

The Patrick Moore Practical Astronomy Series

For further volumes:
<http://www.springer.com/series/3192>

Choosing and Using Astronomical Eyepieces

William Paolini



William Paolini
Vienna, VA, USA

ISSN 1431-9756

ISBN 978-1-4614-7722-8

ISBN 978-1-4614-7723-5 (eBook)

DOI 10.1007/978-1-4614-7723-5

Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013939732

© Springer Science+Business Media New York 2013

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

This book is dedicated...

*To my wife, whose love is more inspiring
than any promise of celestial discovery, and
whose beauty is more alluring than any
star-filled sky...*

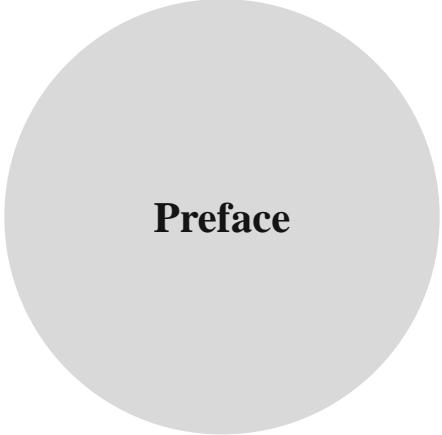
*To my parents, whose love and guidance is a
beacon as sure as the Northern Star... To my
siblings, whose companionship in life brings
comfort like the sight of a familiar
constellation... To my children, whose loving
hands hold the shining stars that are the
hopes, dreams, and achievements of the future.*



Бул китерти...

Менин жубайыма, сүйүсү, ааламдын берген ар түрлүү үмүттөрүнөн да артык, дем берген, суктандырган сулуулугу асмандағы жайнаған жылдыздардай болгон ардагыма арнайм...

Менин жөлөп-таяп, жылуу сүйүсү менен таңқы жылдыздай колдогон ата-энелериме арнайм... Өз колдору менен, мага тааныш кошоктошкон жылдыздардай эле ылайыктуу шарт түзүп беришкен менин биртуугандарыма арнайм... Менин сүйүктүү балдарыма, ушул жаркыраган жылдыздарды - келечек, үмүт жана бакыт-таалай катары тапшырам.



Preface

During the mid-1960s, I received my very first telescope. The prospect of what it would reveal was exciting to say the least, and with my brother's help, I took no time in setting it up so I could begin the adventure with some daytime observing. Back then, the attention was all about the "telescope," and eyepieces commanded no fascination of their own. In fact, eyepieces were just another "thing" that came in the box—they were simply a part of the telescope, like the Moon filter and the solar projection screen. Today of course, this has all changed and both the beginner and seasoned amateur astronomer maintain a keen interest in the eyepiece and the many special attributes it brings to the table that are separate and distinct from what the telescope can provide. With the many advances in eyepiece technology, it is also quite easy to assemble a set of eyepieces that individually contain more optical material than even the observer's telescope might have! And taken all together, a small collection of eyepieces can actually cost much more than the telescope itself. For some observers today, they even form fond attachments to their favorite eyepieces, and as they change and upgrade telescopes over time, their eyepieces remain. Because of all of this, the eyepiece of today has taken on a unique life of its own, as something very special and distinct, and as a much valued and discussed component in the observer's optical arsenal. This new standing for the eyepiece I feel is quite deserved, because it is not the telescope that brought us that experience which the popular idiom coined by Tele Vue Optics so wonderfully describes ("Space Walk Effect"), but it is the eyepiece alone that has accomplished this transformation for the amateur astronomer community. In many ways, the eyepiece of the twenty-first century has grown up and is no longer just another "thing" in the box with the telescope. Instead, the eyepiece is for many a well-deserved center of attention in the consumer astronomy market.

In this book, *Choosing and Using Astronomical Eyepieces*, I strove to present the eyepiece in five distinct ways: introductory for those not too familiar with its basic form and function (Chap. 1), more in depth for those wanting to deepen their knowledge and learn a myriad of tricks-of-the-trade when using an eyepiece (Chap. 2), from the perspective of the eyepiece’s Apparent Field of View capability as this is now a popular way of thinking about an eyepiece and has become the basis by many for how they choose and use eyepieces (Chap. 3), from the perspective of other amateur astronomers from around the world to give a broader perspective that goes beyond the technical and into the heart and soul of the eyepiece (Chap. 4), and, finally, from the all-important “gear-head” perspective where, in the final desk reference section of the book, the reader can peruse and refer to the many statistics and photographs on the over 200 popular new and used eyepiece brands and lines detailed (Chap. 5).

