

Contents

<i>Foreword (By Prof. B. J. Thompson)</i>	xiii
<i>Preface</i>	xvii
<i>Acknowledgements</i>	xix
1 Historical background	1
2 Introduction to holography	6
2.1 Recording and reconstruction with plane holograms	6
2.2 The in-line approach	12
2.3 Image–object position relationships	14
2.3.1 Magnifications	16
3 General theory of in-line Fraunhofer holography	18
3.1 Recording process	18
3.2 Reconstruction	20
3.3 Image form in the far-field case	25
3.4 Collimated beams of the same wavelength	27
4 System design considerations	32
4.1 Recording irradiance distribution	32
4.2 Film resolution requirements	38
4.3 Recording range	42
4.4 Film format	43
4.5 Recording source coherence requirements	45
4.5.1 Spatial coherence	46
4.5.2 Temporal coherence	48
4.6 Object velocity and exposure time	50
4.6.1 Transverse movement	51
4.6.2 Longitudinal movement	52
4.6.3 Combined effect	55
4.6.4 Geometry for high velocity particles	56
4.7 Coherence requirements during reconstruction	59
4.8 Diffraction-limited resolution and depth-of-focus	60
4.8.1 Lateral resolution	61
4.8.2 Depth-of-focus	62

<i>Contents</i>	x
<i>4.8.3 Speckle noise</i>	62
4.9 Reconstructed image magnification	64
<i>4.9.1 Microscopic observation</i>	64
<i>4.9.2 Screen projection</i>	64
<i>4.9.3 Closed circuit television system</i>	66
5 Practical considerations	67
5.1 Density of microobjects	67
5.2 Application of relay lenses	71
<i>5.2.1 Single lens</i>	71
<i>5.2.2 Single lens resolution requirement</i>	75
<i>5.2.3 Double lens (telescopic) system</i>	75
<i>5.2.4 Demagnification of large particles</i>	77
5.3 Test-section with single window opening	77
5.4 Very small objects	79
<i>5.4.1 Submicrometer particles</i>	79
<i>5.4.2 Electron-beam and x-ray holography</i>	83
<i>5.4.3 Hologram aperture related effects</i>	84
5.5 Factors associated with recording materials and their processing	85
<i>5.5.1 Exposure requirements with thin absorption emulsions</i>	85
<i>5.5.2 Special processing of thin absorption holograms and signal to noise ratio</i>	88
<i>5.5.3 Thin phase (bleached) holograms</i>	89
<i>5.5.4 Real time recording and measurement</i>	91
5.6 Spatial frequency filtering	91
<i>5.6.1 Filtering of parallel line objects</i>	92
<i>5.6.2 High pass filtering during reconstruction</i>	95
5.7 Exposure controls during recording	101
5.8 Controls during reconstruction	102
5.9 Transparent objects	104
<i>5.9.1 One- or two-dimensional uniform objects</i>	105
<i>5.9.2 Spherical objects</i>	107
5.10 Finite aperture effects	110
<i>5.10.1 Opaque circular cross-section object</i>	111
<i>5.10.2 Opaque line objects</i>	112
5.11 Other developments	114
6 Analysis of reconstruction	116
6.1 Relationships between object and image points	117
6.2 Image analysis with fixed hologram	119
<i>6.2.1 Object location and transverse magnification</i>	119
<i>6.2.2 Volume magnification</i>	121
6.3 Image analysis with hologram on translation stage	122
<i>6.3.1 Transverse magnification and two image positions</i>	123
<i>6.3.2 Effect of transverse hologram movement</i>	127
<i>6.3.3 Volume magnification</i>	131
6.4 Effect of different media	134
6.5 Effect of hologram magnification	135

<i>Contents</i>	xi
7 Aberrations and their control	138
7.1 Primary aberrations	138
7.2 Tolerance limits	141
7.3 Hologram center and related parameters	141
7.3.1 <i>In-line method</i>	141
7.3.2 <i>Off-axis method</i>	144
7.3.3 <i>Diffused illumination</i>	146
7.3.4 <i>Hologram movement during reconstruction</i>	147
7.4 Limitations of collimated beams without scaling	148
7.5 Control of aberrations	150
7.5.1 <i>Elimination of spherical aberration</i>	152
7.5.2 <i>Plane wave recording and spherical wave reconstruction</i>	154
7.6 Cylindrical test-sections	159
7.6.1 <i>Medical ampules</i>	159
7.6.2 <i>Cylindrical tunnels</i>	160
7.7 Other developments	166
8 Hologram fringe-contrast and its enhancement	167
8.1 Fringe-contrast in Fraunhofer holography	167
8.2 Object shape and fringe visibility	169
8.2.1 <i>Visibility at the hologram center</i>	170
8.2.2 <i>Visibility at outer positions in the hologram</i>	170
8.3 Object shape and noise	174
8.4 Techniques to enhance the visibility	174
8.4.1 <i>Divergent recording beam</i>	175
8.4.2 <i>Gaussian recording beam</i>	178
8.4.3 <i>Interference filters as Fourier processors</i>	181
8.4.4 <i>Non-blocked zero-frequency filtering</i>	183
9 Non-image plane analysis	187
9.1 Analysis of the far-field pattern	187
9.1.1 <i>Coherent background method</i>	187
9.1.2 <i>Spatial filtering method</i>	190
9.2 Analysis by misfocusing	192
9.2.1 <i>The pattern form</i>	193
9.2.2 <i>Collimated beams and circular objects</i>	197
9.2.3 <i>Role in accurate measurements</i>	198
9.2.4 <i>Role in automated analysis</i>	199
9.3 Fourier transform analysis	202
9.4 Related developments	205
10 Velocimetry and high speed holography	209
10.1 Multiple-exposure holography	209
10.1.1 <i>Direction analysis</i>	211
10.1.2 <i>Holocinematography and transient phenomena analysis</i>	212
10.2 Displaced diffraction pattern analysis	214
10.3 Direct analysis from far-field patterns	215
10.4 Fraunhofer plane analysis	217

<i>Contents</i>	xii
<i>10.4.1 Identical one-dimensional displacement of particles</i>	218
<i>10.4.2 Particles moving differently</i>	220
11 The off-axis approach	223
11.1 Basic recording and reconstruction arrangements	223
11.2 Relay lenses and related magnifications	226
<i>11.2.1 Double lens telescopic system</i>	227
<i>11.2.2 Single relay lens</i>	227
11.3 Diffused subject illumination	228
11.4 Film resolution requirements	229
11.5 Allowable subject movement	231
11.6 Very small or far objects	231
11.7 Specialized techniques	234
<i>References</i>	237
<i>Index</i>	262