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Book Reviews

Paul R. Yoder, Jr., Book Reviews Editor

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Applied Optics and Optical Engineering, Volume 10

Robert R. Shannon and James C. Wyant, eds., x + 508 pp., illus., index, references. ISBN 0-12-408610-1. Academic Press, 1250 Sixth Ave., San Diego, CA 92101 (1987) $89.00 hardbound.

Reviewed by Paul R. Yoder, Jr., Taunton Technologies, Inc., 631 Main Street, Monroe, CT 06468.

This tenth volume of the series initiated by Rudolf Kingslake in 1965 carries on admirably the tradition of high caliber periodic updating of the state of the art in optics and optical engineering. The eight chapters are all written by recognized experts in their respective subjects. Although the chapters differ widely in subject matter and in depth of treatment, all are well written, easy to understand, and contain a wealth of valuable information. The index is adequate, the book is sturdy, and the many figures are clearly reproduced.

In the first chapter on "Thin-Film Optical Coatings," H. A. Macleod begins by briefly summarizing the historical development of the technology, the various techniques used in vacuum deposition, methods and apparatus used in process monitoring, and techniques for testing the finished product. The balance of the work deals in modest detail with the theory of coating design, effects of design and manufacturing variations on performance, and effects of the environment and manner of use. There are 135 references cited to facilitate further study.

"Dimensional Stability of Materials Useful in Optical Engineering," by S. F. Jacobs, is the subject of the second chapter. The author describes ultraprecise differential instrumentation developed over a period of years to measure the extremely small variations with temperature of dimensions of low-expansion materials. Measurements reported include effects of temperature cycling on Zerodur, Invar, and fused silica; thermal expansion homogeneity of Heraeus-Amersil T08E fused quartz; and expansivity of Schott Duran, Ohara E6, Zerodur, Invar, and Super-Invar. The advantage of the latter material over conventional Invar is limited to a small temperature range. In the conclusion of the chapter, Jacobs indicates the advantages and disadvantages of the differential measurement technique and lists some follow-on experiments that should prove useful to the community.

In Chap. 3, W. B. Wetherell gives the most complete discussion of "Afocal Lenses" this reviewer has ever seen. Not only are classical telescopes of Galilean and Keplerian forms discussed in detail, but also the afocal relay system, binoculars, periscopes, range finders, afocal devices used for deviating a beam, reflecting afocal systems, axicons, zoom attachments, anamorphic attachments, atmospheric dispersion compensators, finite conjugate afocal relays, alignment telescopes, and Fourier transform lenses! A wealth of diagrams (54) clarify function of the devices, while equations are used appropriately to relate parameters and to define first-order characteristics. The two appendixes are especially noteworthy; the first is a two-page discussion of the earliest history of the telescope, identifying the key participants in the nebulous "invention" of the device, while the second is a list of some 130 patents dealing specifically or generally with afocal systems. While certainly not exhaustive, the list does provide a valuable source of further information as well as insight into the historical development of the technology. The list of references, while surprisingly short (39) for a treatise of this length, does include major pertinent works.

Chapter 4 is a graphic "Catalog of Zernike Polynomials" prepared by C.-J. Kim and R. R. Shannon. The values of the Zernike set in describing aberrations and the effects of disturbances such as atmospheric turbulence and surface/alignment defects are first explained. The mathematical basis for the technique is then summarized briefly. The balance of the chapter is a library of computer-generated figures showing, for each of the first 37 terms, (a) wavefront error contour map, (b) isometric plot of the wavefront error, (c) isometric plot of the point-spread function, and (d) isometric plot of the modulation transfer function. A constant 0.1 wave rms value is assigned to each aberration. The presentation is intended to help interpretation of sources of errors in actual optical systems. This reviewer can appreciate the potential usefulness of the method and hopes the authors (or others) will report selected analyses and/or experiments to illustrate its application in specific detail for the benefit of the community.

