
Index

- absolute temperature 23, 30
 Ackeret, J. 4, 5, 223, 230
 acoustics 2, 26, 27
 Adams, N. A. 226, 230
 Adamson, T. C. Jr. 115, 224, 230
 adiabatic change 31
 aeroacoustics 5, 7, 161, 227
 aerodynamics, acoustic version of 26, 27, 149
 aerofoil
 boundary condition 148
 far field 152
 hypersonic 152
 Laplace's equation 148
 lift coefficient 150
 linear theory 26, 145
 nonlinear theory 152
 oscillation 160, 161
 subsonic 148
 supersonic 148–51
 thin 26, 146
 transonic 4, 152–60
 wave-drag coefficient 151
 aeronautics 2
 Agarwal, R. 6, 224, 230
 Ahuja, K. K. 244
 air
 enthalpy 53
 internal energy 53
 isentropic relations 53
 sea level 3
 specific heats 53
 speed of sound 53
 aircraft, hypersonic 2
 Amiet, R. K. 161, 227, 230
 Anderson, J. D. 54, 224, 230
Annual Review of Fluid Mechanics 6, 225
 Apazidis, N. 225, 230
 Ardalan, K. 220, 227, 230
 Ardavan, H. 227, 230
 argon 51
 Argrow, B. M. 231
 Arnette, S. A. 226, 230
 astrophysics 5
 Atkins, M. D. 243
 Auriault, L. 244
 available energy 33
Aviation Week 5
 Avogadro's constant 47

 Bachor, H.-A. 239
 Bader, R. 6, 160, 224, 234
 Balakumar, P. 226, 230
 ballistics 4, 133
 Balsa, T. F. 226, 230
 Barkhudarov, E. M. 204, 225, 230
 barotropic flow 29
 perfect gas 53
 Barre, S. 226, 230
 Bassett, G. M. 226, 230
 Bassom, A. P. 243
 Bastin, F. 226, 230
 Batchelor, G. K. 28, 230, 239
 Bauer, F. 161, 230
 Beattie, D. R. 231
 Beavan, J. A. 160, 223, 239
 Bechtold, J. K. 236
 Beltrami flow 60
 Ben-Dor, G. 115, 204, 224, 231, 232, 237,
 238, 245
 Benjamin, R. F. 237
 Bergmeier, G. G. 233
 Bernoulli's equation 56, 210
 polytropic gas 61, 63
 steady flow 59
 irrotational flow 62
 Bers, L. 131, 161, 224, 231

Bertolotti, F. P. 226, 231
 Bethe, H. A. 115, 223, 231
 Bethe–Weyl theorem 92
 Bethe–Zel’dovich–Thompson fluid 92
 bi-characteristic curve 77–8, 80–1
 bi-characteristic direction 76, 79
 bi-characteristic equations 79
 Bickley, W. G. 6, 142, 223, 231
 Blackaby, N. D. 226, 231
 Blaisdell, G. A. 226, 231
 Bleakney, W. 115, 223, 231
 body force 10, 15, 17, 21
 conservative 57
 due to gravity 27
 body torque 20
 Boeing 5
 Boltzmann’s constant 47, 51
 Bonnet, J. P. 224, 231
 Borisov, A. A. 224, 238
 Botta, N. 227, 231
 boundary layer 5, 55
 in rarefied gas 21
 boundary, thermally insulating 31
 Bourne, N. K. 225, 231
 Bowman, C. T. 240
 bow shock 154, 157
 Boyd, I. D. 225, 226, 231
 Boyle’s law 46
 Bradshaw, P. 224, 231, 236
 Brazier, J.-Ph. 243
 Brennen, C. E. 242
 Bridges, J. 226, 231
 Broadwell, J. E. 225, 231
 Brouillette, M. 225, 231
 Brown, B. P. 225, 231
 Brown, S. N. 226, 232, 243
 Brusniak, L. 226, 232
 bubble, subsonic 157
 bubble, supersonic 153
 Buresti, G. 131, 227, 232
 Busemann, A. 5, 223, 224, 232
 Buttsworth, D. R. 204, 225, 226, 232

 Cabannes, H. 115, 223, 232
 Cambon, C. 227, 232, 243
 Candel, S. 230
 Candler, G. V. 204, 237, 240
 Cappelli, M. A. 231
 carbon atom, mass of 47
 carbon monoxide 51
 Carnot’s law 47
 Casarosa, C. 131, 232
 Cassel, K. W. 226, 232
 Cattafesta, L. N. 240
 Caughey, D. A. 160, 224, 232
 Chandrasekhar, S. 5
 Chang, C.-C. 227, 232

