Nuclear Fission. By Robert Vandenbosch and John R. Huizenga. Academic Press (1973). 422 pp. $28.50.

We in the nuclear energy business live on fission. The basic interpretation of this process was given promptly after its discovery through the liquid drop model. An important deepening of the understanding was arrived at by A. Bohr in 1955 when he pointed out the dominant role of the intermediate state at the saddle point. The low excitation at this stage makes neutron induced fission a few-channel process in contrast to the expectation from the great variety of fission products. Finally, Strutinsky in the late 1960's found a way to introduce corrections to the liquid drop model to incorporate the shell features which are otherwise to prominent in the properties of nuclei. This led to the discovery of the double hump structure of the barrier in the actinide region which explained the existence of shape isomers which decay by spontaneous fission and the characteristics of subthreshold fission. The whole field is now in ferment and full of excitement. The appearance of a new book by two well qualified authors is thus an important event which raised hopes for a synthesis. They have only been partially fulfilled.

As to the format of presentation, no complicated nuclear theory calculations have been reproduced. However, many results are quoted and copiously illustrated by graphs and tables, although not always with enough explanations. Experimental arrangements are only described schematically if at all. Thus, with some exceptions, no great demand is made on the analytical skill of the reader, but he is assumed to have a thorough knowledge of general nuclear physics. Such concepts as the Nilsson model for deformed nuclei and its associated diagrams, the pairing energy, the Wood-Saxon potential are used but not explained.

The coverage of the material is encyclopedic. All isotopes for which fission phenomena are observed are included from the rare earth region to the heaviest known to date. Also all inducing agents are treated—neutrons, photons, charged particles and at all energies. No special emphasis is given to neutron induced fission of the common fissile and fertile isotopes, though, of course, this area is the richest in experimental information. The literature coverage is excellent. References are added to each chapter with full coverage of 1972 and a sprinkling of 1973, and a complete author index appears at the end. The table of contents is fairly detailed. However, in contrast, the subject index is rather short and not very helpful.

The presentation is rather rigidly structured. After an introduction on the discovery of fission and the scope of the book, an all too short chapter discusses the fission barrier. It does not quite convey the excitement this basic topic has engendered in recent times. The most elementary and physically clearest model for the origin of the double hump, the anisotropic oscillator, is not mentioned. After that the discussion is divided into three parts, the events associated with the transition state nucleus, the scission configuration, the post-scission phenomena. Even within these sections the chapters are strongly compartmentalized. This results in the necessity for many back and forth references when different processes are influenced by a common cause. The outstanding example is the structure and height of the fission barrier which plays a role almost everywhere.

The discussion is more extensive than intensive. Almost everything you always wanted to know about fission is touched upon, at least qualitatively. If there are discrepancies in experimental evidence or conflicting theoretical interpretations, arguments for all pros and cons are given with some restraints on definite judgments.

A special feature is the discussion of the angular distribution of fission products as induced by all agencies—photons, neutrons, or charged particles. The relevant chapters are in complexity and detail much above the level of the rest of the book. This is undoubtedly due to the fact that the authors have been very active in this field.

The greatest lacuna in our present understanding of fission is the lack of adequate dynamic models for the ascent to and descent from the barrier as well as a description of the scission process. The cataclysmic event of fission is one of enormous complexity with an interplay of collective and individual degree of freedom at mostly high excitation energies. Thus to this day no compelling explanation of the predominance of asymmetric fission has been achieved. The authors recognize this state of affairs and sum up the attempts which have been made to attack the problem. There are two opposite limiting courses which are tractable. The first is the adiabatic hypothesis according to which the individual particle states adapt continuously to the changing shape. The second is the sudden approximation where the nucleonic motion cannot adapt to the shape at all. The truth must lie somewhere in between, but with different degrees of freedom behaving differently.

Summing up, the book is mostly for the nuclear physicist who wants an overview of the large area of fission phenomena. It is somewhat less suited for the reactor physicist or engineer who wants extensive data on specific isotopes.

Finally, the definitive book on fission will only be written when a fuller understanding of the dynamics of the process has been achieved.

Lothar W. Nordheim

General Atomic Company
San Diego, California 92138

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About the Reviewer: Lothar Nordheim was already a versatile theoretical physicist of repute when in 1943 he was called to serve as a principal physicist to what has come to be known as Oak Ridge National Laboratory. There he learned the reactor business from the ground up and contributed materially to it. He has held academic positions at Purdue and Duke University. In 1950-52 he served as resident consultant at Los Alamos to assist in *weapons development. Since 1956, at General Atomic, he has been successively chairman of the Theoretical Physics Department, Senior Research Advisor, and Consultant. His activities have covered both basic nuclear physics as well as numerous aspects of reactor physics. From 1963 to 1972 he has served on the Advisory Committee for Reactor Physics of the U.S. Atomic Energy Commission. He is a fellow of the American Nuclear and Physical Societies and a member of the Editorial Advisory Committee of* Nuclear Science and Engineering.

Promethium Technology. Edited by E. J. Wheelwright. American Nuclear Society (1973). 416 pp. $22.50.

