Subject and name index

A page number in bold type refers to a definition or description, and (p) denotes a problem.

Abel's integral 339-42 Abramovici, F. 6, 612 Abramowitz, M. 205, 233, 236, 249, 360, 457, 463, 465, 612 absorbing medium 277f, 391-3, 413, 417ff absorption of energy in radio wave 13, 20, 391, 412f, 595; see also attenuation absorption of sun's radiation 7 accumulation of energy 452, 596 acoustic waves see sound waves acoustic gravity waves 6, 20 Adams method of integration 553, 575 additional memory 189, 261, 429, 505ff adjoint differential equation 185, 426, 594 adjoint fields 185, 189, 426f, 431f adjoint matrix 185 adjoint medium 426 adjoint of polarisation 196(p) adjugate of matrix 185 admittance matrix 302ff, 307, 566-9 admittance, wave 301ff, 442, 444 aerials 429-35, 436f(p), 578, 582(p), 602, 603 Agy, V. 347, 612 Airy, G.B. 204, 223, 612 Airy integral functions, Ai, Bi, 177, 197(ch. 8), 201, **204**, 214f, 227f(p), 240, 251, 282, 285, 288f, 345, 348, 425, 440-5, 488, 499ff, 566 Airy's integral 204, 227, 248 Aitchison, G.J. 394, 612 Aitken, A.C. 521, 612 Akhiezer, A.I. 62, 612 Allis, W.P. 43, 60, 116, 612 Al'pert, Ya.L. xv, xvi, 19, 57, 62, 84, 89, 104, 106, 108, 109, 112, 115, 251, 376, 407, 612 Altman, C. 185, 362, 390, 427, 499, 518, 553, 555, 576, 579, 612, 613, 622, 638 ambiguity in refractive index 267, 269 ambiguity in terms ordinary and extraordinary 88, 89-94, 154 Ampère's circuital theorem 28

352, 425 amplitude-phase diagram 173, 223, 235, 506, 556 amplitude, planes of constant 36, 37(p) analogues of progressive waves 178 analytic continuation 35, 330, 361, 427, 469 analytic property of as 486 angular spectrum of plane waves 109, 130, 142, 254ff, 282, 313ff, 320, 379, 418, 420, 425 angular width of window 540 anisotropic ionosphere differential equations 181ff W.K.B. solutions 187ff, 192 anisotropic medium 4, 6 anisotropic plasma 68ff, 308-12, 356(ch. 13), 480(ch. 16), 520(ch. 17), 550(ch. 18) antennas see aerials antireciprocity 431ff, 579 anti-Stokes line 200, 210ff, 220, 228(p), 244, 246, 451, 454, 461, 500 aperture, diffraction by 322 apparent bearing 277 apparent loss of energy 595-7, 599, 608 Appleton, E.V. 9, 39, 44, 46, 75, 328, 331, 335, 349, 353, 355, 358, 613 Appleton-Hartree formula xv, 75 Appleton laboratories xv Appleton-Lassen formula 59, 60, 75, 86, 88, 102(p), 106, 121, 407 for low frequency 98 for high frequency or small N 98, 99 approximations for refractive index and polarisation 94ff Arantes, D.S. 391, 519, 613 Arecibo 47 arbitrary constants (Stokes phenomenon) 209 Argand diagram 235 Arndt, D. 59, 61, 621 Askne, J. 554, 613

amplitude and imaginary part of phase 279, 331,

astigmatic pencil 317 bilinear concomitant vector 186, 426ff, 432 asymptotes 242ff binomial theorem 171, 181 asymptotic approximations 169, 441f, 460ff, 488 Birkoff, G. 184, 615 Bitoun, J. 131, 407, 613 range of validity 213 asymptotic expansions, series 59, 61, 95, 207f, Boardman, Z.M. 376, 618 461 Bolt, B.A. 6, 618 asymptotic form 209, 243, 454, 461 Boltzmann distribution function 398 atmospherics 48, 376 Boltzmann-Vlasov equations 4, 42 attachment coefficient 8, 15 Booker, H.G. xvi, 1, 14, 20, 57, 89, 94, 97-9, attenuation 10, 255, 312, 323-5, 352f, 391-3, 124, 137, 139, 142, 145, 149, 151, 152, 154, 412f. 450 155, 160, 259-61, 278, 279, 301, 312, 349, from Booker quartic 277f, 293(p) 351, 449, 478, 505, 545, 564, 565, 592, 615 see also absorption Booker quartic (equation) 89, 141(ch. 6), 144, Aubry, M.P. 131, 407, 613, 615 163(p), 185, 191, 221, 256, 259, 273, 301, audible frequencies, audio frequency amplifier 307, 483, 486, 488, 492, 554, 555, 561, 571, 376 573, 580, auroral hiss 543 at magnetic equator 151 auxiliary subroutine 552, 555, 581 at magnetic pole 163(p) attenuation from 277f average collision frequency 11, 58, 59 average electromagnetic fields 23-5, 44f derivation 144ff average force on electron 40, 41 determinant form 183, 521 axis ratio 73ff, 99(p), 100(p) discriminant 152f, 160, 492, 523 double root, equal roots 148, 150, 152f, 157f, Bachynski, M.P. 5, 11, 42, 636 160, 163(p), 192, 262f, 265, 483, 485ff, 492ff, backscatter 518 520(ch. 17) Backus, G.E. 6, 17, 603, 614, 623 east-west and west-east 151, 153ff Bailey, R.C. 604, 606, 614 effect of collisions 160ff Bain, W.C. 603, 614 north-south and south-north 155ff Banerjea, B.K. 50, 519, 614, 636 properties 146ff Baños, A. 3, 229, 239, 241, 614 special cases 151ff Barber, N.F. 304, 326, 614 three equal roots 150, 159, 160, 495, 526 Barnard, S. 152, 614 Booker ray tracing equations 257, 259 Barnes, E.W. 469, 591, 614 Booker's theorem 477-9 barrier 459, 533f, 536, 541, 591ff Born, M. 114, 115, 616 Barrington, R.E. 379, 380, 394, 614, 637 Bossy, L. 558-60, 616 Barron, D.W. 302, 308, 547, 568, 574, 614 Bouger's law 260, 291, 292(p), 349, 564f Barrow, W.L. 222, 614 boundary conditions 142, 172, 303, 305, 441f, base of ionospheric layer 362f, 370, 398(p) 554 basic equations 22(ch. 2) at infinity 217, 440 Batchelor, D.B. 535, 536, 597, 614, 641 boundary frequency 383, 385, 387 Bauer, P. 14, 614 bound electrons 373 Baybulatov, R.B. 604, 614 Bowles, K.L. 14, 616 bearing error 277, 507 Boyd, R.L.F. 13, 616 Becker, W. 371, 614 Bracewell, R.N. 298, 587, 603, 614, 616 Bell, T.F. 603, 634 Bradbury, N.E. 15, 616 Belrose, J.S. 312, 379, 380, 603, 614, 615, 637 Bradley, P.A. 349, 351, 617 Bennett, J.A. 184, 391, 392, 407, 412, 417, 615, branch cut 89, 212, 219, 239, 468, 481, 493f, 496, 621 501, 580, 593, 595, 600, 608 Benson, R.F. 535, 615 branch point 239, 486, 493, 566; see also Bernstein, I.B. 414, 615 coupling point, turning point Breit, G. 13, 346, 617 Berreman, D.W. 182, 615 Breit and Tuve's theorem 346, 350f, 356 Bers, A. 481, 486, 612, 623 Bertoni, H. 317, 634 Brekhovskikh, L.M. 1, 172, 288, 466, 617 Bessel functions 204f, 443, 445, 454f, 598f Bremmer, H. 172, 304, 617 Bessel's equation 205, 454, 467, 470, 590 Brewster angle 306 Beynon, W.J.G. 14, 20, 42, 335, 349, 353, 355, Brice, N.M. 44, 57, 380, 382, 383, 624, 637 Briggs, B.H. 20, 476, 617 613, 615 Bi see Airy integral function Brillouin, L. 169, 180, 222, 617 biaxial 115 broadening of pulse, wave packet 137, 414 Brown, G.M. 20, 615 Bibl, K. 13, 615 bilinear concomitant 184-7, 189, 196(p), 577, Brown, J.N. 365, 641 594 Buchsbaum, S.J. 612