Chang, C.-L. 161, 226, 232
 channel flow at low Mach number 131
 Chaplygin, S. A. 220, 223, 232
 Chaplygin’s equation 208
 polytropic gas 210
 separable solutions 210
 sonic line 208
 characteristics 4
 curves 68
 flow round bend 174
 ordinary differential equation on 169
 surfaces 67–75
 two-dimensional flow 165
 Charyk, J. V. 6
 Cheng, H. K. 224, 232
 Chéret, R. 115, 237
 Cherry, T. M. 131, 232
 Chisnell, R. F. 225, 232
 Cho, H.-J. 235
 choked flow 125–6
 Chpoun, A. 204, 225, 232
 circulation 65
 Clausius–Clapeyron equation 29
 Clemens, N. T. 226, 232
 coefficient
 Joule 43
 Joule–Kelvin 43
 Joule–Thomson 43
 of nonlinearity 37, 42; *see also* nonlinearity,
 coefficient of
 of thermal expansion 37, 88–9
 Cohen, D. 160, 223, 237
 Cole, J. D. 160, 161, 224, 232, 240
 Colella, P. 204, 225, 232, 236
 Coleman, G. N. 227, 232, 236, 243
 Colonius, T. 226, 227, 233
 combustion 3, 5, 7
 compressibility 1, 2
 isothermal 37
 perfect gas 49
 polytropic gas 53
 neglect of 27
 due to weight of fluid 27
Concorde 2
 conduction, thermal 28
 conductivity, thermal 19, 20
 nonnegative 32
 cone of normals 73–83
 conical flow 133
 conservation of energy 16–18
 conservation of mass 7–14, 18
 conservation of momentum 14, 18
 constitutive relation 20
 contact discontinuity 86
 contact line 86
 contact surface 86
 Cook, L. P. 160, 224, 232

- Cope, W. F. 223, 233
 Corke, T. C. 235
 Courant, R. 5, 6, 83, 115, 176, 204, 220, 221, 224, 233
 Cowley, S. J. 226, 231, 233
 Cox, E. A. 227, 233
 Cramer, M. S. 161, 225, 227, 233, 240
 Crickenberger, A. B. 233
 Crighton, D. G. 233, 235, 241
 critical condition 122
 critical curve 216–17
 critical Mach number 153
 critical point 37
 critical speed 95, 122
 Crocco, L. 131, 223, 233
 Crocco's equation 56, 58, 61, 63, 64
 Crow, S. C. 225, 233
 Crutchfield, W. Y. 204, 236
 Cumberbatch, E. 83, 245
 Curle, S. N. 220, 224, 233
 Curran, E. T. 224, 233
- Daily, J. W. 246
 Davies, H. J. 220, 224, 233
 Davies, R. M. 239
 degrees of freedom of molecules 50–1
 Delale, C. F. 225, 227, 233
 delta wing 161–2
 Demmig, F. 237
 Derby 4
 Descartes, folium of 110
 detachment condition 185, 193
 detachment line for regular reflection 189, 192–3, 196
 diatomic gas 51
 Dillmann, A. 226, 227, 233
 Ding, Z. 225, 233
 discharge from reservoir, maximum 126
 discontinuity, weak 67
 dissipation of acoustic energy 20
 dissociation 51
 Dolez, N. 244
 Dolling, D. S. 232
 Donaldson, C. duP. 6
 Donovan, A. F. 229
 Donovan, J. F. 226, 233, 243
 Doppler 4
 factor 2
 Dowling, A. P. 237
 drag coefficient 151
 Duck, P. W. 226, 233, 244
 Durand, W. F. 223, 233
 Durbin, P. A. 227, 234
 Dussauge, J. P. 230
- Earnshaw, S. 5, 223, 234
 edge in hodograph method 215–18
- Einstein, A. 4
 Elliott, G. S. 230
 Emmons, H. W. 229
 Emrich, R. J. 115, 223, 231
Encyclopedia of Physics 6, 222, 229, 230
 energy
 acoustic 20
 available 33
 equation 19, 23, 24
 fluid-dynamical 42, 50
 ideal fluid 55
 perfect gas 50
 thermodynamic 33
 equipartition 51
 Gibbs 33
 Helmholtz 33
 internal 16, 31, 33
 air 53
 isentropic derivatives 43
 perfect gas 46, 50
 polytropic gas 51, 53
 kinetic 17
 molecular 20, 47
 total 58
 translational 20
 vibrational 51
 enthalpy 3, 21, 33, 36
 air 53
 free 33
 isentropic derivatives 44
 perfect gas 46
 polytropic gas 52, 53
 thermodynamic derivatives 43
 entropy 3, 21, 23, 36
 definition 30
 gradient 60
 ideal fluid 32
 increase 19, 31–3
 jump 80
 at weak shock 91
 non-ideal fluid 32
 perfect gas 48
 polytropic gas 52
 epicycloid, in hodograph method 216–17, 219
 equation
 Bernoulli's 56
 Chaplygin's 208
 Clausius–Clapeyron 29
 conservation form 18
 Crocco's 56, 58, 61, 63, 64
 Euler's 24
 hypergeometric 210
 Kármán–Guderley 160
 Laplace 148
 momentum 22
 Navier–Stokes 21

250

equation (*cont.*)
 non-conservation form 18
 of state 21, 29, 34, 40
 convex 37, 88, 89, 202
 ideal gas 45
 perfect gas 45–7
 transonic small-disturbance 160, 163
 transport 82, 83
 Tricomi's 209
 vorticity 57
 wave 26, 148, 161
 equilibrium, molecular 20
 equilibrium state 29–31
 equilibrium thermodynamics 32
 equipartition of energy 51
 Erlebacher, G. 225, 227, 233, 234, 242
 Erwin, D. A. 241
 Euler equations 24
 Evvard, J. C. 131, 223, 234
 expansion fan 129, 133

