An Introduction to Fluid Mechanics and Heat Transfer, 3rd Edition. By J. M. Kay and R. M. Nedderman. Cambridge University Press, New York (1975). $18.95.

This text, in the opinion of this reviewer, will be a very useful pocket handbook for the practicing or research engineer who has to deal with a variety of fundamental ideas in fluid mechanics and transport phenomena. Its principal virtue, as the authors stated in their Preface, lies in its highly condensed account of the basic physical and mathematical principles relating to many engineering processes. This reviewer finds no comparable book by any American publisher.

Although the authors did not explicitly state their intended readers, the book must be viewed primarily as a textbook because it is based on their lectures given at Cambridge University over a period of many years. When viewed as a classroom textbook, the principal part of the book is written extremely well in terms of its literal style and material content.

Admittedly, in trying to introduce any scientific subject, a few fundamental concepts must be accepted as basis for subsequent development. The essential contribution of an author is the selection of those basic concepts that will be the easiest to comprehend. But in many places where a physical notion is first introduced, the authors tend to use an approach that is complicated for the uninitiated and unnecessary for the mature readers.

For example, in Chap. 1 the concept of hydrostatic pressure is introduced with "This follows directly from the absence of shear stress." Since it is assumed that the reader is familiar with the principles in hydrostatics and that it has already been stated that the fluid is at rest, the concept of pressure can be introduced without mentioning the more difficult notion of shear stress. Moreover, later in the same chapter, when the viscosity is introduced, it is stated that "a full discussion of these shear stresses will be given in a later Chapter."

Similarly, the concept of temperature is introduced by first requiring the reader to accept the idea of thermal equilibrium and by then defining the temperature of the equilibrium state of two bodies in contact. Since the authors already mentioned earlier the difficulty of defining temperature without the notion of heat, it is hard for this reviewer to see why the idea of thermal equilibrium should be an easier notion for the reader to accept than that of heat.

The general three-dimensional partial differential equation of continuity is introduced by means of contour integrals in Chap. 2. The partial differential equation governing heat conduction is derived in Chap. 8 by a similar approach. Although the authors claim that to save space, vector notation (hence the contour integral sign) is used occasionally, this reviewer questions the need to develop the equations of continuity and energy in this fashion. First, none of these differential forms of equations are needed in subsequent development. Second, in an introductory text it would be better to concentrate on the physical concept without the advanced mathematical juxtaposition to diffuse the presentation (unless the intended reader is very proficient in mathematics but short in physical concept). Third, to keep on the same level of mathematical sophistication as the presentations in the other chapters, simple one-dimensional equations of continuity in Chap. 2 and of energy in Chap. 8 would be sufficient. The general equation of continuity should be introduced in Chap. 12, since Chaps. 12 through 18 give the general mathematical theories of fluid flow and convective heat transfer, which include the general heat conduction equation as a special case. The materials contained in Chaps. 12 through 18 must be viewed separately from the rest of the book (see below).

The book is divided into 3 main sections and 23 chapters. Chapters 1 through 11 constitute an elementary introduction to fluid mechanics and heat transfer. Chapters 12 through 18 give the basic mathematical theories in fluid flow and heat transfer, including the derivations of the Navier-Stokes equation and Prandtl's boundary layer and mixing length theories. Chapters 19 through 23 are concerned with applications of fluid mechanics and transport phenomena in processing engineering. Since Chaps. 19 through 23 are on the same level as, and indeed can be considered as a continuation of, the first eleven chapters, Chaps. 12 through 18, where more advanced mathematics are used, must be viewed as a separate entity. As befitting an introductory text, the content in Chaps. 12 through 18 is concise and can be taken as a convenient advanced reference for the other part of the book or a possible source of selection for presentation if used as a textbook. The thrust of the book must rely heavily on the content of Chaps. 1 through 11 and 19 through 23.

