maintained throughout the book, there are a few lapses that may be misleading or are lacking in rigor. On page 6, for instance, it is a bit of a jar to read that "0/0 may be any number, or is indeterminate." Also, on page 95, in connection with a discussion of orders of infinitesimals (which could easily have been avoided entirely, and should have been), one finds the statement that "an infinitesimal of the nth order is ultimately indifinitely small compared with one of the $(n-1)$th or lower order."

Several topics not customarily seen in similar treatises are considered here, such as finite differences, line coordinates, least squares, and orthogonal functions. An interesting feature is the inclusion of epicene and expocyclic functions, "thereby avoiding the introduction of complex numbers in the treatment of the elementary theory of functions of real variables" (p. 443), and similarly using these real functions when dealing with linear differential equations in Chapter XX.

FREDERIC H. MILLER

Department of Mathematics
Cooper Union, New York

Physics

Scientific Papers Presented to Max Born. Sir Edward Appleton *et al.* Hafner, New York, 1953. 94 pp. Illus. $2.50.

This "modest volume of essays," as it is accurately described in the foreword, was prepared last year as a tribute to Professor Born upon his retirement at a vigorous 70 years from the Tait Chair in the University of Edinburgh. In 10 brief essays the contributors, most of them old friends and colleagues of Born, treat a variety of subjects ranging from the ionosphere to the theory of algebraic fields.

The hero of the work appears himself only in the lines of a formal bibloigraphy that somehow becomes about as interesting as many a scientific paper. Almost 300 papers by Born and his coworkers are listed, and nearly a score of books, two still gaining form in his fruitful hands. If, like this reviewer, you owe much to Professor Born's books, to the *Restless Universe* in its charm and depth, to the compendious, *Optik,* to the meaty *Atomic Physics,* or to any of the others, you will be especially struck by this list. But anyone may see in the titles a kind of précis of the physics of our century. Here are named the elegant early exploitations of special relativity 40 years back, the complex and powerful theory of lattice vibrations, the studies on collisions in which that essential first bridge to understanding, which we now call the Born approximation was built, the adiabatic approximation, still the heart of the theory of molecular structure, and many more. There are less familiar matters, too, such as the boldly nonlinear electrodynamics and the still hotly discussed kinetic theory of liquids. All these are a good harvest indeed.

About 30 years ago Born set one stone which has become the builders' chief cornerstone. Hamiltonians and wave equations may give way to state vectors and path integrals, but the statistical interpretation of the probability amplitude remains the foundation of every quantum theory. It is fitting and proper that four of the 10 papers of the present book, papers by Bohm, de Broglie, Einstein, and Landé, in three tongues, all address themselves to this general question. Once again Professor Einstein acutely questions the completeness of quantum mechanics, because (if I may peremptorily summarize his careful thought) it cannot lead to an unambiguous classical limit of specific, and not probabilistic, description. He dismisses the use of the wave packet, it seems to me, too lightly, on the grounds of its finite duration. It is interesting indeed that the makers of casual alternatives to quantum theory, Bohm and de Broglie, earn from him the same blame because their theories make a particle in a well stand still, while classical physics gives it a velocity, and the ordinary quantum theory of stationary states only a probability ensemble of two possible velocity values. Their answers contain much of what a quantum mechanician would say in his own defense. Landé has a thoughtful paper again emphasizing the naturalness of the statistical theories.

The other papers range from a specialized piece on the theory of flame propagation by von Kármán and S. S. Penner to a conjectural little note by P. Jordan on fundamental biology. Courant, Schrödinger, and Weyl are other contributors whose names serve to remind us again how great a debt we all owe to those Göttingen years of decades back. Sir Edward Appleton, the one experimenter, writes his views on the interaction of the ionosphere with the earth's magnetic field and speaks as the spokesman of Edinburgh, which Professor Born has served and graced for 17 years.

As a frontispiece there is a signed photographic portrait of Professor Born, elegantly made by a London photographer, whose name, Lotte Meitner-Graf, is not without interest for physicists. The fabric of the history of physics in our time is closely knit.

