apparatus for tests other than low-frequency a.c. tests—Constant direct-current tests—Mechanical and valve rectifiers—Localization of faults in h.v. cables—High-frequency tests—Damped and undamped oscillations—Surge or impulse tests—Steepness of wave-front—Impulse ratio—Notes on the testing of insulators, insulating materials, and cable lengths—Nature of dielectric breakdown—Solid and liquid specimens	

CONTENTS

xi

	PAGE
CHAPTER XII	
LOCALIZATION OF CABLE FAULTS	510
Common faults in cables—Blavier and voltage-drop tests—Loop tests—Murray, Varley, and Fisher loop tests—Fault-localizing bridges—Tests for an open-circuit fault—Induction method of testing	
CHAPTER XIII	
ELECTRICAL METHODS OF MEASURING TEMPERATURE	525
General methods of measuring temperature—Electrical-resistance pyrometers—Laws of resistance variation with temperature—Methods of using platinum resistance thermometers—Indicators and recorders—Thermo-electric pyrometers—Thermo-electric e.m.f.s—Radiation pyrometers—Stefan-Boltzmann law of radiation—Fixed- and variable-focus types—Optical pyrometers	
CHAPTER XIV	
EDDY CURRENTS	545
The nature and effects of eddy currents—Eddy currents in cylindrical conductors and in thin sheets—Influence of eddy currents upon the flux distribution in iron plates—Eddy-current losses in armature conductors—Eddy-current damping with metal formers and discs	
CHAPTER XV	
WAVE-FORMS AND THEIR DETERMINATION	563
Wave-form distortion and the composition of complex waves—Fourier's theorem—Harmonic analysis—Perry method—Thompson and Runge method—Harmonic analyser—Shapes of current wave-forms when the voltage wave is complex—Resonance with harmonics—R.M.S. values and power in the case of complex wave-forms—Determination of wave-forms—Oscillographs—Electromagnetic, electrostatic, and cathode-ray types—Theory of Duddell oscillograph and accuracy of wave-form reproduction	
CHAPTER XVI	
TRANSIENT PHENOMENA	611
Definition—Initial conditions when a steady voltage is impressed upon, or removed from, circuits containing resistance, inductance, and capacitance—Transients when the impressed voltage is alternating—Laplace transformations	
CHAPTER XVII	
MEASURING INSTRUMENTS	634
Classification—Absolute and secondary instruments—Indicating instruments—Control, balancing, and damping—Constructional details—Recording instruments—Quick-response recorders—Integrating instruments	
CHAPTER XVIII	
AMMETERS AND VOLTMETERS	655
General considerations—Classification of instruments—Errors in ammeters and voltmeters—Moving-iron instruments—Torque equation—Errors in m.i. instruments—Design data—Moving-coil instruments—Permanent-magnet and dynamometer types—Extension of range of moving-coil instruments—Errors—Design data—Thermal instruments—Precision measurements with the vacuo-thermo-junction—Electrostatic instruments—Quadrant electrometer theory—Attracted-disc electrometer—Kelvin absolute electrometer—Vacuum-enclosed e.s. voltmeters—Commercial forms of electrostatic voltmeters—Induction instruments—General principles—Ferraris type—Compensation for frequency and temperature errors—Shaded-pole type—Valve voltmeters—Rectifier instruments—Testing sets	

