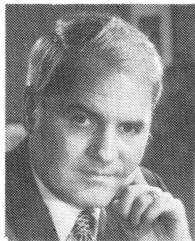


## Instant Photoinstrumentation



**W. G. Hyzer, P.E.**

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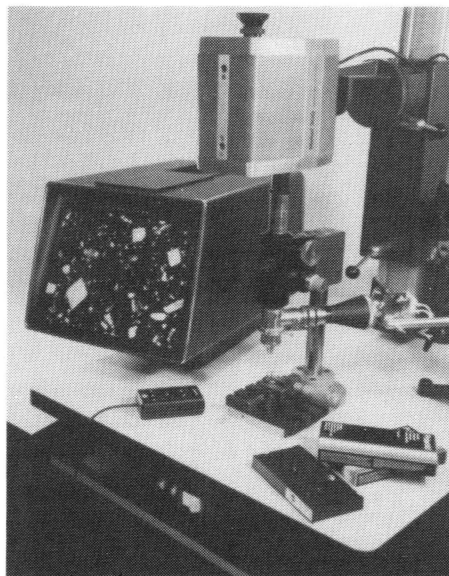
### Instant High-Speed Motion Analysis System

I don't expect many readers of this column to disagree with my observation that the diffusion-transfer-reversal (DTR) process perfected by Edwin Land in the late 1940s has revolutionized instrumentation "still" photography in the laboratory, plant, and field by virtue of its instant imaging capability. Through simple trial-and-error methods using media based on this technology, scientists and engineers with little or no background or interest in the theory or practice of photography have been able to experiment more efficiently and freely in their chosen fields of research, unhindered by delays and inconveniences associated with conventional wet-processing methods of photography. In fact, these and ensuing developments in instant imagery have actually conditioned many technical workers—and the general public as well—to fully expect to see a recorded image of an experiment within a matter of seconds after it is exposed onto film. Instant photography has become accepted as a way of life!

It is not surprising that practitioners in the field of high-speed cinematography have continued to long for this same kind of "quick look" capability involving the images recorded on their instrumentation films, but the time delay associated with the need for wet processing of high-speed cinematographic films has also become accepted as a necessary way of life by most workers. Investigations that rely entirely upon the analysis of data recorded on motion picture film must often come to a complete halt following the exposure of each film until it is returned from the laboratory in a processed form suitable for viewing. In many situations, high-speed instrumentation photography is forced to play a subordinate role (or no role at all!) in the experimental process because the turn-around time between the recording of data and the analyzing of it is simply too long to be cost effective. The capability of photographing a high-speed event on motion picture film, then processing it so it can be viewed within minutes of the time it was exposed, has not been practical except within a few facilities equipped with film-processing installations located in close proximity to the areas where the high-speed photography is being performed. Turn-around times of the order of 30 to 45 minutes or so are possible under the best conditions, but the resulting images must be viewed in black and

white only, and are usually restricted to a negative—not a positive—rendition of the subject on the screen. Advances in portable and efficient rapid-processing machines for conventional motion picture films have not kept pace with the needs of practitioners who require quick visual access to their recorded data to effectively trouble-shoot an ailing machine or to verify the results of one experiment before proceeding on to the next.

A new 8 mm High-Speed Motion Analysis System introduced earlier this year by Polaroid Corporation represents a breakthrough in instant color recording technology that is likely to change the way of life for many workers in the field. The new system is capable of recording fast-acting phenomena at rates up to 300 frames per second, internally processing the record on the spot in 90 seconds, then projecting it back in full color and in slow motion at rates ranging from 2 to 18 frames per second or stop action, Fig. 1. The advent of this system now makes it



**Fig. 1. The Polaroid Instant High-Speed Motion Analysis System in operation in the author's laboratory. The Mekel 300 Instant Analysis Camera is shown mounted on a microscope with extra Polaroid Phototape Cassettes in the foreground and the Polavision Analyzer behind the camera. The hand-held remote-action control unit for the Analyzer is shown on the table in front of the Analyzer screen.**

possible for high-speed photography to play a far more *active* role in the scientific process. Guesswork is virtually eliminated. With an image ready for viewing on the system's built-in screen within 90 seconds of completing an experimental run, the investigator either knows (s)he's right, or if (s)he's not, (s)he can take it again—right away, without delay. Conditions of an experiment can be varied, recorded, analyzed, varied once more and the cycle repeated again and again on the spot, in rapid succession, in full color, without a darkroom, and all under the complete control of the experimenter.

The Polaroid Instant High-Speed Motion Analysis System is made up of three key ele-

ments: 1) the Polaroid Polavision Phototape Cassette, the light sensitive software component of the system; 2) the Mekel 300 Instant Analysis Camera, with its precision 8 mm pin-registered intermittent film movement designed specifically to accommodate the Phototape Cassette; and 3) the Polaroid Polavision Analyzer, required to project phototape images onto its built-in 12-inch screen.

The key invention that makes instant high-speed color movies possible is the Polaroid Polavision Phototape Cassette. It is a light-tight, completely self-contained film cartridge that requires no threading or manipulation and packages all the color chemistry needed to process the entire 39 feet of 8 mm film in 90 seconds. The cartridge inserts into both the camera and the Analyzer in full daylight without threading. Processing of the exposed phototape is controlled automatically in the Analyzer, which also functions as a projector and viewing device for the processed phototape. The process employed in forming the instant color image in the cassette should be of particular interest to readers of this column. The additive color in the Polavision image is formed by a coated filter screen of red, green, and blue vertical stripes in interdigitated array. The spacing is 177 lines per millimeter across the emulsion surface. Each stripe serves independently as a color filter during exposure of the silver halide grains. For the case of exposure to red light, for example, only the silver halide grains beneath the red-filter lines are fully exposed; those under the blue- and green-filter lines remain unexposed. The processing fluid is applied to the film through a small nozzle in the form of a viscous reagent. There it spreads out into a microscopic layer 10 microns thick on the emulsion surface. The exposed silver halide grains will develop to form a negative silver image. The unexposed and undeveloped grains responsible for the positive image are completely dissolved by a silver halide solvent in the processing reagent. The liquid containing these silver ions migrates to a microscopically thin adjacent layer where the silver is precipitated out into a mirror-thin (about 0.2 micron thick) positive silver image of high optical density compared to that of the developed negative silver image left in the adjacent emulsion layer. The large differences in optical densities between the positive and negative images allow them to co-exist permanently in the film. During projection, light is passed through the black-and-white positive images in the red-image areas and then through the red stripes to illuminate the screen with red light. The blue and green image components comprising the final positive multicolor image are produced similarly.

This film has a speed rating of 25 ASA under incandescent light conditions. A black and white film with an ASA speed rating of 125 is also available from Polaroid. Its resolution capability is in the range of 80 line pairs per millimeter. Processing time is also 90 seconds.

The Mekel 300 Instant Analysis Camera operates at variable speeds in single-frame increments from 4 frames per second up to 300 frames per second. The camera features a through-the-lens light metering system and a parallax-free reflex viewfinder for through-the-lens ground-glass framing and focusing. It accepts

most C-mount lenses. The rotary shutter with fixed 90-degree aperture angle provides a top speed of 1/1200 second at 300 frames per second. The integral light metering system is unique in the field of high-speed photography.

The Polavision Analyzer operates at a normal forward speed of 18 frames per second; four discrete pulse rates of 2, 4, 6, and 9 frames per second; single frame forward; complete stop action; fast reverse; instant replay; and mid-cycle cartridge ejection. All functions are controlled by a remote hand-held control unit. All modes of projection onto the unit's built-in rear-projection screen are under the control of the operator performing the analysis. Its exceptionally bright image can be viewed clearly under most ambient-light conditions. Image-motion data can be plotted directly onto graph paper by holding the onion-skin paper against the screen's flat front surface.

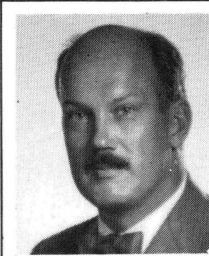
The reader is referred to Refs. 1 and 2 for a more complete description of this system.

I fully expect the unique advantages offered by this new system to revolutionize high-speed motion analysis techniques in many plant and laboratory situations and to open up entirely new areas of application requiring instant images in full color at an affordable price.

#### REFERENCES

1. W. G. Hyzer, Instant Analysis of High-Speed Events with Color Camera, *Industrial Research Development* 22, 5, May 1980.
2. W. G. Hyzer, Instant High-Speed Analysis, *Photomethods* 23, 7, July 1980.

## The History of Optics



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### The Legacy of Fourier

In his eulogy of Joseph Fourier to the Paris Academy of Sciences, Francois Arago concluded, "My object will have been completely attained if . . . each of you have learned that the progress of general physics, of terrestrial physics, and of geology will daily multiply the fertile applications of the *Theorie de la Chaleur*, and that this work will transmit the name of Fourier down to the remotest posterity." Although Arago thus predicted a legacy of the use of Fourier's mathematical treatment used to describe the conduction of heat, in 1833 he could hardly envisage those benefits to be derived in optics. Today, Fourier optics and Fourier transform spectroscopy are widely practiced by practitioners with little knowledge of the life of Joseph Fourier.

