RADAR SYSTEM ENGINEERING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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RADAR SYSTEM ENGINEERING

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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 earliest plans for the Radiation Laboratory Series, made in the fall of 1944, envisaged only books concerned with the basic microwave and electronic theory and techniques that had been so thoroughly developed during the wartime work on radar. These plans were laid aside for a time when it became clear in this country that several months of fighting remained in the European war.

When work on the Series was resumed in the early summer of 1945, the books planned, as before, dealt with basic matters and with techniques. Every effort was made to point out the general applicability of the work reported and to avoid special emphasis on its application to radar, since radar itself was thought to have only a limited importance.

The end of the Pacific war made it possible to put more effort on the job of preparing the Series than had been available earlier. The books on theory and techniques having been planned as comprehensively as appeared to be worth while, the work was extended by the addition of five books concerned with radar and allied systems.

Of those five books, this is the only one that deals with radar itself. One book takes up the use of radar in navigation, one concerns the design of radar scanners and radomes, one treats the design and construction of beacons, and one describes hyperbolic navigational systems—in particular Loran.

This book is intended to serve as a general treatise and reference book on the design of radar systems. No apology seems to be needed for the fact that it deals primarily—though by no means altogether—with microwave pulse radar. Thousands of times as much work has gone into pulse radar as into any other kind, and the overwhelming majority of this work has been concerned with microwave pulse radar. The superiority of microwaves for almost all radar purposes is now clear.

The first eight chapters of this book are intended to provide an introduction to the field of radar and a general approach to the problems of system design. Chapters 9 through 14 take up the leading design considerations for the various important components that make up a radar set. These chapters are so thorough in their treatment that Chap. 15, which gives two fairly detailed examples of actual system design, can be quite brief. Chapters 16 and 17 take up two new and important ancillary

techniques that are not dealt with fully elsewhere in the Series: moving-target indication and the transmission of radar displays to a remote indicator by radio means.

For fuller information than can be found in this book on any detailed point of design, the reader is referred to one of the other books of the Series. In a sense, this book specializes to radar the techniques reported more fully elsewhere in the Series.

Radar is a very simple subject, and no special mathematical, physical, or engineering background is needed to read and understand this book.

Because the book covers the entire field of effort of the Radiation Laboratory and the other wartime radar establishments, its contributing authors are more numerous than those listed for most other volumes of this series. I am especially grateful to L. J. Haworth and to E. M. Purcell, whose contributions have been more extensive than those of other authors, and whose advice on editorial problems has often been extremely helpful. In addition to the authors already listed, whose names appear in the book in connection with the material they have written, I wish to thank the following men for their work in providing essential background material that did not eventually find its way into the book: R. M. Alexander, A. H. Brown, J. F. Carlson, M. A. Chaffee, L. M. Hollingsworth, E. L. Hudspeth, R. C. Spencer, and I. G. Swope. Changing plans for the book also reduced the acknowledged contribution of E. C. Pollard far below the very considerable quantity of material he prepared.

I owe an apology to all the authors for the liberty I have often taken in altering their original text to fit the final framework of the book and my own ideas of style. Because most authors left the Laboratory immediately on finishing their writing, and much of the editorial work had to be deferred until the book was substantially complete, it has not always been possible to adjust with the authors the alterations in their manuscripts that have seemed desirable to me.

The general acknowledgments I owe as Editor-in-Chief of the Series are set forth in the Series Index. In connection with the preparation of this book, however, it is a pleasure to thank Dr. B. V. Bowden, of the British Air Commission, not only for his assistance as an author but also for his general comments on the book as a whole. I am grateful to Lois Capen for her work in following the preparation of illustrations, and to Phyllis Brown for general secretarial assistance.

LOUIS N. RIDENOUR.

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