

EDITORIAL

We are pleased to bring to our readers in this issue a special feature profiling the optical engineering effort in the area of "Optical Communications." Dr. Warren Birge, our guest editor for this issue, has been extremely cooperative in this undertaking, and has earned the gratitude of the editorial staff of **Optical Engineering**. We would like, also, to thank the authors for their cooperation and contributions in bringing this timely subject matter to our readers.

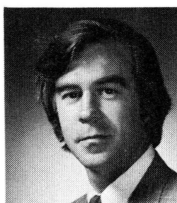
Also, in this issue, we are pleased to feature a number of other contributed papers. Three of these are in the general area of "Coherent Optics in Mapping," and we hope to include a special feature on this subject next year.

The special feature for the November/December 1974 issue will be "The Impact of Lasers in Spectroscopy," with guest editors Dr. Shaoul Ezekiel from M.I.T. and Dr. Stanley Klainer from Block Engineering, Inc. The issue promises to be both exciting and timely, covering a very broad range of activities within the general area.

We have finished plans for special features in each of our issues for 1975, and we shall announce them in the November/December issue. Also, beginning with the next two issues, our readers can expect to read some new Forum columns.

John B. DeVelis, Editor
OPTICAL ENGINEERING

FORUM



MEDICINE

WILLIAM R.
HENDEE

Thermography: A Screening Method for Breast Cancer?

One of the ways that the human body maintains constant temperature is by exchange of radiant energy between the skin and objects in the immediate environment. In 1957, Lawson observed that cancer can alter the pattern of emission of thermal energy from the female breast.¹ This observation stimulated a number of studies of thermographic detection of breast cancer and a number of publications with contradictory conclusions regarding the effectiveness of thermographic techniques. To some degree, these contradictions probably reflect inadequate experience of persons interpreting thermographic images, and improper ambient conditions such as asymmetrical air flow during the thermographic examination.

Cancer of the breast is the leading cause of death from cancer in women in this country. Despite advances in surgery, radiation therapy, and chemotherapy, mortality statistics for this disease have not improved, partly because the disease often is in a relatively advanced state at the time of detection. Currently, early detection is the most promising approach to improving the mortality statistics for breast cancer, and to this end considerable interest has developed in the establishment of screening programs for early detection of breast cancer in asymptomatic women. To utilize x-ray examinations as the screening technique for the 38,000,000 women in the United States over 40 years of age would require 1900 full-time screening centers staffed by 3800 radiologists and 11,400 technologists and supporting personnel, at a cost of \$621,300,000 per year.²

A less expensive screening technique to identify a smaller population of high risk women for x-ray examination could reduce these resource requirements to a more practical level. This technique may well be thermography. To determine the feasibility of the screening approach, the American Cancer Society and the National Cancer Institute currently are funding 20 breast cancer detection demonstration projects which will compare the accuracy of x-ray, palpation, and thermographic

techniques for detection of breast cancer. Hopefully, these projects will confirm the usefulness of thermography as a screening method for identification of a small proportion of asymptomatic women who are at greater risk for breast cancer.

Confirmation of this expectation will immediately raise questions of interest to engineers and physicists involved in medical instrumentation. Currently, thermographic images are displayed on a cathode ray tube and photographed in a conventional manner, often with Polaroid film. These images then are evaluated by visual comparison of the thermal pattern from the two breasts. This comparison should be amenable to automatic pattern recognition techniques which could increase the speed and reduce the resources required for thermographic screening. These savings should easily compensate the additional hardware costs for electronic storage and computer analysis of thermographic information required for automatic pattern recognition.

Physicists and engineers involved in medical instrumentation should follow the breast cancer demonstration projects with considerable interest.

1. R. N. Lawson: Thermography: new tool in investigation of breast lesions. *Canad. Serv. Med. J.*, 13: 517-524, 1957.
2. A. H. Dowdy, W. F. Barker, C. D. Lagasse, L. Sperling, L. J. Zeldis, and W. P. Longmire, Mammography as a screening method for the examination of large populations, *Cancer*, 28, 1558-1562, 1971.

William R. Hendee
University of Colorado Medical Center
Denver, Colorado 80220



RADIOMETRY & PHOTOMETRY

IRVING J. SPIRO

More on Nomenclature

At the end of the last column, I mentioned the proposals by Fred Nicodemus, Jon Geist, and Edward F. Zalewski of NBS* and asked for the reader's comments.

This column takes the form of a letter from Nicodemus, in which he amplifies some of his thoughts on "pointance" and "areance."

From: Fred E. Nicodemus, NWC
(Code 5143)

*By the time you read this Nicodemus will have left NWS and taken his new position at the National Bureau of Standards where he will supervise the publication of a book on "Optical Radiation Measurements."

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To: I. J. Spiro, Aerospace
 Subject: Proposed new terms—"pointance" and "areance"—for use with "sterance" in the proposed "phluometry" nomenclature for radiometry (incl. photometry).

"The more I learn about the nomenclature business, the more I'm convinced that it's poor strategy ever to start right in to "sell" any real innovation. It's practically useless to try directly to get it accepted, however logical and timely it may appear to you and to others who have been concerned with nomenclature and nomenclature problems. Furthermore, I think it's very important not to get tagged with the label of reformer or missionary, zealously trying to promote innovations. This just "turns people off." This has made me particularly cautious in connection with the *Wiley Reference Book on Radiometric Nomenclature*, which is my first priority at the moment. In the book, I'm trying primarily to report facts concerning the very confused situation that actually exists and secondarily to point the way toward reduction of that confusion, as much as possible in terms of already-existing and reasonably well established nomenclature. I have considered Jones' "phluometry" nomenclature as meeting that criterion, though perhaps a bit marginally, and so have gone ahead to advocate its adoption, mainly by adopting and using it myself as the common "language" in terms of which I define and discuss the other nomenclature in the book draft.