Buckley, R. 404, 414, 416f, 429, 617 circuit elements (electric) 429, 576 Budden, K.G. many references in text, 612, 614, circuit relations (connection formulae) 180, 216, 616-18; 467, 473, 591 Builder, G. 358, 613 circular polarisation 69, 82, 309, 372ff, 435, 530, Bullen, K.E. 6, 618 584 Burke, M.J. 312, 615 circularly polarised components, resolution into Burman, R. 447, 466, 472, 618, 624 300, 312, 372f, 585 Burnside, W.S. 152, 618 Clemmow, P.C. 5, 11, 43, 45, 47, 49, 57, 106, Burton, E.T. 376, 618 107, 109, 116, 119, 142, 182, 184, 188, 282, Businger, J.A. 622 481, 485, 507, 519, 577, 618, 619 C.M.A. type diagrams 107, 116ff, 124, 134, 135 calculus of variations 410 coalescence and limiting polarisation 521, 543f Calvert, W. 368, 622 and windows 505, 521, 532ff canonical equations for a ray 403-9, 404, 436(p) at infinity 544 Haselgrove form 407ff C1 521, **522**, 523-5 vector form 405 C2 388, 495, 521, **522**, 525-34, 543f Capon, I.N. 351, 407, 618 of coupling points 520(ch. 17) Carlini, F. 170 Cohen, M.H. 514, 619 Caron, P.R. 593, 638 coincident coupling points 155, 489, 491, 493f, Carpenter, D.L. 18, 376, 379, 618, 619 520(ch. 17) carrier frequency, wave 321, 356 col 231 Cartesian coordinates 28, 103, 141, 402-8, 412, cold plasma 4, 63(p), 66 414, 429f Collar, A.R. 521, 623 catastrophes 288 Collin, R.E. 430, 577, 620 cathode ray oscillograph 320, 499 collision frequency 10ff, 42ff, 57-62 Cauchy relations 229ff height dependence 12, 479(p) caustic measurement 312, 331, 602 transition 71ff, 86ff field near 281-92 intensity of light near 223ff velocity dependence 5, 11, 57ff caustic surface 222, 279, 281ff, 343, 345, 416, 425 collisionless plasma 44, 53, 68, 75, 104, 112, 117, cavity definitions of fields 23, 25, 28, 40 129, 134, 327(p), 328ff, 345ff, 372ff, 376ff, CCIR see Comité Consultatif International des 530 Radiocommunications collisions 5, 42ff, 57-62 centre of window 534, 541 and Booker's theorem 477-479 Čerenkov emission 534 and equivalent height, phase height 330f, 360change of adjective, description, name 92, 93, 128, 139, 155, 382, 387, 496f, 501f, 531, 534, and equivalent path 331 and group refractive index 137, 138 change of reference level 296, 313-315 and Martyn's theorem 352f Chapman layer 7ff, 196(p), 332-5, 453, 511, 543, effect on Booker quartic 160ff 572 effect on refractive index 86, 89 Chapman law 8, 9, 15, 549 electron-electron, electron-ion 61f Chapman, S. 7, 619 in wave interaction 394-8 characteristic admittance 302 Comité Consultatif International des characteristic admittance matrix 303, 307, 568 Radiocommunications (CCIR) 349, 352 characteristic impedance of free space 31 Committee on Space Research (COSPAR) 14, 619 characteristic matrix 521 characteristic waves 162, 165, 188, 557, 559, 572, comparison medium 175f, 216 see also ordinary, extraordinary compensating singularities 205 Chatterjea, B. 152, 155, 160, 565, 614 complete mode conversion 531f Chebyshev polynomials 372 complex angle shift 317-319 Chen, F.F. 448, 597, 641 complex angle of incidence 149, 420, 428 Cheng, F.T. 553, 619, 623 complex axes 51 Chessell, C.I. 606-8, 619 complex Brewster angle 306 Chester, C. 251, 286, 619 complex conjugate and adjoint 187, 427 complex conjugate roots of Booker quartic 148, Child, J.M. 152, 614 chorus 4 187, 592 Chu, L.J. 222, 619 complex curvature of wave front 317 complex direction of electric field 27 cigar-shaped surface 268 CIRA 619 see International Reference complex equivalent height 330f, 361 Atmosphere complex equivalent path 279, 324f, 331

```
complex functions 229ff
                                                     Coulomb force 42, 44
complex group refractive index, velocity 325, 361
                                                     coupled equations 175, 188, 480(ch. 16)
complex height 68, 79, 88, 152, 330
                                                       first order 482-92
  of reflection 195, 330, 361f, 440, 459, 517f
                                                       matrix form 188, 487, 491, 527
complex mass and collisions 44
                                                       near coupling point 485-92, 522
                                                       second order 481, 491, 507ff, 519(p)
complex numbers and harmonic time variation
     26, 32
                                                       vertical incidence 483ff, 489ff
                                                     coupling 83, 94, 152, 505
complex path of integration 569, 580, 608
complex phase 168, 170, 193, 195, 316, 421, 505
                                                       between upgoing and downgoing waves 174ff,
complex phase path 286, 324f, 331, 421
                                                     coupling echo 485, 499, 517f
complex point source 418
complex Poynting vector 34
                                                     coupling matrix 188, 482f, 487, 491f, 519(p), 527,
complex principal axes 50ff
complex range shift 317-19
                                                     coupling parameter \psi484, 490, 511ff, 518(p), 544
complex rays 417-28, 429, 432, 535, 540f
                                                     coupling, phase integral method 387f, 489, 499-
  anisotropic medium 388, 391, 425-8
                                                         502
  isotropic medium 282, 286, 424f
                                                     coupling point
complex reference level 478
                                                       isolated 488
complex refractive index 6, 34, 35, 68, 89ff, 137,
                                                       turning point 80, 94, 152, 153, 154, 157, 160,
     417ff
                                                         161, 222, 387, 458, 480, 483, 485ff, 491,
complex space coordinates 35, 317, 417ff
                                                         492ff, 496ff, 503, 512, 520ff, 566, 607
complex step size 420, 553, 562, 568
                                                     coupling region 499, 516, 545
complex time 324, 418
                                                     coupling terms 480, 482
complex values
                                                       neglect of 188f, 480
  of q 147ff, 160ff, 171, 541, 554
                                                     covariant 51, 64(p)
  of X and Z 79, 88, 152, 512
                                                     Coyne, T.N.R. 312, 615
  see also complex height, complex z plane
                                                     Crampin, S. 6, 620
complex variables 229ff
                                                     critical angle 306, 474
                                                     critical coupling 388, 494, 495-499, 530
complex vectors 25, 26ff, 37(p), 38
complex wave normal 36, 37
                                                     critical coupling frequency 496, 498, 519(p)
complex X plane 492ff
                                                     critical height see transition height
complex z plane 152, 195, 218-21, 361, 387, 477,
                                                     Crombie, D.D. 304, 326, 614,
     494, 499-502, 512, 580f, 608
                                                     Crompton, R. W. 10, 58, 620, 627
Computation Laboratory, Cambridge, Mass.
                                                     cross modulation see wave interaction
     205, 620
                                                     crossover 105, 383ff
computing xiii, 10, 223, 352, 400f, 418, 439,
                                                     crossover frequency 57, 63(p), 381, 383, 531
     451, 480, 517, 519(p), 551ff, 555, 561, 566,
                                                     crossover level 382, 384, 386
     572, 583, 603-6
                                                     crystal 6, 51, 104
  Ai and Bi 201, 205, 444
                                                     crystal optics 113ff
concentration of electrons 7, 23f, 38f
                                                     cubic equation 149, 425
condenser 32
                                                     cubic lattice 40
confluent hypergeometric function 587, 600f
                                                     cumulative coupling 430, 507, 545
conformal mapping 481, 524
                                                     cumulative phase change 168, 195, 220
connection formula 216, 451, 455, 467
                                                     curl 28, 64
Connor, K.A. 418, 425, 620
                                                     current density j, J 24, 26
                                                     current in ionosphere 565
constancy of energy flow 168ff
constant electron concentration 479(p)
                                                     curvature of
                                                       earth 260, 346, 349, 351, 563ff, 579
constitutive relations 38(ch. 3), 162, 509
continuous waves 62(p), 602
                                                       h'(f) curve 322f
                                                       N(z) 216-18, 477
contour integral 195, 202, 208, 218ff, 229, 291.
                                                       N(z) at maximum 9, 15, 332, 334, 476
     361, 459, 469, 500-2; see also phase integral
                                                       q^{2}(z) curve 199
contour map 230ff, 234, 237f
                                                       ray 404
contravariant 51, 63(p), 64(p)
                                                       ray surface, wave front 139, 142
convex lens 223f
                                                       refractive index surface 95, 106, 107
convolution theorem 322f
                                                     cusp 283, 287f
Cooper, E.A. 361, 464, 497, 572, 618, 620
                                                       in ray path 267
coordinate system 28, 66, 103, 141
                                                       in ray surface 113, 136, 139(p)
Copson, E.T. 467, 620
                                                     cut see branch cut
Cornu spiral 223, 235f, 248
                                                     cut-off 6, 79, 105, 112, 124, 126, 139(p), 140(p),
Cory, H. 390, 499, 553, 555, 613, 622
                                                          597
COSPAR see Committee on Space Research
```

```
frequency 54, 68, 125, 126, 135
                                                     disappearance of energy 595-597, 599, 608
cyclotron frequency 4, 46
                                                     discontinuity
                                                        of dN/dz 335, 441f, 458, 464, 478, 572
cylindrical lens 223
cylindrical structures xiv, 20
                                                        of the constants 209
cylindrical waves 224
                                                     discrete strata 142, 172, 254, 553-5
                                                     discriminant of Booker quartic 152f, 160, 523,
D-layer 9, 15ff
D-region 19, 364, 393, 394, 518, 588, 602, 603,
                                                     dispersive medium 5
                                                     dispersion of whistler 378
Dällenbach, W. 577, 620
                                                     dispersion relation 403, 406, 408, 425
damping of electron motion 10-12, 42-4, 57ff
                                                       cold plasma xv, 64, 74ff, 77ff, 78, 101(p), 103,
Daniell, G. J. 111, 139, 291, 618, 620
                                                          144, 146
dark side of caustic 282, 287, 425
                                                       crystal 114
Da Rosa, A.V. 375, 623
                                                     displacement, electric d. D 25, 26, 66
Darwin, C.G. 41, 101, 556, 620
                                                     displacement current 20(p), 25, 28
Davids, N. 52, 104, 499, 514, 518, 620
                                                     distortion of pulse 137
                                                     disturbances, ionosphere and magnetosphere
Davies, K. xiii, 10, 13, 347, 349, 365, 368, 612, 620
Debye length 24, 44ff, 64(p)
                                                          19ff
                                                     disturbing wave 393
Debye, P. 45, 620
Deeks, D.G. 10, 17, 60, 319, 549, 603, 620
                                                     divergence theorem 34, 576
de Groot, W. 339, 620
                                                     divergent series 207f
Denisov, N.G. 448, 621
                                                     dominant term 210, 213, 425, 454
Deschamps, G.A. 281, 317, 418, 621, 642
                                                     Doppler shift
destructive interference 506, 545, 547
                                                       of ionospheric reflection 13
determinant 152, 416
                                                        on ray 407
                                                     double image point 319
determinant form of curl 28
deviative absorption 393
                                                     double refraction 4
de Witt, R.N. 287, 640
                                                     double root 148, 150, 152f, 157f, 160, 163(p),
diagonal elements of coupling matrix 506,
                                                          192, 262f, 265, 483, 485ff, 492ff, 520(ch. 17)
                                                     double saddle point 232, 252, 253(p), 256, 285,
                                                          313, 421
diagonal matrix 51, 52, 183, 188, 506, 554
dielectric constant, tensor; 113 see also
                                                     double steepest descents 251ff, 256, 283, 285,
                                                          313, 316, 421
    permittivity tensor
differential equations
                                                     doubly refracting medium 4, 142
  coupled form 188
                                                     Dougherty, J.P. 5, 11, 14, 43, 45, 49, 368, 619,
  for A 567
                                                     downgoing wave 148, 263
  for anisotropic ionosphere 181ff, 182,
                                                     Downing, A.M. 13, 621
    550(ch. 18)
                                                     ducts in magnetosphere 376, 379
  for isotropic ionosphere 166f
                                                     Dudeney, J.R. 351, 617, 621
  for limiting polarisation 546-548
                                                     Duncan, W.J. 521, 623
  for R 569, 570-2
                                                     Dunckel, N. 379, 619
  for $2 573
                                                     duration of encounter 64(p)
  for ray path 257, 259f, 404, 408f
                                                     dynamics 221
  for vertical incidence 484, 490f, 508, 509,
                                                     dynasonde 13
    546ff, 571f, 584f, 597, 599
                                                     Dyson, P.L. 391, 392, 615, 621
  for 'vertical' polarisation 180
  fourth order 182, 188
  of Ricatti type 547
                                                     E-layer 2, 9, 14, 15, 335f
  of theoretical physics 207, 447, 466
                                                     E-region 9, 393, 394
diffraction 225, 235, 322
                                                     earth flattening approximation 260f, 438, 564f
diffusion of electrons 8
                                                     earth
digital ionosonde 13
                                                       atmosphere 1
                                                       curvature 3, 141, 260, 346, 349, 351, 563ff, 579
Dingle, R.B. 59, 61, 208, 621
dipole, magnetic field of earth 2, 17, 565
                                                       magnetic field: and electron, ion, motion 4,
dipole moment per unit volume 24, 40
                                                          45, 46; form of 17, 565; horizontal 308, 485;
directed beam 134, 258
                                                          spatial variation 436(p), 565; vertical 309,
direction cosines of Y 46, 53, 68, 141, 551
                                                          485, 564, 518(p), 583-91
                                                     east-west propagation 153ff, 163(p), 326(p), 554,
direction
  of energy flow 34, 37(p), 76f, 101(p), 108f, 148
  of ray 108-10, 134, 140(p), 254f, 257, 592
                                                     Eckersley law 379
                                                     Eckersley, T.L. 42, 221, 222, 376, 378, 379, 501,
  of wave normal 104, 110, 111, 134, 139-40(p),
                                                          545, 621
    391, 408
```

```
of pulse 321, 329
Eckhart, C. 467, 621
eclipses 20
                                                        of rays 281
edge focusing 290
                                                        of refractive index surfaces 140(p), 543
effective collision frequency 11, 42, 43, 45, 57, 60,
                                                      Epstein distribution, layer 470-6, 478f, 479(p),
    62, 65(p)
                                                      Epstein, P.S. 467, 470, 590, 622
effective refractive index 373, 446f
effective stratification vector 405, 436(p)
                                                      equal refractive indices 80ff
effective value of q 221, 446, 592
                                                      equal roots of Booker quartic see double root
                                                     equation of motion of electron 39, 45, 449
eigen columns, rows, of matrix 183, 186, 521,
                                                      equator (magnetic) 293(p), 326(p), 485, 508, 554
     561, 593
                                                      equivalent frequency at vertical incidence 351
eigen values of matrix 51, 183, 521, 593
                                                      equivalent height, h'(f) 13, 329, 333, 350, 353-
eigen vector of matrix 51
eikonal equation 402
                                                           4(p), 476, 571, 602
                                                        bounded limit, ext. wave 359
eikonal function 170, 402f, 429, 507
                                                        calculation of 359-62, 398(p)
Einziger, P.D. 621
                                                        effect of lower edge of ionosphere 362f, 370,
elastic waves 6
electric displacement d, D 25, 26, 66
                                                        linear and exponential N(z) 353-4(p)
electric field intensity e, E 23, 26
                                                        parabolic N(z) 332-6, 464ff
electric permittivity
                                                        sech^2 N(z) 335
  of plasma 33, 50, 52-57, 146
                                                      equivalent path 258-9, 278, 321, 329, 345-8,
  of vacuum \varepsilon_0 22
electric polarisation p, P 24, 26, 39
                                                           412f, 465, 571
electric vector
                                                      error
                                                        in Abel method 340-342
  horizontal 166ff, 194f, 199ff, 439ff
                                                        in data 604
  in plane of incidence 180f, 301, 446-453
                                                        in W.K.B. approx. for Ai 206
electromagnetic fields of characteristic waves
     162f
                                                      error accumulation 406
                                                      error function 233ff, 325
electron concentration 23, 24
                                                      error integral 233, 248
  calculation from h'(f) 15, 337–342, 354(p),
                                                      error upper bound 177
     369-372
  height dependence xiv, 7-10, 14-16
                                                      Es see sporadic E
  measurement methods 13, 14, 313, 602ff
                                                      essential singularity 480
electron-electron collisions 61, 62
                                                      Euler's constant 465
                                                      Euler's equations 410f
electron-ion collisions 61, 62
                                                      Euler's theorem 408, 410
electron plasma 46, 52, 53, 104, 112
electron production 7
                                                      evanescent wave 5, 35, 68, 77, 83, 85, 179, 366,
                                                           440, 446, 459, 502, 559, 599
electrons only plasma 46, 52, 53, 55, 492, 535,
                                                      Evans, J.V. 14, 622
     583ff
electron temperature 80
                                                      Evgrafov, M.A. 222, 622
                                                      exact coalescence 521ff, 532, 544
  measurement methods 14
electron velocities 4f, 40, 45, 58, 394-7
                                                      exact crossover 383, 385, 388, 399(p), 496,
electron viscosity 62
                                                      exponential N(z) 10, 331, 353-4(p), 453-6, 472,
electron waves 6
                                                           478, 585ff
electrons
                                                      exterior caustic 282, 287, 290
  prevented from moving 100(p), 589
  rate of production 7
                                                      extraordinary (ray, wave) 81, 85, 88, 154, 307-
                                                           12, 430, 481f, 480(ch. 16)
ELF see extremely low frequency
ellipse and complex vector 27, 36, 37(p)
                                                        C.M.A. type diagram 117
ellipse in plane of propagation 36, 37(p)
                                                        coupling 83, 480(ch. 16)
elliptical polarisation 30, 31, 36, 67, 69, 99(p),
                                                        cut-off 126, 597
                                                        equivalent height 337, 359-68
     374
Ellis, G.R.A. 505, 532, 534, 621, 622
                                                        group refractive index 125ff
Ellis window 505, 532
                                                        penetration frequency 357ff
energy balance, electrons 394-7
                                                        polarisation 71, 73, 193, 372ff, 489ff
energy
                                                        ray direction 106, 134
  in ray pencil 280, 414ff, 428
                                                        ray paths 263f, 268-77, 407, 434f
  stored 63(p), 428, 596
                                                        ray surface 120-123
energy flow, flux 36, 279
                                                        reflection 492ff, 573
                                                        refractive index 96, 160, 193
energy input to plasma 26, 32, 62(p)
energy loss at reflection 450, 452
                                                        refractive index surface 120-3, 147
entire function 460
                                                        resonance 127, 592, 597
envelope
                                                        slow wave 84
```

