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material is organized much as in a review article, but with attempts at consistent interpretation in terms of crystal defects, electronic structure, etc. In my opinion the most serious defect in this book is the lack of detailed treatment of the theoretical investigations of the electronic structure of graphite. Even if these are regarded as incomplete, a much better feeling for that which is understood and that which is obscure would undoubtedly result from close study and integration of theory and experiment. In spite of this deficiency, the book can be wholeheartedly recommended to all physical chemists, inorganic chemists, and solid-state physicists.

Photo-Electronic Image Devices. Symp. Proc. (London, Sept. 1958). Edited by J. D. McGee and W. L. Wilcock. Vol. 12 of Advances in Electronics and Electron Physics, edited by L. Marton and C. Marton. 397 pp. Academic Press Inc., New York, 1960. $12.00. *Reviewed by W. T. Wintringham, Bell Telephone Laboratories.*

THIS volume, the twelfth in the series, "Advances in Electronics and Electron Physics", edited by L. and C. Marton, is the proceedings of a symposium on image tubes and related devices held at Imperial College of London University, September 3–5, 1958. The symposium was arranged under the enthusiastic leadership of Professor J. D. McGee. Representatives of almost every laboratory in the world working on image tubes and their application took part in the symposium. However, as Professor McGee points out, he was unsuccessful in persuading workers from the USSR to attend and present papers.

The absence of Russian scientists from this symposium is to be regretted. Praiseworthy results reported in the Russian journals indicate a high level of interest and of competence in the USSR in areas covered at the London meeting. Consequently, the cause of science would have been furthered by a free discussion of *all* of the work in progress on image tubes.

For somewhat more than thirty years scientists have been improving photoelectric camera devices and circuits. About ten years ago scientists working in other fields recognized that the tools devised for television might be useful in the laboratory as well as for entertainment. In particular, the fact that the quantum efficiency of a photocathode might be a hundred times greater than that of a photographic emulsion and the fact that television techniques might be used to increase the contrast between a bright image and its background suggested the advantages to be gained by borrowing from television.

This approach to the problem of increasing the sensitivity of image-recording systems is reflected in the fact that about one third of the papers in the symposium treat tubes derived directly from the television camera tube family. All of these tubes have the property of integrating and storing the effect of radiation incident on the photocathode. Hence the electrical signal resulting from scanning may represent the result of exposures lasting for seconds or minutes. Experiments with a most interesting tube of this type are described by W. Heimann of the Physikalisch-Technische Werkstätten. In this tube the electrons required for the scanning process are produced by scanning the photocathode with a moving spot of light (a spot scanner in television language). Removal of the usual hot-cathode from the image tube is shown to improve performance in two ways: first, the vacuum can be better; and second, the same electron optics are used in the charge storage and the reading processes with the result that the effect of distortion-producing aberrations is cancelled.

Another interesting experiment using televison-developed principles is described by C. A. Greatorex of the Institute of Cancer Research at the University of London. This is the application of spot-scanning techniques to x radiation to allow more effective use of fluorescent image intensifiers. The electron beam in the x-ray tube is scanned over an extended target to produce radiation from a raster. This raster is imaged on the object by a pinhole. The radiation transmitted through the object falls on a luminophor in a scintillation counter. The output of the counter is used as a television signal and is displayed on a television monitor. In this system the intensifier screen does not work in imaged radiation and therefore can be used most efficiently. The net result is a reduction of exposure of the object to x radiation.

Developments stemming from the "snooperscope" of World War II are described in another group of papers presented at this symposium. In their simplest form, tubes of this family include photo-emissive cathodes, the electrons from which are imaged on fluorescent screens at the far ends of the tubes. Provided the radiation from the phosphor can be collected efficiently by a photographic emulsion, the increase of photon efficiency of the cathode over that of the emulsion yields a radiation recorder of increased sensitivity. Tubes in which the phosphor is coated on a thin membrane to allow the emulsions being brought close to the phosphor are described by several authors. B. Zacharov and S. Dowden of Imperial College have brought this technique to the highest level disclosed at this symposium by holding the photographic emulsion in close contact with a mica window by vacuum.

Further work on a variant of this technique is described by R. Lallemand, M. Duchesne, and G. Wlériche of the University of Paris. Instead of a fluorescent screen, the photographic emulsion is placed in the plane of the electron image. The advantages of this method of operation are offset by the fact that the life of the photocathode is shortened by gas liberated from the emulsions. However, for some laboratory applications this appears to be a very promising technique.

The brute force technique of assembling several pairs of photocathodes and fluorescent screens within a single envelope to produce tandem or multistage image intensifiers is described by R. G. Stoudenheimer of the

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Radio Corporation of America and by M. M. Wachtel, D. D. Doughty, and A. E. Anderson of the Westinghouse Research Laboratories. This pre-eminently practical approach is by no means as impressive as the imaginative application of optical feedback to a single-stage image tube. The use of a single photocathode-phosphor pair regeneratively coupled by an optical system is discussed by Arthur Roberts of the University of Rochester and by Martin L. Perl and Lawrence W. Jones of the University of Michigan. The difficulties of this approach are clearly outlined and one can hope that solutions to the several important problems will be found.

Another imaginative approach to the problem of increasing the sensitivity of image tubes is that taken by J. D. McGee, E. A. Flinn, and H. D. Evans of Imperial College and by J. Burns and M. J. Neumann of the University of Chicago. Each of these groups is working to interpose a large number of parallel electron multipliers between the photocathode and the fluorescent screen. This approach may turn out to be entirely impractical, but it is refreshing to find experimenters who are willing to exhaust its possibilities in the face of such pessimism.

Even though these new tools are more sensitive than those previously available, one is struck by the fact that not a single participant in the symposium felt that the limit had been reached. The ultimate limit, of course, is set by the fact that the quantum efficiency of a photocathode must always be less than unity. But at present the performance is still bounded by electron-optical deficiencies, stray emission within experimental tubes, and by similar phenomena rather than by quantum efficiency.

The subject matter of the thirty papers in these proceedings ranges from bare descriptions of laboratory experiments to theoretical studies of the performance of image systems. Except that papers on solid-state image intensifiers are missing, any student of photoelectric image devices will find at least one paper in this volume treating his field of interest. The papers taken collectively give the student a good picture of the state of the art as of the date of this symposium.

Foundations of Electromagnetic Theory. By John R. Reitz and Frederick J. Milford. 387 pp. Addison-Wesley Publishing Co., Inc., Reading, Mass., 1960. $8.75. *Reviewed by Jacques Romain, University of Elisabethville, Katanga.*

THIS is not just another textbook on electromagnetism, but a rather different one from those which every physicist knows. One of its main features is the use of atomic concepts to enlighten the study of electromagnetic fields inside matter, and a simple exposition of the relations of microscopic and macroscopic pictures of electric and magnetic fields in that case. There is also an introduction to plasma physics: general principles and typical examples chosen to make clear the main approaches to plasma physics. The in-