	PAGE
CHAPTER XIX	
EXTENSION OF INSTRUMENT RANGE	710
Ammeter shunts on d.c. and a.c.—Voltmeter multipliers—Connections of test sets—Instrument transformers—Comparison with shunts and multipliers—Current transformer theory—Ratio and phase angle errors—Design considerations and construction—Characteristics of current transformers—Effects of variation of power factor, secondary burden, and frequency—Precautions in using current transformers—Voltage transformers—Ratio and phase angle expressions—Design considerations—Characteristics of voltage transformers—Effects of variation of power factor, secondary burden, and frequency—Testing of current transformers—Absolute and comparison methods—Testing of voltage transformers—Absolute and comparison methods	
CHAPTER XX	
THE MEASUREMENT OF POWER	763
Mean power in a.c. circuits—Wattmeter measurements in single-phase circuits—Wattmeter errors—Methods of connection—Use of instrument transformers with wattmeters—Correction factors—Methods of measurement without using a wattmeter—Measurement of three-phase power—Three, two, and one wattmeter methods—Wattmeters—Dynamometer type—Standard wattmeters—Commercial wattmeters—Cambridge nickel-iron-cored wattmeters—Induction wattmeters—Comparison of dynamometer and induction types—Electrostatic wattmeters—Methods of use—Calibration of commercial wattmeters or watt-hour meters by electrostatic wattmeter—Polyphase wattmeters—Summation methods—Measurement of reactive power	
CHAPTER XXI	
THE MEASUREMENT OF ENERGY	807
Classification of energy meters—Electrolytic meters—Motor meters—Mercury motor meters—Errors in motor meters—Watt-hour mercury meters—Commutator meters—Grassot fluxmeter as a quantity meter—Single-phase induction-type watt-hour meters—Errors in s.p. meters—Polyphase watt-hour meters—Clock meters—Remote indication—Meter testing—D.C. meter tests—Fictitious loads—Glynn electronic stabilizer—A.C. meter testing—Meters for special purposes—Prepayment meters—Maximum-demand indicators—Two-rate meters—Summation metering—Measurement of kVA	
CHAPTER XXII	
MEASUREMENT OF SPEED, FREQUENCY, AND PHASE DIFFERENCE	855
Rotational speed measurements—Stroboscopic methods—Measurement of linear speed—Frequency standards—Frequency meters—Phase or power-factor meters—Synchrosopes	
CHAPTER XXIII	
ELECTRONICS AND ELECTRONIC MEASURING DEVICES	882
Physics of the thermionic valve—The diode—The triode—The tetrode—The pentode—The pentode voltage-amplifier—The thyatron—Negative feedback—Servo-mechanisms—Velocity feedback—Servo-systems using velocity feedback—The cathode-follower—Applications of the cathode-follower—The differential cathode-follower—The auto-repeater—A counting-rate meter—Evershed and Vignoles quick-response recorder—The Q-meter—Electronic counters—Application of electronic counters	
EXAMINATION QUESTIONS	921
INDEX	943

INSETS

	<i>facing page</i>
TABLE II. DIMENSIONS OF ELECTRICAL AND MAGNETIC QUANTITIES	56
FIG. 2.15. A 250-kV COMPRESSED-GAS CAPACITOR	98
TABLE VI. CAPACITANCES OF VARIOUS SYSTEMS OF CONDUCTORS	156

AUTHORS' NOTE ON THE RATIONALIZED M.K.S. SYSTEM OF UNITS

IN previous editions of the book the C.G.S. system of units was used throughout, but the rationalized M.K.S. (metre-kilogramme-second) system is now being used increasingly, especially in the teaching of electrical engineering, and it has been adopted throughout this edition. The derivation of the system is discussed in Chapter II. It has important advantages in that practical units—ampere, volt, ohm etc.—are used throughout and the conversion factors necessary in the C.G.S. system are eliminated. The only complication in this system is the introduction of the primary magnetic constant $\mu_0 = 4\pi \times 10^{-7}$ and the primary electric constant $\epsilon_0 = \frac{1}{36\pi \times 10^9}$, which must be memorized. Each of these constants has a value of unity in the C.G.S. system.

In the M.K.S. system, force is measured in "newtons" and lengths in metres. A newton is the force necessary to give a mass of 1 kilogramme an acceleration of 1 metre per sec per sec and it is equivalent to 10^5 dynes in the C.G.S. system.

With the introduction of the M.K.S. system, the view has been expressed, in some quarters, that the classical methods of deriving electromagnetic and electrostatic formulae should be revised. This is because the unit magnetic pole used in the classical derivations has no physical existence, and it is possible, instead of using this concept, to explain the origin and properties of the magnetic field in terms of the effects of electric currents. The classical methods, however, provide a simple means of studying the properties of fields and are therefore adhered to in Chapter I. A very full discussion of alternative methods of developing field theory will be found in Ref. (24) at the end of Chapter I.