expense of the more commonplace makes it a very poor pedagogical instrument for the uninitiated.

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About the reviewer: Bob Albrecht is a professor of nuclear engineering at the University of Washington. He has been teaching nuclear reactor dynamics for the past 11 years and doing research related to stochastic fluctuations in nuclear reactor observables. Dr. Albrecht obtained his PhD at the University of Michigan in 1961 and received the Mark Mills award in that year for a paper based on his dissertation. During 1967-1968 he spent a year doing research at Kernforschungszentrum Karlsruhe.

Optimal Control of Nuclear Reactors. By Ronald R. Mohler and C. N. Shen. Academic Press, Inc., New York (1971). 320 pp.

This book is based on and primarily features specific research by the authors in the control of nuclear powered rocket engines. Its first two chapters give a condensed survey of reactor kinetics and optimal control fundamentals to refresh the memories of those already knowledgeable in these areas. Readers not so qualifying are likely to be left "standing at the starting gate." The last chapter gives selected optimal control topics from other sources. Remaining is the main body of the text which is devoted to analytical and numerical applications in nuclear rocket control.

Typical subjects treated from the standpoint of their utilization in optimal control are the Euler-Lagrange equation, the Bellman-Hamilton-Jacobi equation, the maximum principle, and linear programming. Typical problems solved utilizing these methods are reactor startups with minimum time or minimum propellant consumption. In these problems typical imposed constraints would be not exceeding control capabilities or not exceeding limits on thermal stresses.

A more descriptive book title might be "Optimal Control Theory and Its Application to Nuclear Rockets." While the needs of rocketry are quite unique and specialized, nevertheless many general aspects of control theory and applications are clearly presented. In this respect the two control chapters written by Shen are outstanding. They overlap and repeat some material in Mohler's chapters. But perhaps Shen goes too far in lucidity when a step by step numerical conversion is given to show 1 g/cm^3 of water contains 6.94 lb/ft^3 of hydrogen.

The chapters by Mohler also are largely derivations of reactivity control methods of achieving a minimum cost (ex., fuel usage) functional. A variety of methods is treated in detail—even down to pages of FORTRAN statements of a quasi-linear programming algorithm. Computer utilization in achieving results is a necessity and here this book is quite up to date.

Specific examples of results—graphs of power, reactivity etc. during rocket startups—are frequent. These remind one of the practical utility of the methods presented. The reader is therefore intermittently brought back from the abstract world of the calculus of variations and into the world of concrete practical reality. Also assisting in this respect are discussions of the physical processes involved and of intuitive rationale for results obtained.

There is no special glossary, though Shen's chapters define some terms as they are used. A policy for defining control and reactor jargon or for defining lesser used mathematical terms might exist in a school text, but would not be required in a book of this nature, aimed at the experienced specialized researcher. An example of the lack of a policy is defining "bang-bang" control on the last pages, after it has been repeatedly mentioned throughout the book.

It is not to be expected from the book title that one would find an excellent treatment of heat transfer and thermal stresses spanning a third of a chapter, and also lucid extensive discussions of the neutron kinetics equations at various places. But with these topics adequately treated in many texts, it would have been better to devote their space to control theory—such as expanding the variety of optimum control topics in the last chapter.

The authors intended this book for systems theoreticians, nuclear engineers with a strong background in control theory, and graduate students specializing in this field. It will well serve this select group, who, moreover, should no doubt find the bibliographies listing original papers well worth pursuing.

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Fast Reactor Safety. By John Graham. Academic Press, Inc., New York (Dec. 1971). 367 pp. $18.00.

The author's preface states that this book is intended "as a university text for reactor safety applied to fast reactors in general and applied to liquid metal-cooled fast breeders (LMFBRs) in particular." The author also intends the book "as a text for graduates and undergraduates in nuclear engineering who are attending courses in reactor safety." Within this context, the book approaches its objective, albeit with mixed success and a rather different emphasis than I might choose. The publisher's statement on the book jacket that "this volume presents the latest information on the whole field of safety as applied to the fast breeder reactor power system," however, is not valid. Nor is the jacket statement that the book will be of "great interest to . . . practicing nuclear engineers and power engineers who want to acquire a working knowledge of nuclear safety." Finally, by way of introduction, the book does not, as stated in the forward by J. J. Taylor, "examine, as quantitatively as our present technological capability permits, the specific features of safety of the fast system."

Then, what is the book? The main chapter headings are as follows: Safety Evaluation Methods, System Disturbances, Safety Criteria, Special Fast Reactor Characteristics, Containment, and Licensing.

