as 12 cm^3 (coaxial) and 1.0 cm^3 (planar) detectors with the point source 3 cm from the front surface.

2. The diffusion coefficients for water listed in Table 9.3 on p. 556 are too high by a factor of 10. They should read:

$$\overline{D}_0 = (3.585 \pm 0.01)\ 10^4\ \text{cm}^2/\text{sec (Ref. a)}$$

$$\overline{D} = 0.130\ \text{cm (Ref. a)}$$

$$= 0.144\ \text{cm (Ref. b)}.$$

3. On p. 693, Eq. 5, the second term in the square bracket should be $\phi_i \phi_i^\dagger \cdot \delta(\Sigma_{ai} V_i)$.

Fusion Energy Conversion. By George H. Miley. American Nuclear Society (1976). 454 pp. $39.80.

This book is intended to provide a framework and essential background for future research, development, and engineering programs for achieving improved energy conversion techniques for nuclear fusion reactors. The first 76 pages are devoted to introduction, fuel cycles, and energy balances (93 references), followed by 76 pages on direct conversion of charged-particle energies to electricity (82 references), 80 pages on electromagnetic coupling (100 references), 72 pages on thermal conversion (123 references), 54 pages on nonelectrical conversion (127 references), and appendices covering ten miscellaneous topics (96 references), plus an update of recent references (21, of which 7 are dated 1976).

Chapter 1, "Introduction," discusses scientific engineering, economic, and environmental considerations of potential fusion reactors. Also included is an overview of the contents of the book. The deuterium-tritium (DT) reactor will have an ~90% energy release via neutrons and radiation, thus necessitating a thermal conversion cycle. Later generation fusion power plants may involve the ecologically more satisfying DD- or D^3He-fueled systems.

Chapter 2, "Fuel Cycles and Energy Balances," treats cross sections and reactions over the range 1 to 1000 keV. The primary D-T-Li cycle is treated, and a useful comparison is given of several possible DD cycles and the D^3He cycle as regards total energy release and the fraction of power in charged particles. More recent studies suggest that D^3He may be another order of magnitude freer of neutrons than Miley indicates. "Exotic" fuel cycles are treated, but no clear-cut answers are presented on their feasibility. Detailed treatments of various system efficiencies and of energy multiplication in blankets are given. Projections are presented on potential fusion reactor plant performance.

Chapter 3, "Direct Collection," discusses the direct conversion of charged-particle energies to electrical energy, emphasizing the Lawrence Livermore Laboratory approaches. Toroidal divertors for direct conversion are also treated. These approaches seem rather torturous to the reviewer, and it may be that a new invention is needed to obtain simple, efficient direct collection at high-dc voltages.

Chapter 4, "Electromagnetic Coupling," treats methods of expanding the plasma against the magnetic field, the use of internal currents (e.g., the bootstrap current in tokamaks) to do work via inductive coupling, and plasma exhaust expansion in an inductive magnetohydrodynamic channel. As with direct collection, all these concepts involve the use of only the charged particles, but convert their energies via an intermediate, inductive method to electrical energy.

The complexity of both direct and indirect coupling technologies does not bode well for the case of the pure DT reactor, since only ~10% (reviewer's estimate) of the net energy flow from the plasma is in charged particles. The advanced fuels DD and D^3He appear to be ideal candidates for direct and electromagnetic coupling, though roughly half the charged-particle energy release shows up as radiation losses which will necessitate a thermal cycle.

Chapter 5, "Thermal Conversion," is applicable to *all* fusion-reactor-fueled systems (DT, DD, D^3He, D^6Li, $p^{11}B$), since about half or more of the energy release from the plasma is in neutrons and/or radiation which demand a thermal cycle for energy conversion. Tritium-handling systems (important even in the "clean" D^3He cycle), heat pipes, magnetofluid pumping, and power conversion cycles are covered in this chapter.

Chapter 6, "Nonelectrical Conversion," discusses several applications of the intense sources of neutrons, radiation, and high-temperature plasma. This includes fissile breeding, the fusion-fission hybrid reactor, fission product and actinide burning, materials and chemical processing, and synthesis of portable fuels. The prospects of using waste heat from fusion reactors for agricultural and for industrial processes are treated. Fusion propulsion prospects are also presented.

