Book Reviews

Nuclear Reactor Materials. By B. R. T. FROST AND M. B. WALDRON. Simmons-Boardman, New York, 1959. 79 pp., paperback, $2.75.

This book is one of a series of Nuclear Engineering Monographs providing succinct coverage of various reactor disciplines on a college student level.

This volume is based on a series of lectures by the Harwell Metallurgy staff. The six chapters cover the fields of Theoretical Metallurgy, Structural Materials, Fuel Materials, Liquid Metals, Ceramics-Cermets, and Corrosion. An excellent bibliography is provided for supplementary studies, plus a brief index.

The author-editors are the eminent Drs. Frost and Waldron, Principal Scientific Officers of the United Kingdom Atomic Energy Research Establishment at Harwell.

In view of the size of our own Reactor Handbook Materials volume the task of condensation to 79 pages is formidable indeed. The authors have provided an admirable panorama of the highlights of the nuclear materials spectrum. The text is very well written and is generally adequately fortified by suitable tables, charts and drawings. Typographical errors are infrequent; the reviewer will contact the authors directly regarding corrections and possible changes for a revised edition.

As would be expected the text has a slight bias toward gas-cooled reactors. Also the reviewer senses perhaps excessive tact in the treatment of some of our American reactor projects; for example, the Liquid Metal Fuel Reactor (p. 46) and the Homogeneous Reactor (p. 73). The "no details available" on the Seawolf is disturbing (p. 44); this reactor had many interesting features which we should make available, particularly since it has been displaced for submarine propulsion.

Now let us consider a few specific areas as follows: A good supplement to the theoretical metallurgy chapter would be the Williams and Homerberg text (on which the reviewer was weaned). The beryllium ductility dream is now showing faint promise of realization in the zone purification work by Wilsdorf at Franklin Institute (p. 30). There is considerable interest in the recent development of pyrolitic graphite and also the so-called "impervious" graphite (p. 61). The motivation behind our flurry on hydrides is their remarkably high hydrogen content per unit volume (p. 62). The thorium description might as well mention the activity build-up after reprocessing; this is no small problem (p. 40).

For his dessert the reviewer now selects zirconium and hafnium, having developed a fondness for these metals, as coordinator of their development in the Naval Reactors Branch. The statement on page 33 regarding the development of zirconium technology is not clear. Close examination of the careers of titanium and zirconium will reveal that despite similarities and a stronger start for titanium, the zirconium field did pioneer in several important areas. This debt of "big brother" to "little brother" has not been generally appreciated. Regarding the Zr vs. Al battle one should bear in mind that whereas designers once prayed for corrosion resistance they now clamor for strength (pp. 28, 72).

Finally, a section on control (p. 62) is hardly complete without hafnium (p. 73) and Cd alloys, neither belonging in the category of the chapter title.

In conclusion the authors are to be commended for their contribution in this compact materials volume. The intended audience will find it both enjoyable and quite useful.

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(Editor's Note: Mr. Kerze is currently Chief of the Technical and Economic Data Section of the U.S. Atomic Energy Commission's Division of Reactor Development. His experience in reactor materials is extensive. After working with Prof. H. C. Urey on H_2-D_2 catalytic exchange and UF_6 purification at Columbia University in 1940 to 1942, he taught Chemical Engineering at New York University for 4 years. Following this, he spent 4 years at Oak Ridge National Laboratory in the development of MTR fuel elements, as well as the beryllium reflector and the control and shim rods for that reactor. From 1950 to 1955 he was on Admiral Rickover's staff where he was concerned principally with the development of zirconium and hafnium. He was principally responsible for the development of the hafnium control rods for naval reactors. From 1955 to 1958 he was in charge of spent fuel reprocessing programs.)

Nuclear Propulsion. Edited by M. W. THRING. Butterworths, London, 1960. 300 pp., 80 figures, index. $9.50.

Nuclear Propulsion, edited by M. W. Thring of Sheffield University, is a collection of 16 related essays, written by 13 different authors, intended as an introduction to the field of nuclear propulsion. Its contents span the entire range of scientific specialties involved in this field: nuclear physics, reactor design, the thermodynamics of jet and rocket propulsion, heat transfer, metallurgy, ship design, and some aspects of medicine and biology. Because of this the essays are very simply written. Those devoted to basic sciences record coherently, but without any proof or argument, the essential relevant facts. Others sketch the limitations of the various technologies. The rest describe the constraints put by these facts and limitations on the design of nuclear propulsion systems. The style is introductory, and none of the chapters requires anything more than an ordinary scientific or engineering background to be understood.

The book begins abruptly with a chapter about the structure of the nucleus and nuclear reactions, there being neither a preface nor an introductory chapter. This is bad, since it prevents the potential reader from finding out what the actual contents of the book are, what program is to be followed in the book, what background is assumed, and thus, what is most important, whether the book is suitable for him. It is true that the book has a table of contents, which should supply some of this information; but it consists only of chapter titles, and such a cryptic title as "Progress in Nuclear Propulsion" reveals little of the chapter's contents.

