without undue regard to "requirements" of any kind.

All *teachers* of physics, whether in the secondary school or the college are under great obligations to Mr. Kent for his clear, excellent and simple explanation of this debated subject.

FRANKLIN T. JONES

UNIVERSITY SCHOOL,
CLEVELAND, OHIO

NOTE ON FREE PUBLIC MUSEUMS

WHILE reading Mr. Henry L. Ward's very excellent paper on "Modern Exhibitional Tendencies of Museums of Natural History and Ethnology designed for Public Use," recently published,[1] the following interesting statement was noted:

> In fact, to the best of my knowledge, the Public Museum of the City of Milwaukee was the first institution of this nature to throw open its doors for the free admission of the public on every day of the year, a regulation to that effect having been adopted and put into force in December, 1905.

It is exceedingly gratifying to note that this progressive institution has been among the first to recognize that public museums are for the people and that all should be admitted freely with as little hindrance as possible. In this commendable movement, however, the Chicago Academy of Sciences has about ten years' priority over the Milwaukee Museum, its doors having been continuously open to the public since October 1, 1894. The hours are 9 A.M. to 5 P.M. week days and 1 to 5 P.M. Sundays. It is interesting to note that the Willner bequest of $100,000 recently received by the academy was won because the children were allowed free access to the building, especially on Sunday afternoons, and were given more or less attention. Mr. Willner once said to a friend, as he observed the interest of the children in the museum exhibits, "I think this institution is deserving of support." The fact that the academy received one third of his fortune is ample evidence that he believed in the educative value of institutions of this character.

FRANK C. BAKER

[1] Trans. Wis. Acad. Sciences, Arts and Letters, XVI., pp. 325–342, 1908.

SCIENTIFIC BOOKS

The Theory of Electrons and Its Applications to the Phenomena of Light and Radiant Heat. By H. A. LORENTZ.

This book is based upon the course of lectures delivered by Professor Lorentz at Columbia University in March and April, 1906. But the author has introduced into the book considerable material not given in the lectures and has also given in the form of notes many mathematical proofs which were omitted in the lectures.

It was naturally expected that this book by an author, who is himself responsible for a large part in the remarkable development of the modern theory of electrons, would prove of absorbing interest to physicists and to those in general who have any knowledge of the importance and fascination of the subject. As was expected, this is the case.

The author states in his preface that he is perforce obliged to restrict himself greatly in discussing the applications of the theory as to the number of topics considered, and remarks that the work of Voigt on magneto-optical phenomena, of Planck on radiation and of Einstein on the principle of relativity, has not received the attention which its importance would justify. The scope of the book will to some extent be revealed in the present brief review.

In the first chapter the fundamental formulæ of the electron theory are derived from Maxwell's well-known theory, with the aid of auxiliary hypotheses which the nature of the subject demands. Referring to Maxwell's equations, the author calls attention to the fact that, while they are useful and adequate in the treatment of many problems, there are yet many problems for which they are not. He goes on to say:

> Moreover, even if they were so, this general theory, in which we express the peculiar properties of different ponderable bodies by simply ascribing to each of them particular values of the dielectric constant, the conductivity and the magnetic permeability, can no longer be considered satisfactory when we wish to obtain a deeper insight into the nature of the phenomena. If we wish to understand the way in which electric and magnetic properties depend on the temperature,

the density, the chemical constitution or the crystalline state of substances, we can not be satisfied with simply introducing for each substance these coefficients, whose values are to be determined by experiment; we shall be obliged to have recourse to some hypothesis about the mechanism that is at the bottom of the phenomena. It is by this necessity that we have been led to the conception of electrons, *i. e.*, of extremely small particles, charged with electricity, which are present in immense numbers in all ponderable bodies, and by whose distribution and motions we endeavor to explain all electric and optical phenomena which are not confined to the free ether.

After the development of the fundamental equations, the first chapter is chiefly devoted to the general properties of free electrons. Use is made of the quantity named by Abraham the electromagnetic momentum and employed by him in his "Prinzipien der Dynamik des Electrons." The interesting question of the electromagnetic mass of the electron receives comprehensive treatment, in which the necessary distinction between "longitudinal" and "transverse" mass is very clearly brought out. With a view to their subsequent application in connection with the influence of the earth's motion upon optical phenomena the fundamental equations for a moving system are derived. The chapter closes with a brief review of Drude's theory of the conduction of electricity in metals, and of a revised form of this theory, proposed by the author, and considered by him to be somewhat more rigorously developed than that of Drude.

In the second chapter the subject of emission and absorption of heat is discussed from the standpoint of electron theory, with the view of indicating how far this theory may lead toward the elucidation of the mechanism involved in the phenomena.

Reference is made to the classical work of Kirchhoff, Boltzmann and Wien in connection with black body radiation, and it is remarked that the results obtained by Boltzmann and Wien represent all that could be expected from the methods of thermodynamics and general electromagnetic theory, and that these results afford small clue to the discovery of the real nature of the mechanism of emission and absorption.