P. MORRISON

Department of Physics, Cornell University

Thunderstorm Electricity. Horace R. Byers, Ed. Univ. Chicago Press, Chicago, 1953. 344 pp. Illus. $6.00.

Thunderstorms are the most spectacular electric manifestations of the atmosphere. In 1912, C. T. R. Wilson suggested that they acted as the generators which maintain an electric charge on the earth in the presence of the considerable current conducted by the atmosphere. Although this hypothesis has met with considerable favor ever since, it is only in the last few years that substantial experimental evidence in its support has been available. It is, therefore, an appropriate time to gather together the known facts on the electric behavior of thunderstorms and (to quote the editor's preface) "bring some order out of the chaos of facts on thunderstorm electricity." This was the object of a conference held at the University of Chicago in April, 1950, and sponsored by the U.S. Air Force Cambridge Research Center. This book makes available the material presented at that conference, together with some results obtained since that time.

It thoroughly covers the subject of thunderstorm electricity and spreads into many neighboring fields, such as cloud thermodynamics, the charging of dust

particles, propagation of atmospherics, ice-crystal growth, and the more universal aspects of atmospheric electricity. There is scarcely an experimental fact of any importance on the subject that is not covered either in the text or through the references. Most of the important recent experiments are described in detail, many by those who performed them.

Most of the book is devoted to field observations and laboratory experiments directed toward determining the mechanism by which a thundercloud charges certain atmospheric particles positively and others negatively and separates these to form a positively charged upper part and negatively charged base. The number of different mechanisms considered and the divergence of lines of experiment show that no proposal has been universally accepted as yet.

The sixteen chapters have been written by 20 authors, all specialists in at least one phase of the subject. The first two chapters serve to place the subject in the perspective of atmospheric electricity as a whole. Chapters 3 and 10 describe potential gradient and conductivity measurements in relation to thunderstorms. Chapters 4 and 5 review the meteorology of thunderstorms and the properties of hydrometeors. Then follow four chapters principally devoted to charging mechanisms that may be of importance to the electric phenomena of thunderstorms, and observations on the disposition of charges in thunderclouds. Chapters 11–13 deal with lightning from the point of view of the electrostatic and radiation (that is, "atmospherics") fields it produces, with the following chapter devoted to the location of thunderstorms by this means. The last two chapters cover the more applied fields of the prevention of lightning damage to aircraft and power lines.

One serious omission is the absence of an adequate description of the technique and principles involved in radar mapping of thunderstorms. Its inclusion would have made many of the statements of Chapter 4 more meaningful to those not familiar with the capabilities of this method.

The book is liberally provided with diagrams and photographs, all of high quality. In several diagrams, ambiguity is introduced by the crossing of solid lines. Misprints are rare, but they have an annoying habit of appearing in formulas. In Chapter 2, for example, "W" and "w" are used interchangeably for the specific resistance. References to diagrams are sometimes misleading, for example, the abscissa of Fig. 12 of Chapter 7 is described as being on a 3/2 power scale, whereas actually both abscissa and ordinate are on logarithmic scales. The use of *Thunderstorm Electricity* as a reference book would have been enhanced by the addition of an index.

The reader who is looking for a simple and definite explanation of the mechanism of charge generation in thunderstorms will be disappointed. But when such an explanation is forthcoming, its author will doubtless owe a debt of gratitude to this book.

W. D. PARKINSON
Department of Physics, Fordham University

Dislocations and Plastic Flow in Crystals. A. H. Cottrell. Oxford Univ. Press, New York, 1953. 223 pp. Illus. + plates. $5.

Dislocations in Crystals. W. T. Read, Jr. McGraw-Hill, New York, 1953. 228 pp. Illus. $5.

Two excellent books devoted to dislocations have now appeared. Fortunately the two complement each other nicely.

In most cases, a wealth of experimental observations stimulate the induction of a set of basic principles that may be used to give a concise description of the entire field of phenomena. Once the basic principles are known, one can travel the reverse road and use them to deduce the results to be expected in specific circumstances.

