## CONTENTS

Foreword to the English edition	5
Authors' preface to the English edition	7
reface	9
BASIC RELATIONSHIPS AND METHODS	15
(Gyula András Nagy)	
(A) TIME-CONSTANT ELECTRIC-MAGNETIC FIELD	15
1. Maxwell's equations	15
2. Electric-magnetic potentials	17
<ol> <li>Exact solution of the potential equations by the use of quadratures</li> <li>Exact solution of the potential equations by other methods</li> </ol>	19 22
(B) ELECTRIC-MAGNETIC FIELDS WITH SPECIFIC STRUCTURE	32
5. Axially symmetric fields	32
6. Derivation of axially symmetric induction distribution from the flux	
function 7. Fields with planar distribution	41 43
8. Derivation of planar induction distribution from the scalar potential	
in the excitation region	50
9. Quadrupole fields	53
(C) APPROXIMATIVE SOLUTION OF THE POTENTIAL EQUATIONS	62
10. Method of difference equations	62
<ol> <li>Approximative calculation formulae for electric-magnetic fields of specific</li> </ol>	
structure 12. Other methods of approximative solution	66 70
Some complementary notes concerning field calculations and related literature	73
Some complementary notes concerning neig calculations and related literature	(3
(D) DETERMINATION OF THE ELECTRIC-MAGNETIC FIELD	79
BY MEASUREMENT	
13. Analogy between electron flow in a vacuum and conductors	80
14. Analogy in plane and axially symmetric fields	82
15. Electrolytic tank. Resistance network 16. Other methods of measurement of electric-magnetic fields	88 92
(E) CLASSICAL EQUATIONS OF MOTION	96
17. Newton's equations of motion	97
<ol> <li>Equations of motion in axially symmetric fields</li> <li>Equations of motion in fields with planar distribution</li> </ol>	100
20. Paraxial equations of motion	104 107
21. Paraxial equations of motion in axially symmetric fields	109
22. Paraxial equations of motion in fields with planar symmetry	111
23. Paraxial equations of motion in quadrupole fields Supplementary observations on the equations of motion	112

(F) APPROXIMATIVE SOLUTION OF THE EQUATIONS OF MOTION	N 114
24. Step-by-step integration 25. Difference method 26. Other methods	115 121 125
(G) DETERMINATION OF TRAJECTORIES BY MEASUREMENT	127
27. Basic methods of the determination of trajectories by measurement 28. Other possibilities of determining trajectories by measurement Examples of special problems from application fields	127 129 130
REFERENCES FOR CHAPTER I	131
II. SPACE-CHARGE FLOW	147
(Gyula András Nagy)	
(A) GENERAL CHARACTERISTICS OF SPACE-CHARGE FLOW	147
<ul> <li>29. Space-charge limited flow</li> <li>30. Basic equations of space-charge flow</li> <li>31. B. Meltzer's method for determination of the characteristics of the flow fit</li> <li>32. The 3/2 law of the space-charge flow</li> <li>33. The scaling law of the space-charge flow</li> </ul>	147 149 eld 151 152 154
(B) IMPORTANT CASES OF SPACE-CHARGE FLOW	156
34. Space-charge flow between parallel infinite plane surfaces 35. Space-charge flow between coaxial infinite cylindrical surfaces 36. Space-charge flow between concentric spherical surfaces	156 162 169
(C) SPECIFIC PROBLEMS OF SPACE-CHARGE FLOW	175
37. Space-charge flow between non-parallel infinite plane surfaces 38. The field of the space-charge flow in the vicinity of a given plane surface 39. Other cases and problems relating to space-charge flow	175 e 179 183
REFERENCES FOR CHAPTER II	193
III. ELECTRON: GUNS	199
(Miklós Szilágyi)	
40. The basic principle of the Pierce gun	199
(A) ELECTRON GUNS PRODUCING PARALLEL BEAMS	200
41. Production of strip electron beams 42. Production of cylindrical electron beams 43. Production of hollow electron beams	200 206 212
(B) ELECTRON GUNS PRODUCING CONVERGENT BEAMS	214
44. Production of plane-symmetric convergent beams (wedge-beams) 45. Production of axially symmetric convergent beams (conical beams) 46. A brief survey of other types of electron guns producing high curre	214 217
density beams	232
REFERENCES FOR CHAPTER III	233

