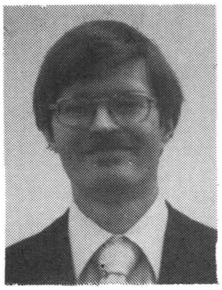

Editorial

H. J. Caulfield, Editor

Whom Do We Honor?

In his usual delightful fashion, Professor Richard Feynman recently recounted stories, insights, and observations from his life in science during a one hour interview on U.S. public television. All of what he said was enjoyable, but I think he erred in at least one judgment. He expressed disdain for organizations that form committees to determine who is worthy of an honor. With due deference to his insight, let me offer my own analysis in support of another view.

First of all, let me say that much of Professor Feynman's analysis seems right to me. I have seen grown men behave in childish and dishonorable ways in search of "honor." This is sad and upsetting. I, too, sometimes feel it would be better to have no honors. Most of the time, however, I remember my intense pleasure at seeing colleagues receive justly deserved honors. I also remember that seeking to do important work worthy of a prestigious prize is not the same as actively campaigning to receive it. In both cases the honor is a motivator (the only motivator in the latter case). So it appears that the honor is neutral as a motivator, prompting honorable conduct in many and dishonorable conduct in a few.

As one not likely to receive a major honor, I am in a position Feynman has never occupied—that of the spectator scientist. As a spectator scientist, I take great pleasure in the award of a justly deserved honor to a colleague. I am not quite sure why. The main reason, I suppose, is that most of my colleagues are very nice people. Some of them also do superlative work. I recognize that. So does everyone else. Awarding them an honor does not make me feel any different about them. It does, however, make me happy that these awards, made on behalf of us spectator scientists, say publicly what I can say only in private, i.e., "Thank you for enriching my work and my scientific pleasure." In the end, the genius of *modern* science is more than the geniuses in science. The latter are essential, but so are the rest of us. Modern science uses all of us in our own roles. My ego is not hurt by honoring individuals for their unique and wonderful contributions. Rather, I take pride that I can truly call such people colleagues. Honors remind us of the most important side of science: the human side.

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LASER ALIGNMENT OF PARALLEL MECHANICAL AXES 10 METERS APART

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Abstract. A technique using a laser to align the parallelism of a nest of rotational axes or surfaces 10 m apart to within 1/2 arc minute will be described. The parallelism of rotational axes 10 cm apart of two cylinders can be aligned and measured with optical instrumentation, such as plane mirrors, an autocollimator, or a telescope. When the sizes of the cylinders are enlarged and the separation is increased 100-fold, these approaches are impracticable because an autocollimator of twice the aperture diameter and structure of the 200 inch telescope at Mount Palomar would be required.*

1. INTRODUCTION

Consider two rods measuring about 15 cm (6 in.) long, 12.5 mm (½ in.) diameter, placed 10 cm apart [Fig. 1(a)]. These cylinders can be adjusted and measured for parallelism by using standard machine shop tools and gauges, such as a micrometer, calipers, height gauge, indicator, surface plate, and spirit level.

If the rods or cylinders are staggered axially, the task of adjusting or measuring the parallelism of the cylinders becomes more difficult [Fig. 1(b)]. This difficulty is further increased when the task is redefined to specify the parallelism of the axes of rotation instead of the physical geometry of the rods or cylinders.

When the above model is scaled up—

Separation of axes	10.0 m (33 ft)	100-fold increase
Length of cylinders	0.5 m (20 in.)	3-fold increase
Diameter of cylinders	0.5 m (20 in.)	40-fold increase
Stagger of cylinders	1.0 m (40 in.)	

—the problem of adjusting and measuring the accuracy of parallelism between the two axes of rotation of staggered cylinders in an industrial environment requires a different approach. It is a solution to this problem we wish to address (Fig. 2).

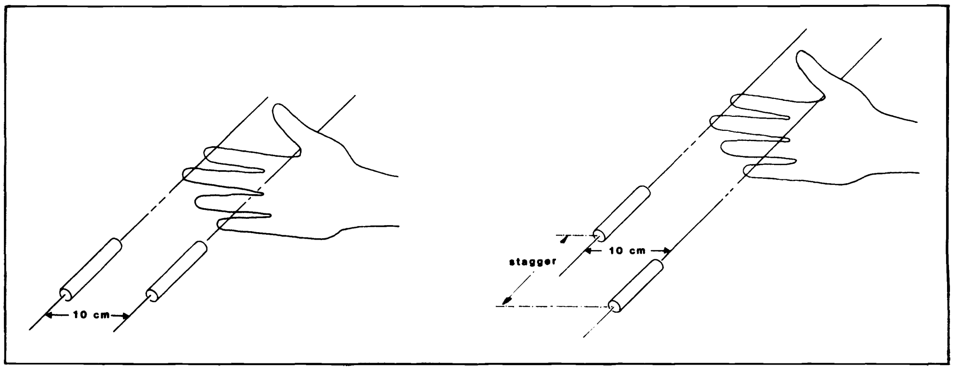

Fig. 1. (a) Two rods 10 cm apart. (b) Staggered parallel cylinders.

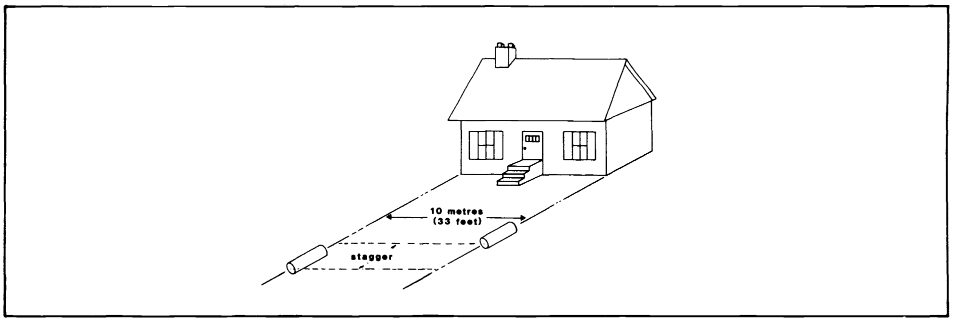

Fig. 2. Two parallel staggered cylinders 10 m apart.

