This second edition of the Elementary Encyclopedia has received such extensive additions that the third volume of the original appears in two parts. The first of these was reviewed in this BULLETIN, page 87 of the current volume. The second part, under consideration, contains the revised books entitled "Graphik" and "Wahrscheinlichkeitsrechnung." The first book has a new section on "Axonometrie und Perspektive." "Two new books have been added to meet the views of certain critics of the first edition: "Politische Arithmetik" and "Astronomie." Other changes are minor.

The third book includes the theory of interest and actuarial computations. The theory of interest is based upon compound interest, in the sense that simple interest is looked upon as an annuity in perpetuity. Only the elements of insurance are developed.

The fourth book deals with spherical astronomy and the calculation of orbits. The subjects considered are astronomical coordinates, determination of time, variations of stellar coordinates, observations with instruments, determination of latitude and longitude, and orbits.

The additions to this useful work will be welcome in many quarters. While one might criticize the proportional amount of space devoted to them, and to the other divisions of the book, such criticism would arise from purely personal views as to what applications are important, and would vary from person to person. The authors and editors are deserving of praise for the work taken as a whole.

JAMES BYRNIE SHAW.

A History of the Theories of Aether and Electricity from the Age of Descartes to the Close of the Nineteenth Century. By E. T. WHITTAKER. London, Longmans, Green, and Co., 1910. xiii+475 pp.

EITHER consciously or unconsciously, Whittaker must be imbued with a missionary spirit which leads him forth into dark places to enlighten them with opportune gospel. Three of his books, Modern Analysis (1902),* Analytical Dynamics (1904),† and this History, bear ample evidence to this.

We do not lack for works on the theory of functions, but

* Reviewed in the BULLETIN, volume 10, p. 351, by M. Bôcher.
† Reviewed in the BULLETIN, volume 12, p. 451, by E. B. Wilson.

they are unfortunately similar and similarly placed. Take for example Osgood's Funktionentheorie, a consummate work of art, delightfully fit the student of pure mathematics, but so completely concerned with method and point of view and beauty that the student who must use his analysis gets little from it. Indeed most modern works on analysis are modern to the point of abolishing analysis. The prime and unique feature of Whittaker's Modern Analysis is the welding together of modern method with the older analytic facility so that the whole may be of use to the physicist and astronomer.*

We do not lack for works on mechanics; but Whittaker's is unique, and again the uniqueness consists in the amalgamation of the old with the new, of the admirable English problem-solving with the theoretical advances and advantages of integral invariants, continuous groups, and the like.

It is obvious that this power to judge values, to pick and combine the essentials in different points of view, is vitally necessary to the successful composition of a history of ether and electricity such as is here offered to the public. It is fortunate that one who has shown the power so clearly should have undertaken the work and brought it forth at a time particularly opportune.

There is no time at which a well-coordinated history of a vast branch of science can be considered inopportune, but the years when a great theory has at last conquered the world after considerable opposition and is taught far and wide by that conservative element who, had they been alive and teaching during its incipiency, would have ignored it or fought it, the years when the progressive element are looking forward to new points of view, to new theories, not yet thoroughly formulated,—these years are indeed the best in which such a history may appear.

Relative to the ether we are now in precisely this sort of period. Maxwell's theory of action through an all-pervading plenum has had its triumphal acceptance. Those who could not or would not understand the theory have for the most part passed away. One of the greatest and one of the last of them was Lord Kelvin. He was a deep student of fluid and of elastic media, he was ever seeking an intelligible mechanical

* We do not wish at all to impugn any of Bôcher's criticisms in the review just cited as to the incompleteness of the rigorous treatment in some parts of Whittaker's Modern Analysis.

conception of the ether; he apparently never found one which was completely satisfactory to him, and it is doubtful if he ever became a real sympathizer with Maxwell's ether. To all this the publication of his Baltimore lectures in 1904 bears witness.

These difficulties which bothered Kelvin and which troubled everybody in the early days of the theory have by no means all been resolved; they have merely been ignored. The real triumph has not been physical but psychological; we no longer ask those awkward questions which are inimical to the theory, we take the whole fabric as we find it and unquestioningly make application of it. If there be questions, they are of a different sort.

In recent years some active minds have been looking forward toward the formulation of new theories, toward the abolition of the ether. The theory of relativity and the hypothesis of energy quanta have been the two ideas upon which they have chiefly focused their attention. If they in their turn shall triumph, it will probably be not for the reason that all the questions which the opponents of the theories now bring forth shall have been satisfactorily answered, but because the questioners shall have ceased to question. We advance by ignoring our known ignorance and by concentrating upon our assumed knowledge.