"Promethium Technology" is a monograph published under a cooperative program of the U.S. Atomic Energy Commission (USAEC) and the American Nuclear Society (ANS) in which special technical subjects are covered that are primarily of interest to the nuclear community. In this volume, work done primarily in USAEC laboratories on promethium and its compounds is summarized by Earl Wheelwright and nine other contributors who have special knowledge concerning various aspects of promethium research and development.

The volume is divided into 13 chapters covering the history of the discovery and identification of element 61, later named promethium, the chemical and physical characteristics of the element, the nuclear and radiation characteristics of the isotopes, separations chemistry, health-physics data, preparation and properties of the metal and oxide, analytical chemistry, fabrication of source, and the applications in medicine and industry.

On the whole, I liked the book. It gives a wealth of information on promethium (primarily ^{147}Pm, of course), and it should be a good reference for anyone planning to work with promethium. The literature search appears to have been quite thorough; the references cited are numerous and appear to be easily obtainable. It is doubtful that most researchers will be interested in much of the detail given, but it is helpful to have such a well-researched source document available to cover most questions that might arise in working with promethium.

While the monograph is an excellent source of specific information on promethium, several sections are also quite valuable as general references on basic nuclear technology. Chapters 3 and 4 by Van Tuyl on promethium formation, nuclear properties, dose rates, and shielding calculations are particularly noteworthy in that they are more clearly written and easily understandable than most textbooks and handbooks that I have seen on similar subject matter. For this reason, teachers may wish to consider this monograph as an auxiliary text, even though it is written about a specific element.

Wheelwright's Chap. 2 on chemical processing is similarly a good review of the general chemical technology encountered in separating and purifying fission products, including precipitation and several techniques of solvent extraction and ion exchange. Here again, the nonspecialist reader will find the descriptions of various kinds of elution techniques, the use of complexing agents, and the effects of process variables quite clear and easier to understand than those given in the average textbook.

That promethium is one of the more innocuous common radioisotopes is borne out by Chap. 7 on biological considerations. The 2.62-yr ^{147}Pm radiation is 100% soft beta (0.2246 MeV) plus a small amount of bremsstrahlung so that external exposure problems are minimal. Ingestion via aerosols into the lungs is the chief hazard. More data are given on ingestion studies than I have seen previously, most of which should be reassuring to the prospective promethium user. Practical radiation protection measures are discussed and useful data for controlling personnel exposure are given in Chap. 8.

The analytical chemistry section is short, to the point, and well referenced. As is always the case, an abundance of useful general chemistry of the element is brought out in the discussion of analytical chemistry. It was noted that this section deals only with the chemistry and does not mention the instrumentation and procedures needed for measuring isotopic contamination from 5.53-yr ^{146}Pm, 5.4-day ^{148}Pm, and 43-day ^{148m}Pm.

Promethium is customarily used in the form of the oxide. Chapter 10 is devoted to the prepartion of the oxide and a detailed description of its physical properties, ranging from thermal diffusivity to surface tension of the molten oxide. Most of these data were developed for calculations needed in safety and environmental impact statements. Information is also included on promethium-samarium systems (^{147}Sm is the nonradioactive daughter that grows in as ^{147}Pm decays) and the reactions of Pm_2O_3 with water.

Promethium metal was also needed to determine physical properties and for nuclear experiments. Wheelwright and colleagues prepared the metal by reacting $PmCl_3$ with calcium metal and iodine in a reduction bomb; a 92% yield of 96% pure promethium was obtained, which was cast, machined, and used for physical properties tests. The preparation of promethium metal by simultaneous reduction with thorium metal and distillation of promethium by Kobisk and Grisham at the Oak Ridge National Laboratory is also described. (Kobisk found that high-purity promethium metal, as with other high-purity rare earth metals, is quite ductile and can be easily cold-rolled into thin films.) The measurements of the melting point of promethium varied with test samples and methods but appears to be ~1100°C.

The uses of ^{147}Pm are chiefly for small heat sources or to generate milliwatts of electricity either by thermocouples or semiconductor devices. In all cases the oxide is compacted, usually pressed into cylindrical shape, and encapsulated in noble metals or superalloys. The final chapters are devoted to these operations and short descriptions of the applications up to this time.

I would recommend the monograph as a reference book to those interested in handling and using promethium. It also would be useful as a supplementary textbook, as was pointed out earlier in this review.

A. F. Rupp

113 Outer Drive
Oak Ridge, Tennessee 37830

March 18, 1974

About the Reviewer: A. F. Rupp (BSChE, Purdue, 1933) was assigned by the DuPont Co. to the University of Chicago's Manhattan Project in 1943; he worked on the original graphite reactor and plutonium processes at Clinton Laboratories (now the Oak Ridge National Laboratory) and at Hanford. In 1946 he organized the radioisotope program at Oak Ridge National Laboratory, which later also encompassed the stable-isotopes separations program. He was director of the isotopes program until retirement in 1973 and is now a consultant on radioisotopes, radiochemical processing, and waste management. He is a member of the American Chemical Society, and the American Institute of Chemical Engineers and is a Fellow of the American Nuclear Society and of the American Institute of Chemists.