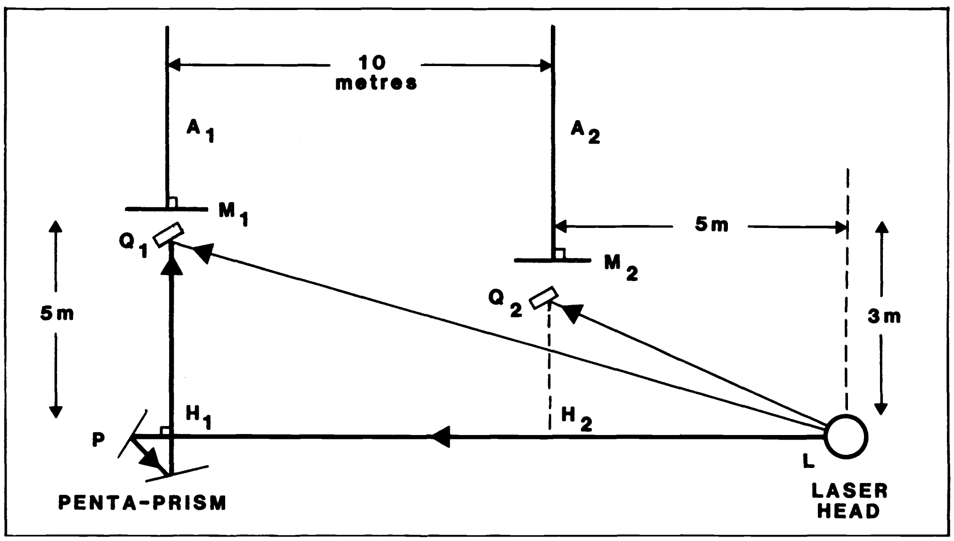

Fig. 3. Schematic of system layout.

2. DESCRIPTION

In Fig. 3, A_1 and A_2 represent the two cylinder axes that are to be adjusted for parallelism to within 1/2 arc minute; L is a helium-neon laser precision assembly† designed to sweep out manually a laser beam in a plane; P is a pentaprism mounted in a precision x-y stage assembly† with controls for three additional angular degrees of freedom; Q_1 and Q_2 represent the location of quadrant detectors†; and M_1 and M_2 are 75 mm diameter plane mirrors mounted into the ends of the cylinders and capable of fine adjustment for normality to the axes of rotation of the cylinders (Fig. 4).

3. PROCEDURE

The laser beam from the laser head L is set and leveled at a height close to—within ±25 mm, depending on the diameter of the mirrors M_1 and M_2—the plane formed by the axes A_1 and A_2.

This beam is directed separately towards the quadrant detectors at Q_1 and Q_2, each of which is

Continued on Page SR-180

*This paper was presented at The Max Born Centenary Conference, OPTICS 82, ECOSA 82, Sept. 7-10, 1982, Edinburgh, Scotland. The paper presented there appears in SPIE Proceedings Vol. 369.

†Laser System Model 711, Hamar Laser Instruments, Inc., Welton, Connecticut, USA (Fig. 5).

Continued from Page SR-178

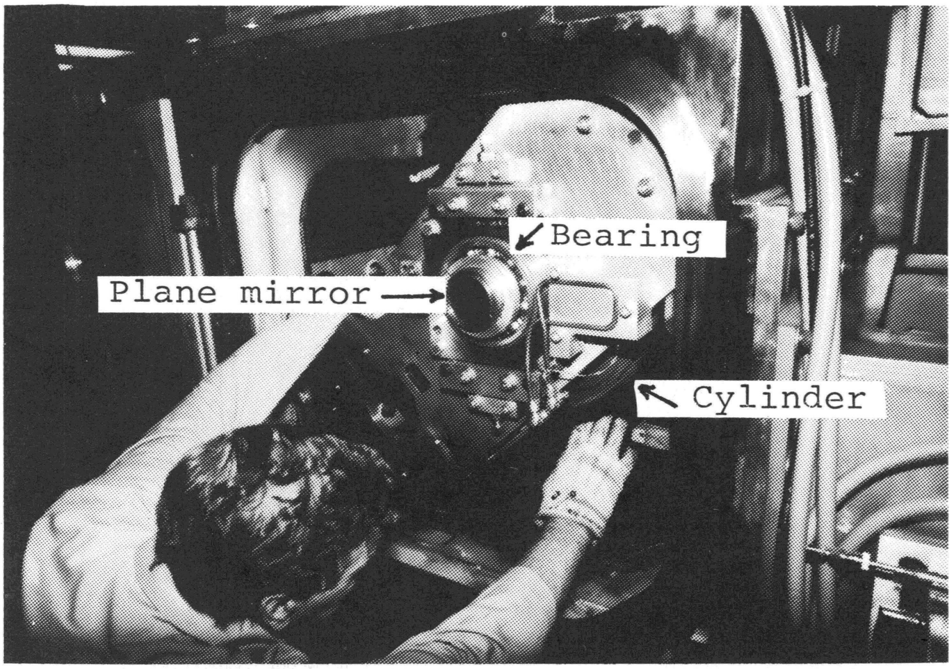

Fig. 4. A cylinder, bearing, and mirror *in situ*. (Photograph courtesy of Energy Conversion Devices, Inc.)

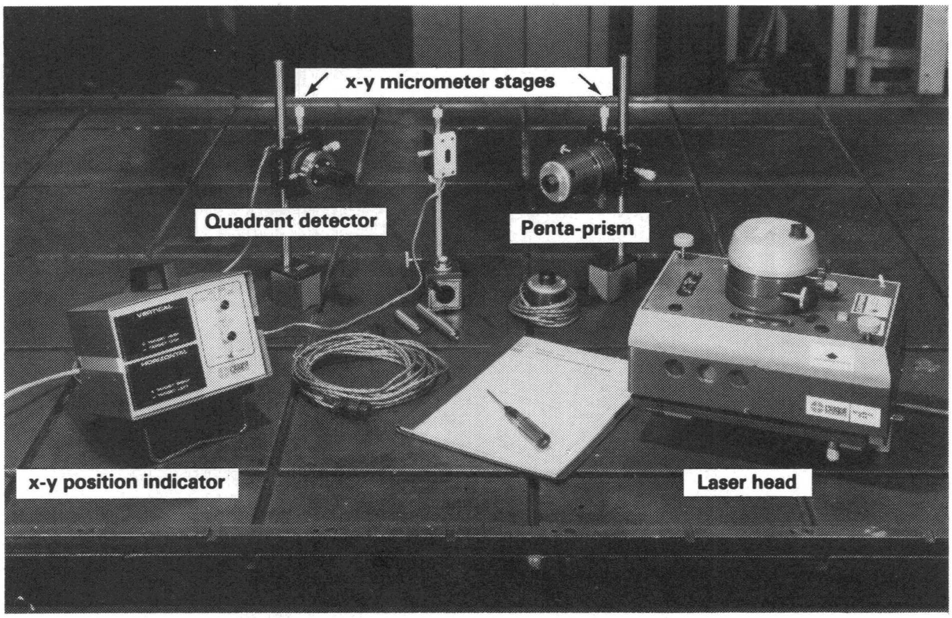

Fig. 5. System subassemblies. (Photograph courtesy of Hamar Laser Instruments, Inc.)

adjusted in height for a null reading.