Dislocations were invented to provide an understanding of the behavior of crystals during permanent deformation. Unfortunately, there are still several aspects of the deformation problem that are not understood.

Cottrell leads one into the dislocation concept by this historical path describing the observed geometric nature of the slip process in crystals and showing how the low observed shearing strength leads naturally to the type of crystal imperfection called a dislocation. Following a geometric description of the nature of the lattice distortions around an edge and a screw dislocation, Cottrell describes the elastic stress systems that exist in materials containing dislocations. These elastic stresses which extend to large distances lead naturally to his discussion of the interaction forces between dislocations and the interaction force between an impurity atom and a dislocation. The effects of the periodic lattice structure are then considered, and, among other things, partial dislocations, crystal growth, the Frank-Read dislocation source, and the dislocation model of grain boundaries are treated.

In the remaining two chapters, Cottrell gradually leads one from situations that are well understood to cases in which even the data are suspect, to say nothing of the theories. In the chapter dealing with the yield strength, there are certainly various aspects of the theory and of its relation to experiment that are well founded. For example, consider Cottrell's own theory of the upper yield stress. By now, this is a beautiful theoretical development well checked by experiment. On the other hand, very recent data by Blewitt and coworkers (published since Cottrell's book) refute certain aspects of the ideas presented concerning slip in solid solutions. Other similar cases can be found in the last chapter on work-hardening, annealing, and creep. Cottrell himself gives fair warning regarding the uncertainties in the last chapter. Some individuals might object to a discussion of a field that is as yet not well worked out, but actually this is where the future fun is to be had. Anyone, but particularly those not well versed in the field of dislocations and plastic flow, will welcome Cottrell's well-balanced account of the present incompete state of our knowledge concerning the mechanical strength of crystals.

In *Dislocations in Crystals,* Read to a large extent adopts the deductive approach. He introduces the reader to the dislocation as a type of flaw in the crystal structure. His first seven chapters give principally a clear and well-diagramed geometric exposition of the nature of the crystalline disturbance in the vicinity of one or more dislocations. It is true that the concepts of the force on a

dislocation and that of the line tension are introduced, but the main emphasis is on the geometry. The generation of new dislocations by the Frank-Read mechanism is carefully pictured. Chapter 7 gives a clear and rather complete discussion of the geometric nature of the particular dislocations and stacking faults appropriate for a given crystal structure. Thus far in the book practically no quantitative experimental observations are mentioned; a small number of qualitative observations are used to guide the theory. This is in contrast with Cottrell, where order of magnitude estimates appear frequently and from the beginning.

Read begins active quantitative calculation in Chapter 8, which deals with the elastic stresses produced by dislocations and with the associated elastic energy. Chapter 9 is concerned with the forces acting between dislocations and with a qualitative discussion of the anchoring of dislocations by impurities.

The second portion of the book applies the theory to two problems in which the theory makes definite predictions that have been verified by experiment. Read shows in the case of the growth of crystals from the vapor or from solution that Frank's dislocation theory (i) predicts the observed steps on the growing crystal face and (ii) correctly predicts the degree of supersaturation required. Read and Shockley's theory of the grain boundary energy fits observations on five or more metals and contains only one adjustable parameter. In addition, the possible motions of a grain boundary are discussed.

To summarize, Cottrell probably gives a more well-balanced picture of the present status than Read. Read, by concentrating on partial dislocations, crystal growth, and on the grain boundary energy is able to give a very thorough, lucid treatment of these fields.

JAMES S. KOEHLER
Department of Physics, University of Illinois

Radioactive Isotopes. An introduction to their preparation, measurement, and use. W. J. Whitehouse and J. L. Putnam. Oxford Univ. Press, New York, 1953. 424 pp. Illus. $10.

The authors of this book are to be commended for presenting a concise and lucid account of the physical background—a knowledge of which is helpful to all who use radioactive isotopes as research aids. They have imposed the requirement that the text deal with material sufficiently general to interest an audience of widely varying background while avoiding overspecialization.

