

WILLIAM T. PLUMMER

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WTP Optics, Inc.
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Education:

B.A. Physics and Mathematics, Johns Hopkins University, 1960
Ph.D. Physics, Johns Hopkins University, 1965
Certificate, Tuck Executive Program, Dartmouth College, 1987

Employment:

Known for development of phenomenal new design and manufacturing technologies, notably the early introduction of quality plastic aspheric lens surfaces in photography, and for the first uses of generalized and free-form aspheric optical surfaces in high-volume cameras. Interests and contributions span the full range of product development, from unusual design concepts through all the analysis, tooling, instrumentation, and procedures needed for effective manufacture. Published more than 40 professional papers in optics, astronomy, acoustics, and other fields. Has given more than 50 invited technical talks before university, scientific, industrial, government, and commercial groups in several countries.

March 2001 to Present - Consultant

Founder and President since June 2002 of WTP Optics Inc., offering innovative optical design, engineering, and manufacturing support.

Consultant in the development of an interferometer for measurement of surface quality and dimensions of certain non-spherical industrial surfaces. Provided clients with lens quality instrument evaluation; outside advice on acquisition of a startup telecom manufacturing company; design of an infrared scanner for paper and plastic sheeting; design, development, manufacture, and testing of optical parts for digital cameras; specifications for a teleconferencing camera system; improvement of barcode-reading optical hardware; improvement of illumination efficiency in fingerprint readers; advice on a proposed military optical product; new methods for manufacturing aspheric infrared optics; optical system design for a robotic laser-guidance application; tooling and testing for projection video systems; and many other subjects.

Technical witness with Gardner Carton & Douglas LLC in 2001-4 for analysis and opinion in a patent infringement suit and counter suit related to the mechanical design of compact commercial zoom photographic lenses, and in 2003-4 with Wilmer Cutler Pickering Hale & Dorr in a patent suit and counter suit related to the design of microlithographic equipment. Technical witness with other firms on issues related to diffractive optics, molded lenses, medical optical components, spectacle lens design and manufacture, optical disk data storage, and other topics.

Received 101 U.S. Patents for optical, mechanical, electronic, and chemical inventions, unique product designs, and effective ways to manufacture them.

1969 to March 2001 - Polaroid Corporation, Cambridge, MA

Scientist, Senior Scientist, Engineering Fellow, Senior Manager. From 1978 Director of Optical Engineering, and from 1997 Senior Director / Divisional Vice President. Built and maintained a center of excellence. Achieved technical integration across optical science, lens design, mechanics, electronics, and submicron precision engineering to support Polaroid hardware product development at the concept and system level. Guided optical component and subsystem manufacturing groups to develop new technologies and set product standards. Provided technical relationship with overseas suppliers to meet product goals. Enabled product design teams to introduce new

manufacturing concepts and functional advances to products. Managed Optical Engineering, Model Shops, Concept Engineering, Optical Storage, and CAD System groups.

Personally solved key development problems and contributed to the system design, optical design, and mechanical design of major high-volume photographic products (SX-70 Single Lens Reflex folding instant camera, OneStep and "Sun" camera series, Spectra camera, Captiva camera, and other models), with their associated manufacturing instrumentation and special tooling. Guided opto-mechanical design for both enhanced function and cost reduction of high-resolution laser diode medical printers.

Responsible for a high-power laser diode manufacturing group of about 30 engineers and technicians in the late 1990's. Responsible for development of a high-power laser digital print head and product hardware for other medical and industrial applications of grouped laser diodes; included frequency doubling, development of a multi-watt single-mode fiber laser at 1.06 micron for commercial applications, development and manufacture of a microlensed laser diode product.

Member of management staffs of Engineering R & D, Product Engineering, and Central R&D divisions. Member of corporate engineering promotion board, 1981 to 1988. Member of Business Imaging marketing staff, 1990 to 1991. Member of manufacturing Plant Management Team for Optical and Precision Molding and Assembly, 1990 to 1993.

1991 to Present - M.I.T., Cambridge, MA

Senior Lecturer, faculty Search Committee member, Mechanical Engineering Department. Member of PhD student dissertation committees, 2004 to present.

1984 to 1988 - Tufts University, Medford, MA

Visiting Industry Professor, Electro-Optics Technology Center; Electrical Engineering Department.

1967 to 1969 - University of Massachusetts, Amherst

Assistant Professor, Physics and Astronomy. Researched infrared scattering properties of artificial cumulus clouds, of hydrocarbons, and of particulate materials suspected in planetary atmospheres. Studied optical properties of pinhole cameras, mechanics of simple knots, earth conductivity analysis for geophysical prospecting, and infrasonic oscillations in limestone caverns.

1965 to 1967 - U.S. Army, Washington, DC

Captain, Signal Corps. Scientific intelligence officer with Top Secret clearance.

1963 to 1965 - Johns Hopkins University Laboratory of Astrophysics and Physical Meteorology, Baltimore

Dissertation work with Professor John Strong. Responsible for optical and data systems in a balloon-carried astronomical experiment to measure water vapor and other components of the Venus atmosphere, successfully flown twice in 1964. Consulted for J.H.U. Applied Physics Laboratory to improve instruments for measuring optical and thermal properties of satellite surface coatings.

1963 to 1965 and 1967 to 1969 - Muffoletto Optical Company, Baltimore

Consultant. Designed lenses for laser research, ultraviolet spectroscopy, wide-angle submarine viewing, medical imaging, laser diode collimation, and other purposes.

1960 to 1964 - Johns Hopkins University Physics Department

Teaching Assistant. Conducted Optics Laboratory courses for four years. Compiled a laboratory manual. Designed new laboratory facilities. Lectured in Geometrical and Physical Optics.

