ELECTROMAGNETIC THEORY.

BY

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VOLUME I.

LONDON:
"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY,
LIMITED,
SALISBURY COURT, FLEET STREET, E.C.

Printed and Published by
"THE ELECTRICIAN" PRINTING AND PUBLISHING CO., LIMITED
1, 2 and 3, Salisbury Court, Fleet Street,
London, E.C.

PREFACE.

THIS work was originally meant to be a continuation of the series "Electromagnetic Induction and its Propagation," published in *The Electrician* in 1885-6-7, but left unfinished. Owing, however, to the necessity of much introductory repetition, this plan was at once found to be impracticable, and was, by request, greatly modified. The result is something approaching a connected treatise on electrical theory, though without the strict formality usually associated with a treatise. As critics cannot always find time to read more than the preface, the following remarks may serve to direct their attention to some of the leading points in this volume.

The first chapter will, I believe, be found easy to read, and may perhaps be useful to many men who are accustomed to show that they are practical by exhibiting their ignorance of the real meaning of scientific and mathematical methods of enquiry.

The second chapter, pp. 20 to 131, consists of an outline scheme of the fundamentals of electromagnetic theory from the Faraday-Maxwell point of view, with some small modifications and extensions upon Maxwell's equations. It is done in terms of my rational units, which furnish the only way of carrying out the idea of lines and tubes of force in a consistent and intelligible manner. It is also done mainly in terms of vectors, for the sufficient reason that vectors are the main subject of investigation. It is also done in the duplex form I introduced in 1885, whereby the electric and

magnetic sides of electromagnetism are symmetrically exhibited and connected, whilst the "forces" and "fluxes" are the objects of immediate attention, instead of the potential functions which are such powerful aids to obscuring and complicating the subject, and hiding from view useful and sometimes important relations.

The third chapter, pp. 132 to 305, is devoted to vector algebra and analysis, in the form used by me in my former papers. As I have at the beginning and end of this chapter stated my views concerning the unsuitability of quaternions for physical requirements, and my preference for a vector algebra which is based upon the vector and is dominated by vectorial ideas instead of quaternionic, it is needless to say more on the point here. But I must add that it has been gratifying to discover among mathematical physicists a considerable and rapidly growing appreciation of vector algebra on these lines; and moreover, that students who had found quaternions quite hopeless could understand my vectors very well. Regarded as a treatise on vectorial algebra, this chapter has manifest shortcomings. It is only the first rudiments of the subject. Nevertheless, as the reader may see from the applications made, it is fully sufficient for ordinary use in the mathematical sciences where the Cartesian mathematics is usually employed, and we need not trouble about more advanced developments before the elements are taken up. Now, there are no treatises on vector algebra in existence yet, suitable for mathematical physics, and in harmony with the Cartesian mathematics (a matter to which I attach the greatest importance). I believe, therefore, that this chapter may be useful as a stopgap.

The fourth chapter, pp. 306 to 466, is devoted to the theory of plane electromagnetic waves, and, being mainly descriptive, may perhaps be read with profit by many who are unable to tackle the mathematical theory comprehensively. It may be also useful to have results of mathematical

reasoning expanded into ordinary language for the benefit of mathematicians themselves, who are sometimes too apt to work out results without a sufficient statement of their meaning and effect. But it is only introductory to plane waves. Some examples in illustration thereof have been crowded out, and will probably be given in the next volume. I have, however, included in the present volume the application of the theory (in duplex form) to straight wires, and also an account of the effects of self-induction and leakage, which are of some significance in present practice as well as in possible future developments. There have been some very queer views promulgated officially in this country concerning the speed of the current, the impotence of self-induction, and other material points concerned. No matter how eminent they may be in their departments, officials need not be scientific men. It is not expected of them. But should they profess to be, and lay down the law outside their knowledge, and obstruct the spreading of views they cannot understand, their official weight imparts a fictitious importance to their views, and acts most deleteriously in propagating error, especially when their official position is held up as a screen to protect them from criticism. But in other countries there is, I find, considerable agreement with my views.

Having thus gone briefly through the book, it is desirable to say a few words regarding the outline sketch of electromagnetics in the second chapter. Two diverse opinions have been expressed about it. On the one hand, it has been said to be too complicated. This probably came from a simple-minded man. On the other hand, it has been said to be too simple. This objection, coming from a wise man, is of weight, and demands some notice.

Whether a theory can be rightly described as too simple depends materially upon what it professes to be. The phenomena involving electromagnetism may be roughly divided into two classes, primary and secondary. Besides the main