LORAN

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Long Range Navigation

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First Edition

NEW YORK · TORONTO · LONDON
McGRAW-HILL BOOK COMPANY, INC.
1948

LORAN

THE MAPLE PRESS COMPANY, YORK, PA.

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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 preceding volumes of the Radiation Laboratory Series are surveys of radar system engineering, radar systems of navigation, and radar beacons. Like radar, the long-range system of navigation described in this volume depends upon the transmission and reception of pulsed radio signals, but it makes use of much lower radio frequencies and does not involve reflection from a target.

The Loran system was developed at the Radiation Laboratory during World War II to meet the needs of the Navy in convoy operations and to provide all-weather navigation for aircraft by day and night. At the close of the war, some 70 Loran transmitting stations were in operation, providing nighttime service over 60 million square miles, or three-tenths of the surface of the earth. About 75,000 shipborne and airborne navigation receiver-indicators had been delivered by various manufacturers, while the Hydrographic Office had prepared and shipped $2\frac{1}{4}$ million charts to the operating agencies.

The purposes of the present volume are to describe the Loran system, its principles and its equipment, as they existed at the end of the war and to offer suggestions for their adaptation and improvement for civilian service in time of peace. Since electronic time measurements are fully discussed in other volumes of this series, these techniques have not been treated in detail here. Similarly, relatively little space has been devoted to material found in the instruction books for various items of Loran equipment.

Wherever possible, the individual chapters have been written by those members of the group who have been most closely associated with the material concerned. However, many former members of the group who contributed greatly to the development of Loran concepts and equipment have been unable to describe their work in this volume. To Mr. Melville Eastham belongs the credit for the organization and administration of the Loran Group during the difficult early days. His leadership made the whole development possible and procured the needed support from the Services before the merit of the system had been fully demonstrated. Mr. Donald G. Fink and Professor J. C. Street made many

contributions and successively assumed the administrative burdens after the retirement of Mr. Eastham and before being called to more responsible duties elsewhere. Throughout the program Mr. Walter L. Tierney, who managed all field activities, was a source of strength to the entire group. Professor J. A. Stratton made valuable preliminary studies of propagation at Loran frequencies, but his knowledge and talents were soon demanded for other purposes. After the Loran system had been successfully demonstrated, Mr. Robert J. Dippy, the originator of the Gee system, brought the experience of the British laboratory, TRE, to bear upon Loran problems and helped the group especially in improving the designs of the receiver-indicator and the transmitter timer.

The U.S. Coast Guard, Bureau of Ships, General Electric Company, Sperry Gyroscope Company, Fada Radio and Electric Company, Radio Engineering Laboratories, and the Bartol Research Foundation have kindly supplied photographs and granted permission for their use as illustrations of Loran ground stations and equipment. The Hydrographic Office has granted permission for the reproduction, as Appendix A, of a summary report on its Loran program. Thanks are also due to Miss Constance Henderson for her aid in preparing the drawings and to Miss Corinne Susman for her capable service as editorial assistant.

THE AUTHORS.

CAMBRIDGE, MASS.,
October, 1946.

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