

INDEX

- Abbe
 - erecting system, 221
 - Type A prism, 225, 226
 - Type B prism, 225, 226
 - version of Porro, 220
- Aberration
 - compensator, 535, 543
- Absorption
 - light, 13, 197, 199, 371
 - thermal, 4, 629
- Acceleration PSD, 6
- Adaptive
 - mirror, 433
 - optics, 334
- Air bags, 453
- Aligning, 525
 - microscope objectives, 527
- Alignment, 131, 414, 428, 514
 - accuracy, 410
 - device, 520
- Aluminum reflective coating, 223
- AlumiPlate, 422
- Amici prism, 216, 217, 218, 228
- Annular rings, 457
- Antireflection, 299
 - coated, 184, 185, 186
 - coatings, 25, 289, 297, 526
- Assembly
 - all plastic, 161, 162
 - drop in, 134, 135
 - epoxy-bonded, 700
 - lathe, 135
 - poker chip, 141
- Athermalization, 586, 612
 - techniques, 585
- Axial
 - compliance, 612, 616
 - preload, 602
- Axicon prism, 237, 238
- Baker-Nunn, 157
- Bauernfeind prism, 233, 234
- Beam footprint, 303
- Beamcombiner, 215
- Beamprint, 301
- Beamsplitter, 215, 216
- Bent optic, 582
- Bevel, flat, 105
- Binocular, 152, 170, 513, 673
 - M19, 154, 177, 673
 - objective, 635, 637
- Biocular prism, 242
- Bipod, 343, 482, 483, 494, 495, 497, 592
- Birefringence, 3, 21, 23, 25
- Bonded
 - mirror, 367
 - mirror mountings, 366
 - optics, 630
 - prism, 274
- Bonding, 274, 276, 279, 280, 281, 282,
284, 366, 368, 371, 372, 375, 381,
383, 386
 - boss, 382
 - lens, 515
- Brazed, 315, 337, 343, 345
- Burnished, 527, 535
- Camera, 157
 - lens, 137, 138
 - objective, 135, 137, 662
- Cantilevered, 92
 - spring, 260, 695
- Cast mirror, 314–316
- Catadioptric, 658
- Cell, burnished, 75, 76
- Chandra telescope, 433
- Clocked, 131
- Coating, 299
- Coefficient of thermal defocus, 590, 592
- Compressive contact stress, 559
- Conductive coating, 184
- Contact areas, 274
- Contamination, 1, 3, 5, 11, 13, 38, 506
- Continuous circular flange, 363, 610, 622,
695
- Contoured-back configurations, 304
- Controlled grinding, 557, 559
- Cooling, rapid, 623, 624
- Core, 328
- Corrosion, 1, 3, 5, 11, 12, 28, 661
 - resistance, 378, 422
- Counterweighted lever-type mountings,
465
- Cube corner prism, 215, 238, 239, 240,
379
- Cylindrical pad, 268, 565, 566

- Deformation, 441, 457
 - contours, 448
- Delta prism, 230, 231, 232
- Differential thread, 146, 165, 166, 167
- Diopter adjustment, 168, 169, 171, 172
- Dispersing prism, 242, 244
- Dispersion, 21, 27, 243, 244, 245, 666, 676, 678
- Dome, 188, 189, 192, 193, 199, 201, 202
- Double-arch mirror, 699
- Double-sided prism, 279
- Dove prism, 206, 222, 223, 225, 227, 230, 274
 - double, 206, 223, 224, 227, 272
- Dowel pin, 427
- DR, 449
- Drop-in assembly, 134, 135, 511
- Dual collimator, 689
- Dual-roller chain support, 448
- Dynamic relaxation (DR), 449, 450

- Earth orbit, 16
- Echelle Spectrograph/Imager (ESI), 676
- Edge-contacted lens, 133
- Egg crate, 318, 319
- Elastomer, 106
 - ring, 109, 513
- Elastomeric, 258
 - bonding, 353
- Electroless nickel (ELN), 337, 345, 422, 423
 - plating, 338, 422
- Erosion, 1, 3, 14, 184, 185, 200, 557
- Error budget, 30, 33, 420, 495, 681
- Eyepiece module, 177

- Factor, a_G , 10
- Far Ultraviolet Spectroscopic Explorer (FUSE), 681
- Finite-element analysis (FEA), 7, 109, 139, 331, 370, 423, 450, 454, 459, 485, 487
 - analyses, 464, 495, 506, 696
 - model, 482, 483, 501, 639
 - modeling, 639
 - techniques, 331