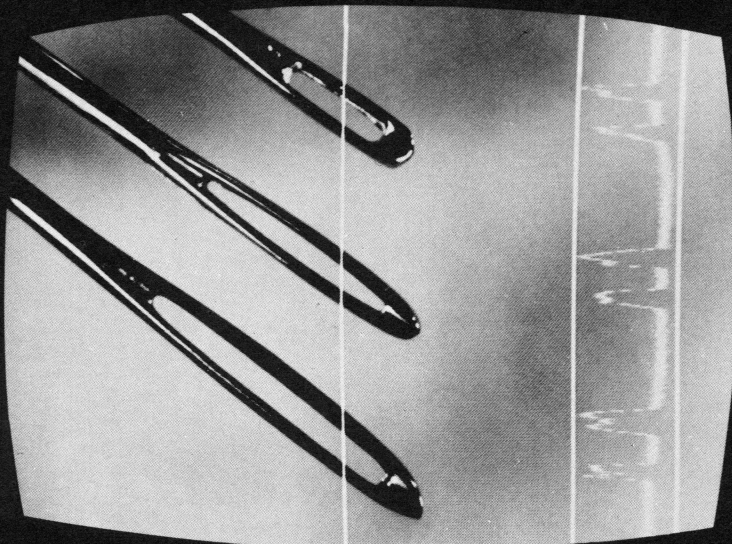
It is of interest to review Fourier's life and to reflect on the manner of man who brought to us a keener understanding of optical phenomena. Much of the information that I have gleaned of his life is derived from the aforementioned eulogy, which was written by a friend and admirer. It was also written after a turbulent period in French history when the passion of patriotism gave rise to overindulgent attitudes toward behavior. I cite this to indicate that it has been necessary to separate fact from fancy, and to warn you that my attempts to present a clear account of Fourier's life, may at times, be obscured by the biases introduced into the documents available to me.

Fourier was born at Auxerre, which is about 160 km southeast of Paris, on 21 March 1768. At the age of eight, Fourier was orphaned. A neighbor lady, who recognized his courteous manners and his precocious natural abilities, recommended him to the Bishop of Auxerre. Through this influence, Fourier was admitted into the military school conducted locally by the Benedictines. The precocity recognized by the neighbor lady was soon evident as Fourier anonymously authored many of the sermons delivered by high dignitaries of churches in Paris.

Although evidently a gifted child, Fourier exhibited many of the characteristics of youth. He was petulant, noisy, and vivacious. However, during his fourteenth year Fourier became interested in mathematics and settled down (or as Arago writes, "He became sensible of his real vocation").

Being educated in a military school directed by monks, Fourier wavered between a career in

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the church and with the military. Although he preferred the latter, this was not then possible, as Fourier's father had been a tailor rather than one of the nobility. Fourier thus entered the Abbey of St. Benoit-sur-Loire, but before taking his vows, the social upheaval in France attracted him to a teaching position. He was appointed to the principal chair of mathematics in the Military School of Auxerre.

He soon displayed an unusual talent by lecturing on rhetoric, history, and philosophy as a substitute for his colleagues when they became ill. Thus, although he was hired to teach mathematics, his lectures on these several topics were undertaken with distinction and attracted a delighted audience of diverse backgrounds. This characteristic distinguished Fourier throughout his career.

In the year 1789 Fourier read a paper to the Paris Academy of Sciences on the resolution of numerical equations of all degrees. This work, enunciated by Fourier at the age of 21, formed the cornerstone upon which he developed his future mathematical work. In this paper, Fourier extended some of the prior contributions of Lagrange. Nevertheless, Fourier's accomplishment had little appeal for the pure mathematicians, who felt that it lacked rigor. To the physical scientist, however, Fourier's results were warmly received (and still are) since they simplified calculations.

Returning to Auxerre, Fourier enthusiastically embraced the principles of the Revolution. This was a period of revolution not only politically but in the arts and sciences as well. For example, the reformation of weights and measures was begun at this time, leading to the introduction of the metric system. Alas, the temper of the time had taken many of the savants into military activity or, like Lavoisier, had removed them permanently.

Fortunately, Napoleon in his rise to power realized the futility of ignorance in building a meaningful empire and he encouraged the creation of schools. In 1794, the Ecole Normale was created and Fourier was rewarded for his patriotism in Auxerre by being appointed to the chair of mathematics. This school was destined to last but a few months, at which time the Ecole Polytechnique was established. Again, Fourier was called and he responded by embellishing his reputation for clearness, method, and erudition. His lectures attracted a fastidious and numerous audience.

Soon after the formation of the Ecole Polytechnique, Napoleon began to dream of restoring Egypt to its ancient splendor. And what better way to accomplish this than by introducing French culture to this now backward country? Napoleon realized that to achieve this goal he required more than a mere army. He would need leading scientists, and for this purpose he chose Gaspard Monge and Claude Louis Berthollet. Both of these men were members of the Paris Academy of Sciences, on the faculty of the Ecole Polytechnique, and recognized as among the leading scientists of the time. They, in turn, asked Fourier to join them and he did so. In Cairo they established the Institute of Egypt with Monge as the first president and Fourier as perpetual secretary.

In Egypt Fourier distinguished himself by extending his mathematical researches to: a general solution of algebraic equations, methods of elimination, and indeterminate analysis. His breadth of interest was also manifest by his contributions in: general mechanics, an aquaduct to



Joseph Fourier (1768-1830), French mathematician. From a sketch by Boilly. (The Bettmann Archive, Inc.)

conduct water from the Nile to the Castle of Cairo, a proposal to explore the site of the ancient Memphis, a descriptive account of the revolutions and manners of Egypt, and a wind machine to promote irrigation.

However, Napoleon's dream to "rescue them from the galling yoke under which they had groaned for ages . . . (and) to bestow upon them without delay all the benefits of European civilization" (I quote from Arago's eulogy) was a failure. The uncivilized Egyptians failed to respond to the cultural feast proffered. Napoleon soon surreptitiously returned to France as did Monge, leaving Fourier to cope on his own. During Fourier's continued stay in Egypt, Napoleon conquered much of Europe and became the virtual ruler of France. Nevertheless, his fortunes in Egypt never proved successful and within three years of his stealthy departure, Fourier and the others he had left followed.

Upon his return to France, Fourier was named Prefect of the Department of l'Isere. Although this area was a hotbed of political dissensions, Fourier, by displaying great diplomatic skill, soon established harmony among the near-warring factions. The situation was brought to such a quiet state that Fourier could continue his efforts in mathematics and letters. From Grenoble, the principal city of Isere, Fourier wrote his *Theorie Mathematique de la Chaleur*. This was Fourier's outstanding scientific effort.

Fourier's effort received a mixed reception. The pure mathematicians again pointed out the lack of rigor in his treatment. Pure mathematicians and mathematical physicists have nearly always been at odds: the former disdaining any treatment that avoids the scrutiny of rigid proof; the latter pleased to have a procedure to express the results of their observations.

Fourier recognized that any function whose graph displays a periodicity can be considered to be a sum of sinusoidal functions. That is,

$$f(x) = \sum_n A_n \sin nx.$$

(The purist may note that I have taken some liberties in expressing the Fourier series. Pshaw.)

This series is now known as a *Fourier series*. Its real value to optics, of course, is that it leads to an integral transform whereby a periodic function of space, for example, may be transformed to a periodic function of time. By this means the spectral characteristics of a radiating source may be separated by a Michelson interferometer to provide a time varying signal in which time is not directly related to wavelength. However, by means of the Fourier transformation this can be accomplished. Generally, the transformation is undertaken with a computer, although prior to the introduction of computers other means were employed.

Fourier had submitted his treatment of the conduction of heat, in which his series was fundamental, to the Paris Academy in 1811, for which he was awarded its mathematical prize in 1812. As noted, some reservations were expressed with the favorable judgment. However, Fourier never admitted the validity of this dissension, giving unmistakable evidence near the close of his life that he thought it still unjust by causing this memoir to be published in the Academy records without changing a single word!

This work had a tremendous impetus to the research of his colleagues who considered the geological heat content, the temperature of celestial regions, and the effects of heat on biological growth. During this period, Napoleon's influence had blossomed and faded. In 1815, Napoleon escaped from Elba and made a triumphal march on Paris. Fourier had mixed reactions to this news. He left Grenoble for Lyons, where some of the royalty had assembled. They greeted Fourier coldly and doubted that Napoleon could have captured nearby Grenoble. Consequently, Fourier was told to return and protect the (already fallen) city. Fourier had barely left Lyons when he was arrested by Hussars and conducted to Napoleon's headquarters.

Confronted by Napoleon, Fourier explained that his *duty* compelled him to act as he had. Napoleon forgave Fourier, but did not endear himself when he told Fourier that, "I have made you what you are."

Fourier was appointed Prefect of the Rhone and given the title of Count—promotions Fourier dared not reject. However, this appointment as Prefect lasted but a short time. Fourier returned to Paris with no income and no financial reserve. It was a turbulent time for many. Napoleon's career ended at Waterloo, and the Bourbons were restored to power in Paris.

Fourier applied for a federal pension for his 15 years of service to his country. He was rudely repelled. However, a former student at the Ecole Polytechnique, upon learning of Fourier's plight, enabled him to receive the directorship of the *Bureau de la Statistique* of the Seine.

The Academy of Sciences sought at its first opportunity to elect Fourier to its society. Political intrigue, sanctioned by Louis XVIII, prevented anyone who had been associated with Napoleon from election to the Academy. (Arago noted, "In our country, the reign of absurdity does not last long.") A year later, in 1817, the Academy again unanimously nominated Fourier to a place in the section of physics. This time there was royal confirmation without difficulty.

