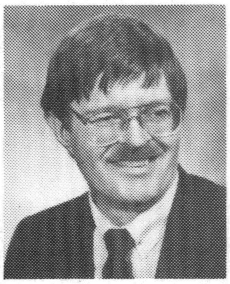

Editorial

H. J. Caulfield, Editor

A New Editor for *Optical Engineering*

This editorial is being written the day after the U.S. national elections. It is a time of change and yet a time of continuity. Likewise, in this journal there are both changes and assurances of continuity.

Beginning July 1, 1985, the new Editor of *Optical Engineering* will be Professor Jack D. Gaskill of the Optical Sciences Center at the University of Arizona. Jack has had a distinguished career as both a researcher and an educator. He has accepted his new assignment as Editor with enthusiasm and with the desire to continue the process of making this journal relevant to the needs of its readers. I personally look forward to watching the fruits of his enthusiasm and abilities as they manifest themselves over the next several years.

My retirement as Editor is one that I planned six years ago when I first assumed the task. My intent then was to stay long enough to have some positive impact on the journal but not so long as to have it identified with me personally. The succession from one editor to the next should be a process that strengthens the journal. Jack and I have already begun to plan an orderly transition, but you will read more about that in future issues. For the time being, manuscripts should continue to be sent to me. Manuscripts that arrive either in my office or Jack's office after July 1 will be dealt with by Jack.

It is our sincere hope and belief that the transition will present no problems to any of our readers or authors. It is also my belief that a new editor will offer a freshness that a battle-scarred veteran cannot produce.

As your retiring Editor, I must stress that the journal owes a great deal to the many volunteers who during my term have worked long and hard to make this a good and useful journal, for it is usefulness that is the final measure of a journal's value.

Jack D. Gaskill

OPTICAL ENGINEERING EDITORIAL SCHEDULE

March/April 1985

Integrated Optical Circuit Engineering

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Infrared Optics

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Nelson Wallace
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May/June 1985

Surface Metrology

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National Bureau of Standards
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301/921-2159

Image and Hologram Data Reduction

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July/August 1985

Holographic Interferometry

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Nonlinear Optical Materials, Devices, and Applications

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September/October 1985

Holography

Lloyd Huff
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513/229-2113

Forum

Optics at. . .

The Optical Sciences Center: Part II

Kathleen S. Seeley
Jack D. Gaskill
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Tucson, Arizona 85721

(This is the final installment in a two-part report on the Optical Sciences Center. Part I, presenting a brief history of the Center, was published in the November/December 1984 SPIE Reports section of Optical Engineering. *The facilities and current research programs are addressed in this portion.)*

FACILITIES

The Optical Sciences Center is a 70,000 sq ft facility specifically designed for the pursuit of research and the training of graduate students in the optical sciences. The building, which is actually two discrete structures in one, contains well-maintained laboratories, classrooms, administrative space, a well-equipped instrument shop, an optical polishing facility and associated seven-story test tower, an electronics shop, and several associated service facilities.

Research is also carried out in other locations. For example, portions of the research in atomic and molecular spectroscopy and laser physics are conducted in laboratories located in the Physics building. The Digital Image Analysis Laboratory is located in the Electrical Engineering building, and most of the experimental work in medical optics is undertaken at the Arizona Health Sciences Center, located approximately half a mile north of the campus.

The demands for additional office, laboratory, and teaching space brought about the addition of an Annex in 1976. The Annex, located only five minutes' walk away from the Center, houses seven faculty members, a large classroom, and several laboratories. The majority of laboratory space in the Annex is dedicated to infrared and detector research.

Plans are now in preparation for a 30,000 sq ft addition to the east side of the main building.

OPTICAL POLISHING FACILITY

The 8000 sq ft optical polishing facility presently contains equipment capable of polishing a wide range of optics, from the ends of 50 μm optical fibers to 3 m telescope mirrors. Specialized polishing and test equipment makes this facility uniquely suited for the fabrication of large optics.

To take advantage of advances in mirror-blank glass fabrication technology and to fully utilize the available space, the Optical Sciences Center has purchased a computer-controlled large optical generator. This 8 m capacity optical generator, delivered in July 1984, is the largest such machine in the world. It gives the University of Arizona a unique position in optical fabrication.

The large optical generator complements the optical test tower, which was designed as an integral part of the building. The tower is capable of testing an f/2 mirror of 8 m diameter, which is 2 m larger than any previously built.

The optical polishing facility is staffed by six opticians, a manager, and a support staff of three. The opticians have fabricated such state-of-the-art optics as the 2 $\times$ 20 mm faceted fused silica light pipes for the Pioneer Venus probe, a 30 cm cube of fused quartz used as an atomic clock for the National Bureau of Standards, the six Multiple Mirror Telescope primary mirrors, and the 2.5 m primary mirror for the Cerro Tololo DuPont Telescope in Chile.

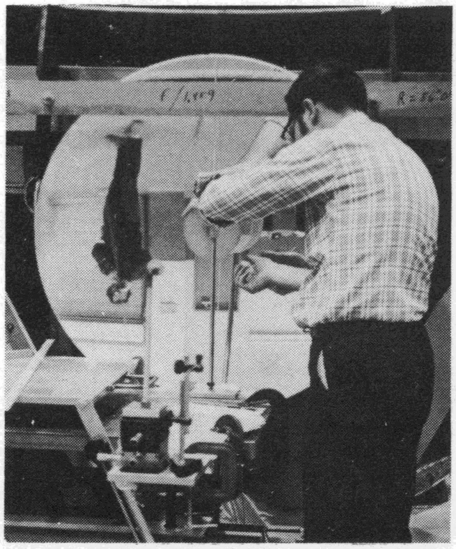
The optical polishing facility also has 18 polishing spindles in the small optics area and 1.2, 1.5, 2.2, and 3 m Draper-type polishers in the large optics area. Appropriate test optics are also available, including a 1.8 m flat and 1.8 and 1.5 m spheres.

New techniques being investigated in the shop include a hybrid digital/analog aspheric generator and the fast finishing of surfaces using bound diamond belts.

Shop personnel are skilled in all of the traditional optical test methods, including Foucault, Hartmann, and Lyot testing. Several interferometers, including a Zygo, are used to produce data that can be computer processed to create surface contour maps and component evaluations. Recent equipment additions include a pair of real-time interferometers operating in the visible and 10.6 μm wavelengths. These interferometers operate directly with a computer and permit consistent interferometry over the entire range of fabrication steps from generation to final figuring.