- Fit
 - interference, 77, 83, 84, 139
 - ring threads, 85
- Flange, 190, 513, 580, 605, 616
 - circular, 181
 - clamping, 582, 583
 - retaining, 94, 662
- Flange-like deflections, 605
- Flange-type retainer, 157, 625
- Flat bevel, 625, 653, 655
 - interface, 576
- Flat pad, 268
- Flexure, 280, 360, 391, 408, 412, 413, 416, 417, 421, 679
 - assemblies, 389
 - axis, 478
 - blades, 683
 - interfaces, 476
 - link, 503
 - mountings, 115, 285, 380, 413, 540
 - rods, 473
- Foam
 - core, 328, 343, 699
 - mirror, 704
 - silicon, 332
- Focus adjusting wedge system, 248, 249
- Focus adjustment, 249
- Force (F), 18
- Four-bipod mounting, 498
- Frankford Arsenal prism
 - No. 1, 234, 235
 - No. 2, 234, 235
- Fresnel, 25, 250
 - reflectance, 534
 - reflections, 526
- Friction
 - coefficient of, 49, 66, 363, 737
- Frit bonding, 315, 322
 - construction, 323
- Fungus, 1, 3, 14, 745

- Gemini
 - mirror, 499
 - telescope, 433, 455, 494
- Geostationary Operational Environmental Satellite (GOES), 359
- Ghost
 - image, 289, 296, 300
 - imaging, 346

- ray, 216
- reflection, 297, 298, 299
- Gold, 177, 186, 289, 295, 337, 371, 422
 - coated, 156, 594
 - plated, 588
- Gravity calculations, weight and center of, 68
- H₂O absorption, 727
- Hale telescope, 469, 471
- Heat, absorption, 629
- Heating, rapid, 623
- Hextek
 - construction, 323
 - corporation, 324
 - process, 325
- High pressure, 15
 - window, 191
- High-power, high numerical aperture
 - microscope objectives, 529
- High-shock environments, 142
- High temperature (T_{MAX}), 15
- Hindle
 - mounts, 394, 471, 478
- Hollow corner retroreflector (HCR), 375, 376
- Horizon, 498
- Horizontal axis, 484, 487
- Hub mounted, 685
- Hubble Space Telescope (HST), 433, 460, 465, 500, 588
- Humidity, 11, 12
- Hydraulic
 - actuator, 460
 - mechanism, 452
 - mountings, 483
 - system, 498
- Ideal
 - radial mount, 437, 442, 443, 451
- Image orientation, 2, 293
- Index of air varies with temperature, 589
- Indium, 177, 181
- Infrared, 641
- Infrared Astronomical Satellite (IRAS), 156, 157, 419, 585, 686
- Integral, 421, 428
 - flexure, 413, 414
- mountings, 399
- mounting provisions, 412
- Interface, 411, 428
- Interference fit, 139, 622, 668
- Keck telescope, 396, 471
- Kinematic mounting, 254
- Kuiper Airborne Observatory, 337, 338
- Lateral
 - motion, 465
 - position, 465
 - transfer, 379
- Lathe assembly, 135, 657
- Law of reflection, 205
- Leman prism, 236, 237
- Lens
 - bonded, 116, 117
 - camera, 137
 - element, centering, 44
 - multiple spring clips, 92
 - plastic, 122
 - relay, 132
 - threaded retainer, 363
- Lever, 394
 - mechanism, 452, 463, 441
- Light absorption, 197, 199, 371
- Liquid pinning, 517, 518, 541
- Locating pin, 382, 567, 569
- Low earth orbit, 15
- Low pressure, 15
- Low temperature (T_{MIN}), 15
- Machined core, 325
- Mangin, 296, 299
- Manufacturing procedure, 129
- Mechanisms
 - hydraulic, 452
 - lever, 452
 - pneumatic, 452
- Mercury tube
 - edge mount, 452
 - supports, 451
- Metal, burnished, 77
- Metrology mount, 457, 460, 462, 501
- Microyield strength (S_{MY}), 18
- Minimum thickness, 131