"Unfortunately, the "phluometry" scheme as Jones proposed it has two very definite weaknesses: (1) it retains the clearly defined*, but widely and badly misused, term "intensity" for the quantity of flux-per-unit-solid-angle (the directional distribution of any flux that obeys geometrical optics); and (2) it includes the completely new, coined term "incidence" for the quantity of flux-per-unit-area (the positional or areal distribution of flux) which, unfortunately, is very frequently "corrected" to "incidence" by a secretary, typesetter, or proof reader who can't find it in any dictionary. Dr. Jones and Prof. Jurgen Meyer-Arendt have devoted quite a bit of time and effort to searching for better alternatives for these two terms, particularly for "intensity," but so far without success. One of their strong criteria is that, to facilitate direct translation into other languages, a term should have Greek or Latin roots, preferably Greek. In addition, it should

*At least clearly distinguished from exitance or incidence and from sterance, although there are basic questions (see next paragraph) about the definition of "intensity."

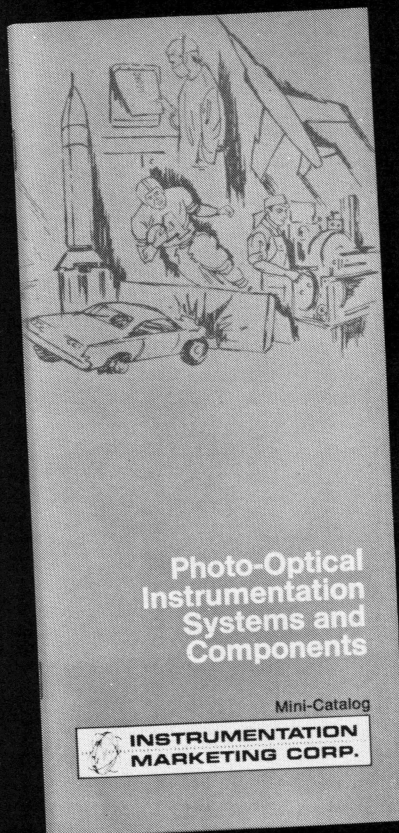
be terse, preferably with easily recognized connotation or meaning relevant to the technical application, etc.

"Recently, I was discussing some basic problems of defining "intensity" with Ed Zalewski of NBS. He and Jon Geist have been much concerned there with inadequacies in the basic CIE definition in relation to its realization in useful physical standards of adequate accuracy. In the course of that discussion, he remarked that they had several alternative terms to suggest: "inverse-square constant," "inverse-square invariant," and "pointance." The first two, while certainly clear as to meaning, are probably too long and cumbersome to achieve wide acceptance. However, "pointance," which I later learned was first proposed by Jon Geist, caught my attention as an excellent choice—terse, with a clear connotation of the desired meaning, and a purely geometrical one appropriate for the "phluometry" approach, so that it would pair well with "sterance." It also has a Latin root.

"Later, it also occurred to me that the term "areance"* could similarly be coined to serve for the quantity of flux-per-unit-area (positional distribution of flux), for which there is now only the awkward phrase "surface density of radiation flux" or "surface density of flux," for the general concept or quantity, and the terms "incidence" and "exitance" for the incident and exitent flux-per-unit-area, respectively. My thought is to use "incident areance" for "incidence" and "exitent areance" for "exitance," thereby eliminating the second problem term "incidence." I have never quite understood why it's important to have separate terms for the incident and exitent quantities in this case. There's never been a similar set for the more basic "sterance" quantities of "radiance," "luminance," etc., i.e., for the flux-per-unit-projected-area-and-solid-angle or flux-per-unit-throughput (the simultaneous distribution of flux in area and direction; the throughput distribution of flux). No one seems to have a problem with "incident sterance" (incident radiance, incident luminance, etc.) and "exitent sterance" (exitent radiance, exitent luminance, etc.). Furthermore, these could all be shortened, in accordance with my suggestion for combining single syllables rather than multiple words Appl. Optics, Vol. 12, No. 4 April 1973, pp. 904-5, as follows: "in-areance" and "in-sterance" for the

*In a telephone conversation on 18 June 1974, Nicodemus disclosed to me that he had just learned that Prof. Jurgen Meyer-Arendt had proposed the term "areance" over a year ago in a communication to Dr. R. C. Jones. Thus if the term is adopted, credit should go to Prof. Meyer-Arendt and not Nicodemus who proposed the same term independently, but a year later.

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by M. FRANÇON

translated by GRACE MARMOR SPRUCH

This monograph presents the fundamentals and important applications of holography in concise, clear, and elegant form. The first part of the book reviews—in a descriptive manner—the necessary fundamentals of optics, with emphasis on spatial and temporal coherence and the principles and applications of holography. The second part presents an elegant mathematical treatment of holo-

graphic theory, using the Fourier transform. Chapter three again considers the principal phenomena, using interference and diffraction theory, and concludes with descriptions of several types of image storage. The fourth chapter is devoted to holography by computer, and the final one discusses optical filtering and pattern recognition.

1974, 160 pp., \$11.00/£5.30

ADVANCES IN QUANTUM ELECTRONICS, Volume 2

edited by D. W. GOODWIN

CONTENTS: E. R. PIKE and E. JAKEMAN: Photon Statistics and Photo-Correlation Spectroscopy. M. R. BROWN, A. F. J. COX, W. A. SHAND and J. M. WILLIAMS: The Spectroscopy of Rare Earth

Doped Chalcogenides. R. C. GREENHOW and A. J. SCHMIDT: Picosecond Light Pulses.

1974, 308 pp., \$21.00/£7.50

FLOW VISUALIZATION

by WOLFGANG MERZKIRCH

This book covers virtually every widely used technique for visualizing flows in experimental fluid mechanics, aerodynamics, chemical engineering, and heat transfer studies. The methods discussed are: optical techniques for compressible flows, marking flow fields by heat and energy addition, and adding foreign particles into gaseous and

liquid fluid flows. The book emphasizes the physical principles underlying each method, and uses flow pictures to illustrate the various techniques. It also includes an extensive bibliography for those interested in the details of technical performance.