The first chapter is a very well-written summary by R. Street of the University of Sheffield of the basic facts and phenomena of atomic and nuclear physics. It describes in a simple, clear style such topics as: the nuclear atom and atomic structure, the stability of nuclei, the equivalence of mass and energy, the semiempirical mass formula, the laws of radioactivity, the detection of radioactivity, and nuclear reactions and fission. The second chapter, written by C. C. Horton of Rolls-Royce, Ltd., is entitled "Reactor Physics," and covers the interaction of neutrons with matter and the achievement of chain reactions. Here the style is not as smooth as in the first chapter due to the author's attempt to cram too much detail into just a few pages. If the author had contented himself with an entirely qualitative but nonetheless complete description of all the factors affecting the neutron economy (thermal fission, fast fission, fast leakage, resonance escape, xenon poisoning, etc.), he would have done better than he did trying to introduce some of the mathematics involved, e.g., diffusion theory and the calculation of the criticality of some bare reactors. Finally, the chapter is marred by two serious errors: on page 38 the Maxwell spectrum is written incorrectly and on page 45 the erroneous statement appears that ". . . p is a rather sensitive function of the fuel geometry, and is greatest in natural uranium fuel due to the large absorption resonances in the nonfissile U^{238}." Here p should be replaced by $1-p$, the resonance capture probability.

The third chapter, written by Thring himself, deals with the thermodynamics of jet and rocket propulsion. After a brief introductory statement, there is an analysis of the efficiency attainable in open and closed cycle gas turbines and in turbojet aircraft engines. The second half of the chapter discusses the exit velocities attainable with rocket engines. The chapter is written in rather more detail than is warranted by the tone of the rest of the book. The fourth essay, by D. G. Ainley of the National Gas Turbine Establishment, is a simple and clear one which describes the properties and limitations of ordinary gas turbines as well as the special features of nuclear gas turbines. Chapter 5, written by C. Hulse, is entitled "The Design of Nuclear Reactors," and discusses in an elementary way all the phenomena which affect the choice of fuel, moderator, coolant, and reactor type. It does a commendable job of summarizing a wealth of information, but is marred by several bad misprints. Due to an unfortunate inversion of two sentences on page 93, the remark "It should be noted that this system is not possible when natural uranium is used as the fuel" is applied to *heterogeneous* rather than homogeneous systems.* Figure 5 on page 96 does not match its caption and is in fact entirely the wrong drawing.

The sixth chapter, by A. R. Entwisle of the University of Sheffield, is a discussion of metallurgical problems. The first half of the chapter describes the general phenomena (allotropy, growth, swelling, compatibility, etc.); the second is mainly a detailed discussion of the metallurgical aspects of the Shippingport reactor. In Chapter 7, R. G. Siddall of the University of Sheffield competently surveys the heat transfer problems occurring in nuclear engineering. Chapter 8 is a short anonymous chapter on reactor control and instrumentation, compressed unfortunately to the point of unintelligibility. Chapter 9 is a commendable essay written by E. Norton of Yarrow and Co., Ltd., a man who obviously knows his business, which compares nuclear and conventional propulsion systems for ships from an economic point of view. Chapter 10, due to S. G. Bauer of Rolls-Royce, Ltd., is also good, being directed to discussing what can be said about the choice of ship and the choice of reactor. Chapter 11, also anonymous, is entitled "Some Observations on the Application of Nuclear Power to Aircraft," and tries to project the nature of nuclear-powered aircraft. Although this chapter is in general well-written, there occurs in it the almost unforgivable slip: "This xenon isotope 135 has a very high fission (sic) cross section. . . ." Chapter 12, by J. E. R. Holmes of A. E. E., Winfrith, is entitled "Progress in Nuclear Propulsion," and appears to be a summary of the three chapters preceding it. Chapter 13 is a very well-written introduction to the general features of rockets, the limitations of chemical rockets, and the possibilities for nuclear rocket propulsion due to H. D. Turner of the University of Sheffield. The only drawback to the chapter is that the books recommended for further reading are specified only by title, neither the author nor the publisher being given. Chapter 14, also written by H. D. Turner, is called "The Preparation, Storage and Properties of Working Fluids." This chapter is principally devoted to the liquefaction and storage of hydrogen. Chapter 15 is a short, but clear, description of the uses of ceramic materials in reactors by J. White of the University of Sheffield. The last chapter, 16, is entitled "Medical and Biological Aspects of Life in Sealed Cabins," and was written by G. R. Hervey of the University of Sheffield. It is a discussion of the measures which must be taken to maintain a crew over the long periods of time which may be involved in trips in nuclear-powered vehicles. Such things as the composition and purification of atmospheres, the control of capsule temperatures, and the estimation of human food and water requirements form the content of this chapter. Perhaps inclusion of this chapter among 15 essays on the engineering aspects of nuclear propulsion is a bit far-fetched, but I found the information interesting and have no complaint to make.