INTERFEROMETRY LABORATORY

Accurate testing is critical to the successful fabrication of optical components and systems. When an optical system is being constructed, interferometric techniques tell the optician how well the system will perform and how much additional work is needed to improve its performance. Interferometric techniques are useful for measuring both surface roughness and overall contour. The purpose of the interferometry laboratory is to teach the student about the fundamentals of testing and to serve as a research area for delving into new problems in optical testing. Research is currently being done to speed up the optical testing process, to obtain more accurate test results, and to provide the optician with the data in the form that is most useful. Studies are being made of direct phase measurement interferometry that combines conventional interferometers with solid-state detector arrays and microprocessors. Techniques are also being developed to reduce the effects of turbulence and vibration. Techniques in infrared interferometry are being improved to accurately test ground surfaces before they are polished. If optical surfaces can be ground to precise specifications, much time-consuming optical polishing can be eliminated, thereby speeding up the fabrication process. In addition, computer-generated holographic techniques for testing aspheric surfaces have been developed. A long-term goal of the laboratory is to develop computer-controlled optical polishing for the fabrication of precision aspheric surfaces.



Optical testing being performed by Bob Parks.

QUANTUM OPTICS AND OPTICAL BISTABILITY LABORATORY

Quantum optics research is directed toward understanding the fundamental interaction between coherent light and simple atomic systems such as alkali vapors. Recent and current studies have included interference rings, continuous-wave on-resonance enhancement of the on-axis intensity arising from beam stripping and Fresnel diffraction, conical emission, self-focusing optical bistability, and optical chaos. Earlier work in quantum optics demonstrated optical bistability using a Fabry-Perot interferometer containing sodium vapor, in which the refractive index depends upon the light intensity. A system is "bistable" if the output has two stable states for the same input. Bistable and other similar nonlinear systems someday may be used for optical computing.

Optical computers that can perform numerical operations with light instead of electricity may provide the speed that researchers need to perform complex calculations. Before an optical computer can become a reality, though, scientists must develop optical analogs to electronic circuit devices such as switches. The purpose of the optical bistability research is to study optical switching and to improve optical devices so that they switch faster, operate at room temperature, and use a minimum of power. Recently, room-temperature optical bistability in a gallium-arsenide/aluminum-gallium-arsenide superlattice was achieved with a laser diode as the only light source and with only a few milliwatts of power. Optical bistable devices require an optical nonlinearity; that is, the optical path length or absorption coefficient must depend upon the intensity of the light. The search for very large and fast nonlinear refractive indices is an important part of optical bistability research. If fast, low-power nonlinear etalons can be achieved, they could be used for picosecond decision making in a parallel optical processor or as short-term memories for optical array interconnects between electronic processors in a supercomputer.

NONLINEAR SURFACE INTERACTIONS LABORATORY

Basic research and its application to optical communications are pursued in this laboratory. Currently, theories are being developed and experiments are being performed concerning the physical properties of very thin metal films, the utilization of thin metal films as optical waveguides in the infrared, the third-order nonlinear response of dielectric, semiconductor, and metal waveguides, and the nonlinear magnetic interaction of surface magnetoplasmon polaritons.

Studies under way include investigation of the physics of very thin metal films to determine the characteristics of long-range surface-plasmon polaritons in the visible wavelengths, investigation of the long-range surface-plasmon polaritons of thin metal films embedded between two identical media to determine their usefulness as optical waveguides, the study of indium antimonide guided wave bistability and how it controls the on/off states of an etalon, identification of possible third-order nonlinear interactions enhanced by a guided wave, and the study of fast channel-waveguide nonlinear interactions in the visible region for applications in optical communications.

NONLINEAR OPTICS LABORATORY

This laboratory has concentrated on the development of generalized holographic processes in which static gratings in a medium are replaced by dynamic gratings formed instantaneously in the medium by means of nonlinear optical effects. The production of real-time transmission holograms was the first goal of the laboratory, and the interferometry that makes use of nonlinear optical mechanisms for the testing of holographically generated wavefronts was developed here. In addition, the laboratory produced the first field-usable two-wavelength interferometer with large effective wavelength.

Ongoing interests include the development and testing of new nonlinear optical materials and processes. The basic tools are Q-switched lasers, operating at 1.06 and 1.3 μm. Materials that are being studied include lithium niobate, lithium sulfate, lithium formate, lithium iodate, potassium dideuterium phosphate, potassium titanium dioxide phosphate, and silicon.

GUIDED WAVE LABORATORY

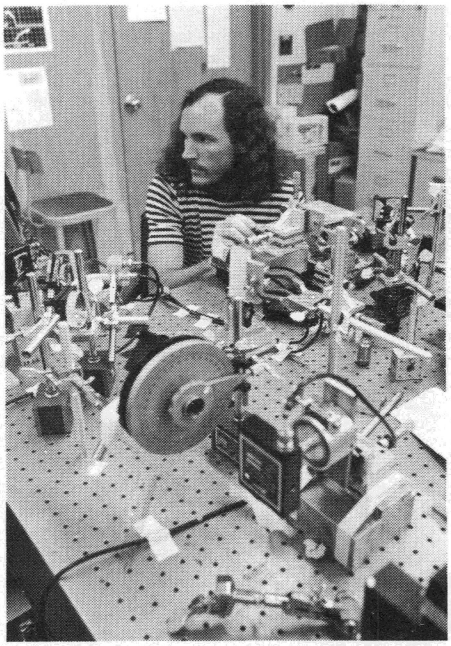
The fields associated with guided waves are useful both for probing surface and thin-film phenomena and for carrying out a variety of linear and nonlinear optical processing operations because they are confined in one or two dimensions to within a few optical wavelengths of a surface. The goal of this laboratory is to explore such phenomena to increase the understanding of surface science and to develop new concepts in the application of guided waves to all-optical signal processing. Nonlinear phenomena in thin-film integrated optics waveguides are being studied to demonstrate mathematical operations such as convolution on a picosecond time scale, optical bistability, switching, logic, amplifiers, and limiters in a variety of materials ranging from semiconductors to organic films. Nonlinear waveguide techniques are also being developed to investigate the electronic and vibrational properties of deposited monolayers. Light scattering techniques are used to probe the elastic and structural properties of organic monolayer films and the liquid state of a solid boundary.

THIN FILMS LABORATORIES

The study of optical thin films has been of considerable interest at the Center since its inception. Facilities for both physical and chemical vapor deposition were assembled, with the latter playing a key role in solar selective absorber development in the late 1970s. More recently, an active investigation into the microstructure of thin films has been pursued. One avenue of inquiry involves the addition of energy to the growing film by photon irradiation and both ion and electron bombardment to improve film structure. Other programs include the improvement of astronomical reflector coatings, the design and deposition of broadband, wide-angle multilayer filters, the elucidation of form birefringence, and the investigation of possible materials for bistable devices.