In Chap. 5, R. E. Parks addresses "Traditional Optical Fabrication Methods" with the intent to bridge communications gaps between designers, engineers, and opticians and thus help avoid pitfalls resulting from inadequate appreciation of *how* and *why* optics are made and tested the way they are. Parks divides his discussion into two basic parts, dealing first with making one of a kind (called "one off") followed by consideration of the changes in processes when larger quantities are involved. After explaining the merit of using catalog optics in certain applications, Parks provides very useful guidelines for ordering raw material. He stresses the importance of early involvement of those who later will fabricate the parts. Methods and equipment used in rough shaping, generating, loose abrasive lapping, polishing and figuring, centering, edging, cleaning, and inspection are summarized. The discussion of quantity production methods includes use of pressings, multipart blocking, and control of fabrication processes. The author acknowledges that much has been left out of this brief (26-page) chapter. Indeed, hardly anything is said about processing flatwork such as prisms. This reviewer regrets that Parks did not expand his coverage to give the reader greater benefit of his personal experience in the practical aspects of producing high quality optics.

The longest chapter in this volume is by G. M. Sanger and deals with "The Precision Machining of Optics." Based on material generated by many individuals (acknowledged at the end of the chapter) in connection with an SPIE-sponsored "Advanced Institute on Diamond Turning," this detailed and authoritative work discusses basic machine types; techniques for shaping various types of components; machine control techniques; cutting tools; postmachining polishing, testing and cladding; vibration control and utilities; and "current status, applications, and trends." With 77 figures, 7 tables, 96 references, and a clearly written text, this treatise should become a landmark reference in the field.

M. P. Chrisp describes the design and use of reflective surface relief gratings and their in-plane mounts in Chap. 7, "Aberration-Corrected Holographic Gratings and their Mountings." Basic aberration theory and its historical development, grating and mounting designs (classical and newer types), techniques for accomplishing those designs, systems involving holographic gratings and other optical elements, and the types of aberrations that have been corrected by holographic gratings are covered. The treatment is comprehensive and includes numerous (109) references. It is highly recommended reading for novice and expert alike.

New techniques for accomplishing holographic interferometry in real time and at a high sampling rate are described in the final chapter, "Basic Electronic Speckle Pattern Interferometry," by O. J. Løkberg and G. A. Slettemoen. In this work, the principles of the ESPI technique are established and related to basic holographic interferometry. The manner in which fringes are formed is then derived and explained in terms of basic apparatus setups. Modes of operation and applications are described and illustrated. The chapter closes with a status report on the development of the technique (as of 1983) and a survey of its positive and negative features. There are 90 references, many of which deal with industrial applications in analyzing transient phenomena such as vibration analysis of moving parts, detection of defects in components, detection of strain in moving structures, and biomedical research.

On the whole, it is believed that this volume will make a worthy addition to the libraries of all optical scientists and engineers.

The Measurement of Appearance, Second Edition

Richard S. Hunter and Richard W. Harold, xvi + 411 pp., illus., index, bibliography, glossary, appendix. ISBN 0-471-83006-2. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158 (1987) $65.00 hardbound.

Reviewed by David L. MacAdam, The Institute of Optics, University of Rochester, Rochester, NY 14627.

Written by a pioneer of the subject, this book's purpose is to explain the attributes of appearance of objects and methods available for measuring them. It is intended as a textbook and as a reference source. The book fulfills its primary purpose. It discusses all, and perhaps more than most readers might want to read, about appearance and proposals for measuring it. The primary premise is that object appearance involves not only color but also such attributes of appearance as gloss, luster, and translucency.

The first six chapters (94 pages) are clear, thorough, and well organized. They are concerned with (1) the physical characteristics of light sources that influence the appearance of objects and need to be specified and controlled for measurement of appearance and (2) the physical properties of objects that control the interactions of light with objects, which are related to their appearance and need be considered in its measurement.