transition 92ff wave in 31, 544 see also Z-mode freezing in of magnetic field 2, 17 extremely low frequency (ELF) 97, 378, 399(p) Freidberg, J.P. 452, 623 Fresnel diffraction pattern 322 Fresnel integral 233, 236, 248 F-layer 2, 9, 14, 15, 328, 335f, 366ff, 372, 503 F1-layer 15, 337, 365 Fresnel reflection and transmission coefficients F2-layer 15, 42, 337, 365 306, 309, 444f, 473ff F-region 393 frictionless slope 339 factorial function 253(p), 455f, 474, 476, 585, 591 Friedman, B. 251, 286, 619 fadeout 19 Fuchsian equations 467 Faraday rotation 13, 99, 372-6, 373, 399(p), 435, Fuchs, V. 481, 486, 623 514, 547 Fukami, T. 604, 631 Faraday's law of electromagnetic induction 28 full wave solutions Farley, D.T. 14, 621, 622 anisotropic ionosphere 388-391, 550(ch. 18), Farmer, F.T. 41, 331, 622 583(ch. 19), 606 Fedoryuk, M.V. 222, 622 isotropic ionosphere 438(ch. 15) Feinstein, J. 449, 622 full wave theory 5, 16, 194, 335, 507, 606 Fejer, J.A. 14, 47, 312, 368, 394, 397, 449, 450, fully ionised plasma 1, 2, 17 478, 573, 616, 622 functional analysis 603 Felsen, L.B. 57, 239, 317, 418, 425, 620, 621, 622, Fung. P.C.W. 553, 619, 623 Furry, W.H. 212f, 623 Fermat's principle 224, 293(p), 409-12 Ferraro, A.J. 394, 641 gamma function 463; see also factorial function Ferraro, V.C.A. 2, 622 Gans. R. 169, 623 Feshbach, H. 228, 632 Gardner, F.F. 312, 623 fictitious homogeneous medium 163, 482 Garrett, A.J.M. 398, 623 Field, E.C. 604, 622 Garriott, O.K. 4, 7, 8, 15, 20, 375, 623, 635 fields of characteristic waves 162 Gauss's theorem 28 Fijalkow, E. 390, 499, 553, 613, 622 Gaussian curvature 106 first order coupled equations 482ff, 487 Gaussian function 414 Fleagle, R.G. 622 Gaussian quadrature 360 flipover 499 Gaussian units 22, 23, 31 Flixborough explosion 20 Gendrin, R. 98, 623 flow of energy 33, 168 generalisation of Snell's law 405 flow of energy in progressive wave 76ff generalised hypergeometric series 590f flux of particles 169 generalised magnetoionic theory 59 focus 280f, 290 geometrical image point 314-19, 327(p) Fokker-Planck equation 42 geometrical optics 168, 194, 419; see also ray Foley, G. 153, 492, 494, 628 theory forecasting of MUF 349-352 geophysics 6, 507, 603 forecasting of N(z) 349 Gibbons, J.J. 137, 514, 623 formation of layers 7ff, 20 Gibson, G.A. 408, 623 Försterling, K. 280, 448, 449, 466, 481, 484, 490, Gilbert, F. 6, 17, 603, 614, 623, 624 491, 508, 509, 623 Gillmor, C.S. xv, 624 Försterling's coupled equations 481, 491, 507ff, Ginzburg, V.L. xiii, xv, 45, 58, 62, 80, 89, 430, 509f, 514-17, 544, 584, 597 466, 596, 624 Försterling variables 510, 519(p) Giraud, A. 624 four characteristic waves 142f, 162, 165, 188, Golant, V.E. 80, 596, 624 Golden, R.M. 603, 631 four parts of h'(f) curve 364 Goldstein, S. 75, 624 four reflection, transmission, coefficients 298f good path 502, 535f Fourier analysis 49, 320-325, 449 Good, R.H. 524, 632 Fourier integral 49, 50, 109, 128, 130, 320 Goos-Hänchen shifts 315ff, 317, 327(p), 551 Fourier transform 321ff, 329 Goos, F. 317, 624 fourth order differential equation 4, 87, 165, 188, Gordon, W.E. 1, 13, 616, 624 551, 587-91 Goubau, G. 582, 624 fourth reflection condition 597 Goubau's reciprocity theorem 582(p) fractional hop whistler 377, 380 Gould, R.N. 447, 466, 472, 618, 624 Frazer, R.A. 521, 623 gradual boundary of ionosphere 473f free space Graff, P. 131, 407, 613, 615 below ionosphere 141, 513, 562f, 588ff Graham, A. 51, 521, 624 reference 535 gravity 1, 2

