while Bobbitt provides an alphabetical list of references at the end of the text. I find the running reference style more convenient in reading.

Bobbitt's discussion of preparative techniques and the transfer of thin-layer experience to columns is much like Randerath's, except that Bobbitt interjects many details that are suggestive of personal experience. Randerath seems to be quoting the literature, while Bobbitt seems to be relating his own observations. Randerath discusses, in a descriptive way, the theory of thin-layer chromatography, while Bobbitt does not.

On the other hand, Randerath contributes personal experience by devoting almost ten pages to a description of the techniques and applications of ion exchange thin-layer chromatography, while Bobbitt does little more than mention this subject. Randerath's discussion covers the separation of purines, pyrimidines, and nucleotides and includes a treatment of the quantitative determination of the latter. He also describes the available ion exchange cellulosic materials and certain important details of their preparation.

In discussing means of visualizing spots on thin-layer chromatograms, Bobbitt very effectively employs a comprehensive table and thereby compresses a large amount of information into a small space. By contrast, Randerath's descriptive treatment of this material must be considered fragmentary.

The contrasting ways in which Randerath makes use of description and Bobbitt of tables are most clearly shown in the large sections devoted to specific applications. Bobbitt employs a series of tables, including references. Randerath, on the other hand, following headings similar to Bobbitt's, employs a descriptive technique that often provides more information but necessarily does not cover as much ground. Both methods have their advantages. The tabular method gets a vast amount of information into a small space, but it suffers from the limited space available for headings. For example, Bobbitt's table on steroids includes several categories called "Miscellaneous steroids," which leave the reader with an excessively large number of suggestive references. Randerath, on the other hand, does not cover quite as much material but does manage to discuss selected aspects in greater detail. Clearly both approaches have their advantages, and for this reason these books supplement rather than duplicate each other in their treatment of specific applications of thin-layer chromatography.

The timing of these books is very good. Much detailed information has accumulated, and most important classes of compounds and materials have been investigated. Novel techniques will be introduced and new systems studied, but both of these books are essentially up to date and reasonably comprehensive.

WILLIAM A. STRUCK

Upjohn Company,
Kalamazoo, Michigan

Mathematics

Elementary Theory of Analytic Functions of One or Several Complex Variables. Henri Cartan. Translated from the French edition. Hermann, Paris; Addison-Wesley, Reading, Mass., 1963. 228 pp. Illus. $10.75.

This is a very attractive book for mathematicians, especially for those who are sympathetic with Bourbaki and familiar with his terminology. It presents the essentials of its topic elegantly, accurately, and concisely, using modern ideas and methods very effectively. It is not, at least at present, for the casual reader who wants to look up a reference or refresh his memory. The subject matter is standard—how could it be otherwise!—but the words are unfamiliar, and no concessions are made to the uninitiated. In many cases the new terminology is really justified, since it lets a result appear as simply a special case of a familiar theorem in, say, general topology or algebra; in other cases there seems to be no obvious reason for the change. The subject is treated almost entirely as an end in itself; there are no indications that it can be used outside of pure mathematics and hardly any that it can be used anywhere else in pure mathematics.

Whereas most introductory texts begin with differentiable (holomorphic) functions, Cartan approaches the subject via power series: first he does everything possible with formal power series, then fixes attention on the convergent ones. Integrals come next. The index of a closed path with respect to a point is first defined by integration; this allows the author to handle the topological problems easily before he comes to Cauchy's theorem. Next come analytic functions in more than one variable (unusual material for an introductory text) done very briefly, the author's intention being to illuminate the theory of harmonic functions and to prepare the necessary material for discussing analytic differential equations. After this we meet sequences of analytic functions and conformal mapping. The proof of the "Riemann mapping theorem" (a phrase not used in the book) is remarkably concise and transparent. Riemann surfaces are introduced via one-dimensional abstract complex manifolds (these are Riemann surfaces in the classical sense); Cartan prefers to save the name "Riemann surface" for a complex manifold endowed with a holomorphic mapping. Next we have an accurate discussion of analytic continuation, which would hardly be possible in a more conventional text. The book ends with proofs of the existence and fundamental properties of analytic solutions of analytic differential equations.

R. P. BOAS, JR.

Department of Mathematics,
Northwestern University

The Chemistry of Carbenes

Divalent Carbon. Jack Hine. Ronald, New York, 1964. vi + 206 pp. Illus. $7.

This book is written in the well-known style of its author, Jack Hine, a pioneer in the chemistry of carbenes. It is divided into eight chapters, arranged in a logical order; the chapters begin with the simplest carbene, methylene, and proceed, with discussion of the more complex methylenes, in a way that is easy to follow.

Hine, who is primarily a physical organic chemist, places more emphasis on reaction mechanisms and pays less attention to the usefulness of methylenes in chemical synthesis. He also points out some of the unsolved problems of carbene chemistry and suggests how they can be solved, thus making the book useful to the researcher.

Although the author states in the preface that he includes "all the relevant literature available" to him by July 1962, several works are omitted.

Moreover, scattered reference is made to papers that appeared later in 1962 as well as to some published in 1963, but a thorough coverage of the later period is not attempted.

