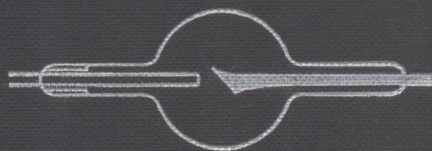
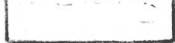


RADIOLOGY PHYSICS



JOHN KELLOCK ROBERTSON

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Radiology Physics

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

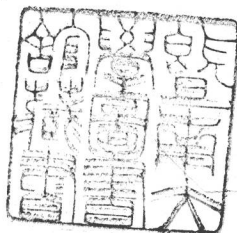
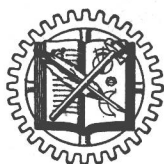
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By

JOHN KELLOCK ROBERTSON, F.R.S.C.

*Professor of Physics,
Queen's University, Kingston, Canada*

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RADIOLOGY PHYSICS

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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.

SECTION	PAGE
1. ELECTROMAGNETISM	1
2. ELECTROMAGNETIC INDUCTION	2
3. ALTERNATING CURRENTS (A.C.)	3
4. STRENGTH OF A.C.	5
5. MEANING OF R.M.S.	6
6. INDUCTIVE AND NON-INDUCTIVE CIRCUITS	6
7. IMPEDANCE AND INDUCTIVE REACTANCE	8
8. CAPACITATIVE REACTANCE	10
9. COMBINATION OF RESISTANCE AND CAPACITY	11
10. RESISTANCE, CAPACITY AND INDUCTANCE	11
11. PHASE DIFFERENCE	12
12. POWER FACTOR	14
13. CAPACITY AND PHASE DIFFERENCE	15

CHAPTER II. PRODUCTION OF HIGH VOLTAGE. Part I.

14. THE INDUCTION COIL	16
15. THE TRANSFORMER	18
16. INSULATION	20
17. EFFICIENCY AND POWER RATING OF TRANSFORMERS	20
18. TRANSFORMER RATING	21
19. RECTIFICATION	22
20. OPERATION OF TRANSFORMER WITH MECHANICAL RECTIFIER	24
21. NATURE OF TUBE CURRENT	24
22. POLARITY INDICATOR	25

CHAPTER III. MEASUREMENT AND CONTROL OF HIGH TENSION VOLTAGE

23. SPARK-GAP METER	27
24. CORONA	29
25. PRIMARY VOLTMETER	29

SECTION	PAGE
26. ELECTROSTATIC VOLTMETER	30
27. CURRENT THROUGH A HIGH RESISTANCE	32
28. THE SEEMAN SPECTROGRAPH	33
29. CONTROL OF TUBE VOLTAGE BY RHEOSTAT	33
30. VOLTAGE CONTROL BY AUTO-TRANSFORMER	34

CHAPTER IV. CATHODE RAYS

31. CONDUCTIVITY OF AIR	36
32. CONDUCTIVITY OF AIR AT REDUCED PRESSURE	38
33. APPEARANCE OF VACUUM TUBE	39
34. PROPERTIES OF CATHODE RAYS	39
35. NATURE OF CATHODE RAYS	42
36. STRUCTURE OF THE ATOM	45
37. MEANING OF IONIZATION	46
38. IONIZATION BY COLLISION	47
39. ELECTRON BOMBARDMENT	47
40. ORIGIN OF ROENTGEN RAYS	48

CHAPTER V. POSITIVE RAYS AND ISOTOPES

41. NATURE OF CONDUCTIVITY AT ATMOSPHERIC PRESSURE	49
42. CONDUCTIVITY AT REDUCED PRESSURE	49
43. POSITIVE RAYS	50
44. CHEMICAL ANALYSIS BY POSITIVE RAYS	51
45. ISOTOPES	54
46. DETERMINATION OF ATOMIC WEIGHTS BY PHYSICAL METHOD	55
47. DISCOVERY OF DEUTERIUM	55
48. THE PROTON	56

CHAPTER VI. ROENTGEN TUBES

49. TWO TYPES OF TUBES	58
50. THE GAS TUBE	58
51. REGULATION OF CURRENT IN GAS TUBE	59
52. BLACKENING OF TUBES	60
53. METHODS OF COOLING A TARGET	61
54. THERMIONIC EMISSION	61
55. HOT FILAMENT RECTIFIERS	63
56. HOT FILAMENT X-RAY TUBE	63

CONTENTS

xi

SECTION	PAGE
57. PREPARATION OF HOT FILAMENT TUBES	66
58. FOCUSING	66
59. THE ANODE AND TARGET	68
60. CONTROL OF TUBE CURRENT	68
61. VOLTAGE STABILIZER	71
62. X-RAY PROTECTION AND METALIX TUBE	74
63. LINE FOCUS	75
64. ROTATING ANODE	76
65. RATING	77
66. SHOCKPROOF TUBES	80
67. OIL IMMERSION	80
68. LOW VOLTAGE TUBES	80