In addition, there are programs on new materials and processing techniques for optical thin films. These include chemical vapor deposition and reactive evaporation of the phase transition material samarium sulfide and ion bombardment for the coating of plastics and the patterning of waveguides and aspheric optics.

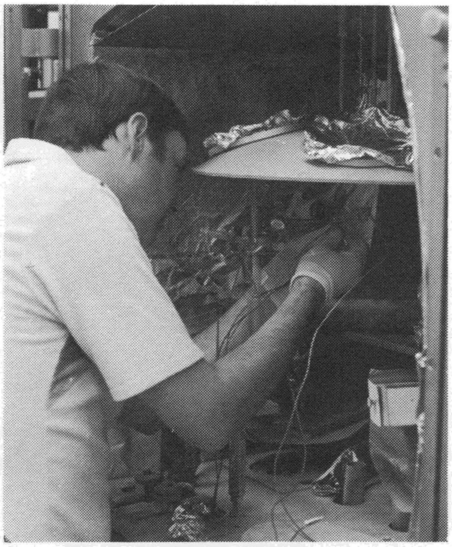
The Thin Films Laboratory has several box coaters, including a state-of-the-art Balzers 760 cryopumped, computer-controlled system with twin electron beams and twin resistive sources, plus an advanced scanning monochromator thickness monitor, several bell-jar coaters, an rf magnetron sputtering system, three chemical vapor deposition systems, and specialized substrate preparation equipment and post-deposition annealing furnaces.



Jack Jewell conducting an experiment in the Optical Bistability Laboratory.

INFRARED LABORATORY

The infrared Laboratory is used for both theoretical and applied studies of infrared instrumenta-



John Wharton adjusting thin-film coating equipment.

tion. The major experimental facilities consist of an automated scatterometer, a cryogenic refractometer, a radiometric calibration facility, and infrared interferometers.

Scattering studies have included the comparison of theory with measurements for a wide variety of samples from a black etchant to "superpolished" mirrors and lenses. The results are often applied to the design of optical mirrors and lenses. The results are often applied to the design of optical instruments that must be largely immune to out-of-field scattered light.

A one-of-a-kind cryogenic refractometer is used to measure the refractive indices of materials from 0.5 to 50 μm at temperatures ranging from 20 K to 800 K. The results are used by the various designers of infrared devices.

The radiometric calibration facility utilizes National Bureau of Standards sources and monochromators for routine calibrations, but pioneering work in infrared and visible radiometry with the use of "self-calibrating" detectors is also conducted.

Some of the projects that have been completed or that are under way include the design and construction of an all-reflective 2 m diameter optical system, a five-channel radiometer for the visible and near-infrared region, a solar spectroradiometer that will be used to monitor 22-year and 13-day variations of the solar spectral irradiance, a portable scatterometer capable of measuring the scattering function of large mirrors that are in place, a lightning sensor for use in aircraft, a two-color thermograph to demonstrate the efficacy of ratio-temperature medical thermography, and a geosynchronous lightning sensor.

DETECTOR LABORATORY

The detector laboratory is used both for research in the area of optical radiation detection and as a graduate student laboratory.

The purpose of the detector laboratory is to familiarize the students with the test equipment and procedures needed to measure the performance parameters of various detectors. Emphasis is placed on noise measurements and preamplifier designs.

Research is currently being performed to evaluate state-of-the-art charge-coupled devices used in the infrared spectral region. Studies of platinum silicide Schottky diodes are directed toward understanding the internal photoemission process in a metal silicide, evaluating and characterizing the array performance parameters, and establishing optimum optical designs for staring infrared charge-coupled device arrays.

Other areas of research include the evaluation of silicon charge-coupled devices for uniformity of response and stability and x-ray imaging using charge-coupled device arrays and infrared image enhancement techniques.

OPTICAL MEASUREMENTS LABORATORY

The Optical Measurements Laboratory serves the Center by characterizing the thin films deposited by the Thin Films Laboratory, by supporting other projects in progress at the Center, notably research on waveguides, optical polishing, and infrared materials, and by assisting other university departments, outside businesses, and research laboratories. The laboratory contains several spectrophotometers and performs measurements of both specular and diffuse reflectance and transmittance over a broad wavelength range. In addition, specialized optical instruments, excellent optical microscopes, and a surface profilometer are maintained. Laboratory personnel and users are also involved in chemical and structural surface analysis at other university and off-campus facilities.

DIMENSIONAL STABILITY LABORATORY

Science and industry have an ever-increasing need for optical materials that are dimensionally stable over wide ranges of temperature and time. With the precision made possible by laser interferometry, it is possible, for example, to observe the daily length changes of even the most stable metals maintained at constant temperature. The major measurement tool employed is the frequency-stabilized laser with which length changes are measured to a precision of better than one part per billion. Laser interferometric techniques are used to follow length changes in samples maintained in computer-controlled environments of low pressure and variable temperature. With this instrumentation, changes of length at temperatures as low as 6 K can be determined, as well as changes of length with time at constant temperature, uniformity of thermal expansivity, and reproducibility of thermal expansivity.

Materials that have been investigated in this lab include fused silica, Cer-Vit, silicon, Zerodur, ULE, borosilicate glasses, Invar, Superinvar, and graphite composites. Students in this lab become familiar with a wide range of disciplines, including interferometry, stable lasers, servo engineering, computer control, thermal and frequency standards, cryogenics, vacuum engineering, and ultrastable structural design.

MEDICAL IMAGING RESEARCH LABORATORY

This laboratory, located at the Arizona Health Sciences Center Annex, is devoted to research in nuclear medicine. Currently, a program is under way to study various aspects of nuclear imaging, especially tumor detection. It is hoped that tumors made radioactive by tumor-seeking radiopharmaceuticals can be detected at an early stage by imaging equipment now under development.

Four different projects, funded by the National Cancer Institute, are under way. The first project is to build a modular scintillation camera in which each module consists of a scintillation crystal that converts gamma rays to light. A digital electronic system is then used to determine the coordinates of the gamma rays from the photomultiplier signals. The second project is the development of coded-aperture imaging, which is a way of reconstructing three-dimensional images of gamma-ray sources. The intermediate coded image is not recognizable, but by digital decoding it is possible to reconstruct an image of the three-dimensional volume. The third project is the development of miniature radiation detectors for localizing small tumors. These will be either hand-held detectors used during surgery or endoscopic detectors for esophageal imaging. The fourth project involves image evaluation and optimization of gamma-ray imaging systems either for automatic feature extraction and pattern recognition or for diagnosis by human observers.

