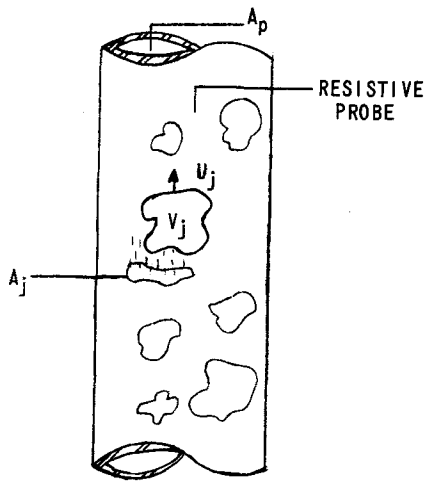

Fig. 1. Irregularly shaped bubbles in a pipe.

An idealized analysis indicates the effects of the bubble size distribution on the gas contact time and on the volumetric void fraction. For the purpose of illustration, the actual behavior of bubbles moving in a liquid is approximated by an infinite-medium solution. Influence of pipe wall on all aspects of bubble size and motion is neglected, bubbles are uniformly distributed across the area perpendicular to flow, and all bubbles of the same radius move at the same velocity. For these conditions, the average bubble chord pierced by the probe has a length of $(4/3)r$. The variance or standard deviation of the chord about the average is $(\sqrt{2}/3)r$, or roughly half the radius. This variance is large enough to create difficulties in obtaining bubble size directly from the traces.

The bubble size distribution function, $B(\zeta)$, discussed by Bankoff and Neal [their Equation (2.2)] is reiterated here:

$$B(\zeta) = \int_o^\zeta b(Z)\, dZ \qquad (4)$$

where $Z = r/R$ and $B(\zeta)$ is the probability that the nondimensionalized radius of a bubble striking the probe is less than ζ. The density function, $b(\zeta)$, is the derivative of $B(\zeta)$ with respect to ζ.

To obtain a simple expression for void fraction in terms of the bubble size distribution, a few assumptions will be made. The assumptions are not crucial to the analysis but illustrate the procedure of obtaining void fraction for a simple case. For an infinite flow field, velocity and size of the bubble are independent of the bubble position relative to the probe. If the bubbles are noninteracting, bubble velocity should be a function of radius only (Figure 2). The average bubble transit time for a bubble of radius r is then

$$\bar{\theta}(r) = \frac{\bar{\delta}\,(r)}{U\,(r)} \qquad (5)$$

(Continued on page 786)

(Continued from page 783)

glects consideration of the movement of the solid in the bed which is important in the chemical reactions in many cases.

The reader will find the material and presentation interesting and provocative, but the state of the art appears to be more appropriate for journal articles and symposia than for a book.

E. R. Gilliland
Massachusetts Institute of Technology

Process Control, Peter Harriott, McGraw-Hill, New York (1964). 374 pp. $13.50.

This book has arrived on the scene just in time to fill a vital need for the professor of chemical process dynamics and control and for his student. It provides an intermediate level text which combines, in an integrated fashion, both automatic control theory and the dynamic response of chemical plant apparatus and its associated control system.

Previously one could choose only from the elementary texts in the field, such as those of N. H. Ceaglske, G. D. Shilling, or T. J. Williams and V. A. Lauher, or from the quite advanced and specialized texts such as Campbell's *Process Dynamics*. Many thus chose one of the many excellent texts of the mechanical or electrical engineering fields at the sacrifice of applications and examples from the chemical field. Therefore Professor Harriott's text should find a welcome reception at our universities and colleges.

This book further justifies its choice as a textbook by a natural breakdown into three progressively more comprehensive and more difficult areas of discussion; by a wide choice of problems at the end of each chapter; by the use of excellent illustrative examples and figures, and by a quite complete author and subject index and table of nomenclature and symbols.

Chapters 1 through 7 of the book can be considered as a review of the basic concepts of automatic control with attention focused on the mathematics of automatic control and on the use and the dynamic response of typical automatic control equipment. While similar to the treatment given in any good text on automatic control, regardless of the field of engineering involved, this section does correlate the theory quite well to the field of chemical engineering through the use of examples taken from the chemical process area.

A second section comprised of Chapters 8 through 13, less 11, and Chapter 16 presents a comprehensive view of several of the specialized areas of the chemical process control field such as control valves and their use, level control, flow control, pH control, theory and use of complex control schemes such as cascade control and feedforward control, and methods of obtaining optimum controller settings.

The third section, Chapters 11, 14, and 15, gives excellent reviews and discussions of the three major areas of chemical process dynamics and control investigation today—heat exchangers, distillation columns, and chemical reactors.

Despite its overall excellence, the book does have some drawbacks which perhaps should be called to the reader's attention for his evaluation of their importance. Foremost of these concerns the problems following each chapter. Many of them might be difficult for the student at the level of knowledge he will presumably have when he encounters them. Several others call for the use of data from the literature or the reference to other independent textbooks, some of which are relatively old. Second of this reviewer's concerns relates to the author's choice of subject matter. It would be a major aid to the student if the subject of temperature control in general could have been treated to the extent of level control, flow control, etc. This is particularly important since such systems tend to have an entirely different level of time constants, etc. The subject of heat exchangers is well covered but is only a part of the temperature control field. Likewise, the subject of analytical instrumentation application and response, which is becoming so vital to chemical process control, is effectively limited to the discussion of pH control in Chapter 16. Perhaps both of these important subjects will be greatly expanded if and when a second edition is prepared.

The textbook *Process Control* is thus one which is highly recommended for any two-semester senior level or beginning graduate student course in chemical process dynamics and control.

Theodore J. Williams
Monsanto Company

Advances in Heat Transfer—Vol. 1, Edited by Thomas F. Irvine, Jr., and James P. Hartnett, Academic Press, New York (1964). 459 pages. $18.00.

The publishing industry provides a useful service to the scientific community and earns a significant income by marketing collections of review articles which are variously entitled "Progress In . . .," "Annual Reviews of . . .," "Modern Developments In

(Continued on page 787)