CHAPTER VII. VALVE RECTIFICATION

69. SELF-RECTIFYING TUBES	83
70. VALVE RECTIFIERS	84
71. TYPES OF VALVES	85
72. HALF-WAVE RECTIFICATION	87
73. FULL-WAVE RECTIFICATION	87
74. TUBE RATING AND TYPE OF RECTIFICATION	88
75. THE USE OF CONDENSERS WITH VALVES	90
76. THE GREINACHER CIRCUIT	91
77. THE VILLARD CIRCUIT	93

CHAPTER VIII. GENERAL PROPERTIES OF X-RAYS

78. PHOTOGRAPHIC EFFECT	95
79. FLUORESCENT EFFECT	95
80. CHEMICAL AND DEHYDRATING EFFECTS	96
81. BIOLOGICAL EFFECTS	96
82. IONIZATION EFFECT	96
83. PENETRATING EFFECT	97
84. QUALITY AND TUBE VOLTAGE	98
85. QUALITY AND HALF VALUE LAYER (H.V.L.)	99
86. HOMOGENEOUS BEAM AND EXPONENTIAL LAW	102
87. PROTECTION	103

CHAPTER IX. ELECTROMAGNETIC WAVES

88. THE SPECTROGRAPH	106
89. MEASUREMENT OF WAVE LENGTH	107

SECTION	PAGE
90. THE ANGSTROM AND MILLIMICRON	110
91. THE INFRARED	111
92. INFRARED RADIATION IN MEDICINE	111
93. ELECTRIC WAVES	111
94. THE ULTRAVIOLET	112
95. SOURCES OF ULTRAVIOLET	113
96. THE USE OF ULTRAVIOLET IN MEDICINE	114
97. BACTERICIDAL EFFECT OF ULTRAVIOLET	118
98. PRODUCTION OF VITAMIN D	118
99. X-RAYS AND GAMMA RAYS	118

CHAPTER X. MEASUREMENT OF WAVE LENGTH OF X-RAYS

100. REFLECTION OF X-RAYS	119
101. X-RAY SPECTROMETER	121
102. X-RAY SPECTROGRAPH	121
103. SHORTEST WAVE LENGTHS	122
104. GENERAL AND CHARACTERISTIC RADIATIONS	123
105. WHITE RADIATION	124
106. CHARACTERISTIC RAYS	125
107. WAVE LENGTH AND PENETRATION	125
108. K, L, AND M RAYS	126
109. INTERPRETATION OF K, L, AND M WAVE LENGTHS	127
110. MEANING OF CORRESPONDING WAVE LENGTHS	130
111. EFFECTIVE WAVE LENGTH	130
112. RELATION OF FOCAL SPOT TO WAVE LENGTH	132

CHAPTER XI. SECONDARY X-RAYS AND ABSORPTION

113. SECONDARY X-RAYS	133
114. SCATTERED RADIATION	134
115. CHARACTERISTIC RADIATION	135
116. PHOTO-ELECTRONS	136
117. SEEING IONS	136
118. RECOIL ELECTRONS AND SCATTERING	137
119. NATURE OF ABSORPTION	138
120. FILTRATION AND CRITICAL ABSORPTION WAVE LENGTH	138
121. THE MEANING OF CRITICAL ABSORPTION WAVE LENGTH	140
122. ABSORPTION COEFFICIENTS	142
123. MASS ABSORPTION COEFFICIENT	144

CONTENTS

xiii

SECTION	PAGE
124. A NUMERICAL EXAMPLE	146
125. THE COEFFICIENTS μ AND τ	147
126. SCATTERED RAYS AND RADIOGRAPHY	148
127. DIAPHRAGMS AND SECONDARY RAYS	149
128. THE POTTER-BUCKY DIAPHRAGM	149
129. CAUSES OF GRID SHADOWS	150
130. LYSHOLM GRID	152

CHAPTER XII. ROENTGEN RAY DOSAGE

131. QUALITY AND INTENSITY	153
132. ABSOLUTE INTENSITY AND LAW OF INVERSE SQUARE	154
133. MEANING OF INTENSITY IN X-RAY DOSAGE	154
134. MEANS OF MEASURING ABSORBED X-RAY ENERGY	155
135. DOSAGE BY IONIZATION	157
136. SATURATION IONIZATION CURRENT	157
137. IONIZATION CHAMBERS	159
138. THE ROENTGEN	159
139. DETERMINATION OF EFFECTIVE VOLUME	162
140. NULL METHOD OF MEASURING IONIZATION CURRENT	163
141. CORRECTION FOR TEMPERATURE AND PRESSURE	164
142. 1937 DEFINITION OF THE ROENTGEN	165
143. THIMBLE CHAMBERS	166
144. VICTOREEN CONDENSER-METER	167
145. AIR DOSE, TISSUE DOSE, AND BACK SCATTER	168
146. DEPTH DOSAGE	170
147. THRESHOLD ERYTHEMA DOSE	172
148. SPECIFICATION OF TREATMENT CONDITIONS	173