CONTENTS	•	13

IV. SPACE-CHARGE EFFECTS IN ELECTRON BEAMS	238
(Miklós Szilágyi)	
47. Electron beam characteristics; our assumptions; space-charge effects	238
(A) POTENTIAL DISTRIBUTION ACROSS ELECTRON BEAMS	241
48. The potential field generated by the space-charge of an electron beam	241
49. Potential distribution in hollow electron beams	243
50. Potential distribution in cylindrical electron beams	254
51. Potential distribution in plane-symmetric electron beams	260
(B) SPREADING OF ELECTRON BEAMS DUE TO SPACE-CHARGE	263
52. Electron-beam motion in uniform potential region (spreading of a drifting	
beam)	263
53. Spreading of cylindrical electron beams	265
54. Spreading of sheet electron beams	276
55. Spreading of hollow electron beams	283
56. Spreading of elliptical-cross-section electron beams	286
REFERENCES FOR CHAPTER IV	289
LELECTROSTATIC FOCUSING OF HIGH-INTENSITY ELECTRON BEAMS	293
(Miklôs Szilágyi)	
(A) THE PERIODIC FOCUSING	293
57. Periodic electrostatic focusing	293
58. Illustration of the periodic focusing on the basis of the optical analogy	295 295
(B) FOCUSING OF ELECTRON BEAMS BY AXIALLY SYMMETRIC	
PERIODIC ELECTROSTATIC FIELDS	298
59. Focusing by a sequence of axially symmetric thin lenses	298
60. Focusing of cylindrical electron beams by periodic electrostatic fields	202
61. The beam configuration in the case of non-optimum conditions	319
	325
63. Focusing of hollow electron beams by axially symmetric periodic electro-	020
static fields	341
(C) PERIODIC FOCUSING BY BIFILAR HELICES	348
64. Focusing of solid electron beams by bifilar helices	348
65. Focusing of hollow electron beams by bifilar helices	356
(D) FOCUSING OF ELECTRON BEAMS BY PLANE-SYMMETRIC	
PERIODIC ELECTROSTATIC FIELDS	358
66. Focusing by a sequence of plane-symmetric thin lenses	358
67. Focusing of sheet-electron beams by periodic electrostatic fields	361
68. Focusing of thick sheet beams	370
(E) FOCUSING OF CURVILINEAR SHEET-ELECTRON BEAMS USING	
ELECTROSTATIC FIELDS	377
69. The centrifugal electrostatic focusing	377
70. Periodic electrostatic focusing by systems with curvilinear axis	384
(F) PERIODIC FOCUSING BY QUADRUPOLE FIELDS	389
71. Focusing by a sequence of thin quadrupole lenses	390
72. Focusing of electron beams by periodic electrostatic quadrupole fields	395
REFERENCES FOR CHAPTER V	401

INDEX

VI. FOCUSING BY MAGNETIC AND ELECTRIC-MAGNETIC FIELDS	
(Gyula András Nagy)	405
(A) FOCUSING BY HOMOGENEOUS MAGNETIC FIELD	406
73. Axially symmetric beam 74. Plane-symmetric heam	406 409
(B) BRILLOUIN FOCUSING	411
<ul><li>75. Axially symmetric beam</li><li>76. Plane-symmetric beam</li><li>77. Focusing in the transition region of a non-ideal <i>Brillouin</i> field</li></ul>	411 414 417
(C) FOCUSING BY PERIODIC MAGNETIC FIELD	<b>42</b> 0
78. Axially symmetric beam 79. Plane-symmetric beam	421 425
(D) FOCUSING BY SIMULTANEOUSLY ACTING PERIODIC ELECTRIC AND PERIODIC MAGNETIC FIELDS	428
80. Axially symmetric beam 81. Plane-symmetric beam	428 434
(E) FOCUSING BY INCREASING MAGNETIC FIELD	436
82. Axially symmetric beam 83. Plane-symmetric beam	436 438
(F) COMPLEMENTARY FOCUSING	440
84. The basic principle 85. Calculation of complementary fields	440 440
(G) GENERAL PARAXIAL BEAMS WITH STRAIGHT AXIS	442
86. The basic principle 87. Calculation of the axis induction and of the space-charge	442 443
(H) FOCUSING BY QUADRUPOLE FIELD	444
88. Magnetic fields independent of z	444 446
89. Magnetic fields periodic along z 90. Electric and magnetic fields periodic along z	449
91. Magnetic fields increasing with z	450
(I) HOLLOW BEAMS	452
92. Brillouin focusing in the axially symmetric case 93. Brillouin focusing in the plane-symmetric case	452 456
(J) OTHER PROBLEMS OF MAGNETIC FOCUSING	459
94. New interpretation of the equations of motion and their application for the approximative solution of focusing problems	459
95. Focusing by simultaneously acting homogeneous and periodic magnetic fields	405
96. Specific focusing problems dealt with in the literature	468
REFERENCES FOR CHAPTER VI	482
INDEX	493