quite good, and most readers will find that the chapters serve as excellent review pieces.

These volumes will represent important sources of information for chemical engineers in research, process development, and process design. Coupled with the parent series that provides alphabetically arranged information, they represent an important resource that belongs in every technical library related in any way to the needs of chemical technologists and scientists. A subscription to the alphabetical series is not necessary in order to purchase these unit operations volumes. This reviewer recommends them highly!

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Laboratory Studies of Heterogeneous Catalytic Processes

E. G. Christoffel (ed., Z. Paál), Elsevier Studies in Surface Science and Catalysis, Vol. 42, New York, 1989, 263 pp., $144.00.

This book is faithful to its name in presenting several aspects of the experimental study and analysis of heterogeneous catalytic reactions. The material is divided into four chapters: Introduction, Basic Phenomena and Concepts in Catalysis, Investigation of Heterogeneous Catalytic Reaction Systems, and Laboratory Reactors. The material is presented in very concise form and encompasses a wide range of technical levels. It thus serves primarily as a valuable, condensed reference work rather than a textbook in this reviewer's opinion.

The material of Chapter 3 on investigations of catalytic reactions is undoubtedly the strong point of the book. Contents start with means for investigation of reaction mechanisms, proceed to development of kinetic models with an excellent dicussion of parameter estimation methods, and conclude with discussions of mass transport and deactivation effects. A number of examples are included with the text material that serve as a valuable introduction to the original literature. The coverage of Chapter 4 on laboratory reactors is complimentary to that preceding, and applications of various typical reactors (flow, micropulse, etc.) are described in some detail. The contents of these two chapters can be highly recommended as supplementary to the contents of most current texts on catalysis or reaction engineering.

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Handling of Bulk Solids, Theory and Practice

By P. A. Shamlou, Butterworths, Stoneham, MA, 1988, 193 pp., $49.95.

This book attempts to address the field of bulk solids handling on a more global basis than has been addressed previously. It is written in a style appropriate for advanced undergraduate or graduate courses on the topic, but also seems to have up to date references in most chapters so that the materials will be valuable to practitioner and researcher as well.

This book is broken down into eight chapters consisting of:

1. Bulk Solids Flow and Handling Properties
2. Pressure Profiles in Bulk Solids Storage Vessels
3. Design of Storage Vessels or Particulate Solids
4. Gravity Flow of Particulate Solids
5. Pneumatic Conveying of Bulk Solids
6. Hydraulic Transport of Particulate Solids
7. Mechanical Conveyors
8. Safety in Bulk Solids Handling

The first half of the book covers solids behavior in bins or vessels, with the interaction of the solids to the vessel and the vessel to the solids. This is a rather comprehensive treatment and should provide both the student and the designer with adequate information to handle this topic rather thoroughly. The references employed in the text are extensive and current, indicating the author's comprehension of the topic, and the historical references are not ignored.

The second half of the book addresses the pneumatic, hydraulic and mechanical transport, along with safety considerations. It is refreshing to see a chapter dedicated to safety to forward community awareness of safety issues for design considerations in the bulk handling of solids. The treatment of the transport sections is adequate, providing the reader with basic information on the topic and giving sufficient information to begin the design process. The detail present in the bin and vessel sections is somewhat lacking for the transport section, a lack which could stem from the author's interest and experience. Some current literature and small points are missing but these do not detract from the overall objective of the book, i.e., to provide information in one place about everything from storage to delivery of bulk solids.

The writing style is straightforward and clear in its approach. I believe that this book is a definite contribution to the field of bulk solids and handling. It is essential for the industrial and academic community to recognize the importance of this topic and that the behavior of solids is not like those of gases and liquids. This book goes a long way to meeting this challenge and should be considered for courses which cover bulk solids.

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Gas-Liquid-Solid Fluidization Engineering

By L. S. Fan, Butterworths series in Chemical Engineering, Stoneham, MA, 1989, 763 pp., $85.00.

This monograph presents a very detailed review of an important and timely subject. The author should be complimented for a rather complete presentation of the available literature on the hydrodynamics, mixing and transport characteristics of a variety of three-phase fluidized bed columns. The monograph should be useful to both industrial practictioners and students involved in re-

search in three-phase fluidized bed systems.

