

INDEX

(B) refers to Bénard convection, (R-B) to Rayleigh–Bénard convection, and (T-V) to Taylor vortex. Bold numbers indicate where entries are defined.

- amplitude, 16, 47, 98, 119–20, 122–3, 130, 137–9, 142, 155–6, 278
- amplitude equations, (B) 48, (R-B) 72, 98–9, 137–9, 142, 144–46, (T-V) 271–3, 279; *see also* Landau equation
- bounded layers, 142, 144
- aspect ratio, (R-B) **65**, (T-V) **219**
- axisymmetric Taylor vortices, 199, 215, 242 *et seq.*
- amplitude of, 268, 271–3, 289
- anomalous modes of, 251–4, 256
- co-rotating cylinders, 221
- counter-rotating cylinders, 219, 221
- end effects, 219, 243, 248 *et seq.*
- minor vortices, 255–6
- moderately supercritical, theory of, 281 *et seq.*
- nonuniqueness of, 245–8, 281, 287
- numerical studies of, 287
- onset of, 214, 218, 221–2, 250, 276
- short fluid columns, 251, 254
- stability diagram of, 215, 220–1, 281–3
- streamlines of, 218–19, 221, 288
- subcritical, 248
- supercritical, 222, 242 *et seq.*
- unique wave number of, 285–7
- velocity distribution of, 227
- wavelength of, 217, 242–8, 281, 283–6, 290
- weakly nonlinear theory of, 248, 268 *et seq.*
- balance theorem, (R-B) 19, 23, **24**, 25, 72, 96, 121, 129, (T-V) 222, 269, 271
- Bénard cells, 7, 10, 26, 54–5, 57, 59
- Bénard convection, **36** *et seq.*, 54 *et seq.*, 70
- linear theory of, 36 *et seq.*
- weakly nonlinear theory of, 47 *et seq.*, 61, 126
- bifurcation
- imperfect, 33, 56, 80, 181
- subcritical, 33, 156
- supercritical, 20, 80, 216
- bimodal convection, 88
- Biot number, 40–2
- boundary conditions, (R-B) 16, (B) 38, (T-V) 211
- free, 16
- free–free, 13, 18, 25
- lateral, (B) 61, (R-B) 66, 145
- rigid, 16
- rigid–free, 13, 25
- rigid–rigid, 13, 19, 25
- boundary layer, lateral, 143
- bounded layers, (R-B) 25, 65–8, 70, 72, 80–3, 138
- Boussinesq approximation, 11, **14**, 33, 37, 44, 49, 119, 129, 153
- buoyancy, 12, **24**, 25, 37, 46, 59, 64
- buoyancy-driven convection, *see* Rayleigh–Bénard convection
- cell patterns, 25 *et seq.*, 65 *et seq.*, 151
- circular concentric, (R-B) 67–8, 70, 74–5, 77, 82–3, 88, 159–60, 165, 178
- disordered rolls, (R-B) 75–6, 82, 87, 117, 165

