are subjects for continual technological research. Such research leans increasingly on basic physical investigations of the properties of solids, liquids and gases. This is convincingly illustrated in the book under review, which discusses various methods for the more direct conversion of energy into the convenient electrical form of such widespread use in modern life.

The standard method of powerplant generation of electrical energy involves the several stages of conversion of the chemical energy of fossil fuels (or the energy of nuclear fuels) into thermal energy, thence into mechanical energy by means of some form of heat engine and finally into electrical energy through the Faraday dynamo effect. The present volume, one in the Inter-University Electronics Series, is devoted to an examination of five methods for the direct conversion of thermal into electrical energy. These are based respectively on the photovoltaic effect, the fuel-cell concept, the thermoelectric effect, magnetohydrodynamics and thermionic emission. Each subject is treated by one or more experts in the field, all but one of whom are research scientists or engineers in various research and development laboratories of the General Electric Company. Sutton, the editor of the volume and a member of the staff of the Avco-Everett Research Laboratory, also contributes the section on magnetohydrodynamic power conversion.

An unusually helpful feature of the volume is the thorough treatment of the physical basis of each conversion process. The section on the photovoltaic cell (prepared by J. F. Elliott), for example, is prefaced by a very clear, if brief, exposition of the nature and behavior of semiconductors. This is followed by a description with clear diagrams and well drawn graphs of the properties of various types of cells and the uses to which they are being put, mainly of course in the space-exploration field, in which solar energy is available as the primary source.

Increasing interest in the fuel cell as a direct energy converter is recognized in a 60-page article written by W. T. Grubb and L. W. Niedrach. Such a cell, like a battery, transforms chemical energy directly into electrical energy, but since the oxidizable material can be very much lighter than that in the conventional electric battery, the fuel cell possesses distinct weight advantages. The fundamental principle of the fuel cell is clearly described, and numerous practical models are discussed, along with appropriate diagrams.

AVCO MARK V MHD GENERATOR produces a dc output of 31.3 megawatts. It is a rocket-driven device with a self-excited magnet, requiring no outside power.

The thermoelectric effect has, of course, been known for a long time, but until relatively recently was not used for energy conversion. The measurement of the thermoelectric properties of certain semiconductors has recently aroused renewal of interest in the practical possibilities of the effect, particularly in the field of small-scale refrigeration. The basic reversible and irreversible thermodynamics of thermoelectricity is very well presented in the article by Steven I. Freedman, and the practical applications are by no means overlooked.

The magnetohydrodynamic power generator provides an ingenious application of the Faraday electromagnetic induction effect, involving no moving solid parts. It can therefore operate at high temperatures, leading to greater overall efficiency. Compactness of size can also be achieved. It is believed that such devices can be built to generate powers of the order of tens of megawatts for short intervals of time. The article contains an excellent discussion of design characteristics.

The thermionic vacuum tube as an amplifier, that is, a device for drawing energy at a greater rate out of a given source, has long been known, but the use of the effect in direct energy conversion from thermal to electrical form is of more recent origin. Its possible advantages in providing electrical power in remote regions, for example under the sea and in outer space, are now beginning to be realized. This section in the book, prepared by E. Blue and J. H. Ingold, surveys both advantages and difficulties, with an excellent review of the fundamental principles.

All who are interested in any aspects of the problem of energy conversion will find this volume of prime importance.

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Topics in elementary particle theory

RECENT DEVELOPMENTS IN PARTICLE PHYSICS. (Summer school, Honolulu, August 1965) Michael J. Moravcsik, ed. 263 pp. Gordon and Breach, New York, 1966. $15.00

by Don B. Lichtenberg

Summer schools in theoretical physics are rapidly proliferating. Among others are the well established schools

at Brandeis and Boulder as well as those in Edinburgh, Varenna, Istanbul, Sicily and Corsica. In his preface the editor deplores the fact that until the Hawaii summer school was established in 1965 there were no summer schools handy to the regions bordering both sides of the Pacific. Rather than establishing two schools (one, for example, in Japan and the other on the American west coast), a strange compromise was made by establishing one school in the middle of the Pacific. If the school helps bring a better meeting of minds between American and oriental physicists, it will be worthwhile.