1957 to 1960 - Johns Hopkins University Laboratory of Astrophysics and Physical Meteorology

Research Assistant. Supported optical and mechanical preparation for early balloon astronomy experiments. Planned and appeared in a P.S.S.C. educational film, "The Photoelectric Effect."

Professional Associations / Society Memberships:

Optical Society of America (Fellow)
Society of Photo-Optical Instrumentation Engineers (Fellow)
National Speleological Society (Fellow)

Awards and Honors:

Phi Beta Kappa, 1960
Army Commendation Medal, 1967
David Richardson Medal for applied optics, Optical Society of America, 1980
Joseph Fraunhofer Award for optical engineering, O.S.A., 1997
Robert M. Burley Prize for optical engineering, O.S.A., 1997
Elected to Membership, National Academy of Engineering, 1999
Steve Benton Memorial Award, 2006, from the New England Section, O.S.A.

R&D 100 Award, 1992, from R&D Magazine for “One of the 100 Most Technologically Significant New Products of the Year”; for the Pegasus 1010 Photon Tunneling Microscope (developed by a Polaroid team from our Patent No. 4,681,451)
Photonics Circle of Excellence Award, 1993, from Photonics Spectra Magazine, for developing one of the twenty-five best new products of the year; for the Photon Tunneling Microscope.
American Men and Women of Science, Who’s Who in Science and Engineering, Who’s Who in America, Who’s Who in the World
Polaroid Technology Hall of Fame, 2000

Ph.D. Dissertation Supervised:

C. Londoño, “Design and Fabrication of Surface Relief Optical Elements, or Kinoforms, with Examples for Optical Athermalization” Electro-Optics Technology Center, Electrical Engineering Department, Tufts University, 1992

Doctoral Committee Memberships:

S. Awatar, “Analysis and Synthesis of Parallel Kinematic XY Flexure Mechanisms”, Precision Engineering Research Group, Mechanical Engineering Department, Massachusetts Institute of Technology, 2004

P. Willoughby, “Elastically Averaged Precision Alignment”, Precision Engineering Research Group, Mechanical Engineering Department, Massachusetts Institute of Technology, 2005

D. Golda, “Design and Fabrication of Micro-Fabricated Two-axis Electromagnetic Actuators for Small-scale Nanopositioners” Precision Systems Design and Manufacturing Laboratory, Mechanical Engineering Department, Massachusetts Institute of Technology, 2006

T. Wortman, “Multi-Modal Methods for Identifying Skin Cancer”, Precision Engineering Research Group, Mechanical Engineering Department, Massachusetts Institute of Technology, 2016

Patents:

Dr. William T. Plummer

1. #3,704,617; December 5, 1972; “Method and Apparatus for Fabricating Imaging Means”
2. #3,709,131; January 9, 1973; “Method and Apparatus for Aligning a Viewing System”
3. #3,718,078; February 27, 1973; “Smoothly Granulated Optical Surface and Method for Making Same”
4. #3,735,685; May 29, 1973; “Reflective Imaging Apparatus”
5. #3,744,391; July 10, 1973; “Camera with a Stigmatic Fresnel Optical Element”
6. #3,754,458; August 28, 1973; “Light Seal for a Reflex Camera Viewfinder”
7. #3,761,179; September 25, 1973; “Mirror Testing Apparatus”
8. #3,797,922; March 19, 1974; “Azygous Ophthalmic Lens and Spectacles for Correcting Presbyopia”
9. #3,810,221; May 7, 1974; “Viewfinder for a Reflex Camera”
10. #3,821,767; June 28, 1974; “Light Seal for a Reflex Camera Viewfinder”
11. #3,836,931; September 17, 1974; “Eye Lens in a Single Lens Reflex Camera Viewfinder Providing Field Tilt Compensation”
12. #3,848,980; November 19, 1974; “Projector Apparatus and System Employing Unique Screen”
13. #3,872,749; March 25, 1975; “Ruling Engine for Generating Dies to Mold Anamorphic Fresnel Optics”
14. #3,877,044; April 8, 1975; “Reflex Camera Viewing System with Stigmatic Exit Pupil”
15. #3,900,858; August 19, 1975; (with Mary Conlin McCann and Vivian K. Walworth) “Camera to Microscope Adapter with a Special Optical Element”
16. #3,902,792; September 2, 1975; “Landscape Lens”
17. #3,904,294; September 9, 1975; (with Nathan Gold) “Automatic Lens Testing Apparatus”
18. #3,971,052; July 20, 1976; “Compact Galilean Viewfinder”
19. #3,976,368; August 24, 1976; (with Mary Conlin McCann and Vivian K. Walworth) “Special Optical Element for Camera to Microscope Adapter”

Patents (Cont'd):

20. #4,006,971; February 8, 1977; "Reflective Imaging Apparatus"
21. #4,018,514; April 19, 1977; "Apparatus for Retinal Photography"
22. #4,021,825; May 3, 1977; (with John J. McCann, Mary C. McCann, Myron A. Seiden, and Vivian K. Walworth) "Adapter for Operatively Coupling an Automated Camera to an Optical Instrument"
23. #4,102,581; July 25, 1978; "Unicell Photoelectric Photometer"
24. #4,105,300; August 8, 1978; "Defocused Unicell Photometer with Aspheric Zone"
25. #4,105,308; August 8, 1978; (with R. Calvin Owen, Jr.) "Aspheric Plastic Triplet"
26. #4,111,561; September 5, 1978; "Defocused Unicell Photometer with Diffusion Zone"
27. #4,130,357; December 19, 1978; (with Irving Erlichman) "Flexible Shutter for Photographic Camera"
28. #4,147,408; April 3, 1979; "Back Projection Viewing Screen"
29. #4,157,216; June 5, 1979; "Adapter for Optically Coupling a Photographic Camera with a Viewing Device"
30. #4,162,833; July 31, 1979; "Photographic Camera"
31. #4,193,675; March 18, 1980; "Photographic Camera"
32. #4,204,269; May 20, 1980; "Optical Element for Redistributing the Light Output of a Photoflash Lamp Assembly or the Like"
33. #4,208,112; June 17, 1980; "Photographic Camera Accessory"
34. #4,226,515; October 7, 1980; "Photographic Camera"
35. #4,251,146; February 17, 1981; "Photographic Apparatus for Providing a Signal Visible in a Camera Viewfinder"
36. #4,264,167; April 28, 1981; "Adapter for Coupling a Camera with a Viewing Device"
37. #4,272,186; June 9, 1981; "Camera Method and Apparatus for Recording with Selected Contrast"
38. #4,282,548; August 4, 1981; "Method and Apparatus for Measuring and/or Setting Lens Focal Distance"
39. #4,293,892; October 6, 1981; "Zoom Light Apparatus"