 Falcovitz, J. 236
 fan, expansion 129, 133
 Fanno line 131
 Farnborough 4
 Fedorchenko, A. T. 227, 234
 Ferguson, D. F. 238
 Fernández de la Mora, J. 242
 Fernando, E. M. 226, 234
 Ferrari, C. 5, 160, 224, 234
 Ferri, A. 83, 115, 142, 176, 223, 224, 234
 Ffowcs Williams, J. E. 224, 234
 F-function 152
 Fichman, M. 235
 Field, J. E. 115, 204, 224, 231, 238
 flight, high-speed 1
 flow
 ballistic 133
 barotropic 29
 Beltrami 60
 compressible 5
 three types 25
 conical 133
 effectively incompressible 3, 27
 high speed
 definition 1, 26
 history 3
 homenergetic 59
 homentropic 29, 55
 hypersonic 1, 2, 3, 5, 20, 21
 incompressible 1, 2, 3
 inviscid 29
 irrotational 55
 isoenergetic 59
 low speed 2
 nonsmooth 67

Index

one-dimensional 12, 84, 132, 178
 rarefied 21
 Ringleb's 213–16
 smooth 55
 spiral 211
 steady 55, 58
 subsonic 1, 2, 148
 supersonic 1, 2, 148–51
 Temple's 220
 transonic 1, 2, 4, 152–60
 Flügge, S. 6, 222, 229
 fluid
 complex 20
 homogeneous 39
 ideal 28, 46
 Newtonian 20, 22, 23
 physical properties 28
 fluid dynamics, computational 4
 fold, in hodograph method 215–16
 folium of Descartes 110
 force 8
 fictitious 11
 Fox, M. D. 225, 234
 frame, inertial 11–12
 Frankl, F. I. 5, 223, 234
 free energy
 Gibbs 33
 Helmholtz 33
 free enthalpy 33
 Freidberg, J. P. 131, 243
 Frick, C. W. 160, 223, 234
 Friedlander, F. G. 83, 234
 Friedrichs, K. O. 5, 6, 83, 115, 176, 204, 220,
 221, 223, 224, 233, 234
 Friedrichs theory 68, 166
 fundamental gas-dynamic derivative 37
 Fu, Y. 226, 234

 Gai, S. L. 54, 239
 Gallis, M. A. 226, 234
 Gamow, G. 5
 Garabedian, P. 161, 230
 Garrick, I. E. 160, 223, 234
 gas
 dense 92
 diatomic 51
 ideal 45, 46
 monatomic 51
 perfect 37
 Grüneisen parameter 49
 polytropic 51
 gas constant 3, 51
 universal 45, 47
 gas dynamics 28
 gas-particle mixture 131
 General Electric 5

- Germain, P. 6, 160, 224, 234
 Ghosh Choudhuri, P. 226, 234
 Gibbs free energy 33
 Gibbs function 29, 33
 isentropic derivatives 45
 perfect gas 49
 polytropic gas 52
 thermodynamic derivatives 45
 Gilruth, R. R. 229
 Gimelshein, S. F. 224, 236
 Glass, I. I. 115, 204, 224, 231, 234
 Glauert, H. 160, 223, 234
 Gnoffo, P. A. 224, 235
 Goddard, F. E. 131, 223, 229, 235
 Goldshtein, A. 227, 235
 Goldstein, M. E. 224, 226, 230, 235
 Gracewski, S. M. 233
 Grésillon, D. 224, 231
 Griffith, W. C. 115, 224, 226, 235
 Grinstein, F. F. 224, 235
 Grosch, C. E. 226, 235, 236
 Grove, J. W. 204, 225, 235, 236
 Grubin, S. E. 226, 235
 Grüneisen parameter 41, 42, 89
 negative 91
 perfect gas 41, 49
 polytropic gas 53
 positive 88
 Guderley, K. G. 6, 115, 223, 224, 235
 Guderley supersonic patch 183–4
 Guha, A. 225, 235, 246
 Gülen, S. C. 225, 235
 Guo, Y. P. 226, 235
 gust interactions 161
 Gutfinger, C. 235
 Gutmark, E. J. 224, 235

 Haas, J.-F. 237
 Haase, W. 243
 Haddad, O. M. 226, 235
 Hall, P. 231, 233, 234
 Hamiltonian 79
 Hamilton's equations 78
 Hammerton, P. W. 225, 226, 235
 Harvey, J. K. 234
 Hatta, N. 236
 Hawthorne, W. R. 229
 Hayes, W. D. 115, 223, 224, 235
 He, J. 226, 235
 head 58, 59
 Heaslet M. A. 223, 230, 235
 heat flow 17, 30
 heat flux 8, 10, 20, 21
 heat function 33
 Heilig, W. 236
 Heiser, W. H. 224, 233