There are 8 chapters. The first three provide a short summary of nuclear reactions, modes of nuclear disintegration, and properties of the radiations encountered in using radioactive isotopes. Most of the space is allotted to the next three chapters, which deal with production of radioactive isotopes and detection, measurement, and gross effects of the radiations. These chapters are particularly well organized. There are two final chapters, one a short but well-condensed exposition of applications, and the other a general treatment of problems involved in manipulation of radioactive material. There are also an interesting historical introduction and four appendices listing physical constants, isotope masses, thermal neutron capture cross sections of the elements, and an abridged isotope table. Finally, there are name and subject indexes.

According to the authors' preface, the preparation of this book was begun in 1948. Apparently, it was not finished until 1951. Two years more passed before publication. Consequently, despite the publication date of 1953, the material covered relates only to work published before 1951. Both the advantages and disadvantages of this leisurely schedule are apparent. Thus, the format is exceptionally good, and the text shows evidence of careful editing. On the other hand, a considerable fraction of the material presented seems somewhat transitory for crystallization in such an excellent (and expensive) format.

The present volume, together with others in the series of textbooks on associated subjects published by Oxford, demonstrates that know-how in the application of nuclear physics to all the sciences and to engineering is as well developed in England as anywhere in the world.

MARTIN D. KAMEN
The Edward Mallinckrodt Institute of Radiology
Washington University School of Medicine

Principles of Transistor Circuits. Richard F. Shea, Ed. Wiley, New York; Chapman & Hall, London, 1953. 535 pp. Illus. $11.

This book, which represents a cooperative effort of the engineering staff of the General Electric Electronics Laboratory, surveys the mushrooming field of transistor circuits. Any attempt to cover such a rapidly growing subject is bound to be a bit blurred in spots and is faced with the problem of obsolescence sooner than a text in an established area. In this case, the authors were faced with the additional problem of producing a volume that would be of value to both students and established engineers. In the interest of the later group, analogies between vacuum tube and transistor circuits are emphasized wherever possible. This point of view restricts discussion of some of the very interesting and potentially useful circuits, such as those possessing complementary symmetry. On the whole, however, this book represents a good summary of the state of transistor circuit theory at the time of its publication, and it should serve as a useful introductory volume for some years to come.

After a brief chapter outlining semiconductor principles, the authors devote five chapters to the transistor, as a linear circuit element, which can be completely described by measurements on its external terminate. T network small-signal equivalent circuits are derived for the grounded emitter, base, and collector configurations in Chapter 3; these are applied to the analysis of single stage and then multistage amplifiers in Chapters 4 and 5. The practical problems of maintaining quiescent operating points, despite the marked variation of transistor characteristics with temperatures, are treated in Chapter 6 under the heading Bias Stabilization. In this reviewer's eyes, the only weakness of the "small-signal" portion of the book is a failure to emphasize some of the other very useful equivalent circuits that can be employed. This is particularly true in Chapter 9 where the properties of transistors at high frequencies are considered. The choice of a fixed parameter equivalent circuit, which can best predict the transistor performance at high frequencies, is an active problem at the present time; it

seems desirable, therefore, to maintain a flexibility of thinking in this regard, particularly in view of the very considerable limitations of the T network equivalent.

Chapters 10–13 consider small-signal design of high-frequency amplifiers and oscillators. This section discusses in detail some of the useful coupling schemes for band-pass and video amplifiers. The lack of a satisfactory high-frequency equivalent circuit and the importance of the "built-in" feedback of a transistor makes the value of some of this analysis questionable. Qualitative results can be obtained but little more. The discussion of oscillators is extremely meager.

In Chapter 14, the authors do finally point out some of the more general approaches to transistor circuits, but unfortunately many readers may never be aware of this since the material is introduced as an illustration of matrix analysis, a completely unnecessary sophistication.

Large-signal analysis of conventional amplifiers is presented in Chapter 7, and switching circuits are treated in Chapter 19. The power amplifier discussion concentrates on the grounded-base configuration, despite the equal importance of the grounded-emitter and collector configurations.

