Your Editor Has A New Home

Unlike the distinguished editor of another fine optics journal whose new home is really quite old, I have a home so new that (at this writing) it is unheated, unfurnished, uncomfortable, and unsuited for editing. By the time this is published all that will have changed.

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Tricks of the Trade

AN AUTOMATED METHOD FOR THE MANUFACTURE OF OPTICAL CORRECTION PLATES

Michael Hercher
Optra, Inc.
1727 Revere Beach Parkway
Everett, Massachusetts 02149

THE PROBLEM

Due to the unavoidable passage of an optical beam through a less-than-perfect optical component (e.g., prism, laser rod, crystal, window, etc.), an optical beam which should be diffraction limited in collimation is not. Instead, it has 10 to 100 waves of reproducible, spatially irregular distortion. The problem is to compensate for this distortion in an economical manner as possible.

A SOLUTION

The usual approach to this type of problem would be to make a compensating plate which was hand-figured by a skilled optical technician; after passage through this compensating plate, the distorted wave front would, because of the equal and oppo-

e site distortion introduced by the compensating plate, emerge undistorted and apparently pristine.

The problem with this approach is that, because of the skill and hand labor required, it is expensive. If—as is often the case—the distorted wave front is not available to the optical technician in the form of the less-than-perfect optical component, then he or she must work from an interferogram of the distorted wave front. This makes the task even more difficult, and further increases the time and labor required.

We have defined an approach to this problem which takes advantage of existing automated equipment to make a correction plate. The approach is particularly well suited for the situation where many correction plates are required, so that the one-time setup expenses can be more easily justified.

Stated briefly, the idea is to scale up the distortion to a macroscopic scale (i.e., mm versus wavelengths) so that a numerically controlled milling machine can generate the required correction-plate contour, and to then scale it back down to the required microscopic scale. The key to the method lies in the use of a fluid which nearly matches the refractive index of the contoured macroscopic correction plate. A bonus of this approach is the fact that the correction plate itself does not require polishing—it needs only to be fairly finely ground, which can usually be accomplished directly by the numerically controlled milling machine.

Consider a distorted wave front such as that represented by the interferogram in Fig. 1. Let us assume for the purposes of illustration that the maximum peak-to-peak wave-front distortion is 100 wavelengths at 5000 A, or 5 x 10^-3 cm. Thus a conventional, optically polished correction plate made of glass with a refractive index of 1.5 would have a maximum variation in thickness of \( \Delta d = 10^{-2} \) cm (so that \((n-1)\Delta d = 5 \times 10^{-5} \) cm).

Now consider an immersed correction plate, such as that shown in Fig. 2. The correction plate itself still has a refractive index of \( n = 1.5 \), but it is now immersed in a fluid with a refractive index \( n' = n - \Delta n \).

In this case, the maximum variation in thickness of the correction plate \( \Delta d \) would be defined by the equation

\[
\Delta d \Delta n = 5 \times 10^{-7} \text{ cm}.
\]

In effect, the use of the immersion fluid has allowed us to scale up the figure of the correction plate by a factor equal to \((n-1)/\Delta n\). If this factor was equal to 50 (i.e., \( \Delta n = 0.01 \)), then the maximum varia-
tion in thickness of the immersed correction plate would be 2.5 mm.

In practice, the first step in this technique is to digitize the interferogram of the offending wave front. This is readily accomplished using the type of digitizing tablet which is a standard accessory for a minicomputer. It is, of course, also necessary to know which are the highs and lows in the interferogram. Once the wave-front distortion information is digitized, it has to be converted to a set of instructions for a numerically controlled optical milling machine—with the appropriate scaling factor as discussed above. It is tedious to generate the software necessary to achieve this conversion (digitized interferogram to numerical instructions for the milling machine), but once done, it never needs to be done again (at least in principle).

I have tested this technique using a finely ground spherical glass surface with various immersion fluids to make weak lenses of varying focal lengths. At a scale factor of 50, there was no detectable scattering from the immersed surface, and the transmitted wave fronts were very clean and spherical to better than a quarter-wave.

Fig. 1. Interferogram of typical distorted wave front suitable for correction by the technique described herein.

