SPECIAL ISSUE ON OPTICAL COMPUTING

"Optical Computing" can be interpreted either narrowly or broadly. This Special Issue reflects a broad interpretation of those words which we hope to explain here and illustrate by the papers in this issue. Both the word "optical" and the word "computing" need interpretation and definition. Rather than using arbitrary definitions, we have used rather operational definitions. That "optical" includes visible light phenomena is beyond dispute. A wide variety of wave phenomena (e.g. sound, microwaves) and ray phonomena (e.g. X-rays, γ-rays), exhibit behavior similar to that of visible light in appropriate circumstances. We have found from a number of International Optical Computing Conferences, that workers in these areas have much in common that can be called "optical" although some have suggested we add "... and quasi-optical." In any case, the underlying phenomena are so general that the broad view espoused here has begun to pay demonstrable dividends. "Computing" may be interpreted narrowly as "number crunching," more broadly as manipulation of fields (of numbers, photons, etc.), or most broadly as the acquisition and rearrangement of information. Always taking the broadest sense we have viewed "optical computing" as the acquisition and/or manipulation of information by electromagnetic or acoustic waves or rays. To the extent that digital computers cooperate with optical computing, they must be part of the whole study.

Dr. Winston E. Kock was invited to write the opening paper because of his unique background as a leader in three disparate worlds: academia, corporate, and governmental. His paper leads from a brief historical overview to a rational rather than a "science fiction" approach to "Optical Computing and Change." His paper is based in part on the work of President Warren G. Bennis of the University of Cincinnati, whose prior commitments prevented him from accepting the invitation to be co-author.

The field of optical computing has been dominated by coherent optical computing for many years. A fairly standard coherent optical computing apparatus has evolved. Carlson and Francois have analyzed a generalization and extension of the standard coherent optical processor and thereby widened the field of its applications.

The now-classical operations performed by coherent optical computers are being extended in many directions. The next three papers document those extensions. Leith shows how complex (holographic and nonholographic) spatial filters can be used to improve images, view through distorting media, and correct for low-quality optical elements. Goodman surveys the fields of nonlinear and generalized linear processing and shows their great advantages with respect to the older purely linear processing methods. Stroke *et al.* deal with the deconvolution of images with particular emphasis on electron microscopy. Then they introduce a method whereby coherent optical methods, supplemented by digital computers, can be used to derive crystal structures in X-ray crystallography.

The introduction of digital computers in the previous paper provides an apt transition to Thompson's assessment of hybrid (optical–digital) processing systems. A hybrid system will use optical and digital processing components each for its own peculiar strength. Thompson goes beyond review to an assessment of the trends and hopes in this area.

Casasent and Psaltis illustrate the hybrid processor concept with a paper on new optical transforms it makes possible. The advantages of these for pattern recognition are shown.

Noncoherent techniques of optical computing are also developing rapidly. To introduce information about a three-dimensional object into a computer, we would like to be able to measure the three-dimensional surface coordinates of that object directly and quickly. Caulfield *et al.* examine the promise and limitations of a technique to do this with a new kind of laser photography. The tremendous success of digital reconstruction of images for transaxial tomography raises the question of whether those computations might be performed optically and, if so, of what advantages might result. Barrett and Swindell answer those questions in their paper. While Barrett and Swindell use X-rays to record their data, Tricoles and Farhat use microwaves. They show that microwave holography is a practical solution to certain classes of real problems. Monahan *et al.* review the use of incoherent light to correlate data fields and show that the correlator is a far more general processor than might be assumed naively.

It is normally assumed that optical processors are necessarily fully analog and hence of little use for real number crunching, where, for example, small differences between large numbers must be calculated. The work by Schaefer and Strong on "Tse Computers" introduces a technique whereby some of these "limitations" on optical computers may be overcome.

It often happens that we want to gather information by optical or microwave means through a randomly variable medium. The considerable progress which has been made toward determining efficient means for minimizing these effects and achieving near fluctuation-free imaging has been organized and discussed by Bates *et al.*

For both coherent and incoherent optical processors, speed requires a spatial light modulator. Casasent has collected and analyzed the systems currently available and presented them in a form which should (essentially for the first time) make it possible to compare and choose among them.