great heights, conditions at 217, 221, 389, 440, Helliwell, R.A. 376, 626 444, 451, 454, 461, 471-3, 478, 551, **560**ff, Herlofson, N. 63, 626 568, 574 Hermitian matrix 33, 50 greater than critical 93, 494, 496-499, 503, 514, Hermitian orthogonal, 575 516 Herring, R.N. 351, 401, 536, 627 Green, G. 170, 176, 624 Hertzian dipole 282, 313, 556 Greifinger, C., Greifinger, P. 479, 624 Heun, K. 467, 627 Heun's equation 447, 467 ground wave 3 group path 278; see also equivalent path Hibberd, F.H. 394, 627 high frequencies 222 group refractive index 131, 137, 140(p), 346, 360, Hines, C.O. 42, 380, 627 complex 137, 361 Hirsch, P. 448, 627 group retardation in lower layer 336, 363ff Hollingworth interference pattern 319 Hollingworth, J. 319, 603, 627 group velocity 103(ch. 5), 128ff, 135, 140(p), 255, 346, 379, 412, 436(p) Holt, O. 312, 627 group velocity surface 137, 139(p) homogeneous boundary conditions 228(p) Guha, U.C. 519, 636 homogeneous differential equations 26, 515 guided waves 3, 6, 149, 222, 288, 297, 551, 563f homogeneous function 408 guiding of whistlers 376, 379, 391 homogeneous medium, plasma 38, 66 Gurevich, A.V. 47, 395, 624 horizontal dipole aerials 578f Gurnett, D.A. 380, 382, 383, 390, 534, 624, 636, horizontal polarisation 166ff, 439ff, 477f, 588f 637 differential equation 166, 199f, 453, 457ff, 470ff gyro-frequency 4, 46 reflection 194f horizontal range 342-351 measurement 275, 358 horizontal ray 261f, 285f half thickness (semi-thickness) 332, 463f, 476 horizontal variations in ionosphere 20, 380, 400 Hall, G. 552, 624 horizontally stratified 1, 2 Hamilton, W.R. 404f, 408, 624 Horowitz, S. 519, 555, 627 Huang, X. 13, 372, 627, 635 Hamilton's canonical equations 404f Hänchen, H. 317, 624 Hückel, E. 45, 620 Hankel function 252(p), 454, 599 Hugill, J. 106, 618 Hara, E.H. 59, 625 Hutatsuishi, G. 553, 554, 632 Huxley, L.G.H. 10, 58, 394, 396, 620, 627 Harang, L. 503, 625 Hargreaves, J.K. 7, 625 Huyghens's principle 223ff hybrid frequencies 57, 368 harmonic waves 23, 25ff harmonics 449, 450, 596 hyperbola 242 Harper, J.D. 60, 553, 554, 628 hyperboloid surfaces 116 hypergeometric equation 467-9, 602 Harrison, M.D. 603, 639 Hartree, D.R. 75, 101, 288, 401, 443, 445, 477, hypergeometric function 469, 472; see also confluent hypergeometric function 556, 625 Harvey, C.C. 414, 625 hypergeometric series 468, 590 Harwood, J. 603, 616 Haselgrove form of ray equations 407ff, 414 illuminated side of caustic 224, 282, 286 Haselgrove, C.B. 407, 408, 625 image of transmitter 315-19, 327(p) Haselgrove, J. 370, 407, 408, 412, 625, 639 imaginary refractive index 35, 36, 37(p) Hashimoto, K. 376, 625 imaginary step size 562 Hayes, M.G.W. 545, 549, 625 impedance, wave 301ff Heading, J. xv, 170, 176, 180, 182, 216, 222, 223, impulse 376 447, 455, 457, 458, 460, 462, 466, 472, 478, Ince, E.L. 184, 627 479, 481, 483, 486, 507, 515, 521, 528, 556, incoherent scatter xiv, 5, 13, 14 579, 587, 588, 590, 591, 600, 601, 619, 625, independence of characteristic waves 510 independent second order equations 166, 584, heating 33, 37(p), 391, 394-8, 452, 595 of ionosphere 47, 450 induction, electric see electric displacement heavy ions xiv, 380 infinite equivalent height 333, 334, 337, 358, height as complex variable 68, 79, 88, 152, 330, 362-5, 465f 387, 477, 494, 499-502 infinite fields, vertical polarisation 449 height, see equivalent height, phase height, true infinite group refractive index 360 height, Cartesian coordinates infinite refractive index 79, 80ff, 86, 95, 96, 98, 105, 366, 446, 580 Heisler, L.H. 7, 632 helium ions 63(p), 379, 381-3 infinite root of Booker quartic 149, 154, 155, helium whistler 380, 385 580, 591ff

infinitely distant source 281, 421f neglect of 4, 39, 46, 98 infinitely high mountain 230, 235, 237 ions and electrons, force between 12, 40 infinitely massive ions 53, 55 irregular singularity 200, 207ff, 467 infinities of ε_1 ε_2 54, 56 irregularities of electron concentration, infinity refractive index xiv, 288, 311, 312, 348, 365, in q curve 150, 591ff 368, 505, 518, 604 point at 207 irrotational vector field 402 isolated coupling point 485ff, 489, 520 inflection point isolated reflection (turning) point 459 in refractive index surface 106, 116, 148, 160 isolated resonance 593-6, 598f in ray surface 113 inhomogeneous differential equation 515 isolated saddle point 249f, 284 inhomogeneous medium, plasma 38 isolated zero of n or q 198ff, 451 inhomogeneous waves 36, 37(p), 100(p), 282, isotropic ionosphere 328(ch. 12), 394, 438(ch. 15) 306, 562, 574 isotropic plasma 4, 67ff, 409 initial ordinary, extraordinary wave 497 isotropic stratified medium 143, 165ff, Inoue, Y. 519, 555, 627 328(ch. 12) Institute of Electrical and Electronics Engineers isotropic tensor 414-417 iterative process 561 69, 627 ITU see International Telecommunications Inston, H.M. 280, 627 integral equation 338, 369, 556 Union integral function 460 integrals of Barnes type 469, 591 Jackson, J.E. 368, 370, 627 Jacobsson, R. 439, 571, 627 integrating factor 184 integration Jalonen, L. 607, 627 by steepest descents 229(ch. 9), 238-40, 241ff Jeffreys, B. 169, 170, 185, 208, 215, 228, 443 445, 515, 628 by stationary phase 247f, 254, 283, 285 Jeffreys, H. 6, 33, 169, 170, 185, 208, 215, 216, integration methods, numerical 552f 228, 414, 416, 515, 628 interchange see change interference 364, 394 Jeffs, R.M. 280, 627 interference pattern 288f, 319, 348, 464 Jenkins, F.A. 173, 373, 628 interior caustic 282, 287 Jespersen, J.L. 551, 576, 579, 634 Johler, J.R. 60, 97, 308, 553, 554, 628 internal conical refraction 114 Johnson, W.C. 549, 632 International Astronomical Union 69, 627 International Reference Atmosphere (CIRA) 14, Johnston, T.W. 5, 11, 42, 636 Jones, D. xv, 108, 273, 382, 383, 385, 531, 534, International Reference Ionosphere (IRI) 14, 16, 535, 543, 628 Jones, R.M. 417, 628 Jones, T.B. xv, 13, 20, 153, 492, 494, 603-6, 614, International Telecommunications Union (ITU) 628 International Union of Radio Science (URSI) 14 Journal of Atmospheric and Terrestrial Physics interplanetary plasma 21 10, 393, 628 interpolation 361, 401 Jull, G.W. 417, 427, 428, 434, 435, 618, 628, 629 Jupiter 535 inverse square law 28 inversion of ionospheric data 17, 602-606 Kane, J.A. 10, 629 of matrix 49, 52 Katsufrakis, J. 380, 637 ion-acoustic wave 5 Kelso, J.M. 73, 89, 280, 514, 517, 629 Kennel, C.F. 19, 629 ion cyclotron whistlers 93, 377, 380-91, 495f, 530ff Kennett, B.L.N. 6, 629 ion gyro-frequency 55, 57 Kimura, I. 376, 380, 407, 625, 629 kinetic energy of electrons 63-4(p), 394-397 ion-ion hybrid frequency 57 kinetic theory 4, 43, 57 ionograms 362ff, 503 ionosonde 12ff, 80, 138, 346, 356, 362, 391, 397, wave interaction 397f 607 King, G.A.M. 370, 629 King, J.W. 394, 629 at oblique incidence 347f Knecht, R.W. 365, 642 ionosphere 1(ch. 1), 14ff Ko, K. 481, 486, 623 artificial modification 47, 450 observations of 12-14, 602f Kramers, H.A. 169, 180, 629 ionosphere storm 19 Krasnushkin, P.E. 564, 604, 614, 629 Kraus, J.D. 375, 629 ion plasmas xiv, 3ff, 54ff ion plasma frequency 55 Kravtsov, Yu.A. 281, 629 ions xiv, 54ff, 182 Kumagai, H. 376, 625