Fig. 2. Immersion-type correction plate.

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ICO MEETING REPORT

S. K. Case
University of Minnesota
Sam Horvitz
Naval Underwater Systems Center
Cardinal Warde
Massachusetts Institute of Technology
R. N. Wilson
European Southern Observatory

The Twelfth Congress of the International Commission for Optics (ICO) was held in Graz, Austria during August 31 through September 5, 1981.

The topic "Astronomical and Space Optics" formally represented about one third of the material of the conference, the other topics being "Unconventional Image Formation and Optical Information Processing" and "Optical Materials." Naturally, there was some overlap, and a number of papers in the other two sections were also of considerable interest to the community specifically interested in astronomical and space optics.

Invited papers were quite long (30–40 minutes), and it was a particular achievement of the organizers to have made these papers available at the start of the conference in written form as a book (published by Taylor and Francis Ltd., London, 1981) under the title Current Trends in Optics, edited by F. T. Arecchi and F. R. Aussenegg. In the astronomical optics or related fields,
the following invited papers appear in this volume: Labeyrie and Weigelt on "Interferometric Methods in Astronomy" (verbal presentation only by Weigelt), Fienup on "Image Reconstruction from Stellar Interferometry," Meinel and Meinel on "Prospects of Solar Energy" and "Options for Next Generation Telescopes," partial verbal presentation by Anel in the context of a more general talk—see below), Hu Ningsheng on "An Overview of Astronomical Optics in China," Longair (replacing O'Dell) on "The Space Telescope" (verbal presentation only, but may be submitted to Optical Acta or elsewhere), Lemaître on "Optical Manufacturing with Elastic Deformation Methods," and Angel on "Next Generation Telescopes" (verbal presentation only and replacing Meinel).

Most of the fields of current interest in astronomy were, therefore, well covered in these excellent papers. Oral contributed papers were short (10 minutes plus discussion) and were divided up into five sessions, each of six papers, with the following broad titles: "Telescopes and Optical Instruments (2 sessions), "Adaptive Optics and Telescopes," "Image Processing in Astronomy," and "Image Formation With Nonvisible Radiation." These titles seemed to reflect quite well the areas and intensity of activity, and the general level was high. The steadily growing importance of speckle methods in interferometry, adaptive (active) optics, and the nonvisible field of optics was well demonstrated, both here and in the Poster Session to which one afternoon was devoted, with 20 presentations. This poster session was most stimulating and successful, many presentations being excellent in both style and content. Such poster sessions seem to assume an increasing role in conferences—they offer many advantages in a relaxed style.

A special issue of Optica Acta (January 1982) will be devoted to the publication of about 40 of the more than 200 contributions and will be selected by the journal's own refereeing system. Other (or longer) contributions may be published later in the same journal, or elsewhere. Some may nevertheless regret that the whole proceedings are not published in a single conference volume, as is becoming more and more the normal style.

INFORMATION PROCESSING

In the area of information processing, four invited papers sampled the broad spectrum of this important field. A paper by G. Tricoles and N. H. Farhat entitled "Unconventional Imaging" reviewed and summarized the methods and applications of imaging with electromagnetic waves. The emphasis of this paper was on the experimental, but the authors did point to the theoretical efforts that make use of physical optics approximations and the more rigorous inverse scattering theories. The authors stressed the fact that significant diffraction in experiments at these wavelengths has influenced the properties of the contributions and will be selected by the journal's own refereeing system. Other (or longer) contributions may be published later in the same journal, or elsewhere. Some may nevertheless regret that the whole proceedings are not published in a single conference volume, as is becoming more and more the normal style.

Among the methods reviewed in this paper were microwave holography, hologram matrix radar technique, Steenberg's microwave imaging radio camera, frequency swept holography, adaptive arrays, and over-the-horizon radar. Applications discussed included radio wave propagation in the ionosphere and the troposphere, imaging of objects, detection of dielectric inhomogeneities, and antenna and radome diagnostics.

The paper by J. R. Fienup on "Image Reconstruction for Stellar Interferometry" described an iterative algorithm that has successfully been used to reconstruct an object from its Fourier modulus using the fact that the object's brightness spatial distribution is nonnegative.

