

Contents

<i>Preface</i>	<i>page</i> x
<i>Introduction</i>	I
PART I. THE FORMATION AND NATURE OF THE IONOSPHERE AND MAGNETOSPHERE	3
1 The neutral atmosphere modified by the sun's radiation	3
1.1 Introduction	3
1.2 The gases of the atmosphere	3
1.2.1 Diffusive equilibrium	4
1.2.2 The exosphere. Escape of hydrogen and helium	6
1.3 The sun's radiation	9
1.3.1 Photon radiation	9
1.3.2 Particle radiation. The solar wind	13
1.3.3 Solar disturbances	14
1.4 The action of solar radiations on the atmosphere	16
1.4.1 Absorption of photon radiation	16
1.4.2 Ionization by particle radiation	19
1.4.3 The distribution of electrons or dissociation products after loss and movement	21
1.5 Chemical effects of solar radiation	25
1.5.1 Oxygen	25
1.5.2 Nitric oxide	28
1.6 The heating of the atmosphere	29
1.6.1 The temperature of the atmosphere	29
1.6.2 Atmospheric density deduced from satellite orbits	31
2 The ionospheric layers. The sub-peak ionosphere	37
2.1 Introduction	37
2.2 Rate of production of electrons	38

2.3	The composite F layer	<i>page</i> 41
2.3.1	Recombination	41
2.3.2	Reactions involving charge-exchange or ion–atom rearrangement	43
2.3.3	Diffusion	46
2.4	The F 1 layer	46
2.5	The E layer	48
2.6	The D region	48
2.6.1	The ionizing radiations	49
2.6.2	Ion chemistry	49
2.6.3	Negative ions	50
3	The F layer peak and above	55
3.1	The peak of the F 2 layer	55
3.1.1	Movement of the peak	55
3.1.2	Behaviour near the geomagnetic equator	56
3.2	Above the F layer peak	58
3.2.1	Oxygen ions	58
3.2.2	Hydrogen ions	60
3.2.3	Helium ions	61
3.3	Energetic photo-electrons. Electron and ion temperatures	62
4	The magnetosphere	66
4.1	The boundary of the magnetosphere. The magnetopause	66
4.2	Charged particles in the highest ionosphere	74
4.2.1	The plasmasphere	74
4.2.2	Trapped particles	78
5	Geomagnetism, ionospheric currents and ionospheric storms	83
5.1	Currents in the ionosphere	83
5.1.1	The atmospheric dynamo and motor	84
5.1.2	The polar current system	88

5.2 Solar disturbances: ionospheric and magnetic storms	<i>page</i>	90
5.2.1 Sudden ionospheric disturbances (SIDs)	91	
5.2.2 Ionospheric and magnetic storms (polar regions)	92	
5.2.3 Ionospheric storms (non-polar regions)	97	
5.2.4 Proton storms. Polar cap events (PCEs)	99	
PART 2. THE PRINCIPLES GOVERNING SOME IONOSPHERIC PROCESSES AND EXPERIMENTAL METHODS	101	
6 Collisions and diffusion	101	
6.1 Collisions	101	
6.2 Diffusion	105	
6.2.1 Diffusion of plasma	107	
6.2.2 Distribution of a plasma with several kinds of ions	109	
6.2.3 Diffusion influenced by the geomagnetic field	110	
6.3 Air drag and ion drag	112	
7 Movements of charged particles in magnetic fields	115	
7.1 Movements without collisions	115	
7.1.1 Motion of a free charged particle	115	
7.1.2 Motion under a constant applied force	116	
7.2 Movements in the presence of collisions	117	
7.2.1 Motion under a constant applied force	117	
7.2.2 Movement of an ionospheric irregularity	122	
7.2.3 Ionospheric conductivities	123	
7.3 Converging field lines. Trapped particles	127	
7.4 'Frozen-in' field lines	131	
8 Electromagnetic, hydromagnetic and electro-acoustic waves	135	
8.1 Introduction	135	
8.2 Properties common to all electric waves	136	
8.3 Conditions for zeros and infinities in the refractive index	138	
8.4 The motions of the electrons	140	

8.5	Longitudinal propagation in a magnetic field	<i>page</i> 144
8.5.1	Only electrons moving	144
8.5.2	Refractive index greater than unity (the whistler mode)	147
8.5.3	Electrons and ions both moving. Hydromagnetic waves	150
8.5.4	Cross-over frequencies	153
8.6	Transverse propagation in a magnetic field	156
8.6.1	Only electrons moving	156
8.6.2	Electrons and ions both moving	160
8.6.3	The upper and lower hybrid frequencies	163
8.7	Electro-acoustic waves	166
8.7.1	Interaction of waves and particles. Landau and cyclotron damping	169
8.8	Groups, angular spectra and wave packets	171
9	Exploration of the ionosphere with radio waves	177
9.1	Introduction	177
9.2	Ionospheric sounding	179
9.2.1	Resonances observed with topside sounders	185
9.3	Partial reflection	187
9.4	Incoherent scatter or Thomson scatter	189
9.5	Wave interaction	194
9.6	Doppler and Faraday measurements	196
9.7	Whistlers and micropulsations	198
9.7.1	Method of recording	199
9.7.2	Electron whistlers	199
9.7.3	Electron-ion whistlers	205
9.7.4	Ion whistlers (micropulsations)	208
9.7.5	Very low frequency (VLF) hiss	209
10	Experiments in space vehicles. Some fundamental principles	210
10.1	Introduction	210

10.2	Measurement of electron and ion concentrations and temperatures	<i>page</i> 211
10.2.1	Langmuir probes	214
10.2.2	Radio frequency measurements in the ionospheric plasma	219
10.3	Measurements on energetic particles	220
10.4	Mass spectrometers	223
10.4.1	The magnetic deflection mass spectrometer	224
10.4.2	The Bennett high frequency mass spectrometer	225
10.4.3	The quadrupole mass spectrometer	226
10.5	Measurement of magnetic fields	227
10.5.1	The flux-gate magnetometer	227
10.5.2	Alkali-vapour magnetometers	229
10.6	Measurement of electric fields	232
<i>Appendix A</i>	Chapman's theory of a production layer	235
<i>Appendix B</i>	The time-constant for loss by diffusion	239
<i>Appendix C</i>	List of main symbols and Conversion of units	241
<i>Bibliography</i>		244
<i>Index</i>		253