 Heister, S. D. 227, 235
 Helenbrook, B. T. 236
 helium 51, 132
 Helmholtz free energy 33
 Helmholtz function 29, 33
 isentropic derivatives 44
 perfect gas 49
 polytropic gas 52
 thermodynamic derivatives 44
 Henderson, L. F. 115, 204, 225, 232, 236
 Henderson line 189, 197–8
 Henderson point 188, 189, 190, 197–8
 Henderson region 189, 197–8
 Hilbert, D. 83, 176, 220, 233
 Hilbert transform 148
 Hirschberg, A. 241
 hodograph equations 208
 polytropic gas 210
 hodograph method 206
 hodograph plane 108, 212
 hodograph transformation 206
 Holmes, R. L. 225, 236
 homenergetic region 59, 60, 63
 homentropic flow 29
 Hornung, H. G. 115, 204, 224, 236
 Houas, L. 237
 Houwing, A. F. P. 239
 Howarth, L. 5, 222, 223, 229, 236
 Howe, M. S. 227, 236
 Hu, F. Q. 244
 Huang, A. 237
 Huang, P. G. 227, 236
 Hugoniot, H. 115, 223, 236
 Hussain, F. 231, 245
 Hussaini, M. Y. 6, 233, 234, 239, 242
 Huygens construction of wavefront 75
 hydrodynamics 2
 hydrogen 51
 hypergeometric equation 210
 hypergeometric function 211
 hypersonic flow, ionization in 21
 hypersonic similarity parameter 114, 152
 hysteresis in shock reflection 184–5
 Hyun, J. M. 226, 236

 ideal fluid 28, 46, 55
 ideal gas 45, 46
 Igra, O. 225, 236
 Illingworth, C. R. 115, 223, 236
 Im, H. G. 226, 236
 internal energy 10, 31, 33
 air 53
 isentropic derivatives 43
 perfect gas 46, 50
 polytropic gas 51, 52, 53
 thermodynamic derivatives 42–3

252

inversion curve 44
 ionization 2, 21, 51
 irreversible process 32
 irrotational flow 55
 isentropic derivative
 enthalpy 44
 Gibbs function 45
 Helmholtz function 44
 internal energy 43
 perfect gas 48, 50
 standard form 42
 isentropic exponent 41
 perfect gas 49
 polytropic gas 53
 isentropic flow of air 53
 isentropic flow of ideal fluid 55
 Ishii, R. 227, 236
 isothermal bulk modulus of elasticity 37
 isothermal compressibility 37
 perfect gas 49
 polytropic gas 53
 Ivanov, M. S. 224, 226

 Jackson, T. L. 226, 235, 236
 Jacobian of hodograph transformation 214–15
 Jacobs, J. W. 225, 237
 Jameson, A. 161, 237
 Janzen, O. 223, 237
 Jendoubi, S. 244
 Jenkins, D. G. 237
 Jenkins, D. W. 235
 jet 5
 cellular shocks 130
 fully expanded 130
 overexpanded 129, 202
 supersonic 4
 underexpanded 130, 140
 Johnson, J. N. 115, 237
 Jones, R. T. 160, 223, 237
 Jones, T. V. 232
 Joseph, D. D. 227, 237
 Joule coefficient 43
 Joule–Kelvin coefficient 43–4
 Joule–Thomson coefficient 43
 Jourdan, G. 225, 237
Journal of Fluid Mechanics 5, 6, 115, 225
 jump conditions 9, 19, 85
 mass 7, 11
 momentum 16
 energy 16
 vortex sheet 86

 Kalkhoran, I. M. 227, 237
 Kantrowitz, A. R. 176, 223, 237
 Karagozian, A. R. 235
 Kármán–Guderley equation 160
 Karni, S. 241

Index

Kassoy, D. R. 245
 Kazakia, J. Y. 235
 Kazhikhov, A. V. 224, 243
 kelvin, unit of temperature 30
 Kelvin circulation theorem 28
 Kelvin, Lord 23
 Kelvin temperature scale 23, 30
 Kerimbekov, R. M. 226, 237
 Kerr, R. M. 245
 Kerschen, E. J. 161, 235, 240, 241
 Kevlahan N. K.-R. 204, 225, 237
 Khorrami, A. F. 226, 237, 243
 kilogram-mole 47
 Kim, J. 232
 kinetic theory 46
 Klages, D. 225, 237
 Klein, D. L. 237
 Kleiser, L. 230
 Kluwick, A. 131, 227, 233, 237
 Knight, D. D. 234
 Konrad, W. 226, 237
 Korn, D. 161, 230
 Korobkin, A. 225, 226, 227, 237
 Kosinov, A. D. 226, 237
 Kreiss, H. O. 242
 Krothapalli, A. 244
 Kruger, C. H. 54, 224, 245
 Kubota, T. 245
 Kulkarny, V. A. 204, 244
 Kuo, C.-Y. 220, 226, 237
 Kuo, Y. H. 223, 237
 Kurosaka, M. 234
 Küssner, H. G. 160, 223, 238
 Kutateladze, S. S. 224, 238
 Kutta condition 148
 Kynch, G. J. 115, 223, 238

 Ladenburg, R. W. 229
 Lafon, P. 230
 lambda shock 157
 Lancaster, O. E. 229
 Landahl, M. T. 160, 224, 238
 Landau, L. D. 28, 54, 115, 220, 223, 224, 238
 Laney, C. B. 6, 224, 238
 Laplace's equation 148
 Laval nozzle 127
 design condition 130
 pressure distribution along 127
 Law, C. K. 236
 Lawrence, H. R. 229
 Lee, C. J. 232
 Lee, S. 225, 238, 239
 Lee, S. R. 236
 Lee, S. S. 238
 Legendre transformation 214, 220
 Lei, S.-Y. 161, 232
 Leib, S. J. 226, 238

