La Notion de Temps. O. COSTA DE BEAUREGARD. Pp. 207, Hermann & Cie., Paris, 1963. Price 18F;

Le Second Principe de la Science du Temps. O. COSTA DE BEAUREGARD. Pp. 158, Editions du Seuil, Paris, 1963.

As a part of the general broadening of the scope of physics that has been perceptible in recent years, physicists are approaching philosophical problems with less reserve than once they did, and among the still considerable flow of books and papers of which only the first paragraphs need be read there are emerging a number by physicists of high qualifications which command our attention, and often our assent.

Olivier Costa de Beauregard has written two earlier books on relativity, but for several years his published papers have tended to focus on questions treated in the volumes under review, the two halves of a thesis for which, twenty years after his Doctorate of Science, he was recently awarded a Doctorate of Letters by the Sorbonne.

The problem at the center of this work is to understand the extension of the world in four dimensions. Hermann Weyl has written "The objective world simply *is*, it does not *happen*. Only to the gaze of my consciousness, crawling up along the life line of my body, does a section of this world come to life as a fleeting image in space which continually changes in time." Quite apart from their authorship, these lines requires our attention. They are certainly true in some sense, but we must try to understand their meaning in terms of (a) the principle of indeterminacy, (b) the increase of entropy, and (c) the data of human consciousness. The first two of these make it increasingly difficult to relate the future with the present as the interval grows longer, and all three seem to introduce an asymmetry between phenomena lying in the forward and backward light cones that is foreign to the relativisitic formulation.

It is Costa de Beauregard's opinion that the three problems must be solved together, and his work, though it does not end with statements putting all in order, is a complex and many-sided argument. He writes not as a philosopher with a system but rather as an epistemologist; "Epistemology," he says, "is, for us, a reflective commentary on operational scientific theories, and the exact opposite of a systematic statement of categories *a priori.* Where the scientific formulation goes, there must go the epistemological commentary with arms and baggage, be it through the Alpine passes like Hannibal's elephants or through the Needle Gate like the camel in the Evangel." This is the work that up to now physicists have tended to shirk, even though we probably have much to learn from it.

The first volume deals with what the author calls the first principle of time, the relativistic equivalence between space and time which calls for a covariant formulation of physical theory. After an introductory survey of modern physics which may be too short for some readers and too long for others, we reach the main epistemological problem which relativity theory poses for quantum mechanics, that of making the theory covariant. Covariant wave equations are not enough, for the whole apparatus of Hermitian operators, expectation values, and transition probabilities expresses a totally nonrelativistic view of nature. The author replaces the traditional apparatus with a formulation in terms of relativistic wavefunctions with quantized amplitudes which this reviewer believes is the only way in which it can be done.

The discussion now passes, in the second and possibly the more controversial volume, to questions of irreversibility and the human consciousness of time. The "second principle" of the title is the necessity of using retarded formulas to describe physical interactions, or equivalently, in Einstein's phrase, "the impossibility of telegraphing into the past." After showing in some detail why irreversible behavior cannot be got out of any physical model unless it is first put in, the author launches into an extended and very interesting discussion, based on information theory, of irreversibility as a characteristic of consciousness. In this he passes far beyond Boltzmann's considerations and attacks, in contemporary terms, questions which may have been regarded in Boltzmann's time as peripheral, but which now may well require definite answers before some great future step in physics can be taken.

DAVID PARK
Williams College

Mathematics and the Physical World. MORRIS KLINE. Pp. 546, Doubleday and Company, New York, 1963. Price $1.95 (Paperback).

Kline begins this book with prefatory comments to the effect that "mathematics is valuable largely because of its contributions to the understanding and mastery of the physical world," and ends it with last-page sentiments that "mathematics may be the queen of the sciences and therefore entitled to royal prerogatives, but the queen who loses touch with her subjects may lose support and even be deprived of her realm." He urges the view that the mathematician's first duty is to aid in the exploration of the physical world; only as a spare-time avocation may he pursue mathematics for its own sake. Among the majority of modern mathematicians, this view probably goes over like a lead balloon. The view will, however, be applauded by some physicists, including many teachers of physics who will find this book generally good reading, although a bit tedious in spots.

Stronger recommendations to get this paperback re-edition of Kline's 1959 book can be made to students of physics, especially undergraduates and advanced high-school students, inasmuch as Kline addresses himself primarily to the reader who has not yet gone very far in each subject treated. A strongly historical emphasis runs through the book, and students should especially profit from and enjoy the many well-chosen anecdotes and quotations drawn from the history of mathematics and of mathematical physics.