The astronomical eyepiece, once a little considered accessory, is today a much revered, discussed, and transformative component of a telescopic system. No longer are our explorations restricted to “porthole” views with eyes held tight to optics; instead the eyepiece has been the liberator, taking us to ever new heights in observing where the bounds of Earth can seemingly slip away as we immerse our way through space and among the stars.

Vienna, VA, USA

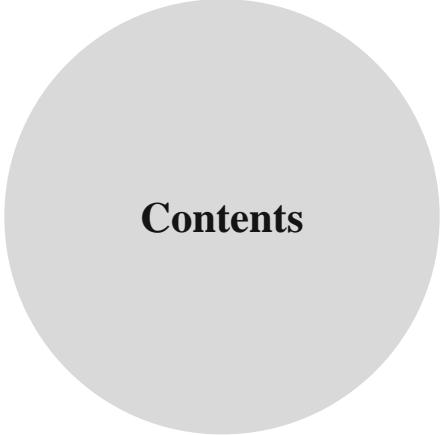
William Paolini Jr.

Acknowledgments

My sincere gratitude goes out to the many individuals and organizations for their contributions and support. Without their selfless contributions of expertise, advice, essays, and photographs, this book would not have been possible. Thanks to Agena Astro Products, Al Nagler, Alexander Kupco, Alpine Astronomical , Andreas Braun, Andy Howie, Baader Planetarium, Blake Andrews, Bob Luffel, Bob Ryan, Brendan Cuddihée, Brent Kikawa, Carlos Hernandez, Carol Anderson, Celestron, Charles Brault, Chris Mohr, Christoph Bosshard, the CloudyNights.com online community, D. Regan, Daniel Mounsey, David Elosser, David Ittner, David Nagler, Denkmeier Optical, Don Pensack, Doug Bailey, Doug Richter, Ed Moreno, Ed Ting, Elmira Amanbekova, Eric Sheperd, Erik Bakker, Erika Rix, Eyepieces Etc., Fred Lamothe, Fukuura Masato, Gary Chiang, Gary Hand, Gary Russell, Geoff Chester, Glen Moulton, Hands On Optics, Hernando Bautista, I. R. Poyser Brass Telescopes, Ian Poyser, Irvin Vann, James Curry, James Spiesterbach, Jamie Crona, Janet Deis, Jeremy K., Jiang Shi Hua, Jim Barnett, Jim Rosenstock, John Levine, John W., John Watson, Judson Mitchell, Keith Howlett, Konstantinos Kokkolis, Kson Optics-Electronics Company, Larry Eastwood, Long Perng Optics, Lyra Optic, Malcolm Neo, Marisa Dominello, Mark Liu, Marty Stevens, Maury Solomon, Meade Instruments Corporation, Michel Guévin, Michelle Meskill, Mike Bacanin, Mike H., Mike Hankey, Mike Ratcliff, Mike Rowles, Mike Sutherland, Mike Wooldridge, Neil English, Neville Edwards, Orion Telescopes & Binoculars, Patrick O'Neil, Paul Surowiec, Paul Webb, Peter Sursock, Phil Piburn, Raisa Kydyralieva, Roman Seestakov, Russ Lederman, Russell Optics, Samuel de Roa, Sherry Hand, Sophia Tu, Springer Science and Business Media, Stephen Bueltman, Stephen Chen, Steve Couture, Steve G., Steve Staph, Steven Cotton, Surplus Shed, TALTELEOPTICS, Tamiji Homma, Tele Vue Optics, Thomas McCague, Tim Wetherell, Tom Morris, Tony Miller, U.S. Naval Observatory, Uwe Pilz, Vixen Optics, Wade Wheeler, and William Rose. If I have inadvertently omitted a contributor

to this effort, please accept my sincerest apologies and know that I am forever appreciative of the help and support you so graciously provided.