laboratory measurements of v 58, 60	Lockwood, G.E.K. 368, 630
Lacoume, J.L. 184, 559, 629	logarithm of frequency 363
lamination method for $N(z)$ 369	logarithmic term in E_x 449
Landau, L.D. 399, 430, 629	long whistler 377
Landau damping 595	longitudinal component of electric field, and
Landmark, B. 394, 499, 549, 629	polarisation 75ff, 101(p)
Lange-Hesse, G. 52, 630	longitudinal propagation 76 , 82, 85, 89, 124,
Langer, R.E. 216, 218, 450, 488, 630	132, 140(p), 267, 269, 392, 584ff
Langmuir probes 13	Lorentz, H.A. 5, 43, 82, 630
Langmuir wave 5, 49	Lorentz polarisation term 40ff, 378
Lanzerotti, L.J. 19, 629	
Laplace integral 202	Lorentz reciprocity theorem 577 Lorentz treatment of collisions 5, 10ff, 43
Laplace transform 338	loss-free medium 35, 147, 168
Lapshin, V.I. 62, 612	Lotsch, H.K.V. 317, 630
Lassen, H. 75, 280, 623, 630	
lateral deviation 131, 260, 273 –7, 315, 366, 375,	low frequency 84, 127, 138, 496ff, 550(ch. 18),
	586f see also very low frequency
391, 401, 507, 596 at vertical incidence 274	low frequency ionograms 365
	lower hybrid frequency 57, 98
east-west and west-east 275	lower triangular matrix 370
general azimuth 276	lowest ionosphere 58
Lawrence, R.S. 407, 630	Ludwig. D. 281, 486, 630
ledge 336f, 362, 365, 368	Luxembourg effect see wave interaction
Lee, H.S. 394, 641	Lyman $-\alpha$, $-\beta$ 9
Lee, K.F. 449, 478, 616	M :II D.G. (02 (21
left-handed polarisation 69	Macmillan, R.S. 603, 631
Leinbach, H. 13, 630	magnetic energy 32, 63(p)
Lenz's law 2	magnetic equator 293(p), 326(p), 485, 508, 554
Lepechinsky, D. 497, 499, 630	magnetic field
less than critical 93, 494 , 496–9, 502f, 514	of earth: and motions of electrons, ions 4, 45,
level line 230ff, 247	46
level of reflection 262–273, 442	of wave 46-8
L.G. approximations 170; see also W.K.B.	magnetic field intensity
Lied, R. 394, 499, 629	h, H 23, 26, 46f
Lifshitz, E.M. 399, 430, 629	ℋ 31, 66
lightning flash 47, 376, 378f	magnetic induction b, B 25
light waves 373, 571	magnetic meridian, propagation in 263, 266,
limiting points of spiral 236	268–73, 407, 494f, 537
limiting polarisation 70, 153, 192, 256, 430, 498,	magnetic permeability 326(p)
510, 513, 521, 529, 543 –9	magnetic plane 429, 433
limiting region 545, 547ff	magnetic pole 22, 24
Lindquist, R. 517, 630	of earth 163(p), 293(p), 309, 503, 508
Lindsay, R.N. 182, 640	magnetic storm 19
linear and homogeneous equations xiii, 26, 574	magnetic stress 2
linear differential equations 26, 480, 515	magnetohydrodynamics 97
linear electric circuit, system 429, 576	magnetoionic splitting 256 , 263f, 356, 365, 498
linear height distribution of electrons 10, 197ff,	magnetoionic theory xiv, 66(ch. 4), 103(ch. 5)
331, 342f, 347, 353(p), 424f, 439–41, 443–5,	magnetopause 17
478	magnetoplasma 4, 66
linear interpolation 351, 401, 436(p)	magnetosheath 17
linear wave polarisation 29, 34, 36, 67, 69, 73,	magnetosphere xiii, 2, 17ff, 400
114, 498, 546, 581(p)	magnetotail xiii, 3, 18
linearly polarised aerials 431, 434, 435	Mambo, M. 553, 554, 604, 606, 631, 632
line of steepest descent, ascent 230ff, 237, 241ff	Manning, L.A. 338, 631
line of steepest descents 230ff, 237	Margenau, H. 58, 60, 631
Liouville, J. 170, 176, 630	Martin DE 246 252 621
Liouville method 175ff	Martyn, D.F. 346, 353, 631
	Martyn's theorem
Lipson, S.G. and Lipson, H. 114, 173, 630	
Lisak, M. 554, 613	Martyn's theorem
Lisak, M. 554, 613 Little, C.G. 13, 407, 630	Martyn's theorem for attenuation 352f, 356 for equivalent paths 346, 350f, 356 Maslin, N. M. 281, 283, 284, 288, 292, 343, 394,
Lisak, M. 554, 613 Little, C.G. 13, 407, 630 Liu, C.H. 20, 642	Martyn's theorem for attenuation 352f, 356 for equivalent paths 346, 350f, 356 Maslin, N. M. 281, 283, 284, 288, 292, 343, 394, 631
Lisak, M. 554, 613 Little, C.G. 13, 407, 630	Martyn's theorem for attenuation 352f, 356 for equivalent paths 346, 350f, 356 Maslin, N. M. 281, 283, 284, 288, 292, 343, 394,

Mather, W.E. 380, 614	narrow beam 134, 257f
Mathews, J. 51, 631	Nearhoof, H.J. 73, 514, 629
Mathieu's equation 477	negative ions, massive, 4
matrix equations 6, 46, 163, 308, 310, 369ff	Nertney, R.J. 73, 514, 517, 623, 629, 632
for inverting integral equation 369ff	neutrality of plasma 4, 48, 49
matrix forms	neutral particles in ionosphere 2, 42
	Newbern Smith see Smith, N.
of differential equations 182	
of Maxwell's equations 145	Newstead, G. 503, 632
matrix inversion 370–372	Nicolet, M.J. 12, 633
matrix theory 183ff, 521ff, 526	Nicolson, P. 288, 625
matrix susceptibility 49	non-deviative absorption 393
matrizant 558ff	non-linear differential equation(s) 170, 188, 449,
Matsushita, S. 15, 365, 637	568
maximum	non-linear effects in ionosphere 47, 48, 395, 449
in $h'(f)$ curve 337, 364f	595f
of electron concentration 221, 523	non-penetrating mode 559, 575, 582(p)
maximum usable frequency, MUF, 289, 328,	nonreciprocity 326(p), 429
348-52, 354(p)	non-singular matrix 485, 486, 544, 563
Maxwellian velocity distribution 11, 58, 396, 398	normal
Maxwell's equations 23, 25, 27ff, 31, 48, 108,	to ray surface 111, 112, 115
113, 145, 162, 166, 174, 181, 326(p), 402,	to refractive index surface 108ff, 114, 115, 404
412, 428, 440, 449, 556, 565, 576	425, 427
in principal axes 64(p), 101(p)	normal form of differential equation 446, 515
May, B.R. 603, 614	normal incidence
mean free path of electron 11, 58, 60, 397	reflection at sharp boundary 306, 308–12
mechanical model 339	see also vertical incidence
Meek, J.H. 503, 631	
Melrose, D.B. 535, 538, 631	normalisation 51, 184, 186 f, 190f, 427, 483, 506,
Michel, J.G.L. 288, 625	519(p)
Miller, J.C.P. 205, 457, 631	north-south propagation 150, 155ff, 163(p), 485,
	579
Miller, K.L. 607, 632	Northover, F.H. 457, 633
Miller, S.C. 524, 632	nose frequency 136, 379
Millington, G. 138, 155, 160, 275–7, 292, 346,	nose whistler 377, 379
349, 353, 360, 545, 621, 632	numerical integration of differential equations
Mitchell, R.W. 452, 623	388-91, 463f, 477, 517, 540, 547, 549,
Mobbs, A.J. 603	550(ch. 18)
mode condition (guided waves) 222	numerical swamping 558, 559, 568, 574
mode conversion 92, 387–90, 481, 497f, 501,	Nuttall, J. 368, 633
503ff, 517, 531, 532 f, 544, 547, 596	Nygren, T. 553, 574, 607, 627, 633
modified refractive index 261, 564	
modulation of disturbing and wanted wave 394,	oblate refractive index surface 157
396	oblique axes 51
Moiseyev, B.S. xvi, 62, 89, 104, 106, 109, 112,	oblique incidence 494, 505
115, 251, 612	horizontal polarisation 199ff, 494, 505
molecules 1, 40	rays at 342-53
Monaghan, J.J. 49, 368, 621	vertical magnetic field 587-91
monoenergetic 59	vertical polarisation 446-52
Morgan, M.G. 549, 632	observations of ionosphere 12ff
Morse, P.M. 229, 632	ocean as inverted ionosphere 6
Morse, R.L. 452, 623	Olver, F.W.J. 170, 177, 205, 206, 208, 210, 467,
Mott, N.F. 169, 632	633
MUF see maximum usable frequency	one magnetoionic component 309-11, 431-3
Mullaly, R.F. 106, 107, 116, 119, 619	optical activity 113, 398(p)
multiple reflections 142, 173, 555	optical waves 182
Munro, G.H. 7, 632	optic axes 104, 114
Murata, H. 7, 632	optic ray axes 115, 119, 139(p)
Musgrave, M.J.P. 6, 632	optimisation principle 604
TILOUGENTO, ITEM, I. U. UJA	ordered part of electron volumes 11 (2)
Name I 552 554 604 606 621 622	ordered part of electron velocity 11, 62(p), 395
Nagano, I. 553, 554, 604, 606, 631, 632	ordinary point of differential equation 206f, 460
Nakamura, K. 604, 606, 631	517, 566, 580
Namba, S. 304, 642	ordinary (ray, wave) 81, 85, 88, 154, 307–12,
National Bureau of Standards 351, 632	430ff, 481ff, 480(ch. 16)

