chapters also makes systematic reading of the book somewhat difficult.

However, in the light of all written above, and notwithstanding the shortcomings mentioned, Professor Aris' book represents a fundamental and valuable effort which, I am sure, will be held in high esteem by the readers.

Academy of Sciences USSR B. LEVICH

Translated by D. NINKOVIC

S. N. B. MURTHY (Editor), **Turbulence in Internal Flows: Turbomachinery and Other Engineering Applications.** Hemisphere, Washington (1977).

THIS Proceedings of a Project Squid workshop held in mid-1976 will be a most welcome addition to the library of the active researcher in turbulence phenomena. Such readers will be grateful to the participants, the editor and the publisher for a set of papers that are mostly of a high standard, a number of papers that review major directions of work by particular research groups, a presentation of the work that contains few errors in equations or figures and a prompt publication of the proceedings. The book conveys a fairly accurate sense of the state of the art of turbulence experiment and theory. The active worker can scarcely avoid finding several fascinating papers in this volume, the particular papers depending somewhat on his interests.

Conversely, the design engineer is likely to be disappointed in this book, for it provides him very little concrete assistance. Such a reader may well wish to avoid this book, unless he is able to take a very generalized view of what is relevant reading material. Developments based on the digital computer will eventually offer the designer practical prediction procedures for the more complex flows met with in applications. The rate at which particular applications have yielded rather suddenly, at least in part, to the predictive approach (e.g. the optical output of CW gas lasers, the internal flow of a centrifuge, the performance of a liquid propellant gun, aspects of the internal combustion engine, multi-phase flows in nuclear reactor safety studies) makes it possible to hope that many further significant applications will become accessible to computation within years, rather than decades.

The twenty-one papers and the ensuing discussions of this volume are grouped into three sections: Fundamental Problems, Modelling Procedures and Turbomachinery Applications. A fourth section includes a panel discussion on research in this field and a summary of the conference. The opening pages review the state of the art at the last major conference dealing with "Turbulence in Internal Flows" in 1965, provide a very useful bibliography of significant and relevant developments since that time, and list the project SQUID workshops held on selected subtopics since the 1965 conference.

This schedule of conferences suggests that the organizers may have hoped that the present conference would be the place where the experimental and theoretical developments in the numerous relevant disciplines would be synthesized into a coherent program for research and for design calculations. However, the field simply is not ready for that. Instead, one must be content with a first-rate state of the art report.

These proceedings are not a review paper. Each author deals partially, and from his own point of view, with one or several extremely complex fluid flow phenomena. When preceding developments are summarized and put into perspective, it is usually the author's own research program that is given systematic review. Thus the conference was a hard one to summarize. The papers, which are highly rewarding upon careful study, do not readily yield to a casual reader a systematic view of what measurements have been done, and which are needed, to understand particular complex flows, nor do they easily reveal which flows are subject to theoretical analysis with current methodology and by which methods, at what accuracy and at what cost. Any such synthesizing views must be contributed by the reader, and can only arise from considerable expertise in turbulence research.

The two papers making the strongest impression on the conference participants were probably those by S. Corrsin and W. Kollman and by J. L. Kerrebrock. Corrsin represented the velocity field as a static uniform shear plus a fluctuating field expanded in three dimensional series in space and power series in time, averaged over a periodicity cell to represent ensemble averaging and solved for an initial condition of a uniform shear plus a Taylor Green vortex cell. The results were good enough to indicate qualitative agreement with experiment and to indicate that the evolving turbulent flow field resulted largely from stagnation points with the "right" direction of energy transfer, while those with the "wrong" direction of energy transfer were damped structures. Kerrebrock reported on detailed space and time resolved measurements of flow angles, entropy rise, and flow Mach numbers, as well as a harmonic analysis of the pressure fields, at stations upstream and downstream of a high-pressure ratio transsonic axial compressor rotor. The flow is dominated by a single periodicity which changes with position downstream and is associated with the evolution of the highly swirling flow shed by the rotor blades. The truly turbulent features of the flow are comparatively minor. The origin of the periodic flow is not fully explained, but might be accounted for by the eigenmodes of a perturbation theory.

The remaining papers, including many of high quality, dealt with numerous additional features of turbulence that distinguish "complex" flows from "simple" ones. Flow configurations were emphasized that resemble those arising in turbomachinery and aircraft flight. Phenomena dealt with include flow deformations (1) in a curved duct and (2) at the junction of a wing and an aircraft body, flow interactions between (1) freestream turbulence and/or initial boundary layers and the plane mixing layer, (2) turbulent shear flow and a turbulent boundary layer, (3) two wakes, and (4) cascade flows and freestream turbulence, as well as rotational effects of (1) coaxial jets with swirl and (2) flow manipulators for swirling flows. Considerable attention was given to a variety of prediction methods applied to a number of flow configurations of interest, though without much systematic comparison between methods.

An evolving view on turbulence modeling, based on LASL experience, is that the Reynolds stress transport equations with appropriate closures offer the best practical, long-range chances for a detailed and computable description of the many types of turbulent flows of applied interest, but that a systematic treatment of closure models, in which all terms permitted by general modeling rules would be considered and coefficients determined by experiments and numerical simulations of high accuracy, is badly needed. Computational costs will remain a major limitation for this approach.

