

Principles of
AERONAUTICAL
RADIO ENGINEERING

BY

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PRINCIPLES OF AERONAUTICAL RADIO ENGINEERING

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PREFACE

Since this book is believed to be the first purporting to discuss the principles of aeronautical radio engineering, it seems mandatory that this subject be defined. Shortly after some enterprising individuals began to consider the airplane as the basis for a different transportation system, it was realized that the means that had been employed for *navigating* between fixed terminals were not applicable to *avigating* between these terminals, particularly as it was desired that the airplane complete its journey in all types of weather. It likewise became apparent that radio was the only medium that could be employed to perform this task successfully. Radio-engineering principles were extended to include solutions to the peculiar problems of transportation by air, and it is this extension that I have chosen to call the "Principles of Aeronautical Radio Engineering."

The word "extension" implies a starting point; therefore it is necessary to explain how I determined the point where ordinary radio engineering ends and aeronautical radio engineering begins. Of course, there is no such well-defined point. It was necessary to cover many subjects that, if removed from the covers of this book, would be without characteristics to distinguish them from other types of radio engineering. Although attempting to adhere strictly to aircraft applications, I have discussed in greater detail the fundamentals of those subjects that I have heard most frequently debated by practicing aeronautical radio engineers.

Since this book is intended chiefly to cover the extension, no attempt is made to go into the first principles of radio engineering, much less the fundamentals of electrical engineering. It is assumed that the reader has some preliminary knowledge of radio and at least understands the terms used in describing the characteristics of the apparatus. There are many fine books available on the subject of radio and communications engineering written by authors far more capable than I; so if the reader lacks this essential knowledge, he should go to them before he attempts to read this book.

To the practical man, this book may seem too mathematical, but the mathematician will recognize the limited depth of my derivations. The derivations of only those formulas thought to be particularly significant in this work are presented. It was thought that these derivations would be useful to the designers of equipment, but that the subject would not be completely nebulous to one who does not understand them. For the serious mathematician, references are given which will serve to allow the mathematical formulas to be traced to their sources.

In order to understand fully the application of the principles set forth, it is necessary that the reasons for their developments be known; therefore, the book is sprinkled with a liberal treatment of the history and philosophy behind each development.

Although the major interest today is centered on military aviation, this book is written chiefly from the standpoint of continental commercial airline operation. It is believed that the same principles hold in both fields, but that tactical requirements demand further extensions. Although the information contained in this book may not be sufficient for military use, it should, however, serve the purpose for which it was written, that is, as a basis to which additions can be made by the student.

In some cases it will be found that after describing a problem, the solution is covered in a too offhand manner. For this I apologize. It must be remembered that much of this subject matter is new, and although solutions have been worked out, they often have not been thoroughly tested, and it is therefore not possible to give too many details. The factor of secrecy has come into many of the discussions. For both commercial and military reasons, some of the facts cannot be published.

As to the source of my material, some of the first work in this field was done by the United States Army Aircraft Radio Laboratories and by the National Bureau of Standards. Workers in these laboratories published many papers with accounts of their work. From these papers certain information was obtained. The Communications Laboratory of United Air Lines Transport Corporation was organized in 1929 for the purpose of working on the application of radio equipment to aircraft and the associated problems and has worked diligently in this field ever since. The entire files of this laboratory were made available to me. The work that had been handled by the Bureau of Standards was later

transferred to the Radio Development Section of the Bureau of Air Commerce (now the Civil Aeronautics Administration), and this group has been responsible for all the developments of ground-station facilities. Descriptions of many of their researches have been published in Technical Development Reports which the public is allowed to reproduce. Also the Bell Telephone Laboratories, associated with the Western Electric Company, the Bendix Radio Corporation, the International Telephone and Radio Manufacturing Company, and the Radio Corporation of America must be mentioned as having contributed significantly to the development of aeronautical radio apparatus and thus to this book. To all these organizations I wish to express my appreciation, and to the Institute of Radio Engineers, the American Institute of Electrical Engineers, the Franklin Institute, the Institution of Electrical Engineers, and the National Advisory Committee for Aeronautics, which allowed me to reproduce some of the material that had appeared in their publications.

In particular I wish to express my thanks to A. E. Harrison, formerly of Aeronautical Radio, Inc., for his review of Chap. II; to Andrew Alford of the International Telephone and Radio Manufacturing Company for his review of Chap. III; to R. R. Brunner of the Bendix Radio Corporation for his review of Chap. IV; to W. E. Jackson, chief of the Development Section of the Civil Aeronautical Administration, for his review of Chap. VI; to F. C. McMullen of the Western Electric Company for his review of the section on the WECO altimeter in Chap. VII; to Harry Diamond of the Bureau of Standards for his review of Chap. VIII; to Charles R. Burroughs for his review of the section on the calculation of field strength in Chap. IX; to A. F. Trumbull, superintendent of Aircraft Radio Maintenance of United Air Lines, for his review of Chaps. XI and XII; to N. E. Klein and other of my colleagues of the United Air Lines Communications Laboratory, for their contributions; and, last but not least, to my wife for her patience in correcting the sentence structure and assistance in preparing the entire manuscript.

P. C. SANDRETTO.

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