We are living at a time of (at least attempted) transition, and that is the opportune time for Whittaker's History to appear. The author himself with his true insight and admirable balance seems to recognize this, and to state it well in the closing paragraphs of the work.

Chapter I contains an account of the theory of the ether in the seventeenth century, founded upon the rather vague speculations of Descartes, but very influential owing to the sway of Descartes over the minds of scientists for a considerable time. Light was the chief physical phenomenon which at this time was subject to experiments sufficiently accurate to test a theory, and Newton and Huygens are the chief names. In Chapter II we turn our attention to electric and magnetic science prior to the introduction of the potentials. Here we are in the domain of action at a distance. Chapter III is on galvanism from Galvani to Ohm.

With Chapter IV we come to the luminiferous medium from Bradley to Fresnel, though during some of the period the idea of a medium was not very strong. The ether as an elastic solid is the subject of Chapter V. Here we are still interested in a luminiferous medium and, with the exception of Boussinesq's work and some of W. Thomson's, we are dealing with the writers of the first half of the last century. It is of course impossible for the author to arrange everything in rigorously chronological order; that would violate too greatly the logical sequence. The analysis of various optical theories, other than the electromagnetic, as set forth in these two chapters will be highly useful to teachers of optics.

The work of Faraday is the almost exclusive topic in Chapter VI. This would naturally lead to the work of Maxwell (Chapter VIII) without interruption were it not for the fact that the mathematical electricians of the middle of the nineteenth century, whose work could hardly have been done before Faraday's experiments, adopted as the basis of their work the conception of action at a distance instead of Faraday's physical conceptions of lines of force. The work of these mathematicians is therefore analyzed in Chapter VII between Faraday and Maxwell.

Chapter IX discusses models of the ether (subsequent to Maxwell). The contributions of the more immediate followers of Maxwell are taken up in Chapter X. Under the title of conduction in solutions and gases from Faraday to J. J. Thomson we return in Chapter XI to discrete theories of electricity; and in the concluding Chapter XII is found an account of the theory of the ether and electrons in the closing years of the nineteenth century, at the very close of which comes Richardson's work on thermionics, belonging actually to the twentieth century.

One theory which might properly have been mentioned, but was not, is that contained in Reynolds's Submechanics of the Universe. Here is a discrete ether and an exceedingly complicated mathematical investigation, which seems both worthy and needful of explanation to the readers of this History. With the exception of this omission from Chapter IX, we find no point for adverse criticism.

To go into further detail with regard to the contents of this History, which should and will be widely read, is needless. Suffice it to say that a careful study of all of the work twice, and of many portions of it several times, leaves but one resolution, namely, to continue the study indefinitely; for there is always something new to learn where so much material is so well presented. EDWIN BIDWELL WILSON.

Theorie der elliptischen Funktionen. Von M. KRAUSE unter Mitwirkung von E. NAETSCH. Leipzig, B. G. Teubner, 1912. vi+186 pp.

ANOTHER text in Jahnke's series for engineers and students. Its object is to give a brief development of elliptic functions for the sake of rendering intelligible those formulas, figures, and tables which relate to elliptic functions in Jahnke and Emde's Funktionentafeln. The titles of the chapters are: Introduction, General theory of Jacobi's functions, Special theory for the real domain, Legendre's normal integrals, Weierstrass's functions, Representation of the general doubly periodic function by means of the foregoing types, Reduction of the general elliptic integral to normal forms. The development is based on the ϑ-functions, and makes relatively little use of the theory of functions of a complex variable. The prominent place given to the ϑ-functions is commendable. In most cases these series converge with extraordinary rapidity and are readily available for computation. The attention to the functions *sn, cn, dn* is also advantageous; in physical problems where the trigonometric functions offer a first approximation, these elliptic functions are the most natural to use. The p-function is admirably discussed, and especial mention should be made of the reduction of the p-function with conjugate imaginary periods to the related p-function with real and pure imaginary periods. It is noteworthy that the authors use a plain p, and not $\wp$; perhaps this latter contortion is on the road to abandonment.

From some points of view it might have been better to assume and use a greater, even a great, amount of the theory of functions of a complex variable; the work would not have been so elementary, but it would have been more instructive. We note with regret that Jahnke has not announced in his series a text on the theory of functions. Such a text, properly executed in the interest of physicists and engineers, would be a welcome addition to his series. Perhaps Lewent's Konforme Abbildung will supply much of the lack; for it is in connection with conformal representation (and elliptic functions) that the function theory becomes most vital to the student of applied mathematics. Whether such a student will