BOOK REVIEWS

Plasmas and Controlled Fusion. By David J. Rose and Melville Clark, Jr. 493 pp. The M.I.T. Press and John Wiley & Sons, Inc., New York, 1961. $10.75. *Reviewed by Howard Chang, Stanford Research Institute.*

PLASMA physics is the protean and fashionable discipline concerned with the behavior of systems composed mainly of electrons and ions in which the electromagnetic forces between the charged particles and the effect of electromagnetic fields and boundaries that may be present are important in determining the behavior of the systems. Since many people now use the term "plasma physics" synonymously with such venerable branches of physics as surface-gas interactions, gaseous discharges, arc discharges, glow-discharge phenomena, and electron-beam dynamics, and with such novel fields as controlled thermonuclear fusion, ion and plasma propulsion, cosmic and ionospheric physics, and magnetohydrodynamics, the use of the adjective "protean" to characterize plasma physics is fully justified. The adjective "fashionable" is used advisedly, since the number of people actively engaged in plasma physics and the number of papers appearing on this fascinating and important subject have increased exponentially during the last decade. As proof, one can cite the appearance of several new journals devoted almost exclusively to research in plasma physics, the creation of a Division of Plasma Physics by the American Physical Society in 1959, and the establishment of plasma-physics laboratories in numerous industrial and nonprofit research organizations.

Unfortunately, plasma diagnostics is still in its infancy. That is, the models of plasma used by theoreticians are highly idealized, and almost insuperable difficulties arise in designing and performing experiments in plasma physics that can be interpreted simply and unambiguously. Consequently, plasma physics has been facetiously stigmatized as the science rich in theoretical concepts of dubious applicability.

Let it be agreed, then, that any physicist intrepid enough to attempt to write a book on such a many-splendored subject as plasma physics is faced from the outset with an embarrassment of riches. If he is not to spend a lifetime writing a tome as large as a volume of the *Encyclopedia Britannica*, he must exercise discretion and genius in carefully selecting the topics that he will cover in his book. Once the important decision of subject matter has been skillfully made, he must possess the technical competence and literary gift to write with clarity and diligence on each subject and carry each discussion to a logical conclusion dictated by the limitations of space and human knowledge. In short, it is inevitable that in any book on a "many subject" discipline such as plasma physics, there will be sins of omission and sins of commission.

To be sure, at this late date there is no dearth of books on plasma physics. However, the serious student will have difficulty in finding a book that leads him straight to the heart of the subject and gives him power to apply its concepts intelligently. He refuses to be bored by diffuseness and general statements which convey nothing to him and will not tolerate a pedantry which makes no distinction between the essential and the nonessential. As mentioned earlier, much of the difficulty is due to the fact that plasma physics is so many different things to different people, and the only way out of this dilemma is to write books on "Plasma Physics for Experimentalists" and "Plasma Physics for Theoreticians" and, if the writers of college outline series ever get hold of this field, "Plasma Physics without Calculus".

It is always an unalloyed pleasure to review a superbly written textbook, and *Plasmas and Controlled Fusion* obviously belongs in that enviable category. It is an authoritative, carefully written, lucid, and up-to-date book on classical plasmas and the problems of controlled thermonuclear fusion. (In a classical plasma the particles are considered to possess no internal degrees of freedom, and the average electrostatic potential between the charges is much less than the mean thermal kinetic energy.) A graduate textbook, it presupposes the usual undergraduate courses in atomic physics, differential equations, electromagnetism, and thermodynamics. In a space of less than five hundred pages, it contains almost everything in Spitzer's classic, *Physics of Fully Ionized Gases*, in an expanded and intelligible form, the gist of Delcroix's tract, *Introduction to the Theory of Ionized Gases*, most of the material in Chandrasekhar's admirable book, *Plasma Physics*, a good treatment of hydromagnetics, and an excellent summary of recent approaches to controlled fusion and energy recovery from hypothetical systems. Additionally, it contains a very detailed, valuable, and readable account of plasma stability, devices based upon the pinch effect, mirror-like devices, and the stellarator. The problems at the end of each chapter supplement the text and add considerable value to the book.

Anodic Oxide Films. By L. Young. 377 pp. Academic Press Inc., New York, 1961. $11.00. *Reviewed by H. A. Liebhafsky, General Electric Research Laboratory.*

IN the desperate hunt for materials to meet the increasingly severe demands imposed by modern civilization, the more exotic metals continue to receive major attention. It is a truism that with most metals one had better pay about as much attention to adherent oxide films as to the metal underneath—no matter whether the film is formed chemically or electrochemically. To no metal is the truism more applicable than to tantalum, on which it is possible to produce, by anodic oxidation in various aqueous electrolytes, an adherent oxide film, remarkable in itself, and produced by a process equally remarkable. The success of the new tantalum capacitors amply supports this statement.