- Lele, S. K. 224, 233, 238, 239, 240, 245
 Léorat, J. 244
 Leppington, F. G. 161, 227, 238
 Lesser, M. B. 115, 204, 224, 230, 238
 Levy, A. 225, 238
 Lewis, B. 229
 Li, H. 204, 225, 232, 238
 Liepmann, H. W. 54, 224, 238
 Lifshitz, E. M. 28, 54, 115, 220, 224, 238
 lift coefficient 150
 Lighthill, M. J. 4, 6, 28, 54, 115, 160, 204, 220,
 223, 224, 238, 239
 Likhterov, L. 227, 239
 limit line in hodograph method 213, 216–19
 Lin, C. C. 229
 Liu, J. J. 204, 225, 239
 Lomax, H. 223, 224, 230, 235, 239
 Lozzi, A. 204, 236
 Lu, G. 226, 239
 Luo, K. H. 245

 Maccoll, J. W. 223, 244
 MacCormack, R. W. 224, 239
 MacCrossan, M. N. 226, 239
 Mach, E. 3, 4, 5, 115, 204, 223, 239
 Mach
 angle 167
 disc 128, 180, 182
 intersection 180
 line 4
 in Prandtl–Meyer expansion 135
 refracted 202, 203
 number 1, 4, 25, 26
 critical 153
 history 5
 lower atmosphere 3
 reflection 180, 194
 double 182–4
 Henderson points, lines and regions 197
 inverse 183
 normal reflected shock 189, 198
 number of configurations 195
 sonic criterion 197
 sonic line 189
 stationary 180, 183
 transitional 182–3
 von Neumann point and line 196
 von Neumann region 198
 shock 3, 180
 soot 3
 stem 180
 triangle 167
 triple point 129, 180
 wave 67–8, 100
 in shock reflection 193
 Magi, E. C. 227, 239
 magnetohydrodynamics 5

 Mahesh, K. 225, 239
 Mair, W. A. 160, 223, 239
 Majumdar, S. J. 227, 239
 Malik, M. R. 226, 230, 232, 239
 Mallinson, S. G. 54, 225, 239
 Mansour, N. N. 231, 232
 Manwell, A. R. 220, 224, 239
 Mashayek, F. 227, 239
 Maslov, A. A. 237
 mass equation 19, 21, 24, 55
 mass source 7
 Matarrese, M. D. 239
 matched asymptotic expansions 4, 152
 Maxwell's relations 34
 McDonnell Douglas 5
 McDonough, J. M. 235
 McIntyre, T. J. 225, 239
 Mdivnishvili, M. O. 230
 mechanical equilibrium condition 180, 185
 Mee, D. J. 241
 Meier, G. E. A. 243
 Meiron, D. I. 220, 230
 Menikoff, R. 54, 115, 204, 224, 235,
 236, 239
 Messiter, A. F. 115, 224, 226, 230, 239
 Meyer, R. E. 83, 176, 223, 239, 240
 Meyer, Th. 142, 223, 240
 Mikhailov, V. V. 224, 240
 Miles, J. W. 64, 160, 224, 240
 Miller, M. F. 226, 240
 Milne–Thomson, L. M. 28, 220, 240
 Mitchell, B. E. 227, 240
 mixing layer 5
Modern Developments 5, 229–30
 modulus of elasticity 37
 Moin, P. 233, 238, 239, 240, 245
 molar mass 47
 mole 47
 molecular energy 47, 51
 molecular mass 47
 molecular weight 47
 Molenbroek, P. 220, 223, 240
 momentum equation 19, 22, 24, 55
 Monaco, J. F. 161, 227, 240
 monatomic gas 51
 Mond, M. 225, 240
 Monge cone 73–82
 Moody, D. M. 226, 240
 Moore, D. W. 227, 240
 Moore, F. K. 6, 223, 229, 240
 Morawetz, C. S. 160, 240
 Moretti, G. 115, 224, 240
 Morgan, R. G. 232
 Morris, P. J. 226, 240
 Moser, R. D. 232
 Mudford, N. R. 54, 239, 244
 Mungal, M. G. 232, 240

254

Muntz, E. P. 241
 Murman, E. M. 161, 240
 Myers, M. R. 161, 227, 240

Nakoryakov, V. E. 224, 238
 NASA 4
 Naughton, J. W. 226, 240
 Navier–Stokes equations 21
 negative shock 115
 Neiland, V. Ya. 224, 240
 neon 51
 Newton, I. 35
 Newtonian fluid 20, 22, 23
 Nieuwland, G. Y. 160, 224, 240
 nitrogen 51
 nonconservation form of equations 18–19
 nonlinearity, coefficient of 37, 42
 negative 91–2
 perfect gas 49–50
 polytropic gas 53
 positive 88–9
 rarefaction shock 92
 nonsmoothness 7, 67
 normal shock 87, 101
 nozzle
 converging 125
 converging-diverging 127
 Laval 127
 in Mach reflection 201
 transonic 131
 N-wave 133, 152

oblique shock
 angle 98
 attached 98–9, 103
 deflection angle 98–9, 106–9
 detached 99, 103
 downstream Mach number 104–5
 hypersonic limit 101, 107, 113, 118–19
 jump conditions 104–5
 maximum deflection 100–1, 107, 114
 Prandtl's relation 108, 118, 204
 pressure-deflection polar 110–14
 sonic downstream velocity 106
 strong 100–2, 111
 transonic limit 101, 107, 113–14
 weak 100–2, 111