PHOTOELECTRONIC IMAGING LABORATORY

This laboratory also is located at the Arizona Health Sciences Center and is devoted to the application of photoelectronic imaging devices in diagnostic medicine. Research and development work is oriented primarily to the field of diagnostic radiology, but work is also being done in such other fields as ophthalmology.

Several research projects are currently under way, including the development of an x-ray imaging system capable of imaging occlusions of 0.5 mm diameter in a 2 mm diameter coronary artery, analysis of the storage and communications requirements for developing a digital radiology department to replace the present-day film-based department, evaluation of photoelectronic imaging devices, and the development of a system to obtain digital images in ophthalmology that are comparable to those obtained from film.

PSYCHOPHYSICAL AND HUMAN FACTORS LABORATORY

The purpose of this laboratory is to evaluate imaging systems by applying a variety of statistical techniques and psychological and psychometric theories to assess changes in such human perceptual performance as accuracy, detection, and sensitivity. One goal of the laboratory is to aid in the development of more useful systems by informing the developers about the strengths and weaknesses of the new systems from a psychological and psychophysical perspective. Another goal is to develop the experimental, statistical, methodological, and theoretical tools to refine and enhance this type of research.

Research is currently being performed in conjunction with the Radiology and Psychology departments and with the Department of Instructional Research and Development. One specific project is to determine the specific spatial and contrast needs for the development of a total digital radiology department.

Current research areas include the evaluation of new imaging systems developed here and in other departments, the refinement and adaptation of a variety of methodological and statistical approaches traditionally employed in psychological and psychophysical research, the development of interactive computer systems based on user needs, the development of techniques that enable more refined separation of important features needed by the human observer to differentiate between different object classes, and the development of computer software for designing and conducting experiments and analyzing the collected data.

DIGITAL IMAGE ANALYSIS LABORATORY (DIAL)

The DIAL facility is located in the Electrical Engineering building. DIAL provides the facilities for research involving the processing, manipulation, and analysis of imagery by digital computer. In addition to being a major component in programs of sponsored research, DIAL is used regularly for teaching. The use of DIAL for research and education is shared by the Electrical Engineering Department, the Optical Sciences Center, and the Committee on Remote Sensing.

DIAL equipment resources include a PDP-11/70 computer, an International Imaging Systems I^2S 70/E image processing and display computer, 227 megabytes of disk storage, a color hardcopy camera, and two tape drives. The I^2S 70/E includes six 512×512 pixel refresh memories, four graphics planes, three color pipeline processing channels with a feedback arithmetic/logic unit, a color CRT display monitor, and an interactive trackball-controlled cursor. The I^2S computer is capable of near-real-time convolution, interactive zoom and roam, contrast manipulation, histogram arithmetic, and multispectral pattern recognition. The software available at DIAL is extensive, including both interactive and batch image processing packages.

Some of the research projects that have been completed or that are in progress are interpolated DPCM image data compression, optical spline interpolation, visual models in optical data compression, interframe compression of time-varying imagery, multispectral image data compression using staggered array detectors, the transformation of images into statistically stationary behavior, space-variant image processing, data compression based on computed tomography, geometrical rectification and restoration of Pioneer 11 images of Saturn, a study of the effects of image processing algorithms on image quality as judged by trained photointerpreters, the use of Landsat imagery for mapping agriculture, surface mining, and arid land vegitation, pattern recognition of objects in thermal scanner imagery, eye-cued communication for patients with motor neuron disease, and pseudocolor enhancement of medical imagery and radiographs.

REMOTE SENSING PROGRAM

The remote sensing program can be divided into two areas. The first is the in-flight, absolute radiometric calibration of satellite remote sensing systems, which is conducted at White Sands, New Mexico. Concurrent ground-based spectral reflectance and atmospheric measurements are made during the overpass of earth remote sensing satellites such as the Landsat Multispectral Scanner System, the Thematic Mapper, and the French SPOT system. Calibration is achieved by using these ground-based measurements as input to a radiative transfer program to predict the radiance at the sensor and then by comparing this prediction with the digital counts from the sensor when it views the measured ground area.

The second area includes field, laboratory, and computer studies concerned with instrument design and construction, absolute calibration, and atmospheric radiative transfer.

Field measurements include validation of the boundary effect—an atmospherically induced crosstalk between adjacent areas of different radiances, the effect of the surround on the ratio of direct-to-diffuse solar irradiance for the validation of assumptions used in radiative transfer programs, and the influence of atmospheric and ground-induced polarization on spectral reflectance data. The laboratory work concerns the design and construction of an automated sun-tracking spectropolarimeter, the use of self-calibrated detectors in the absolute spectral calibration of field spectropolarimeters, the construction of near-Lambertian, rugged field reflectance standards, and the development of methods to measure the absolute spectral reflectance and non-Lambertian properties of such standards. The computer work involves sensitivity studies of the relation between atmospheric input values and the output of a radiative transfer program, mainly for the White Sands project, testing of a radiative transfer program that includes polarization, and development of a Monte Carlo program for theoretical corroboration of the boundary and surround effects.

ATOMIC, MOLECULAR, AND LASER PHYSICS LABORATORIES

Spectroscopy is the key technique for probing the structure of matter and its interactions with radiation. In the past decade the development of many high-resolution techniques based on coherent radiation sources has revolutionized this discipline and has led to advances in areas including the measurement of fundamental constants, the testing of fundamental theories of nature, the elucidation of chemical processes, and the monitoring of the evolution and fate of the stars.

The Atomic, Molecular, and Laser Physics laboratories, located in the Department of Physics, have a broad range of high-resolution stabilized coherent sources covering the spectrum from the microwave region through the visible region, a fast ion-beam spectrometer, a microwave-optical spectrometer, and a time-of-flight molecular fragmentation spectrometer, all operating under microcomputer control.

SUPPORT FACILITIES

The Optical Sciences Center has a terminal room connected to the University Computer Center's DEC 10 that is equipped with keypunches, a card reader, and a fast printer. Numerous microcomputers are available for staff and student use.

The Reading Room contains a large collection of optics-related books and subscribes to the most pertinent journals in the field of optics. New titles are continually added to the collection, and an interlibrary loan service is provided.

A photographer and well-equipped photo lab are available for the production of slides and photographic prints.