Mirror hub mounting, 388, 686
 Mirror mountings, 371
 clamped, 353
 MISR, 593, 594
 MMT, telescope, 335, 488, 491, 492, 493, 494, 626
 Modular construction, 152, 154, 155, 673
 Modulation transfer function (MTF), 224
 Molybdenum TZM, 625
 Monolithic
 assembly, 323
 closed sandwich, 339, 340
 construction, 319
 fused mirror blank, 321
 mirror substrate, 320, 325
 ULE mirror blank, 322
 Mount, bonded, 60 625
 Multiangle Imaging Spectro-Radiometer, 592
 Multiaperture window, 185
 Multiple
 lead thread, 168, 169
 mirror telescope, MMT, 486
 Multiple-point supports, 453

 Neutral surface, 325, 340, 433, 445, 472
 Nonkinematic, 270

 OAO-C, 319
 Objective, 146, 232, 388, 513, 514, 525, 532, 641, 658
 module, 153
 plastic, 121
 reflecting microscope, 425
 Ocular prism, 239, 241
 Optical transfer function (OTF), 597
 Orientation, 43, 294
 Outgassing, 106, 177, 482, 687

 Pad
 cylindrical, 268
 elastomer, 369, 370
 flat, 268
 resilient, 261
 Partial dispersion, 21
 Pechan prism, 227
 Pellicle, 346, 347
 frame, 348
 Penta
 mirror, 371, 372, 374
 prism, 227, 228
 roof, 373
 Periscope, 293, 668
 Phased, 131
 Photographic
 application, 388
 objective lens, 145, 167
 Pin, 257, 566
 Plastic, 120
 dowelling, 517
 injection-mold, 123
 lenses, 160
 modular assembly, 164
 Pneumatic
 actuators, 460, 488
 cylinder, 457, 491
 mechanism, 452
 mounting, 483, 494
 Poisson's ratio (ν), 19
 Poker chip, 127, 141, 142, 511, 519, 538, 539, 540, 643, 644
 Polishing, 465
 Porro
 erecting system, 217
 mirror, 375
 prism, 208, 209, 216, 219, 220
 Power spectral density (PSD), 8, 9, 742
 Precision spindle, 533
 Preload requirements, 65
 Pressure differential, 190
 Principal functions, 205
 Prism
 Abbe Type A, 225, 226
 Abbe Type B, 225, 226
 Amici, 216, 217, 218, 228
 apertures, 209
 axicon, 237, 238
 Bauernfeind, 233, 234
 biocular, 242
 bonded, 274
 cube, 215
 cube corner, 238, 239, 240
 delta, 230, 231, 232
 dispersing, 242, 244
 double Dove, 206, 223, 224, 227, 272
 double sided, 279

- Dove, 206, 222, 223, 225, 227, 230, 274
- Frankford Arsenal No. 1, 234, 235
- Frankford Arsenal No. 2, 234, 235
- Leman, 236, 237
- ocular, 239, 241
- Pechan, 227
- penta, 227, 228
- Porro, 208, 209, 216, 219, 220
- reversion, 225
- rhomboid, 221, 222
- right angle, 206, 215
- roof penta, 228, 229
- Schmidt roof, 232
- thin wedge, 245