Ockendon, H. 224, 240
 Olejniczak, J. 204, 225, 240
 Olson, W. T. 229
 Orient Express 2
 Oswatitsch, K. 223, 224, 240, 241
 overexpanded jet 129, 202
 oxygen 51

Pai, S.-I. 224, 241
 Panaras, A. G. 225, 227, 241

Index

Panda, J. 226, 241
 Park, J. S. 236
 Parry, A. B. 227, 241
 Passerel, D. 204, 232
 Paterson, A. R. 64, 241
 Paull, A. 227, 241
 Peake, N. 161, 227, 239, 241
 Pease, R. N. 229
 Pedelty, J. A. 226, 241
 perfect gas 37
 barotropic flow 53
 coefficient of nonlinearity 49–50
 coefficient of thermal expansion 49
 definitions 45–7
 enthalpy 46
 entropy 48–9
 equation of state 45–7
 fluid-dynamical energy equation 50
 gas constant 45
 Gibbs function 49
 Grüneisen parameter 41, 49
 Helmholtz function 49
 importance 45
 internal energy 46, 50
 isentropic derivatives 48, 50
 isentropic exponent 49
 isothermal compressibility 49
 Joule coefficient 43
 molecular weight 45
 sound speed 49
 specific heats 47, 50
 thermodynamic derivatives 48

Peters, M. C. A. M. 227, 241
 Pham-Van-Diep, G. C. 225, 241
 Pippard, A. B. 54, 241
 piston, accelerating 178
 Plohr, B. J. 54, 115, 224, 239
 Polachek, H. 115, 204, 223, 241
 polytropic gas 39
 Bernoulli's equation 61, 63, 64
 Chaplygin's equation 210
 coefficient of nonlinearity 53
 coefficient of thermal expansion 53
 definition 51
 enthalpy 52–3
 entropy 52
 Gibbs function 52
 Grüneisen parameter 53
 Helmholtz function 52
 hodograph equation 210
 internal energy 51, 52, 53
 isentropic exponent 53
 isothermal compressibility 53
 molecular energy 51
 Prandtl's relation 96
 Rankine–Hugoniot relation 94
 shock conditions 93–8

- shock polar 109
 sound speed 53
 specific heats 51–2
 strong shock 98
 Prakash, J. R. 227, 241
 Prandtl, L. 223, 241
 Prandtl–Glauert factor 148
 Prandtl–Meyer expansion 129–30, 133–44,
 175, 202–3
 in flow round bend 141–2, 175–6
 Prandtl–Meyer function 138, 172
 Prandtl's relation 96, 108, 117
 Prasad, P. 83, 224, 241
 Pratt, D. T. 224, 233
 Pratt and Whitney 5
 pressure 19
 equilibrium 20, 24, 31
 mechanical 19–24, 31
 pressure-deflection polar 110–114, 187, 189
Princeton Series 222, 229, 230
 Probstein, R. F. 224, 235
 propeller 5
 Prosperetti, A. 245
 pseudo-steady flow 180–1
 Puckett, A. E. 224, 238
 Puckett, E. G. 204, 236
 Pullin, D. I. 220, 230, 239, 240

 Quine, C. 230
 Quirk, J. J. 225, 241

 Ragsdale, W. C. 235
 Raizer, Yu. P. 6, 54, 115, 224, 246
 Raman, G. 226, 242
 Rankine–Hugoniot relation 88–90, 92, 94
 Rankine, W. J. M. 115, 223, 242
 Rao, K. K. 241
 rarefaction shock 92, 115, 161
 rate of strain 21
 Ravindram, R. 83, 241
 ray 76–7
 cone 74
 conoid 73–9
 direction 80–2
 tracing equations 79
 Rayleigh, Lord 115, 223, 242
 Rayleigh line 131
 reflection
 Mach 180, 194–9; *see also* Mach reflection
 regular 180, 187–94
 Reichenbach, H. 5, 224, 236, 242
 Reijnen, A. J. 241
 Reisman, G. E. 225, 242
 relaxation effect 20
 Renault, R. A. 224, 245
 reversible change 30–1
 Reynolds, W. C. 231, 242

 Reynolds number 26
 Ribner, H. S. 226, 242
 Rich, J. W. 224, 242
 Riemann, B. 83, 176, 223, 242
 Riemann invariant 170, 172–4
 Riemann variable 170
 Riesco–Chueca, P. 226, 242
 Ringleb's flow 211–14
 Robinson, A. 5
 Robinson, S. K. 224, 244
 Roe, P. L. 224, 242
 Rolls–Royce 4
 Rosenhead, L. 239
 Roshko, A. 54, 224, 238
 Rossby number 26
 Rossini, F. D. 54, 223, 229, 242
 Rott, N. 5, 224, 242
 Ruban, A. I. 232, 237
 Rusak, Z. 161, 227, 242
 Rusanov, V. V. 224, 242
 Rutkevich, I. M. 240
 Ryzhov, O. S. 160, 224, 226, 242

