

## *Contents*

<b>Preface</b>	ix
<b>Introduction</b>	1
<b>Chapter 1 / Basic Properties of Axially Symmetric Motions in Magnetohydrodynamics</b>	18
1.1. Magnetohydrodynamic Equations	18
1.2. Some Facts about Orthogonal Curvilinear Coordinates	21
1.3. Differential Operators in Orthogonal Curvilinear Coordinates	24
1.4. The Most Commonly Used Rotational Coordinate Systems	25
1.5. Axisymmetric Motions	29
1.6. Relation between Stokes Stream Function and Self-Magnetic Field of an Electric Current in Problems with Axial Symmetry	32
1.7. Feasible Schemes for Axially Symmetric Electric Current Distributions	35
1.8. Magnetic Field in Axisymmetric Flow	41
1.9. Electric Field in Axisymmetric Flow	55
1.10. Full Set of Equations for Axisymmetric Motion	57
<b>Chapter 2 / Solutions in Spherical Coordinates</b>	62
2.1. Definition of the Class of Exact Solutions	63
2.2. Low Magnetic Reynolds Number Approximation. Electric Current and External Magnetic Fields	67
2.3. Integral Flow Characteristics and Dimensionless Criteria	72
2.4. Review of the Class of Exact Solutions in Spherical Coordinates	74
2.5. Electrically Induced Vortex Flow in a Cone	84
2.6. Gas Flow in an Electrical Arc	91
2.7. Problems of the Nonlinear Solution	95
2.8. Landau-Squire Flows in the Presence of a Radially Diverging Electric Current	99

2.9. Effect of the Induced Electric Current on the Flow at a Point Current Source	104
2.10. Electrically Induced Flows at Finite Size Electrodes	107
<b>Chapter 3 / Electrically Induced Vortex Flow at a Point Electrode and Azimuthal Rotation</b>	120
3.1. Integral Properties of the Flows Driven by Rotational Electromagnetic Forces	121
3.2. A Model Demonstrating the Effect of Viscosity	123
3.3. Flow at an Immersed Electrode	125
3.4. Asymptotic Solution for High $S$	128
3.5. Electrically Induced Flow with Differential Rotation	133
3.6. Growth of Azimuthal Disturbance in the Electrically Induced Flow at a Point Electrode	136
3.7. Intensification of Rotation in a Closed Volume	143
3.8. Mechanism of Rotation Intensification in an Axisymmetric Vortex	148
<b>Chapter 4 / Flows with Cylindrical Symmetry</b>	154
4.1. External Electric Current and Magnetic Field in Cylindrical Coordinates	154
4.2. Similarity Solutions	155
4.3. Electrically Induced Flow between Two Parallel Walls	162
4.4. Flow with Line Source in a Circular Cone	169
4.5. Magnetohydrodynamic Model of Tornado	174
4.6. EVF in a Cylindrical Container	184
4.7. Effect of Electric Current Configuration on Flow in a Cylindrical Container	190
<b>Chapter 5 / Periodic Electrically Induced Flows</b>	196
5.1. Periodic Distributions of Current and Magnetic Field in Cylindrical Coordinates	196
5.2. Integral Action of Electromagnetic Force	198
5.3. A Method Used to Construct Linear Solution of Periodic EVF in Tubes	203
5.4. EVF in a Tube with Radial Current Supply	209
5.5. EVF in a Tube with Longitudinal Electric Current	216
5.6. EVF in an Annular Tube	224
5.7. Periodic EVF in a Longitudinal Magnetic Field	228
5.8. Longitudinal Magnetic Field Effect on Integral Features of EVF	233
5.9. Nonlinear Interaction of Periodic EVF with Through-Flow	236
5.10. Electrically Induced Flow in a Loosely Coiled Tube	240

<b>Chapter 6 / Bodies in a Current-Carrying Fluid</b>	245
6.1. Effect of Potential Forces on a Body in a Current-Carrying Fluid	245
6.2. Effect of the Rotational Electromagnetic Forces on Axisymmetric Bodies	249
6.3. Flow at a Stationary Sphere	257
6.4. Drag of a Sphere in the Flow of Current-Carrying Fluid	259
6.5. Flows at Spheroids	266
6.6. Discharge between Electrodes of Hyperboloidal Form	269
6.7. Flow at a Cone with an Electric Current Source in the Apex	274
6.8. Motion of a Sphere with a Current-Source	277
<b>Chapter 7 / Heat and Mass Transfer in Electrically Induced Vortical Flows</b>	282
7.1. Equations of Heat and Mass Transfer, and the Nondimensional Numbers	282
7.2. Mass Transfer from a Stationary Spherical Particle in Current-Carrying Fluid	287
7.3. Mass Transfer from a Translating Spherical Particle in a Current-Carrying Fluid	291
7.4. Mass Transfer from a Stationary Sphere in a Longitudinal Magnetic Field	294
7.5. Heat and Mass Transfer in a Cylindrical Container	296
7.6. Thermal Convection in Electrically Induced Flows	307
<b>Chapter 8 / Experimental Investigations of EVF and Applications</b>	311
8.1. Electroslag Welding	311
8.2. Electroslag Remelting	324
8.3. Electric-Arc Furnaces	333
8.4. Hydrodynamics of Furnaces with Multiple Electrodes	335
8.5. Electrical Jet Thrusters	341
8.6. Induction Channel Furnaces	346
8.7. Electrically Induced Flows in a Flat Layer between Ferromagnetic Masses	352
8.8. Electrolytic Aluminium Production	358
<b>References</b>	365
<b>Index</b>	379