Planck's theory of radiation is then discussed. As is well known, this theory is based on the assumption that every ponderable body contains a very large number of electromagnetic resonators. Different resonators may have different natural frequencies. In order to arrive at his well-known radiation formula, Professor Planck assumes that each resonator possesses the peculiar property of being able to receive or give up energy in definite finite amounts only, and not gradually. Many who have attempted to follow Professor Planck's arguments in the development of his theory have found their chief difficulty in this assumption. In view of this fact, the concluding remarks of the author are of particular interest. Referring to Planck's theory, he says:

> Yet, we can not say that the mechanism of the phenomena has been unveiled by it, and it must be admitted that it is difficult to see a reason for this partition of energy by finite portions, which are not even equal to each other, but vary from one resonator to another.

Professor Larmor in the Bakerian lecture of November 18, 1909, referring to Planck's theory, also calls attention to the same difficulty.

The author goes on to develop an electron theory of radiation for metals, and arrives at a formula, valid for long waves, which is in agreement with Planck's for this case.

Finally, Jeans's theory of radiation is briefly reviewed. This theory, as is well known, is based on the assumption that the mechanical theorem of equipartition of energy is applicable to modes of vibration in the ether, and it furnishes a radiation formula which for long waves also agrees with Planck's for this case. The author's concluding remark is again of much interest:

> I shall conclude by observing that the law of equipartition which, for systems of molecules, can be deduced from the principles of statistical mechanics, can not as yet be considered to have been proved for systems containing ether.

Professor Larmor in the lecture referred to above refers to the well-known controversy concerning this matter.

Chapters III. and IV. are devoted to an extended discussion of the Zeeman effect and of the propagation of light in a body composed of molecules. In concluding, the author remarks on the inadequacy of the theory in its present state, and cites the experiments of Wood on sodium vapor, and those of Humphreys and Mohler indicating the shifting of spectral lines by pressure, as beyond the power of the present theory to explain.

In chapter V. optical phenomena in moving bodies are considered. Fresnel's classical work in this connection is reviewed, likewise Stokes's theory of aberration with Planck's well-known amendment. The theory of electrons is applied to the deduction of Fresnel's coefficient. The Michelson-Morley experiment is discussed, and its negative results explained on the assumption of the Fitzgerald-Lorentz shortening effect. The negative results of Rayleigh and of Brace in looking for double refraction due to the Fitzgerald-Lorentz shortening effect are explained on the author's theory of corresponding states for a fixed and moving system. Abraham's results on the energy of a moving electron are discussed. The question of form of the moving electron is also considered; and the difficulty is brought out of reconciling the rigid spherical electron of Abraham, or the electron deformed by motion into an ellipsoid having the original volume, proposed by Bucherer and by Langevin, with the experiments of Rayleigh and of Brace on double refraction in moving bodies. The author's well-known electromagnetic equations for a moving system are derived, and the interpretation which has been given to his results by Einstein in the theory of relativity is clearly brought out.

Even the non-mathematical reader will not find unusual difficulty in reading this book. For the text itself is devoid of intricate mathematical proofs. Those who are interested in following through the analysis involved in the demonstrations of the formulæ employed in the text are referred at the appropriate times to the mathematical notes at the end of the book. Throughout, the reader meets with the usual clear methods of exposition so characteristic of all the author's writings. The book is in English and published by the firm of B. G. Teubner, Leipzig.

A. P. WILLS

Taschenbuch für Mathematiker und Physiker. Unter Mitwirkung von FR. AUERBACH, O. KNOPF, H. LIEBMANN, E. WÖLFFING, u. A. herausgegeben von FELIX AUERBACH. 8vo, pp. xliv + 450. Leipzig und Berlin, Teubner. 1909. 6 Marks.

While the chemists, astronomers, engineers and other professional orders have long possessed pocket manuals for handy reference, a similar convenience has not been provided for mathematicians and physicists. The present little volume supplies this want in a considerable degree, and compresses into a small space a remarkable mass of useful information. The "Taschenbuch" will be issued annually, with constant variation of subjects treated so as to cover eventually as wide a range as may be desirable. The first volume, for 1909, has been delayed by circumstances incident to a new undertaking, but future issues are expected to appear early in each year.

A brief notice of Kelvin's work, accompanied by a portrait, opens the volume. There follow a calendar for the year 1909, several useful tables of astronomical, geographical and other constants, and four-place tables of logarithms, trigonometric and hyperbolic functions, squares and Bessel functions. These conclude the introduction, pages i–xliv. The body of the manual is divided between Mathematics, pages 1–160; Mechanics, pages 161–203; Physics, pages 204–350, and General Chemistry, pages 351–369. Later come lists of mathematical and physical journals and of recent publications, a necrology, the roll of teachers in the higher German institutions of learning and a good index of the volume.

Subjects reserved for treatment in later issues are indicated in the text. Under Mathematics are at present included the fundamentals of arithmetic, theory of numbers, algebra, determinants, theory of groups, infinite series, differential and integral calculus, definite integrals, differential equations, calculus of