1974, 266 pp., \$26.00/£12.50

LASER LIGHT SCATTERING

by B. CHU

This book, intended to serve as an introduction to the interdisciplinary area of laser light scattering, concentrates almost exclusively upon quasi-elastic laser scattering techniques. The book begins with a review of classical electricity and magnetism, along with the general scattering

theory, and then continues with such topics as the basic theoretical concepts related to light-mixing spectroscopy, photon-counting fluctuations, Fabry-Perot interferometry, experimental methods, and many others.

1974, about 300 pp., in preparation

HOLOGRAPHIC NONDESTRUCTIVE TESTING

edited by ROBERT K. ERF

Here, under one cover, is a comprehensive description of holographic nondestructive testing—from the underlying holographic theory to the specific experimental techniques. Topics discussed in detail include: the mathematical basis of continuous-wave, pulsed, and interferometric holography; the practical engineering methods necessary for constructing good holograms; theoretical and practical aspects of the specialized techniques of holographic interferometry, surface contouring, correlation, and vibration analysis; detailed engineering solutions of specific nondestructive testing problems such as the measurement of sur-

face displacement and strain, the detection of cracks, and the inspection of such diverse items as composite materials and structures, cylindrical bores, turbine blades, pneumatic tires and rocket cases; techniques—such as subject motion compensation and synchronized shuttering—to overcome the experimental obstacles of environmental vibration and ambient light often encountered in manufacturing test facilities; and the theory, techniques, and nondestructive testing applications of acoustic and microwave holography.

1974, 462 pp., \$28.00/£14.00

HIGH VOLTAGE ELECTRON MICROSCOPY

Proceedings of the Third International Conference

edited by P. R. SWANN, C. J. HUMPHREYS and M. J. GORINGE

The book forms the full proceedings of the Third International Conference on High Voltage Electron Microscopy held in August 1973 at St. Catherine's College, Oxford, under the auspices of the Royal Microscopical Society. It aims to present a comprehensive treatise on the latest developments and applications of high voltage electron microscopy. Many scientific disciplines are covered, for instance metallurgy, materials science, electron optics, mineralogy, geology, solid state physics,

nuclear materials and biology, and are brought together through their common interest in the techniques of high voltage microscopy. The work includes sections on penetration and contrast theory, instrumentation, image recording, resolution, dynamic experiments, metals and materials applications, radiation damage, environmental cells, biological applications and ultra high voltage electron microscopy.

1973, 488 pp., \$19.75/£7.00



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incident quantities and "ex-areance" and "ex-sterance" for the exitent quantities. I think the meaning will still be quite clear to everyone.

"The introduction of "pointance" and "areance" thus neatly solves the problem of having the two undesirable terms "intensity" and "incidence." It provides us with three well-matched and easily understood purely geometrical terms with no earlier accretions of inconsistent usage—the terms "pointance," "areance," and "sterance." This seems so obvious to me that my first inclination is to jump on the soap box and tell the world that the millenium is here. And I have found a few individuals among those who have wrestled with these nomenclature problems for a time, with whom the idea seem to catch on in much the same way. But, on the other hand, I find there are others "turned off" by these suggestions. They seem to find it impossible or extremely difficult to think in terms other than those that are familiar to them and already a part of their present vocabulary.

"Accordingly, I would like to have the foregoing proposal for "pointance" and "areance" (to go with "sterance") presented to the IRIS Standards Specialty Group as one that I feel merits serious consideration, just to see how others feel about it, but with no indication that I am strongly behind it or pushing it in any way (at least not until and unless some solid support over a fairly wide group has clearly developed). I would, moreover, urge people to try not to form any strong opinions until they have "slept on it" for a while and have given the really new terms a chance to receive a fair comparison with more familiar ones. Perhaps, then, this should be just a preliminary discussion, with a return to the same topic at the next meeting.

"This proposal is not complete, either, without considering the symbols to be used for these quantities. There's no problem with "pointance" for which the same symbol, I, would clearly be adequate. However, the CIE-ANSI scheme of nomenclature, as well as Jones' proposed "phluometry" nomenclature, has no symbol for the general "surface-density-of-flux" quantity that would correspond to "areance." They have only the symbols E for "incidence" ("in-areance" or "incident areance") and M for "exitence" ("ex-areance" or "exitent areance"). One possibility would be simply to use Φ_A ($\equiv d\Phi/dA$); Φ_e, A ($\equiv d\Phi_e/dA$); Φ_v, A ($\equiv d\Phi_v/dA$); etc. for "areance," "radiant areance," "luminous areance," etc. Another possibility would be to use the former symbol W from the old OSA-sponsored ASA Z58.1.1-1953. In either case, the separate symbols E for

"in-areance" and M for "ex-areance" and, for that matter, the term "exitance" for the latter, could also be retained as permissible alternates. I think, however, that "incidence" should be dropped, for the reasons already discussed.

"In much the same way, I'm coming around to the position that there's no harm in keeping "radiance" as a permissible alternate for "radiant sterance" $L_e \equiv d\Phi_e/d\Omega$; "luminance" as a permissible alternate for "luminous sterance" $L_v \equiv d\Phi_v/d\Omega$; and "irradiance" as a permissible alternate for "radiant areance" ("radiant incidence") $E_e \equiv d\Phi_e/dA$. But I would object to retaining "illuminance" or "illumination" as a permissible alternate for "luminous areance" ("luminous incidence") $E_v \equiv d\Phi_v/dA$ when the CIE can come up with such cogent reasons for not using "illumination" at the same time that ANSI gives such good reasons for not using "illuminance." In other words, as long as the new, purely geometrical terms "sterance" and "incidence" or "exitance" (or "areance") are made available, providing a way to speak of the corresponding photon-flux quantities, such as photon sterance L_p , or of the purely geometrical quantity "sterance," common to "radiance," "luminance," and "photo sterance," I see no harm in retaining the older and presently more familiar terms, where they do not introduce ambiguity or perpetuate old problems. In fact, this may help to gain better acceptance for the "phluometry" scheme. It's only in those cases where serious ambiguities or other difficulties are plaguing us that the offending terms and/or symbols should be abandoned completely.