 Salcher, P. 3, 4, 5, 223, 239
 Salinger, G. L. 54, 243
 Samimy, M. 230
 Samtaney, R. 225, 242
 Sandeman, R. J. 239
 Sandham, N. D. 226, 242, 245
 Sarkar, S. 226, 227, 242
 Sasoh, A. 204, 225, 243
 Sauer, R. 6, 224, 243
 Saunders, O. A. 131, 223, 243
 scale height 25, 27
 Schadow, K. C. 224, 235
 Schall, E. 243
 Scheichl, St. 237
 Schiffer, M. 64, 220, 223, 243
 schlieren method 3
 Schnerr, G. H. 233
 screech 130
 Sears, W. R. 54, 220, 223, 229, 237, 243
 Second World War 4, 5, 225
 Seddougui, S. O. 226, 243
 Seebass, A. R. 160, 224, 243, 244
 Seeger, R. J. 115, 204, 223, 241
 Seitz, M. W. 243
 Seldam, C. A. ten 245
 Selerowicz, W. C. 227, 243
 Sen, R. 233
 Séror, S. 226, 243
 Serrin, J. 64, 223, 243
 Settles, G. S. 240
 Shajii, A. 131, 227, 243
 Shapiro, A. H. 220, 224, 243
 Sharp, D. H. 236
 shear layer 5, 55

256

shear viscosity 19
 Shepherdson, J. C. 5
 Shevelkov, S. G. 237
 shock 3–6, 9, 15, 28, 67
 angle 98
 angle of incidence 199–200
 angle of reflection 199–200
 attached 98
 deflection angle 98
 detached 98
 entropy increase 33
 focusing 204
 intersection 129, 182
 jump conditions 85–6
 negative 115
 normal 87, 101
 oscillation 130
 polar 108–10, 114, 118, 119
 polytropic gas 92–8
 Rankine–Hugoniot relation 88, 91–2
 rarefaction 92, 115, 161
 reflection 3, 116, 129, 181–202
 splitting 92, 201
 strength 96
 strong 98, 100–2, 111, 117, 193, 200–4
 tube 133
 vorticity generation 60, 204
 weak 91–2, 97, 100–2, 111, 117, 198
 see also oblique shock
Shock Waves 115
 Shu, C.-W. 234
 Shukhman, I. G. 226, 243
 Simeonides, G. 226, 243
 similarity parameter
 hypersonic 114, 152
 transonic 114, 152, 161
 Simone, A. 226, 243
 simple wave 174, 215
 Sislian, J. P. 115, 204, 224, 234
 Sisson, R. A. 161, 238
 Skews, B. W. 204, 225, 243
 slip line 86, 180, 181, 202
 slip stream 86
 slip surface 86
 Smart, M. K. 237
 Smith, D. R. 226, 243
 Smith, F. T. 226, 227, 237, 243, 245
 Smith, J. E. 131, 223, 243
 Smits, A. J. 224, 233, 234, 237, 243, 244
 Sobieczky, H. 160, 224, 243
 Sokolov, I. V. 230
 Solonnikov, V. A. 224, 243
 sonic boom 152
 sonic circle 216–17
 sonic criterion for Mach reflection 197
 sonic criterion for regular reflection 194
 sonic line 153, 208

Index

 for Mach reflection 189
 for regular reflection 189, 194, 197, 201
 sonic point on shock polar 194
 Sorek, S. 238
 sound
 attenuation 51
 barrier 2
 pulse 149
 speed 1–3
 air 53
 isentropic 35
 isentropic derivatives 42
 perfect gas 49
 polytropic gas 53
 stagnation 61, 64
 wave 2, 25, 26
 Spall, R. E. 239
 specific heat 3
 air 53
 constant 35, 50
 constant pressure 34–5
 constant volume 34–5
 perfect gas 47
 polytropic gas 51–2
 principal 34
 temperature dependence 35
 Spee, B. M. 160, 224, 240
 Speziale, C. G. 234
 Spiegelman, M. 225, 243
 Spina, E. F. 224, 226, 233, 243, 244
 Squire, H. B. 223, 244
 stability 5, 92
 stagnation condition 61, 122
 stagnation sound speed 61, 64, 122
 Stalker, R. J. 225, 241, 244
 Stever, H. G. 223, 244
 Stewartson, K. 5, 224, 244
 Stott, J. A. K. 227, 244
 strain tensor 21
 streamline topology 60
 stream tube 120–5
 stress 8, 14, 21
 tensor 10, 14, 19, 20, 22
 strophoid 110
 Strykowski, P. J. 226, 244
 Stuart, J. T. 5, 224, 244
 Sturtevant, B. 204, 231, 244
 subsonic bubble 157
 Sullivan, D. A. 54, 224, 244
 Summerfield, M. 6
 supersonic bubble 153
 surface of discontinuity 9–13, 15
 Sutherland, W. 223, 244
 Sychev, V. V. 224, 240
 Szumowski, A. P. 243
 Taghavi, R. 242
 tail shock 154, 156

