All of Klein's manuscripts demonstrate an efficient use of words. Much information is contained on each page, yet the writing is thoroughly lucid, and delightful to the reader. Compactness is achieved, though not at the expense of a brief literary gem to introduce each chapter and an apparently easy style of writing throughout. The author makes no attempt to minimize his feelings or to hide his innate wit when he describes overzealous regulatory activities of the government or callous disregard for civilized ethics by municipal or industrial polluters. The result is most enjoyable.

This book is, of course, British, which is particularly apparent in Klein's historical introduction and his review of legal aspects of river pollution. These two chapters are of relatively minor use to an American seeking quick answers to a technical question, but are excellent reading for anyone who will relax long enough to appreciate them. The remaining chapters are more tightly packed with technical information on pollution.

The nature and effects of pollution are carefully outlined and described as to sources, chemical types, physical types, physiological aspects, and biological effects. Industrial wastes are included in all of these phases, and are more specifically covered in the succeeding chapter, in parallel with sewage, as a cause of river pollution. Some of the aspects of industrial pollution are typically British, but nevertheless of interest in American practice.

The uses of river water are explored, including brief sections on conservation and possible substitute sources of water. Standards are discussed for the quality of water for drinking, groundwater recharge, industrial uses including boiler water and cooling water as well as a number of specific industries, agricultural and fishery use, waste transport, navigation, and recreation.

The second half of this volume covers more specifically the biochemical and physicochemical aspects of pollution, and biological aspects including separate chapters on fish and on other aquatic life forms. Klein has called upon coauthors for these subjects, each an expert in his field; the result is an exhaustive survey of current information. Toxic materials are well covered, as are other aspects of the aquatic environment.

Klein's book is well documented with literature citations throughout. Probably not suitable for a beginner's text, it is an excellent reference work for anyone who wishes more than a casual knowledge of stream pollution.

C. Fred Gurnham
Illinois Institute of Technology

Elements of Chemical Reactor Design and Operation, H. Kramers and K. R. Westerterp, Academic Press, Inc. (1963). 245 pages. $10.00.

This new text on reactor design merits the attention of both educators and those in industrial practice for its catholicity of coverage and its attention to those problems which are, at the same time, important for the student and indicative of current practice and application for the design engineer. It is most pleasing to note the successful combination of much of the recent and significant work in chemical-reaction engineering with a continuing sense of the importance of those practical and economic considerations involved in its effective utilization.

The subject material of the book includes analysis of batch, tubular flow, and stirred-tank reactors, and their operation. The discussion is extended to include reactor cascades, the cross-flow reactor model, and some applications to fixed-bed reactors. Nonisothermal and mixing effects in reactor design are treated in detail. A separate section is devoted to the topic of reactor optimization, including isothermal and nonisothermal systems, through discussion of some individual cases; applications of mathematical methods of optimization such as dynamic programming are introduced at the end of this section.

The authors are to be commended for their treatment of all these topics. Presentation throughout is clear and well organized; the subject material chosen for presentation from this large and rapidly developing field is well considered. The value of the book as a text is considerably enhanced by numerous illustrative examples, which are presented after almost every topic, and by the extensive citation of the literature of the field, including most papers of importance in reactor design and analysis.

The text is, thus, very well presented in general; a sole criticism is the omission of a subject index. An overall evaluation, however, must include some questions concerning material which is not presented. It is perhaps unfair to comment on the scope of a work such as this except when the scope is so limited that the material which is presented is adversely affected, or when the presentation is very well carried out and one desires to see the same authors discuss additional, advanced material. The latter comment applies here. The fluidized-bed reactor, for example, is not discussed in detail, and the recent work developing computational models of fixed-bed, catalytic reactors by means of stirred-tank networks is not mentioned at all. The important question of experimental reactors and the problems involved in obtaining reliable kinetic data suffers from condensation; this is unfortunate in the sense that inclusion of a topic in an appendix, as this is, may relegate it to secondary importance in the mind of a student. There are a number of additional points of this nature which might be included here, all dealing with various items which could be extended in scope of discussion. It may be the feeling of the authors that many of these systems, such as fluidized reactors, are not yet well enough characterized to allow treatment in the same manner as material which is presented. In view of the excellence of this book, one may only regret this decision.

The authors have succeeded in their stated attempt to bring forth some type of structure or system by which the problems of reactor design and operation may be treated through the use of methods which possess some generality.

John B. Butt
Yale University

Liquid-Liquid Equilibriums, Alfred W. Francis, Interscience Publishers, New York (1963). 298 pages.

This excellent little book provides a concentrated treatment of the characteristics of liquid-liquid equilibriums in binary, ternary, and quaternary systems. The emphasis is on the manner in which these systems illustrate the principles governing the relationships between regions of solubility and insolubility, the shapes of miscibility gaps and solubility curves, the characteristics of equilibrium tie lines, and other properties. Francis himself has been responsible for developing much of what is known of the properties of these systems, and the book is profusely illustrated with examples, many of which are taken from the author's own extensive researches. Great care is taken to avoid using "typical" systems, no examples of which are known, to demonstrate the principles, and much of the text is devoted to correcting the misinformation which has developed from imaginative use by others of such "typical" systems rather than from direct knowledge.

