more coverage of basic theory of frequency response, Nyquist criteria, and phase-plane analysis. Also, as seems to be true of all books on control, there is little to help the inexperienced engineer select and locate instruments and controls for new process designs or process improvements, and this is where much of the chemical engineering control work is involved.

The examples used might have been selected better in frequency response and they seemed repetitious in on-off control, but in most portions of the book they were very good and thorough. The treatment seemed to be especially good in linearization, stability criteria (except Nyquist), root-locus methods, and some complex control material.

This book should prove valuable for an undergraduate textbook and for self-study and reference on basic control theory by the practicing engineer.

MARSHALL E. FINDLEY
PROFESSOR, DEPARTMENT OF CHEMICAL ENGINEERING
UNIVERSITY OF MISSOURI—ROLLA
ROLLA, MISSOURI

Statistical Fluid Mechanics, A. S. Monin and A. M. Yaglom, M.I.T. Press, Cambridge, Mass. (1971). $18.50.

This book is a timely addition to the field of turbulence and turbulent flows. It includes necessary background material (chapters 1 and 2) for those having only advanced classical fluid mechanics training and little previous background in turbulence. The sections dealing with averages and moments will be particularly valuable to this group. The first two chapters, together with the section on semiempirical theories and Reynolds equations, will be a welcome review for persons returning to the field. The serious reader should have a good background in probability theory in order to effectively use and appreciate the material presented in the later sections.

The authors have extended and expanded the application of fluid mechanics to problems involving the atmosphere. Of particular interest are the sections dealing with thermal effects, suspended particles and their dispersion, and the determination of turbulent fluxes of momentum, heat, and water vapor. Included are many references and extensive experimental data (atmospheric) not generally available in the United States.

F. L. WORLEY
UNIVERSITY OF HOUSTON
HOUSTON, TEXAS

LETTERS TO THE EDITOR

TO THE EDITOR: STABILITY OF TUBULAR REACTORS

We would like to comment on a paper which recently appeared in this journal by Clough and Ramirez (1972) relating to the stability of tubular reactors; the comments also apply to some other papers by these authors (1971a, 1971b).

Firstly, in Appendix A, following Equation (A10), they state that "$\underline{\underline{PA}}_{bb}$ is symmetric" which is not obvious unless P is suitably chosen to satisfy this condition: such a statement should be unambiguously included as an additional condition on the theorem. It so happens in the cases quoted that this condition is satisfied, but certainly it cannot be expected to hold in general.

Secondly, and more important, it appears that it is not appreciated that for the quadratic form $\underline{u}^T \underline{\underline{C}}\, \underline{u}$ (quoted in Appendix A) to be negative definite is not the equivalent to saying that matrix $\underline{\underline{C}}$ is negative definite unless $\underline{\underline{C}}$ is a symmetric matrix. Since $\underline{\underline{C}}$ is not in fact symmetric, it is necessary for the symmetric matrix $\frac{1}{2}(\underline{\underline{C}} + \underline{\underline{C}}^T)$ to be negative definite. Consequently the second condition imposed on $\underline{\underline{C}}$ should be applied to $\frac{1}{2}(\underline{\underline{C}} + \underline{\underline{C}}^T)$.

The following example will help to clarify the point. The quadratic form $ax_1^2 + 2b\, x_1x_2 + Cx_2^2$ can be written in matrix form as

$$(x_1\, x_2) \begin{pmatrix} a & 0 \\ 2b & c \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

According to the procedure recommended by Clough and Ramirez the conditions for $\begin{pmatrix} a & 0 \\ 2b & c \end{pmatrix}$ to be positive definite should be $a > 0$ and $ac > 0$. However, it is well known that the above quadratic will be positive definite if $a > 0$ and $ac > b^2$, as can be verified directly by expressing it in the symmetric matrix form

$$(x_1\, x_2) \begin{pmatrix} a & b \\ b & c \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

This error completely invalidates the results quoted in the paper for the dispersive case but would not alter the final conclusion for the nondispersive case, although the argument should be slightly modified.

The consequences of this are that:

1. For the nondispersive case, inequality (12) should read

$$\left(\frac{\partial P_1}{\partial x} + 2B_nR_1P_1\right)\left(\frac{\partial P_2}{\partial x} - 2B_yR_2B_2\right) - (B_nR_2P_1 - B_yR_1P_2)^2 > 0$$

By choosing $P_1 = P_2 = \exp(-Kx)$, it possible to satisfy inequalities (11) and (12) by letting $K \to \infty$.

2. For the dispersive case and also in Appendix B, inequality (B13) should read

$$\left(r_2\frac{\partial P_1}{\partial x} + 2P_1\, B_1\, R_1\right)\left(r_2\frac{\partial P_2}{\partial x} - 2P_2\, B_2\, R_2\right) - (P_1B_1R_2 - P_2B_2R_1)^2 > 0$$

All the arguments presented in Appendix B are invalid from this point on, and it does not seem possible to obtain any simple criteria for stability.

The theory used by the authors is most suitable for treating first-order partial differential equations. For parabolic or elliptic second-order partial differential equations, other approaches can be used (for example, Murphy and Crandall, 1970; Yang, 1971) and will be the subject of a forthcoming publication.

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M. A. SOLIMAN AND C. MCGREAVY
DEPARTMENT OF CHEMICAL ENGINEERING
THE UNIVERSITY OF LEEDS
LEEDS, LS2 9JT
ENGLAND