Fourier was now able to spend the last years of his life in retirement and in the discharge of academic duties. He became eloquent in discoursing on those facets of life which he had experienced. There are those who find this type of



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eloquence to be somewhat boorish, rather than fascinating. They cite an incident in Fourier's later years as a case in point. Fourier was seated at a table together with some who were strangers to him. One, in particular, was identified as an old officer. To him, Fourier described in great detail the events of a battle that had taken place in Egypt, and of which Fourier had some first-hand knowledge. Fourier concluded his recitation of the details of this battle by noting, complacently, that he felt his memory had served him correctly in recalling these events. His com-

panion, who seemed to have been enthralled by this discourse, assured Fourier that his statements were accurate, and that he based this judgment on the fact that he had personal knowledge of the battle, having been head of the Grenadiers involved!

Although endowed with a sturdy constitution, Fourier had adopted the habit of wearing too much clothing. Thus, although he gave the appearance of corpulence he was, in fact, a quite slender man. He abided in a sterile, ovenlike environment, even keeping his windows closed in

the heat of summer. Visitors found this to be annoying. As a result of this, Fourier developed an aneurism of the heart. In the spring of 1830 he further sustained a fall on descending some stairs. This aggravated his condition and within two weeks he died.

Fourier's name is now used as an adjective describing an eloquent method of handling several optical processes. Thus, we who work in the field of optics revere this man, perhaps unaware that the legacy he left us was beyond expectation.

The fifth annual SPIE seminar on Modern Utilization of Infrared Technology was held at the Town and Country Hotel, San Diego, on 29-30 August 1979. The seminar was divided into four sessions:

1. Mosaic Sensors, Lt. Col. Thomas P. May, USAF Space and Missile Systems Organization, chairman;
2. IR Systems and Detectors, R. Barry Johnson, Science Applications, Inc., chairman;
3. Military Applications, Irving J. Spiro, The Aerospace Corporation, chairman;
4. Scientific Applications, Kennon P. White III, The Aerospace Corporation, chairman

In the opening session on mosaic sensors, Donald J. Carlson et al. of Grumman Aerospace Corporation discussed the development of a staring mosaic module. He pointed out that the module is composed of a series of hollow alumina strips. Detectors are deposited on the edge of each strip with the signal amplifiers and associated electronics and wiring contained in the hollow portion of each strip. Metal tubes housed in notches perform the double task of holding a group of strips together and serving as the conduit for cooling liquid.

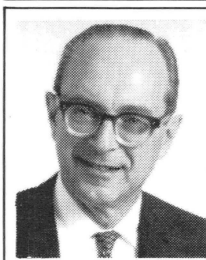
Dain S. Glad and his associates from Aerojet Electro Systems Company, the Naval Ocean Systems Center, and USAF Space and Missile Systems Organization disclosed the pulse bias modulation of a PbS mosaic array. In their presentation a large array of lead sulfide is deposited on a transparent plate. Conduction strips are deposited in rows and (insulated from each other) columns. The columns are sequentially biased to provide signals from any energized areas whose rows are then read out and amplified. Details of construction and testing were presented.

Herbert E. Rauch et al. of Lockheed Palo Alto Research Laboratories, Alexander C. Liang of The Aerospace Corporation, R. T. Pohlman of the Center for Analysis, Richard D. Williams and David L. Fried of the Optical Sciences Company, and Sergio F. Valdes of The Aerospace Corporation, presented papers describing some aspect of improving the performance of a staring mosaic in the face of a deleterious effect.

The last paper in this session, by Thomas J. Janssens of The Aerospace Corporation, described techniques for design optimization of a staring sensor. He presented methods for trading off the various parameters.

The second session, devoted to IR systems and detectors, opened with a paper by Hamilton Barhydt of Hughes Aircraft Company on figures of merit for infrared sensors. He stressed the simplification of performance analyses and elimination of confusion when the analyses are based on photon rather than power detectivity.

## Radiometry and Photometry



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### Review of the Fifth (1979) Annual Seminar on Modern Utilization of Infrared Technology

Equations describing  $D^*$ , responsivity, signal-to-noise ratio and probability of detection were presented in both power and photon terms in order that the reader could see the simplification available. Details were provided for such parameters as range equation and probability of detection for staring and scanning sensors when the system is either background-limited or internal noise-limited.

R. Ascher et al. of Lockheed Palo Alto Research Laboratories discussed track assembly using optical and digital methods. They discussed spatial, temporal, and spectral filters, and a chart was presented that showed power against the number of pixels per second for various processing rates.

T. C. Nast and A. Sherman of Lockheed Palo Alto Research Laboratories described cryogenic cooling of instruments in orbit. This was a comprehensive paper on the use of solid cryogenics in space missions of varying mission duration up to eight years, and cooling loads.

Samuel R. Hawkins et al. of Lockheed Palo Alto Research Laboratories described a test facility for the test and calibration of advanced focal plane arrays. Displays were provided to show such items as an output histogram,  $D^*$ , and responsivity.

James T. Wood of DCS Corporation and John T. Cuttica of the U.S. Dept. of Energy presented a paper on applications of image evaluation techniques to heat loss diagnostic sensors. They discussed the use of a four-bar test chart with 7/1 aspect ratio to determine the minimum resolvable temperature difference (MRTD) with the goals of examining a wall area of  $0.5 \times 0.3$  meters and of recognizing a stud with a probability of 50%.

John Warner of the Royal Signals and Radar

Establishment (England) provided a ray tracing method to determine the optimum rotation axis for a mirror in a thermal imager.

The last paper in this session, by Benjamin Capone and his associates at Rome Air Development Center and RCA Automated Systems Division, concerned a TV compatible Shottky barrier monolithic IRCCD focal plane. They reported on a  $25 \times 50$  array with a dynamic range of 22,000, NEH [areance]  $1.8 \times 10^{-8}$  W/cm<sup>2</sup>, 30 msec star time, NETD and MRTD of  $0.1^\circ\text{C}$ , which they have in operation. The unit operates from 1.2 to  $5.5 \mu\text{m}$  (which can be narrowed by a suitable optical filter) and requires cooling to  $90^\circ\text{C}$ . The sensor output is displayed on a 535 line television screen.

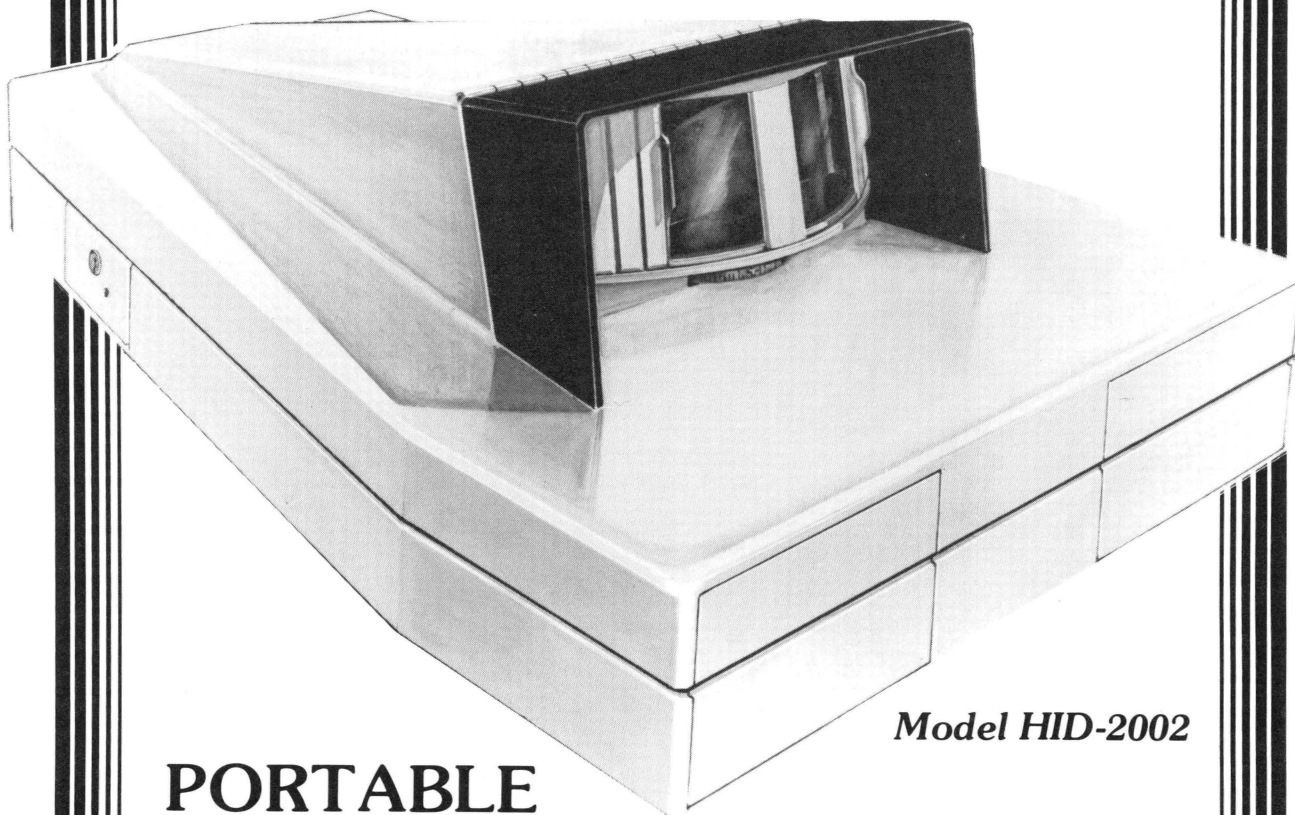
In the third session, devoted to military applications, F. J. LeBlanc presented a paper co-authored with R. E. Huffman, J. C. Larrabee, and D. E. Paulsen of the Air Force Geophysics Laboratory on vacuum ultraviolet backgrounds from space. They described measurements made with a photometer and a spectrometer mounted on a satellite in a polar orbit yielding day-night coverage on each orbit. Their photometer had four filters each about 100 to 150 Å wide centered at 1216, 1340, 1550, and 1750 Å. The spectrometer covered the region from 1100 to 2900 Å. Radiance [sterance] levels, spectrometer records, and global photometer profiles were provided.