The helium-neon laser beam is then redirected and locked along the path H_1H_2 to the pentaprism P. The emergent beam from a pentaprism is always at a constant angle, usually a right angle, to the incident beam, regardless of minor misalignment of the prism to the incident beam.

The pentaprism assembly P is rotated about H_2H_1 to sweep the emerging beam from the pentaprism in a vertical plane until a null reading is obtained on the quadrant detector at Q_1. Thus, the laser beam in the direction H_1Q_1 lies in a horizontal plane. The quadrant detector at Q_1 is removed to allow the laser beam to be reflected from the mirror M_1.

The axis A_1 is adjusted until the beam is reflected back along the incident beam. In a preliminary and separate adjustment, the mirror M_1 is offset from normality with the axis of rotation by about one-half arc minute. With this offset the reflected beam gyrates around the incident beam and describes approximately a two cm diameter circular scan pattern at the beam exit port of the laser head. Fine adjustment of the cylinder's axis is carried out until the circular scan pattern is concentric with the incident beam.

The pentaprism is transferred to location H_2 (Fig. 6). The laser beam along the direction H_2Q_2 is set parallel to the direction H_1Q_1 by repeating the procedure above.

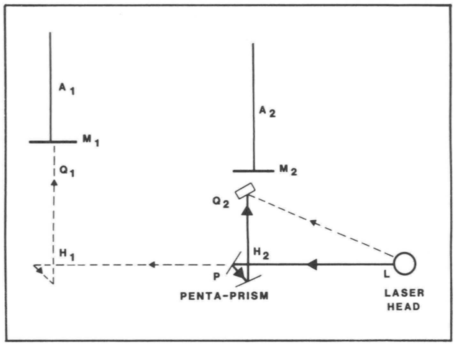

Fig. 6. Pentaprism transferred from H_1 to H_2.

4. ERROR ANALYSIS

The accuracy of the alignment technique depends upon (a) the precision to which the laser beams along H_1Q_1 and H_2Q_2 are set parallel, (b) the mechanical stability of the bearings of the cylinders, (c) the concentricity of the scan pattern to the incident beam, and (d) the minimization of refractive index gradients.

In our system, we calculated that the laser beams along H_1Q_1 and H_2Q_2 were set parallel to within 3 arc seconds in a vertical plane. Initially, each cylinder was roughed-in to a horizontal plane to within 10 arc seconds using a 37.5 cm (15 in.) long spirit level*. Assuming that there was no permanent refractive index gradient along the direction H_2H_1, and because we used the same pentaprism at positions H_1 and H_2, the parallelism in a horizontal plane of the emergent beams in the direction H_1Q_1 and H_2Q_2 was assured.

Mechanical stability and quality of the bearings were improved until perturbations in the circular pattern were not detectable. The scan pattern perturbations signify the existence and identify the location of problems in the bearings of the cylinders.

The maximum error we had in adjusting the concentricity of the two scan patterns to the incident beam corresponded to 15 arc seconds of misalignment in the parallelism of the axes of rotation.

Refractive index gradients, because of thermals and turbulence caused by personnel activity in the industrial environment, produced variations in quadrant detector positioning for a null reading. These variations were eliminated by allowing the air to settle down overnight and by carrying out the adjustments in the early morning before there was any activity.

5. COMMENTARY

For a requirement in which greater accuracy is essential, we would recommend the introduction of a larger pentaprism and suggest the joint use of a laser and a theodolite coupled by a beam combiner. The laser would essentially be used to aim and track the reticle image of the autocollimator of the theodolite.

6. CONCLUSION

This technique allowed us to adjust and measure the parallelism of the axes of rotation, 10 m apart, to within 1/2 arc minute.

7. ACKNOWLEDGMENTS

We thank the management of Energy Conversion Devices, Inc. for its support in this project approach and our colleagues for their technical assistance.

*Starett Master Spirit Level, Cat. No. 199Z.

Conference Report

ULTRASONICS INTERNATIONAL '83 HALIFAX, NOVA SCOTIA, CANADA

Pal Greguss, Jr.
Technical University Budapest
Budapest, Hungary

Optics and acoustics are interwoven with each other in many aspects, especially if high frequency acoustics, i.e., ultrasonics, is considered, and, as a result, newer disciplines such as optoacoustics, acousto-optics, photoacoustics, and others have emerged. Although optical people present papers at ultrasonic conferences, and those interested mainly in ultrasonics read papers at optical meetings, in both cases, most of the authors perceive themselves as "guests," rather than members of the audience. Fortunately, I did not have this impression when attending the optoacoustics sessions at the Ultrasonics International '83 conference, sponsored by the Canadian Acoustical Association, the Canadian Society of Nondestructive Testing, and, last but not least, by the journal *Ultrasonics,* held July 12–14, 1983, in Halifax, Nova Scotia, at Dalhousie University, and led by an organizing team headed by Prof. H. W. Jones.

R. Mertens et al. of Rijksuniversiteit, Gent, Belgium, presented a general theory on the diffraction of light by adjacent parallel ultrasonic waves. The novelty of this theory is that in contrast to earlier theories it uses only one system of reference. In spite of this simplification, the presented theory yields exact boundary conditions at the plane of separation of the two ultrasonic waves.

A. Slivinsky et al. of the University of Gdansk, Poland, in collaboration with O. Leroy of Katholieke University, Leuven, Belgium, verified experimentally the dependence of light intensity distribution in diffraction orders as a function of the phase shift between the adjacent ultrasonic beams and compared it with the theoretical prediction.

J. Szilard et al. of the University of Technology, Loughborough, United Kingdom, reported on a new stroboscope for schlieren and photoacoustic visualization of ultrasound which offers extremely short flash duration (10 ns or less) independent of repetition rate, is free from jitter, has a long working life, and is of small size. These remarkable technical data have been achieved by using a Stanley Hi-Super Bright LED in impulse mode. The output energy per flash was of 0.03 μJ. Thus, applied to conventional ultrasonic schlieren systems, ultrasonic fields become clearly visible with very good contrast since the emission of the LED is nearly monochromatic.

R. W. B. Stephens et al. of Chelsea College, London, United Kingdom, after reviewing the basics of photoacoustic spectroscopy, reported on the measurement of thermal and optical properties of various powders, using nonresonant photoacoustic cells over a wide range of wavelengths extending from the UV into the IR up to a wavelength of 12 nm.