The book gives the general impression of having been hastily prepared. It contains a great many misprints and errors, the very worst of which have been mentioned here. These inaccuracies are annoying at best and at worst may be quite misleading. Quite often symbols and terms are used which are not defined in the text. Occasionally unintentional changes in notation occur, especially the sudden change from a capital to a lower case letter or vice versa. There are some spelling errors; most are typographical errors, but the consistent rendition of "propellant" as "propellent" in Chapter 13 is an undignified mistake. Finally, there is much repetition: the phenomenon of xenon poisoning is

* Even when applied to homogeneous systems the statement is not quite right, since solutions of natural uranium in D_2O can be made critical.

explained to a greater or lesser extent in no less than five different places in the book.

In spite of these defects, however, I think this book is well worth reading for anyone with a technical background who is looking for an introduction to the field of nuclear propulsion.

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Heavy Water Lattices. Compiled by H. D. BROWN. International Atomic Energy Agency, Vienna, 1960. 142 pp. $1.50.

This booklet serves as the proceedings of a panel convened by the International Atomic Energy Agency in September 1959 in Vienna on the lattice physics of heavy water reactors. Its chief value is as a record of that meeting, since its value as a status report has largely been diminished by time and since some of the technical material presented in a preliminary or fragmentary fashion has since been published more fully.

The book contains two sections—a Proceedings and an Appendix. The 24-page Proceedings section contains a very brief summary of the topics discussed during the week-long meeting. Program status reports were given by the panel members from Canada, France, Norway, Sweden, the United Kingdom, and the United States. These status reports indicate the degree of effort being made in heavy water reactor physics at that time. An interesting table summarizes estimates of the accuracy of buckling measurements that have been and are being performed, from which it was concluded that measurements made in the different laboratories agree within the probable errors.

The 102-page Appendix contains 16 supporting technical papers solicited from the panel members and their colleagues. These papers cover a wide variety of topics. Of greatest value are the papers bringing up to date the various procedures for correlating experimental buckling measurements that had been described at the 1958 Geneva Conference. These papers include a complete listing of the equations used in Sweden for lattice calculations, a previously unpublished correlation from Harwell, a list of corrections to previously published buckling measurements from Savannah River, and a French analysis of some Savannah River experimental results. As far as I know this information is not widely available elsewhere.

The most important experimental paper has since been published.* Among the other experimental papers are:

1. A list of buckling values obtained in the ZEBRA exponential facility in Sweden on fuel assemblies of UO_2 rod clusters (both with D_2O coolant and with the coolant passages empty),

2. Temperature coefficient measurements measured in ZEEP at Chalk River,

3. A ZEEP experiment on the effective cross section of Zircaloy-2,

4. Some preliminary results of ZEEP experiments in which the neutron flux inside several fuel pieces was measured with several different detectors to give an indication of the departure of the reactor spectra from dE/E, and

5. ZEEP measurements on the reactivity effect of removing coolant from lattices of multiple rods (published more fully in CRRP-942).

This paper-bound book was published promptly, the printing is excellent, the drawings are well reproduced, and there is only a minimum of typographical errors.

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Elements of Nuclear Engineering. By GLENN MURPHY. Wiley, New York, 1961. 213 pp.

Professor Murphy is Head of the Department of Nuclear Engineering at Iowa State University and also serves as senior engineer at the Ames Laboratory of the U. S. Atomic Energy Commission. He has served as Vice-President for the American Society of Engineering Education and is at present chairman of the Committee on Objective Criteria for Nuclear Education, a joint undertaking of the American Nuclear Society and the American Society of Engineering Education.

The objective of this book is "to present at the college senior level a survey of the field of nuclear engineering for the purpose of indicating its scope, potentialities and limitations." It "is not a text in nuclear physics, a treatise on reactor theory, or a handbook on industrial use of radioisotopes." It is "simply to help undergraduate students in engineering decide whether or not they wish to explore this exciting field."

The text material is divided into three sections. Section I, comprising the first 73 pages, covers an introductory chapter on the engineer and nuclear energy, nuclei and nuclear reactions, and radiation. In Section II, covering 77 pages, reactor theory and engineering considerations of nuclear power are treated. Section III contains 49 pages devoted to radiation detection, shielding, radiation effects, and industrial uses of radioisotopes.

It appears to me that this division does an injustice to the chemical engineering aspect of nuclear engineering. A closer look reveals that slightly less than two pages are devoted to the topics of fuel reprocessing and the control of radioactive wastes. At the risk of appearing to be a traitor to my own interests in the field, I am persuaded that the problems encountered in waste control and fuel reprocessing are at least as difficult and challenging as those of reactor physics, for example. Therefore, the two pages (comprising 1% of the total) devoted to fuel reprocessing and waste

* E. HELLSTRAND, T. BLOMBERG, AND S. HORNER, The temperature coefficient of the resonance integral for uranium metal and oxide. *Nuclear Sci. and Eng.* 8, 497–506 (1960).