Despite the individual points criticized here this reviewer feels that *Principles of Transistor Circuits* is, on the whole, a good book. The material presented is readable, and it should serve the avowed purpose of introducing engineers familiar with vacuum-tube circuits to some of the possibilities and idiosyncrasies of transistor circuits.

ALAN B. MACNEE

Department of Electrical Engineering
University of Michigan

Chemistry and Biochemistry

Present Problems in Nutrition Research (in German, English, and French.) *Experientia,* suppl. I. Proceedings of the symposium held in Basel, Sept. 1–4, 1952, under the auspices of the International Union of Nutrition Sciences. F. Verzár, Ed. Verlag Birkhauser, Basel–Stuttgart, 1953. 312 pp. Illus. Sw. fr. 32.

Nutrition is unique among scientific disciplines for its catholicity. In its study of the requirements, digestion, utilization, and metabolic fate of essential and nonessential nutrients, it coincides with much of biochemistry and physiology and touches some parts of microbiology. In its quantitative aspects, it can be superimposed upon bioenergetics and with some aspects of environmental physiology. Because of its implications in nutritional, as well as degenerative, diseases and its relation to the problem of resistance to infection, it is of growing importance in medicine and public health. It is an essential basis of animal husbandry. Because nutrients must be translated into foodstuffs, food chemistry is an integral part of the science of nutrition. Because, in turn, these foodstuffs must be produced, procured, economically available, palatable, and acceptable, the nutritionist must possess some degree of familiarity with agriculture, canning, milling, and refrigeration techniques, and with the branches of economics dealing with the production and distribution of foodstuffs as well as with the buying power of consumers. He must know something of the statistical methods used in population studies, be acquainted with known facts on the psychology of taste, and recognize social and religious tradition determining food habits as well as legal practices governing enrichment and addition of chemicals to foods. Truly, the nutritionist can apply to himself the verse of Terence: *Humani nihil a me alienum puto.*

This universality is strikingly reflected in the volume summarizing the proceedings of the Symposium on Present Problems in Nutrition Research that was held in Basel. This book, ably edited by F. Verzár, presents some 20 talks given by well-known European nutritionists as well as the discussions that followed each talk. Particularly outstanding, in the opinion of this reviewer, were the presentations of Tremolières (Surveys of Food Attitudes and Habits); Cuthbertson (Microbiology of Digestion); Bigwood (Free and Combined Amino Acids in Foodstuffs); Karl Thomas (Utilization of Synthetic Fats); Abramson (Chemicals in Foods and Their Control by Health Authorities); Dam (Vitamin E as an Antioxidant); Folley (Practical Possibilities of Use of Hormones in Nutrition); Beznak (Relation of Dietary Fat to Work and Growth); and Demole and Cremer (Present-day knowledge of Dietary Role of Fluorine and Other Minerals). W. R. Aykroyd, the director of the Nutrition Division of the Food and Agriculture Organization, gave a lucid and comprehensive review of the nutrition work of FAO. A. G. van Veen, also of FAO, discussed the question of satisfactory protein sources for supplementary child-feeding programs, a point of great importance now that Kwashiorkor (protein deficiency syndrome) is emerging as the most urgent world-wide nutrition problem.

The book, attractively printed, represents an excellent cross section of present-day problems and is a valuable addition to the nutritionist's library.

JEAN MAYER

Department of Nutrition
Harvard School of Public Health, Boston

A Simple Guide to Modern Valency Theory. G. I. Brown. Longmans, Green, London–New York, 1953. 174 pp. Illus. $2.50.

Although this book was originally written by a master at Eton for use in English public (that is, private) schools by "advanced sixth form pupils," many chemistry students in this country, both undergraduate and graduate, as well as older chemists who wish to keep abreast of modern developments will find this slim volume of great usefulness. In a simple, mainly qualitative manner and with a minimum of mathematics, the author has presented a clear and concise account of modern valency theory.

A short historical introduction, tracing the development of the concept of valency from Berzelius and Dumas to the present, is followed by an outline of atomic structure, including a simply written but excellent chapter on the arrangement of extranuclear electrons. This is succeeded by a discussion of electrovalent, covalent, and