Patents (Cont'd):

40. #4,299,468; November 10, 1981; (with Monis J. Manning) "Photoelectric Radiometer for Photographic Apparatus"
41. #4,356,538; October 26, 1982; "Photographic Lighting Apparatus"
42. #4,416,514; November 22, 1983; "Color Filter"
43. #4,443,067; April 17, 1984; (with R. Calvin Owen, Jr.) "Zone Focusing Optical System"
44. #4,457,618; July 3, 1984; "Optical System for Use in Electronic Enlarger"
45. #4,499,164; February 12, 1985; "Image Carrying Media Employing an Optical Barrier"
46. #4,498,748; February 12, 1985; (with Peter W. J. Jones and Dennis W. Purcell) "Camera for Photographing Scale Models"
47. #4,531,702; July 30, 1985; "Injection Mold for Forming Optical Fiber Connector"
48. #4,549,891; October 29, 1985; "Method for Forming a Non-symmetrical Optical Fiber"
49. #4,561,753; December 31, 1985; (with Philip G. Baker) "Selective Photoresponsive Sensing Circuit"
50. #4,589,745; May 20, 1986; "Geometric LED Layout for Line Exposure"
51. #4,610,536; September 9, 1986; (with William K. Smyth and Richard J. Chen) "Laser Scanning and Printing Apparatus"
52. #4,647,975; March 3, 1987; (with Lawrence E. Alston and Donald S. Levinstone) "Exposure Control System for an Electronic Imaging Camera Having Increased Dynamic Range"
53. #4,650,292; March 17, 1987; (with James G. Baker) "Analytic Function Optical Component"
54. #4,649,324; March 10, 1987; (with John M. Guerra) "Method and Apparatus for Adjusting CRT Geometry"
55. #4,675,531; June 23, 1987; (with Peter P. Clark) "Optical Scanner Having a Multi-Surfaced Lens Arrangement for Producing a Rotationally Symmetric Beam"
56. #4,687,926; August 18, 1987; "Spectrally Filtered Lens Producing Plural f-Numbers with Different Spectral Characteristics"
57. #4,701,045; October 20, 1987; "Method and Apparatus for Reducing Optical Artifacts"
58. #4,681,427; July 21, 1987; "Electronic Printing Method"
59. #4,681,451; July 21, 1987; (with John M. Guerra) "Optical Proximity Imaging Method and Apparatus"

Patents (Cont'd):

60. #4,689,184; August 25, 1987; "Method for Forming an Optical Connector"
61. #4,689,005; August 25, 1987; "Molding Apparatus"
62. #4,707,063; November 17, 1987; "Widely Spaced Fiber Optic Connector and Multiplexer / Demultiplexer Using Same"
63. #4,689,696; August 25, 1987; "Hybrid Image Recording and Reproduction System"
64. #4,759,596; July 26, 1988; (with Hong Po) "Wavelength Selective Optical Cavity Including Holographic Filter Layers"
65. #4,786,964; November 22, 1988; (with Hugh R. MacKenzie) "Electronic Color Imaging Apparatus with Prismatic Color Filter Periodically Interposed in Front of an Array of Primary Color Filters"
66. #4,806,034; February 21, 1989; "Write Head Controller with Grid Synchronization"
67. #4,814,118; March 21, 1989; (with Robert J. Boyea) "Method of Fabrication of Components for Connecting Optical Fibers"
68. #4,816,939; March 28, 1989; (with Vernon E. Ford, Jeremy K. Jones, and John J. Mader) "Magnetic Recording Media and Servo System Using Light-Transmitting Optical Gratings"
69. #4,843,481; June 27, 1989; "CCD Scanning Apparatus for Use with Rotary Head Printer"
70. #4,882,594; November 21, 1989; "Method for Making a Smooth, Uniform Image of a Laser Diode Array"
71. #4,925,267; May 15, 1990; (with Robert J. Boyea) "Structure and Fabrication of Components for Connecting Optical Fibers"
72. #5,028,110; July 2, 1991; "Fiber Optic Component"
73. #4,971,869; November 20, 1990; "Color Encoding Photographic Film"
74. #4,989,959; February 5, 1991; "Anti-Aliasing Optical System with Pyramidal Transparent Structure"
75. #4,992,824; February 12, 1991; "Apparatus and Method Utilizing an L.C.D. for Printing"
76. #5,176,972; January 5, 1993; (with Iris B. K. Bloom and Richard A. Minns) "Imaging Medium with Low Refractive Index Layer"
77. #5,260,828; November 9, 1993; (with Carmaña Londoño) "Methods and Means for Reducing Temperature-Induced Variations in Lenses and Lens Devices"

Patents (Cont'd):