334 *Index*

- finite rolls, (R-B) 70–2, 75
 hexagonal, (B) 7, 9–10, 39–40, 43, 47–52, 54–9, 62–3, 70
 hexagonal, (R-B) 12, 26, 29–30, 43, 63, 82, 120–3, 154, 156, 158–59, 161
 irregular, (R-B) 66, 70, 73, 75, 77–8, 83, 86, 125, 151–2
 models of, (R-B) 151–2
 patches, (R-B) 95, 125–6
 preferred, (B) 52, (R-B) 87, 119, 124–5, 129–30, 156, 158
 rectangular, (R-B) 27–8, 70, 120, 123
 regular, (R-B) 66, 75, 77–8, 82, 86–7
 ring cells, (R-B) 30–1, 67, 157, 178, 185, 190
 rolls, (R-B) 12, 20, 26, 27, (B) 40, 49–50, (R-B) 68, 70, 72–3, 76–7, 80, 82, 87, 97–8, 121, 123–5, 130–1, 136, 156, 158, 161
 square, (R-B) 12, 27–9, (B) 61, (R-B) 67–8, 70, 73, 121, 161
 triangular, (R-B) 30, (B) 61
 cell size, (B) 9, (R-B) 19, (B) 59, 63; *see also* wavelength
 supercritical, (B) 47, 50, (R-B) 89
 centrifugal convection, 184; *see also* convection with rotation
 chaos, 103–4, 141, 201, 237–8, 241, 258
 circulation in hexagonal cells
 ascending, (B) 7, (R-B) 156, 158
 descending, (R-B) 63, 156, 158
 fluids, 7, 63, 153
 gases, 64, 153
 containers, (R-B)
 annulus, 73,
 circular, 66, 70, 74–5, 77, 82, 88
 finite, 73–4
 rectangular, 66–73, 75–6, 82, 88–9, 93, 97, 143
 square, 66–70, 72–3, 82, 92
 continuity equation, 13, 37, 119, 211
 continuum of supercritical wave numbers, (R-B) 20, (B) 47, 51–2, (R-B) 87, 119, 124, 126–8, 152, (T-V) 216, 246, 281
 controlled initial conditions, (R-B) 68, 94–5, 126, 132–4, 162
 convection; *see also* Bénard convection; Rayleigh–Bénard convection
 one-dimensional, 73
 onset of, (R-B) 13, 19, 23, 25, 32–5, (B) 41–6, 56, 59, (R-B) 64–6, 72–3, 80, 82–3, 86, 107, 119, 136, 142–3, 154, 160–1, 163
 nonlinear, (R-B) 87 et seq., 119 et seq.
 convection equations, 15, 71
 nonlinear, 120, 122, 129, 131, 139, 147, 149
 convection in spheres and spherical shells, 187 et seq.
 pattern of, 189
 with rotation, 190
 convection with nonuniform heating, 162 et seq.
 critical Rayleigh number of, 169–70
 density circulation, 163, 166–8
 longitudinal rolls, 165, 169–70
 onset of convection, 168–9
 rolls, of alternating size, 163–6, 168
 supercritical wave numbers, 171–2
 transverse rolls, 169–71
 convection with rotation, 173 et seq.
 after rigid rotation, 174, 184
 centrifugal circulation, 178–80, 186
 centrifugal force, effects of, 179, 181, 185, 187
 Chandrasekhar's model, 174, 185–7
 circular concentric rolls, 178
 circular rolls of alternating size, 179
 Coriolis force only, *see* convection with rotation, Chandrasekhar's model
 critical Rayleigh number of, 174–5, 180–1, 185
 critical wave number, 174–5
 onset of, 174, 181, 184
 patterns of, 177
 subcritical, 181
 cooling, (R-B) 78
 Couette flow, 203 et seq., 208, 210–12, 216, 226, 260
 spherical, 302
 stability of, 205, 275–6
 velocity distribution of, 227
 critical slowing down, 34
 critical temperature difference, (R-B) 9, 12, 19, 25, 32–3 (B) 42, 64, (R-B) 64–66; *see also* Rayleigh number, critical
 curvature of rolls, (R-B) 149–50
 defects, (R-B) 66, 77, 129, 147–8, 151
 deformable surface, (B) 41, 43, 49, 58
 degeneracy, 25, 66, 74, 87, 120, 123, 178
 dissipation, 12, 24, 25, 72, 75, 119
 disturbances

- azimuthal, (T-V) 276
 finite (R-B) 33–5, 46, 81–2
 infinitesimal, 5, (R-B) 14, 16, 21, 34, (B) 36–7, 39, 51, (R-B) 123, 128
 infinitesimal, axisymmetric, (T-V) 211–12
 three-dimensional, (R-B) 129
- Eckhaus instability, 20, 127, 281, 283
 energy equation, *see* thermal conduction, equation of
 energy theory (energy method), 34–5, 46, 57, 209
 envelope method, 145
 equation of state, (R-B) 14, (B) 37, (R-B) 119
 equilibrium amplitude, (R-B) 138, (T-V) 268–9, 271, 283
 equilibrium state, (R-B) 119, 136
 expansion of fluid, thermal, 80
- free surface, (R-B) 11, (B) 38
- Ginzburg–Landau equation, (R-B) 142, 146, (T-V) 249, 273
 Görtler vortices, 260
 grain boundaries, 148
 growth rate, (R-B) 17, 21–2, (B) 39, (R-B) 137, 142, (T-V) 212, 216
- heat transfer, convective, 99, 106 et seq.
 discontinuities of, 111
 as function of aspect ratio, 112–14
 in helium, 110–12
 supercritical, continuously increasing, 108, 111
 transitions of, 107–10, 114
 by turbulence, 113–15, 118
 higher modes, (R-B) 31–2
 horizontal temperature differences, effects of, (R-B) 80
 hysteresis, 89, 156, 162, 234
- initial conditions, effects of, (B) 61, (R-B) 126, 156, (T-V) 234, 236, 245, 249–50, 257
- Landau equation, 22, 48, 99, 120, 130, 136 et seq., 273–4
 laser–Doppler velocimetry, 97, 105, 236, 272
 lateral boundaries (lateral walls), (B) 61, (R-B) 65–7, 69, 81, 87–8, 93, 106, 142, 147
- linear approximation, (R-B) 14, (B) 37, (T-V) 213
 Lorenz model, 140–1
- Marangoni number, 40, 41
 critical, 39, 41, 42, 44–6, 56–7
 marginal state, 17, 19, 40
 maximum heat transfer, 121, 124
 membrane equation, 12, 17, 25–6, 29–31, 39–40, 46–7, 70, 123
 models of supercritical convection, (R-B) 139 et seq., 152
- narrow gap approximation, (T-V) 212, 275
 Navier–Stokes equations, 13, 37, 47
 cylindrical coordinates, 211
 nonlinear, 119, 140, 277
 nonlinear terms of, 47–8, 128, 131
 neutral state, 17
 non-Boussinesq effects, (R-B) 153 et seq.
 critical Rayleigh number, 155, 160
 critical wave number, 155, 160
 hexagonal cells, 154, 156–62
 onset of convection, 154, 160
 pattern selection, 154–5
 rolls, 156–62
- nonlinear stability theory, 119
 nonuniqueness, supercritical (R-B) 20, (B) 47, (R-B) 96, 124–6, (T-V) 233, 235, 245–8, 257
- Nusselt number, 85, 106, 108, 112, 114
- oscillatory convection, *see* time-dependent R-B convection
 overall circulation, 163, 179, 300–1
 overstability, 21, 176, 177
 critical Rayleigh number of, 176
- pattern selection, (R-B) 72, 82, 155, 165
 planform, (R-B) 65 et seq.; *see also* cell patterns
 Prandtl number, 15
 principle of exchange of stabilities, (R-B) 23, (B) 41, (T-V) 216
- quantization condition, (R-B) 83, 95, 147, (T-V) 243, 282, 284
- radius ratio, 211
 ramp, (R-B) 149, (T-V) 285
 Rayleigh–Bénard convection, 12, 13 et seq., 39–41

