Books

Optical Image Evaluation (Proceedings of NBS Semicentennial Symposium, 1951). NBS Circular 526. 289 pp. U. S. Government Printing Office, Washington 25, D. C., 1954. $2.25. *Reviewed by W. T. Wintringham, Bell Telephone Laboratories.*

The era of black magic, or of art, in lens design is slowly coming to an end, and the symposium on optical image evaluation during the NBS semicentennial in 1951 was one indication of its passing. The formal papers and the discussion at this symposium have been published in *Optical Image Evaluation.*

A list of those represented in this symposium is an impressive roster in itself. Papers were presented by: A. Arnulf of the Institut d'Optique (Paris); James G. Baker of the Harvard College Observatory; H. S. Coleman of the Bausch & Lomb Optical Company; Arthur Cox of the Farrand Optical Company; G. Toraldo di Francia of the Istituto Nazionale di Ottica (Arcetri); Donald P. Feder of the National Bureau of Standards; Max Herzberger of the Eastman Kodak Company; R. E. Hopkins, Howard Kerr, Thomas Lauroesch, and Vance Carpenter of the University of Rochester; L. E. Howlett of the National Research Council (Ottawa); Erik Ingelstam and Per J. Lindberg of the Royal Institute of Technology (Stockholm); R. Kingslake of the Eastman Kodak Company; Duncan E. MacDonald of Boston University; André Maréchal of the Institut d'Optique (Paris); Harold Osterberg and Robert A. McDonald of the American Optical Company; O. H. Schade of the Radio Corporation of America; E. W. H. Selwyn of Kodak Limited; R. V. Shack of the National Bureau of Standards; A. C. S. van Heel of the Technical University (Delft); F. E. Washer of the National Bureau of Standards; and F. Zernike of the Natuurkundig Laboratorium (Groningen).

An introduction by Irvine C. Gardner of the National Bureau of Standards serves to set the perspective for the entire symposium. He ends his statement as follows: "This brief resume gives an idea of the large field of engineering knowledge concerning image evaluation that remains to be filled in. The papers of this symposium touch upon most aspects of the problem in more or less detail but, like most useful scientific work, the papers also suggest the large amount of work that remains to be done." All of the papers reflect this same judicious tone.

One might reasonably expect T. Smith to have been a participant in this symposium. Unfortunately he was unable to be present and to submit a paper. But he addressed a letter to the symposium which, printed at the end of the present volume, serves as a fitting capstone for the whole proceedings.

Thirty years ago, image evaluation was carried out by examining the image on a lens bench and by expressing the results in terms of the appearance of the image. However, interpretation of the results of lens bench testing in terms which were significant to the user of a lens was only moderately practicable. The introduction of resolution testing patterns about twenty years ago was a step forward in helping the user evaluate lens performance. But, these early test charts were made with high contrast, and the objects to be imaged in practice usually were of low contrast. Test chart observations were brought closer to practice about ten years ago through the use of charts having limited contrast. Only a little later, somewhat more objective measures of resolution were introduced, where scanning techniques were used to obtain a numerical expression for the reduction of contrast produced by an optical system imaging a test chart.

Many of the papers in this symposium were concerned with the correlation of the results of these laboratory tests with the performance of imaging systems in the field. And unfortunately, the correlation is none too good. We still are none too well aware of exactly what characteristic it is of a star image or of the image of a resolution test chart which should be examined to permit us to say with assurance that we have the most economical design for some specific application.

Other papers treated the calculation of the distribution of energy in images from the physical properties and the dimensions of the components of an imaging system. It has been found here that geometric optics generally does not have sufficient power to yield enough information about the image. But the availability of modern high-speed computers allows image calculations through the methods of physical optics, so that there is some hope of bringing design and measurement into agreement.

Optical Image Evaluation is as much a record of lack of knowledge as it is a report of principles and of methods. As such, it should prove to be a powerful spur to the imaginations of all optical workers.

Actions of Radiations on Living Cells (Second Edition). By the late D. E. Lea. 416 pp. Cambridge University Press, New York, 1955. $6.00. *Reviewed by P. Morrison, Cornell University.*

This is a well-made offset re-issue of Dr. Lea's book, changed only in the correction of a few numerical tables, and by adding several pages of brief notes made by Dr. Lea himself. The clarity and compact power of this book, both on the physical and the biological side, still commend it to all who want to gain an entry into the subject. Its enthusiasm for target theory and naïvete in general, while they still stimulate, look to-

day, however, even less plausible than they did in the years just after the war when the first edition appeared. After such a warning, any aspirant to learn radiation biology can profit from this fine work, newly available.