78. #5,327,291; July 5, 1994; (with James G. Baker and Jon Van Tassell) "Compact Objective Lens"
79. #5,408,447; April 18, 1995; (with F. Richard Cottrell, A. K. Juenger, H. R. MacKenzie, and W. J. McCune) "Method and Apparatus for Scanning of Image in Integral Film Structure"
80. #5,449,586; September 12, 1995; (with F. Richard Cottrell, A. K. Juenger, H. R. MacKenzie, and W. J. McCune) "A Diffusion Transfer Integral Film Unit"
81. #5,652,612; July 29, 1997; (with Carl A. Chiulli and Yalan Mao) "Apparatus and Method for Enhancing Printing Efficiency to Reduce Artifacts"
82. #5,900,902; May 4, 1999; (with Carl A. Chiulli and Yalan Mao) "Apparatus and Method for Enhancing Printing Efficiency to Reduce Artifacts"
83. #5,933,278; August 3, 1999; (with Douglas S. Goodman and Jeffrey W. Roblee) "Monolithic Multi-faceted Mirror for Combining Multiple Beams from Different Light Sources by Reflection"
84. #6,011,577; January 4, 2000; (with Douglas S. Goodman and Jeffrey W. Roblee) "Modular Optical Print Head Assembly"
85. #6,061,372; May 9, 2000; (with Marc Thompson and Douglas S. Goodman) "Two-Level Semiconductor Laser Driver"
86. #6,066,857; May 23, 2000; (with Stephen D. Fantone, Luis A. Figarella, David A. Imrie, Harry McKinley, Howard Stern, and Jon E. Van Tassell) "Variable Focus Optical System"
87. #6,097,552; August 1, 2000; (with Wayne L. Gordon and James J. Zambuto) "Autofocus Actuator Device"
88. #6,101,333; August 8, 2000; (with Julian G. Bullitt, Jon Van Tassell, and George D. Whiteside) "Method and Apparatus for Acquiring Electronic and/or Photographic Images"
89. #6,104,533; August 15, 2000; (with Peter P. Clark) "Viewfinder with Diffractive Optical Element"
90. #6,122,115; September 19, 2000; (with Jeffrey W. Roblee and Douglas S. Goodman) "Method and Device for Mounting Optical Components"
91. #6,221,554; April 24, 2001; (with Philip R. Norris, Harry R. Parsons, Donald W. Preissler, and Robert J. Wadja) "Self Developing Film Unit"
92. #6,283,374; September 4, 2001; (with Stephen D. Fantone, David A. Imrie, Jon E. Van Tassell, Philip E. McKinley, Harry R. McKinley, Luis A. Figarella, Howard Stern, John H. Dowling, and Steve Meister) "Symbology Imaging and Reading Apparatus and Method"

Patents (Cont'd):

93. #6,595,427; July 22, 2003; (with Vivek K. Soni, J. Barry Mahoney, and Richard G. Egan) "Method and Apparatus for Encoding and Decoding Information in a Non-visible Manner"
94. #6,643,390; November 4, 2003; (with Peter P. Clark and Douglas S. Goodman) "Compact Fingerprint Identification Device"
95. #6,786,416; September 7, 2004; (with Vivek K. Soni, J. Barry Mahoney, and Richard G. Egan) "Method and Apparatus for Encoding and Decoding Information in a Non-visible Manner"
96. #6,994,257; February 7, 2006; (with Vivek K. Soni, J. Barry Mahoney, and Richard G. Egan) "Method and Apparatus for Encoding and Decoding Information in a Non-visible Manner"
97. #7,426,020; September 16, 2008; (with George W. McClurg and John F. Carver) "System for Print Imaging with Prism Illumination Optics"
98. #7,591,557; September 22, 2009; "Solid State Method and Apparatus for Making Lenses and Lens Components"
99. #7,926,942; April 19, 2011; "Solid State Lenses and Lens Components"
100. #7,959,286; June 14, 2011; "Solid State Lenses and Lens Components"
101. #9,008,137; April 14, 2015; (with Aland K. Chin, Richard H. Chin, and Jonah H. Jacob) "Method and Apparatus for Compact and Efficient Introduction of High Radiant Power into an Optical Fiber"

Most of my listed patents were accompanied by issued foreign patent equivalents.

For my own US patents (98), (99), and (100) I have been issued these foreign equivalents:

Japanese patent JP5078880B2

Canadian patent CA_2607846A1

I have a related European patent application pending.

I have a pending application filed March 15, 2014, together with two co-inventors, entitled "Method and Apparatus for Acquiring a Digital Image of a Biometric Feature."

I have a pending application filed July 9, 2014, together with members of a client corporation, entitled "Methods and Reflective Apparatus for Combining High-Power Laser Beams".

Publications:

1. Palmer, C.H. Optics Experiments and Demonstrations Johns Hopkins University Press, 1962 (Signed sections by W. T. Plummer)
2. Bottema, M., W. Plummer, and J. Strong, "Water Vapor in the Atmosphere of Venus" Astrophys. J. **139**(3), 1021-1022 (1964)
3. Bottema, M., W. Plummer, J. Strong, and R. Zander, "Composition of the Clouds of Venus" Astrophys. J. **140**(4), 1640-1641 (1964)
4. Bottema, M., W. Plummer, and J. Strong, "A Quantitative Measurement of Water Vapor in the Atmosphere of Venus" Ann. Astrophys. **28**(1), 225-228 (1965)
5. Bottema, M., W. Plummer, J. Strong, and R. Zander, "The Composition of the Venus Clouds and Implications for Model Atmospheres" J. Geophys. Res. **70**(17), 4401-4402 (1965)
6. Plummer, W.T., and J. Strong, "Conditions on the Planet Venus" Astronautica Acta **11**(6), 375-382 (1965)
7. Plummer, W.T., "Some Techniques for Cave Exploration" Nat. Spel. Soc. Bul. **28**(1), 22-37 (1966)
8. Plummer, W., and J. Strong, "A New Estimate for the Surface Temperatures of Venus" Astrophys. J. **144**(1), 422-424 (1966)
9. Plummer, W.T., "Hot Shadows on Jupiter" Science **153**(3742), 1418 (1966)
10. Plummer, W., and J. Strong, "An Answer to F. D. Drake" Astrophys. J. **149**, 463-464 (1967)
11. Plummer, W.T., "Ghost Lines in Spectra from an Interferometric Hologram" Japan. J. Appl. Phys. **6**, 1250-1251 (1967)
12. Plummer, W.T., and R.H. Hauck, "An Absorption Integral for Planetary Atmospheres" Planet. and Space Sci. **16**, 729-736 (1968)
13. Plummer, W.T., "Venus Clouds: Test for Hydrocarbons" Science **163**, 1191-1192 (1969)
14. Plummer, W.T., "Infrared Reflectivity of Frost and the Venus Clouds" J. Geophys. Res. **74**(13), 3331-3336 (1969)
15. Plummer, W.T., "Near Infrared Reflection Spectra of Artificial Cumulus Clouds" Appl. Optics **8**(10), 2079-2081 (1969)
16. Plummer, W.T., "Infrasonic Resonances in Natural Underground Cavities" J. Acous. Soc. Am. **46**(5)(Part 1), 1074-1080 (1969)