In this algorithm, the iterations are usually started with an array of random numbers as the initial estimate of the object; the algorithm then successively Fourier transforms back and forth between the space domain and the spatial frequency domain, modifies the estimate according to the known information in each domain. In the frequency domain, the computed Fourier modulus is replaced by the measured Fourier modulus, and the computed phase is unaltered. In the space domain, the object is forced to satisfy the nonnegativity constraint.

The author claimed that the iterative algorithm converges fast enough to make it practical to reconstruct images of complicated two-dimensional objects, and its solution has been found to be usually unique for the two-dimensional case. A computer program was obtained, and its convergence was also described. The author further claimed that the reconstruction method is not overly sensitive to noise and may, therefore, be practical for reconstructing images from real-world telescope data.

Y. Ichikawa in an invited paper entitled "Interactive Image Processing for Image Restoration and Enhancement" described an iterative method for man-machine interactive image processing using a minicomputer-based digital image processing system. The author pointed out that, in practice, the type of degradation and the exact features of the point spread function due to the imaging system are hardly known, and, therefore, to realize restoration of a blurred image without knowledge of the blur, a man-machine interactive technique is usually applicable. In this man-in-the-loop scheme, the human observer judges the processed image on a refreshed CRT monitor in the digital image processing system, selects a better processing function, and feeds it back to the computer. This process is repeated until a satisfactory restored image is obtained.

The author showed and illustrated that the iterative methods used for solving simultaneous linear equations are well suited for image restoration by the man-machine interactive processing method. These methods (i) require very little memory capacity and very short computation time, (ii) allow the operator to interact with the system since the images are processed in the space domain, and (iii) always converge with the aid of simple modification.

In the area of image enhancement, the author described a simple method for designing digital filters for smoothing and differentiation, and contrast enhancement, as well as an optical/digital hybrid processing scheme for image enhancement. In the hybrid processing scheme, the imaging lens attached to the TV camera that forms the input to the system. The human observer plays the role of an optical processor to perform two-dimensional convolution. The author claimed that this hybrid system has advantages in the use of total processing time, ease of data handling, and cost.

"Optical Matched Filtering in Noncoherent Illumination" was the title of the paper presented by N. George and G. M. Morris. This paper described an idealized matched filter system which consists of the following sequence of optical elements: a wavelength-independent Fourier transform optical system, a frequency-plane filter, an imaging system, a compensating grating, and another wavelength-independent Fourier transform system. Using the diffraction theory, the authors showed that the amplitude impulse response of this system does not vary with wavelength, making the system ideally suited for use with broadband, spatially incoherent sources.

The achromatic Fourier transform optical system is central to the idealized matched filter. To realize the achromatic Fourier transform, the authors proposed a configuration consisting of three dispersive lenses, and used a chain-matrix geometric optics development to analyze the configuration.

They concluded that a wide-band Fourier transform configuration can be realized using a separated, three-element design, in which each grouping consists of a lens and a holographic zone-plate cascade.

MATERIALS AND COMPONENTS

Invited papers described optical figuring of aspheric (G. LeMaire), experiments with BSO crystals (J. P. Huignard), high-speed holographic recording media (M. P. Petrov), and phase conjugation components (A. Yariv).

Real-Time and Active Optical Elements. Contributions in this area described spatial light modulators (L. N. Kompanets, et al.) and (C. Warde), BSO crystals (H. J. Tiziani), liquid crystal devices (R. A. Athale and S. H. Lee) and (P. Soltan), and acousto-optic modulators (M. Barabas, et al.). Several papers describing systems employing television equipment were given by Hauser, Holmman, Gotz, and Jahns. S. Engman and P. Lindblom described a new image dissector tube.

Optical Elements and Systems. A colorful poster showed relay optics for color TV systems (K. Knop). Gradient index optical elements were described by S. Cornbleet. An improved resolution autocollimator (GuQu-Wu) and a new spectrometer (E. J. Farlie) were reported. A compact Fourier processing system was reported by G. Molew, et al., and an achromatic holographic stereogram by S. Benton.