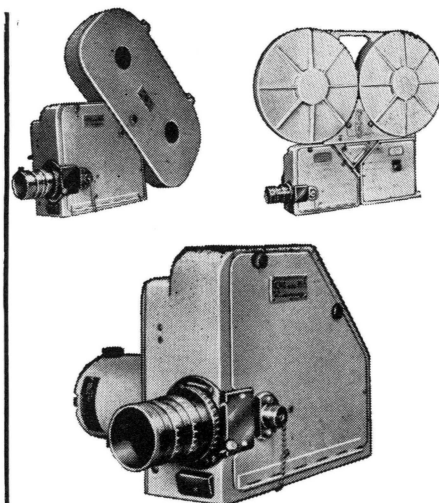
"I transfer to the NBS effective 23 June, . . . I'll remain here for a few days longer, after joining NBS, to get my household goods shipped, and then start driving East (I hope not limited to 55 MPH) to arrive in Gaithersburg, Md., early in July. Editing, revising, and otherwise cleaning up the nomenclature book for actual publication is estimated to take about another year while, at NBS, we'll be getting under way with the exciting three-year project to prepare and publish a Self-Study Manual on Optical Radiation Measurements. An estimated twenty percent of the effort of the entire Optical Radiation Section, under Dr. Henry J. Kostkowski, will be devoted to this project over the three years and it will be my full-time primary responsibility to pull it all together."

Again, I ask all readers to consider the terms "pointance" and "areance" as proposed by Nicodemus above and send us your comments.

Irving J. Spiro

The Aerospace Corporation

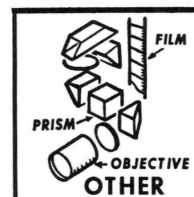
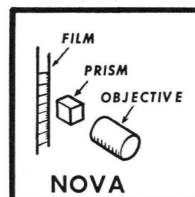
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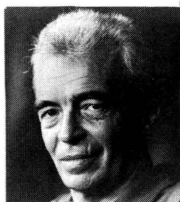
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COLLECTIVE OPTICS

CHAN STREET

Application of Distributed Sources

In our last two columns we discussed collective systems that utilized sources that were small enough to be considered as point sources and it was also assumed that they were isotropic. In the next few issues we will consider the application of distributed sources, such as tungsten filament lamps and the special considerations that must be taken into account for this type of source.

The present design of this type of lamp usually has a set of nested coils so arranged that when viewed perpendicular to the plane of the filaments they are seen as a closely packed set of cylindrical sources, as shown in Fig. 1a.

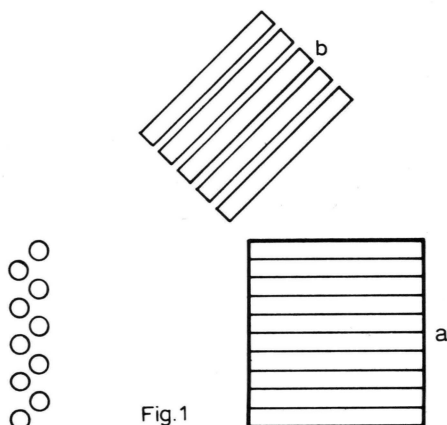


Fig. 1

It should be borne in mind that this type of source does not obey Lambert's Law. As seen in Fig. 1b, that at 45° on a strictly geometric basis, the apparent size of the array has reduced to 0.74 of the on axis width but it also has only half the illuminated area, which brings the effective radiant output to 0.50 of the on axis value. At 60° off axis the width further reduces, but the nested coils are now visible. At this point the effective radiation has increased to 0.588. Of course, the coils are not so ideally spaced in a real lamp and a polar plot would not follow exactly this geometric pattern.

In Fig. 2 is a polar plot of a 750 W CWA lamp with a proximity reflector. The dash line shows a cos function that would result if the lamp obeyed Lambert's Law. As can be seen in the region between 0° and 40° , the plot lies inside the cos function, which can be explained by the back filament coils being gradually masked off as the viewing angle increases. Then as the 45°

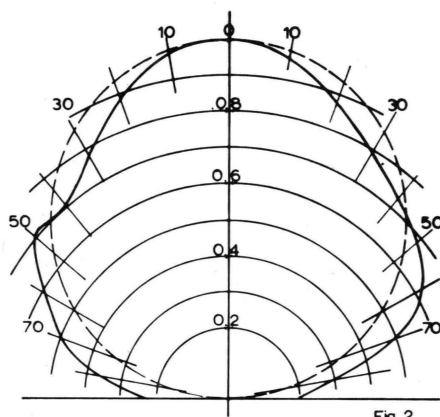


Fig. 2

point is passed, the back coils again become visible and add to the total radiation so the resulting emission between 50° and 90° exceeds the cos function. In Fig. 3 is shown a polar plot of a 1000 W DDB. This lamp contains a fairly carefully nested set of filaments but without a proximity reflector. The effect at the transition point of 45° is much more pronounced than that shown in Fig. 2.