336 *Index*

- bounded, 65 et seq.
- linear theory of, 11 et seq., 25, 86
- moderately supercritical, theory of, 131 et seq.,
- non-Boussinesq, *see* non-Boussinesq effects
- nonlinear, 87 et seq.
- weakly nonlinear, theory of, 119 et seq., 137
- Rayleigh number, **15**
 - critical, 13, **18**, 19–20, 32, 42, 45, 71, 73–5, 84, 86, 108, 155, 160–1
- Rayleigh's stability criterion, 207–10, 220, 221
- reproducibility, 75, 151–2
- Reynolds number, **214**
 - critical, 217
- shape assumption, (T-V) 242, 269
- soft boundaries, (R-B) 147
- spiral turbulence, 261–3, 265; *see also* turbulent Taylor vortices
- stable, **21**
- stability diagram, (R-B) 20, (B) 42, 45, 51, (R-B) 125, 127, 132–6, 144, 157–8, (T-V) 209, 215, 221, 235, 263–4
- stochastic effects, (R-B) 77
- subcritical convection (subcritical instability), (R-B) 32 et seq., (B) 46, 49, 52, 56–7
- sudden start, (T-V) **246**, 252, 257–8, 281
- superposition
 - with nonuniform heating, 163–4
 - with rotation, 179, 186
- surface depressions, (B) 7–8, 44, 57–8
- surface elevations, (B) 44, 58–9
- surface tension, 7, 11–12, 36–9, 43, 46, 51, 54–5, 58, 64
- surface-tension-driven convection, *see* Bénard convection
- symmetry breaking, 70
- Taylor number, 174, **214**
 - critical, **215**, 216–17, 228, 251
 - as function of radius ratio, 217
- Taylor vortex instability, 210 et seq., 254; *see also* axisymmetric Taylor vortices; wavy Taylor vortices
 - critical wavelength of, 216, 222; *see also* wave number, critical
 - linear theory of, 213 et seq., 249
 - nonlinear theory of, 268 et seq.
 - onset of, 214, 216, 218–22, 226, 228, 254, 263
 - spiral form of, 223–4, 279
 - supercritical, 231 et seq., 242 et seq.
 - wide gap, effects of, 217
- Taylor vortices between conical cylinders, 299–301
 - vortices of alternating size, 300
- Taylor vortices between rotating spheres, 301 et seq.
 - basic flow, 302–3, 305
 - local critical Reynolds number, 302
 - stability diagram, 304
 - turbulent vortices, 303
- Taylor vortices between eccentric cylinders, 291 et seq.
 - clearance ratio, **291**, 292, 294, 296, 298–9
 - critical Taylor number, 293–4, 298
 - eccentricity, **291**, 293–5, 298–9
 - onset of instability, 291, 294
 - separation, 293, 295–8
 - theory of, 298–9
 - torque of, 293–4, 299
 - wavelength of, 295, 299
- Taylor vortices between two rotating cylinders, 210 et seq., 263 et seq.
 - spiral turbulence, 261, 265
 - spiral vortices, 265–6, 277
 - stability diagram of, 263–4
 - twisted vortices, 266–7
- temperature distribution in R-B convection, 99, 118
- temperature distribution, static fluid, 15, 157
- temporal evolution, finite amplitude, (R-B) 146–7
- thermal conduction, equation of, 13, 37, 47–8, 167
 - nonlinear, 119, 128
- time-dependent R-B convection, 99, 104, 106, 135
 - boundary layers, effects of, 105–6
 - broad band frequencies of, 100, 102–4, 136
 - coherent oscillations of, 102, 104, 136
 - large aspect ratio, 102, 104
 - lateral walls, effects of, 106
 - line frequency spectrum of, 102–4
 - nonlinear theory of, 135
 - onset of, 102, 105, 116, 136
 - oscillations of, 100, 104–6
 - sharp frequencies of, 102, 136