Holographic Optical Elements. A large number of papers in this area described increasing use of these optical elements by K. Case and P. R. Hau- gen detailed the use of multi-facet holograms to produce customized optical elements. Laser beam scanners produced by the multi-facet technique were presented by V. Gerbig. The use of volume gratings for spatial filtering (D. Peri), multi-hologram imaging systems (K. J. Rosenbruch and I. Weingärtner), and holographic optical elements for coherent noise reduction (T. R. Empson and R. W. Smith) were reported. Descriptions of holographic optics used in partially coherent light (D. Courjon, et al.) and of a clever two-grating color separation scheme (H. Dammann) were presented.

Recording Materials. Complementing the holographic optical element papers were presentations describing optical recording materials. Properties of dichromated gelatin were detailed by O. Salmen and T. Keinonen. Thermoplastic development (T. Saito, et al.) and color-center recording (P. Ketolainen and O. Salmen) were described. Uses of photorefractive (L. M. Conors, et al.) and photosensitive crystals (R. Grous son and S. Mallick) were presented.
OPTOELECTRONIC COMPONENTS MARKET IN EUROPE

The West European aggregate demand for optoelectronic devices—including readout devices, sensor devices, solid-state emitters, and photovoltaic solar cells—is expanding at an encouraging rate. From 1980 totals of $388 million, the market is expected to reach some $792 million by 1986 and thus realize an annual growth rate of 12.5% in real terms. If one factors in the demand for fiber optic cables and connectors—two sectors at embryonic stages but poised at the brink of potentially explosive growth—then the market will move to $922 million and grow at a 14.5% real annual rate over the same period. Viewing the present-day marketplace by end users, W. Germany, followed by France and the U.K. account for 70% of total optoelectronic device consumption. Of particular concern to potential European suppliers of these devices—particularly solid-state types—are the impact of imports from the U.S. and Far East. They have been substantial and amount to well over half of total demand in the solid-state segment. In the glass-envelope and emerging fiber optic segments, the European suppliers have done better. Since the optoelectronic device consumption rests on the fate of various end-equipment markets, European (as well as off-shore) device suppliers are carefully tracking such home markets as solid-state calculators, watches and visual display systems, computer peripherals, data links and telecommunications systems, portable and industrial instrumentation and control, home electronics, automobile instrumentation, and energy conservation planning, to name a few.

On the optoelectronic technical front, it would not be unreasonable to expect developments into higher brightness LEDs, extended temperature range and larger-digit LCDs, more rectangular CRTs, further improvements in single and multi-line gas discharge and vacuum fluorescent panels, still more improvements in electroluminescent displays, some isolated inroads on CRTs by CCD arrays, and continued breakthroughs in the fiber optics area. Frost and Sullivan has completed a 346-page analysis of the Optoelectronic Components and Fiber Optic Cable & Connector Markets in W. Europe which: categorizes the market by product grouping and establishes both the historical base and present-day market demand; discusses European national and regional economic and political considerations impacting the marketplace (including imports, exports & tariffs); analyzes, in-depth, the key end-use equipment markets for optoelectronics—including a production forecast for each to 1986; assesses most likely technological trends by product type; profiles major European and off-shore suppliers to the marketplace—their products, sales & strategies; and forecasts optoelectronics demand to 1986 for 15 products within seven European countries or regions, with separate forecasts for fiber optic cables and connectors.

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FORUM
continued from Pg. SR-066

ACTIONS TAKEN BY ICO
The following actions were taken by the ICO:
(1) Established a committee to aid developing nations with financial and material assistance from
SPIE-The International Society for Optical Engineering.
Dr. A. Tescher, President, SPIE
Dr. W. H. Steel, Australia
Dr. A. Handejo, Randung Institute of
Technology, Indonesia
Prof. Dr. H. Frankena, Secretary General of
ICO Delft, Netherlands
(2) Established a commission for liaison with ISO
(International Standards Organization).
Dr. W. H. Steel, Australia
Dr. K. Rosenbrach, Federal Institute for
Applied Physics at Braunschweig FRG
Plus one vacancy to be filled by the U.S.
Committee
(3) Election of the following officers:
Prof. J. Tsujiuchi (President)
Prof. A. W. Lohmann (Past President)
Prof. H. J. Frankena (Secretary General)
Dr. N. Howard (Vice President & Treasurer)
V. P.'s:
Prof. F. T. Arecchi
Prof. K. Biedermann
Prof. S. Lowenthal
Prof. T. Skalinski
Dr. P. Varga
Plans were initiated for a joint IOCC-83/ ICO
meeting in April 1983 and ICO XIII, August 1984
at Sapporo, Japan with a satellite meeting to be
chaired in New Zealand by Prof. R. H. T. Bates.
Editor's Note: See the SPIE Reports Book Review
section of this issue for a review of Current Trends
in Optics (Eds., F. T. Arecchi and F. R. Ausser-
egg), which contains printed versions of 17
invited papers presented at the 12th Congress
of the International Commission for Optics.

