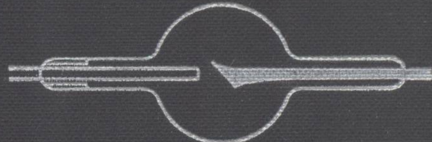
RADIOLOGY PHYSICS



JOHN KELLOCK ROBERTSON

Radiology Physics

AN INTRODUCTORY COURSE FOR MEDICAL OR PREMEDICAL STUDENTS AND FOR ALL RADIOLOGISTS

By

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Radiology Physics

Courtesy Metropolitan Museum of Art

X-ray of the painting, *Portrait of a Lady by Pourbus*, made at the Fogg Art Museum, Harvard University, under the Milton Fund.

To

my wife

PREFACE

With the ever increasing applications of physics in medicine the problem of giving the medical or the premedical student adequate instruction in physics has become one which demands action. To teach in one year the fundamental principles of physics, and at the same time to deal adequately with those applications with which a medical student should be familiar, is well nigh impossible. At Queen's University the problem has been solved and, on the whole, satisfactorily, by giving instruction in two successive years. In the first year, the student is given the usual course in general physics, with the omission of electricity and magnetism. In the second year, lectures and laboratory work in electricity and magnetism lead naturally to a consideration of such topics as x-ray transformers, x-ray tubes, conduction of electricity through gases, radioactivity, nuclear physics, and high frequency currents. RADIOLOGY PHYSICS covers, with some amplification, the work given by the author in the second half of this course.

It is hoped that this book will prove suitable as a text for similar courses elsewhere, especially for those institutions which agree with the Committee on the Teaching of Physics for Premedical Students* in their opinion "that the American Association of Physics Teachers should go on record as in favour of making the physics prerequisite two years instead of one." RADIOLOGY PHYSICS is also commended to all radiologists and radiological technicians who wish, not a handbook, but a simple explanation of the physical principles underlying the use of their apparatus. Although a knowledge of elementary electricity and magnetism is assumed, the mathematical treatment is reduced to a minimum.

In the preparation of the manuscript, the author has made some use of an earlier book on *X-rays and X-ray Apparatus*, and his thanks are due the President of D. Van Nostrand Company, Inc., for permission to use some of the material in the more recent *Atomic Artillery*. Under each illustration due acknowledgment is made where necessary, but my special thanks are due the Philips' Gloeilampenfabrieken, Eindhoven, Holland, the General Electric X-ray Corporation, Dr. J. G. Trump of the Massachusetts Institute of Technology, and Mrs. Edith Quimby and Dr. G. Failla of the Memorial Hospital, New York, for photographs and other material. Acknowledgment

* The American Physics Teacher, 5, 267, 1937.

is also made of the kindness of Mr. A. C. Baldwin, Mr. G. E. Simons, and Dr. J. Gross, of the General Electric Corporation, and Mr. Victor Hicks of the Westinghouse X-Ray Company.

It is a pleasure to thank my wife for her valuable assistance throughout the preparation of the book, and my colleagues Dr. B. W. Sargent, who read part of the manuscript, and Dr. H. W. Harkness, who read the chapters on high voltage. With Dr. Sargent the author has had many discussions. My friend and colleague Dean A. L. Clark has again provided clerical and other assistance and it is a pleasant duty to express to him my appreciation.

J. K. R.

QUEEN'S UNIVERSITY,
KINGSTON, CANADA
October, 1940.

CONTENTS

Chapter I. ALTERNATING CURRENTS.

Chapter II. PRODUCTION OF HIGH VOLTAGE. Part I.

Chapter III. MEASUREMENT AND CONTROL OF HIGH TENSION VOLTAGE

CHAPTER XII. ROENTGEN RAY DOSAGE

CHAPTER XIII. RADIOACTIVITY

APPENDIX

CHAPTER I

ALTERNATING CURRENTS

The aim of this text is to present in a systematic way the fundamental physical principles utilized in the field of radiology. It is assumed that the reader has had a general course in physics such as is given in the first year of liberal arts or to premedical students, but the author does not hesitate to review and to amplify important parts of the elementary course. For example, at the outset the student is asked to recall a few principles in electricity and magnetism, that branch of physics whose applications abound in radiology.

1. Electromagnetism. — All students are familiar with the fact that when a bar magnet is placed beneath a sheet of paper on which iron filings are sprinkled, the filings arrange themselves along regular lines. This simple experiment indicates that in the region around the magnet there is a *magnetic field of force.* To visualize this field we say that it is traversed by magnetic lines of force, the actual number of lines being so chosen that at any particular place, the *intensity* or strength of the magnetic field is equal to the number of lines passing through an area of 1 sq. cm., the area being at right angles to the direction of the lines. A field of unit intensity, it will be recalled, is equal to 1 dyne per unit pole and is called 1 *oersted.*

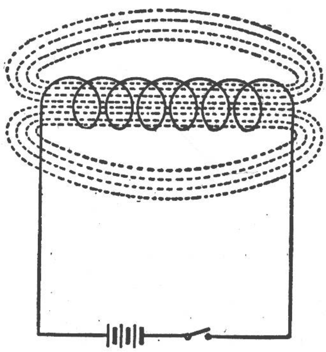

FIG. 1. Lines of Force are linked with a solenoidal coil carrying a current.

These lines of force are closed curves which leave the north pole of the magnet and enter the south, constituting what is called a *magnetic flux* through the magnet. Indeed, whenever magnetic lines pass through any region, we speak of a magnetic flux through that region.

Elementary experiments with electric currents prove that a magnetic field surrounds a wire carrying a current and show that, if the wire is bent into a solenoidal coil, as in Fig. 1, one end of the solenoid is a north pole, the other a south. Moreover, if the air inside the solenoid is replaced by a core of soft