CHAPTER XIII. RADIOACTIVITY

149. THE DISCOVERY OF RADIOACTIVITY	175
150. THE NATURE OF THE RADIATIONS	176
151. ALPHA RAYS	176
152. BETA RAYS	179
153. GAMMA RAYS	180
154. RADIUM IN TREATMENT	181
155. STRENGTH OF A RADIUM SOURCE	182
156. DOSE IN ROENTGENS	183
157. RADON	184

SECTION	PAGE
158. GROWTH OF RADON	187
159. THE CURIE AND MILLICURIE	189
160. DISINTEGRATION AND NATURE'S TRANSMUTATION	189
161. ARTIFICIAL TRANSMUTATION	193
162. PROTECTION	195
163. OTHER RADIOACTIVE FAMILIES	195

CHAPTER XIV. PRODUCTION OF HIGH VOLTAGE. Part II SUPERVOLTAGE TUBES AND HIGH SPEED PARTICLES

164. IMPORTANCE OF SUPERVOLTAGE	196
165. THE INDUCTION COIL	197
166. THE CASCADE GENERATOR	197
167. VAN DE GRAAFF ELECTROSTATIC GENERATOR	199
168. MEASUREMENT OF SUPERVOLTAGE	202
169. SUPERVOLTAGE TUBES	204
170. HIGH SPEED PARTICLES. THE CYCLOTRON	207

CHAPTER XV. ARTIFICIAL RADIOACTIVITY

171. NUCLEAR BOMBARDMENT	215
172. PROTON BOMBARDMENT	216
173. DEUTERON BOMBARDMENT	216
174. ARTIFICIAL ALPHA PARTICLES	217
175. DISCOVERY OF THE NEUTRON	217
176. OTHER METHODS OF PRODUCING NEUTRONS	219
177. IMPORTANCE OF THE NEUTRON	220
178. PROTECTION AGAINST NEUTRONS	221
179. NEUTRON BOMBARDMENT	221
180. THE POSITRON, THE MESOTRON, AND COSMIC RAYS	222
181. ARTIFICIAL OR INDUCED RADIOACTIVITY	223
182. RADIOACTIVE INDICATORS	226
183. GAMMA RAY BOMBARDMENT	227
184. MASS AND ENERGY	228
185. ENERGY FROM DESTRUCTION OF MATTER	230
186. EMISSION OF GAMMA RAYS IN NUCLEAR REACTIONS	231
187. STRUCTURE OF THE NUCLEUS	232

CHAPTER XVI. HIGH FREQUENCY CURRENTS

188. CLASSIFICATION OF CURRENTS	233
189. THE GENERATION OF DAMPED HIGH FREQUENCY CURRENTS	234

CONTENTS

xv

SECTION	PAGE
190. EXPERIMENTAL DEMONSTRATION OF HIGH FREQUENCY	236
191. PRIMARY TESLA CIRCUIT	237
192. DIATHERMY WITH DAMPED OSCILLATIONS	238
193. SECONDARY TESLA CIRCUIT	239
194. THE TRIODE VALVE	240
195. GENERATION OF UNDAMPED OSCILLATIONS	242
196. DIATHERMY WITH UNDAMPED OSCILLATIONS	243
197. THE GENERATION OF ELECTRIC WAVES	244

APPENDIX

I. SOME USEFUL CONSTANTS AND CONVERSION FACTORS	247
II. TABLE OF ATOMIC NUMBERS, ATOMIC WEIGHTS AND STABLE ISOTOPES	248
III. PROBLEMS AND EXAMINATION QUESTIONS	250
IV. INTERNATIONAL RECOMMENDATIONS FOR X-RAY AND RADIUM PROTECTION	257
INDEX	263

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*.

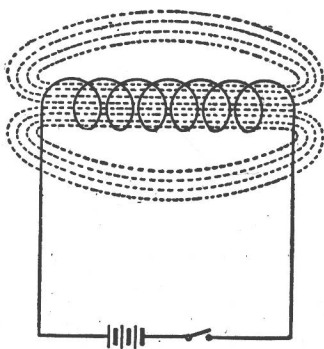


FIG. 1. Lines of Force are linked with a solenoidal coil carrying a current.

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