

**ROENTGEN RAYS AND
PHENOMENA OF THE ANODE
AND CATHODE: PRINCIPLES,
APPLICATIONS AND THEORIES**

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EDWARD P. THOMPSON & WILLIAM A. ANTHONY

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DR. WILLIAM KONRAD ROENTGEN. pp. 69 to 85.

Born in Holland, 1845.

From a photograph by Hanfstaengl, Frankfort-on-the-Main.

ROENTGEN RAYS
AND 124205
PHENOMENA
OF THE
ANODE AND CATHODE.

PRINCIPLES, APPLICATIONS AND THEORIES

BY

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Author of "Inventing as a Science and an Art."

CONCLUDING CHAPTER

BY

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PREFACE.

IN addition to the illustrated feature for exhibiting the nature and practical application of X-rays, and for simplifying the descriptions, the book involves the disclosure of the facts and principles relating to the phenomena occurring between and around charged electrodes, separated by different gaseous media at various pressures. The specific aim is the treatment of the radiant energy developed within and from a discharge tube, the only source of X-rays.

Having always admired the plan adopted by German investigators in publishing accounts of their experiments by means of numbered paragraphs containing cross-references and sketches, the author has likewise treated the investigations of a large number of physicists. The cross-references are indicated by the section sign (§). By reference, the *analogy, contrast, or suggestiveness* may be meditated upon. All knowledge of modern physics is based upon experiments as the original source. Inasmuch as many years may be expected to elapse before the innumerable peculiarities of the electrical discharge will be reduced to a pure science, and also in order that the contents of the book may be of value in the future as well as at present, the characteristic experiments of electricians and scientists are described, in general, by reference to their object, the apparatus used, the result, the inferences of the experimenter, and the observations of cotemporaneous or later physicists, together with a presentation here and there of theoretical matters and allusion to practical applications.

The classes of reader to which the book is adapted may best be known, of course, after perusal, but some advance intimation of the kind that the author had in view may be desired. Let it be known that, first, the student and those generally interested in sci-

ence ought to be able to comprehend the subject-matter, because experiments are described, which are always the simplest means (*e. g.*, in a popular lecture) for explaining the wonders of any given scientific principles or facts. Thus did Crookes, Tyndall, Thomson (both Kelvin and J. J.), Hertz, etc., disseminate knowledge—by describing their researches and reasoning thereon.

In view of the tremendous amount of experimenting which has been carried on during the past few years in connection with the electric discharge, it was difficult to determine just how far back to begin (without starting at the very beginning), so that the student and general reader, whose object is to become acquainted especially with the properties of cathode and X rays, might better understand them. The author realized that it was necessary to go back further and further in this department of science, and he could not easily stop until he had reached certain investigations of Faraday, Davy, Page, and others, which are briefly noticed in an introductory sense. Take, for example, the inaction of the magnet upon X-rays in open air. § 79. Of course, it would be of interest for the student to know about Lenard's investigations relating to the action of the magnet upon cathode rays inside of the observing tube. § 72*a*. It would follow, further, that he would desire to know about Crookes' experiment relating to the attraction of the magnet upon cathode rays within the tube. § 59. In order that he might not infer that Crookes was the first to investigate the action of the magnet upon the discharge, it was evident that the book could be made of greater value by relating the experiments of Prof. J. J. Thomson as to the discharge across and along the lines of magnetic force, § 31, and Plücker's experiment on the action of the magnet upon the cathode column of light. § 30. The interest became increased, instead of diminished, by noting De la Rive's experiment on the rotation of the luminous effect of the discharge by means of the magnet. § 29. Being now quite impossible to stop, Davy's electric arc and magnetic action upon the same had to be alluded to, at least briefly. § 28. On the other hand, the very earliest experiments with the discharge in rarefied air are not described—occurring as remotely as the eighteenth century—so ably treated of in Park Benjamin's work. Those facts that have some mutual

bearing are brought forward to serve as stepping-stones to the investigation of cathode and X rays.

Secondly, the author often imagined that he was writing in behalf of the surgeon and physician and those who intend to experiment, especially when he found in his investigations of recent publications descriptions in detail of the electrical apparatus employed in experimenting with X-rays. He improved the opportunity of repeating the statements of the difficulties, and how they were overcome ; also, the precautions necessary to be taken, and, besides, the kind of discharge tubes and apparatus best adapted for particular kinds of experiments. The chapter on applications in diagnosis and anatomy, etc., is of especial interest to physicians.

Thirdly, as the discovery of the Roentgen rays has established a new department of photography, those who are interested in this art may be benefited by the results and suggestions disclosed in connection with photographic plates, time of exposure, adjuncts for best results, precautions for obtaining sharp shadows, and steps of the process, from beginning to end, for carrying on the operation.

Fourthly, expert physicists and electricians, professors, etc., need something that the above classes do not, and this is the reason why the author has not assumed the burden of carrying any line of thought or theory from the beginning to the end of the treatise, nor has he made the book in any way a personal matter by criticising experiments, nor even by favoring the views of one over the other, unless it is in an exceptional case here and there ; but in each instance the investigator's name is given, and that of the publication in which the account may be found, so that the scientist may refer thereto to test the correctness of the author's version of the matter, or to learn the nature of the minute details and circumstances.

The author suggests that the study of the phenomena of the discharge tube would not be amiss in scientific schools and colleges. He argues that in view of all experimenters in this line having been made enthusiastic and fascinated by reason of (1) the beautiful effects, (2) the field being always open to new discoveries, (3) the direct practical and theoretical bearing of the peculiar actions upon other departments of electricity, light, heat, and magnetism, (4) the pleasure in attempting to obtain results reported by others, and espe-

cially the large amount of valuable theoretical and practical instruction resulting therefrom, by repeating the experiments or studying them, and (5) the possible applications of the discharge tube in connection with electric lighting and in the new department of sciagraphy by X-rays, and for other good and valuable considerations—it follows that students who have been through or who are studying a text-book of physics and electricity would be greatly benefited by a course in the discharge-tube phenomena.

In view of the large amount of dictation necessary in order to complete the work in such a short period, and in order that the subject-matter might involve the treatment of the latest work of the French and German as well as of the English and American, and inasmuch as the journals of the latter did not always contain complete translations and, for better service in behalf of the readers, the authorship was shared with others, and, therefore, much credit is due to Prof. Anthony for final chapter, to Mr. Louis M. Pignolet for assistance in connection with French periodicals and academy papers (§§ 63*a*, 84, 99, 101*a*, 103*a*, 112*a*, 124*a*, 128, *at end*, 139*a*, 154, 155, 156, 157, 158, and 159): to Mr. N. D. C. Hodges, formerly editor and proprietor of *Science*, who obtained some pertinent accounts, (§ 97*a*, 97*b*, 99*A*, *B*, *C*, *D*, to 99 *T*, inclusive) by investigations of recent literature at the Astor Library, New York; and also to Mr. Ludwig Gutmann (Member American Institute of Electrical Engineers) for a few translations from the German.

Credit is given in each instance to all societies and publications by naming them in the respective paragraphs herein. In nearly every case the author prepared his material from original articles and papers contributed by the investigators to the societies or periodicals.

The author has prepared himself to withstand, with about half as much patience as he expects will be required, all criticisms based upon disappointments which may be experienced by the true, or the alleged true, first discoverer of any particular property of the electric discharge not duly credited. He has been particular in presenting knowledge as to physical facts and principles, but not equally, perhaps, as to the originator of the experiment, or as to the actual first discoverer, for the simple reason that the book is in no sense a his-