Publications (Cont'd):

17. Plummer, W.T., and R.K. Carson, "Mars: Is the Surface Colored by Carbon Suboxide?" Science **166**, 1141-1142 (1969)
18. Plummer, W.T., "The Venus Spectrum: New Evidence for Ice" Icarus **12**, 233-237 (1970)
19. Plummer, W.T., and R.K. Carson, "Venus Clouds: Test for Carbon Suboxide" Astrophys. J. **159**(1), 159-163 (1970)
20. Plummer, W.T., "Theory of the Climbing Knot" Appendix B of "Prusiking", by R. Thrun, pp. 61-74 (Speleo Press, Austin, Texas, 1973)
21. Plummer, W.T., "Focus Screen Optimization" Appl. Optics **14** (11), 2762-2765 (1975)
22. Plummer, W.T., "Fast Automatic Lens Testing for Extended-Field Image Quality" Appl. Optics **15** (3), 805-810 (1976)
23. P. Davidorf, F.H., W. Plummer, and E.H. Land, "Indirect Fundus Camera" Trans. Section on Ophthalmology. American Academy of Ophthalmology and Otolaryngology, **81** (5), 910-911 (1976)
24. Plummer, W.T., "The Martian Surface: Other Evidence Suggesting Carbon Suboxide" Proc. of Viking Conf. on Simulation of Mars Surface Properties, NASA Ames Research Center (May 5-6, 1977)
25. Plummer, W.T., "Photographic Shutters: Better Pictures with a Reconsideration of Shutter Efficiency" Appl. Optics **16**(7), 1914-1917 (1977)
26. Plummer, W.T., "Unusual Optics of the Polaroid SX-70 Land Camera" Appl. Optics **21**(2), 196-202 (1982)
27. Baker, J.G., S.D. Fantone, and W.T. Plummer, "In Memoriam, Dr. Edwin Herbert Land, May 7, 1909–March 1, 1991" Optics & Photonics News **2**(5), 5 (May, 1991)
28. Plummer, W.T., and L. Gardner, "A Mechanically Generated Hologram?" Appl. Optics **31**(31), 6585-6588 (1992)
29. Londoño, C., W.T. Plummer, and P.P. Clark, "Athermalization of a Single-Component Lens with Diffractive Optics" Appl. Optics **32**(13) 2295-2302 (1993)
30. Plummer, W.T., "Precision: How to Achieve a Little More of it, Even after Assembly" in Intelligent Automation and Soft Computing, Vol. 1; M. Jamshidi, C. Nguyen, R. Lumia, and J. Yuh, Editors. TSI Press series, proceedings of the World Automation Congress, Albuquerque, NM, pp. 193-198 (1994)
31. Plummer, W.T., "The SX-70 Camera: The Optics" Optics & Photonics News **5**(10) 44-48 (Oct., 1994)
32. Plummer, W.T., "Leaving No Stone Unturned" Optics & Photonics News **5**(10) 39 (Oct., 1994)

Publications (Cont'd):

33. Plummer, W.T., "A New Optical Illusion?" Optics & Photonics News **6**(1) 42-43 (Jan., 1995)
34. Plummer, W.T., J.J. Mader, J.W. Roblee, and J. Van Tassell, "Precision Engineering at Polaroid" Proc. of the Pre-Conf. Day, pp. 24-29, Precision Engineering in Industry – International State of the Art, Eighth Int. Precision Eng. Seminar, Université de Technologie de Compiègne, France; M. Bonis, et al., Ed. (May 15, 1995)
35. Plummer, W.T., "Beyond Raytracing" Engineering Program, Optical Soc. of Am. 1995 Ann. Mtg., pp 307-343 (Sept., 1995)
36. Goodman, D.S., J.W. Roblee, W.T. Plummer, and P.P. Clark, "Multi-Laser Print Head", SPIE **3430**, Novel Optical Systems Design and Optimization II, 21 pp (July, 1998)
37. Plummer, W.T., J.G. Baker, and J. Van Tassell, "Photographic Optical Systems Using Nonrotational Aspheric Surfaces" Appl. Optics **38** (16) 3572-3592 (1999)
38. Clark, P.P., D.S. Goodman, and W.T. Plummer, "Compact Finger Imager", SPIE **3789**, Current Developments in Optical Design & Optical Engineering VIII, 7 pp (July 1999)
39. Singh, R., A.K. Chin, Q.X. Zu, F. Dabkowski, R. Jollay, D. Bull, J. Fanelli, D.S. Goodman, J. Roblee, and W.T. Plummer, "Description and Applications of High Brightness Multi-Laser-Diode System", SPIE **3945A**, presented at Photonics West, 22-28 Jan. 2000, San Jose, CA (LASE 2000)
40. Plummer, W.T., "Free-Form Optical Components in Some Early Commercial Products", Extended Abstract, Proceedings ASPE Winter Topical Meeting on Free-Form Optics: Design, Fabrication, Metrology, Assembly, pp 68-71 (Feb., 2004)
41. Plummer, W.T., "Free-Form Optical Components in Some Early Commercial Products", Proc. SPIE **5865**, Tribute to Warren Smith: A Legacy in Lens Design and Optical Engineering, pp 586509-1 to -7 (Aug. 2005)
42. Plummer, W.T. and S.D. Fantone, "James G. Baker", in Memorial Tributes, Volume 11, National Academy of Engineering, pp 6-11 (The National Academies Press, Washington, DC, 2007)
43. Plummer, W.T., "A New Way to Mold Lenses with Freeform and Structured Surfaces", Proc. ASPE Spring Topical Meeting on Structured and Freeform Surfaces, pp 11-12 (March 2011)