- Takayama, K. 204, 231, 243
 Taktakishvili, M. I. 230
 Tam, C. K. W. 224, 226, 227, 244
 Tanaka, M. 227, 244
 Taran, J. P. 224, 231
 Tarkenton, G. M. 233
 Tayler, A. B. 224, 240
 Taylor, G. I. 115, 223, 244
 Taylor, H. S. 229
 Taylor–Maccoll similarity solution 133
 Teipel, I. 224, 244
 temperature
 absolute 23, 30
 gradient 20
 thermodynamic 30
 Temple, G. 223, 244
 Temple’s solution 220
 Terekhin, V. E. 230
 Terent’ev, E. D. 242
 thermal conduction 28
 thermal expansion, coefficient of 37, 49, 53
 thermodynamic change
 adiabatic 31
 irreversible 31, 32, 34
 isentropic 31, 36
 nonisentropic 36
 reversible 30–2, 34
 thermodynamic derivative
 enthalpy 43
 Gibbs function 45
 Helmholtz function 44
 perfect gas 48
 thermodynamic equilibrium 32
 thermodynamic formulae
 arbitrary fluid 37–45
 perfect gas 45–50
 polytropic gas 50–3
 practical 39
 reference collection 39
 standard form 40
 thermodynamic potential 33
 thermodynamic temperature 30
 thermodynamic variable 20–1, 29, 31, 33
 thermodynamics
 first law 31
 second law 30–1
 third law 24, 31
 Thies A. T. 244
 Thompson, P. A. 54, 115, 224, 235, 244
 throat 123
 Tijdeman, H. 160, 224, 244
 Timman, R. 223, 244
 Tirskey, G. A. 224, 244
 Toepfer, A. 3
 Tomasini, M. 227, 244
 total energy 58
 total head 58
 transition curve in hodograph method 215–19
 transonic
 equation 157, 158
 similarity solutions 163
 flow past aerofoil 4, 153
 nozzle 131
 similarity parameter 114, 152, 159
 small-disturbance equation 160, 163
 transport equation 82–3
 Treanor, C. E. 224, 242
 Tricomi, F. G. 160, 224, 234
 Tricomi’s equation 209
 Trigub, V. N. 235
 triple point 129, 180
 triple-shock entropy theorem 202
 Trouvé, A. 246
 Truesdell, C. A. 6, 229
 Tsien, H. S. 64, 223, 244, 245
 Tukey, J. W. 5
 turbine 5
 turbulence 5, 227
 Turkel, E. 224, 245
 Umeda, Y. 236
 underexpanded jet 130, 140
 United Technologies 5
 upwind differencing 160
 vacuum condition 122, 216
 vacuum-condition circle 217
 Vainshtein, P. 235
 van den Berg, H. R. 227, 245
 van der Gulik, P. S. 245
 Van Dyke, M. 6, 115, 204, 224, 245
 variable
 non-thermodynamic 21
 selected 21
 of state 20
 thermodynamic 20–1, 29, 31, 33
 Varley, E. 83, 245
 velocity gradient 19–21
 vena contracta 125–6
 vibrational energy 51
 Vickers, I. P. 226, 245
 Vincenti, W. G. 54, 224, 245
 Virgona, R. J. 204, 236
 Virk, D. 227, 245
 viscosity 19, 28
 bulk 20
 nonnegative 23, 32
 shear 19
 temperature dependence 20
 Volta Congress, Vth 5
 volume, specific 21
 von Kármán, Th. 223, 245
 von Mises, R. 220, 221, 224, 245
 von Neumann, J. 4, 115, 204, 223, 245
 von Neumann

258

von Neumann (*cont.*)
 criterion 180, 185, 196
 line 189, 196–7, 201
 paradox 198
 point 188, 189, 190, 196
 reflection 182–3, 185, 198
 region 189, 197–8
 von Neumann–Henderson theory 185
 von Ringleb, F. 223, 245
 vortex, compressible 211
 vortex sheet 9, 15, 80, 180
 jump conditions 86
 vorticity 22, 60, 65
 equation 57
 generation at shock 60, 91
 Vreman, A. W. 226, 245
 Vuillon, J. 204, 225, 245

Walker, J. D. A. 232, 235, 237
 Wang, C.-W. 161, 242
 Wang, F. Y. 237
 Wang, M. 225, 226, 245
 Wang, Y.-C. 242
 Ward, G. N. 64, 160, 223, 224, 245
 Watanabe, M. 225, 245
 Watson, L. T. 161, 240
 wave 5
 equation 26, 148, 161
 simple 174, 215
 wave-drag coefficient 151
 wavefront 76, 77, 80

Index

Wells, V. L. 224, 245
 Weyl, H. 5
 Whitham G. B. 28, 152, 176,
 224, 245
 Wijnands, A. P. J. 241
 wind tunnel 52
 engineering 131
 supersonic 132
 Woodward, P. R. 230, 241
 work function 33
 Wright, M. J. 204, 240
 Wu, J.-M. 245
 Wu, J.-Z. 227, 245
 Wundrow, D. W. 235

Yang, J. 225, 245
 Yanta, W. J. 235
 Young, A. D. 223, 245
 Young, J. B. 225, 246
 Yu, K. H. 224, 227, 235, 246
 Yuhi, M. 236

Zabusky, N. J. 225, 242, 246
 Zang, T. A. 234
 Zeitoun, D. 204, 245
 Zeitoun, D. E. 243
 Zel'dovich, Ya. B. 6, 54, 115, 224, 246
 Zeman, O. 234
 Zeng, S. M. 246
 Zierep, J. 233
 Zukoski, E. E. 245