with scientists outside Russia, and with the courage to express his thoughts freely. Throughout, Kapitza reveals his love for Rutherford and the enormous benefits he derived from his thirteen years in England. Honesty and generosity are seen to be his outstanding characteristics. A loyal citizen of the U.S.S.R., he sees both her strengths and her weaknesses. Problems of the organization of science in the technological age, and of its use for the welfare of mankind, are of great importance to Kapitza. Readers will learn from Albert Parry's book that an eminent Soviet scientist is very like an eminent American or European scientist, and such understanding is of immense value today.

Mark Oliphant worked with Rutherford in the Cavendish Laboratory from 1927 to 1937, during which time he became a close personal friend of Peter Kapitza. Since the war he has visited the U.S.S.R. several times, and, apart from these opportunities to see the Kapitzas, he and his wife have kept in contact by correspondence. During the war he worked at Oak Ridge and Berkeley as a British member of the Manhattan Project. In 1950, he left England to return to his native country, Australia, with responsibility for the physical sciences in the newly established Australian National University.

DOSIMETRY DETAILED

Title Mathematical Theory of Radiation Dosimetry

Authors J. J. Fitzgerald, G. L. Brownell, and F. J. Mahoney

Publisher Gordon and Breach Science Publishers, Inc., 1967

Pages ix + 747

Price hardback $30.25; paperback $11.50

Reviewer Arthur B. Chilton

The authors of this book are workers and consultants within the nuclear research complex in the Boston-Cambridge area. The first is also associated with the faculty at Harvard University. The second, who is on the faculties of both Harvard and the Massachusetts Institute of Technology, is a co-editor of Hine and Brownell's *Radiation Dosimetry*, considered for a decade the definitive compendium on that subject.

The preface states that the book is an educational text for health physicists, radiological engineers, and radiological health specialists, written to help them develop the understanding needed to properly analyze potential hazards from radioactive materials and other radiadiation sources. The level of presentation is for first- and second-year graduate students. The authors express hope that in addition the book will be useful to students and practitioners in the fields of nuclear physics, nuclear engineering, reactor shielding, and medical physics.

The title may be misleading to some. I expected the book at first sight and heft to be a rather thorough exposition of the theoretical fundamentals underlying the measurement of absorbed dose and related quantities, with special emphasis upon the mathematical exposition of the theory—something of an expansion and updating of the material found in Whyte's *Principles of Radiation Dosimetry*.

However, it is not this at all. The authors in their introductory chapter distinguish between "theoretical radiation dosimetry," which they define as involving the *estimation* of dose, and "applied radiation dosimetry," defined as the *measurement* of dose. The fact that there are also important theoretical and mathematical problems associated with dose *measurement*, e.g., examination of the Bragg-Gray cavity principle and its elaborations, does not dissuade the authors from their terminology; thus one finds this book on "theory" devoted exclusively to *estimation* of dose. (In this review I will use the term "dose" in a generic sense.) Having overcome this semantic difficulty, one is then in a position to judge how well the authors carry out their intentions.

The information is quite well organized. After an introductory chapter, two chapters on fundamentals, one covering nuclear and radiation physics and the other radiation biology, are presented, not as definitive works on their respective subjects but as broad surveys to serve as background material. The main portion of the book is divided between six chapters on dose prediction for external sources and two on internal source dosimetry. The external source chapters cover interactions between matter and gamma rays, neutrons, beta-rays, heavy charged particles, and high energy particles and dose prediction for each of these forms of radiation. The final two chapters include one on biomathematical models for internal source distribution and one on the dose prediction for internal emitters.

In my opinion, the chapter on the background physics, which contains 108 pp., is much longer than necessary. Some material is only remotely related to dosimetry, and much of the related material is repeated in even greater detail later. However, the chapter on radiobiology appears much more praiseworthy. It is shorter, with little repetition in other chapters; the text serves excellently as a survey for students in engineering and physics who might not otherwise be exposed to a separate course in radiobiology. The parts dealing with the interactions of various types of radiation with matter cover their subject well, concentrating on items of direct concern to dosimetry, while gliding over points of less immediate interest. The depth and sophistication appear proper for the type and level of student for whom it is written.

The chapter on gamma-ray dosimetry is almost the heart of the book. It contains 138 pp. of theory on dose calculation, gamma-ray transport, and attenuation. Included are a large compilation of formulas and graphs, for calculating gamma-ray energy fluxes, and dose rates from a variety of simple standard source configurations, that penetrate a number of idealized standard shielding configurations. Most formulas are based on an elementary exponential attenuation process; however, the concept of the buildup factor as a corrective measure for such oversimplification is explained in some detail.

