Physics of Nuclear Kinetics. By G. Robert Keepin. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts; (1965), 435 pp, Price $12.50.

In the opening paragraph of his preface Dr. Keepin expresses a concern for the appropriate timing of this book. This reviewer commends him for an excellent choice of timing. The simple fact that 561 references are listed (some duplicated) indicates that an authoritative digestion is needed. The scope covers the nuclear physics, reactor measurements, and the theory of reactor kinetics. In the study of reactor transient characteristics, where rapid development in understanding and application can be foreseen, this book should prove valuable for its stimultaion, even though the probability of obsolescence for this part of the book is higher.

The first five chapters essentially convey a physical understanding of the process of fission, manifesting the energetics that relate the fission fragments, neutrons, and gamma rays associated with fission. The sections on delayed neutrons are, of course, those written most intensely. It is interesting that the fitted six-group period and yield data are recommended for reactor kinetics application in preference to five- or nine-group fitted data or radiochemical data. Photoneutron production is included, since it is often significant in reactor kinetics. The emphasis on physical understanding and the digestion of available data are the essential features of these chapters.

The second group of five chapters is devoted to applications, and discusses both theoretical and experimental methods in various aspects of reactor kinetics. The relation of reactivity, and of various types of changes in reactivity, to kinetic responses is developed in these chapters, the last chapter being devoted to system stability. These sections emphasize approaches developed at Los Alamos and these are, of course, largely applicable to the highly enriched fast reactors in use there. Many aspects of the kinetics problem in large (power) reactors or the required approaches are not mentioned. In particular, stability is discussed as a safety problem, while it is more likely to be considered an operating problem or limitation.

For those working in the field of reactor science and engineering, it is inevitable that *Physics of Nuclear Kinetics* will be a valuable and authoritative source of data. The many tables and charts are presented in excellent, useful fashion. They cover both the data of "fission physics," once a fission has been initiated, as well as the digestion of these data into the form most directly useful to the reactor physicist. The appendix includes tabulations of several functions, such as reactivity vs period and the zero-power transfer function for three fissile isotopes.

The great contribution of *Physics of Nuclear Kinetics* lies in its value as a reference work. It is likely to be considered definitive in the presentation of nuclear data basic to reactor kinetics. Although students of nuclear engineering will find this a very valuable addition to their libraries, it is not well suited to stand as a text, since the theoretical treatments in the chapters on reactor kinetic behavior are in some cases sketchy. Despite this shortcoming, it is probably the best book available for use as a text in reactor kinetics.

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About the Reviewer: W. Rudolph Kanne received his PhD in physics at the Johns Hopkins University in 1937. Before joining the General Electric Company in 1946, he was associated with the University of Wisconsin, the Illinois Institute of Technology, the University of Chicago and the DuPont Company. He is presently Manager of Core and Fuel Engineering at the Atomic Power Equipment Department of the General Electric Company in San Jose, California.

Carbides in Nuclear Energy. Volumes I and II, edited by L. E. Russell, B. T. Bradbury, J. D. L. Harrison, H. J. Hedger and P. G. Mardon, Macmillan and Co., Ltd., London, England; St. Martin's Press, Inc., New York is U S distributor for this book, 966 pp, $42.00, (1964).

These volumes constitute the record of the proceedings of an international symposium on the technology of uranium, plutonium and thorium carbides held at Harwell in November, 1963. Sixty-seven papers were presented and discussed at the symposium, and these have been faithfully recorded and presented, with abstracts in three languages. Twenty-five of the papers have to do with the subject of synthesis and fabrication of carbides, nineteen deal with phase relations, eighteen are concerned with physical, chemical and mechanical properties, and five introduce the subject of irradiation damage to carbides. The symposium was arranged to bring together scientists and engineers from laboratories throughout the world which have been engaged in research efforts on these carbides as nuclear fuels. As a result, some of the papers represent studies just recently completed, and other papers fall in the category of research in progress. The over-all effect is to provide an excellent cross-sectional view of the-state-of-the-technology of nuclear carbides as it existed in November, 1963.

A great variety of new physical, mechanical, chemical and constitutional data on nuclear carbides was presented for the first time at this conference. In addition, some controversial areas of knowledge were apparently cleared up. For example, the formation of uranium sesquicarbide (U_2C_3), which has a large and complex unit cell, is shown to occur by a "nucleation and growth process," which can be described by conventional time-temperature diagrams and which is characterized by long "incubation periods" at temperatures as high as 1400°C. Likewise, three separate investigations produced results showing convincing evidence that uranium monocarbide (UC) can form a solid solution containing up to 35 to 37 mole% of the hypothetical phase, "UO."

On the other hand, some new areas of controversy became apparent. Uranium-plutonium carbides are of considerable interest as fuels for fast reactors; but conflicting views were presented with regard to the magnitude of the problem of volatilization of plutonium during fabrication of these fuels. A number of less serious controversies became apparent in connection with the large amount of constitutional information that was presented. The existences of a number of new phases such as UC_{1-x} and $UNiC_2$ were proposed, and it quickly became clear that more information about the exact compositions, structures and temperatures of stability of these phases was needed.

