of subroutines that can be used to build, within a wide range, the procedure for content analysis that the user wishes to explore. The user supplies a dictionary of word categories (or uses one prepared for another application) which defines groups of words which he believes are indicative of some concept (for example, the category POSITIVE VALUATION may contain "good," "excellent," "desirable," and so on). He must then extensively edit the text to be processed, marking with tags the intended senses of ambiguous words, the referents of pronouns, and any syntactic features he wishes considered. He then decides what summary statistics are of interest—frequency counts by category, weighted frequency counts, or, most useful, frequencies of combinations of categories with constraints on ordering and nearness. Using the subroutines provided he constructs the program which will process his edited text. The General Inquirer provides some important operations, such as finding root forms of words by removing affixes, but does not do any sophisticated linguistic analysis.

How useful is this package of programs? Judging by the sample of applications reported, comprising 60 percent of the present book, it has been quite useful to a variety of social scientists, with some interesting results ranging from analysis of presidential nomination acceptance speeches to studies in psychotic language. Such broad application attests to the careful design, enthusiastic promotion, and ease of use of this tool.

This volume is, however, more than a description of the General Inquirer and its applications. The first part contains a thorough review of the history and philosophy of content analysis, being equally careful in pointing out its limitations and its potentialities. The techniques at present available can provide important information from a significant and ubiquitous source of data which in principle is much richer than the narrow channel provided by traditional methods of psychological experimentation. It is obvious, however, that such gross techniques alone cannot recover all, or even the most important, information from these data (for instance, whether an author's arguments are valid, his assertions true, and his intentions moral).

The authors of the book assume the reader knows nothing about anything and proceed to tell him a great deal. While this makes the book long-winded, it also makes it comprehensible to a wide audience from the sciences and the humanities.

ROBERT K. LINDSAY
Mental Health Research Institute, University of Michigan, Ann Arbor

Statistical Ensemble

Differential Space, Quantum Systems, and Prediction. NORBERT WIENER, ARMAND SIEGEL, BAYARD RANKIN, and WILLIAM TED MARTIN. M.I.T. Press, Cambridge, Mass., 1966. 188 pp., illus. $7.50.

Several apparently unconnected topics in mathematics and mathematical physics are drawn together, in this book, by their common reliance on the concept of the statistical ensemble. These topics are (i) the mathematical theory of the Brownian motion process (where the ensemble is composed of individual Brownian paths), (ii) analysis in function space (for example, integration of a function over an ensemble of Brownian paths), (iii) prediction of time series (where prior observation on a sample from an ensemble is used to predict the future), and (iv) the problem of "hidden variables" in quantum mechanics.

All these topics were investigated and illuminated by Norbert Wiener. About ten years ago, a seminar under his guidance at M.I.T. was devoted to this material. The present volume developed from that seminar; some new material, post-1956, has been added. The actual writing was divided up, each author accepting responsibility for certain material, and Rankin was the editor.

My impression is that this book can be read comfortably only if one has command of a rather high level of mathematics. But much of the material in the book should be of great interest to physicists, particularly those working in statistical mechanics and in the foundations of quantum theory. For example, the chapter on prediction of time series is important for certain recent work in non-equilibrium statistical mechanics. The chapter on integration in differential space describes elegant techniques that are now being used to solve specific problems in the statistical mechanical theory of phase transitions.

The book closes with an interesting analysis of the question of hidden variables in quantum mechanics. Is the standard "Copenhagen interpretation" of quantum mechanics, involving use of statistical ensembles, a necessary one, or is it only sufficient? Wiener and Siegel contributed to this discussion by constructing a Brownian motion interpretation of quantum mechanics, in which the individual Brownian path, while not predictable in practice, may be predictable at least in principle. Whether their interpretation is physically significant is presently unclear; but the discussion here sets forth their views clearly.

ROBERT ZWANZIG
Institute for Fluid Dynamics and Applied Mathematics, and Institute for Molecular Physics, University of Maryland, College Park

Mathematics Made Easier

Lie Groups for Pedestrians. HARRY J. LIPKIN. North-Holland, Amsterdam; Wiley, New York, ed. 2, 1966. 194 pp., illus. $6.50.

The theory of Lie groups has played an increasing role in the development of physics in the last few years. Unfortunately, a large proportion of physicists are insufficiently educated in this mathematical field and tend to regard its machinations with awe and suspicion. Available texts are too formal and often too extensive to assist those who merely want a good idea of how these techniques are applied in physics. *Lie Groups for Pedestrians* is intended for just these people.

The author achieves his aim by adopting an informal pedagogical approach. Rather than presenting formal definitions and derivations, he leans heavily on analogy with the familiar angular momentum algebra, which enables him to stress the physical content of the material and to convince the reader of its simplicity. He begins by outlining the benefits of a group theoretic approach, and retains the interest of the not-too-mathematical reader by interspersing physical applications throughout the book. The material covered is obviously influenced by the author's experience and contains some of his original contributions. As these comprise both nuclear and elementary-particle physics, the book will appeal to, and be appreciated by, people in rather different fields. There is an extensive discussion of the group SU(3), applied to high-energy physics and in a different way to nuclear physics. The differences between this group and the more familiar SU(2) are pointed out and their physical implications discussed. In such a small book, certain subjects must inevitably be omitted. In some cases, like the Lorentz group, this omission is regrettable.