The papers of G. Veith of Max Planck Institut für Festkörperforschung, Stuttgart, Federal Republic of Germany, attracted attention not only because in his work surface acoustic wave detection was used for photoacoustic imaging for the first time, but also because some of the detection methods were based not only on acoustics but on optical means, too, thus allowing the application of this new imaging technique not only to piezoelectric substrates but also to all solid materials. The synchronous optical detection system proposed by the author could be highly efficient since a probe beam could be used as one part of the surface acoustic wave (SAW) exciting beam, which could serve as a high precision phase-sensitive laser probe at every point of the substrate. Since the exciting and probe beams are strongly synchronized, a stroboscopic image of a standing SAW can be obtained. By delaying the probe beam with respect to the exciting beam, the surface acoustic wave can be imaged at different times, which simplifies the visualization of SAW propagation characteristics.

The papers presented at the optoacoustic sessions were introduced by a review paper by P. Greguss of the Technical University Budapest, Hungary, entitled "On the crossroads of ultrasonics and optics." He emphasized that in spite of the fact that acoustics and optics generally have developed in separate ways, nevertheless, sometimes these lines of development not only approach each other but also may even form crossings which then are starting points of new disciplines either as a result of recognized analogies in the propagation behavior of these two energy forms or as a result of their interaction with matter, or both. He expressed his feelings that the marriage of acoustics and optics would have a significant effect not only in such fields as nondestructive testing, but also in biomedical applications.

Book Reviews

The Fourier Transform and Its Applications to Optics, Second Edition

P. M. Duffieux, 197 pp., illus., index. ISBN 0-471-09589-3. John Wiley and Sons, Inc., 605 Third Ave., New York, NY 10158 (1983) $33.95.

Reviewed by Henry Stark, Dept. of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12181.

This seminal work by Duffieux, first published at Besançon some four decades earlier,[1] was reissued with changes in a second edition in French in 1970,[2] and published in English by John Wiley and Sons, Inc. in 1983. Thus, even the second edition is dated (for example, there is no mention of holography); this, combined with (1) the absence of both a bibliography and problem sets, and (2) awkward English usage and an unusually terse and nonidiomatic style, makes this book wholly unsuitable for classroom use. Nevertheless, the appearance of this work in English gives the Fourier optical community a golden opportunity to discover the origin of the "modern" view of linear optical phenomena, i.e., via the Fourier transform. It is interesting to note that Duffieux's ideas were still being fought in the mid-1950s, when a leading figure in optics wrote,[3]

> One should not indulge too much in dealing with coherent and semi-coherent illumination, frequency analysis, and all straightforward translations of well-known radio communication results into optical technology . . .the eye is not the ear, and any interpretation of vision in terms of frequencies is really too farfetched.

Exactly why the ideas so successfully used in communication engineering percolated so slowly into the mainstream of optics is an interesting historical question. From our present vantage point we could have argued that all linear, invariant phenomena are describable by convolution and Fourier transform relations, and, therefore, all that was needed to apply the mathematical tools already available in other fields to optics was to replace the time argument t by the space argument x. Apparently, however, that is not how things went. Still, they did percolate, and Duffieux's ideas made many of us—originally educated as electrical engineers—overnight experts in optics. Some of us even had the *chutzpah* to make up equivalence tables, e.g., a lens = a chip waveform, a hologram = a square-law detector, etc.

The second edition of Duffieux's book has ten short chapters, the first five of which deal with Fourier series, integrals, and linear systems theory. The material there is standard and is presented better in other places, as in the books by Gaskill[4] or Papoulis.[5] Chapter six deals with Fraunhofer diffraction, but in a fashion not destined to make matters easy for the reader. Unfamiliar concepts such as the Laue-Epler sphere and the circle of extension, diagrams nearly impossible to decipher, and sentences such as ". . . Linear optics happily accepts nonlinear phenomena among its fundamental phenomena. . ." do a good deal to exasperate the reader. Chapter seven ("Plancherel's Theorem and Correlation") is a discussion of what we would call Parseval's theorem and its extensions. Chapters eight ("Stigmatic Pupils"), nine ("Discrete Functions"), and ten ("Transmission of Spatial Frequencies") deal with various topics in Fourier optics that we take for granted now but probably were revolutionary concepts back in 1946. Indeed, scanning through this book is bound to raise some excitement in the reader because he is coming face to face with original source material: *there is no look-alike antecedent* (except for the first edition, of course) for this book. Still, to learn Fourier optics in 1983 one would not go to Duffieux's book any more than one would go to Newton's *Principia* to learn mechanics.

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Applications of Optical Fourier Transforms

Henry Stark, ed., 545 pp., illus., index, bibliography. ISBN 0-12-663220-0. Academic Press, 111 Fifth Avenue, New York, NY 10003 (1982) $67.50.

Reviewed by W. J. Miceli, RADC/ESO, Hanscom Air Force Base, MA 01731. (Present address: Naval Ocean Systems Center, San Diego, CA.)

Why should anyone read *Applications of Optical Fourier Transforms?* It is often said that we live in the computer age and that maturing VLSI/VHSIC technology will marshall in a world dominated by digital information processing. Setting this inveigling platitude aside long enough to perform a more than cursory examination of technology requirements associated with image/signal processing, the merits of optical processing systems soon come into focus. Recognizing that data processing system requirements are continually driving hardware development, it is becoming essential that both processing system users and developers understand and appreciate the applications of optically implemented Fourier transforms. This book is an idea whose time has come.

As the title suggests, this comprehensive volume presents the fundamentals and applications of optical Fourier transforms. The twelve chapters, each written by accomplished researchers, review the theory and measurement of optical Fourier transforms, and elaborately discuss such topics as pattern recognition, signal processing, photographic image measurement, space-variant optical systems, surface acoustic wave devices, the human visual system, and incoherent optical processing systems. These general topics embrace a host of extremely diversified specific applications, such as diatom identification, clinical and vision research applications of speckle, and radar signal detection. A summary cannot begin to adequately acknowledge the many applications covered in this book.

Notation is consistent, and the references at the end of each chapter are comprehensive. There is also an eight page topical index at the end of the book. The multidisciplinary nature of the topics covered suggests wide reader appeal, and the assiduity of the entire volume will appeal to those who seek to learn, as the editor says, ". . .some of the extraordinary achievements of Fourier optics."

Is this book worth $67.50? In my opinion, yes. I particularly liked the clear, concise, and thorough mathematical development of the first chapter, entitled "Theory and Measurement of the Optical Fourier Transform," written by Henry Stark. It was beneficial to read such a complete discussion of the conditions under which the light distribution in the back focal plane of a lens is indeed related to the Fourier spectrum of the input. The entire issue of measurement accuracy, including extensive sections on "windowing" and spectral estimation, serves as a firm theoretical background from which the applications later discussed can be justly evaluated and appreciated.

