MICROWAVE MAGNETRONS

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MICROWAVE MAGNETRONS

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MICROWAVE MAGNETRONS

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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 pulsed 10-cm magnetron, perfected by the British in 1940, constituted the starting point for the development of microwave radar. From that time until the end of the war the magnetron proved to be one of the most important components in radar systems. As a consequence of this, the armed services, both in this country and in England, instigated extensive programs of research and development to produce new types and improve the characteristics of existing ones. The program soon became a major one for the electronic industry. At the Radiation Laboratory alone, over forty highly trained physicists and engineers spent more than four years studying magnetron performance and producing new designs. Comparable effort was expended by the many other industrial and research laboratories. The result was over twenty distinct types of magnetrons, producing powers in the tens to thousands of kilowatts at frequencies that were largely unexplored before 1940. What is more important, this program led to a better understanding of the principles of magnetron operation and to an increased appreciation of the importance of the field of electronics at high frequencies.

During the war very little attention could be given to evaluating, correlating, and recording these new developments, and what reports were written are disconnected and incomplete. Actually, much of the information existed only in the minds of the investigators and in their personal notebooks. The purpose of this book is to present in a usable form this large amount of theoretical and practical knowledge.

Conditions surrounding the preparation of the volume produced special problems. The time available was short, considering the amount and complexity of the material, and a division of labor among many authors was necessary. This permitted the selection of authors best qualified to present different subjects but resulted in a not too consistent style and level of presentation. Furthermore, it was appreciated that although microwave magnetrons were developed for use in radar systems, their importance to science and engineering was much broader; thus the material for the book was evaluated largely in terms of its possible future usefulness, and the uncertainty of this resulted in a tendency to include

too much rather than too little. More serious are the errors that may not have been eliminated because of insufficient time for adequate review.

The book contains a large fraction of what was known, as of January 1946, about the theory, design, and operation of magnetrons in the frequency range 1000 to 25,000 Mc/sec and the many modifications that extend the usefulness of these tubes. There is in this book, because of its radar background, a strong emphasis on magnetrons intended for pulsed operation, but the treatment is extended to c-w applications whenever possible.

The scope is dictated by the primary premise that all information necessary to "make a magnetron" be included. As a result, the character of the chapters ranges from a detailed theory of the various aspects of magnetron operation to the details of construction of production magnetrons. An introductory chapter reviews the early work on magnetrons, including the first 10-cm tube of the British, and presents the basic principles of magnetron operation in order to orient the reader unfamiliar with the subject.

Except for this introduction, the material is arranged so that theory precedes practical considerations. A final chapter gives operating data and important dimensions for a variety of magnetrons.

Although the authors of this volume were nearly all members of the MIT Radiation Laboratory or Columbia Radiation Laboratory, a great deal of the material included originated in the industrial concerns of this country and England. References to contributions by other laboratories is given whenever possible, but the free exchange of information existing during the war makes the origins of many of the ideas uncertain. In particular, the contributions of the Bell Telephone Laboratories and the Raytheon Manufacturing Company have been extensive and in many cases undistinguishable from those of the MIT and Columbia groups. The important contributions of these and the many other institutions are acknowledged.

The early work of the British deserves special recognition. All too few references to it are found in this volume, because soon after the original design was divulged to laboratories in this country, the development here proceeded along rather independent lines. The British magnetron, however, was the key to the production of high-power microwaves. A discussion of this tube and its important features is found in Chap. 1, based on material kindly furnished by Professor J. T. Randall and Dr. H. A. H. Boot who, more than any others, were responsible for its invention.

Acknowledgments are due to the many who reviewed chapters of the book. In particular, mention should be made of Dr. Lewi Tonks of the General Electric Company, Drs. W. B. Hebenstriet and H. D. Hagstrum

of the Bell Telephone Laboratories, Drs. A. Nordsieck and A. V. Hollenberg of Columbia University, Dr. Lloyd P. Smith of Cornell University, and Miss Helen Wieman for her assistance in preparing the manuscript for publication.

In conclusion, the editor wishes to emphasize that a book of this magnitude could not have been written without the wholehearted cooperation of all the authors, many of whom worked on the manuscript long after leaving the Radiation Laboratory.

GEORGE B. COLLINS.

CAMBRIDGE, MASS.,
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