Invited Talks:

1. "Conditions on the Planet Venus" W.T. Plummer and J. Strong. Moon and Planets Session of the Am. Geophys. Union Mtg., Washington, DC., April 22, 1966.
2. "Infrared Studies of Mars and Venus" W.T. Plummer. Symposium on Planetary Atmospheres, NASA Goddard Inst. for Space Studies, New York, March, 1970.
3. "Method of Measuring Surface Micro-ripple of Finished Optics to 10-Å Accuracies" C.V. Muffoletto and W. Plummer, Opt. Soc. Am. Spring Mtg. 1971.
4. "Optical Component Design for the New Polaroid Land Camera" W.T. Plummer, Opt. Soc. Am. Fall Mtg., San Francisco, Oct. 1972.
5. "Testing of Lenses for Polaroid Land Photography" R.F. Weeks, W.T. Plummer, L.K. Ting, N. Gold. Opt. Soc. of Am. Fall Mtg., Rochester, NY., Oct. 1973.
6. "Rapid Evaluation of Extended-Field Photographic Quality of Lenses" W.T. Plummer. Seminar-in-depth on "Image Assessment and Specification", jointly sponsored by the Opt. Soc. of Am. and the Soc. of Photo-Opt. Inst. Engrs., Rochester, May 21, 1974.
7. "Solving Quality Control and Reliability Problems with Optics" W.T. Plummer. Panel Discussion at S.P.I.E. seminar at San Diego, Calif., May 1975.
8. "Fast Automatic Lens Testing for Extended-Field Image Quality" W.T. Plummer. S.P.I.E.-Sira Inst. course on Quality Assurance in Optical and Electro-Optical Engineering, Delft, Sept. 1975.
9. "Optics of the Polaroid SX-70 Land Camera" W.T. Plummer. Joint meeting, local chapters of the Opt. Soc. of Am. and the Soc. of Phot. Sci. and Engrs., Lexington, Mass., Jan. 22, 1976.
10. "Optical and Mechanical Intrigue in the Polaroid SX-70 Land Camera" W.T. Plummer. Boston chapter A.S.M.E., Dec. 9, 1976. Burlington, VT, A.S.M.E., April 21, 1978. Central Mass. A.S.M.E., Westminster, Mass., April 19, 1979.
11. "The Martian Surface: Other Evidence Suggesting Carbon Suboxide" W.T. Plummer. Viking Conf. on Simulation of Mars Surface Properties, NASA Ames Res. Cent., Calif., May 5-6, 1977.
12. "Replicated and Plastic Optics" W.T. Plummer. Panel Disc., S.P.I.E. Tech. Symp. at San Diego, Calif., Aug. 24, 1977. Also: Optical Fabrication Workshop, Opt. Soc. of Am., Framingham, Mass., June 9, 1978.
13. "Unusual Optics of the Polaroid SX-70 Land Camera" W.T. Plummer. Symp. in honor of Prof. John Strong, Univ. Mass., Amherst, March 1981.
14. "Unusual Optics of the Polaroid SX-70 Land Camera" W.T. Plummer. Visiting Physicist lecture, A.I.P., at the Johns Hopkins Univ., Baltimore, May 1981.

Invited Talks (Cont'd):

15. "Optics at Polaroid" W.T. Plummer. Physics Dept., Chekiang Univ., Hangchow, China, September 1981.
16. "Use of Optical Concepts to Design and Tolerance Non-Optical Parts of the Photographic System" W.T. Plummer. Opt. Soc. of Am. mtg. on Applied Optics, Rochester, NY, May 1982.
17. "Frontiers of Optical Engineering" W.T. Plummer. S.P.I.E. Mtg., Cambridge, Mass., Nov. 1984.
18. "Generalized Aspheres in High Volume Camera Production" W.T. Plummer. Opt. Soc. of Am. Fall Mtg., Washington, DC., Oct. 1985.
19. "Unusual Optics in Polaroid Photography" W.T. Plummer. Am. Assoc. of Physics Teachers, sectional mtg., Keene, NH, Nov. 1985.
20. "Generalized Aspheric Surfaces in Polaroid Photography" W.T. Plummer. Soc. of Phot. Sci. and Engrs., Ann. Conf., Minneapolis, May 20, 1986.
21. "Generalized Aspheric Surfaces in Polaroid Photography" W.T. Plummer. Univ. of Rochester Inst. of Optics, Colloq., Feb. 4, 1987.
22. "Obecné asférické cocky v polaroid-fotografii" W.T. Plummer. INTERKAMERA Aplikovaná Optika '87, Prague, March 1987.
23. "Non-Rotational Aspheric Lens Surfaces in Polaroid Photography" W.T. Plummer. Inventors Assoc. of New England, M.I.T., Cambridge, Mass., April 1987.
24. "Non-Rotational Aspheric Lens Surfaces in Polaroid Photography" W.T. Plummer. Opt. Soc. of Am. and Soc. of Phot. Sci. and Engrs., ann. joint dinner mtg. of New Eng. chapters, Waltham, Mass., Feb. 16, 1989. Tucson chapter, Opt. Soc. of Am., Univ. of Arizona, Dec. 1989.
25. "Strings, Ropes, and Infrasonic Resonances, with Applications to Underground Caverns" W.T. Plummer. Mechanical Engineering Colloquium, M.I.T., Cambridge, Mass., Oct. 30, 1992.
26. "Precision Engineering at Polaroid" W.T. Plummer. Weekly Seminar, Precision Engineering Section, Natl. Inst. of Sci. and Tech., Gaithersburg, MD, Nov. 10, 1992.
27. "Diffractive Optical Elements in the Real World" P.P. Clark, C. Londoño, and W.T. Plummer. Optical Design for Photonics Topical Mtg., Opt. Soc. of Am., Palm Springs, CA., March 1993.
28. "Precision Mechanical Assembly Issues in Polaroid Photographic Products" W.T. Plummer. ARPA Workshop on Precision Assembly, La Jolla, CA., July 1993.
29. "System Design and Manufacturing Issues" W.T. Plummer. Panel disc., Systems and Instrumentation Technical Group Mtg., Opt. Soc. of Am., Toronto, Oct. 6, 1993.