Chapter 2, "Pattern Recognition via Complex Spatial Filtering," introduces the theory and applications of complex spatial filters. The statistical characteristics of Fourier plane irradiance patterns are treated in Chap. 3, entitled "Particle Identification and Counting by Fourier-Optical Pattern Recognition."

Chapter 4, "Signal Processing Using Hybrid Systems," promotes the combination of optics, analog electronics, and digital computers. "Fourier Optics and Radar Signal Processing" (Chap. 5) discusses recent progress of synthetic aperture radar and other radar waveforms.

Chapter 6, "Applications of Optical Power Spectra to Photographic Image Measurement," involves photographic image evaluation measuring the optical power spectra of signal and noise. "Fourier Optics and SAW Devices" are extensively discussed in Chap. 7, followed by "Space-Variant Optical Systems and Processing" (Chap. 8).

Chapter 9, "Fourier Optics in Nonlinear Signal Processing," treats a number of nonlinear systems and components and shows how they can be used in many applications, for example, digital logic. The relation between optical Fourier transforms and the human visual system is established in Chap. 10, "Optical Information Processing and the Human Visual System."

Chapter 11 is entitled "Statistical Pattern Recognition Using Optical Fourier Transform Features." The final chapter (Chap. 12), "Incoherent Optical Processing," is a very lucid treatment of imaging systems tailored for image/signal processing. After developing an input/output model based upon a telecentric imaging system illuminated by an arbitrary source, the authors consider the effects of restricting the size and/or spectral bandwidth of the source. The relative advantages of spatially incoherent and spatially coherent/temporally incoherent sources are discussed, and numerous applications of such incoherent optical processors are mentioned.

Applications of Optical Fourier Transforms picks up where Goodman's *Introduction to Fourier Optics* leaves off. One comes away from this book acknowledging that when optics is properly mated with electronics, the potential is awesome.

Continued on Page SR-184

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Optical Production Technology, Second Edition

Douglas F. Horne, 432 pp., illus., index, references. ISBN 0-85274-350-5. Adam Hilger, Ltd. (Publisher), Techno House, Redcliffe Way, Bristol, BS1 6NX, England; Heyden & Son Inc. (U.S. Distributor), 247 South 41st St., Philadelphia, PA 19104 (1982) $90.00.

Reviewed by Frank Cooke, Frank Cooke, Inc., 59 Summer St., North Brookfield, MA 01535.

This book is a must for the serious student of current optical production techniques. It succeeds Twyman's famous *Prism & Lens Making.* Many new optical machines and procedures are amply described and well illustrated. However, where the older methods are still valuable, they are also included.

The accuracy of the technical descriptions is beyond doubt. For this reason alone the text is quite valuable. Another facet that makes it enjoyable as well is its inclusion of history and background of the optical world from ancient Egypt to the present. For instance, we learn that crystal glass comes from the Greek "Krstallos"—or frozen ice—and we learn how the glass was made.

The section on production of large mirrors starts with a historical review, which adds much to our modern approach. Horne realizes in a most appreciative way that "What's past is prologue."

The progressive optician may note with some alarm, yet satisfaction, the description of modern computer-controlled machines to generate aspheric surfaces so accurate and smooth as to go directly to polish. To many an old timer, this revolution in optical machinery may come as a sobering shock.

When and how to use plastic lenses, especially aspherics, are nicely described. Those working with polycrystalline materials will find suggestions of great value.

In rereading the book to write this review, I was impressed by the thoroughness and competence of the author. The explanations of almost every task facing the optical worker are so well presented that the text may well become a bible in the field of optical production technology. If you are manufacturing optics, secure a copy.

The Art of Electronics

Paul Horowitz and Winfield Hill, 716 pp., illus., index, references. ISBN 0-521-23151-5. Cambridge University Press, 32 E. 57th, New York, NY 10026 (1980) $27.95.

Reviewed by Joseph L. Horner, SPIE Reports Editor, *Optical Engineering,* Rome Air Development Center/ESO, Hanscom Air Force Base, MA 07131.

The first thing you are probably wondering is why a book on electronics is being reviewed in *Optical Engineering.* I am doing it because this is far and away the finest book on the subject of electronics I have come across in the last decade. More and more of our research, even as opticists, involves the use of electronics, whether in controlling the experiment or system (the ubiquitous microprocessor) or retrieving the data (the ever-present op-amp). Therefore, I hope I am doing a real service to the optical community by making others aware of this book.

P. Horowitz and W. Hill say in the preface that the book grew out of a set of notes for a one semester course at Harvard University. However, the book goes far beyond this, and indeed can serve not only as a textbook but also as a very thorough reference book. The scope of the material is quite large, starting with basic electricity in Chap. 1, transistors in Chap. 2, feedback and op-amps (Chap. 3), filters and oscillators (Chap. 4), voltage regulators and power supplies (Chap. 5), and field effect transistors (Chap. 6). The book contains much material helpful to someone actually building or troubleshooting a circuit. For example, Chap. 7 is devoted to noise of all types, interference, grounding, and shielding. In addition, there are two chapters on digital electronics and two on microprocessors. The remaining chapters cover construction techniques, high-frequency techniques, and measurements. There are eleven appendixes, a chapter-by-chapter bibliography, and an index. At the end of many of the chapters there are problem sets. The style is very easy to read—I would almost say colloquial. For example, on p. 93 they refer to the #741 op-amp as a "wee-beastie."

The book has several other features I like. At the end of the chapters on circuits, there are several pages of "bad circuits" and "circuit ideas." The "bad circuits" are schematic drawings with no explanation of why they are bad. The reader must figure this out for himself, and the preceding chapter provides the necessary information to do this—if you read it carefully enough. The "circuit ideas" contain novel arrangements and configurations not discussed in the text.

Numerous tables and charts (44 to be exact) are provided, and components are named by device number. The trouble with most books having material like this is that it is obsolete or lists very obscure and esoteric parts. Not so with this book. The authors obviously have a great deal of practical experience in current state-of-the-art electronic design. At the same time, the discussions and explanations are rigorous enough to satisfy the most demanding expert.

There is an accompanying Laboratory Manual ($9.95) that fits in with the book quite nicely. I am presently going through it with our technician.

I think this book fills a need that has existed for quite some time. There was a book of this nature and caliber (*Digital Electronics for Scientists,* by H. V. Malmstadt and C. G. Enke) published in 1969. Unfortunately, it was not revised, and much of the material slowly went out of date. I fervently hope the authors of *The Art of Electronics* will rewrite and update it periodically.

Finally, in this age of inflation with prices occasionally hitting the $100.00 mark, this book is a veritable steal at $27.95. I cannot recommend this book highly enough to anyone whose research or experiments require some electronics.