C.M.A. type diagram 116	Pettersen, G.W.E. 435, 628, 629
coupling 83, 480(ch. 16)	Pfister, W. 504, 587, 633
cut-off 126	phase 26, 109, 168, 170, 175
equivalent height 359-68	planes of constant 36
group refractive index 125ff	see also complex phase
penetration frequency 357ff	phase advance on reflection 195, 218, 221f, 262,
polarisation 71, 73, 193, 372ff, 489ff	285
ray direction 106, 134	phase change on reflection 316, 474
ray paths 263, 266ff, 274-7, 407, 434f	phase height 329, 333, 353-354(p), 465, 571
ray surface 117, 119, 147	phase integral formula
refractive index 160, 193, 376	for coupling 501
refractive index surface 117, 119	for reflection 220, 456, 458, 464, 474, 510
resonance 127	phase integral method 218ff, 541
transition 92ff	for coupling 223, 387f, 489, 499 -502
see also whistler mode	for reflection 195, 218ff, 456-9
Ott, H. 239, 633	phase memory 167ff, 189, 193, 220, 256, 402f,
oxygen ion 379, 382, 383	429, 505f
Oya, H. 535, 633	phase path 278 , 286, 320, 329, 421, 424, 426, 432, 465
Pack, J.L. 10, 58, 633	phase velocity 129; see also wave velocity
Panton, A.W. 152, 618	Phelps, A.V. 10, 58, 633
parabolic cylinder function 214, 457, 461f	physical optics 173, 223ff, 556
parabolic height distribution of electrons 10,	Pickle, C.B. 365, 633
221, 332–4, 343f, 347–50, 361, 456–66, 476,	piecewise linear models 443-6
478, 524, 572, 587, 607	Piggott, W.R. 361, 365, 603, 633, 634
parabolic ray path 262, 342	Piliya, A.D. 80, 596, 624
paraboloidal refractive index surface 538, 542	Pitteway, M.L.V. 13, 63, 146, 152, 161, 319, 492,
parallel plate condenser 32	543, 551, 561, 574, 575, 576, 579, 603, 633,
parallel sided slab of plasma 63(p), 326f(p)	634
parametric instabilities 47	plane polarised see linear wave polarisation
Park, C.G. 18, 619	planes of incidence 295, 439
Parker, E.N. 19, 629	of constant amplitude 36, 37(p)
Parkinson, R.W. 499, 514, 517, 518, 620, 633	of constant phase 36
partial penetration and reflection 15, 194, 439,	plane wave 3, 29, 30, 66, 165
445, 463f, 475f, 477, 521, 524, 607	planetary waves 6, 20
partial reflection method 10, 13, 311, 312, 518	plasma frequency 3, 39, 48
partial standing wave 30	plasma instability 35, 47
partial fields, waves 188, 482 , 557	plasma oscillations 3, 48ff, 63(p), 83
partitioning of matrix 304, 310, 490, 560, 563,	plasma physics xiii, 4, 481
567, 570	plasma wave 5, 49, 80, 596
passive medium 35, 86	plasmapause 18
path	plasmas 3ff, 35, 47
of integration 230, 242ff	plasmasphere 18
of wave packet see ray, ray path	plate-like cavity 25
Paul, A.K. 404, 638	Platteville, Col. 47
Pawsey, J.L. 312, 623	Plumpton, C. 2, 622
Pearcey, T. 288, 633	pocket calculator 55, 307, 347
Pedersen, P.O. 344, 633	Poeverlein, H. 264, 267, 270, 556-8, 634
Pedersen ray 344, 348	Poeverlein's construction 264ff, 274, 543, 592
pencil of rays 224, 258, 279ff, 414-17	Poincaré criterion, definition 208, 213f, 250, 454,
pendulum 196(p)	462
penetrating mode 576, 582(p)	point at infinity 207f
penetration 334, 424	point of inflection
penetration frequency 14, 15, 194, 199, 332, 357f,	in q curve 520
445, 457ff	in refractive index surface 106, 160
perfect differential 184, 506	in ray surface 113
permeability 326(p)	point source 111, 280f, 313, 316, 327(p), 414ff,
permittivity	418ff, 541
electric 33	polar cap absorption (PCA) 19
of vacuum ε_0 22	polar coordinates 290, 408f, 563f
permittivity matrix, tensor 50, 52-7, 146	polarisability of molecules 1, 40
Petit, M. 624	polarisation

```
electric see electric polarisation
                                                          also wave packet
  of whistler 377, 381ff, 386, 391
                                                      pulse shape 320-5
  on ray 261, 430
                                                      q(Booker's variable) 142ff, 143, 166ff, 197ff, 263,
  see also limiting polarisation
                                                           301, 407, 439, 483, 486, 554, 580
polarisation ellipse 37(p), 72, 75, 587
                                                        as eigen value 183, 521, 561
  major axes 74
                                                        equal values 262, 265, 521
polarisation equation 70ff
                                                        zeros of 262
polarisation fading 435
                                                      quadratic approximation for refractive index
polarisation, reversal of sense 382-387
                                                          surface 538
polarisation term 40
                                                      quadratic equation
polarisation, wave 68ff, 99-100(p), 399(p), 509,
                                                        for n<sup>2</sup> 77f, 103, 593
    529, 533
                                                        for polarisation 70, 71-4
pole
                                                        for q^2 151, 518(p) for qs 486, 539
  near saddle point 238f, 315
  of \psi 512, 514, 518(p)
                                                     quantum mechanics see wave mechanics
  of refractive index see infinite refractive index,
                                                      quartic equation 419; see also Booker quartic
    infinite root, resonance
                                                      quasi-longitudinal (QL, QL2) 95ff, 494
polynomial method for finding N(z) 370f
                                                      quasi-transverse (QT, QT2) 95ff, 494
positive ions 54ff, 379
Postan, A. 288, 518, 553, 613
                                                      Ra, J.W. 317, 634
Poston, T. 288, 499, 634
                                                      radar 13
potential function 230, 402
                                                      radiation field 431
potential barrier 459, 533
                                                      radiation pressure 47
power flux in ray pencil 279-81, 415
                                                      radio astronomy 290, 292, 328, 375, 535
power input to plasma 32, 33, 62, 63
                                                      radio fadeout 19
Poynting's theorem 34
                                                      radio windows 83, 85, 150, 268, 495, 505, 521,
Poynting vector 26, 33ff, 76, 100(p), 108, 111,
                                                          529, 532-43
    168, 178f, 185-7, 254, 292(p), 401, 413, 415,
                                                      Radio Science 47, 407, 450, 634
    426, 594
                                                      Radio waves in the ionosphere (RWI) xiii, xiv,
precursor 323
                                                          many references in text, 617
prediction of MUF 348-352
                                                      Raghuram, R. 603, 634
predominant frequency 128
                                                      random thermal velocities 4, 39, 62
predominant values 110, 254, 258
                                                      rank
predominant wave 257, 314, 316, 320
                                                        of matrix 526
predominant wave normal 110, 391
                                                        of tensor 414
pressure of radiation 47
                                                      Rao, M.M. 608, 635
Price, G.H. 553, 634
                                                      Rao, R. 137, 623
principal axis of magnetoplasma 50ff
                                                      Ratcliffe, J.A. xvi, 9, 19, 20, 41, 43, 68, 89, 298,
principal axis coordinates 63(p), 64(p)
                                                          331, 339, 349, 365, 394, 397, 497, 556, 587,
principal axis elements 53ff
                                                          603, 616, 618, 622, 627, 635
principal rays 429
                                                      rationalised units 22
principal terms of coupled equations 480, 482
                                                      Rawer, K. xiii, 11, 13, 14, 15, 43, 69, 75, 89, 280,
                                                          290, 365, 368, 393, 472, 475, 476, 497, 519,
principal values of integral 342
probes 13
                                                          559, 634, 635, 638
                                                      ray 103(ch. 5), 108ff, 110, 129, 131, 148, 254ff,
probing frequency 356ff
probing the ionosphere 80, 328ff
                                                          257ff. 594
Proc. Inst. Elect. Electronic Engrs. 368, 634
                                                        entering ionosphere from free space 407
                                                      ray path 255-277, 257, 263
progressive wave 29, 30, 35, 37(p), 66, 162, 165f,
    169, 170, 174, 176, 183, 186, 227(p), 402,
                                                        horizontal 262
    412, 442, 482
                                                        in magnetic meridian plane 263f
projected path 268, 275-7
                                                        equations 257, 259
prolate refractive index surface 157
                                                        not reversible 507
propagation constant, k 29, 130, 481
                                                      ray pencil 224, 255, 413, 418, 429
propagator 559
                                                        signal intensity in 414-417
protonosphere 380
                                                      ray refractive index 111, 374, 410f, 426, 429
protons 4, 19, 379, 381
                                                      ray surface 108ff, 111ff, 115, 116-124, 136,
proton whistler 377, 380
                                                           139(p), 376
                                                      ray theory 168, 193f, 222, 382, 428-435
pseudo rays 422-424
psi (\psi) coupling parameter 484, 490, 511f,
                                                        anisotropic ionosphere 356(ch. 13)
    518(p), 544
                                                        isotropic ionosphere 328(ch. 12)
                                                      ray tracing 222, 380
psi function 465
pulse 128ff, 258, 328ff, 354(p), 394, 550, 571; see
                                                        general 351, 400(ch. 14)
```