A feature of the book that must perplex any reviewer trying to suggest the best audience for the book is the wide range of levels of the topics treated. The first few chapters explain elementary concepts of arithmetic, geometry, and algebra; final chapters deal with differential equations, variational problems, and modern postulational mathematical systems. A freshman physics or mathematics major might find at least the historical aspects of the beginning of the book enjoyable; he is quite likely to find directly helpful some of the individual topics in classical mathematical physics in the middle of the book; and perhaps later, in his advanced undergraduate years, he can dig out his copy and get a good deal out of the closing chapters.

Kline raises his readers' hopes that the closing chapter will present some clear and perhaps profound discussion of that ever-recurring question: Just why is it, just how can it be, that mathematics proves so powerful a tool in exploring what we loosely call the real physical world? Kline's final answer is: "It may be that the effectiveness of the mathematical representation and analysis of the physical world is as unexplainable as the very existence of the world itself and of man. . . . If the attempt to understand why it works leaves us with an enigma . . . this merely means that we have an intriguing subject for further study and contemplation." That answer is honest, but seems just a bit lame after a buildup extending through most of the book.

The author shows himself a competent and enthusiastic champion of the importance of mathematical physics in the modern world, and makes very clear that he is a critic of those of his fellow mathematicians whom he accuses of "sailing with the wind" in their choice of research topics and placing "undue emphasis on abstraction, generality, rigor, and logically perfect deductive structures" in their mathematics teaching. The book will probably not sell well in mathematics departments.

J. E. McDonald
Institute of Atmospheric Physics
University of Arizona

Handbook of High Vacuum Engineering. H. A. Steinherz. Pp. 358, Reinhold Publishing Corporation, New York, 1963. Price $11.75.

Few areas of technology have played as important a role in advancing scientific knowledge as high vacuum engineering. Also, this area has introduced new techniques into industry ranging from vacuum dehydration to circuit miniaturization. The book under review introduces all of the modern methods of vacuum engineering to the design engineer and scientist. The author, a recognized specialist in the vacuum field, has gathered together in one volume much material which otherwise could only be found distributed through many research notes and experimental articles. Recent literary practices have even discouraged discussion of these techniques. As a consequence, books of this kind are warmly received and generally useful to the scientist, engineer, and teacher.

The author intended this book as a handbook "for those responsible for the design, construction, operation, and maintenance of high vacuum systems." Therefore, he has emphasized hardware at the expense of involved description of physical processes. Only in the behavior of gases at low pressure does he go into any detail of fundamentals. Throughout the book his tables and figures contain descriptions of presently available commercial vacuum system components.

After a brief history and discussion of elementary kinetic behavior of gases, the book is divided into chapters on methods of obtaining vacuum, gauges, leak detection, valves, seals, vessel design, traps, and pumping-system design. The concluding chapters discuss various commercial applications including drying and impregnation, freeze drying, distillation, and space environmental simulation. All chapters emphasize the practical design requirements and 398 references give adequate opportunity to examine the literature for details. By concentrating on presently available components and extensive referencing the author has been able to condense an amazing amount of useful technology into 358 pages. This will be an excellent addition to any technical library and will serve as a valuable reference to experimental scientists and engineers.

F. R. Scott
General Atomic
General Dynamics Corp.

Electromagnetic Fields. Sergei A. Schelkunoff. Pp. 425, 150 illustrations, Blaisdell Publishing Company, New York, 1963. Price $9.50

The concept of Maxwell's equations is often a difficult one for the student to understand. Professor Schelkunoff, therefore, devotes a quite extensive introductory portion of his new book to establishing these equations from practical physical aspects rather than theoretical hypotheses. Advanced mathematics is avoided as "it suggests rigor and students may get the erroneous idea that rigor assures truth in the domain of physics." In consistence with this emphasis on the thorough understanding of basic matters the student is warned by the author not to go on to subsequent chapters before having worked his way through the first one at least three times.

The same stress on the phenomenon itself rather than the mathematical technique is found throughout the remainder of the book, which leads from the Coulomb field to waveguides, coupled oscillators and the telegraph equation. Calculus is the main mathematical prerequisite demanded of the student; only for the final chapters some knowledge of differential equations and Fourier series is needed. The necessary vector calculus is briefly summarized in an appendix. Thus avoiding to encourage "pencil pushing at the expense of thinking," the author nevertheless gives a well-rounded mathematical presentation of electromagnetic theory.

Static and dynamic fields are treated together in order to preserve the coherence of Maxwell's equations. The practical aspects of the theory are also emphasized by repeated use of successive approximations to obtain approximate solutions where, as so often in reality, exact ones are not obtainable or needed.