The chapters on neutrons suffer by comparison with those on gamma rays. The authors appear most interested in radioisotopic sources, and one cannot escape the impression that neutron interactions and neutron dosimetry are included more for completeness than with the hope of discussing them definitively. In particular, the sections on neutron transport are simply the standard reactor physics fare. They are, by the authors' admission, included as background, because they contain mathematical concepts which "might be adaptable to radiation-dosimetry calculations." The section on neutron penetration (shielding) is extremely short, without a single mathematical equation or graph. The section on neutron dosimetry is also disappointing: the basic physics and mathematical formulation of the "first-collision approximation" are adequate (except for a somewhat confusing discussion on p. 487, which seems to imply that the gamma rays from hydrogen absorption of neutrons contribute to the first-collision dose); but the discussion of the "multi-collision" dose, the standard basis for present neutron radiation protection practice, is incomplete. At least a standard table for conversion of neutron flux to absorbed- and biological-dose rates could have been provided.

In the chapter on beta-ray interactions and predictions, the authors approach the completeness and thoroughness of the chapters on gamma rays, probably again because of their particular interest in radioisotopic sources; and, for the same reason, the subsequent chapter on heavy-charged and high-energy particles contains only a qualitative discussion on their interactions with matter. The principles of dosimetric prediction for such particles are only briefly surveyed, but no specific mathematical formulas are given nor calculational techniques adequately explained.

The chapters on internal emitters are rather complete and satisfactorily mathematical.

The most important shortcoming of the text is that most all of the sources were published before 1959. Of the ~75 references given, only 3 were published in 1960, none in 1961, and 1 secondary source in 1962. Thus, this text must have been assembled almost entirely on the basis of the state of knowledge of about 1960; few, if any, of the subsequent advances in this field are included. In particular, the development of important new fundamental concepts, the updating of nomenclature, and the emphasis on increased rigor, all of which were recommended by the very authoritative ICRU Report 10a in 1962, appear to have had little impact on this book.

A few comments on details will give some idea of the care to be taken in using this book.

Tables 2.23, 10.6, and 10.7, taken from Etherington's *Nuclear Engineering Handbook*, were checked and found to contain two errors in transcribing the numbers. Although only a small sampling, this indicates at least that the proof-reading was imperfect.

The index appears uneven. For example, there are no entries for "eyes," "gonads," and "life-span," which are discussed with a paragraph or more each; but "spikes," which has little importance to the subject matter and gets only about four lines of text, is included. The entry "LET" cites pp. 116 and 135, but the term is first mentioned and defined on p. 72. Many page references are given for the term "buildup factors for gamma rays," but p. 99, where the concept is first mentioned, is not included.

Occasionally, clear errors appear. For example, the statement is made on p. 21 that the mass increase of a macrosopic body with an increase in kinetic energy is undetectable under ordinary conditions because the mass-energy conversion factor c^2 is so large. Surely, this fact is independent of the system of units used, and it is possible to have systems in which c^2 has any selected positive value. On p. 73, gamma rays are said to have a specific ionization of the order of 2.5 ion pairs per centimeter–a statement that is not likely to stand under careful scrutiny. On p. 292, an unqualified conclusion is drawn to the effect that the energy absorbed per unit volume equals the energy emitted per unit volume (i.e., a spatial equilibrium condition exists), for an infinite-volume source with a uniform activity distribution. In general, this is not true; even if we assume the same type of medium, it is true only if the density is constant. On p. 99, the buildup factor concept is called "empirical or semiempirical." There is no basis at all for such a statement, since buildup factors are capable of precise mathematical definition and calculation, even though the values, after calculation, are often approximated by empirical formulas.

In a few places, the authors could have done better by a slight additional explanation or change of wording. For example, in Chap. 4 the text discusses the fact that under many circumstances the use of the absorption coefficient, μ_a in place of the attenuation coefficient μ in the exponential attenuation factor, gives more accurate answers, but then it reverts to the use of the attenuation coefficient "in order to conform with conventional practice in the literature." It would have been easy for the authors to invite the user, if he believes it to be more accurate, to substitute μ_a for μ in the formulas; thus, they could have avoided the criticism of clinging unnecessarily to an outmoded convention.

On p. 347, the text quite correctly indicates that the moments method has had trouble furnishing a description of the field near point or plane sources; however, one should not infer that the buildup factors near the source are inaccurately given closer than one mean-free-path from the source. Actually, all the curves for point-source buildup factors on pp. 349 to 354 could have been smoothly extrapolated to a value of unity at zero mean-free-paths with a high degree of accuracy. (In connection with these curves distances are specified incorrectly as "relaxation lengths," in spite of the cautionary statement on p. 183 to avoid this mistake.)

Many of the formulas provided for calculating gamma-ray energy flux and dose rate are poorly suited for a source with widely varying photon energies. Their applicability could be easily extended to such sources, if provision were made for handling each photon energy separately and summing the results. A short explanation or slight elaboration to each formula would have accomplished this.