stratified medium 195, 254(ch. 10)	zeros of 79, 357
through reflection level 262	see also group refractive index
uses 255, 401	region I, I(a), II 588
ray tube 432	regular singularity 206f, 447, 467
ray vector 111, 112	Reinisch, B.W. 13, 372, 615, 627, 635
ray velocity 111, 115, 129, 140(p), 403f, 409f	relative velocity of electrons and ions 62
Rayleigh, Baron 169, 170, 635	remainder in series 208
rays, horizontal, field near 285f	removal of electrons 8, 15
real pseudo rays 422	repeated suffixes 33, 188, 414, 505
reciprocal property of surfaces 112	resonance 5, 6, 79 , 112, 116, 127, 132, 133, 135,
reciprocity 261, 278, 576 ff	427, 446, 579–81, 591 –602
with full wave solutions 576–97	in topside ionograms 368
with rays 428–35	resonance cone 105, 106, 113, 117–119, 135
reciprocity theorem 428, 430ff, 576	resonance frequency 135, 140(p)
recombination coefficient, electrons 8	resonance point 160, 493, 495, 553, 593, 607f
rectangular pulse 322–325	resonance tunnelling 427, 596–602
Reddy, C.A. 608, 635	retarding force on electron 10, 43
Reed, J.E. 312, 615	reversal of sense (wave polarisation) 381-90
reference free space 534, 535	reversed resonance cone 106, 113, 117, 118, 120,
reference level	121, 135, 157
for reflection coefficients 296f, 313ff, 455, 458	reversed skip 343
462, 477f	reversed Storey cone 106, 117, 118, 122, 124, 134,
for transmission coefficients 297f	136
reference line 264ff, 495	reversibility of ray path 261, 428
reflection 152, 178, 485	reversion of series 249
at discontinuity of gradient 441-443	Riemann surface 420, 424
at sharp boundary, isotropic medium 172,	right-handed polarisation 69
178, 304ff	riometer 13
at sharp boundary, anisotropic medium 307-	Rishbeth, H. 4, 7, 8, 15, 20, 623, 635
312	Robbins, A. 370, 635, 639
at vertical (or normal) incidence 308-312,	rockets xiii, 10, 13, 379, 606f
489ff	Rodriguez, P. 390, 636
of pulse, wave packet 26ff	Rönnmark, K. 407, 636
reflection coefficient(s) 172, 174, 194f, 218, 221,	Ross, W.J. 375, 623
295(ch. 11), 441, 455, 462, 472ff, 552, 579,	Rota, G.C. 184, 615
600-2	rotation of axes 71, 519(p)
reflection coefficient matrix	
R 299 ff, 303f, 307-9, 325(p) 557, 562f, 566,	rounding errors 405
568–72	Roy, S.K. 59, 61, 621
R₀ 301, 309, 325(p), 585	Royal Society 22, 636
R _c , 92 309–311, 573, 607	Rudsinski, L.I. 452, 623
reflection level 149, 256, 280, 282, 357, 442, 447,	rule of false position 401, 436(p)
450, 459	Runge-Kutta-Merson method 552f
	Rusch, W.V.T. 603, 631
reflection point (turning point) 79, 152, 153, 458, 480, 483, 492ff, 496ff, 592	Rutherford Appleton Laboratory xv, 349
- · · · · · · · · · · · · · · · · · · ·	Rydbeck, O.E.H. 304, 322, 457, 463, 464, 477,
reflection process 166, 169, 175, 178, 197, 220f,	503, 504, 514, 636
442f, 447	0 1 660
refraction of satellite signals 13	S-matrix 560
refractive index 29, 66(ch. 4), 74ff, 103(ch. 5)	saddle point 231, 237, 242ff
as vector 78, 103, 108, 109, 113, 146, 254,	Saha, M.N. 519, 636
403f, 408, 429	satellites 13, 356, 375, 379, 380
dependence on frequency 124ff	scale height 7, 11, 536
dependence on electron concentration 80ff	Scarabucci, R.R. 391, 519, 613
effect of collisions 86ff, 89ff	scattering from irregularities 20, 312, 505, 518
equal values 79	Schatzberg, A. 579, 613
infinity of 79	Schelkunoff, S.A. 301, 571, 636
isotropic plasma 67ff	Schmerling, E.R. 368,627
of air 1	Schrödinger equation 167, 169
space 104, 264, 403f, 408	Schwarzian derivative 176, 216
surface 104ff, 110, 114, 116-24, 131, 136,	scintillation 1, 20
139(p), 146, 147, 264, 404, 416, 425, 428,	screening of ions in plasma 45
538, 592	sea surface 325(p)

Seaton, S.L. 349, 616	624 624 627
	624, 634, 637
sech ² distribution 332–5, 475f,	smoothing out in a plasma 24, 25, 40, 44, 48
second order coupled equations 481, 491, 519(p)	Snell's law 142, 254, 260, 264, 305f, 346, 403,
second order differential equations xiii, 165, 170,	405, 418, 421f, 564f,
438(ch. 15), 584ff, 593ff	Snyder, M.A. 372, 637
second window 273, 538, 542 f	solar corona 535
seismic waves, seismology 6	
	solar flare 19
semi-thickness see half thickness	solar wind 3, 17, 19
Sen, H.K. 5, 58, 59, 60, 636	Sommerfeld, A. 3, 170, 239, 253, 402, 637
Sen-Wyller formula 57ff, 60, 145, 182, 312, 554	Sommerfeld contour integral 252(p)
separation	sound waves 6, 167, 196(p), 414
constants 144	source
into upgoing and downgoing 174f	at infinity 421
of differential equations 439, 583f, 588	dimensions of 255
of variables 143	
	distributed 517
series solution of differential equation 201, 207f,	south-north propagation 150, 155ff, 163(p), 485,
448	579
shape of pulse 320-5	space charge (in plasma) 3
Sharaf, A.L. 438, 466, 636	space vehicle xiii, 134, 156, 266, 429
sharp boundary, reflection at 178, 296, 304-11,	spatial dispersion 38, 113, 398(p)
473–5, 570	spectral analyser, spectrogram 133, 377ff, 380
sharply bounded anisotropic medium 307-12	Spencer, M. 20, 617
sharply bounded isotropic medium 304ff	spherical distribution of charge density 41
sharply bounded model ionosphere 304, 319	spherical polar coordinates 290, 408f, 563f
Shaw, I.J. 397, 635	spherical refractive index surface 104, 105
Shaw, R.R. 534, 624	spherical stratification 260, 290, 292(p), 564f
Shawhan S.D. 380, 382, 624, 637	spherical wave 3, 141, 313ff
	spikes 368
Shellman, C.H. 604, 636	
Shinn, D.H. 131, 360, 398, 636	spiral 225-7, 506; see also Cornu spiral
Shkarofsky, I.P. 5, 11, 42, 636	spitze 150, 266 ff, 495
Shmoys, J. 448, 627	splitting see magnetoionic splitting
shock front (earth's bow) 17	sporadic E, E _s 15, 20, 354(p), 365, 380, 606-8
shooting method 401, 418	Spracklen, C.T. 20, 628
short wave fadeout 19	square law N(z) 477, 587
short whistler 377	square root in Appleton-Lassen formula 88,
S.I. units 22, 301	153, 494
	.,
side-band frequencies 323	standing wave 30, 227(p), 569f
signal intensity 414–17, 432	Stanley, J.P. 587, 637
silvered glass 326(p)	starting solutions 551, 560ff, 568, 574
simple reflection 572	stationary phase 109, 129, 130, 137, 236, 252,
single coupling point 520, 566	254, 257f, 330
singular matrix 485f, 522, 525, 572, 574	method of 247, 283, 285
singular point, singularity 200, 223, 230, 447,	stationary time see Fermat's principle
450, 517, 593	steepest descent, ascent, lines of 230ff
singularities 200, 205, 480, 493ff, 566	steepest descents 110, 214, 229(ch. 9), 238ff, 418,
sinusoidal layer, distribution of $N(z)$ 476	591
six-dimensional space 108, 403, 425	double 251 ff, 283, 285, 421
sixth degree equation 106, 111	higher order approximations 249ff
skip distance 280, 288 f, 343, 345, 348, 425	Stegun, I.A. 205, 233, 236, 249, 360, 457, 463,
slab model of ionosphere 326f(p)	465, 612
slit, diffraction by 322	step size 552f, 568, 570, 580, 608
slowly varying function 109, 240	step-by-step process for integration 401, 551
slowly varying medium 38, 165(ch. 7), 170, 172,	Stepanov, K.N. 62, 612
178, 456	
	Stevens, E.E. 365, 637
Sluijter, F.W. 447, 467, 602, 640	Stewart, 1.N. 288, 634
Smith, E.K. 14, 15, 61, 365, 637	Stirling's formula 253(p), 456, 474
Smith, L.G. 607, 632	Stix, T.H. 5, 55, 637
Smith, M.S. 60, 153, 155, 189, 261, 492, 494, 495,	Stokes: name used for two distinct purposes 200
499, 503, 506, 507, 518, 520, 521, 526, 532,	Stokes, G.G. 200, 210, 211, 637
539, 572, 580, 581, 592, 618, 637	Stokes constant see Stokes multiplier
Smith, N. 41, 349-51, 637	Stokes diagram 200, 211, 220, 454, 460f, 535f
Smith, R.L. 44, 57, 379, 380, 382, 383, 603, 614,	Stokes (differential) equation 178, 200–4, 212,
,,,,,,,,,,,,,,,,,,	bioaco (dinordinal) equation 1/0, 200-4, 212,