Invited Talks (Cont'd):

30. “Industrially Relevant Applications of Precision Engineering to Consumer Products” A.H. Slocum and W.T. Plummer. M.I.T. Symposium on University-Industry Research Partnerships, Cambridge, MA, Nov. 4, 1993.
31. “Precision Mechanical Design Experiences in High-Volume Polaroid Cameras” W.T. Plummer. Mechanical Engineering Colloquium, M.I.T., Cambridge, Mass., March 15, 1994.
32. “Innovations in Design for Manufacturing in the High Volume Camera Business” W.T. Plummer. Defense Science Research Council / ARPA Workshop on Low Cost Uncooled Infrared Systems, La Jolla, CA, July 6, 1994.
33. “Precision: How to Achieve a Little More of it Even After Assembly” W.T. Plummer. Fifth International Symposium on Robotics and Manufacturing, Wailea, Maui, HI, Aug. 16, 1994.
34. “Optical Design Concerns of some Unusual Polaroid Cameras” W.T. Plummer. Symposium on Optical Systems and Instrumentation, Opt. Soc. of Am. Annual Meeting, Dallas, TX, Oct. 3, 1994.
35. “Precision Engineering at Polaroid” W.T. Plummer, J.J. Mader, J.W. Roblee, and J. Van Tassell. 8th International Precision Engineering Seminar, Compiègne, France, May 15, 1995.
36. “Beyond Raytracing” W. T. Plummer, Opt. Soc. of Am. Annual Meeting, Portland, Oregon, Sept. 13, 1995. (Tutorial)
37. “Advanced Uses for Injection-Molded Plastic Optical Components” W.T. Plummer, Conference on Optical Manufacturing Technology, Dept. of Optics and Optoelectronics, Beijing Institute of Technology, China, Sept. 3-4, 1996.
38. “Some Controversial Topics in Opto-Mechanical Design” W.T. Plummer, LEAP session on the Product Development Process, CLEO mtg., Baltimore, MD, May 21, 1997.
39. “Precision Engineering at Polaroid” W.T. Plummer, J.J. Mader, J.W. Roblee, and J. Van Tassell. Am. Soc. for Precision Engineers Annual Meeting, St. Louis, Missouri, Oct. 27, 1998.
40. “Unusual Optical Designs and Components in Polaroid Cameras” W.T. Plummer, Physics Dept. Seminar, Harvard University, Nov. 4, 1998.
41. “Unusual Optical Components in High-Volume Polaroid Products” W.T. Plummer, Rochester chapter, Opt. Soc. of Am., Feb. 2, 1999.
42. “Unconventional Optics for Commercial Applications” W.T. Plummer, Staff Colloquium, Natl. Inst. of Standards and Tech., Gaithersburg, MD, Oct. 1, 1999.

Invited Talks (Cont'd):

43. “System Design for Manufacture: the Polychrome Laser Diode Platform” W.T. Plummer, Symposium, *The Future of Manufacturing: New Developments in Technology and System Design*, Laboratory for Manufacturing and Productivity, M.I.T., Cambridge, Mass., April 19, 2000.
44. “Free-form Optical Components in Some Early Commercial Products” W.T. Plummer, Keynote Address, Winter Topical Meeting, *Free-Form Optics: Design, Fabrication, Metrology and Assembly*, Am. Soc. for Precision Engineering, Chapel Hill, NC, Feb. 4, 2004.
45. “Free-form Optical Components in some Early Commercial Products” W.T. Plummer, *Tribute to Warren Smith: A Legacy in Lens Design and Optical Engineering*, SPIE Conference on Optics and Photonics, San Diego, CA, Aug. 1, 2005.
46. “Two Easy Pieces: a Double Program with Two Presentations” I. Physics of the Pinhole Camera. II. A New Way to Mold Aspheric Lenses for the Infrared. W.T. Plummer, New England Section / Opt. Soc. of Am., Lexington, MA, Sept. 21, 2006.
47. “A Cool New Way to Mold Infrared Lenses” W.T. Plummer, Optics & Optoelectronics Session Keynote Address, iMAPS New England 34th Annual Symposium, Boxborough, MA, May 1, 2007.
48. “A New Way to Mold Freeform and Structured Optical Surfaces” W.T. Plummer, Seminar, *Computational Optical Sensing and Imaging*, University of Colorado at Boulder, Feb. 7, 2011.
49. “A New Way to Mold Lenses with Freeform and Structured Surfaces” W.T. Plummer, Spring Topical Meeting, *Structured and Freeform Surfaces*, Am. Soc. for Precision Engineering, Univ. of North Carolina at Charlotte, March 7, 2011.
50. “Polachrome Laser Diode Platform” W.T. Plummer and Jeff Roblee, New England Section / Opt. Soc. of Am., Auburndale, MA, Oct. 18, 2012.
51. “Design of the Polaroid SX-70 Camera” W.T. Plummer, Seminar, New England School of Photography, Boston, MA, Nov. 7, 2012.
52. “Freeform Optical Surfaces in Commercial Products and a New Molding Process for the Infrared” W.T. Plummer, Colloquium, Institute of Optics, University of Rochester, Rochester, NY, Oct. 28, 2013.