Essays on the Use of Information Theory in Biology. Edited by Henry Quastler. 273 pp. University of Illinois Press, Urbana, Illinois, 1953. Paperbound, $4.00. *Reviewed by J. G. Hoffman, Roswell Park Memorial Institute.*

The evanescent quality that makes living cells click has been known by many different names. These names have ranged from spirit to negative entropy. It now turns out that negative entropy and information are directly related. It is said that amid the universal increase of entropy there is a temporary reversal inside living things because they can make and handle information. This book presents a new way of thinking about these matters. Of the nineteen essays twelve are devoted to a study of information in living matter.

The first seven essays outline the theory and definition as well as the measurement of information. These provide means for taking hold of the living process, and from there on it is apparent that there is much room for discussion about the ability of living things to make information. It is not altogether clear whether life is measurable by the negative entropy or whether it is the process of reeling off the information with which entropy is equivalent, or whether life is molecular organization itself. Some very stimulating answers to these questions are given in this book. The mystical thing called organization has never been adequately defined. Yet it is always well known by its presence, and it is here subjected to a thorough search and analysis.

One of the simplest experiments imaginable would be to put living cells in a calorimeter and watch for the exchange of heat. An alternative would be to make a thermal analysis by heating the cells through a range, say, from 95°F to about 105°F. Many ideas and counter ideas of what should happen in such experiments, from a theoretical standpoint as well as in the light to practical realities, are indicated in various ways throughout this book. If the cells are alive they will give off heat, and at the same time try to keep down their internal entropy. If the temperature rises the living cells may run into difficulties. Fuses may blow; some of the many different kinds of governors may jam or freeze; and enzyme systems may be completely destroyed. Or, if the cells die, and the calorimeter measures the heat of death, what are the theoretical expectations and practical limitations? In other words, what are the internal rearrangements in living matter by which we might be able to deduce its essential structure?

The data selected by the essayists to carry out their diverse discussions of information in biological systems, is in itself most instructive. There are excellent tabulations of the properties of molecules of amino acids along with pictures of molecular models and their structural formula. For example, there is a remarkable table of information about identical twining which K. S. Tweedell uses to develop the information content of germ cells.

The essays are practical in the sense that they aim directly to show where theory is applicable. One needs only to point to Information Theory and the Structure of Proteins, by H. R. Branson. This essay presents extensive calculations on the information content of amino acid residues, as well as on twenty-six of the well-known macro-molecular proteins. Or, in another field, the essay by M. R. Irwin on Genes and Antigens. goes directly to data on men, birds, and cattle, and provides, incidentally, a nice synopsis of intricate genetic relationships.

A word has to be said about the last essay called The Information Content and Error Rate of Living Things, by Dancoff and Quastler. When making animals or cells, life probably makes many mistakes; but they are quickly hidden because they die. Those that do survive seem mighty impressive because they are nearly perfect. Yet, even though they are nearly perfect, they still may be sports, or mutants, or possibly cancer cells. Taking account of the number of atoms in a human being, the authors carry out speculations on the orders of magnitude of information in the atoms, and in the molecules in germ cells. For example, the essential information for creating a new individual, which is contained in a germ cell, amounts to ten million printed pages, or the content of a library of considerable size. The authors then procede to compute the fidelity of reproduction of living cells, and the rate of mistakes probable or allowable. One basic question raised is that of data: how will we measure mistakes that cannot live? The estimates are extremely coarse; yet they are, as the authors say: "better than no estimate at all".

This volume carries the reader to profound thoughts. It is of interest to biologists and biophysicists, because of the specific kind of data which the essayists have selected for demonstrating the theory. Physicists in general will be interested because there is an attempt to nail down the ephemeral relationship between entropy and life. The text is well written and concise. The illustrations are generous and serve their purpose well. The effort of fifteen different essayists combines to make a concrete discussion of how information theory provides a new way of thinking about living things.

Rocket Exploration of the Upper Atmosphere. Edited by R. L. F. Boyd and M. J. Seaton, in consultation with H. S. W. Massey. 376 pp. (Pergamon Press, England) Interscience Publishers, Inc., New York, 1954. $11.00. *Reviewed by S. F. Singer, University of Maryland.*

This book published as a supplement to the well-known *Journal of Atmospheric and Terrestrial Physics* is the report of the first major international scientific conference concerned with rocket exploration of the earth's upper atmosphere, held in Oxford, England, Au-