The editorial staff produces a weekly newsletter, edits and prepares journal articles, grant proposals, and final reports for submission, and produces camera-ready copy for chapters, books, and brochures.

The business office oversees the financial administration of the Center, including contracts and grants, maintains personnel payroll, processes the ordering and receiving of equipment and supplies, and makes travel arrangements for faculty and staff.

INSTRUMENT SHOP

The instrument shop is staffed by four instrument makers and is well equipped with lathes, milling machines, band saws, hydraulic presses, surface grinders, sheet metal machines, welding equipment, a glass bead machine, and an overhead crane. The shop produces one-of-a-kind instruments such as the laser scanning microscope, swing-arm generator components, interferometer components, and test mirror mounts.

ELECTRONICS SHOP

The electronics shop is responsible for designing and building electronic components for the laser scanning microscope and the thin-film scanning monochromator monitor, interfaces for interferometers, electronics for the radiological simulation camera, and electronic control loops for measuring how magnetic tape is deformed under stress. The group also lays out printed circuit boards and maintains much of the electronic equipment in the building.

MECHANICAL ENGINEERING

The mechanical engineer produces mechanical designs for research projects at the Center. Specific projects have included the laser scanning microscope, mounts for axicon mirrors, and the multispectral linear array satellite. Design capability involves mounting of precision optics, particularly unusual or lightweight configurations, precision movement at the submicrometer level, and the use of finite element analysis for determining optical deflections.

ACKNOWLEDGMENTS

This paper comprises the contributions of many individuals, primarily faculty and staff of the Optical Sciences Center, and the authors gratefully acknowledge their participation.

Book Reviews

Optical Fibre Sensing and Signal Processing

B. Culshaw, x + 223 pp., illus., index, references, appendices. ISBN 0-906048-99-0. Peter Peregrinus Ltd., London, on behalf of the IEE; available through Inspec Dept. of the IEEE, 445 Hoes Lane, Piscataway, NJ 08854 (1984) $57 hardbound.

Reviewed by Richard A. Soref, Rome Air Development Center, Hanscom Air Force Base, Bedford, MA 01731.

Fiber optic sensing and optical signal processing are two rapidly growing fields, as evidenced by the increasing number of international conferences devoted to these subjects. Fiber sensors, for example, first gained "legitimacy" at the 1983 Optical Fiber Sensors (OFS) conference in London and will be further explored at OFS '84 in Stuttgart and OFS '85 in San Diego. An author addressing such an expanding field can give his readers a "snapshot" of work in progress or can explain the principles underlying the work. Dr. Culshaw has done both.

The author, who is professor of electronics at the University of Strathclyde, has set himself the task of elucidating the two new subjects in optical engineering, concentrating on optical principles, giving illustrative examples, and describing the relevant electronics and mechanical engineering. He has largely succeeded in this task, and the book is both well-organized and skillfully written. The author has a practical bent and can convey the "flavor" of actual sensors and systems.

The book is brief because, as the author states in the preface, "a full and detailed treatment would run to several volumes, which I would never have completed and you the readers would never have purchased . . . ."

Of the 13 chapters in the book, only one deals with signal processing, and that 19-page section focuses as much on integrated optical devices (A/D converters, high-speed samplers) as on fiber devices (delay-line processors). So, the signal processing portion of the title is a little misleading, given the abbreviated treatment.

There are chapters on fiber principles, optical sources, photodetectors, and demodulation techniques, as well as chapters that survey the fiber sensor art as of 1982, when the book was written. This material includes intensity modulation transducers (e.g., microbending devices), phase modulated sensors (e.g., Mach-Zehnder and Sagnac interferometers), frequency modulation sensors (e.g., Doppler-shift velocimeters), wavelength distribution sensors (e.g., phosphorescent color-modulated temperature sensors), and polarization modulation sensors (e.g., Faraday-, Pockels-, and Kerr-effect transducers and photoelastic transducers). These five categories are probably all-inclusive, and it is likely that any new sensor developed in the future will be explicable in terms of intensity, phase, etc., although occasionally there are surprises and a device does not fit neatly into a slot. A chapter titled "Some Speculations" grapples with the shape of future sensor systems and touches on topics such as the multiplexing of multiple sensors by wavelength-division or time-delay. The list of references includes some key papers and texts but is a bit shorter than I would have liked. The five appendices on classical optics concepts are useful because they cover sensor-foundation topics not often encountered in optical communications texts.

The book appears to have been written by an experimentalist for other like-minded souls. The author chose, as he states, to "develop relatively simple arguments rather than to enter into considerable academic detail which often obscures the development of physical intuition." There are few equations, and subjects are analyzed mainly in prose. This narrative form works fairly well here because the author has a good grasp of his subject. However, a theoretician would probably find the book unsatisfying because of insufficient mathematical detail and inadequate depth of treatment.

The book would probably not succeed as a college textbook, nor was it intended to. Instead, it is an excellent self-contained introduction to optical fiber sensors for scientists and engineers unfamiliar with this area.

Patent and Trademark Tactics and Practice

David A. Burge, 2nd edition, 213 pp., index, glossary, appendices. ISBN 0-471-80471-1. John Wiley and Sons, 605 Third Ave., New York, NY 10016 (1984) $29.95.

Reviewed by James E. Maslow, Patent Attorney, U.S. Air Force, 424 Trapelo Road, Waltham, MA 02154.

Creative people should protect the fruits of their labor. Intellectual property law—including the law of patents, trademarks, copyrights, trade secrets, etc.—comprises the legal means for such protection. The present book discusses this important body of law.

The author states on p. vii of the Preface that his intention in writing this book is "to outline fundamental principles that should be understood by inventors and businesspersons. . . [interested in] intellectual property." On p. 5 of the text, the author states the book's purpose as being to provide for lay clients who deal with patent attorneys "a primer outlining the fundamentals of intellectual property practice." Thus, intellectual property law, of which patents and trademarks are but a part, is clearly the subject of this text, the book's title being somewhat of a misnomer. In any event, this review considers the following questions: Is this book acceptable as a primer on the law of intellectual property? Is it useful? Is it usable as a reference tool?

