fuel element and coolant temperature distributions in the axial and radial directions are derived. The ratio of pumping power to reactor heat extraction in terms of given axial and radial coolant temperature rises are developed. The principles discussed in this chapter are then utilized in two typical reactor heat transfer design problems.

The third chapter consists of a number of miscellaneous topics. The turbulent liquid metal solutions of Martinelli and Lyon at low Peclet moduli are shown to reduce to the slug flow solution. Remarks on heat conduction in clad fuel elements, effectiveness of finned surfaces, and some of the differences between the cooling characteristics of water and liquid metals are also presented.

One difficulty in writing a monograph on a subject like reactor heat transfer is that although some parts of the field are sufficiently elementary so that they can readily be described in limited space, the more difficult parts can only be referenced. It appears to the reviewer that Mr. Hall has capably presented some of the important elements of reactor heat transfer.

H. F. Poppendiek
Geoscience Ltd.
Solana Beach, California

(About the Author: Our reviewer, Heinz Poppendiek, is currently president of Geoscience Ltd. of Solana Beach, California. He has been an assistant professor at the University of California and was for some time a section chief in charge of heat transfer, fluid mechanics, and physical properties at the Oak Ridge National Laboratory. His fields of research have included heat transfer, fluid mechanics, reactor theory, and, recently, space science.)

Numerical Methods for Nuclear Reactor Calculations. By G. I. Marchuk. Translated from Russian by Consultants Bureau, New York, 1959. 295 pp., $22.50.

The author's objectives in writing this book seem, at first glance, to be clearly laid out in his opening comments. On page 2 he says "This monograph is a discussion of the fundamental problems arising when using numerical methods for nuclear reactor calculations." and, on page 3 "Problems relating to the general theory of nuclear reactors . . . are barely touched upon." One soon discovers, however, that these comments are misleading. Marchuk's book, in fact, contains more material on reactor theory than on numerical methods. Dr. Marchuk has set himself a very difficult task. Apparently he wants his book to be completely self-contained. He derives all the basic equations of reactor theory, develops the most important approximations, and then shows how the reactor equations (in their various approximate forms) can be solved numerically.

Many of the advantages and defects of Marchuk's book stem from this structure. The advantages are clear. Surely the numerical analyst who deals with reactors wants to know something about reactor theory. Probably he prefers a condensed presentation of reactor theory, a presentation which stresses its mathematical, rather than its physical, content. This book, one might think, would suit his needs quite well.

On the other hand it is difficult to condense reactor theory without the omission or distortion of key arguments. Marchuk has not always succeeded in avoiding this pitfall. On page 59, for example, we find a derivation of the Wigner thin resonance formula. This derivation involves a Taylor series expansion of the scalar flux, $\varphi(u')$, about a neighboring lethargy u. Only one term of the series is retained. Yet the flux varies rapidly near the resonance energy, and the reader may well ask why such a drastic truncation of the Taylor series is permissible.

The Taylor series approach is used, throughout this book, in the derivation of approximate expressions for slowing-down integrals. Often it is not used very carefully. In deriving age theory, for example, the author puts series expansions for $\Sigma_s\varphi$ and $\Sigma_S j$ into the P_0 and P_1 slowing-down integrals. It is asserted that, upon dropping terms whose coefficients are "of the first order of smallness" one is left with the age diffusion equation. But, if the coefficients are to be ordered in ascending powers of $1/A$ (where A is the mass of the scatterer), this statement is wrong.[1] Otherwise it is ambiguous.

In Marchuk's section on perturbation theory a different type of problem arises. This section is clear and useful, but the author never mentions the connection between perturbation theory and variational methods. He does not point out that the perturbation theory expression for the reactor eigenvalue is stationary with respect to variations in the flux. In fact variational principles are not discussed anywhere in this book.

Apparently Marchuk has chosen to pass over the more subtle features of reactor theory in order to get on to his main subject, namely, numerical methods. But he has also sacrificed much material on numerical methods in order to make room for reactor theory. One notices this first when Marchuk discusses the power method, the "outer" iterative procedure for solving reactor problems. He proves that the iterative procedure converges for bare reactors, but says nothing about its rate of convergence. He makes no mention, either, of the many devices which have been used to accelerate convergence of the outer cycle. In a later section in the iterative solution of two-dimensional difference equations there is, again, no discussion of convergence rates.

The *Sn* method is described briefly, but only in one of its early forms. At the end of his section on *Sn*, the author says: "This [S_4] approximation is even more accurate than the P_3 approximation. . . ." Upon what evidence is this conclusion based? It seems possible from the context that the author is referring to one specific problem, namely, the eigenvalue computation for a bare sphere. It seems safe to assume, also, that when Marchuk refers to the P_3 approximation, he means the P_3 approximation with Marshak boundary conditions. These are the only boundary conditions he discusses. But this reviewer is not familiar with any comparisons between the S_4 approximation and the P_3 approximation with Marshak boundary conditions.

Perhaps, at this point, the reader will conclude that Marchuk's book has little value. This is by no means true. The book has many fine features. It is convenient to have so much material on reactor theory covered in such a concise form. Despite occasional lapses, Marchuk's presentation is, for the most part, simple and clear. His section on resonance capture in lumps is particularly interesting. Here he compares the Russian and western resonance escape formulas, and he does this very well.