The character of the book changes at Chap. 7, where it becomes less well organized and is marred by incomplete, misleading, and even erroneous information. What follows is an analysis of some of the points in the discussion of color and color differences that this reviewer found to be inaccurate.

On p. 96, consistent determinations of the luminosity curve are said to be made by (1) whole-spectrum heterochromatic brightness comparisons, (2) the "cascade" method of comparison of small wavelength differences, in progression through the spectrum, and (3) flicker photometry, in which perception of differences of colors is prevented by moderately rapid alternation of different wavelengths. In practice widely different results are obtained with these three methods, no pair of which agree. Those inconsistencies cause problems of current practical importance in lamp design and evaluation and in illuminating engineering.

Perhaps of less practical importance, but nevertheless fundamental, is the erroneous caption for Fig. 7.2 on p. 98. The filter primaries used by J. Guild cannot be specified by single wavelengths. Single-wavelength primaries would produce pairs of color-matching curves that are precisely zero at those wavelengths, for all observers. Such curves are shown in Fig. 7.3 for the results obtained by W. D. Wright, who did use single-wavelength primaries. The curves obtained by Guild, shown in Fig. 7.2, cross the zero axis at various wavelengths in the ranges from 459 to 464, 530 to 543, and 605 to 629 nm. That is evidence that Guild did not use primaries that can be identified with the wavelengths shown in the caption of Fig. 7.2.

Figure 7.9 on p. 110 does not, as stated in lines 4–6, show "how chromaticities of objects move with a shift from Illuminant C to Illuminant A." The caption of the figure states correctly the significance of the shifts.

Neither of the methods indicated on p. 111 is adequate or recommended by the CIE (Commission Internationale de l'Eclairage), or any authority, for simulating color constancy. The multiplying constants mentioned in line 22 are mentioned nowhere else. The description on p. 104 of the selected-ordinate method is for that reason incomplete. (The paragraph that follows it is also incomplete: the selected-ordinate method has been used for on-line tristimulus integrators, where it obviated need for multiplication or intricate mechanism. Errors resulting from random spectrophotometric errors are minimized by use of the selected-ordinate method.) Finally, use of dominant wavelength and purity was never proposed by anyone except Hunter and Harold, on p. 111, for simulating chromatic adaptation or color constancy. It is not suitable for either purpose. Use of the von Kries coefficient law for such purposes, which has been recommended for trial by the CIE, is nowhere mentioned in this book.

The ellipses in Fig. 8.5 (p. 128) were obtained by transformation of circles drawn in Fig. 8.4. Like those in Fig. 8.5, from which they were derived, the ellipses in Fig. 8.9 (p. 132) would represent uniform chromaticity spacing only if Fig. 8.4 were a perfectly uniform chromaticity diagram. When the nearly equivalent diagram shown in comparison with it in Fig. 8.6 was recommended in 1960 by the CIE, it was merely described as "more nearly uniform than the x,y diagram." In 1976, the CIE replaced that diagram by one with the vertical v (blue-to-yellow) axis expanded 50%. Therefore, the ellipses in Fig. 8.5, which correspond to circles in the diagram that was never accepted as uniform and that has been abandoned by the CIE, and the ellipses in Fig. 8.9, which were derived from those in Fig. 8.5, cannot represent just-perceptible (uniform) differences, as incorrectly stated in the caption of Fig. 8.9.

Lines 13–15 on p. 136 incorrectly state that the Munsell renotation system is based on visual bisections of differences between colors. Newhall et al. [J. Opt. Soc. Am. 33, 385–418 (1943)] reported that the judges drew arrows from the measured x,y chromaticities of actual Munsell colors to chromaticities that they thought revised colors should have in order to exhibit more accurately the chromas and hues designated by the original notations.

In the 4th line from the bottom of p. 138, the multipliers mentioned were used with sets of equal numbers of selected ordinates. Those are the multipliers mentioned previously on p. 111 without explanation and omitted entirely on p. 104.