From the data shown in these polar plots, it is quite obvious that the type of lamp used can have a pronounced effect on the intensity distribution at the film plane of a projection system. The more modern design of lamps with proximity reflectors do not deviate so markedly from Lambert's

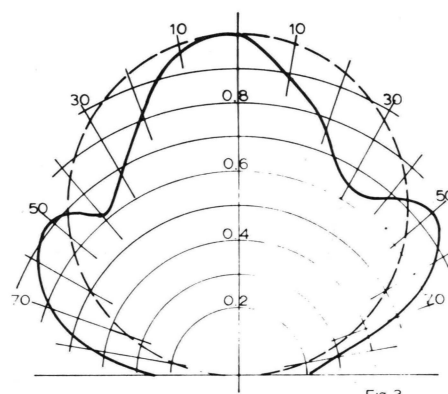



Fig. 3

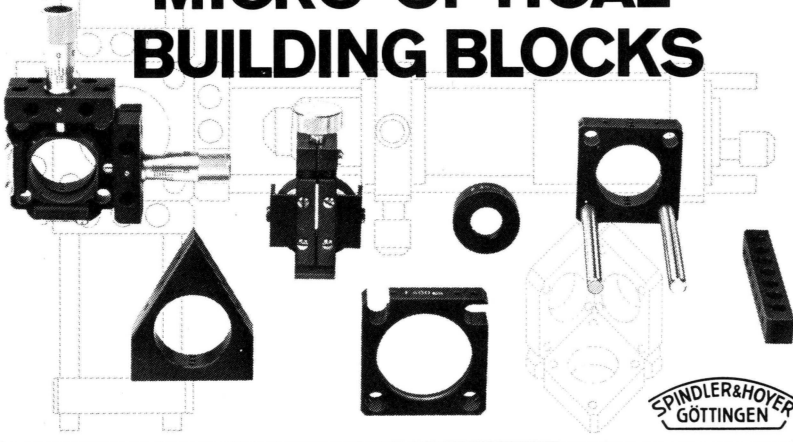
Law that one cannot achieve reasonable control over the field distribution by assuming they are correcting for a cos fall-off. This, of course, is contingent upon the necessity of maintaining the image of the source in the entrance pupil of the projection lens when viewed from all regions of the image field. The problems encountered in achieving this latter situation will be the subject of our next column and represents a markedly different design consideration than when a small source such as a Xe high pressure arc lamp is used as a source.


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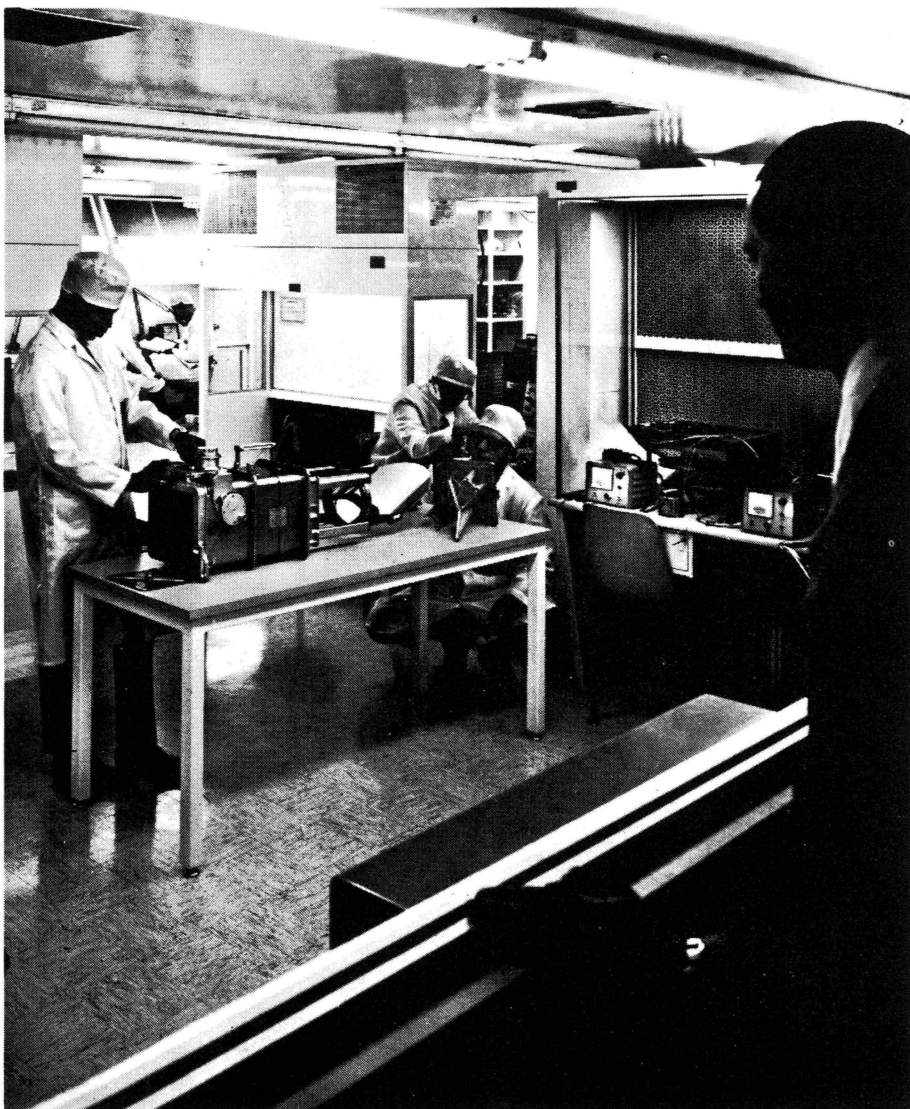
ROBERT D.
LEIGHTY

Topographic Mapping

Recently several excellent articles on optical memories applied to the recording of digital data have appeared in the literature. For example, *Applied Optics*, Vol. 13, #4, published 24 papers pertaining to optical storage of digital data and *Electro-Optical Systems Design*, Vol. 6, #6, featured an article on optical data recording. Suppose, however, that instead of digital data we have interest in storing two-dimensional analog images in optical memories; not two-dimensional information such as the alphanumeric on a typed page but the information in the form of aerial photographs and topographic map sheets. There is a genuine need in the mapping community for simpler, cheaper, and more efficient storage for hundreds of rolls of aerial imagery and thousands of map sheets.

In the remainder of this column I will briefly indicate the nature of the material to be stored and some questions that arise when types of optical stores are discussed. We assume the information density in a high quality 9" by 9" aerial photograph with about 100 l/mm resolution precludes line scan sampling and digital encoding. The photography consists of negative transparencies with densities ranging between 0 and 4.0 and the scenes are of natural and cultural terrain patterns. The map data has a format size of 22" by 29" with line widths of 0.004", topographic symbols, and other annotations all in a binary negative transparency representing color separations of the original map.

