ELECTRONIC MEASURING INSTRUMENTS

Second Edition
Revised

E. H. W. BANNER

ELECTRONIC MEASURING INSTRUMENTS

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PREFACE TO SECOND EDITION

THE READY DEMAND for the first edition showed the need for a book of this level, with its wide readership and scope, but without too much of the detail to be found in specialized papers which would have made the book too cumbersome and expensive.

The continuously growing range of electronic measuring instruments still prevents the book from covering every class of electronic measuring instrument and from being fully up to date, but this second edition has been completely revised and some sections are completely rewritten and enlarged, with the same general layout.

Theory and practice are linked by descriptions of some typical instruments in general use, although no attempt has been made to mention all comparable types on the market.

Digital and analogue computers are not included as such, but many of the techniques described in the chapter on electronic counters are closely related to digital computers.

Again full acknowledgement is made to all those co-authors who made the book possible by their contributions.

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E. H. W. BANNER

PREFACE TO FIRST EDITION

A SHORT SURVEY of the field of the present book published in *Electronic Engineering* for May 1950 led to the expansion into the present book, as there is considerable interest and activity in electronic measurements in industry.

For the purpose of this book the definition of 'electronic measuring instruments' is as follows: 'Instruments to measure either electrical or non-electrical quantities incorporating one or more electronic devices, used either with electrical measuring instruments presenting the reading on a scale or chart, or alternately the electronic device may include its own means of indication, such as the trace on a cathode-ray tube. The readings are quantitative.' 'Quasi-electronic instruments are those which contain some of the elements of an electronic instrument, but which could also be classed by some alternative term in some cases, such as electromagnetic.'

The book is intended for the instrument engineer in general: the instrument user requiring to know more of the scope of electronic measurements: and the student with some knowledge of electronics. It is not an examination text-book.

The book cannot be complete, both on account of space and time. A more comprehensive book would result in such a high cost that use would be restricted, and if it were held up until considered complete then it would never be published.

The choice of what has been included and excluded is the author's, with the general aim of covering the main electronic devices used in measurement; the various classes of instrument using these devices and some typical examples of instruments, the selection of which will necessarily not satisfy all readers. In particular this applies to the quasi-electronic instruments such as the magnetic amplifier, which itself is perhaps no more electronic than is the transformer, but it is included owing to its comparable scope with electronic amplifiers in instruments and because it is not yet generally treated in other books on measuring instruments. Most radio test gear such as signal generators, oscillators, valve testers, etc, is excluded, other than valve

voltmeters, which are included in the postulated definition. Present commercial radiation measuring instruments are not described individually as their number is legion and the technique is growing so rapidly that such descriptions would soon be out of date. One source of reference to these specific instruments is in the *Brochure of Instruments and Accessories for Radio-Isotope Applications*, published by the Scientific Instrument Manufacturer's Association.

Page references and chapter bibliographies are included, but are not intended to be exhaustive or they might well occupy half the book. In particular they are scarce for long-developed devices such as thermionic valves, and more complete for newer devices such as those used for radiation measurement. Bibliographical references are denoted [B] in the text.

The book endeavours to comply with British Standard terminology, symbols and spelling of technical terms, and quotes British Standards and Codes of Practice, where relevant. Due to alternative recommendations in some Standards it has not always been possible to adhere to uniform graphical symbols, however, drawings having been obtained from various sources.

Constructive suggestions will be welcomed and should another edition be called for they will be taken into consideration.

Possibly the science of electronics is not so young as we think. Were thermocouples and thermopiles used at Thermopylae? And are crystals descended from the Oracle of Delphi? Columns of ions may be akin to Ionic columns and the Odes of Horace have long developed beyond diodes and triodes.

The impact of electrical science on the measurement of many quantities is perhaps exemplified by the fact that any salesman's job is electrical—the conversion of a potential customer to a current customer.

This book was written during 1951 and early 1952, but some important amendments were made in the proof stage at this date.

E. H. W. BANNER

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PART I

THE CHARACTERISTICS OF INDICATING INSTRUMENTS USED WITH ELECTRONIC DEVICES

CHAPTER 1

INDICATING INSTRUMENTS

General

This chapter is a necessary introduction to the subject of electronic measuring instruments, since the indications of many electronic instruments are ultimately presented on one or other of the various types of indicating instruments. For this purpose only, sufficient matter is given here for a ready understanding of those features which are of account in combining electronic devices with measuring instruments. The limitations of both require to be known for the best match to be made. In some cases the limitations of the indicating instrument determine whether or not an associated electronic device is needed; in others it is the characteristics of the electronic device which determine the best type of indicating instrument for a given range or purpose.

The chapter is therefore not a compressed account of all the characteristics and design features of instruments: it consists mainly of data on the limitations of the various types, including minimum voltage and current ranges, frequency range, consumption, accuracy, and mechanical features such as robustness and portability. Where theory is introduced, as in the Table on page 7, it is to list the parameters involved and to show basic scale laws—linear, square, etc.—for subsequent use in the relevant sections on the different types.

Indicating instruments reading volts and amperes, with multiples and sub-multiples, are normally two-terminal instruments requiring no source of supply other than that to be measured. Wattmeters may have four terminals, or three with one common, and also require no source of supply. These instruments are therefore simple to install and use, and where they can be employed they are not only more economical but preferable to instruments of greater complexity.

Such indicating instruments are normally directly calibrated in suitable units although, for use as galvanometers or null detectors, simple degree, or otherwise uncalibrated, scales are commonly fitted.

Where direct-reading electrical instruments cannot be used on account of their limitations of range in volts, amperes, frequency, power consumption, etc., then various electronic (and electrical) devices may be