Book Reviews

From Scientific Search to Atomic Industry. By A. M. Petrosyants. Interstate Printers & Publishers, Inc., Danville, Illinois (1975). 370 pages. $17.90.

To the nuclear engineer visiting Moscow, by far the most arresting sight is not the golden-domed Kremlin, nor the immobile guards at Lenin's tomb, but his words, blazoned in lights across the facade of the old Moscow power station: "Communism Equals Soviet Power plus Total State Electrification." How often in the last few years have I not envied the Soviets the advantage of having their Founding Father resolve the issue of whether electric power is good or evil! In consequence, the development of the Soviet atomic power industry has been serene and logical, without the swings in public policy between over-ambitious undertakings and excessive disillusion that have characterized our own programs.

The book is in the nature of a report to the Soviet people of Mr. Petrosyants' stewardship of the State Committee for the Utilization of Atomic Energy, of which he has been Chairman since 1962.[1] The first edition was addressed to the (Soviet) layman who wanted a better knowledge of his country's accomplishments in atomic industry. Between the first and second Russian editions[2] many technical details were added, and the book now falls in an intermediate zone between lay and technical audiences. The book begins with a summary and partisan review of the history of Soviet physical science from postrevolutionary days to 1960. The next chapter reviews the Soviet high-energy physics, accelerator, and fusion research programs, with emphasis on Soviet accomplishments and contributions to international cooperation. The heart of the book, and by far the most interesting to American readers, is a discussion of the nuclear power industry. The concluding chapters catalog industrial and medical uses of radioisotopes, the Soviet atomic centers, and international cooperation, principally with countries in the Russian orbit.

According to the author, the book "more or less systematically expounds the achievements of Soviet scientists . . . in . . . peaceful uses of nuclear energy." In fact, the book is both more and less than that. For example, a discussion of the adequacy of uranium resources refers to reserves in the U.S., Canada, and South Africa. Although there is a reference to their development of underground leaching for mining low-grade ores, one looks in vain for data on the Soviet Union. The author quotes 1972 forecasts of nuclear power plant capacity in the capitalist countries, which showed, *inter alia*, that the U.S. would have 150 GW(e) in 1980. He makes the astute remark that the forecast growth "is almost fantastic!" However, no corresponding figures are ventured for the USSR. There is no information on the Soviet uranium enrichment plant(s)—who worked on them or what method is used. Likewise, there is the barest allusion to chemical reprocessing plants.

On the other hand, the author is generous in his description of the Russian "serial" commercial reactors: the direct cycle graphite-moderated channel-type 1000-MW reactors, the 440-MW and 1000-MW pressurized water reactors (PWRs), and the sodium-cooled fast breeders. These reactor characteristics are, of course, well known from Soviet journals; the exposition in the book is of particular value for the philosophical discussion that illuminates the evolution and choice of reactor systems.

Enriched uranium is used because "better uranium utilization and a better burnup are achieved . . . enriched uranium permits a wider choice of structural materials, neutron moderator and coolant." While the Russians experimented with six types of thermal reactors, including D_2O and graphite-moderated gas-cooled reactors, they have standardized on two types (and a limited number of sizes) since "numerous suggested reactors have no decisive (economic) advantages" and "the construction of many reactor types would be too hard for industry."

Interestingly enough, Petrosyants declines to forecast either total electrical power or nuclear power capacity in the Soviet Union at the end of the century because of rapid progress in nuclear engineering and "factors unknown at the present time." He expects serial production of fast reactors by 1985, at which time thermal reactor capacities will be "tens of millions of kW"—not a large number in proportion to the total Soviet electrical capacity which was already 180 GW(e) in 1971, and is doubling every 8 years. The first-stage (thermal) reactors shall at first be base-loaded and will build up plutonium to charge the fast reactors. The latter shall gradually take over the base-load "while the thermal reactors one by one shall be transferred to half-peak operation." The fast neutron reactors and their fuel cycle are to have doubling times initially of 8 to 9 years, and later of 6 to 8 years. PWRs larger than 1000 MW are not envisaged, in part to avoid fabrication and transport of huge steel reactor pressure vessels. Channel-type reactors as large as 2000 MW are being studied. By subdividing their cooling systems, it is believed possible to localize the consequences of pipe failures to a point where such reactors can be built near large cities.

Petrosyants emphasizes safety considerations in reactor design and operation. Their safety efforts appear to be directed against probable rather than hypothetical accidents. He shows that nuclear power plants have proven to be less harmful to man's health and environment than coal-fired plants. Progress in waste disposal is detailed in a separate chapter, and the author concludes tranquilly "we

[1] The Committee was established in 1960.

[2] The second edition is translated.

shall undoubtedly witness improvement and even perfection . . . in waste treatment and disposal.'' The author does not concern himself with the possibility of plutonium diversion.

It has been alleged that U.S. reactor designs are unsafe because of competitive pressures. A comparison of performance parameters of Soviet and U.S. PWRs gives some evidence on the subject. The Soviet 1000-MW(e) PWR design point is 111 kW(th)/liter and 5.4 kW(th)/ft; U.S. commercial designs average about 100 and 5.3, respectively.