Major William Weppner of the USAF Space and Missile Systems Organization presented a paper on BMM data-report on actual IR mosaic background measurements. He first described the sensors that were carried to 100,000 feet over Holloman AFB by a 5 million cubic foot balloon. Data on backgrounds both while the sensors are staring at or scanned over the same scene were provided. Time-radiance [sterance] plots and power spectral densities are provided.

Barbara A. Capron and Richard J. Becherer of the MIT Lincoln Laboratories discussed digital restoration of ac coupled infrared images. One feature of the method involves the use of the ratio of the re constant to the repetition rate for pulses for the removal of the dc.

J. J. Gallagher et al. of the Georgia Institute of Technology described many military system applications at near millimeter wavelengths (NMW). They discussed the wavelength region from 3 to  $30 \text{ cm}^{-1}$  and presented numerous charts that showed the effects of rain and clouds on atmospheric attenuation or transmission compared with the visible, SWIR, LWIR, and microwave regions. Nine system applications of NMW were described, and nine potential applications were discussed.

J. F. Ebersole and M. Camac of Aerodyne Research presented a paper on obscuration effects of artillery-produced dust clouds on IR



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E-O systems. They described field experiments in which dust clouds of various sizes are produced and catalogued, and the time required before objects become visible again at varying distances and heights (off the ground).

In the fourth session, devoted to scientific applications, Gary Bailey of the Jet Propulsion Laboratories described the design and test of the near IR mapping spectrometer focal plane for the Galileo Jupiter Orbiter Mission. He provided the details of the unit, which operates in the 1 to 5  $\mu\text{m}$  region using InSb detectors. The unit displays no 1/f noise from dc to 10 Hz.

L. H. Sweeney of the Space Applications Corporation and his associates from the Systems and Applied Sciences Corporation, NASA, and The Aerospace Corporation described their second equatorial IR catalogue. Some 200 IR stars near the celestial equator were measured from various satellite platforms and verified.

E. M. Winter of IBM examined various terrains as seen from the Skylab. He obtained PSDs for various horizontal scans and averaged these to obtain a vertical average.

Prof. L. F. Pau of the French Scientific Mission described an infrared source classification system. He described a system consisting of detectors in the 1 to 4 and 8 to 13  $\mu\text{m}$  ranges mounted nonuniformly on the radial arms. A zoom lens is utilized to change the focal length and reduce the image size when necessary to focus the image on one of several rings of detectors. By examining all eight arms, the instrument can categorize the profile of an object by determining which detector on which arm receives energy. ☐

## Optics Education



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### Optics Education is Subject of Special Issue

There has been a great deal of interest in optics education shown by industrial, governmental, and academic personnel. In response to this interest, an overview of optics education has been published for the optics community and for other interested people. The May 1980 issue of the *IEEE Transactions on Education* (Vol. E-23, No. 2) is a special issue on the subject of "Optics Education." Jack D. Gaskill, Professor at the Optical Sciences Center, University of Arizona, Tucson, has served as Guest Editor for this special issue and has done an excellent job of bringing together significant papers in this area. The contents of this special issue are as follows:

- Guest Editorial, *J. D. Gaskill*
- The Refractive Index of Optics Education in the United States is Unity, *D. C. O'Shea*
- Optics Technology Education Programs in the U. S., *T. K. Gaylord*
- The Undergraduate Optics Laboratory in American Universities, *S. George*
- Optics Education in the United States: Programs and Opportunities, *J. D. Gaskill*

- Short Courses on Fiber Optical Communications, *J. C. Palais*
- A Course in Integrated Optics, *T. K. Gaylord*
- Optical Radiation Detector Laboratory, *E. L. Dereniak, J. M. Palmer, H. Roehrig*
- Some Suggestions on the Teaching of Advanced Geometrical Optics to Engineers, *A. Nussbaum*
- Modern Optics and Electrical Engineering, *A. D. Poularikas, S. Seely*
- An Electro-optics and Microwave Optics Program in Electrical Engineering, *N. H. Farhat, J. Bordogna*
- On-Site Graduate Program in Optics: A Case Study, *P. B. Mumola, J. I. Budnick*
- Graduate Optics Education at the Air Force Institute of Technology, *T. E. Luke, R. L. Hengehold, S. R. Robinson*
- Graduate Training in Optics at the Optical Sciences Center, *J. D. Gaskill*
- Optical Engineering Education at Carnegie-Mellon University, *D. Casasent, C. S. Tsai, J. O. Artman*
- Optics Education at Georgia Tech, *W. R. Callen*
- M.I.T.'s Modern Optics Project Laboratory, *C. Warde*
- A Profile: The Teaching of Optics by the Faculty of the Institute of Optics, *N. George, K. Strand*
- A Program in Modern Optics and Lasers at San Diego State University, *J. A. Davis*
- Optics at Texas Tech University: Learning by Doing, *J. F. Walkup, P. F. Williams, M. A. Gundersen*

This document should be a very valuable resource to all people interested in optics education. Copies of this special issue may be obtained from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854, for \$5 (prepaid) for IEEE members, \$10 (prepaid) for nonmembers.

## Short Courses

**High Speed Motion Analysis—Systems and Techniques, Oct. 6-10, Madison, WI.** For engineers and scientists in \$&D and manufacturing. Will feature lab sessions, opportunity to conduct measurements with a number of high-speed photography and video systems. \$425. John M. Leaman, Dept. of Engineering & Applied Sci., Univ. of Wisconsin-Extension, 929 N. Sixth St., Milwaukee WI 53203. 414/224-4189. ☐

## Industry News

### Honeywell awarded contract

Honeywell's Electro-Optics Center has been awarded a \$3.9 million contract from the U.S. Air Force Avionics Laboratory for development of an infrared sensor capable of passive autonomous terminal homing in missile applications. Sponsored by the Defense Advanced Research Projects Agency, the contract calls for the development and dem-

onstration of a pod-mounted sensor for flight test on a Navy A-6 aircraft.

### Valtec and M/A-COM agree to merge

M/A-COM, Inc., Burlington, MA, has reached an agreement in principle with Valtec Corp., West Boylston, MA, for Valtec to become a M/A-COM company. The agreement in principle is subject to the execution of a definitive agreement and the approval of the stockholders of both companies. M/A-COM will issue one share of its common stock in exchange for each share of Valtec common stock including shares to be issued in conjunction with certain stock options for a total of approximately 4.6 million shares of M/A-COM, Inc. common stock. The agreement calls for Valtec to continue to operate with its present management.

# Book Reviews

## LASER SAFETY HANDBOOK

Alex Mallow and Leon Chabot. vii + 353 pp., illus., index, bibliography. ISBN 0-442-25092-4. Van Nostrand Reinhold Co., 135 West 50th, New York (1978). \$22.50.

Reviewed by John F. Ready, Honeywell Corporate Material Sciences Center, 10701 Lyndale Avenue S., Bloomington, MN 55420.

The authors state that their intent is to "compile under one cover information on the many and diverse considerations that affect laser safety." They succeed in achieving this purpose. However, they succeed not so much by skillful organization and interpretation as by simply reproducing parts of the standards and regulatory codes that affect laser usage.

I feel that this is a significant flaw which detracts from the book's value. Too much of the book is repetition of things that are already available, for example the American National Standards Institute Z136.1 Standard for the Safe Use of Lasers. The laser user faced with implementing safe practices for a specific laser will still need the full Z136.1 standard to be available. This book will not eliminate that need. Neither does the book give the user as much help as it should in interpreting the standard.

One persistent problem with laser safety standards, including the Z136.1 standard, has been their relative complexity, and the difficulty of determining what should be done in specific cases. This perhaps is the greatest need that could have been addressed by a comprehensive book on laser safety. With the exception of a small number of examples worked in Chapters 6 and 7, and Appendix C, the book does little to go beyond the bare restatement of the codes and regulations.

The book appears to be organized into three main sections. The first of these sections, comprising the first five chapters, is devoted essentially to introductory material. The first chapter is a very brief introductory statement. There follow chapters on the basics of lasers, the effects of laser radiation on biological systems, laser hazards associated with things other than the beam, and measurements of the parameters of the laser output. The level of these chapters is relatively low. They will be of most use to a reader who is encountering laser technology for the first time. Chapter 5, on Laser Measurements, in particular seems weak. Although it is important for the user to be able to make such measurements, there is not enough specific information presented. The chapter will not teach someone how to perform the measurements, unless that person already knows how to do them.