The Appendices cover numerous topics, with a very extensive discussion in Appendix A, "Evaluation of $n\tau$ for Various Reactors," of the Lawson parameter $n\tau$, or ρR in the case of pellet fusion, for various situations. Other appendices are: B, "Fusion Fuel Reserves"; C, "Evaluation of Radiation and Fusion Powers"; D, "Requirements for $n\tau$"; E, "Auxiliary Losses, Surface Effects, and Voltage Holding in Direct Collectors"; F, "Energy Recovery in Neutral-Beam Systems"; G, "Compression-Expansion Relations"; H, "Efficiencies for Type-*S* and Type-*P* Cycles"; I, "ATC Scaling and Clamped-Burn Efficiency"; J, "Idealized Analysis of Bootstrap Coupling"; and K, "Comments on Recent Studies."

This is the first comprehensive text on the subject of advanced energy conversion specifically related to potential nuclear fusion reactors. The author is to be commended for his attention to detail and well-paced coverage of a difficult subject matter. The book uses figures extensively. References are adequate for those wishing to pursue the subject further. The text is highly recommended for both plasma researchers and fusion engineers.

It should be emphasized that at the present stage of fusion research, many of the subjects treated in this book are very speculative and highly imaginative, but this is how inventions are generated. Edward Teller once said a new invention consists of six crazy ideas, but until the sixth crazy idea is weaved into the mix, there is no invention and the first five crazy ideas make no sense at all.

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About the Reviewer: J. Rand McNally, Jr. has extensive experience and accomplishments in the areas of atomic and plasma physics, having published over 100 papers in these areas. He is an authority on advanced fusion fuel cycles *and the Ion-Layer fusion reactor configuration. He received his BS in physics at Boston College and his MS and PhD in physics at the Massachusetts Institute of Technology. He has been associated with fusion work at Oak Ridge National Laboratory since 1954, when it was the classified Sherwood Project.*

Safeguards Against Nuclear Proliferation. A Monograph from the Stockholm International Peace Research Institute, The MIT Press, Cambridge, Massachusetts (1975). 114 pp. $14.95.

My ever-growing collection of references about safeguards contains a good deal of doomsday stuff, but every now and again I come across serious papers or books, like this one, that are long on information and short on polemics.

The author is Benjamin Sanders, whose name, somewhat oddly, does not appear on the title page. Mr. Sanders, an official of the International Atomic Energy Agency (IAEA), wrote this book for the Stockholm Peace Research Institute. This is described on the flyleaf as "an independent institute for research into the problems of peace and conflict . . . established in 1966 . . . to commemorate Sweden's 150 years of unbroken peace." The organization is financed by the Swedish government, but its staff and directive boards are international.

Although the book is short and the author has a pleasingly lucid style, it is not easy reading. Partly it is the author's fault; I was bothered by the absence of an index, and I think the discussion could have been organized better, particularly in the historical account. Partly the difficulty is with the material, a tangled network of relationships, treaties, and diplomatic arrangements. There is the Treaty of Rome, the Treaty of Tlatelolco, the Non-Proliferation Treaty, the Statute of the International Atomic Energy Agency, nations who have signed one thing and not another, "Grey Books," "Blue Books," INFCIRCs, and "trigger lists." (This last is a much less menacing concept than the name might suggest.)

The author opens with an account of the history of the growth of safeguards concepts from the days of the Acheson/Lilienthal report, upon which the ill-fated "Baruch Plan" was based, to the present operations of the IAEA. The latter, it should be recalled, arose out of the 1953 "Atoms for Peace" proposal to the United Nations by President Dwight D. Eisenhower. Succeeding chapters deal mainly with how the IAEA tries to provide realistic, consistent, and unobtrusive procedures to make it easier for the nations to find it to their advantage to use nuclear energy for constructive purposes rather than for weapons. The IAEA cannot, as the author points out, impose safeguards but only make them possible on the basis of continuing mutual agreement. Moral suasions, mere words, legalisms, may seem puny things to deal with the imperatives of national interest. One wonders, however, if India would have set off a nuclear explosion in 1974 if the Canada-India agreement had used the specific language of the Non-Proliferation Treaty rather than a general remark about peaceful uses that the Indians interpreted one way and the Canadians another.

There is much information in this slim book. You can find out how safeguards inspectors are hired, how the IAEA finances its work, and how it fosters safeguards research. Substantial appendices are provided containing texts of important treaty sections and statutes. Most of all you can get a feel for the patient, continuing work of the IAEA in trying to create constructive relationships in a complex, ever-shifting world of commercial and nationalistic rivalries. With all its flaws, this book is to be recommended.

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