The first chapter gives introductory material in fairly abbreviated form on point kinetics, thermal effects, reactivity feedback for fast reactors, some aspects of system effects, and fault-tree analysis. Here, as in later chapters, thermal reactors are frequently used as a point of departure to introduce fast reactor concepts. The discussion is mostly qualitative and is sometimes imprecise or incomplete in the physical explanation of the phenomena. Except for the fault-tree section, the topics are little more than identified. For example, the effect of sodium loss on the Doppler effect is not mentioned, and only a page is devoted to the modeling of sodium voiding, while there is a bit more discussion of stability in BWRs and of two phase flow in water reactors. A more detailed examination of reactivity effects would have been helpful, in my opinion.

The second chapter discusses in introductory fashion differences in systems and system disturbances between the low pressure sodium-cooled and the high pressure gas- or steam-cooled fast reactor concepts. Several examples of reactivity perturbation effects are illustrated. There then follows a relatively more extensive, elementary discussion of techniques for assessing system stability (e.g., description of Nyquist criterion, Bode plot, etc.). The Fermi I reactor stability analysis is quoted at some length.

The third chapter introduces the idea of failure criteria for fuel elements and the phenomena that may induce failure and influence the future course of a transient. A possible accident classification system is then mentioned. The AEC General Design Criteria for light water reactors (LWRs) are discussed in terms of their applicability to LMFBRs. The text appears to assume a reader who knows LWRs and the AEC criteria.

The third chapter begins to evince a considerable amount of subjective statement by the author; his opinions come out on various safety matters even more strongly in Chaps. 4 and 5. Here and in later sections, Fermi I, EBR-II, and Dounreay, all 1950s vintage reactors, are used to illustrate systems. The examples may not be illustrative of the larger, oxide-fueled LMFBRs of today and tomorrow.

Chapter 3 closes with a brief, but well-done summary of the relation between safety features and specific postulated accidents.

What I would consider the heart of fast reactor safety, namely a discussion of fast reactor accident analysis, has only 60 pages devoted to it in Chap. 4. The topics treated include voiding effects, criticality in super-prompt accidents, local failure effects, and sodium fires, With so limited a space, the treatment is mostly qualitative, with little examination of analytical methods. The greatest emphasis has been placed on fuel failure propagation, where the treatment is relatively more thorough. This chapter includes a brief discussion of experience with Dounreay, Rapsodie, Fermi I, EBR I, EBR II, etc. Here, as at various places in the book, minor errors have crept in such as: p. 232, Rapsodie: "The Doppler coefficient reduces to zero after 150 days at power due to fuel expansion within the central fuel void."

Chapter 5 on Containment begins with 25 pages on matters of general interest to reactor siting, such as radiological limits and effects, meteorology, and other site considerations. A series of potential design basis accident initiators for the LMFBR is identified by the author, and then each is discussed qualitatively and subjectively, with fairly strong, unqualified opinions presented. In particular the author states several accidents are incredible but gives the reader no quantitative definition of the term. This chapter concludes with a brief discussion of potential effects of an explosive energy release on various aspects of the primary containment, and the matter of post-accident heat removal from a destroyed core.

The last chapter presents a short description of the regulatory process in the USA; it is followed by a short appendix which very briefly describes many computer codes applicable to fast reactor safety analysis.

I find that my impression of the book, coming from a vantage point of considerable background in the regulatory process, agrees generally with that of a younger colleague at UCLA. The book does provide a readable introduction to much of fast reactor safety, and, as such, would be helpful for seniors or first-year graduate students having a first exposure to reactor safety. It is not a "reference book." And, for serious examination or an analytical presentation of almost any subject discussed, reference to other sources is required.

Writing a textbook on fast reactor safety is a most difficult chore. The field encompasses many disciplines and various facets of engineering, and the potential reader ranges widely in his degree of sophistication. Mr. Graham is to be applauded for providing a working tool and a basis on which to build.

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About the Reviewer: David Okrent is now professor of engineering and applied science at the University of California at Los Angeles following a 20-yr association with Argonne National Laboratory. He served the U.S. Atomic Energy Commission as a member of its Advisory Committee on Reactor Safeguards since 1963, and was its chairman during 1966. In 1963 he was a visiting professor at Washington University and, more recently, occupied a professorship at the University of Arizona in the Argonne Universities Association Distinguished Appointment Program. Dr. Okrent received his undergraduate training at Stevens and completed his graduate studies at Harvard.

The Elements of Neutron Interaction Theory. By Anthony Foderaro. MIT Press (1971). 585 pp. $19.95.

This book is a clearly written exposition of neutron interaction theory for a specific audience, namely, first-year graduate students in nuclear engineering. However, it would appear to be useful also for anyone planning to do cross-section analysis, in particular, experimental physicists and those engaged in the evaluation or calculation of neutron cross sections for technological applications. Physics graduate students would find it helpful as an overview of the same area. It covers a set of topics that makes it essentially unique, although the individual topics are covered in separate text-books and review articles. Another feature that makes it useful for its intended purpose is the level of exposition. It is generally below the level of a graduate text in physics, yet gives the reader a comprehensive introduction to the main theoretical tools employed