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Book Reviews

Controlled Thermonuclear Reactions. By L. A. Artsimovich, translated from the Russian; edited by Alan Kolb and R. S. Pease, Gordon and Breach, New York (1964). 400 pp., $19.50.

The author of this work is a distinguished Russian physicist and administrator of a large part of the Soviet Union's controlled fusion efforts. Most of those who have seen him in action at the various international meetings that have been held in this field have a very high regard for his abilities. Artsimovich has always been able to cut through to the heart of matters in a few blunt concise sentences. He has never shown himself afraid to call "a spade, a spade," and has shown uncommon ability to analyze experimental data and interpret its significance in a short understandable fashion.

It is a tribute to the man, as well as to the translators and the distinguished editors (R. S. Pease and A. C. Kolb), that the essential flavor of his approach and personality comes out so remarkably clearly in the book. Artsimovich's sentences have a marvelous ability to sway one to his views. How much more convincing they must be in the original Russian!

He never fails to see the forest for the trees, and this ability means that many of the chapters are real gems. I refer to those chapters that deal with experimental results, especially to chapters V and VI that deal with "Fast High-Power Discharges" and "Heating and Confinement of a Plasma by Sustained Electrical Discharges." These are just the phases of controlled fusion research in which Artsimovich has had a direct hand. His overall description of the results of Z-pinch and θ-pinch experiments, as well as slow toroidal discharges with large external fields (Tokomak studies), is easily the most concise, accurate, and educational discussion of this matter available anywhere. These chapters alone make the book worth reading.

Chapters VII and VIII are entitled "Magnetic Traps: General Principles" and "Specific Types of Magnetic Trap." Here the magic is not quite so overwhelming. Most of this discussion can be found in other texts and in the current literature, although from time to time the essential Artsimovich breaks through when he makes his value judgments on the meaning of certain experiments or the failure to have progressed rapidly enough. For example, note his comments on the stellarator on page 304.

Of course there are flaws in the work. That very quality of cutting impatiently through to the heart of the matter makes Chapters I, II, III and IV rather shallow. These are entitled "Introduction," "The Motion of Particles in Plasma," "Transport Phenomena in Plasmas," and "Magnetohydrodynamic Theory of Plasma." Here, it might have paid to "admire the trees" for a while. Instead, Artsimovich barges very rapidly through a host of phenomena involving particle motion, diffusion and, magnetohydrodynamic equations, using only very quick and dirty techniques to get rough answers. This section of the book contains far too much use of the phrase "it can be shown." I am sure that most theorists, students, and those not versed in this field will find the discussion entirely too curt. Experimentalists in the field may enjoy the approach, however. I should hasten to add that the final results, which are derived in such haste, are invariably correct. This is again a tribute to the author and to the care spent by the editors.

An additional flaw, at least from the viewpoint this side of the East-West frontier, is the almost exclusive tendency of the author to give credit to Soviet physicists for ideas that were developed quite independently in the USSR, USA, and Great Britain during the years in which the project was classified. Some of this is understandable; many of our books have erred in the other direction. However, by now we should be careful to mention all originators, if the works are reasonably simultaneous. For example, on page 30 he credits Budker with the idea of the magnetic mirror machine in 1953. Certainly, at least equal credit must go to Post. On page 127 the theoretical treatment of the dynamics of the fast linear pinch are credited to Leontovich and Osovets. The only mention of the classic work by Rosenbluth and Garwin is in a footnote (added by the editors). Again Budker is credited with the idea of molecular dissociation and trapping of fast ions. Mention should have been made of similar proposals by York and Luce.

In concluding, I think it will help the reader to appreciate more fully the flavor of the book by quoting interesting sections. For example, Artsimovich lambastes those who spend so much time hunting for the thermonuclear neutron by these quotes from pages 161 and 162. "A few words should be said about the nature of the short bursts of neutron radiation observed during the compression of a plasma, as this question is the constant topic of discussion in the papers of some physicists who are chiefly interested in the mechanisms of neutron production and devote much less attention to getting data which characterize the basic physical processes in a contracting plasma. At this point it seems hardly appropriate to try to engage in a detailed discussion of whether or not anyone has yet been successful in obtaining neutrons of thermonuclear origin in a θ-pinch," and in his (Artsimovich's) view, "the artificial excitement created every time anyone announces the detection of 'real' thermonuclear neutrons introduces an unnecessary element of publicity into the work on one of the most arduous scientific and technical problems in existence today." The author also shows less than complete reliance on theory as illustrated by this quote from page 173: "It is immediately evident that the problem of stability is the most dangerous and highly difficult obstacle to the realization of quasi-stationary plasmas. A plasma is a system with an almost infinite number of degrees of freedom. Thus, strictly

speaking, the stability problem is theoretically insoluble; and an answer to the question as to the existence or otherwise of stable states can be provided only by direct experiment." Finally, in his summary, Chapter IX, the author reveals a cautious-but-deep sense of optimism about the outcome of the struggle. On page 382 he says, "It is hardly to be doubted that ultimately the problem of controlled thermonuclear fusion will be solved. Nature can put only a finite number of difficulties on the road to the solution; and when man has overcome them by unremitting creative activity, nature will not be able to invent new obstacles. All that is uncertain is how long the process will last." (See also the last half of page 223 for a remarkably optimistic view of the future of Tokomak machines.)

In closing then, this book can be described as being a major contribution to the literature on controlled fusion research. (Research after 1962 is not included, however.) Selected chapters should be 'must' reading for all workers in the field. Beginners in the field will profit by reading all of it. However, "outsiders" are advised to read some more elementary text, which will introduce them to the terminology in the field, before tackling this one.

Albert Simon

General Atomic
P. O. Box 608
San Diego, California 92112

About the Reviewer: Albert Simon is presently Head of the Plasma Physics Division at General Atomic. He was formerly Associate Director of the Neutron Physics Division at the Oak Ridge National Laboratory and Head of the Fusion Theory Group there. He is the author of An Introduction to Thermonuclear Research, *Pergamon Press, London (1959) and was a Guggenheim Fellow in 1964-1965 at the Risö Laboratory at the Danish Atomic Energy Commission. He has also served as chairman of the American Physical Society Division of Plasma Physics.*