After an introduction in Chap. 1, where some of the physical terminology such as pressure and temperature are defined, the fundamental principles in fluid mechanics and heat transfer are presented in the next ten chapters: fluid mechanics in Chaps. 2 through 7 and heat transfer in Chaps. 8 through 11. Fluids in motion are discussed in Chap. 2 by using the vortex motion as an illustration and by applying Bernoulli's equation to various flow measuring devices. The momentum and energy relations for flows are described in terms of a control volume in Chap. 3, and their applications to pipe flows, jet pumps, and reaction turbines are given in Chap. 4. The fundamental concept of dimensional analysis for fluid flow is introduced in Chap. 5. This is followed by the presentation in Chap. 6 of both the laminar and turbulent friction coefficients in terms of the Reynolds number and the roughness factor for open-channel flows. The fluid mechanics aspect is concluded with the presentation of centrifugal pumps and compressors in Chap. 7. The phenomenon of heat conduction is introduced in Chap. 8, followed by the analysis of both parallel-flow and counter-flow heat exchangers in Chap. 9. The dimensional analysis is again discussed in Chap. 10 to introduce the needed dimensionless numbers in heat transfer. The Reynolds analogy and the Taylor-Prandtl analogy are mentioned in Chap. 11 to show correlations in terms of dimensionless numbers for the turbulent heat-transfer coefficient. From a pedagogical viewpoint, this reviewer would like to see the phenomenon of convective heat transfer discussed in Chaps. 10 and 11 precede discussion of the heat exchangers given in Chap. 9.

As mentioned earlier, the material in Chaps. 19 through 23 is, essentially, a continuation of that given in Chaps. 1 through 11. If there is any difference, it must be that in each chapter the subject matter treated is traditionally considered to belong to a specific branch of engineering. From the viewpoint of processes, it is difficult to see that the flow through a convergent-divergent nozzle discussed in Chap. 19 is particularly different from the flow between compressor vanes given in Chap. 7. In addition to nozzle flow, fluid flows through pipes with friction and heat transfer are also discussed in Chap. 19. In Chap. 20, open-channel flows and the concept of critical depths are illustrated by flows over weirs and hydraulic jumps. The subject of solid particles in fluid flows is introduced in Chap. 21 and illustrated with the analyses of a cyclone collector and a venturi scrubber. Flows through packed beds are discussed in Chap. 22 and illustrated with the phenomenon of filtration. In the same chapter, the critical flow necessary to fluidize a packed bed is also discussed. In Chap. 23, film condensations are analyzed by assuming a linear temperature profile, and the heat transfer to boiling liquid is discussed with a few empirical correlations.

The materials in Chaps. 12 through 18, the mathematical theories of fluid mechanics and heat transfer, consist essentially of the derivations of the various governing equations. These well-known equations can be easily seen from the respective titles used for each chapter. These titles are "Equations of Motions for a Viscous Flow," "Boundary Layer," "Turbulent Flow," "Potential Flow," "Diffusion and Mass Transfer," "The Energy Equation and Heat Transfer," and "Forced Convection." These derivations are further supplemented by six appendices.

Throughout the book, the metric (SI) system is used, and a conversion table to the British system is given in Appendix 7. There are 40 sample problems with a corresponding number of solution outlines given at the end of the book.

In conclusion, the book contains a wealth of fundamental information for easy reference and will be an excellent college textbook—if the lecturer modifies some of the introductory approaches discussed earlier.

Chen Ya Liu

Battelle Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

March 13, 1975

About the Reviewer: C. Y. Liu has been engaged for 20 years in research and development in the areas of fluid mechanics and heat transfer, first at B. F. Goodrich Company and, since 1965, at Battelle Memorial Institute. He is currently a Fellow at Battelle. He taught courses on fluids and heat transfer at New York University (1955-1959) and at Carnegie Institute of Technology (1959-1961). Dr. Liu was also a visiting lecturer at the University of Michigan (1960). He received his BS degree in mechanical engineering from Central University, China, in 1948 and MME and DSc degrees in engineering and applied mathematics from New York University in 1955 and 1959, respectively.