The monograph is divided into three parts. The first part outlines the scope of the monograph and identifies the practical relevance of the subject matter. A very large number of practical examples are delineated and various classifications of three-phase fluidized bed systems are outlined. The second part deals with the major theme of the monograph. The available literature on the hydrodynamics, mixing, mass- and heat-transfer characteristics of three-phase cocurrent upflow, slurry bubble columns, countercurrent flow and batch liquid fluidized bed systems as well as other miscellaneous systems such as draft tube systems, semifluidized bed systems, annular systems and transport systems, is outlined in detail. The third part gives descriptions of various practical applications such as fermentations, aerobic biological wastewater treatment, flue gas desulfurization and particulate removal, hydrotreating and conversion of resids, and other miscellaneous systems such as electrodes, granulation and adiponitrile production, calcium bisulfite acid production, sand filter cleaning, crystallization, flotation, polymerization, coal gasification and methanation, and Fischer-Tropsch synthesis and methanol synthesis which use three-phase fluidization bed systems.

It is clear from the literature reviewed in part 2 of this monograph that during the past two decades, significant research has been carried out to improve our understanding of the physics of three-phase fluidized bed systems. Because of the complexity of these systems, the results for various design parameters are largely presented in the forms of empirical correlations. Wherever appropriate, some theoretical derivations are also outlined. The author has made a good attempt to summarize the present state of knowledge and make appropriate recommendations for each section; however, some recommendations could have been focused more toward practical applications. This could have been done by assessing the applicability of the design parameter correlations for each of the practical applications outlined in part 3.

The author has given an in depth description of various applications for three-phase fluidized bed systems. A review of aerobic biological wastewater treatment is particularly interesting. While it is treated in some cases, models for the reactors and their use in the reactor design and scale-up for each application would have been interesting. Appendix A describes one such model for the catalytic reactors.

While the monograph is generally thorough in its coverage, there are certain points that might also have been included. A brief assessment of micromixing in three-phase fluidized bed systems would have been useful. Important engineering considerations for the operability of various types of columns at various scale and associated instrumentation considerations would have better satisfied the scope of the monograph. Finally, some example calculations illustrating the use of various design parameters would have been useful to the readers.

Overall, the author has done a fine job presenting a detailed reveiw of a very complex and timely subject. The monograph will be an excellent reference guide for the researchers in this area and it can also be used as reading material for a graduate course on the multiphase reactor design.

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Advances in Turbulence

W. K. George and R. Arndt, ed., Hemisphere Publishing Corp., New York, 1989, 234 pp., $60.

This book is a compilation of seven papers that describe recent theoretical and experimental research in turbulence. The papers deal primarily with incompressible, Newtonian fluid mechanics.

Two of the papers describe experimental techniques. The paper by Buchave reviews measurement techniques including hot wire/hot film anemometers, laser anemometry, and recent advances in particle velocimetry. The paper contains references to more than 100 published papers including papers published as recently as 1987. The paper should be useful to beginners as well as people who have some experience in the area.

The paper by Mueller describes the use of smoke visualization and hot-wire anemometry in the study of transitional flows. The paper is comparable in breadth and depth to Buchave's and includes an extensive set of references.

Two papers deal with numerical studies of turbulence. The paper by Taulbee discusses the use of single point closure models. The author focuses on the kinetic energy/dissipation model and the Reynolds stress model for incompressible, isothermal flow.

The paper by Moin and Spalart describes the use of direct numerical simulation to provide information about turbulence. The flows discussed in the paper are low Reynolds number turbulent channel and boundary layer flows. The databases considered were developed by the authors and their collaborators. The main focus is on the use of databases to extract information about eddies rather than on the numerical techniques used in the simulations.

Chevray reviews some of the ideas of dynamical systems and fractals. The Ruelle-Takens theory is described as well as experiments on rotational Couette flow and thermal convection and the various routes to chaos that have been identified. In addition, the phenomenon of chaotic advection in laminar flows is described.

Finally, the papers by George and Lumley discuss some current issues associated with the study of coherent structures. George discusses jet and wake flows, while Lumley discusses ideas about the possible relationship between coherent structures and dynamical systems.

Current research on particle motion in turbulent flow, drag reduction, turbulent heat or mass transfer, compressible flow and several other areas of turbulence research are dealt with tangentially or not at all. On the other hand, the articles in the book are, for the most part, carefully written and should be useful to researchers in the field. Several of the papers, especially the ones on experimental methods, should be helpful to graduate students who are beginning their research projects.

In my opinion, the book would be a useful addition to any engineering library.

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