Radial

- clearance, 621
- compliance, 622, 623
- effects, 617

Radiation resistant, 25

Reflecting microscope objective, 425, 529

Reflection, 206

- law of, 205

Reflective coating, 211, 215, 228, 242, 289, 295

- aluminum, 223
- silver, 223

Refraction, law of, 205

Relay lens, 132

Resilient pad, 258, 261

Retainer, 580, 610, 664

- threads, stress, 87, 88
- threaded, 85, 137, 153, 180, 202, 655, 664

Reversion prism, 225

Rhomboid prism, 221, 222

Right-angle/roof penta system, 229

Right-angle prism, 206, 215

Rim, crowned, 55, 105

Ring flange, continuous annular, 84

Risley wedge system, 246, 247

Roller chain, 446

- support, 445

Roof penta prism, 228, 229

Schmidt roof prism, 232

Seal, 169

- dynamic, 63
- elastomeric, 62

Semikinematic mounting, 254, 255

Semimonocoque, 149

Sharp corner interface 571, 572

Short wavelength spectrometer (SWS), 154, 156

Silver, 337

- coating, 379, 506
- reflective coating, 223

Single crystal diamond chips, 407

Single-arch lightweighted mirrors, 388

Sliding wedge, 248

SMR, 377, 378

Snap, 77, 83

SOFIA telescope, 478

Solid catadioptric lens assembly, 655

Spacer

- design, 127
- length, 128
- thin plastic, 133

SPDT, 29, 36, 37, 130, 154, 155, 337, 338, 399–415, 422, 424–429, 514, 518–519, 533, 535, 643–649, 658

Spherical bearing, 388

Spherical interface, 576

Spherically mounted retroreflector (SMR), 377, 378

Spin cast, 332

Spitzer Observatory, 689

Spitzer Space Telescope, 685

Spring

- cantilevered, 74, 84, 260
- straddling, 259, 262, 265, 268

Spring-loaded mirror mounting, 358

Strain ($\Delta L/L$), 18

Strap

- mount, 437, 438, 446, 450
- support, 445

Stress (S), 18

- generation at point, line, and area contacts, 562
- optic coefficient (K_S), 19
- tolerances, rule-of-thumb, 559

Swarovski Optik, 172, 269

- Tangential, 574
 - flexures, 475
 - interface, 572
- Tapered cross section, 609
- Telescope, 232, 525
 - articulated, 668
 - objective, 143
- Temperature
 - changes, 602
 - gradients, 623
- Thermal
 - conductivity (k), 19
 - diffusivity (D), 19
 - expansion coefficient (CTE or α), 19
 - shock, 623, 625, 741
- Thin
 - plastic spacer, 133
 - wedge prism, 245
- Threaded retainer, 363, 514, 612, 655, 695
- Toroidal interface, 574
- Total internal reflection (TIR), 211, 213
- Tunnel diagram, 207, 208, 209

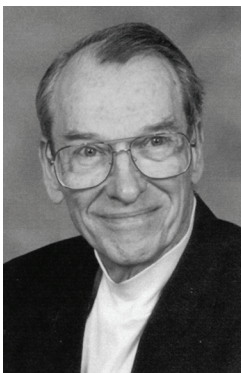
- V-mount, 434, 435, 436, 437, 438, 439, 440, 441
- Vacuum-tight window, 181
- Vertical mirror, 457

- Whiffletrees, 474, 478
- Window, 629

- Yield strength (SY), definition 18
- Young's modulus (E), definition 18

- Zeiss, 146, 170
- Zenith, 498
- Zernike polynomial, 543, 700, 704
- Zoom
 - attachment, 598, 599
 - lens, 165, 173, 600, 601, 653

Biographical Sketch of the Author



Paul R. Yoder, Jr., retired recently from a career as an independent consultant in optical engineering. For more than 50 years he conducted theoretical and experimental research in optics; designed and analyzed optical instruments; and planned, organized, and managed optical technology and electro-optical system projects ranging from conceptual studies and prototype developments to quantity production of hardware. He has held various technical and engineering management positions with the U.S. Army's Frankford Arsenal, The Perkin-Elmer Corp., and Taunton Technologies, Inc.

Yoder authored or coauthored more than 60 technical papers on optical engineering topics as well as *Opto-Mechanical Systems Design* (Marcel Dekker, New York, 1986 and 2nd ed., 1993); *BASIC-Programme fur die Optik* (Oldenbourg, Munich, 1986); Chapter 37, "Mounting Optical Components," in OSA's *Handbook of Optics* Vol. I (McGraw-Hill, New York, 1994); and Chapter 6 "Optical Mounts" in the *Handbook of Optomechanical Engineering* (CRC Press, Boca Raton). He received his B.S. and M.S. degrees in physics from Juniata College (1947) and The Pennsylvania State University (1950), respectively; he is a Fellow of SPIE, a Fellow of OSA, a member of Sigma Xi; and is listed in *Who's Who in Science and Engineering*. Yoder has served SPIE as a member of the board of directors 1982-1984, 1990-1992 and 1994, and was chairman of the publications committee and member of the executive committee, 1991 and 1994. He also is a founding member of SPIE's Optomechanical/Instrument Working Group. He has served as book reviews editor for *Optical Engineering* and as a topical editor for *Applied Optics*. A frequent organizer and chairman as well as an active participant in SPIE and OSA symposia, he has taught numerous short courses on optical engineering, precision mounting of optical components, principles for mounting optical components, basic optomechanical design, and analysis of the optomechanical interface for SPIE, industry, and U.S. government agencies. He also has taught two nationally broadcast courses for the National Technological University Network and has lectured at the University of Arizona and the National University in Taiwan. He received the Director's Award from SPIE in 1996, the Engineering Excellence Award from OSA in 1997, and the George W. Goddard Award from SPIE in 1999.