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[1] E. Greuling, F. Clark, and G. Goertzel, A multigroup approximation to the Boltzmann Equation for critical reactors. NDA 10–96 (September 1953).

The sections on numerical methods are skimpy but what they do contain is certainly worth reading. This reviewer was very much impressed with the section on multigroup slowing-down equations for highly absorbing media.

Some of the material on numerical methods is new; some is old but not well known in the United States. One may cite, as an example, a Russian relaxation method which leads to a diagonal mesh sweep in two-dimensional problems. Apparently much work has been done on this method in Russia, work which seems to have been overlooked in this country.

Discounting its flaws, which we have belabored here, Marchuk's book deserves a wide audience. Nevertheless this reviewer still hopes that Marchuk will give us, some day, the book he promised in his introduction.

E. M. GELBARD
Pittsburgh, Pennsylvania

(About the Author: In 1954 Dr. Gelbard received his Ph.D in physics from the University of Chicago. Since that time he has specialized in the development of numerical methods for the solution of reactor physics problems. Gelbard is now Vice Chairman of the R. M. and C. Division of the American Nuclear Society.)

Plasmas and Controlled Fusion. By DAVID J. ROSE AND MELVILLE CLARK, JR. MIT Press and Wiley, New York, 1961. 493 pp., $10.75.

The authors of this book are MIT professors with a background in teaching, research, and engineering applications of plasma physics. The book developed from their graduate classes for students of mixed background in physical sciences and engineering.

The book contains 493 printed pages. This includes a table of contents, and assorted appendices on notation and conversion of units. There are 200 illustrations and 209 specific references. The printing is superior and there are very few typographical errors.

The display of literary prowess in the introduction is apparently not intended to discourage engineers. This is a book with a mission. The authors have triumphantly written all equations in mks rationalized units and "wish all other systems a speedy trip to oblivion." The authors are to be congratulated on the tenacity with which they have labored to change the units employed in the original papers over to the mks rationalized system.

The content of the book is very ambitious. It attempts to cover the older aspects of ionization phenomena as well as the more recent developments in plasma physics. In addition there are three chapters on fusion devices and two chapters on fusion reactor energy economics. Consequently the depth of penetration of each subject is not impressive. A "once over lightly" treatment of almost every aspect can be found. There is however little discussion of the foundations of the subject. One can learn about some applications, but not much about the applicability of descriptions based, for example, on the hydromagnetic equations or the dynamics of single particles moving in an assigned field. The Vlasov equations do not make an appearance in the book at all which is a little surprising in view of the fact that most modern plasma physics is based on these equations. It is of course difficult to discuss the validity of the hydromagnetic equations or single particle pictures without reference to the Vlasov equations. It would be even more difficult to discuss the velocity-space microinstabilities so that this important aspect of the subject is neglected completely.

The discussion of fusion devices includes linear, toroidal, and θ-pinches, mirror machines, DCX, and OGRA, the Astron and the Stellarator. It is reasonably up-to-date and includes many of the highlights of the experimental results to date. It is descriptive rather than critical. After reading about the experiments one does not have a very good idea about the degree of disparity between theory and experiment that currently exists.

More lucid presentations and more comprehensive treatments of most of the subjects considered can usually be found in other textbooks currently available. However, a textbook with broad coverage that does not presume a substantial foundation in classical physics and mathematics is certainly lacking at this time. The authors have done a creditable task of surveying the current literature and expressing it in a form that should be digestible to someone with an engineering education that includes a reasonable basis in mathematics and classical physics.

NORMAN ROSTOKER
General Atomic
San Diego, California

(About the Reviewer: Norman Rostoker is Assistant Manager of the joint General Atomic-Texas Atomic Energy Research Foundation fusion project, General Atomic, San Diego, California. He was Supervisor of Theoretical Physics, Armour Research Foundation from 1953 to 1956. He received his B.S. degree in engineering physics, his M.S. in applied mathematics from the University of Toronto, and his D. Sc. in physics from Carnegie Institute of Technology.)

Reactors of the World—Second Series. Simmons-Boardman, New York, 1961. 28 pp., 26 illustrations, $3.50.

The second series of "Reactors of the World" presents drawings and data sheets on 13 reactors of various types and national origins. As with the first series, these data sheets have been extracted from the reactor descriptions presented from time to time in the British journal, *Nuclear Engineering.* Those of us who are accustomed to reading this journal have been impressed by the fine detail of the diagrams accompanying the reactor descriptions.

The reactor systems presented in the second series include the British reactors Pluto (heavy water, materials testing), Merlin (light water, research), Hinkley Point (carbon dioxide cooled, power), Zenith (zero power, experimental); the U. S. OMRE (organic, experimental) and N.S. Savannah (pressurized water, propulsion) reactors; the French G-1 (air cooled, production) and G-2 (carbon dioxide cooled, production and power) reactors; the Canadian NRU (heavy water, materials testing) reactor; the Belgian BR-3 (pressurized water, power experiment); the Norwegian Halden (heavy water, experimental); and the Italian Latina (carbon dioxide cooled, power) reactor.

The national distribution of reactors is much improved over the gross preference for British designs, which was apparent in the first series of "Reactors of the World." However, a better national distribution is certainly required to justify the international title.