The book would have benefited from critical editing. The text is written in the repetitious didactic style much affected by Soviet officials. The translators show no inkling that word-by-word translation from Russian does not constitute Engligh. Despite these defects, which make reading a chore, the perspective obtainable from the book is well worth the effort. It may go far to reassure the nuclear engineer, beset by a paranoid opposition, that he is on the right track.

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About the Reviewer: Karl Cohen, after many years in charge of General Electric's Fast Breeder Reactor program, recently renewed his earlier interest in uranium enrichment and visited the Soviet Union in connection with this assignment in 1972 and 1973. Dr. Cohen's earlier contribution to the enrichment of uranium by gaseous diffusion was as Director of the Theoretical Division of the SAM Laboratories, Columbia University, in the early 1940's. Subsequently, he became extensively involved in nuclear reactor programs. Dr. Cohen's academic training was at Columbia.

Nuclear-Reactor Analysis. By Allan Henry. The MIT Press, Cambridge, Massachusetts (1975). 547 pp. $35.00.

It would be presumptuous of any reviewer of this book to introduce its author, Allan Henry, to the reactor physics community. He has contributed prolifically to the literature and culture of reactor physics for over 20 years. In writing this book, he has undertaken the enormous task of organizing his experience and expertise for the benefit of both students and reactor designers. At the risk of having this review read no further, I will state at the outset that this book is an excellent one which should be in the library of all concerned with the physics of reactor design.

As stated in the preface, it is the author's "thesis that a firm theoretical foundation [for reactor design] actually exists and that it can be made intelligible in a rigorous and systematic manner, starting with very simple physical concepts . . . ." In this reviewer's opinion, the author has succeeded admirably in transforming this simple premise into book form.

Chapters 1 and 2 are basically introductory in content, reviewing some of the underlying nuclear physics involved in fission technology, and acquainting the reader with the concepts of cross sections, scattering laws, kinematics of collisions, and the like. Chapter 3 concerns itself with the infinite, homogeneous critical reactor. After writing down the basic balance equation, the author proceeds to discuss multigroup formalism and the numerical solution of the resulting multigroup equations. This is followed with discussions of eigenvalues, approximate analytic solutions for the spectrum, resonance absorption, the Fermi age approximation, and the four-factor formula. In this chapter the tone of the book is set. The energy variable is introduced at the outset, and one-speed theory is not discussed here or elsewhere. Second, the formulation and numerical solution of the multigroup equations are considered before any simple or idealized analytic solutions are discussed. Finally, there is a balanced blend of the new (multigroup, computer, etc.) with the old (age theory, four-factor formula, etc.). This approach is characteristic of the entire book.

Chapter 4 treats the diffusion description of neutron migration, and deals with many aspects of this subject, such as one group, multigroup, boundary conditions, bare reactor solutions, reflected reactors, exponential experiments, etc. An interesting point here is that Fick's law of diffusion is postulated as being reasonable; the derivation of Fick's law from the transport equation is found much later in the book. Chapter 5 deals with the difficult problem of determining group constants in the presence of resonance absorbers. After a brief discussion of the Breit-Wigner formula and Doppler broadening, the author treats ultrafine group methods, analytic approximations such as the narrow and wide resonance formulations, and a host of other topics including multiregion cells, escape and collision probabilities, Dancoff factors, and reciprocity and equivalence relationships. Once again, the modern numerical approach (ultrafine groups) is discussed prior to the older analytic techniques.

Chapter 6 concerns itself with fuel depletion. It is unusual in a reactor physics text to see a chapter devoted to this subject, and its presence here indicates the practical bent of the book. Topics covered include mathematical descriptions of the depletion process, fission product poisoning, conversion and breeding, power shaping, control, and xenon oscillations. Chapter 7, on kinetics, is quite short but probably one of the best parts of the book, reflecting the author's personal interest and contributions in this area. The content of the chapter is quite conventional, covering the basic equations, point kinetics, kinetics parameters, interpretation of reactivity, delayed neutrons, simple analytic solutions, and the inhour formula. The author's pertinent side comments on such things as the kinetics parameters add much to the conventional treatment. This chapter ends with a discussion of the perturbation formalism for reactivity, introducing the adjoint flux in a natural way.

Chapter 8 deals with the transport equation and is standard in its treatment. After deriving the transport equation and introducing its adjoint, the author discusses the eigenfunctions and eigenvalues associated with both equations. This is followed with brief sections on the P-N, B-N, S-N, and Monte Carlo methods of solution. The chapter ends with a derivation of a reciprocity relationship between the flux and its adjoint.

Chapter 9 deals primarily with the derivation of group diffusion theory from the transport equation. It is here that Fick's law of diffusion, postulated in Chap. 4, is obtained via the P-1 approximation to the transport equation. Topics discussed include diffusion coefficients, interface conditions, multigroup methods, few-group parameters, slowing down models, and spectrum calculations. Chapter 10 carries on the discussion of diffusion theory methods and concentrates on the subject of equivalent diffusion theory parameters to account for the heterogeneities encountered in the reactor design. Specific topics treated