Use of a cube-root approximation for Munsell value was published three years before Fig. 8.16 (p. 144). In Proc. IRE 43 (Sept. 1955), J. H. Ladd and J. E. Pinney reported that the standard deviation of the best cube-root formula was 0.029, whereas it could be reduced to 0.018 by use of the exponent 0.352.

Adoption of the simplified version of the Adams-Nickerson space, mentioned on p. 143, was suggested "in the interest of uniformity" as a replacement for *all* other formulas. In 1974, after agreement in favor of the L*a*b* formula at the 1973 preparatory meeting of the CIE committee, the L*u*v formula was injected. At the 1975 CIE Congress, both formulas were included in a single resolution. Only thus, on the coattails of general support for the L*a*b* formula, was the very different L*u*v* formula recommended. Adoption of two formulas, even if "of similar merit" (p. 144), cannot be "in the interest of uniformity." Subsequent amendments and additions, described in pp. 145–148, make the final resolution (with its two formulas) far more complicated than the FMC2 formula, which is not shown anywhere in this book. Complication was the most serious objection ever made to the FMC2 formula. Simplicity and apparent general support for the L*a*b* formula in 1973 led MacAdam to hope that agreement could be reached on it. Only on that basis did he withdraw the FMC2 formula. Since not one but two formulas were recommended by the CIE, MacAdam feels no obligation to support them or to abandon the FMC2 formula, the note on p. 177 of this book notwithstanding.

On p. 153, lines 6–8 state, incorrectly, that the observer "was asked to determine the point at which one [color] became visually different from the other." In fact, the observer changed the color of one half until he judged that it *matched* the other. A perfect match was possible. The standard deviation of 30 attempts to match was taken as one radius of the ellipse. The apparatus was changed to alter the direction of possible variation of chromaticity before each set of 30 matches. Six to ten different directions of change, and thus pairs of opposite radii, were used to determine each ellipse. Contrary to line 3, the observer made about 25,000 color matches, not "observations of color differences." Contrary to lines 16–17, the ellipses do not represent the way the observer "spaced just-perceptible color differences." Each radius is 10 times the standard deviation of matching, or about 3 times the just-noticeable difference.

The observer did not space just-perceptible differences from the centers, as stated in the caption of Fig. 8.17 on p. 154. The observer made 30 attempts to match the color of each center, in each of 6 to 10 series of trials, during each of which possible variations were limited to one direction from the center. The directions were different for the different series of 30 matches.

The word "distortion" in the caption of Fig. 9.3 on p. 177 is incorrect. Nothing was distorted. The points correctly show the standard deviations of color matchings. The circle fits them. The coordinate system is drawn in a well-defined way that utilizes Fig. 9.2 and two other similar figures, which are necessary but omitted from this book.

Figure 9.5 on p. 188 shows only the results of the first of 17 sets of color matchings. It shows the greatest differences found in those 17 sets. Comparable, but much less different, ellipses obtained in the last (17th) set of matchings were published in the same paper as this figure.

In these and many other ways, the history of development of methods for measuring color and color differences presented in this book is inaccurate, incomplete, and biased.

After 143 discursive pages about evaluation of color and color differences, the book finishes with six better chapters on instruments, methods, and examples of applications of measurements of appearance. A 19-page Appendix includes seven tables. The 9-page Bibliography, which is combined quite effectively with an Author Index, contains very few references from the last decade. The 11-page Glossary/Subject Index is quite complete and useful. The book is well designed and printed. It contains very few typographic errors.

The Measurement of Appearance, Second Edition is unique. It can be quite useful to a patient and discerning reader. Although it is idiosyncratic and sometimes inaccurate or biased, it contains much material that cannot be found elsewhere. It is like an enormous mosaic, in which scattered flaws, although serious, may be noticed by only a wary observer.