I also wish to thank my family and friends for their unwavering encouragement and support throughout this process: Aaron Paolini, Anthony Paolini, Jr., Ayanna Amanbekov, Aydar Shailev, Christina Paolini, Christopher Paolini, Claire Paolini, Dastan Sadykov, David Paolini, Dinara Amanbekova, Emily Straub, Frank DiLuzio, Helen Paolini, Jacqueline Diluzio, Janice Kupersmith, Jeanne Ayivorh, John Condia, Laritta Paolini, Louis Paolini, Michael Mencer, Murat Amanbekov, NiiBen Ayivorh, Patricia Amanbekova, Pepper, Raisa Kydyralieva, Russell Kupersmith, Sharon Condia, Ted Straub, Tursun Sadykov, Ulan Amanbekov, Virginia Paolini, and William Paolini, Sr.



Contents

Part I Background

1 Introducing the Astronomical Eyepiece.....	3
Historical Beginnings.....	3
Basic Function	7
Physical Construction	8
Optical Construction	12
Optical Design Characteristics.....	15
Focal Length	16
Apparent Field of View (AFOV)	18
Eye Relief.....	20
Exit Pupil Behavior.....	22
Internal Reflections and “Ghosting”	24
Aberrations (Including Distortions).....	25
2 Choosing Eyepieces and Observing Strategies.....	33
Viewing Comfort and Usability Considerations	33
Eye Relief.....	34
Construction and Mechanical Features.....	35
Size and Weight	41
Visual Impact Considerations	43
Apparent Field of View (AFOV)	44
True Field of View (TFOV)	45
Magnification, Brightness, and Contrast.....	53
Aberration Control (Telescope Dependencies).....	55
Observing Strategies	56
Focal Length Choices	56

Calculating Exit Pupil	60
High Magnification	66
3 Eyepieces and Accessories for Celestial Targets.....	73
Celestial Targets	74
The Moon.....	74
Stars and Clusters.....	76
Nebulae and Galaxies.....	77
The Planets.....	79
Comparing One Eyepiece to Another	83
Eyepiece Accessory Considerations	84
Barlows and Amplifiers	85
Filters	94
Astro Zoom Zoomset (www.astrozoom.de).....	103
Care and Cleaning of Eyepieces	104
4 Popular Eyepieces by AFOV Class.....	109
The 40° (and Less) AFOV Class.....	109
The 50° AFOV Class	118
The 60° AFOV Class	127
The 70° AFOV Class	131
The 80°–90° AFOV Class.....	135
The 100° AFOV Class	144
The 120° AFOV Class	147
5 Advice from the Amateur Astronomer Community.....	149
20 Years of Personal Eyepiece History (1992–2012)	150
Achieving Focus with Long Focal Length-Rated Eyepieces	150
Astronomical Eyepieces: Objects of Pleasure	150
Benefits of Wider AFOV Eyepieces in Undriven ‘Scopes.....	151
Binoviewing on a Budget	152
28 mm Edmund Scientific RKE	153
24 mm Brandons.....	153
Edmund Plössls.....	153
19 mm Smart Astronomy EF’s.....	154
Choosing a Low Magnification Wide-Field Eyepiece	154
Choosing a Zoom Eyepiece	154
Couture Ball Eyepieces (The Do-It-Yourself Planetary)	155
Eyepiece Basics I	161
Eyepiece Basics II	162
Eyepiece Designs for the Critical Lunar and Planetary Observer	163
Eyepieces: Less Is More	164
General Comments on Eyepieces	165
Jolly Small Eyepieces	166
Learning to Use Hyper-Wide AFOV Eyepieces	167
Learning What Eyepieces Satisfy Your Needs	167
Microscope Eyepieces on Your Telescope.....	168

My Thoughts on Eyepieces for General Observing.....	169
Observing Comets and Nebulae: Brilliance and Wide Field	
Is What We Need First.....	170
Planetary Observing: Resolution and Contrast Is What	
We Need First.....	171
Quick Tip for New Telescope Owners.....	172
Sample Eyepiece Sets for Typical Amateur Telescopes	173
Shallow Sky Sketching Eyepieces	173
Should I Buy Complete Sets of Eyepieces or Mix-and-Match?	174
Some Tips for Viewing the Universe Through an Eyepiece	175
The DIY Eyepiece.....	175
The TV Ethos Series of Eyepieces: Virtues Beyond	
Just 100° of Panorama	176
Try Before You Buy	180
Using Zoom Eyepieces Successfully	180
What Is the Best Eyepiece?.....	181
What Makes a “Favorite” Eyepiece?	183
What to Do with Your Old, Inexpensive Eyepieces.....	183
Young People Can Own Nice Eyepieces, Too!.....	184