Yes, the book is a good primer. The basic concepts of intellectual property law are certainly presented. Burge opens the book in Chap. 1 with an overview of intellectual property law and follows this in Chap. 2 with an explanation of the role of, function of, and services available through a patent attorney. Chapter 3 is devoted to the basic features of patents and the patent system, while subsequent chapters are devoted to specific topics, such as what can be patented and by whom (Chap. 4), preparations for filing for a patent (Chap. 5), prosecuting a pending patent application (Chap. 6), using an issued patent (Chap. 7), maintaining proper invention records (Chap. 8), planning a patent program (Chap. 9), disclosing an idea and marketing an invention (Chap. 10), assignments, shoprights and licenses (Chap. 11), and patent protections available abroad (Chap. 12). Subsequent sections of the text are directed to trademarks, to other forms of intellectual property (design patents, plant patents, copyrights, trade secrets), and to preserving and protecting specific types of intellectual property rights (Chaps. 13 to 22).

The foregoing topics cover the essentials of intellectual property law. These topics are treated fairly, although at times the text seems to lack the spark that would make it an enjoyable reading adventure. Nevertheless, the text does qualify as a primer to the extent that the basics are covered. The book is, therefore, a theoretically useful addition to a layperson's library.

I say "theoretically," however, because it may well be that the average lay reader will find that the Index defeats entry into the text. As a test, we may ask: where in the Index would one turn to find out about the basics of filing for a patents? Of course, the headings of "Trademark," "Copyright," or "Trade secret" will not supply the answer. So one looks to the "Patent" heading, which shows 14 subtopics and appropriate page references. The first subheading is "applied for." In fact, this is the most logical point for the average inventor or businessperson to begin such inquiry. But here one is led to a discussion of patent prosecution—the stage *after* an executed application is filed with the Patent and Trademark Office.

The 13 other "patent" subtopics relate to various important items such as the contractual nature of a patent, misconceptions about patents, the value of obtaining patent protection, etc. There even is a subheading devoted to a procedure for establishing a patent protection program for the protection of one's important inventive developments.

No doubt, all the above items of information can be useful, even important, to the reader, Yet, the answer to our test inquiry—seeking the basics of filing for a patent—must continue. In fact, there is no obvious "Patent" subheading that would lead the reader to the answer of the present inquiry.

My point indirectly made, I now state directly that the success of a purportedly instructive text, such as the present text, must be tested by its accessibility to the intended reader. For the average inventor or businessperson, the present book is not fully accessible. The Index is detailed but has apparent defects.

In sum, with these deficiencies in mind, I still recommend this book as a primer. For background it is useful. But for further reference, see Kayton, *Patent Preparation and Prosecution Practice* (Patent Resources Institute); Chisum, *Patents,* Horwitz, *Patent Office Rules and Practice,* or *Patent Law Perspectives* (all published by Matthew Bender & Co.); or Deller, *Deller's Walker on Patent* (The Lawyer's Coop Publ. Co.).

By the way, the answer to our test inquiry can be found in Chap. 5, "Preparing to Apply for a Patent." The Table of Contents succeeds where the Index fails.

Microwave and Optical Ray Geometry

S. Cornbleet, 152 pp., illus., index, references, appendices. ISBN 0-471-90315-9. John Wiley and Sons, 605 Third Ave., New York, NY 10016. (1984) $36.95 hardbound.

Reviewed by Duncan Moore, The Institute of Optics, University of Rochester, Rochester, NY 14627.

The stated purpose of this book is to "create a greater appreciation of fundamental geometry of geometrical optics." The method of doing this is to show how various other areas of geometrical optics apply to "new" problems of guided wave optics, etc. The book is essentially divided into two sections—the study of homogeneous media and that of gradient-index, or inhomogeneous, media. The first four chapters provide a series of analytic solutions for very simple problems of geometrical optics, while the last four chapters study the solutions to the ray equation for various well-defined profiles of the index of refraction. A great deal of material that is covered in the gradient-index section was previously published in the author's book entitled *Microwave Optics* (Chap. 2). In fact, an error that was generated in the first version of this book has been perpetuated in this one. [See p. 71, which should read $(Z\eta_0 \sin\alpha + b)^2 = C^2 - \eta_0^2 x^2 \sin^2\alpha$.]

While the book may be of some interest to people who like to do analytic problems, I find it considerably lacking in the ability to solve real problems. None of the gradients that have been manufactured, either for geodesic lenses or for overlay lenses, has nice analytic solutions. The author gives no indication of how to solve real problems, and, in fact (at Sec. 3.3.3), he states that his method will not work except by a massive amount of computing. This indicates that the methods not only are nearly useless for doing simple problems but would be terribly impractical for any real-life problems.

A second point that I find severely disturbing is the deficiency of references to well-known literature in inhomogeneous, or gradient-index, media. For example, names like Sands, Marchand, Montingnano, Rawson, Moore, and all Japanese authors have been excluded from the reference list. All of these have contributed widely to the literature, and many of the problems the author highlights have, in fact, been solved by them in more general situations. Further, the equivalent of the nonuniform media to nonuniform thickness in guided wave devices is only alluded to in the book. While this problem has been studied in great detail by Southwell, little indication is given of the massive amount of work that has already been published.

I recommend this book to those interested in mathematics and mathematical optics. However, a practicing engineer will find this book lacking in solving real-world problems.

Optoelectronic Switching Systems in Telecommunications and Computers

Herbert A. Elion and V. N. Morozov, (*Electro-optics Series, Vol. 4,* Herbert A. Elion, series editor), xi + 257 pp., illus., index, references. ISBN 0-8247-7163-X. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1984) $37.50 hardbound.

Reviewed by S. Sriram, Amphenol Fiber Optic Products, 4300 Commerce Court, Lisle, IL 60532 and **K. Ganesan,** GTE Research Laboratories, Waltham, MA 02254.

This book presents state-of-the-art concepts in optical and optoelectronic switching systems. The authors have tried to achieve a balance between components, networks, and system architecture. Since no one individual can be an expert in such a wide range of topics, the glossary presented at the end of the book is definitely valuable to the reader.

Extensive references and bibliographies are presented at the end of each chapter. We wish the authors had continued their practice of numbering the references throughout the book. This should be corrected in future editions by numbering at least the key references.

This is a very readable book since the authors have taken the effort to provide the fundamentals of telecommunication switching systems and networks in Chaps. 1 and 2. A reader unfamiliar with telephony will therefore be able to grasp the advanced concepts presented in the latter chapters.

Yet even the advanced researcher in the field will find a wealth of information in this book, especially in the numerous tables that give detailed system requirements and cost estimates for various systems.

The table on future fiber optic components is very interesting. Source wavelengths of 2 to 14 μm are predicted for fiber communications in the late 1980s. While optical fibers have been theoretically estimated to operate with extremely low losses at these wavelengths, the applications for long wavelength sources will largely depend on the successful manufacture of low-loss fibers and suitable detectors.

