WIRELESS

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A TREATISE ON THE THEORY AND PRACTICE OF HIGH-FREQUENCY ELECTRIC SIGNALLING

BY

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PREFACE

THIS BOOK is a development of the author's *Outline of Wireless*, published in 1921 and now for some years out of print. The scope and intention of that small volume were described in the Preface in the following words. "The book is an outline only of the framework of a great and growing subject; but it is hoped that a careful perusal will enable the intelligent reader to appreciate the problems which are presenting themselves, and to read, if he so desire, with understanding any of the discussions of these problems appearing in the technical press." The aim was to present a brief account of wireless theory and practice which should be readable by a competent electrical engineer who had not studied high-frequency phenomena. This aim has continued in the present work to influence the choice of material and the manner of treatment. But in the intervening years engineering achievement and exact scientific research have far advanced, and if the book was to retain its former relation to the subject a corresponding expansion was necessary. Although new matter, rather than alteration of the old, seemed called for, the unity of the book would have suffered if only a partial revision had been made. In the event, the present volume is nearly three times as large as the previous; and apart from a few diagrams but little of the latter remains.

The field over which the book ranges is intended to be that of wireless telegraphy and telephony—the principles and the more prominent present-day practice. I have not included picture telegraphy, tele-kinematography and television, although much of the book is apposite as an introduction to these and other outgrowths of the thermionic technique. Further, I have gladly constricted my task by omitting all discussion of the methods of high-frequency measurement. This subject has been ably dealt with by Mr E. B. Moullin in his *Radio Frequency Measurements* (1926), of which a new edition has just appeared as I write this preface.

In the author's opinion, those readers who seek a general knowledge of modern wireless should study the whole of the book. But if severe restriction to matters of direct engineering application is desired,

Sections 4 and 5 of Chapter III, Sections 2 to 5 of Chapter VII, and Chapter XVII may be omitted. These contain respectively sketches of the theory of propagation in the upper atmosphere, of the internal physics of the thermionic tube, and of the nature and effect of atmospherics. The generalised treatment of triode circuits in Chapter X may be referred to on occasion rather than read. The rigorous division of the Chapters into titled Sections and Subsections, as well as the full index, will facilitate the use of the book for reference by those who have passed the stage of consecutive text-book reading. Students who, unassisted, are making a first study of the subject are advised to leave certain portions of the book until the remainder has been read. These portions are marked with an asterisk in the Table of Contents.

The effects dealt with in electrical engineering—unlike mechanical—are remote from the sense-perceptions and concepts of ordinary daily life. The student can acquire the power of visualisation, and that sense of the naturalness of the phenomena he meets which is a pre-requisite of engineering efficiency, only by supplementing his theoretical studies with much experimental exercise in the laboratory or elsewhere. Particularly in high-frequency work does a lack of prolonged practical experience make itself apparent. Proficiency with mathematical equations and circuit diagrams is indispensible, but is not sufficient to make the student effective as an engineer. He must manipulate the things whose idealised qualities are portrayed in the circuit diagrams; and often a rather long apprenticeship proves necessary. Fortunately, facilities for wireless experimental work of the right character—which is, in a word, metrical—are exceptionally easily provided.

Many years of learning and of teaching wireless have shown me the importance of maintaining always a close touch with numerical values. A circuit disposition of even moderate complexity, supposed to comprise parts A, B, C, D, may behave in diverse ways. The conceivable actions and interactions of the components are so many that one can offer *prima facie* explanations of almost any phenomenon reported. Diagnosis of faults and removal of seeming anomalies must depend on the *sizes* of A, B, C, D; and upon whether there may not, in fact, be other components a, b, c, d, intruding in appreciable amount. Not the least boon conferred by

the thermionic tube is the means it has brought for exact measurement of all sorts, with the consequent opening for fruitful analysis. But while mathematical exploration is of the greatest service, real wireless dispositions are peculiarly liable to contain factors left out of account: sometimes because they were unsuspected; sometimes as an approximation to reduce the complexity of the analysis. Unlike, therefore, the mathematician of Mr Bertrand Russell*, who is not concerned to know what he is talking about or whether his statements are true, the wireless engineer must not only know precisely what physical quantities his symbols stand for; he must have a good notion how large those quantities are. For pointing a moral arithmetic will often be more effective than algebra. Accordingly throughout this book I have tried to convey some idea of size by taking numerical examples: sometimes in the form of an actual instrument or installation; sometimes the results of my own measurements; sometimes as a more or less arbitrary choice intended to typify practical conditions.

In preparing a book of the present character, the author's work is the selection and coordinated presentation of material which is, for the most part, already well known to his readers collectively. He mingles with what others have taught him notions he feels are his own, in the hope that a useful coherent message may emerge. In this process I have doubtless been influenced by the publications and the talk of many workers, not all of whom are referred to explicitly in the text. But in concluding this arduous, if often absorbing, task I wish to acknowledge generally the inspiration I have received on many occasions from contact with two scholarly and original minds. For their writings and their conversation I owe much to Dr W. H. Eccles, F.R.S., with whom I have been associated on the Wireless Telegraphy Commission of 1920–26 and other bodies; and to Mr E. B. Moullin, M.A., until lately my colleague at Cambridge.

I have received technical information, photographs, and permission to reproduce diagrams, from numerous sources, all of which, I trust, are specifically acknowledged in the text. I am grateful for opportunities to examine examples of the most recent wireless practice accorded by the German Post Office and the Telefunken Company, by the British Broadcasting Corporation and the Marconi Company,

* *Mysticism and logic* (1918), p. 75.

and especially by my former colleagues of the Engineering Department of the British Post Office.

My thanks are due to Mr E. St J. Thackeray, B.A., for valuable help in reading the proofs. I hope that few mistakes remain; but the book contains many fresh calculations, and amongst them some errors must be expected. I shall be grateful to readers who point them out.

L. B. T.

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CAMBRIDGE
April, 1931

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NOTES

Throughout the book letters standing for quantities are in italic type. Also, in the case of an article such as a condenser or an inductance coil, an italic letter is used to designate both the article and its size. Thus:

C_1 is a condenser of capacitance C_1
L_2 is a coil of inductance L_2

Where equations or formulas are numbered for identification, the numbers run consecutively throughout the Chapter.

All the Plates are placed together at the middle of the book.

In accordance with the recommendations of the International Electrotechnical Commission (Publication No. 27), the following signs for names of units are used:

A for ampere	F for farad
V „ volt	H „ henry
Ω „ ohm	m „ metre
W „ watt	

Prefix $\mu \equiv$ micro-, e.g. 1 $\mu\mu$F $\equiv$ 1 micromicrofarad $\equiv 10^{-12}$ farad
„ m $\equiv$ milli-, „ 1 mA $\equiv$ 1 milliampere $\equiv 10^{-3}$ ampere
„ k $\equiv$ kilo-, „ 1 kW $\equiv$ 1 kilowatt $\equiv 10^{3}$ watts
„ M $\equiv$ mega-, „ 1 MΩ $\equiv$ 1 megohm $\equiv 10^{6}$ ohms

In addition, db is used for decibel.

In accordance with the recommendation of the International Radio Technical Committee (Hague, Sept. 1929) the following designations of wavelengths have been observed:

Long	= above 3000 m
Medium	= 3000—200 m
Intermediate	= 200—50 m
Short	= 50—10 m
Very short	= below 10 m