The next main grouping of chapters, Chapters 6 to 9, really form the heart of the book. Basically these are the chapters that address the topic of safety practices. Chapter 6 describes protective standards and draws heavily on the Z136.1 standard. It does work through some specific examples based on application of the standard. Chapter 7 deals with the classification

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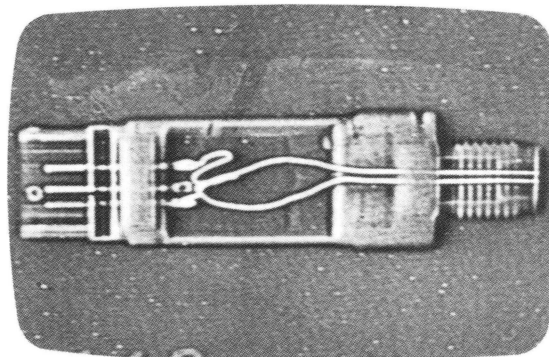
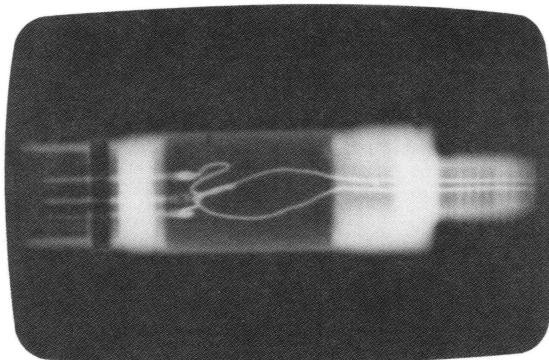
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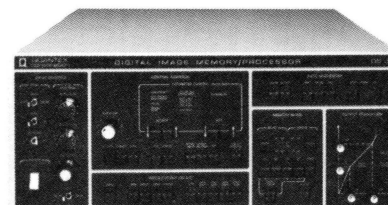
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of lasers according to their level of hazard, following closely the Laser Products Performance Standards of the Food and Drug Administration (FDA). Again, it provides specific examples to help interpret the standard. Chapter 8 describes control measures for laser beam hazards. This chapter is mainly a textual description of the practices recommended in the Z136.1 standard. Chapter 9 describes control measures for other associated hazards, including specific design and user precautions relative to the hazards of high voltage.

The final part of the book covers a miscellany

of topics, including some applications of laser safety in particular usages, like education. The ordering of the chapters is not clear. Some of the information, like selection of laser protective eyewear, would appear to be logically a part of the formulation of a safety program. Other parts are reproductions of other publications.

Chapter 10 covers some of the laws, federal and state, related to laser usage. Chapter 11 describes implementation of a laser safety program. It has some specific information about how one company trains its employees for laser safety. Safety in classroom use of lasers is the



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subject of Chapter 12. A suggested program of medical surveillance for people working with lasers is given in Chapter 13. Chapter 14 discusses laser protective eyewear and its availability. The chapter relies heavily on the laser safety eyewear recommendations, and also uses, perhaps excessively, data on eyewear performance from one commercial manufacturer. A final chapter describes propagation of light through the atmosphere.

Three appendices include a glossary of laser terminology, a reproduction of the New York State code on lasers, and a description of the approach to determining the classification of lasers according to the FDA standard. This last appendix contains specific examples and is one of the better parts of the book. It would be useful for people who have to prepare reports required by the FDA.

An excessive amount of space is devoted to the New York laws. Twenty-four pages are given to a reproduction of the New York State Industrial Code 50 on lasers, and 13 pages to a brochure interpreting that code. This information will be useful for only a small fraction of the readers.

The book does provide some useful information. The examples in Chapters 6 and 7 and Appendix C will help the user interpret the safety standards. Taken as a whole, the book relies too much on repetition of other sources. It does not significantly help the user to determine what to do in a specific case involving laser safety.

## APPLIED OPTICS AND OPTICAL ENGINEERING (Volume VI).

Rudolf Kingslake and Brian J. Thompson, Eds. xv + 511 pp. with list of acronyms, abbreviations, and initials; author index; subject index. Well illustrated with b/w photos, many graphs and line drawings. ISBN 0-12-408606-3. Academic Press, Inc., 111 Fifth Ave., New York 10003 (1980). \$49.50.

Reviewed by William P. Barnes, Jr., Itek Optical Systems, A Div. of Itek Corp., 10 Maguire Rd., Lexington, MA 02173.

When the first five volumes of this "Kingslake Series" were prepared in 1967, lasers and other coherent devices were not treated because "... anything written would probably be out of date by the time it was published ... ." This Volume VI, devoted to coherent optical devices and systems, still runs some risk of partial obsolescence because of the pace of continuing development in this subject area. Its presence should be welcome, however, to anyone engaged in that multidisciplinary exercise we call optical engineering.

As with the initial volumes, this one gathers a large amount of diffused information and usefully fills a gap between handbook condensations, textbook expositions of well-established facts, and the periodical literature reports of newly developing knowledge. The subjects covered include solid, gas, and semiconductor diode lasers, acousto-optics, light valves (two-dimensional spatial light modulators), scanners, optical data processing, infrared detectors, holography, image intensification, and fiber optics for communication. The common thread is the production of coherent radiation, the description of processes and systems which require coherent radiation to function at all, and the discussion of tasks which can be better accomplished with coherent radiation.

This reviewer expects this volume to well serve three purposes:

- a self-teaching introduction to the several subject areas covered,
- a guide to the literature; and
- a ready reference and memory refresher after one's attention has been elsewhere.

The emphasis in all six volumes remains on "principles of operation" and "equipment existing at the present time." The depth of treatment appears to be such as to provide real aid in understanding the subject covered. For exploring any of these items, I would find it difficult to recommend a better starting point.

## ELECTRO-OPTICS HANDBOOK

Glenn R. Elion, Herbert A. Elion. x + 359 pp. 123 line drawings, graphs; index; bibliography; Appendix: Properties of the Elements. ISBN 0-8247-6879-5. Marcel Dekker, Inc., 270 Madison Ave., New York 10016 (1979). \$39.75.

Reviewed by Stephen F. Jacobs, University of Arizona, Optical Sciences Center, Tucson, AZ 85721.

The title of this book seems to me misleading in that it does not contain enough data, curves, and tables to be a useful handbook; nor does it explain principles in enough detail to be a textbook. Instead, there is considerable discussion of systems principles and components in fairly

general terms. While the authors claim to "have presented data that have been useful to them in their work as practicing electro-optic engineers," in the areas of optics, lasers, and detectors, the authors' selections are not an improvement over existing handbooks, such as the *OSA Handbook of Optics*, and in fact contain errors enough to constitute a serious problem. For example, what might be a He-Ed laser? Cw He-Ne lasers aren't limited to 10 mW output, nor are argon lasers limited to 0.3 W. Diagrams of some optical systems are very poor (that of the Twyman-Green interferometer is hard to recognize).

As a test of the usefulness of this handbook, I tried looking for specific answers to some electro-optic questions: I was unsuccessful in finding the voltage necessary to achieve 100% amplitude modulation of light via the electro-optic effect using KDP. What little information I could find was listed under "lasers," but the answer eluded me. Another test case ended in failure to find piezo-electric response (A/volt) of PZT transducers.

In defense of the book, it does discuss a wide variety of subjects which introduce the reader to modern techniques in the area of optical communication. Considerable data in this area are presented which are not yet available in handbook form. The chapter subjects usefully cross interdisciplinary lines, and go into computers, electronics, optics, and interfacing with the human element.

To sum up, this book seems much less useful as a handbook than as a general introductory discussion of modern techniques for optical communication.

## ELECTRON-MOLECULE SCATTERING

Sanford C. Brown, Ed. xii +196 pp., illus., index, bibliography. ISBN 0-471-05205-1. John Wiley & Sons, Inc., 605 Third Ave., New York 10016 (1979). \$22.95

Reviewed by Donald G. Truhlar, University of Minnesota, Dept. of Chemistry, Kolthoff and Smith Halls, 207 Pleasant St. S.E., Minneapolis, MN 55455.

This book is composed of papers presented at the October 1977 George J. Schulz Memorial Lecture and Symposium held at Yale University. It contains four long chapters (24 to 39 pages), one short chapter (5 pages), and a reprint of Schulz's own classic paper, "A Review of Vibrational Excitations of Molecules by Electron Impact at Low Energies" (56 pages). Schulz's paper was completed just before his death and emphasizes resonances. It contains references up to 1976 and was first published in *Principles of Laser Plasmas*, edited by G. Befeki (Wiley).

