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MICROWAVE ANTENNA THEORY AND DESIGN

Edited by

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MICROWAVE ANTENNA THEORY AND DESIGN

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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.

ER 20 1964

Preface

THE need that arose during the war for utilizing the microwave region of the radio frequency spectrum for communications and radar stimulated the development of new types of antennas. The problems and design techniques, lying as they do in the domain of both applied electromagnetic theory and optics, are quite distinct from those of long-wave antennas. It is the aim of the present volume to make available to the antenna engineer a systematic treatment of the basic principles and the fundamental microwave antenna types and techniques. The elements of electromagnetic theory and physical optics that are needed as a basis for design techniques are developed quite fully. Critical attention is paid to the assumptions and approximations that are commonly made in the theoretical developments to emphasize the domain of applicability of the results. The subject of geometrical optics has been treated only to the extent necessary to formulate its basic principles and to show its relation as a short wavelength approximation to the more exact methods of field theory. The brevity of treatment should not be taken as an index of the relative importance of geometrical optics to that of electromagnetic theory and physical optics. It is in fact true that the former is generally the starting point in the design of the optical elements (reflectors and lenses) of an antenna. However, the use of ray theory for microwave systems presents no new problems over those encountered in optics—on which there are a number of excellent treatises—except that perhaps the law of the optical path appears more prominently in microwave applications.

In the original planning of the book it was the intention of the editors to integrate all of the major work done in this country and in Great Britain and Canada. This proved, however, to be too ambitious an undertaking. Many subjects have regrettably been omitted completely, and others have had to be treated in a purely cursory manner. It was unfortunately necessary to omit two chapters on rapid scanning antennas prepared by Dr. C. V. Robinson. The time required to revise the material to conform with the requirements of military security and yet to represent an adequate exposition of the subject would have unduly delayed the publication of the book. Certain sections of Dr. Robinson's material have been incorporated into Chaps. 6 and 12.

I take pleasure in expressing here my appreciation to Prof. Hubert M. James who, as Technical Editor, shared with me much of the editorial work and the attendant responsibilities. The scope of the book, the order of presentation of the material, and the sectional division within chapters were arrived at by us jointly in consultation with the authors. I am personally indebted to Professor James for his editorial work on my own chapters.

The responsibility for the final form of the book, the errors of omission and commission, is mine. A word of explanation to the authors of the various chapters is in order. After the close of the Office of Publications and the dispersal of the group, I have on occasions made use of my editorial prerogative to revise their presentations. I hope that the results meet with their approval. The policy of assignment of credit also needs explanation. The interpretation of both Professor James and myself of the policy on credit assignment formulated by the Editorial Board for the Technical Series has been to the effect that no piece of work discussed in the text would be associated with an individual or individuals. Radiation Laboratory reports are referred to in the sense that they represent source material for the chapter rather than individual acknowledgements. References to unpublished material of the Radiation Laboratory notebooks have been assiduously avoided, although such material has been drawn upon extensively by all of us. In defense of this policy it may be stated that the work at the Radiation Laboratory was truly a cooperative effort, and in only a few instances would it have been possible to assign individual credit unequivocally.

The completion of the book was made possible through the efforts of a number of people; in behalf of the editorial staff and the authors I wish to acknowledge their assistance and contributions. Mrs. Barbara Vogel and Mrs. Ellen Fine of the Radiation Laboratory served as technical assistants; the production of figures and photographs was expedited by Mrs. Frances Bourget and Mrs. Mary Sheats. It proved impossible to finish the work by the closing date of the Office of Publications; the Naval Research Laboratory accepted the work as one of the projects of the newly formed Antenna Research Section and contributed generously in personnel and facilities. Special thanks are due to A. S. Dunbar, I. Katz, and Dr. I. Maddaus for their editorial assistance; to Queenie Parigian and Louise Beltramini for preparation of the manuscript; and to Betty Hodgkins who prepared almost all of the figures. The editors are indebted to Dr. G. G. Macfarlane of the Telecommunications Research Establishment, Great Britain, for his critical review of several of the theoretical chapters and his contribution on the theory of slot radiators in Chap. 9. John Powell of the Radiation Laboratory prepared material on lenses that was used in

Chap. 11. The National Research Council of Canada and the British Central Radio Bureau have graciously granted us permission to take material from Canadian and British reports in accordance with current security regulations. The Bell Telephone Laboratory supplied the photographs of metal lens antennas.

SAMUEL SILVER.

NAVAL RESEARCH LABORATORY,
WASHINGTON, D. C.,
April, 1947.

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