Advances in Non-Impact Printing Technologies for Computer and Office Applications

Proceedings of the First International Congress on Advances in Non-Impact Printing Technologies, Society of Photographic Scientists and Engineers, Venice, Italy, June 1981. Joseph Gaynor, ed., 1412 pp., illus., index, references. ISBN 0-442-28167-6. Van Nostrand Reinhold Company, 135 West 50th St., New York, NY 10020 (1983) $75.

Reviewed by Barry V. Harris, Dunn Technology Inc., 759 E. Vista Way, Vista, CA 92083.

The 1981 Venice Conference covered in these proceedings was the first SPSE conference to address the subject of nonimpact printing. Nonimpact printers are forecast to make a major penetration of the office automation market in this decade, at the expense of impact printing systems.

As reflected in current products and development activities, electrophotography is the dominant technology. It is based principally on modified office copier engines, where exposure of the reusable photoconductor responds to digital input via a variety of imaging systems.

Electrophotographic nonimpact printing technology has its roots in high speed machines developed in the 1970s by IBM, Siemens, Xerox, and others to replace impact line printers. Maturation of laser imaging systems has led to the development of slower, much less expensive units that are being placed in small quantities at present, but which have the potential to make major inroads on daisy wheel printer sales over the next three to five years.

Some of the advantages of nonimpact printing include speed, flexibility in character styles and sizes, good print quality, high page packing density, automatic integration of digital logos, production of forms, mixing of paper stocks, computer collation, quiet operation, and competitive price/performance. In addition, several of the current products can operate as facsimile units or as convenience copiers.

In addition to electrophotography, several other imaging/reproduction methods were covered at the conference, notably electrostatics, ink jet, thermal, and magnetographic systems.

The proceedings is divided into eight chapters, each corresponding to the technology subset under discussion; each chapter contains an introduction by the editor. A total of 73 papers are presented, with their accompanying illustrations. About one-third of the book is devoted to optics, the balance to image generation methods of various kinds, toners, exposure control mechanisms, and similar peripheral system requirements.

Roughly half the page count is given to reproduction of visual graphics used by the speakers. The papers appear to have been reproduced directly from author manuscripts; most were typed on various typewriters. Even were they typeset, this book would still be the size of a college dictionary. It is not for casual reading.

Chapter Contents

1. *General Context and Use Requirements of Non-Impact Printers:* The four papers in this chapter cover nonimpact versus impact printer performance, interfacing printers to computers, user experience, and trends in information communications systems. These are general in nature. The paper covering user experience addresses products that have been on the market for some years. Although low-cost nonimpact printers are the dominant theme of the conference, little data are presented about future markets for these products. Organizations represented by speakers in this chapter include Honeywell, IBM, Dataquest, and Tokai University (Japan).

2. *Technologies Basic to Photo and Electronic Printout:* Six of the seven papers in this chapter discuss conventional electrophotographic/electrostatic imagers, e.g., dry toner on plain paper. These cover characteristics such as photoconductor sensitivity, resolution, image quality, reproducibility, and reliability. The seventh is a basic theoretical and experimental study of parametric effects on photoelectrophoresis. Organizations represented include Philips, Xerox, IBM, Siemens, Kalle, and 3M.

3. *Laser, LED, and CRT Electrophotographic Systems:* This is the largest chapter, covering the dominant technologies used in the current crop of some 20 low-cost nonimpact printing products. Of the 18 papers in this chapter, 13 deal with laser

imagers and IR-sensitive photoconductors. The other papers deal with alternative imagers: CRT, LED, magneto-optic light switching (LiSA), and a two-color laser beam printer. Organizations represented include Xerox, Olivetti, Oki Electric, Xerox, Philips, AEG-Telefunken, Nippon T&T, Kalle, Tokai U., Standard Electrik Lorenz AG, Siemens, and Hitachi. Notable by their absence, in view of the fact that they have commercial products on the market, are Agfa-Gevaert, Alcatel, Fujitsu, Kanematsu, Konishiroku, Mita, Minolta, and Ricoh.

4. *Electrostatic and Magnetic Systems:* Electrostatic systems are mature, reflected commercially notably in the Honeywell Page Printing System. Four of the papers in this chapter focus on direct electrostatic imaging, where the paper itself is exposed directly. The next four are based on the indirect process, where a dielectric drum is precharged and selectively neutralized. The indirect method has the advantage of using plain paper, and the disadvantage of requiring more steps in the imaging process. Other papers discuss ion imaging (used in the Delphax printer), magnestylus printing (3M), and magnetographics. We believe that magnetographics has the potential to compete with high speed electrophotographics and with conventional offset printing toward the end of the decade. Organizations represented include Xerox, GE-Toulouse, Mitsubishi, Fujitsu, Dennison Mfg., 3M, CII-Honeywell Bull, du Pont, and Iwatsu.

5. *Thermal Processes and Media:* Thermal printing is experiencing a resurgence due to low cost, inherent reliability, and improvements in quality; developments are being driven by the emerging home computer market. In addition to meeting low-end needs, thermal technologies have the potential for greater speed and resolution and to write on plain paper. The nine papers in this chapter discuss trade-offs in thermal print-head design, color formation using thermosensitive paper, and imaging materials. Organizations represented include CNET (France), Olivetti, Toshiba, Gould, Fuji, and Dai Nippon Printing Co.

6. *Ink Jet:* Continuous stream ink jet printers have been available for years, but most recent development has been directed at drop-on-demand (pulse) mechanisms. These are expected to compete with thermal printers at the low end of the market, since they provide somewhat better resolution and character definition. Much work is in development, as witnessed by the 15 papers presented in this chapter that cover improvements in resolution, speed, inks, and deflection control systems. Organizations represented include Hitachi, Xerox, A. B. Dick, Domino Printing Sciences, IBM, Philips, Olivetti, Nippon Electric, and Sanyo.

7. *Special Topics:* This chapter covers topics that were difficult to categorize but which were relevant to the overall theme of the conference. One Olivetti paper discussed four potential photochemical and photomechanical effects for nonimpact printing. They are (1) a material which is sensitive to light and/or electric or magnetic field; exposure causes changes in surface tension or chemisorption behavior, allowing selective inking and repetitive transfer; (2) a deformation process, roughly analogous to letterpress or gravure printing; (3) selective deposition of metal, as a way of creating an offset printing plate; and (4) a photosensitive ink where light exposure causes only the unexposed areas to transfer, or the reverse. These technologies have not been thoroughly explored for nonimpact printing applications. Agfa-Gevaert presented studies on quantization problems in digital image processing, growing out of work their company has done in connection with Agfa's new Officer P400 nonimpact printing system. Organizations represented include Olivetti, Agfa-Gevaert, Dynamics Research Corp., and Corning (France).