Part II Desk Reference of Astronomical Eyepieces

6 How to Use This Guide	187
Market Overview	187
7 Agena to Docter	191
Agena ED (<i>Discontinued</i>)	191
Agena: Enhanced Wide Angle (EWA).....	192
Agena: Mega Wide Angle (MWA)	193
Agena: Super Wide Angle	194
Agena: Ultra Wide Angle (UWA).....	195
Agena: Wide Angle.....	196
Antares: Classic Erfle.....	197
Antares: Elite Plössl.....	198
Antares: Ortho (<i>Discontinued</i>)	198
Antares: Plössl	199
Antares: Speers-WALER Series (Wide Angle Long Eye Relief).....	201
Antares: W70	202
APM: UWA Planetary.....	203
Apogee: Super Abbe Orthoscopic (<i>Discontinued</i>)	204
Apogee: Widescan III (<i>Discontinued</i>)	205
Astrobuffet: 1 RPD	205
Astro-Physics: Super Planetary AP-SPL (<i>Discontinued</i>)	206
Astro-Professional: EF Flatfield	207
Astro-Professional: Long Eye Relief Planetary	207
Astro-Professional: Plössl	208

Astro-Professional: SWA	208
Astro-Professional: UWA	209
Astro-Tech: AF Series 70° Field.....	209
Astro-Tech: Flat Field	210
Astro-Tech: High Grade Plössl	211
Astro-Tech: Long Eye Relief	212
Astro-Tech: Paradigm Dual ED	213
Astro-Tech: Series 6 Economy Wide Field.....	214
Astro-Tech: Titan Type II ED Premium 2" Wide Field	215
Astro-Tech: Value Line Plössl	216
Astro-Tech: Wide Field.....	217
Baader Planetarium: Classic Ortho/Plössl	218
Baader Planetarium: Eudiascopic	219
Baader Planetarium: Genuine Abbe Ortho (<i>Discontinued</i>).....	220
Baader Planetarium: Hyperion/Hyperion Aspheric	221
Standard Hyperions.....	222
Aspheric Hyperions	222
BST: Explorer ED	222
BST: Flat Field.....	223
Bresser: 52° Super Plössl	223
Bresser: 60° Plössl	224
Burgess: Planetary (<i>Discontinued</i>)	225
Burgess: Wide Angle (<i>Discontinued</i>).....	226
BW Optic: Ultrawide (<i>Discontinued</i>).....	226
Carton: Plössl (<i>Discontinued</i>)	227
Cave: Orthostar Orthoscopic (<i>Discontinued</i>)	228
Celestron: Axiom (<i>Discontinued</i>)	229
Celestron: Axiom LX (<i>Discontinued</i>)	230
Celestron: E-Lux (<i>Discontinued</i>)	231
Celestron: Erfle (<i>Discontinued</i>).....	232
Celestron: Kellner (<i>Discontinued</i>).....	234
Celestron: Luminos	235
Celestron: Omni	235
Celestron: Ortho (<i>Discontinued</i>)	237
Celestron: Silvertop Plössl (<i>Discontinued</i>)	238
Celestron: Ultima (<i>Discontinued</i>)	241
Celestron: Ultima LX.....	242
Celestron: X-Cel (<i>Discontinued</i>).	243
Celestron: X-Cel LX	243
Clavé: Plössl (<i>Discontinued</i>)	244
Coronado: CeMax	246
Couture: Ball Singlet.....	247
Criterion: Ortho/Kellner/A.R. (Achromatic Ramsden) (<i>Discontinued</i>)	248
Denkmeier: D21/D14.....	249
Docter: UWA	250