Suppose for this discussion we limit optical memories to those having definite potential in the near future, thus excluding volume holographic memories. Presumably we are now left with a possible technique involving either microimages or microholograms in the form of one or two-dimensional arrays. Further we consider only archival needs so that access time and reusable materials are excluded. The remaining considerations involve storage density and the geometric and tonal fidelity of the reconstructed image. The reconstructed aerial photograph can have a low level of known systematic geometric and tonal distortions but only a very low level of random distortions to be acceptable, whereas the reconstructed map color separations must have geometric precision within 0.004" and



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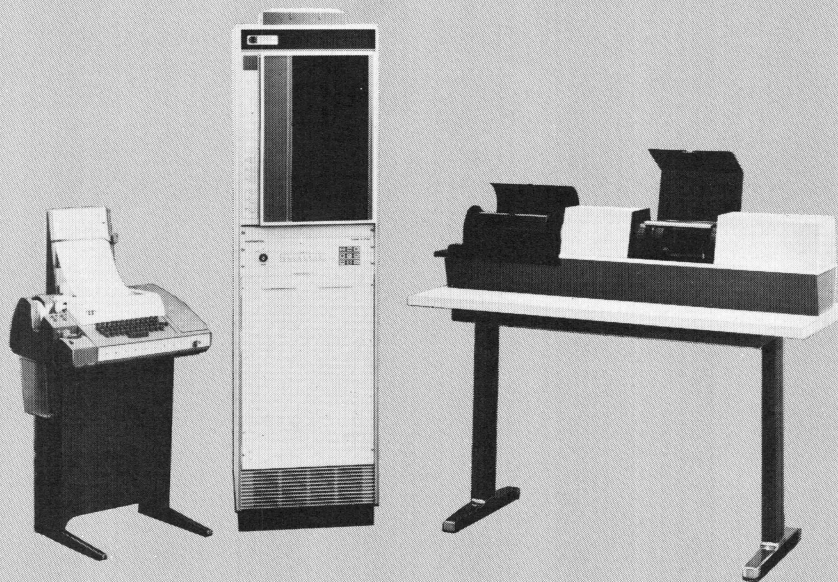
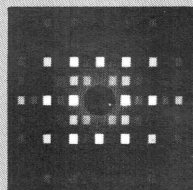
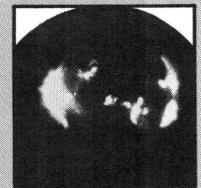
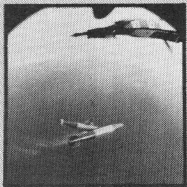
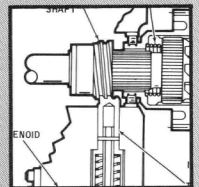
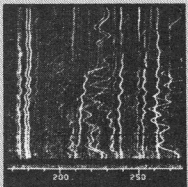
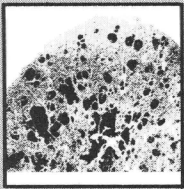
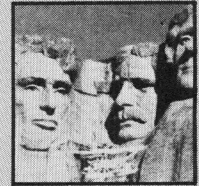
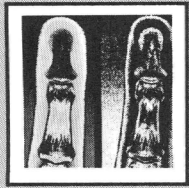
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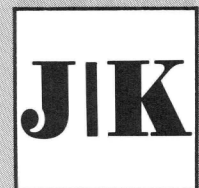
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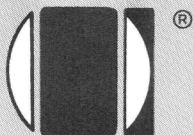
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An article by E. G. Ramberg entitled: "Holographic Information Storage" published in *RCA Review*, Vol. 33, March 1972 indicates the surface necessary for recording by a plane hologram is approximately eight times as that for direct photographic recording. This is a disadvantage only if certainty of full recovery of stored information is not necessary. The redundancy, which is simply achieved holographically, can be very important for information reduction due to noise from dust or scratches. Though there is the potential capability of recording the Bible on the head of a pin, commercially available ultra-high resolution photographic films can record only about 3000 l/mm. This might indicate a potential reduction of 30X but we must ask at least about the dynamic range and linearity of the emulsion for aerial photography storage. A distinct advantage of the direct recording technique allows use of incoherent light but there are potential problems in mechanical focusing tolerances and the need for high-quality lenses for reduction and enlargement to preserve flatness of field.

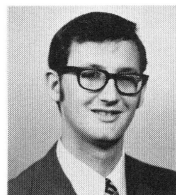
As for the holographic approach Ramberg suggests an out-of-focus lensless Fourier transform hologram with the object illumination modified by the introduction of a finely structured two-dimensional phase grating or aperture plates. Presumably "finely structured" refers to the sampling frequency required to preserve information. To minimize distortions in the holographic approach all geometries for recording must be duplicated to a high accuracy in the reconstruction. Ramberg mentions that intermodulation noise due to scattering could possibly cause image resolution losses for low contrast images. We must also ask about such things as liquid gates, microflat plates, all reflecting, transmitting and recording surfaces.

Emulsion shrinkage is a problem for both the holographic and direct record approaches, as is the processing problems involved with many micro-images or microholograms with a wide range of exposures on a single plate. Additionally, it does not seem practical to encode a large map sheet by either approach without an intermediate recording step and this at least doubles some problems while solving others.

This short column proposes no simple criteria for selection of the technique for optical storage of mapping community data, but hopefully points to the need for study at the level

presently afforded the optical storage of digital data.