8. *Future Directions—Panel:* The panel participants are divided in their predictions of the winning technologies of the future, depending on their employers, but agree that varying applications requirements will allow multiple systems to succeed in the several market areas. At the low end (to 10 pages per minute) the most cost-effective systems are expected to be thermal and ink jet. At this speed, electrophotographics enters the picture. It is expected to be the dominant technology up to a million or more pages per month. However, to capitalize on this market over the longer term, reliability must be improved in photoconductor life, toner life, and noncontact fusing, in addition to more refined internal monitoring systems that forestall major equipment outages.

Summary

One relevant technology subset that received no attention in this conference is the matter of "image drivers." Most of the current low speed nonimpact printers are equipped with video interfaces of limited capability, i.e., without computer interfaces, type libraries, or character generators. Accordingly, a number of U.S. companies have begun to build image drivers which connect these printers to standard computers and convert symbolic data, intended for output on a daisy wheel printer or phototypesetter, into the video format needed to drive the printer engine. These fairly recent developments are of interest to the prospective system builder, as well as to the user. However, developments in this area are so new, and so closely held, that no papers on the subject were covered.

NIP technologies and applications for them depend on application. All of the technologies discussed are competitors with impact printers, ranging from high speed line printers to slow, dot-matrix printers. At the high end, electrophotographics is seen as the dominant choice because impact printer technology is close to its limits, especially with respect to flexibility. Possible future competition will come from magnetographics, electrographics, and ink jet (in that order). At the low end, the choice is between thermal and ink jet. Thermal is favored where the duty cycle is low; ink jet will gain increasing market share where larger numbers of pages are needed.

Finally, winning technologies will depend in large part upon marketing pressure as well as on equipment cost, supplies costs, speed and flexibility, and adaptability to an office environment.

Digital Document Processing

H. S. Hou, 329 pp., illus., author and subject indices, bibliography, problems. ISBN 0-471-86247-9. Wiley-Interscience, John Wiley and Sons, Inc., 605 Third Ave., New York, NY 10158 (1983) $34.95.

Reviewed by Jan P. Allebach, Purdue University, School of Electrical Engineering, West Lafayette, IN 47907.

Digital Document Processing appears to be the first text to cover all aspects of this rapidly growing field. It is an introductory treatment that addresses a wide range of topics in the space of some 300 pages. As stated in the introduction, the author's objective is ". . . to emphasize fundamental principles and algorithms without completely neglecting actual methods of implementation." The author has chosen to discuss some topics in considerable depth while only briefly mentioning others. Although the level of mathematical rigor is generally low, the text will be most easily understood by one who has some acquaintance with linear systems, Fourier analysis, probability, and linear algebra. Many of the concepts are made more accessible by introducing them via examples rather than formal definitions. The book is organized roughly according to the sequence of steps involved in processing a document, but the chapters generally stand alone well.

After a brief preview of the book in Chap. 1, Chap. 2 begins with the input scan process, including the effect of the scanner aperture and sampling. The operation of charge-coupled devices (CCDs) is discussed in some detail. The next topic considered is that of aperture synthesis via a tapped delay line and a more general approach based on the pseudoinverse from image restoration. This chapter concludes with very simple discussions of filtering for image enhancement and threshold selection. Chapter 3 covers shape manipulation. The principal topic is cubic spline interpolation which is covered in depth. Scaling and rotation are also discussed, including Eklundh's algorithm for transposing large matrices. The chapter concludes with edge extraction along with algorithms for thinning and tests for connectivity.

The subject of Chap. 4 is digital halftoning. Following a discussion of the basic principles, the author presents a novel mathematical analysis of the screening process based on an identity involving the integral of the sinc function. This approach does not seem to lend as much insight as the more conventional one, first applied to halftone imaging by Kermisch and Roetling, in which the binary image is directly expanded in a Fourier series with spatially varying coefficients. The chapter continues with the factors involved in choosing a threshold matrix and a good treatment of tone reproduction. A very brief discussion of artificial shading ends the chapter. Chapter 5 describes algorithms for data compression. These include the Huffman, runlength, predictive, block, and contour codes. The modified relative element address designate (READ) code, which is a runlength code that makes use of correlation between adjacent lines, is discussed in detail. Character feature extraction is treated in Chap. 6. The features discussed include moments, skeletons, profiles, projections, and those arising from transforms. Clustering techniques and performance measures are also described.

Chapter 7 differs somewhat in flavor from the preceding chapters. It describes the environment within which documents are prepared and the general aspects of font processing, text editing, and page composition. Chapter 8 treats techniques that are associated with document retrieval including sorting, searching, hashing, and string matching. Chapter 9 considers text recognition. After introducing a Markov model for text, the Viterbi algorithm, dictionary lookup methods, the generalized Levenshtein distance, and syntactical methods are discussed as means of correcting recognition errors. The chapter concludes with a brief discussion of computer analysis of text for readability. The subject of Chap. 10 is document transmission. Following a general discussion of networks and protocols, the chapter delves into error correcting codes based on polynomials in a finite field, and data encryption including the data encryption standard (DES) and public key cryptography. Finally, Chap. 11 considers the output scan process. The first part of the chapter contains a general discussion of output devices. Then, plotting algorithms and vector-to-raster scan conversion are treated. The chapter concludes with a discussion of image quality for black/white graphics and text.

The author has generally succeeded in providing a lucid and informative account of the material outlined above. However, in some sections, the brevity of the treatment makes comprehension of the material more difficult than it might otherwise be. To obtain a more complete understanding, the reader may consult the large number of references that are collected at the end of each chapter. Unfortunately, these references are not cited in the text of the chapters; so it is sometimes difficult to determine which reference, if any, contains additional information pertaining to a specific item in the text.

Technically, the book is uniformly accurate on major points, but there are some minor points which may unintentionally confuse or mislead the reader. To cite a few examples, the Dirac delta function is defined in Chap. 2 as having a value of 1 at the origin and 0 elsewhere, rather than as the limit of a sequence of pulses with unit area and vanishing duration. In Chap. 4, the author seems to suggest that *partial dotting* in the halftone process refers to the asymmetry that occurs as the discrete halftone dot is built up pixel by pixel. Then, on the following page, he correctly associates this term with the partial dots that may result in the halftone image when the image detail is smaller than the period of the screen. Finally, in Chap. 5 on data compression the author states that according to Shannon's source coding theorem, the average code word length is upper bounded by the source entropy plus unity. This seems to imply that the bound holds for all codes, when the theorem, in fact, only guarantees the existence of some codes that meet this bound. It should be emphasized, however, that the flaws of this type are all relatively minor.