8 Edmund Scientific to Nikon	253
Edmund Scientific: Ortho	253
Edmund Scientific: Plössl	254
Edmund Scientific: RKE	255
Explore Scientific: 68° Nitrogen Purged (ES68 N2)	258
Explore Scientific: 82° Nitrogen Purged (ES82 N2)	259
Explore Scientific: 100° Nitrogen Purged (ES100 N2)	260
Explore Scientific: 120° Nitrogen Purged (ES100 N2)	261
Galland/Gailand/Galoc: Ortho/Erfle/König (<i>Discontinued</i>)	262
Garrett Optical: Orthoscopic (<i>Discontinued</i>)	263
Garrett Optical: Plössl	263
Garrett Optical: SuperWide Angle	264
GSO (Guan Sheng Optical): Kellner	264
GSO (Guan Sheng Optical): Super Plössl	265
GSO (Guan Sheng Optical): Superview	266
GTO: Plössl	267
GTO: Proxima	268
GTO: Wide Field	268
I.R. Poyser: Plössl and Adapted Military	269
Kasai: Astroplan (AP)	270
Kokusai Kohki: Abbe Orthos (<i>Discontinued</i>)	271
Kokusai Kohki: Erfle (<i>Discontinued</i>)	273
Kokusai Kohki: Kellner (<i>Discontinued</i>)	274
Kokusai Kohki: Widescan III (<i>Discontinued</i>)	275
Kson: Super Abbe Orthoscopic	275
Leitz: Ultra Wide (30 mm 88°)	276
Long Perng: 68° Wide Angle	277
Long Perng: Long Eye Relief	278
Long Perng: Plössl	279
Masuyama: Masuyama (<i>Discontinued</i>)	280
Masuyama: Orthoscopic	281
Meade: Research Grade Ortho and Wide Field (<i>Discontinued</i>)	282
Meade: Series II Modified Achromatic MA (<i>Discontinued</i>)	284
Meade: Series II Orthoscopic (<i>Discontinued</i>)	285
Meade: Series 3000 Plössl (<i>Discontinued</i>)	286
Meade: Series 4000 QX Wide Angle (<i>Discontinued</i>)	287
Meade: Series 4000 Super Plössl (Four-Element and Five-Element)	288
Meade: Series 4000 Super Wide Angle (SWA) (<i>Discontinued</i>)	290
Meade: Series 4000 Ultra Wide Angle (UWA) (<i>Discontinued</i>)	291
Meade: Series 5000 HD-60	293
Meade: Series 5000 Plössl	294
Meade: Series 5000 Super Wide Angle (SWA)	295
Meade: Series 5000 Ultra Wide Angle	296
Meade: XWA	297
Moonfish: Ultrawide	297
Nikon: NAV-HW (Hyper Wide)	298

Nikon: NAV-SW (Super Wide)	299
Nikon: Ortho (<i>Discontinued</i>).....	300
9 Olivon to Surplus Shed	301
Olivon: 60° ED Wide Angle	301
Olivon: 70° Wide Angle.....	302
Olivon: 70° Ultra Wide Angle	302
Olivon: 80° Ultra Wide Angle	303
Olivon: Plössl	303
Olivon: Wide Angled Plössl.....	304
Opt: Plössl.....	305
Opt: Super View	305
Orion: Deep View	306
Orion: E-Series.....	307
Orion: Edge-On Flat-Field.....	308
Orion: Edge-On Planetary.....	309
Orion: Epic ED II (<i>Discontinued</i>)	310
Orion: Expanse Wide-Field	310
Orion: GiantView 100° UltraWide.....	311
Orion: HighLight Plössl.....	312
Orion: Lanthanum Superwide (<i>Discontinued</i>)	313
Orion: Long Eye Relief.....	313
Orion: MegaView Ultra-Wide.....	314
Orion: Optilux (<i>Discontinued</i>).....	315
Orion: Premium 68° Long Eye Relief	316
Orion: Q70 Super Wide-Field.....	317
Orion: Sirius Plössl	318
Orion: Stratus Wide-Field	319
Orion: Ultrascopic (<i>Discontinued</i>)	320
Owl Astronomy: Advanced Wide Angle	321
Owl Astronomy: Black Knight Super Plössl	321
Owl Astronomy: Enhanced Superwide.....	322
Owl Astronomy: High Resolution Planetary	324
Owl Astronomy: Knight Owl Ultrawide Angle.....	324
Parks: Gold Series	325
Parks: Silver Series	326
Pentax: SMC Ortho (<i>Discontinued</i>)	327
Pentax: XF	329
Pentax: XL (<i>Discontinued</i>).....	330
Pentax: XO (<i>Discontinued</i>)	331
Pentax: XP (<i>Discontinued</i>).....	332
Pentax: XW	332
Rini: Various Eyepieces	334
Russell Optics: 1.25 in. Series	335
Russell Optics: 2 in. Series	336
Siebert Optics: MonoCentricID	337

