

# Contents

<i>Preface</i> . . . . .	v
<b>PART I. BASIC PRINCIPLES OF INFRARED RADIATION</b>	
<b>Chapter 1. The Nature of Infrared Radiation</b> . . . . .	<b>3</b>
1.1. What Is Infrared Radiation? . . . . .	3
1.2. The IR Spectrum . . . . .	4
1.3. Advantages and Disadvantages of IR Systems . . . . .	6
1.4. Historical Background . . . . .	7
Early developments in IR techniques—World War II developments in IR—Postwar developments in IR	
<b>Chapter 2. Basic Physical Laws and Principles</b> . . . . .	<b>14</b>
2.1. Black-body Radiation . . . . .	14
2.2. Planck's Law . . . . .	15
2.3. Wien's Displacement Law . . . . .	15
2.4. Stefan-Boltzmann Law . . . . .	17
2.5. Emissivity . . . . .	17
2.6. Inverse-square Law . . . . .	18
2.7. Lambert's Law of Cosines . . . . .	19
2.8. Use of the Basic Laws in IR Calculations . . . . .	19
2.9. A Generalized IR System . . . . .	22
2.10. Passive and Active IR Systems . . . . .	25
<b>Chapter 3. Infrared Radiation Sources</b> . . . . .	<b>28</b>
3.1. Types of IR-radiation Sources . . . . .	28
3.2. Artificial Sources . . . . .	29
3.3. Active Sources . . . . .	29
3.4. The Nernst Glower . . . . .	31
3.5. Tungsten-filament Lamps . . . . .	31
3.6. Mercury and Xenon High-intensity Short-arc Lamps . . . . .	32
3.7. Cesium-vapor Arc Lamps . . . . .	32
3.8. Special Sources . . . . .	33
3.9. Controlled Sources . . . . .	34
3.10. Natural Sources . . . . .	37

3.11. Background Radiation Sources . . . . .	42
3.12. Source Radiation Intensity . . . . .	45
3.13. Attenuation of Source Radiation . . . . .	46
<b>Chapter 4. Atmospheric Transmission of IR Radiation . . . . .</b>	<b>47</b>
4.1. Absorption . . . . .	48
4.2. Absorption by Water Vapor . . . . .	51
4.3. Absorption by Carbon Dioxide . . . . .	57
4.4. Absorption by Ozone . . . . .	60
4.5. Absorption by Minor Constituents . . . . .	61
4.6. Atmospheric Scattering. . . . .	62
4.7. Atmospheric Attenuation of IR Radiation . . . . .	63
4.8. Attenuation in Haze and Smog . . . . .	64
4.9. Attenuation in Fog . . . . .	64
4.10. Attenuation in Clouds and Rain . . . . .	64
4.11. Atmospheric-transmission Studies. . . . .	65
<b>Chapter 5. IR Optical Components and Systems . . . . .</b>	<b>69</b>
5.1. Purpose and Desirable Features of IR Optical Systems . . . . .	69
5.2. Limitations of IR Optical Systems . . . . .	70
5.3. Optical Components . . . . .	71
5.4. Mirrors . . . . .	72
5.5. Lenses . . . . .	74
5.6. Special Combinations of Lenses and Mirrors . . . . .	82
5.7. Prisms . . . . .	88
5.8. Diffraction Gratings . . . . .	90
5.9. Windows and Irdomes . . . . .	93
5.10. Spectral Filtering by Optical Filters . . . . .	94
5.11. Space-filtering and Scanning Devices. . . . .	95
5.12. Optical Gain . . . . .	100
5.13. Optical-electromagnetic Systems . . . . .	102
<b>Chapter 6. Optical Materials. . . . .</b>	<b>107</b>
6.1. Desirable Properties of IR Optical Materials . . . . .	107
6.2. Crystalline IR Optical Materials . . . . .	111
6.3. Crystal-growing Techniques . . . . .	118
6.4. Glasses . . . . .	124
6.5. High-temperature Optical Materials . . . . .	127
6.6. IR Filters . . . . .	132
6.7. Reflectance and Anti-reflection Coatings . . . . .	137
<b>Chapter 7. Infrared Detectors . . . . .</b>	<b>142</b>
7.1. Classification of IR Detector Types and Their Applications . . . . .	142
7.2. Criteria Used in Comparison of Detectors . . . . .	145
Detector time constant—Responsivity—Relative spectral response— Efficiency to black-body radiation ( $\xi$ )—Noise equivalent input— Detectivity—Jones "S"—Effects of detector operating conditions	
7.3. Near-IR Detectors . . . . .	150
IR photoelectric cells—IR photoemissive cells—Photoconductive cells—Photodielectric cells—Phosphor cells—IR photographic emul- sions—IR image converter tube	

