

TABLE OF CONTENTS

PREFACE / xi

CHAPTER 1. SYSTEM CONSIDERATIONS / 1

- 1.1 Radiometry / 1
 - 1.1.1 Blackbody radiation / 1
 - 1.1.2 Planck's equation / 1
 - 1.1.3 Stefan-Boltzmann law / 2
 - 1.1.4 Wien displacement law / 2
- 1.2 Atmospheric Transmission / 3
 - 1.2.1 Scattering / 3
 - 1.2.2 Absorption / 4
 - 1.2.3 Infrared windows / 4
 - 1.2.4 Computer calculation / 5
- 1.3 Lens Transmission / 5
 - 1.3.1 Transmittance / 5
 - 1.3.2 Reflectance / 5
- 1.4 Coatings / 7
 - 1.4.1 Single layer coatings / 7
 - 1.4.2 Multilayer coatings / 8
- 1.5 Infrared detectors / 8
 - 1.5.1 Basic relations / 8
 - 1.5.2 Types / 10
 - 1.5.3 Arrays / 11
 - 1.5.4 Matching the detector with the optics / 12
- 1.6 References / 13

CHAPTER 2. OPTICS FUNDAMENTALS / 15

- 2.1 Lens Equation / 15
- 2.2 Stops and Pupils / 15
- 2.3 Optical Formulas / 17
- 2.4 Optical Performance Criteria / 18
- 2.5 Telescopes / 19
- 2.6 Primary Aberrations / 20
 - 2.6.1 Definition of the Seidel aberrations / 20
 - 2.6.2 Variation of primary aberrations with aperture and field height / 22
 - 2.6.3 Stop shift equations / 22

- 2.7 Achromatism / 23
 - 2.7.1 Primary achromatism / 23
 - 2.7.2 Secondary spectrum / 24
- 2.8 References / 24

CHAPTER 3. UNIQUE FEATURES OF THE INFRARED REGION / 25

- 3.1 Optical Materials / 25
 - 3.1.1 Materials for the infrared / 25
 - 3.1.2 Calculation of index of refraction / 27
- 3.2 Thermal Compensation / 28
 - 3.2.1 Focus shift with temperature / 28
 - 3.2.2 Athermalization / 28
 - 3.2.3 Athermalization methods / 29
- 3.3 Cold Stop and Cold Shield / 30
- 3.4 Narcissus / 30
 - 3.4.1 Types of retroreflections / 30
 - 3.4.2 Reduction techniques / 31
- 3.5 References / 32

CHAPTER 4. OPTICAL DESIGN TECHNIQUES / 33

- 4.1 The Optical Design Starting Point / 33
- 4.2 Scaling / 33
- 4.3 Optical Materials Selection / 34
- 4.4 Techniques for Compactness / 35
- 4.5 Symmetry Principle / 35
- 4.6 Bending / 36
- 4.7 Aplanatic Condition / 36
- 4.8 Adding an Element / 37
- 4.9 Field Lens Utilization / 37
- 4.10 Conics and Aspheres / 38
- 4.11 Diffractive Surfaces / 39
- 4.12 Aperture Stop Location / 39
- 4.13 Computer Optimization / 39
- 4.14 Tolerances / 40
- 4.15 References / 40

CHAPTER 5. ZOOM LENSES / 43

- 5.1 Types of Zoom Lenses / 43
 - 5.1.1 Optically compensated zoom lens / 43
 - 5.1.2 Mechanically compensated zoom lens / 46

5.2	Infrared Zoom Lens Specifications / 48
5.2.1	Spectral region / 48
5.2.2	Optical system performance / 49
5.2.3	Aperture / 49
5.2.4	Effective focal length / 49
5.2.5	Magnification range / 49
5.2.6	Size constraints / 49
5.2.7	Operating environment / 49
5.2.8	Distortion / 50
5.2.9	Transmission / 50
5.2.10	Narcissus / 50
5.2.11	Vignetting / 50
5.3	References / 50

CHAPTER 6. REFRACTIVE INFRARED ZOOM LENSES / 51

6.1	Target Simulators / 51
6.1.1	CI Systems / 52
6.1.2	Hughes Aircraft Company / 52
6.1.3	Lockheed Martin / 57
6.2	Scanning Systems / 60
6.2.1	Barr & Stroud / 61
6.2.2	Pilkington P.E. / 63
6.2.3	Optics 1 / 66
6.2.4	Precision-Optical Engineering / 68
6.2.5	Zhejiang University, Dept. of Optical Engineering / 69
6.2.6	Electrooptical Industries Ltd. / 71
6.2.7	Scotoptix / 73
6.2.7.1	Boresighted zoom lens / 73
6.2.7.2	Athermalized zoom lens / 73
6.2.7.3	Optically compensated zoom lens / 78
6.2.8	Optimum Optical Systems / 78
6.3	CCD Imaging Systems / 80
6.3.1	Angenieux / 80
6.4	Laser Beam Expanders / 81
6.4.1	Carl Zeiss / 81
6.5	Diffractive Optics / 81
6.5.1	Optics 1 / 85
6.5.2	Optical E.T.C. and Teledyne Brown / 85
6.5.3	Wescam / 90
6.5.4	Texas Instruments / 92
6.6	References / 94

CHAPTER 7. REFLECTIVE INFRARED ZOOM SYSTEMS / 97

- 7.1 Obscured Systems / 97
 - 7.1.1 Korea Advanced Institute of Science & Technology / 97
 - 7.1.2 Center for Applied Optics, University of Alabama in Huntsville / 98
- 7.2 Unobscured Systems / 99
 - 7.2.1 Hughes Aircraft Company / 99
 - 7.2.2 Optical E.T.C. / 101
- 7.3 References / 103

CHAPTER 8. FUTURE TRENDS / 105

- 8.1 Athermalization / 105
- 8.2 Diffractive Optical Elements / 105
- 8.3 Conics and Aspherics / 105
- 8.4 Materials / 105
- 8.5 Detector Technology / 106
- 8.6 Simulators / 106
- 8.7 Mirror Systems / 106
- 8.8 Wavelength Region / 106
- 8.9 Optomechanical Considerations / 106
- 8.10 Computer Optimization / 107
- 8.11 References / 107

APPENDIX 1. MISCELLANEOUS PATENTS / 109

- No. 3,825,315 / 109
- No. 3,947,084 / 118
- No. 4,659,171 / 126

APPENDIX 2. COMPUTER ANALYSIS OF SELECTED PATENTS / 135

- No. 3,825,315 / 135
- No. 3,947,084 / 136
- No. 4,659,171 / 137
- No. 5,144,476 / 138

INDEX / 139