Overall, the book is an excellent and much needed introduction to the diverse topics that concern digital document processing. It should be useful to those who are just beginning to work in this area, as well as to researchers who may wish to broaden their knowledge of the field. Because of its extensive bibliography, the book provides a very good point of entry to the research literature.

Meetings

DECEMBER 1983

Dec. 5-9 2nd South East Asian Survey Congress, Hong Kong. Hosted by The Royal Institute of Chartered Surveyors (HK Branch) and The Hong Kong Institute of Land Surveyors. Congress Secretariat: c/o International Conference Consultants, 57 Wyndham St., Central, 1st Floor, Hong Kong. Tel.: 5-253271. Telex: 72500 HX. Cable: INCONFER.

Dec. 12-14 International Conference on Image Assessment—Infrared and Visible, Oxford, England. Contact Sira Conference Unit. South Hill, Chislehurst, Kent BR7 5EH, England. 01-467 2636. Telex 896649.

Dec. 12-16 Sixth International Conference on Lasers & Applications: Lasers '83, San Francisco, CA. Sponsored by the Society for Optical and Quantum Electronics. SOQUE, P.O. Box 245, McLean VA 22101. 703/241-8909.

Dec. 12-17 Eighth International Conference on Infrared and Millimeter Waves, Miami Beach, FL. Sponsored by IEEE Microwave Theory and Techniques Society, International Union of Radio Science, and U.S. Army Research Office. J. J. Gallagher, Engineering Experiment Station, Georgia Institute of Technology, Atlanta GA 30332.

Dec. 19-22 Indian Association for Quality and Reliability 4th National Convention: 1983, Trivandrum, India. Contact N. K. Debnath, Secretary, Steering Committee, IV National Convention, IAQR, c/o Corporate Quality Assurance Dept., K.S.E.D.C. Sasthamangalam, Trivandrum 695010 India. 61823/67827.

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JANUARY 1984

Jan. 4-6 17th Annual Hawaii International Conference on System Sciences (HICSS-17), Honolulu, HI. Includes sessions on medical information processing. Sponsored by the Univ. of Hawaii and the Univ. of Southwestern Louisiana in cooperation with the Association of Computing Machinery and the IEEE Computer Society. Contact Dr. Bruce Shriver, Computer Science Dept., Univ. of Southwestern Louisiana, P.O. Box 44330, Lafayette LA 70504.

Jan. 8-11 American Astronomical Society 163rd Meeting, Las Vegas, NV. Working Group on Photographic Materials will meet Jan. 10-11 in conjunction with, but separate from, the AAS meeting. American Astronomical Society, 1816 Jefferson Place, N.W., Washington, D.C. 20036. 202/659-0134.

Jan. 22-27 SPIE • Los Angeles Technical Symposium '84 and Exhibit, Los Angeles, CA. Features **Optics in Entertainment II.** Chairman: Chris Outwater, Consultant, Walt Disney Enterprises. **Spatial Light Modulators and Applications.** Chairman: Uzi Efron, Hughes Research Labs. **Advanced Semiconductor Processing and Characterization of Electronic and Optical Materials.** Chairmen: Devendra K. Sadana, Microelectronics Center of North Carolina, and Carl M. Lampert, Lawrence Berkeley Laboratory. **Processing of Guided Wave Optoelectronic Materials.** Chairmen: Robert L. Holman, Battelle Columbus Labs. and Don Smyth, Lehigh Univ. **Laser Assisted Deposition, Etching, and Doping.** Chairman: Susan D. Allen, Univ. of Southern California. **Advances in Display Technology IV.** Chairman: Elliott Schlam, U.S. Army Electronics Technology and Device Lab. **Applications of Lasers to Industrial Chemistry.** Chairmen: R. L. Woodin and Andrew Kaldor, Exxon Research and Engineering Co. **Solid State Optical Control Devices.** Chairman: Pochi Yeh, Rockwell International Science Ctr. **Optical Interfaces for Digital Circuits and Systems.** Chairman: Ray A. Milano, Rockwell International Microelectronics Research and Development Ctr. **New Lasers for Analytical and Industrial Chemistry.** Chairman: Anthony F. Bernhardt, Quanta-Ray, Inc. **CRITICAL REVIEW OF TECHNOLOGY: Optical Computing.** Chairman: John Neff, DARPA. Also included are **Frontiers of Optical Engineering** (student educational session) and related tutorials. SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

Jan. 23-25 Conference on Advanced Research in VLSI, Massachusetts Institute of Technology, Cambridge, MA. Organized by the Microsystems Program, Department of Electrical Engineering and Computer Science, M.I.T. Attendance information: Barbara B. Lory, Registrations, Room 36-575, M.I.T., Cambridge MA 02139. 617/253-8138.

Jan. 23-25 OFC '84—Topical Meeting on Optical Fiber Communication, New Orleans, LA. Sponsored by Quantum Electronics and Applications Society of the Institute of Electrical and Electronics Engineers and Optical Society of America. Optical Society of America, 1816 Jefferson Place, N.W., Washington, D.C. 20036. 202/223-8130.

FEBRUARY 1984

Feb. 12-15 Color and Imaging, Williamsburg, VA. Presented by the Inter-Society Color Council and the Graphic Arts Technical Foundation. Application deadline to attend conference: Nov. 30, 1983. Inter-Society Color Council, Inc., Arrangements Chairman, Bonnie K. Swenholt, Eastman Kodak Co., Bldg. 69, 8th Floor, Kodak Park, Rochester NY 14650. 716/477-6072.

Feb. 16-17 Frontiers in Color Science, Rochester Institute of Technology (RIT), Rochester, NY. Symposium on color science will inaugurate the Munsell Color Science Laboratory at RIT. Contact Dr. Franc Grum, School of Photographic Arts and Sciences, Rochester Institute of Technology, P.O. Box 9887, Rochester NY 14623. 716/475-2230.

Feb. 26-29 SPIE • Application of Optical Instrumentation in Medicine XII: Medical Image Production, Processing, Display, and Archiving and Exhibit, San Diego, CA. Chairmen: Roger Schneider, National Center for Devices and Radiological Health, FDA; Samuel J. Dwyer III, Univ. of Kansas, College of Health Sciences and Hospital. Cooperating organizations: National Center for Devices and Radiological Health, FDA; The Society of Radiological Engineers. SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

MARCH 1984

Mar. 5-7 OSA Topical Meeting on Laser Techniques in the Extreme Ultraviolet, Boulder, CO. Abstract deadline: Nov. 30, 1983. Optical Society of America, 1816 Jefferson Place, N.W., Washington, D.C. 20036. 202/223-8130.

Mar. 11-16 SPIE • Santa Clara Conferences on Microlithography and Exhibit, Santa Clara, CA.