CONTENTS

TABLE OF SYMBOLS, ix.

CHAPTER

1 ELECTROSTATICS AND MAGNETOSTATICS

Introduction, 1. Definition of the Unit of Electric Force and the Unit of Magnetic Force, 1. The Constant ϵ, 2. The Constant μ, 4. The Unit of Electric Charge and the Unit of Magnetic Charge, 5. The Electrostatic and Magnetostatic Field, 5. The Electric Intensity **E** and the Magnetic Intensity **H**, 5. Electrostatic and Magnetostatic Potential, 6. Vectors and Scalars, 9. Electrostatic and Magnetostatic Potential Gradient, 10. Electric and Magnetic Induction, 11. Electrostatic and Magnetostatic Flux, 11. Gauss's Law, 13. Poisson's and Laplace's Equation, 14. The Divergence of a Vector, 16. The Divergence of the Electric and Magnetic Induction, 17. Electric and Magnetic Dipoles, 17. The Polarization **P** and the Magnetization **M**, 19. Energy in the Electrostatic and Magnetostatic Fields, 21.

2 THE ELECTROMAGNETIC EQUATIONS

The Electron Theory of the Electric Current, 27. The Continuity Equation for Current, 27. The Static, Steady, and Non-Steady States, 30. Ohm's Law, 30. The Magnetic Shell and the Unit Current, 32. Magnetomotive Force and Ampère's Law, 34. Deductions from Ampère's Law, 36. The Electromotive Force Equation and Faraday's Law, 39. Deductions from Faraday's Law, 40. Maxwell's Displacement Current, 42. Maxwell's Equations, 44. Static State, 46. Steady State, 47. Quasi-Steady State, 48. Further Discussion of the Continuity Equations, 49. Continuity of the Tangential Components of **E** and **H**, 50. Continuity of the Normal Components of **D** and **B**, 52. Units and Dimensions, 53.

3 MAXWELL'S EQUATIONS

Maxwell's Field Equations in Integral Form, 59. Maxwell's Field Equations in Differential Form, 60. Plane Waves and the Wave Front, 62. Longitudinal and Transverse Waves, 63. Propagation of Plane Electromagnetic Waves in Free Space, 64. General Discussion of Electromagnetic Waves, 71. Energy in the Electromagnetic Wave, 73. General Case of Propagation of Plane-Polarized Electromagnetic Waves in an Isotropic Medium, 73. Direction Cosines and the Normal Form of the Equation of a Plane, 76. A General Solution of the Wave Equation, 79. The Poynting Vector, 81.

4 REFLECTION AND REFRACTION OF PLANE WAVES

Reflection from a Perfect Conductor at Normal Incidence, 96. Polarization, 101. Boundary between Two Dielectric Materials, 103. Reflection

CHAPTER

at Normal Incidence, 105. Fresnel's Equations, 107. Polarization by Reflection, 112. Total Internal Reflection, 113.

5 PARALLEL PLANE WAVE GUIDES

Boundary Conditions at a Perfect Conductor, 119. Waves Guided between Conducting Parallel Planes, 119. Transmission Modes; E and H Waves, 122. Transmission Properties of E Waves, 124. Transmission Properties of H Waves, 127. Conditions for Wave Propagation, 128. The Principal or TEM Transmission Mode (Perfect Conductors), 130. Velocities of Propagation, 132. Voltage, Current, and Power Relations in the TEM Mode, 137. The TM_n Transmission Mode (E_n Waves) $n \neq 0$, 139. The TM_1 Transmission Mode (E_1 Waves) $n = 1$, 140. The TM_2 Transmission Mode (E_2 Waves) $n = 2$, 143. The TE_0 Transmission Mode (H_0 Waves) $n = 0$, 145. The TE_n Transmission Mode (H Waves) $n \neq 0$, 145. The E_1 Wave: Resolution into Elementary Waves, 148. Imperfectly Conducting Plates, 156. Wave Propagation in a Metal, 158. The Transverse Electromagnetic Mode (TEM) Imperfect Conductor, 162. The E_1 Wave (TM_1 Mode) Imperfect Conductor, 166. The H_1 Wave (TE_1 Mode) Imperfect Conductor, 169. Attenuation of the H_n Wave (TE_n Mode) Imperfect Conductor, 173. The Attenuation of the E_n Wave (TM_n Mode) Imperfect Conductor, 174. The Attenuation Constants, 174.