In summary, I would not select this book as a primary text for a course in radiation protection, primarily because there is available at least one good and much more up-to-date work on the subject. However, the present book should be an excellent reference work, especially for estimating the hazards from radioisotope sources, and, if used with care, it can be readily recommended to those involved in the teaching or practice of radiation protection.

Arthur B. Chilton has been involved in shielding and related radiation protection for many years, the last six of which have been spent teaching and doing research in the Nuclear Engineering Program of the University of Illinois. Chairman of the Shielding and Dosimetry Division of the ANS, a consultant to both governmental and industrial research organizations on shielding, and a contributor to technical and professional literature for much of his professional life, he would like to point out how much easier it is to be a critic than a creator.

SOME NOTEWORTHY PAPERS

Title Radiation Chemistry, Vol. 1

Editor Robert F. Gould

Publisher American Chemical Society, 1968

Pages xviii + 616

Price $16.00

Reviewer A. O. Allen

The organizers of this international conference sponsored by Argonne National Laboratory, August 12-15, 1968, under the chairmanship of E. J. Hart, spared no expense in bringing scientists from all over the world to their meeting. This volume contains 41 papers, plus 17 abstracts of papers not received in time for complete publication. Contributions from 13 different countries are included. The volume is an impressive testimonial to the widespread interest in basic research in the field of radiation chemistry.

It would be pleasant to be able to say that this compilation presents a comprehensive picture of the present state of radiation chemical science. Unfortunately, this is not the case. Few contributors chose to present a general review of a topic of any breadth. Instead, we have mainly detailed accounts of new experiments, which might have appeared in, e.g., the *Journal of Physical Chemistry*. It is impossible to review each paper in this space. We will mention a few which seem to be of broadest interest.

About half the papers are classed under *"Aqueous Media"*. Several deal with the hydrated electron; R. M. Noyes discusses its thermodynamic properties; D. C. Walker reviews what is known of its role in non-radiation produced reactions, e.g., Na + H_2O; K. Schmidt and E. J. Hart show how useful yields of e_{aq} can be generated photochemically. Most of the other papers present new detail regarding specific reactions brought about by radiation in aqueous solutions of various sorts.

Papers classed here under "Biology" are not really concerned with biology, but rather with radiation effects in chemical compounds of biological interest, such as proteins, amino acids, or nucleic acid components, or with large molecules such as dyes which are apparently thought to behave under radiation like biologicals. The impression one gets is that the chemical changes are complicated and despite much work are little understood in detail. In the case of protein radiolysis, a beginning has been made through the persistent efforts of W. M. Garrison and his co-workers over a period of many years. One paper in this section is noteworthy for its concern with building molecules up by radiation, rather than tearing them down: N. Getoff and G. O. Schenck synthesized the amino acid cystine by gamma-irradiation of a solution containing ethylamine, sodium bicarbonate, and hydrogen sulfide, with the surprisingly high yield G =1.65. This section also includes an interesting review of G. E. Adams, et al. on rates of electron transfer reactions in solution, including data on a large variety of active electron donors, organic and inorganic.

The third section, "Dosimetry", has only six papers. Five are on methods of measuring radiation doses in specific situations; the sixth is of more general interest, being a review of the status of theoretical calculation of radiation-chemical yields and the track structure, by Santar and Bednář of Czechoslovakia. A theoretical paper on structure of heavy particle tracks by Mozumder, Chatterjee, and Magee of Notre Dame, Indiana was included in the *"Aqueous Media"* section. These papers deserve careful reading by everyone interested in the basic principles of radiation chemistry; and the extensive theoretical work of the Czech school deserves much wider appreciation than it has had in this country.

The high price of these volumes will deter their purchase by many libraries. The same amount of material, edited and printed to the same high standard by a regular journal, would cost subscribers only about a third as much. This material, however, should be made available to all active researchers in the field of radiation chemistry.

A. O. Allen (PhD, Chemistry, Harvard University, 1938) was associated with the wartime development of nuclear reactors at the University of Chicago. Since then he has devoted himself to research in the field of chemical effects of high energy radiation, first at Chicago, then at Oak Ridge, and since 1948 at Brookhaven National Laboratory where he is senior scientist. His interests include radiation-induced reactions in aqueous solutions, radiation effects in heterogeneous systems, and measurement of ionization yields in irradiated insulated liquids He is a past president of the Radiation Research Society

A MUST FOR LIBRARY BOOKSHELVES

Title Radiation Chemistry, Vol. II

Editor Robert F. Gould

Publisher American Chemical Society, 1968

Pages xvi 558

Price $16.00

Reviewer D. Metz

This volume, a companion to the one reviewed above, contains those papers presented at the ANL-sponsored International Conference on Radiation Chemistry in the sessions entitled "Gases, Solids, and Oranic Liquids," as well as several plenary session papers addressed to the same general areas. Inasmuch as the book was available at the time