The other four long chapters are "Atomic Processes in Planetary Atmospheres" by Manfred Biondi, "Applications and Needs" by Arthur V. Phelps, "Laboratory Experiments" by Franz Linder, and "The State of the Theory" by Neal F. Lane. The first contains references up to 1978 and the next three have references up to 1977. The authors are leaders in their fields by the highest international standards, and the prospective reader may safely assume that the material in the papers is correct and well presented. Biondi's chapter is concerned with his own laboratory program and field observations (he is author or co-author of 21 of his 26 references) and includes not only electron-molecule processes but also other processes involved in the

ionized regions of the upper atmospheres of the planets. An example is his interferometric measurements of radiation intensities scattered by artificial plasma clouds, created by releasing barium in the F region, to learn more about ionospheric propagation of radio waves. Phelps's chapter reviews technological applications of electron-molecule scattering data, including the commercial production of ozone, high voltage transmission systems, air cleaning by electrostatic precipitators, magnetohydrodynamic generators, isotope separation, CO<sub>2</sub> lasers, and electronic transition lasers. In each case, he sketches first the application, then the current state of our knowledge of the fundamental electron-molecule scattering data involved. Linder's chapter surveys a well-selected group of experiments involving resonances, dissociative attachment ( $e^- + XY \rightarrow X + Y^-$ ), vibrational excitation, and electron scattering in weak and strong radiation fields. Linder was the first to achieve the energy resolution necessary to measure rotational excitation cross sections by electron impact, and his chapter includes an interesting section on the state of the art of energy resolution in electron collision studies. Lane's chapter is now somewhat superseded by his more recent and larger review [*Rev. Mod. Phys.* 52:29 (1980)]. The short review would make much easier reading for a nonspecialist. There is much emphasis on resonances, and examples are restricted to H<sub>2</sub>, N<sub>2</sub>, F<sub>2</sub>, CO<sub>2</sub>, and HCl at impact energies of 10 eV and lower. (Most of the examples in the other chapters are also restricted to small molecules and these low energies.)

The price of the book works out to 12 cents a page, and I consider it a good bargain.

#### HOLOGRAPHY & COHERENT OPTICS

L. M. Soroko; translator, Albin Tybulewicz. xvi + 818 pp., illus., bibliography. ISBN 0-306-40101-0. Plenum Press, 227 W. 17th Street, New York 10011 (1980—original Russian text published 1971; author has made corrections for the present edition). \$59.50.

Reviewed by Demetri Psaltis, Carnegie-Mellon University, Dept. of Electrical Engineering, 5000 Forbes Ave., Pittsburgh, PA 15213.

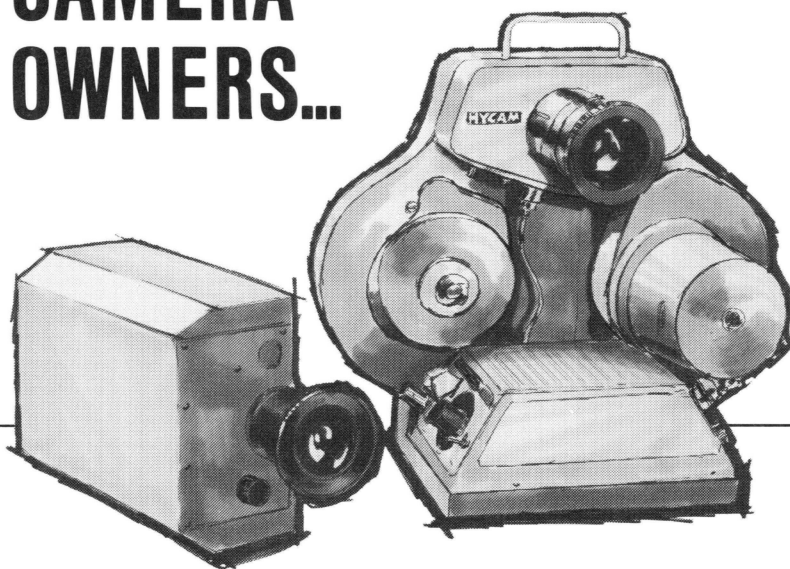
This is an excellent book which develops the necessary analytical tools from linear systems theory and statistics and then uses them to describe the fundamentals of holography and optical information processing. The book was originally published in the USSR in 1971. It is not written in the formal manner of a typical textbook and it is not a research monograph. It is a comprehensive description of coherent optics from an information scientist's point of view. The strength of the book is the good organization and clear presentation of the material. In addition, the author's point of view is often different from the conventional, and thus I believe that even the reader who is familiar with the subject will find the book interesting and informative. For instance, the book emphasizes the use of statistical techniques which are very useful in coherent optics, but often missing from other books on the subject.

Chapter 1 is a brief introduction to the subject of holography and its history.

In Chapter 2 the linear transformations relevant to coherent optics are discussed. The author has interjected numerous explanatory para-

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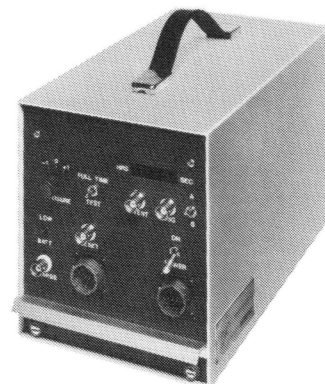


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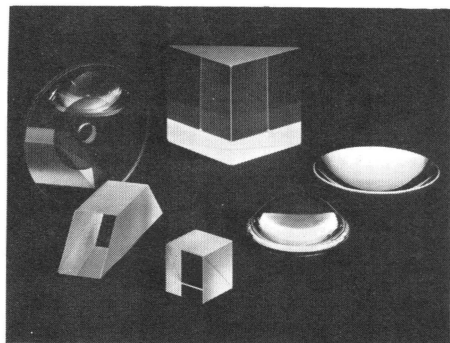
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graphs to give a good intuitive understanding of the material. However, there are occasional inconsistencies in the chapter and the analysis is not always rigorous (for instance, the definition of a linear filter on pages 131-132 is that of a shift invariant linear filter).

Chapter 3 is a brief introduction to statistics where the concepts of ensemble average, stationarity, ergodicity, correlation, and power spectral density are described. The author also finds the opportunity to discuss the matched filter and the ambiguity function in this chapter. (The ambiguity function has been translated as "interminacy" function, and a deterministic signal is called "determinate").

Chapter 4 is an excellent discussion on the coherence of light. The author first defines the mutual coherence function and then gives both an intuitive and an analytical description of the effects of coherence on interference and diffraction. Methods for the measurement of the coherence of an optical field are also examined.

In Chapter 5 the information content of an image (or any spatially and temporally band limited optical field) is calculated. This is done for both coherent and spatially incoherent illumination. The author ends the chapter with a very intriguing conclusion (Theorem 2, page 393), suggesting that one can obtain more spatial degrees of freedom by trading away temporal degrees of freedom.

Chapter 6 (which is almost 200 pages long) is a book within a book on holography. Practically

all types of holography are addressed and the presentation is well organized. The discussion on the effects of spatial and temporal coherence on holography (6.20 and 6.23) is particularly interesting. Specific applications of holography are not discussed.

Chapter 7 is devoted to optical information processing and it is probably the weakest chapter. In sharp contrast with the rest of the book, this chapter is not well organized. Part of the material seems redundant since it is covered in previous chapters. The reader does not get a complete picture of optical information processing methods, their potential and their limitation. Parts of the chapter, however, are very interesting and informative (for instance, the discussion on the information capacity of a bank of matched filters).

Three papers on optical computing by G. W. Stroke and his co-workers are reprinted in the appendix of the book and they complement the book nicely. Credit is due the translator, A. Tybulewicz, and the translation editor, G. W. Stroke, for the generally excellent edition of the book in English.

**LASER HANDBOOK, VOLUME III**  
Malcolm L. Stitch, Ed. x + 846 pp., illus., index, bibliography. ISBN 0-444-85271-9. North-Holland Publishing Co., 52 Vanderbilt Ave., New York 10017 (1979). \$122.00.

Reviewed by Peter K. Cheo, Senior Research Scientist, Electro-Optics Systems Technology, United Technologies Research Center, East Hartford, CT 06108.

This is a rather timely addition to the series. In the past decade, several new and large-scale laser systems, e.g., excimer and chemical lasers, and also some laser applications, in the areas of isotope separation and fusion, have played a rather important role in the growth of the laser community. Research and development in the areas of nonlinear optics, ultrashort pulses, laser spectroscopy, and holography have also reached their peaks during this period.

This volume of the series covers mostly these recent advances in laser technology and laser applications in a total of 878 pages. Part A, Laser Technology, contains six chapters: (A-1) Unstable Resonators by W. H. Steier; (A-2) Waveguide Gas Lasers by R. L. Abrams; (A-3) High Power, Efficient Electrically Excited CO Lasers by R. E. Center; (A-4) Excimer Lasers by J. J. Ewing; (A-5) Chemical and Gas Dynamic Lasers by C. J. Ultee; (A-6) Pulsed Dye Lasers by R. Wallenstein. Part B, Laser Applications, also contains six chapters: (B-1) Technology of Bandwidth-Limited Ultrashort Pulse Generation by W. H. Lowdermilk; (B-2) High Average Power, Efficient Second Harmonic Generation by D. Hon; (B-3) Laser-Induced Chemical Reactions and Isotope Separation by C. D. Cantrell, S. M. Freund, and J. L. Lyman; (B-4) Pulsed Holography by W. Koehnner; (B-5) Advanced Lasers for Fusion by W. F. Krupke, E. V. George, and R. A. Haas; (B-6) Continuous Picosecond Spectroscopy of Dyes by H. E. Lessing and A. vonTena.

The style and caliber of this volume have been kept in line with the first two volumes. Each chapter begins with a brief abstract and a table of contents. A well-balanced presentation of experimental results and mathematical description and interpretation makes this handbook easily

readable. Each chapter contains numerous tables and references for quick access to information. These authors have done an excellent job by introducing the subject in a very clear and understandable manner. It fulfills the primary purpose of the handbook by providing the users who are not specialists with adequate background information without going through a pile of technical papers. However, it serves little usefulness to a specialist who is looking for finer details.