7.4. Intermediate-IR Detectors . . . . .	157
Photoconductive detectors	
7.5. Far-IR Thermal Detectors . . . . .	172
Thermocouples and thermopiles—Bolometers—The Golay pneumatic detector—IR condenser microphone detector—Far-IR-sensitive phosphors—Thermal-imaging devices	
7.6. Background Noise in Detectors . . . . .	182
Signal background noise—Environmental background noise—Internal background noise	
<b>Chapter 8. Infrared-system Design Considerations . . . . .</b>	<b>188</b>
8.1. Preliminary Design Considerations . . . . .	188
8.2. Factors Determining Received Signal . . . . .	193
8.3. Effects of the Optical System . . . . .	195
8.4. Detector Considerations . . . . .	197
8.5. Detection Range . . . . .	199
<b>PART II. APPLICATIONS OF INFRARED RADIATION</b>	
<b>Chapter 9. Infrared Instruments . . . . .</b>	<b>203</b>
9.1. IR Radiometers and Pyrometers . . . . .	203
9.2. Infrared Cameras . . . . .	205
9.3. IR Monochromators . . . . .	207
9.4. IR Grating Spectrographs . . . . .	209
9.5. IR Spectrometers . . . . .	211
9.6. IR Microscope . . . . .	218
9.7. IR Telescopes . . . . .	219
9.8. IR Continuous-process Analyzers . . . . .	220
9.9. Emissivity-measuring Instrument . . . . .	223
<b>Chapter 10. IR Applications in the Sciences . . . . .</b>	<b>225</b>
10.1. IR Spectroscopy . . . . .	225
10.2. IR Applications in Physics and Chemistry . . . . .	232
10.3. IR Applications in the Biological Sciences and in Medical Research .	237
10.4. IR Applications in Astronomy, Astrophysics, Geophysics, and Meteorology . . . . .	240
<b>Chapter 11. IR Applications in Industry . . . . .</b>	<b>247</b>
11.1. IR Applications in Agriculture . . . . .	247
11.2. IR Applications in the Rubber Industry . . . . .	248
11.3. IR Applications in the Petroleum Industry . . . . .	249
11.4. IR Applications in the Printing Industry . . . . .	250
11.5. IR Applications in the Cement Industry . . . . .	252
11.6. IR Applications in the Railroad Industry . . . . .	252
11.7. IR Applications in the Aircraft and Missile Industries . . . . .	252
11.8. IR Applications in the Drug and Pharmaceutical Industries . . . . .	254
11.9. IR Applications in the Cosmetic and Perfume Industries . . . . .	256
11.10. IR Applications in the Plastics Industry . . . . .	256
11.11. IR Television Applications . . . . .	257
11.12. IR Photographic Applications . . . . .	258

11.13. IR Military Applications . . . . .	259
11.14. IR Applications in the Food Industries . . . . .	262
11.15. IR Applications in the Tobacco Industry . . . . .	262
11.16. IR Applications in Criminology and Toxicology . . . . .	263
11.17. IR Applications in the Paint and Coating Industries . . . . .	263
11.18. IR Applications in Air-pollution Studies and Control . . . . .	264
11.19. IR Applications in Atomic Energy . . . . .	264
11.20. IR Applications in the Coal Industry . . . . .	264
11.21. IR Applications in the Textile Industry . . . . .	265
11.22. IR Applications in Industrial Automation . . . . .	265
<b>Chapter 12. Applications of IR in Space Technology . . . . .</b>	<b>269</b>
12.1. Space and IR Radiation . . . . .	269
12.2. Astrophysical and Meteorological Applications . . . . .	273
12.3. Detection of Missiles, Rockets, and Satellites . . . . .	273
12.4. Weather Observations from a Satellite . . . . .	276
12.5. Reconnaissance from Satellites . . . . .	279
12.6. IR Horizon-edge Scanners . . . . .	280
12.7. Investigation of Planets from Probes and Satellites . . . . .	282
12.8. IR Measurements from Plastic Balloons . . . . .	283
12.9. IR Data Link and Communication Systems. . . . .	284
12.10. IR Applications in Space Navigation. . . . .	285
<b>Appendix. Books on Infrared Radiation and Related Subjects . . . . .</b>	<b>289</b>
<i>Index</i> . . . . .	293