6 RECTANGULAR WAVE GUIDES

Waves Guided by a Rectangular Metallic Tube, 177. Transmission Modes. E and H Waves, 178. Transverse Electric (TE Mode) H Waves, 179. Solution by the Method of Separation of Variables, 180. Boundary Conditions for H Waves, 184. H_{nm} Waves in the Dielectric, 185. Transmission Characteristics of H_{nm} Waves, 186. The H_{01} or TE_{01} Wave, 190. The H_{02} or TE_{02} Wave, 193. The H_{11} and H_{12} Waves, 195. Transverse Magnetic (TM Mode) E Waves, 196. The E_{11} or TM_{11} Wave, 198. The E_{12} or TM_{12} Wave, 200. Terminal Devices, 201. Further Discussion of the H_{01} Wave, 202. Voltage, Current, and Power in Perfectly Conducting Wave Guides (H_{01} Wave), 204. Resolution of the H_{01} Wave into Elementary Waves, 207. Imperfectly Conducting Tubes, 214. The Propagation of the H_{01} Wave in an Imperfectly Conducting Tube, 215.

7 CYLINDRICAL WAVE GUIDES

Maxwell's Equations in Cylindrical Coordinates, 228. Waves Guided by Cylindrical Metallic Tubes, 232. Bessel's Differential Equation and Bessel Functions, 236. Electromagnetic Waves in the Dielectric within a Conducting Cylinder, 242. Transmission Modes in a Perfectly Conducting Pipe, 243. Boundary Conditions for E Waves, 244. E_{nm} Waves in the Dielectric, 247. The E_0 Wave. Perfect Conductivity, 250. The E_1 Wave. Perfect Conductivity, 255. Boundary Conditions for H Waves, 255. H_{nm} Waves in the Dielectric, 258. The H_0 Wave. Perfect Conductivity, 259. The H_1 Wave. Perfect Conductivity, 261. Imperfectly Conducting Pipes, 262. Characteristic Impedance of Hollow Pipes, 267. Dielectric Wave Guides, 269. Coaxial Lines, 272. Coaxial Lines. Finite Conductivity, 282. Elliptic Wave Guides and Stability, 284.

CHAPTER

Typical Circuit, 473. Low-Frequency Performance, 474. High-Frequency Performance, 477. Shunt Compensation, 478. Modified Shunt Compensation, 481. Four-Terminal Interstage Networks, 483. Principle of Conservation of Band Width, 487. The Intermediate-Frequency Amplifier, 488. Decoupling Circuits, 493. Power Amplifiers for High Frequencies, 494. Summary, 498.

14 THE NEGATIVE GRID OSCILLATOR

Introduction, 501. Basic Oscillator Theory, 501. Requirements, 504. The Power Oscillator as a Class C Amplifier, 506. Frequency Limits of Triodes, 508. Effects of Tube Geometry, 509. Practical Oscillator Circuits, 513. Practical Oscillator Construction, 515.

15 THE POSITIVE-GRID OR RETARDING-FIELD OSCILLATOR

Introduction, 521. Electron Transit Time in a Plane Triode, 522. Electron Transit Time in a Cylindrical Triode, 525. Frequency and Wavelength of Oscillation, 528. Requirements for Sustained Oscillations, 529. Oscillations in the Grid Circuit, 531. Mechanical Analogy, 533. Phase Selection, 534. Oscillations in the Plate-Cathode Circuit, 536. Oscillations in Plate Circuit or Cathode Circuit, 539. Diode Oscillations, 541. The Spiral Grid Tube, 542. The Backing Plate Tube, 544. Multigrid Tubes, 546. The Divided Plate Oscillator, 548.

16 THE MAGNETRON

Introduction, 552. The Magnetic Field, 552. The Electron Motion with Steady Fields, 553. Cut-off, 557. Voltage Drop along the Filament, 558. Mechanical Dissymmetry, 558. Tilt of Magnetic Field, 558. End Effects, 559. Space Charge, 559. Emission Velocity, 559. Modes of Oscillation, 561. Feedback Oscillations, 562. Dynatron Oscillations, 563. Motion of an Electron in Plane-Parallel Magnetron, 567. Electronic Oscillations in Plane-Parallel Magnetron, 569. Practical Magnetron Oscillators, 571. Electronic Oscillations of Higher Order, 573.

17 TUBES EMPLOYING VELOCITY MODULATION

Introduction, 579. Velocity Modulation, 580. Production of Velocity Modulation, 580. Velocity Modulation Produced in Two Steps, 582. Utilization of Velocity Modulation, 583. The Applegate Diagram, 587. Kinematic Bunching, 589. Current Relations in the Klystron, 591. Phase Shift in the Klystron, 592. The Klystron as an Oscillator, 594. The Cavity Resonator, 598. Design and Applications of the Klystron, 601. The Reflex Klystron Oscillator, 602. The Inductive Output Amplifier, 603. Associated Tubes, 607. Summary, 607.

APPENDICES. 611

BIBLIOGRAPHY 613

INDEX..... 633