It would be an impossible task to give a detailed review on each of the twelve chapters. After plowing through this volume, I, as a reviewer not directly involved in any of these fields, felt that I had gained a good understanding about these topics. Besides its authentic value for every library, this volume is well worth the \$122 price tag, if one wants to acquaint himself with some of the recent advances in lasers.

**LASERS & THEIR APPLICATIONS IN PHYSICAL RESEARCH, Proceedings of the P. N. Lebedev Physics Institute, V. 91 (1976).**

N. G. Basov, Ed., translated from the Russian by Donald H. McNeill. 226 pp., illus., index, bibliography. ISBN 0-306-10949-2. Published in English by the Consultants Bureau. Plenum Press, New York/London (1979). \$42.50 paper.

Reviewed by Michael Hercher, Block Engineering, a div. of Bio-Rad Laboratories, Inc., 19 Blackstone St., Cambridge, MA 02139.

This volume, originally published in Russian in 1976, is primarily directed towards physicists doing research with lasers. It is comprised of five separate papers: "Fluctuating Intensity Regimes in Lasers and Masers," V. A. Dement'ev et al., 73 pages; "A Study of Injection Lasers," A. P. Bogatov et al., 39 pages; "Active Media, Designs, and Plans for Powerful Raman Lasers," A. Z. Grasyuk et al., 34 pages; "The Limiting Characteristics of Power Resonances in Ring Gas Lasers," V. A. Alekseev and L. P. Yatsenko, 12 pages; and "Laser Ranging of the Moon," Yu. L. Kokurin, 65 pages.

The first paper, "Fluctuating Intensity Regimes in Lasers and Masers," develops an approach for describing the dynamic processes in lasers based on a spectral representation of the polarization of the material and the radiation field. This is not light reading, and is a subject matter with a limited number of devotees, none of whom, I would venture to guess, view themselves as optical engineers.

The second paper, "A Study of Injection Lasers, Part II," may be of interest to those involved with the design and fabrication of semiconductor lasers, especially heterojunction lasers. The paper is divided into four chapters on (1) mode structure in injection lasers, (2) study of an injection laser with an external cavity, (3) anomalous mode interactions in injection lasers, and (4) a study of new semiconductor materials for injection lasers. The last chapter, which deals with multi-component solid solutions, provides a nice account of techniques for predicting the properties of lasers made from such materials. The most recent reference cited was in 1975, so that workers who have stayed abreast of developments in semiconductor lasers probably won't find much new in this paper.

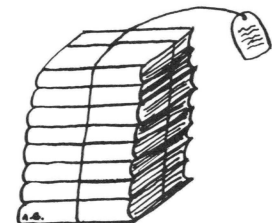
The third paper, "Active Media, Designs, and

Plans for Powerful Raman Lasers," is concerned with the technical details of using liquid nitrogen and oxygen and compressed hydrogen as Raman-active laser media. The first two media provide Raman laser emission at 1.4 and 2.1 microns (when pumped by a neodymium laser at 1.06 microns), and compressed hydrogen provides a tunable Raman laser from 1.87 to 1.9 microns and from 8.3 to 9.1 microns, using the same optical pump wavelength. The paper includes detailed plans for cryogenic cuvettes to be used in Raman lasers. Anyone planning to work in this area would probably benefit from a review of this paper.

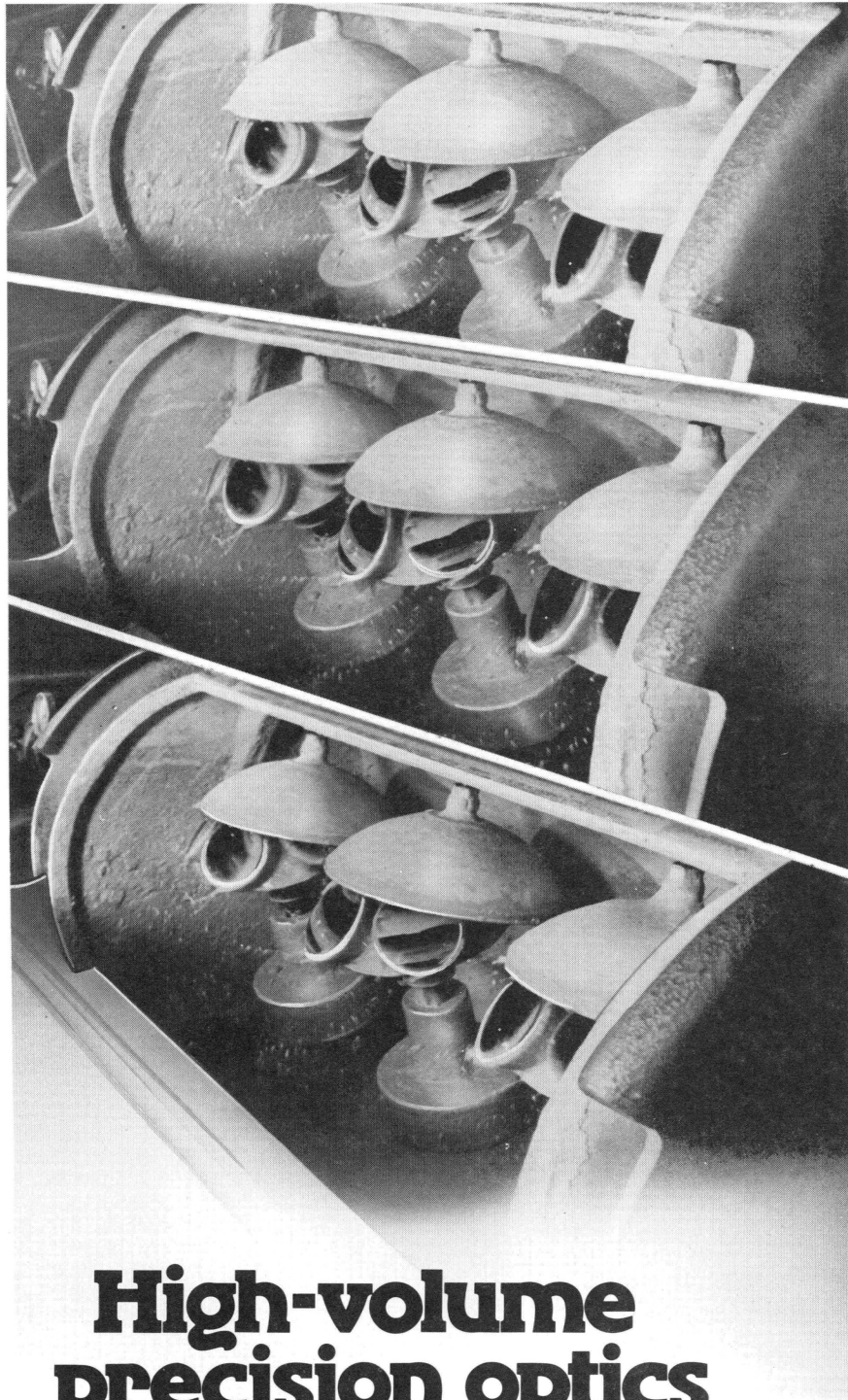
The fourth paper, on "The Limiting Characteristics of Power Resonances in Ring Gas Lasers," summarizes itself as follows: "This paper is devoted to the study of the dependence of the locations of the centers of the resonances and of their limiting widths and contrasts on the pressure of the absorbing and amplifying media, the coupling coefficients, the laser intensity, and other macroscopic parameters." Ring lasers containing a gas sample which absorbs at the same wavelength as that of the laser emission can provide the basis for frequency stabilized lasers with stabilities on the order of  $10^{-13}$  to  $10^{-14}$ ; this paper is concerned with the details of the mechanisms which define the emission frequency of such lasers.

The final paper, "Laser Ranging of the Moon," is only peripherally concerned with lasers but was, to me, the most interesting paper in the volume. It provides a comprehensive account of the lunar ranging problem, including the theory for determining the parameters of the earth-moon system from ranging measurements, a list of scientific problems which may be solved using laser ranging data, radiometric calculations, and an analysis of the optimum configuration for a lunar retroreflector. Detailed descriptions of the Soviet, French, and American lunar retroreflectors are given, and the effects of fabrication errors and thermal cycling are analyzed. The paper concludes with an extensive account of the Soviet data gathering and processing system, and a review of measurements which had been made between 1970 and 1975. Lunar ranging measurements were made with a Q-switched ruby laser as source, and a moderately large telescope as receiver: typical single-shot signals were in the range of 0.3 to 1.5 photoelectrons. Kokurin's highly narrative account not only provides a technically accurate and comprehensive account of these measurements, but also conveys the sense of excitement which attended the search for the reflectors on the moon and the first attempts to obtain useful data from these measurements.

McNeill's translation of these papers is excellent, and the English-speaking scientific community owes a great debt of gratitude to the linguist-scientists like McNeill who provide us with the means for interacting with Russian scientists through their publications.



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## THE MOLECULAR BASIS OF OPTICAL ACTIVITY

Elliot Charney. 364 pp., illus., index. ISBN 0-471-14900-4. Wiley Interscience, div. of John Wiley & Sons, 605 Third Ave., New York 10016 (1979). \$27.50.

**Reviewed by D. C. Walker**, University of British Columbia, Chemistry Dept., 2036 Main Mall, University Campus, Vancouver, B.C. V6T 1Y6, Canada.

Charney has done an excellent job of reviewing the key elements of the physico-chemical basis of optical activity. The overall impression is one of balance, of presenting the valuable sides of competing theories and models. There is enough theory to show the physical scientist what the underlying theory is, but not too much to lose control of its relationship to what the practicing chemist observes.