CITATION FOR THE 1980 DAVID RICHARDSON MEDAL, O. S. A.

“The Polaroid SX-70 Land Camera is probably the most remarkable optical design ever placed in high-volume production. From 1969 through 1973 Dr. Plummer was part of a small design team, led by Dr. Edwin H. Land and including Dr. James G. Baker and Dr. Richard F. Weeks, that conceived of this folding catadioptric single-lens-reflex system and produced an optical design that evolved along with the camera's mechanical and electronic structure. Dr. Plummer made significant personal contributions and provided technical leadership for a small group of scientists and engineers who worked with Dr. Baker to relate his geometric design to the needs of the product, to create precise tooling for plastic molding of unusual optical components, and to set up a range of new manufacturing technologies for producing and assembling high-quality optical elements.

“Dr. Baker's design uses a four-element glass photographic objective, a plane mirror to fold the system, and a reflective Fresnel focus screen. The image formed on the screen is passed by a small aperture stop and relayed to the photographer by an aspheric concave mirror and eyelens. For structural reasons every viewfinder component from the focus screen onward is tilted, decentered, or both. Dr. Plummer introduced non-rotational aspheric surfaces on the eyelens and on a refractive corrector plate at the aperture stop, and designed an astigmatic Fresnel mirror. He built many functioning prototype systems as the design and aspheric tooling progressed so that a careful balance could be made among unfamiliar aberrations represented in the figure of merit, and guided the mechanical design of the camera so these optical parts would be positioned accurately each time the camera is unfolded. He designed a null tester that is used for controlling the shape of the molded concave mirrors and designed a series of instruments for simplifying quality measurements and all assembly adjustments in volume production.

“A surprising depth of investigation was needed to support design decisions. Dr. Plummer studied the basic function of a focus screen to understand a four-way compromise, which occurs in roughening the reflex focus screen. He personally devised the texture that has been replicated in production. In the case of the photographic objective, which moves through its focus range by displacement of the front element, he used analysis based on the modulation transfer function to derive the best subjective focus scale for different object distances with a changing aberration balance. He studied the optics of the shutter mechanism itself, and found that by using an expanding and contracting aperture stop as a shutter the SX-70 significantly improves upon the familiar compromise of motion-freezing against depth of field.

“Dr. Plummer numerically determined the sensitivity of the film plane image to field tilt caused by tilting and decentering of individual lens elements, and used a Monte Carlo computing procedure to relate manufacturing yield to piece-part tolerances in the objective lens. The analysis guided the mechanical design and demonstrated that the best economy requires culling some inferior lenses. To do this, he and his colleagues designed and built a machine capable of testing 1200 lenses per hour with a modulation-related figure of merit that correlates extremely well with subjective quality judgments. In an effort to understand the system tolerance budget he expanded upon and generalized a study begun in 1962 by Dr. R. Clark Jones, of the computed modulation transfer properties of diffusion transfer films, and applied it to a model representing the new SX-70 film. Certain details of the exposure characteristic curve led him to extend a 1953 study by Williams and Clapper on the effect of multiple internal reflections in a color print, and to apply it to the more complicated case of SX-70 film.

“For other manufacturing requirements Dr. Plummer studied the basic physics of bell centering, toleranced lens and mirror surface coatings by relating them to photographic tristimulus color coordinates, and built automatic machines sensitive to local irregularities for screening plane mirrors to a demanding performance criterion.”

CITATION FOR THE 1997 JOSEPH FRAUNHOFER AWARD, O. S. A.

“For his exceptional accomplishments in the field of optical engineering, for making state-of-the-art optical technology affordable, bringing extremely sophisticated optics into the consumer marketplace, and for his expertise and willingness to participate in all aspects of engineering from technology and product development to manufacturing. Technical problems are seen by him as opportunities for invention, and his leadership inspires others to invent as well. He maintains an environment that encourages technical innovation. To do this consistently in a business world is a major accomplishment of engineering.”

CITATION FOR THE 1999 ELECTION TO MEMBERSHIP, N. A. E.

“For contributions to optical science and engineering, and for leadership in high-volume manufacturing of precision optics.”

William T. Plummer: N. A. E. Statement of Technical Interest

One task of Engineering is to make commercial products of all kinds that are better, more versatile, smaller, cheaper, and earlier to market. My interest is to solve the resulting manufacturing problems far upstream through cross-disciplinary teamwork, before designs become viscous or rigid. This goal demands fighting for real clarity in the early concept stage of a design project, and requires doing so with the best and broadest technical team that can be nurtured or borrowed.

In the case of optical science and engineering, and precision engineering, this approach has led us to use a variety of unique and surprisingly sophisticated optical, mechanical, and electronic designs even in mass-produced camera products with molded plastic components. It has also led us to great simplification of the design and assembly of instruments, specialized laser hardware and other manufactured goods, through standard approaches, modularity, rational fixturing and procedures, and modern component fabrication.

I believe that competitive product engineering requires a solid grasp of the obvious, or at least of basic principles imaginatively applied early enough by the right team. We are surrounded by opportunities for better design practice and I am interested in teaching effective ideas through entertaining examples.