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RADIATION LABORATORY SERIES

LOUIS N. RIDENOUR, *Editor-in-Chief*

ELECTRONIC TIME MEASUREMENTS

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ELECTRONIC TIME MEASUREMENTS

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Foreword

THE tremendous research and development effort that went into the development of radar and related techniques during World War II resulted not only in hundreds of radar sets for military (and some for possible peacetime) use but also in a great body of information and new techniques in the electronics and high-frequency fields. Because this basic material may be of great value to science and engineering, it seemed most important to publish it as soon as security permitted.

The Radiation Laboratory of MIT, which operated under the supervision of the National Defense Research Committee, undertook the great task of preparing these volumes. The work described herein, however, is the collective result of work done at many laboratories, Army, Navy, university, and industrial, both in this country and in England, Canada, and other Dominions.

The Radiation Laboratory, once its proposals were approved and finances provided by the Office of Scientific Research and Development, chose Louis N. Ridenour as Editor-in-Chief to lead and direct the entire project. An editorial staff was then selected of those best qualified for this type of task. Finally the authors for the various volumes or chapters or sections were chosen from among those experts who were intimately familiar with the various fields, and who were able and willing to write the summaries of them. This entire staff agreed to remain at work at MIT for six months or more after the work of the Radiation Laboratory was complete. These volumes stand as a monument to this group.

These volumes serve as a memorial to the unnamed hundreds and thousands of other scientists, engineers, and others who actually carried on the research, development, and engineering work the results of which are herein described. There were so many involved in this work and they worked so closely together even though often in widely separated laboratories that it is impossible to name or even to know those who contributed to a particular idea or development. Only certain ones who wrote reports or articles have even been mentioned. But to all those who contributed in any way to this great cooperative development enterprise, both in this country and in England, these volumes are dedicated.

L. A. DUBRIDGE

Preface

THE preservation of the technical advancements represented by the precision circuits of the Radiation Laboratory was made possible through the foresight of Drs. Rabi and DuBridge. They appointed a committee consisting of Drs. L. J. Haworth, G. E. Valley, and the editor to consider the scope and content of a series of books on circuits, which resulted in Vols. 17–22 of the Series. At the termination of hostilities an intensive writing program was put into operation under the able leadership of Dr. L. N. Ridenour and resulted in the completion of the Series on an accelerated schedule. This schedule required the use of as many authors as possible and has inevitably resulted in discontinuities in the method of treatment and scope of material.

The object of this book is to present the method of approach to the problems of time and distance measurement by manual and automatic means, and the practical circuits employed for these purposes. In addition, important techniques of pulse data transmission and pulse-amplitude cancellation methods are included. The accurate measurement of short time intervals is not a new subject since many experiments have been devoted to the accurate determination of the velocity of light. The simplification and increased precision possible through the use of circuit techniques of Vol. 19 of the Series have led to time-measurement techniques that have resulted in practical and accurate radar distance-finding and data-transmitting systems. Since the characteristics of these circuits depend upon those of the radar system, the book is introduced by a survey of techniques for radio distance and speed measurement. The material then continues with a survey of basic techniques and methods in pulse time measurement, including the generation of fixed and movable timing markers and their applications to manual and automatic time measurements. The use of these techniques for precision data transmission and for the relaying of the radar PPI to remote points is next presented, and the book concludes with a discussion of the use of supersonic delay devices for the cancellation of recurrent waveforms.

Many of the developments described in this volume are contributions from other laboratories in this country or in the United Kingdom. It is a pleasure to acknowledge the excellent support to this project by the British Laboratories, and especially Telecommunications Research

Establishment. Through their generosity several experts have visited this laboratory and have contributed much useful information, and, in fact, this book has drawn heavily upon TRE reports. Our gratitude is due Sir Robert Watson Watt, Drs. W. B. Lewis and B. V. Bowden, and F. S. Barton for stimulating and authorizing this excellent exchange of information, which required several visits of Dr. F. C. Williams and others.

The foreword has indicated the difficulty of giving proper credit to all those who contributed to the writing or to the experimental developments that have made this work possible. However, references in the text have been made to journal papers on radar and associated subjects and declassified reports on radar.

Many of the contributors to this volume gave up industrial positions or academic fellowships in order to complete their contributions and much credit is due them for this sacrifice. The authors also wish to express their gratitude to those who contributed important background material from which the final manuscript was written, E. B. Hales, C. L. Longmire, F. Coffin, L. Bess, R. N. Close, I. Sudman, and J. R. Rogers. The speed of this program would have been impossible without the expert assistance of the production department under C. Newton. The efficiency of the typing pool under M. Dolbeare and P. Phillips and the drafting room under Dr. V. Josephson has been of great assistance. In addition, the Technical Coordination Group under Dr. Leon Linford has done much to ensure a coordination of style and a maintenance of standard. The authors wish to name specifically the following editorial assistants, production assistants, and secretaries whose aid has been invaluable in the preparation of this book: Nora Van der Groen, Joan Brown, Joan Leamy, Helene Benvie, Teresa Sheehan, Barbara Davidson, Helen Siderwicz, and Louise Rosser.

A few waveform photographs have been used to illustrate this volume. Nearly all these were taken by C. M. Connelly and the associated photographic work was carried out by P. D. Bales and credit to their work is gratefully acknowledged.

THE AUTHORS.

CAMBRIDGE, MASS.,
May, 1946.

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