In several parts of the book, facts are given and statements made without the supporting reference. With this exception, the book is well written, and it contains all the essential information about carbene chemistry.

EFTHIMIOS CHINOPOROS
Children's Cancer Research Foundation, Boston, Massachusetts

S-Matrix Theory

Mandelstam Theory and Regge Poles. An introduction for experimentalists. R. Omnès and M. Froissart. Benjamin, New York, 1963. xii + 123 pp. Illus. Paper, $3.95; cloth, $7.50.

Regge Poles and S-Matrix Theory. Steven C. Frautschi. Benjamin, New York, 1963. viii + 200 pp. Illus. Paper, $3.95; cloth, $7.50.

Complex Angular Momenta and Particle Physics. A lecture note and reprint volume. Euan J. Squires. Benjamin, New York, 1963. xii + 161 pp. Illus. Paper, $5.95; cloth, $9.

In 1942 Werner Heisenberg put forward the idea of a new kind of theory of elementary particles, which was based solely on the so-called scattering matrix (S matrix). Heisenberg reasoned that physical theory, in the final instance, should be formulated in terms of the observable quantities only. Ordinary quantum mechanics has already eliminated, for example, the concept of well-defined trajectories of particles because these are not exactly observable in principle. The scattering matrix connects the measured properties of particles in the final state of a scattering experiment with those in the initial state; its elements are essentially the transition probability amplitudes between these states. Quantum principles, the conservation of total probability, and invariance principles (such as relativistic invariance) can be formulated directly in terms of the S matrix. It turns out that the S matrix contains not only information about the cross sections of scattering processes but about the stationary, or bound states (composite particles), and lifetimes of unstable particles as well, if some of the variables, like the total energy of the scattered particles (the S matrix is a function of the energy, momenta, spin, and other quantum numbers of the particles), are allowed to take unphysical, even complex, values. Therefore, a knowledge of the S matrix is sufficient to answer all questions with respect to the interactions of particles regardless of whether they are elementary or composite. However, the quantum and invariance principles are essentially of a kinematical nature and do not suffice to determine the S matrix uniquely.

For this reason Heisenberg's ideas remained dormant for more than a decade until some new "dynamical" properties of the S matrix, properties which are based on perturbation theory, were discovered in quantum field theory. These are the analytical properties of the S-matrix elements. It was recognized that by analytic continuation of, say, the energy variable, the amplitude of a certain process describes other related physical processes as well and, to some order in perturbation theory, it is, with the exception of some required singularities, an analytic function. These singularities, moreover, have definite physical meanings: bound states, unstable particles, thresholds of new energetically possible channels, and the like. If one now assumes these analytical properties from the beginning, in addition to the properties mentioned above, one can approximately determine the S matrix, because analytic functions satisfy very stringent additional restrictions, such as the Cauchy relations (dispersion relations).

Since 1959, largely as a result of its successes in the theory of strong interactions where perturbation theory had so-far failed, this fact has given rise to a very extensive development of a new line of physical theory, the S-matrix theory, based on the assumption of analyticity. In general, some difficulties of the field theory are eliminated, and some simplification of the conceptual framework is obtained; but other more serious difficulties—that is, how to deal with a large number of interacting particles—still remain.

The three overlapping monographs under review resulted from the rapid developments that have occurred during the past 5 years, and all are expanded lecture notes, not really textbooks. The analyticity of the scattering amplitude can be studied in the energy and momentum transfer variables (Mandelstam representation) or in the energy and angular momentum variables (Regge representation). These and other representations of the scattering amplitude are advantageous, depending on the situation. The first two monographs deal with both representations, whereas the third monograph, Squire's *Complex Angular Momenta and Particle Physics*, is devoted exclusively to the latter representation.

Now let us discuss the works separately. The monograph by Omnès and Froissart is a very clear introduction to the subject, with a large number of illustrations. As a matter of fact, it is written for experimentalists, but even theorists who are learning the subject can greatly benefit from the monograph. A little less than half of the book is devoted to the analytical properties of the scattering amplitude in nonrelativistic Schrödinger potential theory. This model, which neglects in the unitarity all states with more than two particles, has been very useful in guessing and interpreting relativistic results. Frautschi's monograph is very similar in content and organization to the first one. Again, about half of the space is devoted to nonrelativistic models, the other half to relativistic considerations—that is, half to Mandelstam and half to Regge representation. There is a little more about approximation methods and examples (N/D method, polology, strip approximation) in the second monograph.

In his monograph Squires provides a more detailed and comprehensive review of the properties of the scattering amplitude as a function of complex energy and complex angular momentum, in both relativistic and nonrelativistic cases. The book also contains reprints of eight related articles that complement the text. In the relativistic theory, the study of the analytical properties of the scattering amplitudes becomes very complicated and confused, in general, because statements are made on the basis of certain graphs or certain terms among infinitely many other graphs or terms. Squires is careful to state what has been proved and what is based on conjecture or is assumed. His monograph gives a complete picture of the theoretical problems, many of which are still unsolved, and of practical applications, many of which are still inconclusive.

A. O. BARUT
Department of Physics, University of Colorado