It is made very clear throughout the book that integrated optical switches will play a major role in optical switching systems. A sample calculation is presented to convince the reader of the advantages of using integrated optics over bulk optics. Other types of optoelectronic and bistable switches are also presented for applications in telecommunication switching systems.

Chapters 5 through 8 deal primarily with optoelectronic logic and processors. Once again, integrated optics is mentioned for optical processing applications. Various types of spatial light modulators (SLMs) and acousto- and electro-optic deflectors are also discussed. SLMs play a key role in all the optical processors discussed in the book, and Chap. 5 has a lucid presentation on SLMs. The characteristics of SLMs given in Table 5-4 should also be handy.

We would recommend this book for engineers and system designers involved in optical communication systems.

Laser Interaction and Related Plasma Phenomena, Volume 6

Heinrich Hora and George H. Miley, eds., Proceedings of the Sixth Workshop on Laser Interactions and Related Plasma Phenomena, 1161 + xviii pp., illus., index, references. ISBN 0-306-41395-7. Plenum Press, 233 Spring St., New York, NY 10013 (1984) $135.00 cloth bound.

Reviewed by Theodore T. Saito, Lawrence Livermore National Laboratory, Livermore, CA 94550.

Editors Heinrich Hora and George Miley have compiled an impressive volume of the papers presented at the Sixth International Workshop on Laser Interaction and Related Plasma Phenomena, which was held October 25–29, 1982, at the Naval Postgraduate School, Monterey, California. The workshop had 82 participants from the U.S., the United Kingdom, Japan, France, Brazil, the Federal Republic of Germany, Argentina, Israel, the Soviet Union, Canada, and Australia. Perhaps one of the most valuable contributions of this book is its look into the work going on in this field internationally. The 68 papers covered the following related areas: lasers and laser sources, laser interaction with electrons and free-electron lasers, interaction diagnostics, interaction dynamics, pellet fusion, ion-beam fusion, inertial-confinement fusion reactors, and high acceleration of charged particles.

Papers on lasers and sources not only included descriptions and updates on big fusion laser systems but also ideas for new technology, such as a nice review of nuclear pumped lasers by George Miley and a paper on nuclear pumped lasers utilizing radiant transfer by John D. Cox. In his paper "Multistep Pumping Schemes for Short-Wave Lasers," George Baldwin included some discussion of gamma-ray lasers and accelerator pumping of relativistic ions. His discussions of the pros and cons are helpful in evaluating various techniques. In addition to describing the University of Tokyo's laser, N. Nakano described their code modification, which included diffraction through a spatial filter that showed a 10% higher peak-to-average value than a code without the diffraction. Nakano also reported a new spectrometer design for the 50 to 250 Å wavelength range that employed a specially designed grating with variable pitches. Todd Smith and Donald Prosnitz both discussed free-electron lasers, reviewing electron energy exchange mechanism scaling laws and taking a rudimentary look at the advantages of storage rings versus linear accelerators. Prosnitz addressed a high intensity free-electron laser for inertial-confinement experiments, giving cost and efficiency estimates for a 3 MJ, 250 nm system.

In his review of the research at the Rutherford Appleton Laboratory (England), Oswald Willi considered the following topics: the glass laser system, laser beam "filamentation" and electrothermal instabilities, thermal smoothing, mass ablation rate and ablation pressure, Rayleigh-Taylor instability, ablative implosion experiments, and optimized ablative compression. M. J. Herbst described a new technique of using locally embedded tracers for a new family of laser plasma techniques, which included visualization of the hydrodynamic flow. S. Eliezer (Israel) described his experiments at 10^{12} to 10^{16} W/cm^2, including the electron ion decay instability that was detected through the second harmonic spectra. He also described a two-dimensional x-ray spectroscopy of the laser-produced plasmas and the numerical analysis of laser-produced compression and pressure waves on planar targets. Other interaction dynamics papers covered various x-ray analysis techniques as well as some discussion about stimulated Brillouin and Raman scattering. J. M. Dufor (Centre d'Etudes de Limeil, France) reported the results of his team's investigation of the hydrodynamic instability of high aspect ($R/\Delta R \leqq 240$), up to 300 μm diameter, filled pellets with equimolar DT (deuterium-tritium) at different pressures up to 20 bar. S. Nakai described his work at Osaka University's Institute of Laser Engineering, including their GEKKO XII glass laser and LEKKO VIII CO_2 laser. The implosion properties of their cannonball targets and low-Z-coated and foam-coated glass microballoon (GMB) pellets were also included. Several authors discussed using a laser to accelerate particles, including the papers by D. J. Sullivan and R. H. Pantell.

One of the major problems faced by optical engineers is the lack of time to sit down and document system requirements and describe how they were satisfied. About one-third of this book addresses and answers these types of issues and gives valuable insights to one willing to glean the information from this large volume. Since it is a proceedings, the 68 papers represent the various authors' styles and methods of presentation. Some of the papers by foreign authors require a bit more care in reading. This volume represents an extensive report of the state of the art in the field, and Hora and Miley are to be commended for the timely presentation of this internationally integrated information.

Fiber Optic Communications

Joseph C. Palais, 284 pp., illus., index, references. ISBN 0-13-314196-9 (hardbound); 0-13-314188-8 (paperback). Prentice-Hall, Inc., Englewood Cliffs, NJ 07532 (1984) $21.95 (hardbound); $14.95 (paperback).

Reviewed by S. R. Forrest, AT&T Bell Laboratories, 600 Mountain Ave., Murray Hill, NJ 07974.

Fiber optics technology has come of age. The evidence for this is made obvious by the fact that various companies now talk of the thousands of miles of optical fiber that has been installed to interconnect cities both in the U.S. and abroad, by the number of companies both large and small that exist to provide components for all aspects of optical communications networks, and by the

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appearance of books written at the undergraduate level whose aim it is to describe the fundamentals of lightwave technology to the layman as well as to the professional. Indeed, Joseph C. Palais states in the preface that the book was taken from a set of lecture notes directed at educating undergraduates, engineers, and managers in the basics of fiber optic technology. With such a broad audience, and assuming that the educational level of all the participants in the lectures varied over a considerable range, it is not surprising that the subject is treated in an extremely simple fashion with a minimum of mathematics or proofs added in the text. Anyone who takes on the task of reducing a complex field into a set of simple, brief expositions on topics ranging from wave propagation to semiconductor device theory runs a risk of trivializing the subject matter. For the most part, however, Palais has succeeded in writing a highly readable text that should be completely comprehensible to a large percentage of his intended audience.