The number of students at a typical summer school is quite small, often under 50. Usually, and this case is no exception, the lecturers are noted authorities who bring an up-to-date account of the latest developments in rapidly moving areas of research. Evidently it is felt that what a few dozen students learn at a summer school is not sufficient justification for the time and effort of the noted lecturers because almost invariably proceedings are issued. Thus not only are summer schools proliferating, which is a good thing up to a point, but proceedings are also proliferating, which may be a mixed blessing.

The disadvantage in having many proceedings is that there is inevitable duplication. But there are also advantages. In the first place, the knowledge that what the lecturers say will be published makes them more careful than they otherwise would have been. Secondly and perhaps more important is that the proceedings present advanced students and young research workers with a running account of the progress in rapidly moving areas of physics.

As an example of overlapping topics treated in different books, it may be instructive to compare the present volume to the proceedings of the Brandeis summer school also held in 1965. Both books contain lectures on broken symmetries, current algebras, and bootstrap dynamics, among other topics. Nevertheless it is useful for the dedicated worker to have access to both books. The reason is that research in these areas has not progressed sufficiently for physicists to develop a canonical method of presentation. In fact the points of view of the different workers have sometimes little in common with one another. The young research worker who reads two sets of lectures on the same topic has

a chance to develop a healthy skepticism toward ideas that are at times put forward with unjustified optimism.

I was glad to see in this volume, in addition to lectures on the more popular subjects, some lectures on field theory by Rudolph Haag. This more slowly advancing area of particle physics makes use of mathematical methods that are more rigorous than those used in, for example, bootstraps or current algebras. Those who are prone to make arbitrary manipulations with quantities whose meanings they do not understand will benefit from reading this section. Unfortunately, however, the treatment suffers from a problem characteristic to the field theoretical approach—a paucity of results.

The other authors whose lecture notes appear in this book are H. Miyazawa, Y. Ne'eman, F. Zachariasen, S. Frautschi and the editor. In addition, there were approximately 30 individual seminar talks that the editor, exercising wise restraint, declined to publish.

Although rapid publication of lecture notes is desirable, the fact that many volumes take a year or so to appear shows that it requires a tremendous effort to put them out much faster. It is understandable that physicists are not willing to give this effort. At a time when original journal articles take from six months to a year to appear, a time lag of a year in a book of lecture notes is not excessive. However, the present volume has appeared with somewhat more than the usual delay. I also do not understand what the publisher had in mind in bringing out a paperback at a hard-cover price. The librarians, who in my opinion will be the principal buyers, will simply send their copies to the bindery to rectify the publisher's mistake.

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Fast-moving charges

RAYONNEMENT ET DYNAMIQUE DU CORPUSCLE CHARGE FORTEMENT ACCELERE. By Henri Arzeliès. 478 pp. Gauthier-Villars, Paris, 1966. 88 F.

by L. Marton

The dynamics of high-speed charged particles is a well developed doctrine. There are many excellent treatises on this subject, and it is somewhat difficult to contribute something new to the subject. According to the author of this book, the same is not true for the dynamics of strong accelerations of the same kind of particles. In his introduction he says that weak accelerations are well treated, but the main theme of this book is that strong accelerations have not been treated adequately. He wishes to remedy that situation. Not only, according to him, is the theoretical treatment missing, but he points out (surprisingly in his dedication of the book to several persons) that, though there is common opinion to the contrary, quantitative experiments are completely missing.

The author is professor at the Science Faculties of Rabat and at the Science Faculty of Bordeaux. He is a prolific writer. The front page of the book gives a list of books written by him. In ten years they add up to the impressive total of 2778 pages on the subjects of relativistic kinematics, relativistic dynamics, conducting media in motion, general relativity, gravitation and microscopic and relativistic electricity. Actually the present volume had been announced earlier as Volume 3 of his book on *Relativistic Dynamics and Its Applications*.

During the earlier part of the century it had been a kind of tradition in a certain number of French books to provide them with extremely long prefaces, sometimes on subjects not quite related to the main theme of the book itself. Our author follows (or revives) this tradition. His preface, entitled "The Classification of Sciences," takes up 21 pages and contains a partly philosophical discussion of different sciences and their hierarchy. He comes to the conclusion that there exists a certain type of hierarchy, but that whatever hierarchy of sciences may exist depends on the point of view and its timing and application. It would take us too far to discuss the different ideas developed about classification of the sciences. What is surprising, however, is the proposal of the author to classify through the concept of truth. The author fails to define what he considers as truth; maybe he defines it in another preface written for another book that I have not