A bomb designer's treatise, and his profile

Nuclear Theft: Risks and Safeguards

M. Willrich, T. B. Taylor
252 pp. Ballinger, Cambridge, Mass., 1974. $13.50 hardcover, $4.95 paperback

The Curve of Binding Energy: A Journey into the Awesome and Alarming World of Theodore B. Taylor

J. McPhee
232 pp. Farrar, Straus & Giroux, New York, 1974. $7.95

Reviewed by William A. Higinbotham

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Safeguards is the subject under examination this year by the nuclear industry, the intervenors and government officials, replacing reactor safety in the public eye, although the latter issue is not yet settled to everyone's satisfaction.

The two books under review contributed to this upsurge of interest in safeguards: *The Curve of Binding Energy*, which first appeared as a series of profiles in *The New Yorker* last December and *Nuclear Theft: Risks and Safeguards*, one of a series of books emanating from a Ford Foundation energy study. The latter had its first impact last fall, when it was circulated within the AEC in draft form, months before public release. *The Curve* is a profile of Ted Taylor used as a vehicle to explain the nuclear industry, the potential hazards of diversion of nuclear materials and what the AEC and the nuclear industry have been or have not been doing to protect against these hazards. Along the way Taylor discusses how one or a few clever people might convert UF_6 to U-metal, for example, and go about fabricating a nuclear explosive. *Nuclear Theft* is an excellent presentation of the nuclear-safeguards problem, of the current state of US safeguards and of proposals for dealing with the theft and diversion problems in the future.

Mason Willrich, professor of law at the University of Virginia, has been a major contributor to safeguards literature since he worked for the Arms Control and Disarmament Agency in the mid-1960's. He is author or editor of most of the books on domestic and international safeguards that have been published in this country.

Recently a friend from Germany, who is working in the safeguards field, asked my impression of the Willrich–Taylor book. It seems that *Der Spiegel* has quoted from it to bolster that paper's case against nuclear power. My reply was that the quotes must have been taken out of context. Both Willrich and Taylor believe that nuclear power has a major contribution to make in the years ahead. They are worried, very worried, about nuclear diversion if adequate measures are not taken to protect the vast amounts of nuclear material which expansion of the industry will involve. But, they believe that adequate protection can be provided, indeed that the costs will be modest provided plans are made now and implemented in the future. *Nuclear Theft* is *the* reference work for those who would engage in the safeguards controversy.

There are those who, as John McPhee notes, believe that a dissident group could not make a nuclear weapon even if they had the nuclear materials. Taylor pretty well disposes of this argument in *The Curve*, chapter and verse. An ingenious designer of fission bombs in the 1950's, Taylor deserves respect in this area. The AEC has, in fact, presented similar information to the public over a period of years, albeit in cool technical papers presented at professional meetings. Where there is room for argument is in regard to motivation and to the probable consequences of any such operation. This is one of those frustrating social questions where history is no guide, the likelihood of such acts is pretty small (anyone will agree) but the consequences of a successful operation could be very serious. Physicists, in particular, should feel an obligation to wrestle with this one.

Other reviewers have given *The Curve* good marks as literature, although one reviewer preferred McPhee's treatises on less consequential subjects. This book appears to me to be the magic combination that appeals to the lay reader and educates him, painlessly, on an important subject.

There have been times when the USAEC was seriously interested in safeguards problems: 1959, when the IAEA came into being; 1966, with USA–USSR agreement on the nuclear non-proliferation treaty and now. There have been other times when the problem had low priority. In fact, the large amounts of high enriched uranium and plutonium produced and handled in AEC facilities for the weapons program, naval reactors and experimental reactors have been attractive targets if anyone had wanted to divert. The development of nuclear power with recycle of plutonium to light water reactors, highly enriched uranium for gas-cooled reactors and breeders of fissionable isotopes extends the vulnerabilities geographically and quantitatively. As Willrich and Taylor say: "The AEC should design a detailed system of safeguards for each of the fuel cycles based on use of the best available technology and institutional mechanisms." With them, I believe that the problems can be solved to the extent that nuclear or radiological threats by terrorists or other dissidents can be reduced to a very low level indeed, with far less impact on the cost of power than the recent increase in the price of oil created by the Arabs.

In conclusion, not all of the safeguards problems have been fully explained in these two books, nor have all of the solutions been identified. Our appreciation of the problems and our comprehension of how best to deal with them will continue to develop as time goes on, providing we continue to worry about them.

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Lie Groups, Lie Algebras, and Some of Their Applications

R. Gilmore
587 pp. Wiley, New York, 1974. $24.95

Lie-group theory is one of the areas of mathematics that is most useful in theoretical physics, but is also one of the most difficult for physicists to learn to use correctly and efficiently. A major cause of this difficulty is that to understand the subject it is useful to have a good knowledge of the mathematical foundations of Lie-group theory, particularly algebra (for example, "linear and multilinear algebra," in its modern, coordinate-free form) and differential geometry. Unfortunately, these are subjects in which physicists receive too little training. They are not, in principle, too difficult to learn by self-study, but here one runs into the dominant ideology among physicists that mathematics is "useless" unless it is learned in connection with a specific physical problem. Ironically, theoreticians in other disciplines, such as engineering and economics, are much more willing than physicists to learn seemingly "useless" mathematics, and, perhaps as a consequence, there have been more major breakthroughs in these areas involving the application of mathematics developed in the last thirty years.

Especially welcome because it breaks with the sterile tradition of mathematical "pragmatism" in physics is Robert Gilmore's text. He has written a long and enthusiastic *mathematics* book to teach physicists about Lie-group theory in which he tries to fill the gap between the classic treatises by Racah and Wigner and the typically "modern" mathematics book by Helgason, *Differential Geometry and Symmetric Spaces.* Unfortunately, he has not paid sufficient attention to the prerequisites, and the mathematical level is uneven—one moment assuming only the minimal knowledge of algebra and geometry that is typical of current literature in theoretical physics, the next attempting to describe quite sophisticated modern concepts.

It has many good pedagogical features—nice pictures, interesting examples (too few physical ones though), many advanced topics treated with flair and a major effort to explain intuitive ideas. However, it is flawed by many seriously deficient, confused or mistaken descriptions and definitions of basic topics. For example, the abstract notion of "Lie group" and the relation between Lie groups and Lie algebras—which is the heart of the subject to the mathematician—are handled poorly. Many of the advanced "global" concepts, especially those in connection with symmetric-space theory, could have been written in a more authoritative way. The serious physicist reader should, therefore, also consult pure mathematics books to fill in these gaps. I recommend *Introduction to Lie Groups and Lie Algebras* by Sagle and Walde and *Notes on Lie Algebras* by Samelson. *Symmetry Groups and Their Applications* by W. Miller, and my "Lectures" in *Mathematical Physics, Vol. 2* offer a more modern version of the material in