A number of pleasant surprises with regard to correlations between the results of different investigators came to light at this conference. For example, J. J. Norreys found that departure from stoichiometry and alloying with tung-

sten had a profound effect on the compressive creep behavior of UC. At 1300°C at a stress of 6000 lb/in.^{2}, a 50.5at.%C-U alloy showed a strain of less than 2% in 30 h, while a 49.5at.%C-U alloy showed a strain of over 24% in 30 h. These out-of-pile creep data were dramatized by a striking correlation with irradiation results reported by J. Crane and E. Gordon. After long-term irradiations at centerline temperatures estimated to be about 1060 to 1200°C, hypostoichiometric uranium carbide showed fission-gas releases an order of magnitude greater and density decreases four times greater than stoichiometric uranium carbide.

To a person interested in obtaining the views of the experts with regard to the technology of uranium, plutonium and thorium carbides, the record of this symposium will prove a gold mine. It will be many years before all the property data presented at this symposium are extracted and presented in handbooks; and it will probably take many additional years before the economic realities of actual production experience allow choices to be made between the various syntheses and fabrication techniques described in these volumes.

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About the Reviewer: Walston Chubb joined the Battelle staff in 1951 and is now a Fellow in the Materials Technology Division. For the past seven years he has been technical manager and consultant for a comprehensive research program to develop uranium carbide, its modifications, and associated structural materials as components for high-temperature nuclear reactors. In addition, he has been engaged in research on various other reactor materials including the alloys of zirconium, uranium, thorium, niobium, chromium and iron-chromium-aluminum, and a number of intermetallic compounds, including beryllides and nitrides, as well as carbides. Mr. Chubb is registered as a Professional Engineer in the State of Missouri and is a member of the American Society of Metals, the American Institute of Mining and Metallurgical Engineers and the American Ceramic Society. He received his technical training at Harvard and at the University of Missouri at Rolla.

This review by A. J. O'Donnell covers the following four books, which were published by McGraw Hill, New York (1964). They may be purchased as a set for $62.50 or singly at $18.00. **Radioisotopes and Radiation,** *Recent Advances in Medicine, Agriculture and Industry.* John H. Lawrence, Bernard Manowitz and Benjamin S. Loeb, 138 pages. **Research, U. S. A.,** *Knowledge for the Future.* Albert V. Crewe and Joseph J. Katz, 215 pages. **Education and the Atom,** *An Evaluation of Government's Role in Science Education and Information, Especially as Applied to Nuclear Energy.* Glenn T. Seaborg and Daniel M. Wilkes, 150 pages. **Nuclear Power, U. S. A.,** Walter H. Zinn, Frank K. Pittman and John F. Hogerton, 90 pages.

These four volumes were written and their format designed especially for presentation by the United States at the Third Peaceful Uses Conference in 1964. The general reaction to the books: Attractive, colorful, modernistic designs on the dust jackets; drab covers; an illustrious array of authors; extravagent (or merely American?) titles; unusual size (9 1/4 in. × 9 1/4 in.); generously and well illustrated; continuity of narrative frequently difficult to follow due to random distribution of illustrations with explanatory text set in similar type; an odd group of bedfellows for presentation to a sophisticated gathering of nuclear scientists and administrators.

The books are written with the general reader in mind, some more successfully than others. However, the expert in one field (e.g. nuclear power) may find the other three volumes valuable in gaining a better perspective of over-all progress in peaceful applications of nuclear energy.

The Third Peaceful Uses Conference had as its prime focus nuclear power, and without question the United States had most to say on this subject in terms of experience. The volume devoted to *Nuclear Power, U. S. A.* provides an interesting and informative history of developments in this field up to April 1964. Because of the rapid pace of development in nuclear power, such a book can, at best, provide only an instantaneous picture of the state of the industry as of the date of writing. Those having lived (or suffered) through this period of development may take exception to the authors' treatment of the subject as a smooth and orderly transition.

Appendix B provides an excellent chronology of events, and this reader was pleased to see frequent and appropriate reference to the International Atomic Energy Agency. Throughout the book the illustrations support the associated text most effectively.

Education and the Atom is the most unusual book of the four. It serves its senior author as a vehicle to analyze the general subject of Federal support of research and education, and to set forth several thought-provoking suggestions for future attention at the Executive and Legislative levels of the US Government. For example, the "... creation of a National Humanities Foundation" is suggested (p 18), as is an Institute for Communications Research (p 102). Questions are posed as to whether "... we should have some system of representative government for science," and should we not move toward a unified policy of federal support of research.

In considering further expansion of government-sponsored research the National Laboratories receive considerable attention, as does the general problem of wise selection of appropriate subjects and scientists for support. Of equal importance, but ignored in this (and too often in the administration of government-financed research) is the question "what subjects, what scientists, what laboratories should be phased out or dropped from the Federal Budget?".

That portion of the book in support of the title makes clear the important actions of the AEC in the field of information dissemination—both technical and nontechnical—through education, publications, films and conferences. In the context of East-West Exchange the role of the International Atomic Energy Agency is apparently not fully appreciated as the only organization extant in which the complex scientific, political and administrative interfaces are conducted on an effective, continuing, daily basis between East and West, as well as between industrialized and newly emerging nations.

Radioisotopes and Radiation presents an impressive story of the most widely realized peaceful application of nuclear energy. The pictures tell the story more effectively than does the text, which is burdened with some ponderous sentences. In contrast to the other volumes in the set the authors cite many individual contributors in the applications of radiation and radioisotopes. It is unfortunate that a consistent approach was not taken throughout the set;