The book covers a very wide range of subjects. It opens with a general discussion of optics and electromagnetic theory that should serve the purpose of providing the background needed to understand the propagation of light in waveguides and fibers, a topic that is discussed in the several chapters that follow. After the discussion on propagation through the transmission medium, the book concentrates on sources and detectors. The various components of the transmission system are "assembled" in the latter half of the book, where distribution system architectures, modulation schemes, and the sensitivity and bandwidth advantages of fiber optic systems are discussed.

In reading this book, several prejudices of the author become apparent. The discussions of wave propagation are covered in considerably greater detail than are those concerned with the physics and engineering of optical components. Indeed, the discussions of sources and detectors are cursory, with many of the essential details governing device design being omitted completely. In addition, there is virtually no discussion of integrated optic waveguide devices based on $LiNbO_3$. For example, the role that the double heterostructure plays in carrier confinement in light-emitting diodes and lasers is never clearly defined. However, the explanation of wave propagation and dispersion in waveguides is easy to follow and is, for the most part, complete.

Another emphasis of the book is on short-wavelength, multimode communication systems. Single-mode, long-wavelength systems and devices are covered only briefly. For example, in the chapter on "Distribution Systems" there are interesting discussions of local area networks (LANs) of several different types. However, the ubiquitous point-to-point network of long-haul communications is not covered. The emphasis on short-wavelength systems and LANs is undoubtedly of the greatest immediate interest to the intended audience. Nevertheless, no discussion of fiber optics can be considered complete without a thorough discussion of long-wavelength systems and components. Also, a considerable amount of the long-wavelength device and fiber performance data appear to be out of date for a book published in 1984.

Thus, although there are several topics that are covered too lightly for the reader to appreciate some of the important aspects of lightwave technology, *Fiber Optic Communications* attempts, and by and large succeeds, in bringing an extremely broad and complex subject within the grasp of a wide nontechnical audience. This book can serve as a basic text for short courses for laymen on fiber optic technology as the author claims in his preface.

Short Courses

1985 SPIE Santa Clara Symposium on Microlithography tutorials

The following tutorials will complement the technical conferences scheduled for the week of the **1985 SPIE Santa Clara Symposium on Microlithography, Santa Clara, CA, March 10-15, 1985.**

Sunday morning, March 10, 1985:

Electron-Beam Lithography, R. Fabian W. Pease, Stanford University.

Characterization Techniques for Lithographic Equipment and Processes, Talat Hasan, Prometrix Corporation, and Kevin M. Monahan, Philips Research Labs.

Sunday afternoon, March 10, 1985:

Status of X-Ray Lithography, Armand P. Neukermans, Hewlett-Packard Co.

Optical Characterization Techniques for Microfabrication, Samuel S. So, IBM San Jose General Products Division.

Sunday all day, March 10, 1985:

Plasma Etching and Reactive Ion Etching, John W. Coburn, IBM San Jose Research Laboratory.

Introduction to Microlithography: Resist Materials and Their Processing, C. Grant Willson, IBM San Jose Research Laboratory; Larry F. Thompson, AT&T Bell Laboratories; and Murrae J. Bowden, Bell Communications Research, Inc.

For information contact SPIE, P.O. Box 10, Bellingham WA 98227-0010. 206/676-3290.

American Society for Metals sponsored courses

The American Society for Metals is sponsoring a variety of seminars and courses scheduled over the next year by the Academy for Metals and Materials and the Metals Engineering Institute. These include **Advanced Techniques in Optical Microscopy,** Metals Park, OH, April 29-May 3, 1985, and **Lasers,** Battelle Columbus Labs, Columbus, OH, May 7-9, 1985. For complete list and details, contact Rod W. Allwood, Education Director, American Society for Metals, Metals Park OH 44073. 216/338-5151.

Arizona State Univ. short course

Fiber Optic Communications (sixth annual), Tempe, AZ, March 11-13, 1985. Covers components for and analysis of fiber optic communications system. For information contact the Center for Professional Development, College of Engineering and Applied Sciences, Arizona State University, Tempe AZ 85287. 602/965-1740.

ASME winter short course

Introduction to Computer Graphics, San Diego, CA, Feb. 5-6, 1985. One of variety of short courses offered by The American Society of Mechanical Engineers during the week of Feb. 3. Contact ASME Professional Development Department, 345 East 47th Street, New York NY 10017. 212/705-7398.

ETI winter short courses

Laser Fundamentals and Systems, Anaheim, CA, Feb. 4-8, 1985. Basic elements and analysis of lasers and laser systems including survey of commercial systems. Fee: $840. **Laser Safety, Anaheim, CA, March 4-8, 1985.** Laser output characteristics and potential hazards, safety standards, control measures, and safety program management, etc. Fee: $840. Contact Engineering Technology, Inc., P.O. Box 8859, Waco TX 76714-8859. 817/772-0082.

The George Washington Univ. courses

Intelligent Robots, Washington, DC, Feb. 4-6, 1985. Assessment of impact of automation and robotics on plant design, manufacturing and management techniques, productivity, and costs. Fee: $730. Contact Stod Cortelyou. **Electro-Optics, Fiber Optics, and Lasers for Non-Electrical Engineers, San Diego, CA, Feb. 11-13, 1985.** Covers components, devices, configuration, and systems as applied to instrumentation, measurement, displays, machinery, communications, consumer products, etc. Fee: $730. Contact Dick Jacoby. **Artificial Intelligence—An Applications-Oriented Approach, Washington, DC, Feb. 28-March 1, May 30-31, and Sept. 5-6, 1985.** Covers the design, application, and implementation of an "intelligent" system based on artificial intelligence processing techniques. Fee: $650. Contact Stod Cortelyou. **Expert Systems: A Practical Application of Artificial Intelligence, Washington, DC, March 11-12, 1985.** Presents fundamental concepts and components of expert systems and identifies areas in which they are being applied. Includes methods for testing, validation, and evaluation. Fee: $650. Contact Merril Ferber. **Fiber Optics Systems Design, Washington, DC, March 11-13, 1985.** Design of a representative fiber optic data transmission system. Fee: $730. Contact Shirley Forlenzo. **Video Disc Technology: With Business and Government Applications, Washington, DC, March 25-28, 1985.** Introduction to video disk technology and its application for data storage and retrieval of various information types. Fee: $835. Contact Darold Aldridge. The George Washington University, Continuing Engineering Education, Washington DC 20052. Toll-free 800/424-9773.

Imperial College summer course

Applied Optics Summer Course, London, England, June 24-July 5, 1985. Will include basic concepts of applied optics and laser physics with demonstration experiments and lab visits for

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