IMPRESSIONS OF THE ADVANCED
INFRARED SENSORS CONFERENCE
In October 1981, I attended a conference on
Advanced Infrared Sensors at the IEEE Headquarters
on Savoy Place in London. I was immediately
impressed by the facility, a large three story build-
ing overlooking the Thames with the institution's
name in large letters over the entrances. There is
a large lobby, a separate room for sign-in, two large
"reception" rooms where tea and coffee were served,
two large "display" rooms, and the theater-style
conference hall. I did not visit the second floor, but
I did visit Mr. Ernest Mills, the Director of Learned
Society Services for the IEE, in his offices on the
third floor.
The conference hall "shouts" of technical profes-
sionalism. On entering, one sees a massive
chairman's desk larger than a judge's bench in a
court room; to his left is the speaker's podium, and,
above both of these, the screen. The upholstered
central seats face the bench and slope down from
the back. On either side are seats perpendicular to
the center. Plugs all around the room make it possi-
ble for a page with a mike to reach anyone in the
audience within 5 to 10 seconds after being recog-
nized by the chair for a question.
Surrounding the room at the about the 12 to 15 foot
level are about 20 portraits of famous British (elec-
trical) physicists—Maxwell, Faraday, Rayleigh,
Kelvin, etc. Lights are controlled from the podium.
The chairman remains seated facing the audience
from his "judge's" bench. Seemingly without effort,
the meeting remained on schedule, controlled by
the chairman using signal lights, even allowing suf-
cient time for questions and discussion. At the
conclusion of the conference, one of the organizers
gave a twenty minute summary of the entire confer-
ence. He stated the principal points of each paper,
the correlation with other papers, and how they all
blended into the overall topic of the conference. On
registering, each attendee was given a packet con-
taining a hardcover folder, the preprinted proce-
dings, a list of the attenders preregistered (a
supplemental list was passed out the next day), and
a listing of exhibitors. A separate page was devoted
to each exhibitor, giving not only the products on
display, but also the areas of expertise of the com-
pany. The company personnel on duty were also
listed. To help those attenders not from the area,
the guide also included a map of London, bus and
subway maps, and a map of the local area indicat-
ing eating places.

[This is Part I of a two part report on the Advanced
Infrared Sensors Conference held October 29-30,
1981 at the Institution of Electrical Engineers, Savoy
Place, London, England. Part II, which will appear
in the SPIE Reports section of the July/August
1982 issue of Optical Engineering, will highlight
papers presented at the conference. Ed.]

Book Reviews

An Introduction to Optical Waveguides
M. J. Adams, 401 pp., illus., bibliography, references. ISBN 0-471-27969-2. Wiley-Inter-
science, John Wiley and Sons, Inc., 605 Third

Reviewed by Peter P. Wintersteiner, ARCON
Corporation, 260 Bear Hill Road, Waltham, MA
02154.

An Introduction to Optical Waveguides is a well-
written, up-to-date textbook which will prove use-
ful to anyone attempting to master the physics of
light-guiding structures. One of its virtues is its
truthfulness, and this makes it valuable as a
reference for researchers. However, the author is
successful in his intent to bridge the gap between
the most elementary ideas and the full detail relat-
ing to each topic.