Robert D. Leighty
Supervisory Research Engineer
Research Institute
U.S. Army Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060



INFRARED

R. BARRY JOHNSON

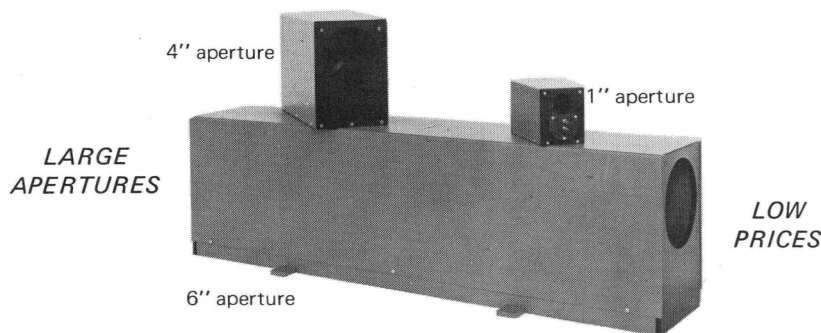
Mr. James Wood of the Night Vision Laboratory will discuss the parameters and measurement techniques used at NVL to characterize thermal imaging systems.

R. Barry Johnson, Principal Engineer
Teledyne Brown Engineering
Cummings Research Park
Huntsville, Alabama 35807
and
Lecturer in Modern Technology
University of Alabama in Huntsville
Huntsville, Alabama 35807

Laboratory Bench Analysis of Thermal Imaging Systems

The design, development, and deployment of thermal imaging systems has been accelerated in recent years in order to exploit the real-world target and background sterance differences in the 3-5 μm and 8-12 μm regions of the electromagnetic spectrum. This emphasis on the procurement of these systems in various stages of development has required a concerted effort on the part of project engineers to write meaningful procurement specifications. Central to these performance specifications is the set of parameters associated with them. Ideally, these parameters must satisfy several basic requirements. First, they must be relatable to the real-world system performance. Secondly, they must be laboratory measurable using well-defined procedures. And thirdly, the parameters must be predictable based on fundamental theoretical calculations in order that they be useful to the system designer. Except for the newest of these parameters, the procedures used to measure them are well documented in the literature.¹⁻⁴ This article will act as a summary of the primary parameters and procedures in use at the Visionics Technical Area of the Night Vision Laboratory, where the resulting data from the measurement of

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1. L. M. Biberman (Ed.), "Guide for the Preparation of Specifications for Real-Time Thermal Imaging Systems," Paper P-676, Institute for Defense Analysis, January 1971.
2. J. M. Lloyd et al., "The Optical Transfer Function of Real Time Infrared Imaging Systems," Proceedings of IRIS, 1970.
3. R. L. Sendall and J. M. Lloyd, "Minimum Resolvable Temperature Difference," Proceedings of IRIS, 1969.
4. J. R. Moulton and J. T. Wood, "Two Port Evaluation Techniques Applied to Commercial Imaging Thermographs," Proceedings of the Technical Program, Electro-Optical Systems Design Conference, 1970.
5. John Johnson, "Image Intensifier Symposium," Fort Belvoir, Virginia, October 6-7, 1958.

James T. Wood
 Visionics Technical Area
 Night Vision Laboratory
 Fort Belvoir, Virginia 22060



INNOVATION
 & DISCOVERY

ROBERT E. LEWIS
 PHILIP E.
 CHANDLER

Blind, Legally

Somewhere at the other end of the line, you may end up with partial vision or may be designated "legally blind." What an irony that would be if, after a notable career in the realm of the SPIE, all the optics, image processing, and good engineering left you with no way to see effectively (even though your retinas functioned well, in a restricted sense). We do not refer to total blindness.

Several of the engineering disciplines have been able to stake out special positions—almost with "patron saint" status—in the assisting of people with handicaps or disabilities. From electronic engineering have come hearing aids for the partially deaf; from mechanical engineering, prosthetic limbs for the crippled; other examples could be cited. There is one kind of disabled person whom the SPIE expertise should be uniquely capable of helping: the "legally blind." These are persons whose retinas are at least marginally functional but who have problems such as near opacity or forward scatter within the eyes—simple lenses do not help them enough, although they are not totally blind.

We propose a rewarding and satisfying activity, perhaps done best only by the SPIE type of person: a spare-time, hobby, or even professional familiarization with what is done in your neighborhood to solve and remove, prevent or diminish, the problems of poor vision. Perhaps you may succeed in enlisting the local section of your

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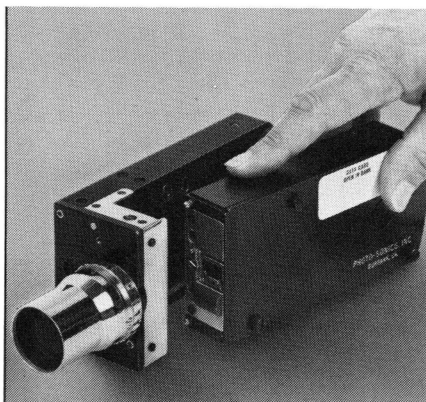
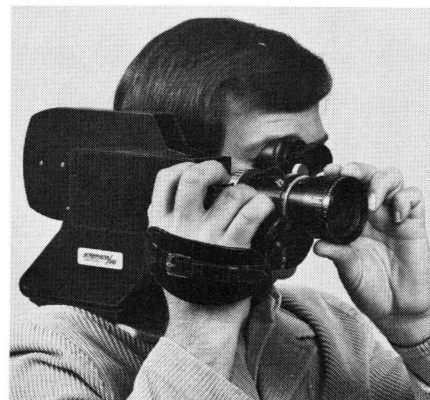


Photo-Sonics 16mm-1VN

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society in a survey or inventory covering, within defined geographic boundaries and known population counts, ophthalmologists, eye surgeons, etc.; oculists; optometrists, opticians; illumination engineers; optical and photographic engineers; self-help and blind aid societies; prescription eyewear dispensers and capabilities; types of vision-test equipment; visibility and photometric equipment; optical shops and capabilities; libraries carrying large-print editions, talking books; driver's license testing and limitations; research activities; insurance safety inspection personnel; stores selling reading aids; access to variable magnification microfilm, microfiche readers.

We would like to urge that the effective use of these things be worked out. For example, near here one community has large-print material in the local libraries and a small-print talking-book index. An adjoining city has these hand carried by friendly visitors to aged and infirm persons who cannot navigate to a library branch. One of us (Lewis) is conducting a desultory survey on his own; in several years' time, no administrators of vision tests were found who had made or heard of flux density level readings at the charts.