The book will be most useful for students and chemists working with liquid-liquid systems and for engineers who must apply this information in the practice of liquid extraction. The author's long association with the petroleum industry is revealed on occasions, as when he lists as the principal commercial solvents only those

(Continued on page 137)

(Continued from page 136)

tion of pressure and composition. The flux-ratio function w is a constant, as seen when Equations (3) and (7) are divided:

$$\frac{dN}{dx} \Big/ \frac{dN_A}{dx} = \frac{dN}{dN_A} = 1 - n$$

When they are integrated one obtains

$$\frac{N}{N_A} = w = 1 - n \qquad (9)$$

or

$$\frac{N_B}{N_A} = -n \qquad (10)$$

This result is a consequence of the stoichiometry of the reaction. Equation (9) permits the effective diffusivity to be expressed in a somewhat simpler way:

$$D_e = \frac{1}{\dfrac{1-(1-n)y_A}{D_{AB}} + \dfrac{1}{D_k}} \qquad (11)$$

To complete the description of the problem an expression is needed which relates the flux N to the pressure gradient and the properties of the porous solid and reaction gases. An exact equation in terms of measureable physical properties has not been obtained but there are available useful expressions which contain one or more constants. For example, Evans and colleagues (2) presented two relationships: one the result of momentum balance and the other from the dusty-gas model. Both give the flux as the sum of a flow at constant pressure and a contribution due to the pressure gradient. The second form, which is more suitable for our problem, can be written as

$$N - \left[1 - \left(\frac{M_A}{M_B}\right)^{1/2}\right] N_A = -\frac{C}{RT}\frac{dP}{dx} \qquad (12)$$

where C is a flow coefficient.

The second term on the left side of Equation (12) is the diffusive slip contribution to the flow; that is, the diffusion at constant pressure. For example, if the pressure gradient is zero Equation (12) reduces to the form

$$N = N_A + N_B = \left[1 - \left(\frac{M_A}{M_B}\right)^{1/2}\right] N_A \qquad (13)$$

$$\left.\begin{aligned} \frac{N_B}{N_A} &= -\left(\frac{M_A}{M_B}\right)^{1/2} \\ \text{or} \qquad \frac{N_B}{N_A} &= -n^{1/2} \end{aligned}\right\} \qquad (14)$$

where M_A and M_B are the molecular weights of the two components. Equa-

(Continued on page 138)

(Continued from page 135)

which are used in the solvent treatment of lubricating oils. But this association also leads him to develop in some detail the difficulties which may arise when the complex systems of that industry are simplified for the sake of expediency to "equivalent" ternaries, as is so often done in the practice of solvent refining. Systems of interest in metallurgy are not specifically mentioned nor are the complex equilibriums found in the distribution of metal compounds between aqueous and organic liquids discussed.

There is an excellent short chapter on experimental techniques, over a hundred pages of tables listing published systems which form two liquid phases(not including some 1,500 systems studied by Francis in unpublished work), a long supplement to the author's earlier book on critical solution temperatures, and a bibliography of over 900 entries. The detailed table of contents and a good glossary of terms substitute for an index.

R. E. Treybal
New York University

Design of Equilibrium Stage Processes, Buford D. Smith, McGraw-Hill, New York (1963). 647 pages. $17.50.

This is a well-written book and fills a very real need. The theoretical equilibrium stage presentation is an excellent method for both teaching and carrying out the calculations involved in separation processes. The concept of a theoretical mixer-separator is an easy one to grasp and generalizations can be extended to cover distillation, extraction, and adsorption. In some chemical engineering curricula a simplified staged operations' course follows the usual mass and energy balances that are the student's introduction to chemical engineering. Frequently, advanced courses in the various separation processes are offered at the graduate level. This book is intended to offer a single approach, and presumably a single course, that would make both students and practicing chemical engineers proficient in the stage calculations of the separation processes.

To a certain extent, the author encounters difficulties in trying to adapt the book for both students and practicing engineers. However, the contradictions involved are recognized by the author in the preface. The first sentences of each of the first three paragraphs of the preface are quoted: "This text was prepared primarily for the plant engineers. . . . Although it is anticipated that the major use of this book will be by practicing engineers, a strong attempt was made to make it suitable also for classroom use. . . . It is, unfortunately, impossible to satisfy both the practicing engineer and the engineering professor with one book." The author also notes that the reader is assumed to have the equivalent of an undergraduate education in chemical engineering. Actually, certain parts of the book assume a familiarity and working knowledge of thermodynamics and calculation methods not necessarily possessed by the average graduate. These factors might indicate that a more unified approach aimed at teaching an engineer or an undergraduate student the subject matter, or additional references to other texts for more detailed presentation of some subjects, would have produced a book that would be easier to use.

The chapter on design variables and the application of this subject matter in all succeeding chapters is an outstanding feature of the book. Beyond its use in phase-rule applications, this subject has been ignored in other texts. The general application of this method of determining variance to design calculations is fully as important as its use in the phase rule.

The author employs difference equations indicating constant net flows in the chapters on enthalpy-composition diagrams and extraction but uses the operating line form of the same equations in x-y diagram methods. This reviewer would prefer that true phase diagram calculations using enthalpy- or temperature-composition diagrams be used to introduce separation calculations for binary systems rather than the McCabe and Thiele method. In this way the importance of constant net flows, discontinuities, and ratios of phases could be emphasized. The use of the x-y-diagram could then be introduced as a shortcut or sufficiently accurate approximation.

Shortcut methods are presented prior to the rigorous methods for multicomponent separations. Here again the conflict between using the book for teaching or practice arises. Presumably the practicing engineer would want to use shortcut methods and might investigate them first. For a complete understanding of the subject matter and adaptation to computer calculations, the reverse approach might be more rewarding.

It should be emphasized that the comments contained in this review represent little more than an expression of a difference in point of view. The book should prove to be extremely useful, and it is hoped that more and more chemical engineers will be exposed to this approach to separation processes.

Charles C. Winding
Cornell University