This is therefore a very valuable acquisition for chiroptical spectroscopists in particular and for all those to whom optical activity is a curiosity. The title is well chosen because two-thirds of the book deals with the basis and the remaining third treats special cases.

The subject index could be greatly improved, however. It is much too scant and does not have the cross-referencing capability that a good index can provide. Another, though much less serious, weakness lies in some ambiguity to be found in categorizing the point groups, as in (2) on page 152. The reader has to be careful to sort out what the author means at that point.

## THE OPTICAL DESIGN OF REFLECTORS, Second Edition

William B. Elmer. 290 pp., illus., index, bibliography. ISBN 0-471-05310-4. Wiley Interscience, div. of John Wiley & Sons, 605 Third Ave., New York 10016 (1980). \$24.95.

**Reviewed by Richard G. Morton**, Exxon Nuclear Co., Inc., Research & Technology Center, 2955 George Washington Way, Richland, WA 99352.

This book not only clearly conveys the art (or science) of reflector design, but also manages simultaneously to take full account of the required illumination pattern, environment of operation, materials of construction, efficiency, and engineering costs.

After carefully laying out the required theoretical basis of design, the book proceeds to deal with almost every type and combination of types of reflector imaginable. Many special cases are considered, such as that where the source must be unusually large compared to the reflector, or where the illumination beam must be asymmetric.

The design examples given in Part 5, as well as the appendices of mathematical parameters at the end of the book, are helpful features for any engineer involved in optical reflector design.

## THE PHYSICS OF MEDICAL IMAGING: Recording System Measurements and Techniques

Arthur G. Haus, Ed. 613 pp., illus. ISBN 0-88318-260-2. American Institute of Physics, 335 East 45th St., New York 10017 (1979).

**Reviewed by H. H. Barrett**, The University of Arizona, Optical Sciences Center, Tucson, AZ 85721.

This volume is a collection of papers presented at a 1979 summer school organized by The American Association of Physicists in Medicine. Topics covered include: (1) Screen-film Systems; (2) Image Intensifier Systems; (3) Electrostatic Systems; (4) CT Scanning, Ultrasound, and Nuclear Medicine; (5) Diagnostic Imaging Procedures & Techniques; and (6) Image Evaluation.

In general, this book is a very useful compendium of information on the various medical image recording systems. The coverage is largely qualitative with a minimum of mathematical detail. Most of the chapters should be readable by interested radiological technicians and physicians, as well as by physicists. It should prove useful as a broad-brush overview for physicists and engineers just getting into medical imaging, and as a ready source of references and physical data for established workers in the field.

The list of authors in this volume reads like a *Who's Who* of medical imaging, and generally each author is writing about his area of greatest expertise. Furthermore, the book is enlivened by transcripts of the discussions that took place at the summer school.

In spite of the length of this book, there are some notable gaps in its coverage. Although there is a brief discussion of film to be used in nuclear medicine imaging, there is no discussion of scintillation cameras. Ultrasonic imaging is given very short shrift, and there is no mention of the emerging technology of imaging with nuclear magnetic resonance. By and large, the emphasis is on diagnostic radiology and not on the broader field of medical imaging, as implied

by the title. Nevertheless, this book fills an important gap in the literature and should be perused by anyone interested in radiographic instrumentation.

## SEMICONDUCTORS & SEMIMETALS Vol. 14

Willardson and Beers. 334 pp.; illus., index, bibliography. ISBN 0-12-752114-3. Academic Press, Inc., 111 Fifth Ave., New York 10003 (1979). \$32.00.

**Reviewed by Jacque E. Ludman**, RADC/ESO, Hanscom AFB, MA 01731.

This new volume in the excellent and well-known Willardson Beers series is up to the usual high standards of the series, but is unusual in that it is a collection of several sections on subjects not very closely related. Three major areas are covered: first, two chapters on semiconductor lasers (Holonyak and Lee; Kressel and Butler); second, a chapter on injection phenomena in space charge limited diodes (Van der Ziel); and finally, a chapter on electron transport (Price).

The first section on photo-pumped semiconductor lasers assumes a familiarity with the fundamentals of operation of semiconductor lasers and could well have used a few introductory pages. For example, the first device depicted is a Ge doped GaAs laser attached to and being pumped by a Ga (AsP) injection laser. Whatever is lacking in the pedagogy of the first few pages is more than compensated by the clear and complete presentation of all the phenomena relating to the long list of III-V materials which can be photo-pumped.

The section on heterojunction lasers is also an excellent and thorough treatment of this complex family of devices whose characteristics vary with material, dopants, topology, etc. The first two sections are both refreshing in that the major foreign contributions to this science are well referenced.

The last two sections are an excellent treatment of injection and carrier transport in semiconductors and insulators. A large part of the material in the section on injection and space charge limited currents was treated in Volume 6, "Inspection Phenomena," but since this volume is now ten years old it is worthwhile to update the material. The inclusion of a treatment of noise is a welcome addition to this area.

## TOPICS IN APPLIED PHYSICS, Volume 30: Excimer Lasers

Charles K. Rhodes, Ed. 194 pp., illus., index, bibliography. ISBN 3-540-09017-7. Springer-Verlag New York, Inc., 175 Fifth Ave., New York 10010 (1979). \$36.30.

**Reviewed by Charles P. Wang**, The Aerospace Corporation, P. O. Box 92957, Los Angeles, CA 90009.

"The development of excimer lasers marked a significant turning point in the development of coherent sources." This is the opening sentence of the book. It is true that excimer lasers are a new class of efficient high-power lasers operating in the visible and ultraviolet spectral region.

The most important feature of excimer lasers is that the lower laser level is repulsive or only slightly bound. As a result, high electrical effi-

ciency, frequency tuning, and long pulse durations are possible. Since the first demonstration of Xe<sub>2</sub>-laser action in 1972, considerable progress has been made toward understanding excimer lasers.

Three years later, 1975, a new class of excimer lasers, rare gas halide lasers, was discovered. The major significance of the rare gas halide lasers is that the formation of excited molecules is not dominated by three-body collisional processes but by efficient two-body (harpooning) processes. Hence laser action can be achieved not only by direct electron-beam excitation but also by electron-beam-controlled-discharge excitation, uv or x-ray preionization discharge excitation, and fast discharge excitation. Since their discovery, the rare gas halide lasers have received a great deal of attention and are currently the most highly developed excimer lasers.

In such a diverse and rapidly developing area it is important, although difficult, to present a current and complete treatment of the subject. This book accomplishes just that. It makes an important contribution to the understanding and development of excimer lasers. It serves as a comprehensive review of the field and a source of references on almost all aspects of excimer lasers. It covers a wide spectrum of topics including electronic structure and radiative transfer by M. Krauss and F. H. Mies; rare gas excimers by M. V. McCusker; rare gas halogen excimers by Charles A. Brau; metal vapor excimers by A. Gallagher; and application by Charles K. Rhodes and P. W. Hoff.

As stated in the introduction, "Chapter 2 provides the main theoretical framework needed for an understanding of the currently known excimer molecules. This includes a description

of valence, ion-pair, and Rydberg systems as well as an analysis of the emission processes and calculations of the optical cross section. Chapter 3 leads directly to the experimental findings in describing three classes of related excimers, namely, the rare gas dimers, the rare gas oxides, and those arising in excited diatomic halogen molecules. The rare gas halogen systems appear in Chapter 4, which also includes a considerable discussion on the technologies applied for excitation. Chapter 5 closes the discussion of differing excimer species with an analysis of metal vapor systems including some relatively exotic molecules such as TiHg. Finally, Chapter 6 reviews applications of excimer lasers, purely scientific and applied, current as well as proposed, which we view as relevant examples."

This book is a valuable contribution to the field for both active researchers and neophytes alike.

## Calendar

1980

**July 10-Nov. 2.** Futuresight, traveling exhibition of the Museum of Holography, New York City. Museum of Holography, 11 Mercer St., New York NY 10013.

**Sep. 2-5.** SPIE/ASP Thermal Infrared Sensing Applied to Energy Conservation in Building Envelopes (Thermosense III) Conference/Workshop, Minneapolis, MN. SPIE, Box 10, Bellingham WA 98227. 206/676-3290.

**Sep. 29-Oct. 2.** SPIE Huntsville Electro-Optical Technical Symposium, Huntsville, AL. SPIE, Box 10, Bellingham WA 98227. 206/676-3290.

**Sep. 30-Oct. 2.** Opto 80, electro-optics conference and exhibit sponsored by the Comité Français de l'Optique, Paris, France. Masson Editeur, 120 Boulevard Saint-Germain, 75280 Paris Cedex 06.

**Oct. 1-3.** IEEE Digital Signal Processing course, Atlantic City, NJ. Vincent J. Giardina, Mgr. of Continuing Ed., 445 Hoes Lane, Piscataway NJ 08854 or Jules Resnick, Federal Aviation Administration, Atlantic City NJ 08408

**Oct. 4-7.** Aspects of Medical Photography: A Symposium, Univ. of Texas Health Science Center, Dallas, TX. Gale Spring, Pathology Dept., University of Texas Health Science Center at Dallas, 5323 Harry Hines Blvd., Dallas TX 75235.

**Oct. 6-9.** Tenth Intl. Laser Radar Conf., Silver  
*Calendar continues on SR-157*

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