Hand magnifiers ("Sherlock Holmes") are the only reading aids cited (with or without auxiliary light) when the open question is asked as to what is available. Opaque projection magnifiers and near-focus binoculars have not been listed upon inquiry. We know of one "legally blind" man who drove his auto regularly without accident. He once spent most of his available savings to make an opaque projector in desk form so that he would be able to read the correspondence necessary to his business.

Is it possible that more effective use of available equipment, skills, and knowledge can be achieved simply by making them known? Or is it the case that there is a gap in the less-dramatic assistance to those who see, but not without real problems? Perhaps new things are needed—what better field for innovation?

Robert E. Lewis
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Palo Alto, California 94303
and
Philip E. Chandler
135 Creek Trail
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OPTICAL SYSTEMS MANUFACTURING TECHNOLOGY

JOSEPH B.
HOUSTON, JR.

The Point-Diffraction Interferometer

The Point-Diffraction Interferometer (PDI) was introduced to the Optical Society of America by Raymond N. Smartt during the Society's Spring meeting in New York City, on April 13, 1972.¹ Since that time, the PDI has been used successfully to test both military optical systems and astronomical telescopes *in situ*, under a wide variety of atmospheric conditions.

The PDI is a simple two-beam interferometer with the reference beam formed at the image of the wavefront to be analyzed. This is achieved by spatially-filtering the image. Smartt's procedure is to take a transparent substrate such as mica, specially cleaved, and coat it with an absorbing film. In this film he locates a pinhole which can be positioned accurately in the image plane of the optical system being evaluated.

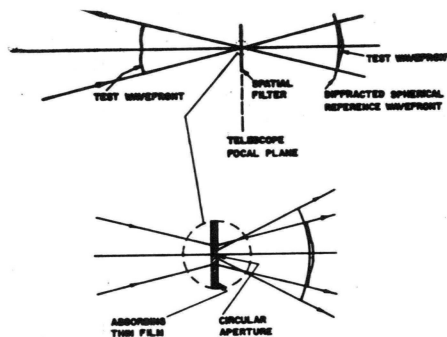


Fig. 1. Optical schematic of the Point-Diffraction Interferometer.

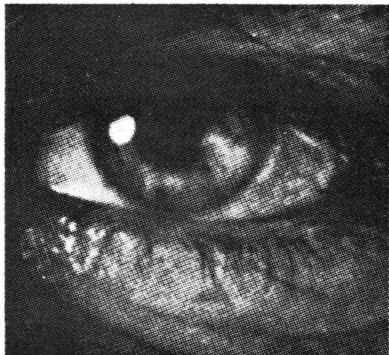
"Referring to Fig. 1,² the direct beam is attenuated by the absorbing film. For typical tests, the diameter of the aperture should be smaller, ideally, than the central diffraction disk of the image. Note that as the aperture is moved away from a centered position on the image, the diffracted amplitude decreases. The interferometer therefore has the property that the fringe visibility varies with the interferometer setting."

Early tests of astronomical telescopes used stellar sources near zenith where seeing is generally best. However,

¹R. N. Smartt and J. Strong, *J. Opt. Soc. Am.* 62, 737 (May 1972).

²R. N. Smartt, "Telescope Test Using the Point-Diffraction Interferometer," private communication July 1974.

LOOKING?



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EDUCATION IN OPTICS

D. J. LOVELL

Peripheral Optical Engineers

The recent resurgence of interest in optics has resulted in a number of engineers with little or no training in optics suddenly being involved in the development of optical instrumentation. Perhaps the engineer was trained in electronics and is now involved in the design of telemetry equipment to be used in sending information from an orbiting telescope to earth. Or perhaps he is a mechanical engineer employed to design the frame of that instrument. In all such cases, the engineer can better perform his job if he has some knowledge of optics. It seems likely that educational institutions will broaden their curricula to provide more courses in optics. How should such courses be structured?

Probably the optics education best suited for those who will be involved in what I term the periphery of optics is not the same as that which serves those who will devote their attention to optics, per se. The latter will probably best be trained in fundamentals such as Maxwell's equations and the difference between the Huygens-Fresnel and Kirchhoff's diffraction theories. The engineer dealing with the peripheral aspects of optics will certainly need to know the effects diffraction produces on an image, but it is unlikely that he will have either the time or the inclination to approach his study of optics by reading such a text as that written by Born and Wolf.

In a previous column, I described some experiments suggested to me as being both informative and stimulating. Such experiments are of particular value to the "peripheral optical engineers." Some years ago I was involved in the development of a telescope to be used as a star tracker. It utilized several slender PbS detectors placed in juxtaposition such that the width of each subtended ten seconds of arc. The engineer who designed the mechanical components used a 6-32 screw to move the telescope in azimuth. Since we experimented with this on a tower overlooking the Atlantic Ocean on cold New England nights, we found it vexatious that a very slight turn of this adjustment moved a star image completely out of the field of view. The situation was rectified only after we had the engineer join us on a cold evening. Such an experiment is most informative, although it need not be done from a

tower on a cold New England night.

The education for the engineer being discussed here should be thoroughly practical. Nearly every electrical engineer is familiar with the frequency response of hi-fi sets. Consequently, the concept of MTF should be readily apparent to him. Accordingly, one can expect that he will then be ready to intelligently apply this concept to the evaluation of optical systems. In a like manner, an electrical engineer should easily grasp many of the concepts of laser action, and be ready to apply this knowledge to instrument development.

As optical systems become more sophisticated, we are increasingly dependent upon engineers trained in cryogenics, those with a knowledge of exotic materials, those versed in vacuum technology, and many others. They can contribute most if they are familiar with optical concepts. Some of this knowledge can be gained in special summer courses, which are generally quite good. But it seems likely that courses in optics for engineers will become more prevalent in undergraduate curricula. I would like your opinion.

*D. J. Lovell
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