- small aspect ratio, 102, 105
 temperature fluctuations of, 99–100, 102
 wavy rolls of, 100, 135
- torque, 203–4, 226 et seq., 287
 breaks of torque curve, 226, 228
 supercritical conditions, 229
 theory of, 269–272
- turbulent, (R-B) 116, (T-V) **256**
- turbulent convection, 116 et seq.
 pattern of, 118
- turbulent Taylor vortices, 202, 225, 256 et seq., 268
 axial wavelength of, 258–9, 262
 axisymmetry in the mean, 258, 260, 262
 continuum of wavelengths, 258
 herring-bone pattern, 260
 nonuniqueness of, 257–8, 263
- uniqueness
 critical wavelength, (R-B) 20, (B) 42, (T-V) 216
 hexagonal Bénard cells, 39–40, 42, 47
 supercritical wavelength, (B) 47, 61, (R-B) 96, (T-V) 245, 268, 285–7
- unstable, **21**
- vertical instability, 163–4, 166, 168, 185–6
- viscosity variation, effects of, (R-B) 64, 153–7, 159–62
- wavelength, (B) 8–9, (R-B) **18**, 19, 23, 32, (B) 59, (T-V) **216**; *see also* cell size; axisymmetric Taylor vortices, wavelength of; wavy Taylor vortices
 critical, (R-B) **20**, 25, (B) 55–6, (R-B) 65, 83, 86, 154, (T-V) **216**, 217, 222
 hysteresis of, (R-B) 89, 93, (T-V) 234
 longer than critical, (R-B) 95, 126, 150
 preferred supercritical, (R-B) 94, 96, 119, 130–1, 141–2
 range of supercritical, (T-V) 246, 281–2
 selection of, (R-B) 145–7, 150
 smaller than critical, (R-B) 94–5, 97, 124
 supercritical, (B) 47, 59, 96, (R-B) 93, 97
 supercritical decrease, (B) 59–60, (R-B) 89, (B) 96
 supercritical increase, (B) 59–60, 63, (R-B) 89–90, 90, 92–94, 96–7, 147
 variation of, (B) 59, 63, (R-B) 89, 94, (B) 96, (R-B) 96, 146, (B) 146
- wave number, (R-B) **17**, 18–19, 28, (B) 39, 51, (T-V) **213**; *see also* wavelength
 critical, (R-B) **18**, 20, (B) 42–3, (R-B) 154, 160–1, (T-V) **216**, 217, 271
 preferred, supercritical, (B) 52, (R-B) 121, 128, 136, 145–7
 range of, supercritical, (R-B) 125, 127, (T-V) 246
 selection, (R-B) 147–50, 152
 supercritical, (B) 47, 52, 126
- wavy Taylor vortices, 200, 212, 223, 225, 231 et seq., 257, 265
 amplitudes of, 240, 268
 axial wavelength of, 235, 245, 257–9
 chaotic, 237–8, 241
 co-rotating cylinders, 233
 counter-rotating cylinders, 233, 276
 critical Taylor number of, 232, 279
 irregularities of, 241, 258
 modulated wavy vortices, 237–9
 narrow gap, effects of, 232, 277
 nonlinear theory of, 277 et seq.
 nonuniqueness of, 233–5, 290
 onset of, 232, 240, 242, 268, 275–7, 279, 280
 periodicity of, 236
 power spectrum of, 236
 preferred state of, 235
 regime diagram of, 232
 second frequency of, 236–9; *see also* wavy Taylor vortices, modulated wavy vortices
 shear instability, 279
 theoretical investigation of, 274 et seq.
 wave speed, azimuthal, 235, 237, 239–40, 268, 280. *see also* wavy Taylor vortices, periodicity of
 wide gap, effects of, 232