214f, 227f(p), 241-7, 439-41, 443-5, 447,	Taylor series 95, 231, 239, 247, 321, 555
450, 467	Tellegen, B.D.H. 393, 638
Stokes line 200, 206, 210ff, 214, 220, 228(p), 242,	temperate latitudes 504
245, 451, 454, 461, 500	temperature
Stokes multiplier 212ff, 216, 221, 228(p), 246,	in ionosphere 4, 14
448, 450ff, 454, 462, 528	of electrons 394
Stokes phenomenon 200, 209 , 220, 241, 246,	tensors 414–17
467, 501, 528 Standar B. 6 630	terrestrial radiations 534
Stoneley, R. 6, 638	Terry, P.D. 252, 391, 417, 418, 422, 424, 425,
storage fields 431, 556	428, 494, 535, 541, 618, 638
stored energy	thermal motions 394, 395
in plasma 32, 63, 596	thermo-nuclear plasmas 535, 597
in wave 179	thin layer 354(p), 475, 606
Storey cone 106, 116–19, 122, 124, 134, 136,	Thomas, J.O. 370, 639
139(p)	Thomas, L. 603, 639
Storey, L.R.O. 106, 376, 638	Thomson scatter see incoherent scatter
Stott, G.F. xvi, 56, 57, 62, 89, 104, 106, 109, 111,	Thrane, E.V. 361, 394, 603, 614, 633, 634, 639
112, 115, 135–7, 140, 251, 419, 612, 618, 638	three equal roots of Booker quartic 150, 159,
Straker, T.W. 298, 587, 603, 614, 616, 638	160, 495, 526
strata 142, 143, 146, 162, 172ff, 301	tides 20
stratified medium 141(ch. 6), 143, 165(ch. 7), 216f	tilt angle 73ff
Stratton, J.A. 32, 34, 137, 638	tilted ionosphere 365
string 195(p)	time average
strong coupling 483	of energy flow 36, 37, 76
structure of ionosphere 14ff	in harmonic fields 32, 34
Strutt, J.W. see Rayleigh, Baron	time of travel
Stuart, R.D. 603, 641	of pulse or wave packet 255, 361; see also
Sturrock, P.A. 368, 638	equivalent height, equivalent path
subdominant term 210 , 213, 425, 454	of wave crest or wave front 111, 403, 409-12;
subprotonic whistler 156, 266, 379	see also phase height, phase path, ray
subscript notation 33, 51, 108, 414, 426, 576	velocity
successive approximations 171, 175, 480f, 509,	Titheridge, J.E. 13, 138, 370, 371, 375, 514, 547,
515ff, 558	630, 639
Suchy, K. xiii, xv, 11, 13, 15, 43, 69, 75, 89, 185,	top of trajectory 342, 344
325, 365, 368, 393, 404, 407, 412, 414, 427,	topside ionogram 367, 369, 371f
428, 497, 519, 559, 576, 579, 613, 635, 638	topside of ionosphere xiii, 13, 365ff
sudden commencement 20	topside sounding 13, 356f, 365 ff, 503
sudden ionospheric disturbance (SID) 19	topside Z-trace 367f
suffix notation see subscript notation	Toshniwal, G.R. 503, 504, 639
summation convention 33, 51, 188, 414 ,	total electron content 375
505, 576	total internal reflection 307, 317
sunspot number 16, 19	total reflection 586
sun	trace of matrix 519(p)
atmosphere 514	trailing diagonal of determinant, matrix 184,
radiation 7	186
zenith angle χ 9	trains of whistlers 378
surface integral 34, 576f	transforming matrix 485, 487, 526, 532, 557f, 573
surface of revolution 104, 112	transition collision frequency 71ff, 86ff, 496
surface waves 3, 6	transition cone 104, 115
susceptibility matrix 49ff, 146, 182, 426	transition direction of wave normal 90ff
Sutton, D.J. 58, 620	transition height 496, 513f
swamping, numerical 558-60, 568, 574f	transition through critical coupling 498f
symmetric tensor 113, 576	transition values of $S = \sin \theta$ 156, 158-60, 532
symmetrical ionosphere, distribution see	transmission coefficient 295(ch. 11), 421, 459,
parabolic distribution, sech ² , sinusoidal	462, 472f, 568, 579, 600–2, 607
layer	transmission coefficient matrix 299ff, 303, 310
	transparency of radio window 535-40, 542f
tables of Airy integral functions 205	transport area of cross section 60, 64(p)
of N(z) 361	transpose of matrix 183
tail of magnetosphere 18	transverse propagation 73, 76, 80, 81, 84, 89,
tail of pulse 323	124, 132, 392; see also east-west
Tang, T. 593, 638	propagation

travelling ionospheric disturbance, TID 7 von Roos, O. 478, 640 trial and error 603 Wait, J.R. 175, 222, 447, 453, 554, 564, 640 triangulated path 346 troposphere 175 Walker, A.D.M. 107, 111, 124, 137, 139, 156, true height of reflection 329, 353-54(p) 182, 376, 380, 565, 640 truncation errors 553 Walker, R.L. 51, 631 tunnelling 439, 459, 533, 593, 596-602 Walkinshaw, W. 1, 261, 564, 565, 616 turning point of ray (also called 'coupling point', Walkup, J.F. 379, 619 'reflection point') 152, 458, 480, 492ff Walsh, E.J. 558, 575, 640 turning points of Ai, Bi, 205f Walters, L.C. 97, 308, 554, 564, 628, 640 Turunen, T. 607, 627 Wand, I.C. 12, 638 Tuve, M.A. 13, 346, 617 Wang, T.I. 390, 531, 640 two separate parabolic layers 336, 363 wanted wave 394 Warber, C.R. 287, 604, 622, 640 ultra-violet radiation 1, 9, 19 warm plasma xiv, 80, 99, 596 uniaxal medium 57, 100(p), 115, 116, 589 Warren, R.E. 287, 604, 622, 640 uniform approximation 216ff, 218, 282, 286, 330, water vapour 1, 175 Watson, G.N. 205, 338, 342, 448, 454, 455, 457, 450, 457, 488, 499ff, 520, 524, 528f unitary matrix 51, 300, 586 462, 467, 477, 528, 598-601, 640, 641 unitary transformation 301 Watson's lemma 250 units 22, 301 Watt, J.M. 552, 624 upgoing wave 148, 263, 561, 592 Watts, J.M. 13, 365, 602, 620, 641 upper bound of error 177 wave admittance 301ff, 442, 444, 533 upper hybrid frequency, resonance 54, 57, 81, wave admittance matrix 302ff 124, 126, 127, 139(p), 368 wave crest, trough 403, 409 Ursell, F. 251, 286, 619, 639 wave front from point source 111, 410 Uscinski, B.J. 639 wave guide xiv, 1, 68, 129, 222, 297, 376, 565 wave impedance 30, 529; see also wave vacuum modes 556f, 562, 570 admittance validity of W.K.B. solutions 176ff, 181 wave interaction xiv, 5, 10, 11, 13, 58, 393-8 valleys 232, 234, 237, 247 wave mechanics 6, 129, 167, 169, 221, 443, 445, in N(z) 371 459 van Duin, C.A. 447, 467, 602, 640 wave normal 110 variation of parameters 515ff wave packet 129, 130, 137, 221, 258, 278, 320-5, Vats, H.O. 97, 98, 616 328ff, 354(p), 391, 412, 418 vector diagram see amplitude-phase diagram wave velocity 34, 67, 111 vector, refractive index as 78, 103, 108f, 113, wave length 146, 254, 402ff, 408 in free space 289, 553 velocity dependence of collision frequency 5, 11, in medium 330, 553 43, 57ff Waynick, A.H. 73, 514, 629 Weber's equation 228(p), 457, 467, 477, 522, 527 vertical component of group velocity 131, 391 Weekes, K. 298, 587, 603, 616, 641 vertical dipole aerials 578f, 602 vertical incidence 131, 192ff, 200, 273f, 329ff, Weisbrod, S. 394, 641 356-72, 391-3, 449, 483ff, 489ff, 493, 499ff, Weitzner, H. 535, 536, 641 507ff, 544ff, 584-7, 592, 607; see also Wentzel, G. 169, 180, 641 west-east propagation 153ff, 163(p), 326(p), 554, normal incidence vertical magnetic field 309, 485, 518(p), 583-91 vertical motions of electrons 440, 589 Westcott, B.S. 438, 447, 453, 466, 475, 556, 641 vertical polarisation 166, 180f, 200, 221, 301, Westcott, C.H. 603, 614 Westfold, K.C. 52, 641 446 - 53vertical propagation in ionosphere 73, 80, 86, Whale, H.A. 131, 360, 636 303, 329ff Whipple, R.T.P. 587, 588, 590, 591, 626 vertical tangents to q curves 150, 157, 158, 160, whistler 4, 42, 106, 119, 134-6, 376-80, 565, 576, 495, 520, 533 579 vertical wave normal 379, 383 whistler mode 85, 86, 106, 140(p), 158, 160, 273, very low frequency (VLF) 13, 16, 60, 194, 223, 367, 376, 497, 514, 542 304, 317, 424, 438, 453, 496ff, 550(ch. 18), whistler polarisation 377 568, 570, 580, 585, 602ff; see also low whistler ray paths 376 frequency White, H.E. 173, 373, 628 Vice, R.W. 312, 573, 622 White, R.B. 448, 597, 640 Vickers, M.D. 370, 639 Whittaker, E.T. 338, 342, 448, 457, 462, 467, Volland, H. 558, 560, 640 477, 528, 600, 601, 641

Whitteker, J.H. 368, 627 Wieder, B. 347, 641 Wilkes, M.V. 9, 477, 587, 590, 618, 642 Willmore, A.P. 13, 642 Wilts, J.R. xv window frequency 54, 56, 105, 136 window point 83, 85, 105, 119, 122, 125, 134, 150, 155, 156, 268ff, 293(p), 495, 537f windows, radio 83, 85, 150, 268, 495, 505, 521, 529, 532-43 wind shear 15 W.K.B. method 170f W.K.B. ranges 572 W.K.B. solutions xiii, 165(ch. 7), 169ff, 219, 243, 256, 388, 402, 441f, 481, 488f, 516, 528f, 543, 572, 588, 598 anisotropic ionosphere 187ff, 192, 483 at great height 551 conditions of validity 176ff, 177, 181, 251, 489 derivation 168f, 170f, 172-177, 180f, 187ff failure of 174, 192, 507 for parabolic N(z) 460 history 170 of Stokes equation 206, 209, 441 properties 178ff source not at infinity 286 vertical incidence 192ff, 451 vertical polarisation 180f

Wolf, E. 114, 115, 616 Wong, K.C. 593, 638 Woodward, P.M., and Woodward, A.M. 205, 642 Wright, J.W. 13, 365, 642 Wronskian 227f(p), 515 Wüster, H.O. 448, 449, 466, 623, 642 Wyller, A.A. 5, 58–60, 636 x-rays 1

Yabroff, I.W. 308, 376, 642 Yeh, K.C. 20, 642 Yokoyama, E. 304, 642

Z-mode **84**, 157f, 163(p), 268, 357, 533, 540, 592 Z-trace 357ff, 362, 367f, 485, **503**–5 Zacharisen, D.H. 13, 620, 642 zenith angle of sun χ 7 zero order approximation 516 zero of Ai and Bi 205f of ε , ε , ε , 54, 56

of A1 and B1 2051 of ε_1 ε_2 ε_3 54, 56 of q 149, 155, 198 of refractive index 79, 357 Ziolkowski, R.W. 281, 642 Zucker, F.J. 430, 577, 642