In this type of presentation, there is usually the danger of sacrificing rigor and detail. It is gratifying that this is not the case in Lipkin's book. Although intended as an elementary text, *Lie Groups for Pedestrians* succeeds in imparting not only relevant facts but much of the spirit of this field of physics, and the book should be very useful to graduate students, experimental physicists, and "pedestrian" theoreticians.

I. KELSON

Physics Department,
Yale University,
New Haven, Connecticut

Analyzing an Industrial Economy

Input-Output Economics. WASSILY LEONTIEF. Oxford University Press, New York, 1966. 269 pp., illus. $8.50.

It is appropriate that in his 60th year Wassily Leontief be honored by the publication of two volumes of his essays of the past 30 years. The 11-article volume reviewed here covers only one facet of his broad interests, input-output analysis.

The notion of relating, on a systemwide basis, the inputs and products of national economic activity did not originate with Leontief. The French physiocrats, headed by Quesnay, made ample use of many of the same ideas in the mid-18th century, formulating the *tableaux économiques*. In the next century, these concepts were rigorously stated in mathematical form and developed further by the Swiss Léon Walras (in *Eléments d'économie politique pure*, Lausanne, 1874). Also, important contributions to the subject were made by Russian mathematicians early in this century. But it was Leontief (himself a Russian by birth and now Henry Lee Professor of Economics at Harvard) who brought the ideas to the point of empirical fruition.

Basically, the concepts involved are extremely simple (these are expounded in three somewhat repetitive essays in the present volume, numbers 2, 7, and 8). Let superscript 58 represent constant 1958 dollars, and let F be an n-component vector of industry final demands, S an n-component column vector of gross industry outputs, $A = n \times n$ matrix of input-output coefficients whose elements a_{ij} denote the constant dollars of output of industry i required to produce a constant dollar of gross output of industry j, and I the identity matrix. Then the fundamental input-output relation in matrix notation is

$$F^{58} = (I - A)S^{58}. \qquad (1)$$

In single-equation notation, for the first industry, this is equivalent to:

$$f_1^{58} = (1 - a_{11})s_1^{58} - a_{12}\, s_2^{58} - \ldots - a_{1n}\, s_n^{58}$$

In other words, the amount delivered to final demand by the first industry is its total gross output less the amounts delivered to all industries (including itself) for use as production inputs.

Thus, to undertake input-output analysis, one needs two vectors, industry output and sales to final demand, plus a matrix (A) of technological relationships. Such data have now been compiled for the United States for 1939, 1947, 1958, and 1964. They have also been constructed for many other countries for various years. The accuracy and detail of these efforts, of course, varies greatly. For example, the 1947 U.S. input-output table has 451 industries and the 1958 table has only 86. The latter is completely consistent with the official income and product accounts, the former is not.

Also, owing to input-output conventions, industry final demand is not the same as final expenditures (consumption, investment, and so forth) in the national income and product accounts. For example, the sale of an automobile generates final demands for the manufacturing, transportation, and trade sectors. Therefore an additional translator is needed. Let G be an m-component vector of gross-national-product (GNP) component expenditures, B an $n \times m$ constant matrix of parameters where b_{ik} denotes the constant dollars of final demand required from industry i to produce a constant dollar of GNP-component expenditure k. Then

$$F^{58} = BG^{58}. \qquad (2)$$

Substituting Eq. 2 into Eq. 1 we find

$$BG^{58} = (I - A)S^{58} \qquad (3)$$

or

$$S^{58} = (I - A)^{-1} BG^{58}. \qquad (4)$$

This yields the amount of constant-dollar gross output directly and indirectly required from every industry, given a vector of constant-dollar GNP-component demands. The usefulness of the technique for business forecasting purposes therefore should be evident.

The relationship may, of course, be differentiated with respect to any GNP demand (defense expenditures, for example) to indicate additional output requirements from any industry. That is,

$$\partial S_i^{58} / \partial G_k^{58} = \sum_{j=1}^{n} (I - A)_{ij}^{-1}\; B_{jk}.$$

This is the kind of game that was played during World War II and in Leontief's consideration of the economic effects of disarmament (essay 9). If the national A and B matrices are segmented to reflect regional technologies and output distributions, then the impact of an arms cut can be ascertained on an industry and area basis (essay 10). (Actually, Leontief augments the matrices so as to describe flows: nationally; from local to national industries; from national to local sectors; and within local industries.)

It is also the kind of game that can be, and is, played for much present-day development planning. Given desired consumption and investment goals, a country can determine what industries it needs to develop in order to achieve its objectives. In fact, one measure of the degree of development is the density of the A matrix (essay 4). For the United States, the matrix has positive entries in nearly every cell; for the less-developed nations it is sparse, with mostly zero entries.

Thus far, we have talked only of in-