Although this Special Issue ends with Casasent's paper, our comments must extend one month into the future to discuss an invited paper by Bartels and Wied which will appear in the February PROCEEDINGS and is very closely related to optical computing. Those authors will discuss "Computer Analysis and Biomedical Interpretation of Microscopic Images; Current Problems and Future Directions." Besides its considerable inherent interest, that paper may serve to focus attention on another problem. When optical computing and digital computing are both applicable to a problem, how can we make a choice? Or can we avoid a choice by hybrid methods?

It is not clear that a summary of the contributions to this Special Issue is possible or useful, but we do feel that an overall metascientific fact emerges from this issue. That is that all aspects of optical computing are broadening. By that we mean that they are taking on new practical problems never previously thought to be within their domain. At such a time in the evolution of a field, even would-be prophets must exercise caution. Tremendous progress has been made in optical computing within the last few years, and more progress is certain. The directions of that progress, however, are not nearly so clear. This Special Issue is a *blik* of a highly dynamic field as of the end of 1976. The best is yet to come.

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Professor Peter Franken	University of Arizona
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H. JOHN CAULFIELD
SAMUEL HORVITZ
WILLIAM A. VON WINKLE
Guest Editors

H. J. Caulfield *(M'69–SM'74) received the B.A. degree in physics from Rice University, Houston, TX, in 1958 and the Ph.D. degree in physics from Iowa State University, Ames, in 1962.*

Since 1972 he has been with the Block Engineering, Inc., Cambridge, MA, where he is currently Manager of the Laser Technology Department. Prior to joining Block Engineering, he was associated with the Central Research Laboratory, Texas Instruments, Inc.; the Special Microwave Devices Operation, Raytheon Company; and the Sperry Rand Research Center. He is the author/or editor of several books, five book chapters, and numerous patents and journal articles. His primary research interests are coherent optics, spectroscopy, and ultra-short pulse phenomena.

Dr. Caulfield is a Fellow of the Optical Society of America, Symposia Vice-President of the Society of Photo-Optical Instrumentation Engineers, and a member of several other scientific societies.

Samuel Horvitz *(A'58–M'68) received the B.A. degree from Williams College, Williamstown, MA, in 1936. He has also done graduate work in applied physics at Harvard University, Cambridge, MA, and in electrical engineering at Massachusetts Institute of Technology, Cambridge.*

He is presently Staff Systems and Engineering Support Consultant to the Head of the Computer Science Department of the Naval Underwater Systems Center, New London, CT. He also serves as Consultant to other governmental agencies, including the National Science Foundation.

Mr. Horvitz is a member of Phi Beta Kappa, the Optical Society of America, and several other scientific and engineering societies. He has been active in IEEE and its societies, and has been one of the organizers of the International Optical Computing Conferences in Zurich, Switzerland, Washington, DC, and Capri, Italy.

William A. Von Winkle *(S'49–A'53–M'53–SM'75) received the B.E. and M.E. degrees from Yale University, New Haven, CT, in 1950 and 1952, respectively, and the Ph.D. degree from the University of California, Berkeley, in 1961.*

He has served as Visiting Lecturer in the Graduate School of the University of Connecticut and as Adjunct Assistant Professor on the Staff of the Hartford, CT, Branch of Rensselaer Polytechnic Institute. Presently, he is the Director for Science and Technology at the Naval Underwater Systems Center and Chief of Research and Development of the New London Laboratory. He is currently responsible for a broad range of research and exploratory development programs in nonlinear acoustics, acoustooptics, advanced sonar arrays, signal processing, and underwater acoustic propagation. He is the author of numerous scientific reports and papers on hydrodynamics and acoustics and has served on various Navy planning and advisory committees.

Dr. Von Winkle is a Fellow of the Acoustical Society of America and is a member of several other professional societies.