Books Received

Astronomical Optics, Daniel J. Schroeder, Beloit College, xii + 352 pp., illus., subject index, references, and bibliography. ISBN 0-12-629805-X. Academic Press, Inc., 1250 Sixth Ave., San Diego, CA 92101 (1987) $45.00 hardbound. Covers the characteristics of telescopes, including those with performance set by geometrical aberrations and the effect of the atmosphere as well as diffraction-limited telescopes designed for observation from above the atmosphere. Also contains discussion of expected optical characteristics for the Hubble Space Telescope.

Persistent Spectral Hole-Burning: Science and Applications, edited by W. E. Moerner, IBM Almaden Research Center, with contributions by G. C. Bjorklund, D. Haarer, J. M. Hayes, R. Jankowiak, W. Lenth, R. M. Macfarlane, W. E. Moerner, K. K. Rebane, L. A. Rebane, R. M. Shelby, A. J. Sievers, and G. J. Small. Volume 44 of Topics in Current Physics. xiv + 315 pp., illus., subject index, references. ISBN 0-387-18607-7. Springer-Verlag, 175 Fifth Ave., New York, NY 10010 (1988) $52.70 hardbound. Describes persistent spectral hole-burning in crystalline and amorphous media and presents overview of recent research efforts toward future applications to optical storage of digital data and optical signal processing. Covers photochemical and nonphotochemical mechanisms that can give rise to spectral hole formation in electronic or vibrational mode absorptions of molecules, ions, and color centers in low-temperature organic and inorganic solids.

Photoacoustic and Photothermal Phenomena, edited by P. Hess, University of Heidelberg (FRG), and J. Pelzl, Ruhr University (FRG). Springer Series in Optical Sciences Volume 58. xix + 573 pp., illus., author index, references. ISBN 0-387-18782-0. Springer-Verlag, 175 Fifth Avenue, New York, NY 10010 (1988) $65.00 hardbound. Proceedings of the 5th International Topical Meeting, Heidelberg, FRG, July 27-30, 1987. Reports progress of this technology in physics, chemistry, biology, medicine, and materials science. Presents theoretical and experimental work in spectroscopy, kinetics and relaxation, trace analysis, mass and heat transport, surfaces and thin films, nondestructive evaluation, and ultrasonics and semiconductors.

Photophysics of Polymers, edited by Charles E. Hoyle, University of Southern Mississippi, and John M. Torkelson, Northwestern University. xi + 531 pp., illus., index, references. ACS Symposium Series 358, M. Joan Comstock, series editor. Developed from a symposium sponsored by the Division of Polymer Chemistry, Inc., at the 192nd meeting of the American Chemical Society, Anaheim, California, Sept. 7-12, 1986. ISBN 0-8412-1439-5. American Chemical Society, 1155 Sixteenth St. NW, Washington, DC 20036 (1987) $99.95 hardbound. Sections cover polymer dynamics and complexation, excimer photophysics, energy migration, photophysics of polyelectrolytes, luminescent polymerization probes, and photophysics of silicon-based polymers.

Signal Analysis and Estimation—An Introduction, by Ronald L. Fante, Textron Defense Systems, Wilmington, Mass. xiv + 448 pp., illus., index, references, appendix, problems. ISBN 0-471-62425-X. John Wiley & Sons, One Wiley Drive, Somerset, NJ 08873 (1988) $44.95 hardbound. Introduction to the analysis using Fourier techniques of continuous and discrete deterministic signals, along with both the estimation and spectral analysis of random signals.

Synthetic Aperture Radar, J. Patrick Fitch, Lawrence Livermore National Laboratory (C. S. Burrus, consulting editor). viii + 170 pp., illus., index, references, 4 appendixes, problems and solutions. ISBN 0-387-96665-X. Springer-Verlag, 175 Fifth Ave., New York, NY 10010 (1988) $36 hardbound. Covers radar processing and imaging, optical processing of SAR data, an overview of related algorithms, signal processing tools, and matched filter derivation and implementation.