Siebert Optics: Observatory	338
Siebert Optics: Performance Series	340
Siebert Optics: Planisphere	341
Siebert Optics: Star Splitter/Super Star Splitter.....	342
Siebert Optics: Ultra	343
Sky-Watcher: AERO	344
Sky-Watcher: Extra Flat.....	345
Sky-Watcher: Kellner.....	345
Sky-Watcher: LET/Long Eye Relief (LER).....	346
Sky-Watcher: Nirvana UWA	346
Sky-Watcher: PanaView.....	347
Sky-Watcher: Sky Panorama.....	347
Sky-Watcher: SP-Series Super Plössl	348
Sky-Watcher: Super-MA Series.....	348
Sky-Watcher: Ultra Wide Angle	349
Smart Astronomy: Extra Flat Field (<i>Discontinued</i>)	349
Smart Astronomy: SA's Solar System Long Eye Relief (<i>Discontinued</i>)	350
Smart Astronomy: Sterling Plössl.....	351
Stellarvue: Planetary	352
Surplus Shed: Erfles	353
Surplus Shed: Wollensak	354
10 Takahashi to Zooming Eyepieces.....	357
Takahashi: LE	357
Takahashi: Ortho (<i>Discontinued</i>)	358
Takahashi: UW	359
TAL: Super Wide Angle	360
TAL: Symmetrical (Super Plössl)	361
TAL: Ultra Wide Angle.....	362
Telescope Service: Edge-On Flat Field.....	363
Telescope Service: Expanse ED.....	363
Telescope Service: NED "ED" Flat Field.....	364
Telescope Service: Ortho	364
Telescope Service: Paragon ED	365
Telescope Service: Planetary HR.....	365
Telescope Service: RK.....	366
Telescope Service: Plössl	367
Telescope Service: Super Plössl.....	368
Telescope Service: SWM Wide Angle Eyepieces	368
Telescope-Service: Wide Angle (WA)	369
Tele Vue: Delos	370
Tele Vue: Ethos	371
Tele Vue: Nagler	372
Tele Vue: Panoptic	374
Tele Vue: Plössl.....	375

Tele Vue: Radian (<i>Partially Discontinued</i>).....	377
Tele Vue: Wide Field (<i>Discontinued</i>)	378
TMB: 100.....	379
TMB: Aspheric Ortho (<i>Discontinued</i>)	380
TMB: Paragon (<i>Discontinued</i>)	381
TMB: Planetary II	382
TMB: Supermonocentric (<i>Partially Discontinued</i>)	383
Unitron: Kellner/Ortho/Symmetrical Achromat (<i>Discontinued</i>).....	384
University Optics: 70°.....	385
University Optics: 80°.....	386
University Optics: Abbe HD Orthoscopic (<i>Discontinued</i>).....	386
University Optics: Abbe Volcano Orthoscopic (<i>Discontinued</i>).....	387
University Optics: König/König II/MK-70/MK-80 (<i>Discontinued</i>)	388
University Optics: O.P.S. Orthoscopic Planetary Series (<i>Discontinued</i>)	390
University Optics: Super Abbe Orthoscopic.....	391
University Optics: Super Erfle (<i>Discontinued</i>).....	392
University Optics: Widescan II/III (<i>Discontinued</i>)	393
VERNONscope: Brandon	394
Vixen: Lanthanum (LV) (<i>Discontinued</i>).....	396
Vixen: Lanthanum Superwide (LWW)	397
Vixen: NLV	398
Vixen: NPL	399
William Optics: SPL (Super Planetary Long Eye Relief).....	400
William Optics: SWAN	400
William Optics: WA 66°	401
Williams Optics: UWAN.....	402
Zeiss: CZJ Ortho (<i>Discontinued</i>)	403
Zeiss: ZAO I/ZAO II (<i>Discontinued</i>)	404
ZAO-I.....	405
ZAO-II.....	405
Zhumell: Z100	406
Zhumell: Z Series Planetary.....	406
Zooming Eyepieces.....	407
Appendix 1 Formulas and Optical Design Data.....	413
Appendix 2 Eyepiece Performance Classes	419
Appendix 3 Glossary of Terms.....	423
About the Author	429
Index.....	431