The growing importance of tantalum in capacitors is alone enough to justify the present book, which appears to be the first dealing mainly with anodic films. Most of the book is in fact devoted to tantalum and the other "valve" metals, so-called because their oxides, produced anodically as adherent layers, function as "barrier" layers or "Sperrschichte". This "Sperrfähigkeit", discovered for an aluminum anode in 1857, makes possible potential differences between metal and electrolyte that increase with the film thickness as this grows by anodic oxidation. These potential differences can reach several hundred volts before interdicting electrical breakdown occurs. It is instructive to compare the sparse, predominantly qualitative, treatment of this phenomenon in Foerster's *Elektrochemie Wässeriger Lösungen* (fourth edition, pp. 438–446 inclusive) with the much longer, predominantly quantitative, treatment in the book under review. The 40-year-old treatment has merit even today; the quantitative is by no means an unqualified success. But the quantitative treatment had to be tried, and the author is to be congratulated for pointing out the many difficulties and uncertainties it encounters. It has as its main objective an explanation of the growth of the anodic film on tantalum. In this growth, the migration of an anion from the electrode through the film toward the electrolyte is of overriding importance; it is a little disconcerting to learn (p. 17) that the charge on this anion is unknown, which means that the ion itself is unknown.

As regards the "valve" metals, the book is admirably complete. The reviewer found in the entire book no errors worth mentioning. The author is a recognized authority in the field, to which he has made many valuable contributions. And yet the reviewer feels the book could have been improved.

Two matters are important in judging the book. First, the field it covers is very complex, and an easy understanding thereof presupposes a good background in corrosion, in electrochemistry, in solid-state physics, and in inorganic chemistry. It presupposes additionally a knowledge of charge transfer and breakdown in dielectrics, of kinetics of reactions in the solid phase, and of the optical properties of thin films. Second, the anodic films on the "valve" metals differ radically as a class from the anodic films on others, the latter films being primarily of interest in connection with corrosion and similar processes. The reviewer wonders whether it would not have been better to restrict this book to the "valve" metals.

The writing by Dr. Young is uneven; in part he seems to have given us a comprehensive literature survey in early draft. As an example by no means isolated, consider the first sentence of Chapter 17: "Franklin (1957) reported that, contrary to the previous assumption of a flat, parallel-sided oxide layer (but see work by Keller et al., section 16.02), these films have a pronounced cell structure which is very similar to that of the porous films (Figure 17.01)." The reviewer no longer complains of having to tunnel or jump several energy barriers in traversing a sentence; but he does suggest that "these films" should be identified in this, the introductory sentence of a chapter, and that the reference to Figure 17.01 belongs elsewhere inasmuch as the figure deals with *non*porous films.

Purchase of the book for its strong points is recommended.

Argon, Helium and the Rare Gases. The Elements of the Helium Group. Gerhard A. Cook, ed. Vol. 1, History, Occurrence, and Properties, 394 pp.; Vol. 2, Production, Analytical Determination, and Uses, 427 pp. Interscience Publishers, Inc., New York, $17.50 each. *Reviewed by William F. Meggers, National Bureau of Standards.*

HELIUM was discovered spectroscopically in the sun's chromosphere during the eclipse of 1868 but its terrestrial presence was not established until 1895. By 1900, five additional inert gases (argon, neon, krypton, xenon, and radon) were found to end six successive periods of the modern atomic chart. For nearly two decades, these gases remained scientific curiosities but their concentration, investigation, and application have zoomed ever since it was discovered that argon constitutes one percent of the earth's atmosphere and helium two percent of some natural gas accumulations. The remainder will always be "rare gases" but their unique and useful properties justify their concentration, further investigation, and exploitation.

Since 1940, some 7000 articles and books have already been published about the inert gases, and this is the main reason for preparing this digest of all available information about them. Fifteen experts have written two volumes on argon, helium, and the rare gases in twenty chapters. The first volume (ten chapters) is devoted to their history, occurrence, and all conceivable properties, including chemical, physical, spectral, structural, thermodynamic, gas-, liquid-, and solid-state. The second volume covers the methods of isolating, purifying, and handling these gases; their uses; and methods for the analytical determination of the gases themselves and of their impurities. These books are filled with accurate, comprehensive, interesting reviews, illustrated with graphs, occasional halftones, and plenty of tables and selected references (900 in Volume 1, 750 in Volume 2). Each volume ends with extensive author and subject