The book is limited to the consideration of ideal isolated waveguides. Chapters 1-5, compris-
ing fully half of the text, deal with planar wave-
guides. They begin with the introductory concepts
and then proceed from constant-index to graded-
derivative guides. Chapter 6 discusses structures with rectangular cross sections. Chapters 7 and 8 deal
with step-index and graded-index fibers, respec-
tively. The heavy emphasis on planar guides is
worthwhile because of repeated references to basic
ideas developed in this section. Also, part of the
author's intention is to present a treatment which
is uniform enough—in its general approach and
also in its notation—to appeal to workers in both
fiber and integrated optics. This purpose appears
to be well served.

Chapters 6 and 7 illustrate, in different ways,
the thoroughness which is typical of each section.
In chapter 6, many different structures with rect-
angular components are considered. After briefly
discussing the TE and TM modes of conducting-
wall guides, the author introduces two ways of
obtaining the (approximate) modes of rectangular
dielectric structures. One of these, the effective-
index method, is applied to constant-index, slab-
coupled guides of various descriptions. Later it is
also used to discuss diffused-channel and strip-
loaded diffused guides, and the stripe-geometry
heterostructure laser. The basic ideas are presented
clearly and supplemented with frequent references
to and descriptions of relevant research efforts. By
way of contrast, Chapter 7 is characterized (although not dominated) by the mathematical
detail which can be invoked to derive the modal
properties of step-index fibers of circular and
elliptical cross section. The accompanying discus-
sion complements the derivations quite satisfac-
torily. The treatment of dispersion is a good one.
A somewhat more extensive section on birefrin-
gence might be desirable. As with Chapter 6, there
are also a few pages on hollow guides, as well as
succinct discussions of research efforts of the past
five years.

The author has apparently chosen not to dis-
cuss certain subjects at all rather than treat them
in a cursory fashion. One obvious omission is a
section on coupled modes—Maxwell’s constant-
index modes of arrays of waveguides. Given current applications in inte-
grated optics and fiber optic sensors, and also in
view of the content of the book as it is, this would
be a natural subject for a concluding chapter or
two. Also absent are discussions of subjects perti-
nent to nonideal guides, such as mode-coupling
and bend losses.

On the whole, An Introduction to Optical
Waveguides is well written, well organized, and
well suited to any interested reader with a physics
background. The scope of the book is clearly
defined, although not all-encompassing, and the

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BOOK REVIEWS

**Current Trends in Optics**


Reviewed by William T. Rhodes, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, GA 30332.

This book contains printed versions of 17 invited papers presented at the 12th Congress of the International Commission for Optics (Graz, Austria, 31 August-5 September 1981). The meeting had as its principal themes astronomical and space optics, unconventional image formation and optical information processing, and optical materials. General overview papers were presented in other areas as well. Selected contributed papers from the conference will appear in a special issue of *Optica Acta*.

The papers in this volume are, for the most part, relatively short review papers; they average 10 pages in length plus references. Virtually all emphasize the authors' own work. A list of authors and titles follows, along with brief descriptive comments:

- H. Kogelnik, "Perspectives of quantum electronics and fiber optical communications." Non-technical description of an extremely rapidly growing area.
- Hu Ningsheng, "Overview of astronomical optics in China." Design, fabrication, and testing.
- G. Weigelt, "Interferometric methods in optical astronomy." Examples of speckle interferometry and speckle holography.
- G. Tricoles and H. H. Farhat, "Unconventional imaging." Microwave holography and imaging, adaptive arrays, with applications.
- Y. Ichikawa, "Interactive image processing for image restoration and enhancement." Computer processing with iterative algorithms.
- J. R. Fienup, "Image reconstruction for stellar interferometry." Application of constrained iterative digital processing methods to stellar interferometry images.
- J. M. Burch, "Assessment of cameras for use at high resolution." High-resolution moiré grid photography.
- B. Catania, "Telecommunications through optical fibers." Fiberoptic communications in Italy.
- J. Zyss, "A molecular engineering approach toward the design of efficient organic crystals for three wave mixing." Overview of significant materials research area.
- G. Lemaître, "Optical figuring by elastic relaxation methods." Manufacture of aspheric surfaces by plastic deformation of glass.
- J. P. Huignard, "Phase conjugation, real time holography, and degenerate four wave mixing in photorefractive BSO crystals." Self-explanatory.

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