However, for truly complex flows, in which chemical reactions or multiphase flow, as well as turbulence and complicated geometries need to be taken into account, the present view suggests the importance of calculations run with the simplest models of the important physical processes in order to discover which phenomena influence the performance of the device most strongly. These latter phenomena are those that one spends the most care (and computer time) on to model accurately. The most influential phenomenon is not always turbulence. For example, in calculations of combustion of premixed fuels it is often found that resolution of the uncertainties in both the detailed types of chemical reactions, as well as the reaction rate constants, are of at least equal importance to an accurate turbulence model. Frequently, too, the computation time is determined primarily by the chemical reactions, rather than by the hydrodynamics.

R. C. MJOLSNESS

M. NECATI ÖZISIK, **Basic Heat Transfer.** McGraw-Hill, New York (1977). 572 pp.

THIS textbook is written for use in undergraduate level courses but can also serve as a reference volume for engineering graduates and industry. There is sufficient material, systematically arranged at different levels, for the spectrum of its possible uses to include: a first course in heat transfer at the junior level, a basic heat-transfer course at a higher level, or a two-quarter undergraduate heat-transfer sequence.

In Chapter 1 the basic concepts of heat transfer and SI system are discussed. The four chapters that follow are devoted to the derivation and the methods of solution of heat conduction problems. The analytical and numerical (finite difference technique) methods are presented with a concise and rigorous approach. It is regrettable that in view of the limited space available, the finite-element method is not discussed. Chapter 6 is devoted to the derivation of the equations of motion and energy. The detailed derivations of this chapter may be omitted without affecting the continuity of the subject. Chapters 7, 8 and 9 deal with heat transfer in internal and external flows. Basic concepts of the mechanism of turbulence are discussed and empirical correlations of heat transfer are presented. Free convection is treated in Chapter 10. Next three chapters provide a systematic analysis of radiative transfer in nonparticipating and participating media. In Chapters 14 and 15, a comprehensive treatment of heat transfer in condensation, boiling and heat exchangers is given. Finally, in Chapter 16, the analysis of mass transfer is closely tied to the analysis of heat transfer.

The systematic, simple and rigorous approach followed in Özisik's textbook will improve the effectiveness of teaching. The text is presented with the minimum amount of mathematical complexity and with careful description of the physical problems and physical significance of various quantities in the mathematical expressions.

The publication is excellent and I am pleased to recommend it to both students and professional colleagues.

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B. E. LAUNDER (Editor), **Studies in Convection: Theory, Measurement and Applications,** Vol. 2. Academic Press, London (1977). Price £8.80.

THIS volume of the series is devoted to aspects of convection relating to combustion, a topic which is receiving renewed interest due to its link with both the energy and environmental questions. The first two chapters are extensive reviews by P. A. Libby on variable density effects and convection in turbulent shear flows and by H. A. Becker on the use of light scattering techniques (marker nephelometry) for measuring concentrations in mixing and dilating flows. Both of these authors give very valuable surveys on their own and related work in these fields together with a development of their own approach to the theory of turbulent reacting flows. I was a little disappointed that Professor Libby did not amplify very much on the problem of counter-fluxes and "negative" turbulence generation which are apparent in his experiments with Stanford on helium mixing with air in a porous pipe; perhaps he is saving this for a later review. The problem does illustrate, however, the intriguing phenomena that await the convection specialist when he ventures into this field. Both of these reviews are recommended to such newcomers as being both readable and comprehensive as well as to workers already in the field.

The last two chapters present what are essentially research reports: S. Elgobashi on a numerical model for prediction of turbulent diffusion flames and D. T. Pratt on the computation of systems involving large numbers of simultaneous chemical reactions. Elgobashi's paper is largely his Ph.D. thesis and gives a full explanation of the theoretical approach together with some comparisons with experimental data. Pratt presents a novel approach to the calculation of a chemically reactive flow field which is capable of handling both equilibrium predictions and full chemical kinetic predictions. Turbulent mixing is treated by a conventional mixing-length/eddy viscosity model and the mixture is assumed locally homogeneous so that the interesting problem of "turbulent chemistry" of "micro-mixing effects" is avoided. Both of these papers are probably too long for normal publication in an academic journal and it is good that they have appeared in print so that they will be more accessible. It is preferable, however, that work of this type should go through the detailed examination by specialist referees that is normal with academic journals.

The jacket blurb implies that the series is attempting to provide both "up-to-date review articles by active research workers" and articles which "break new ground and focus attention on hitherto unpublished results and unrecorded facts". These two somewhat conflicting types of article are both represented in the present volume and there is indeed something for everyone. One is left wondering whether it might not be better for the series to concentrate on either reviews or on long research reports as one would think that the editorial procedures needed are quite different.

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B. E. LAUNDER (Editor), **Studies in Convection,** Vol. 2. Academic Press (1977).

THE SECOND volume of *Studies in Convection*, edited by Brian Launder, deals with theory, measurement and applications. The volume is devoted entirely to aspects of convection relating to chemical reaction and is directed to research workers and postgraduate students in the field of Combustion. It contains four separate articles by Paul Libby from the University of California, San Diego; Henry Becker from Queen's University, Ontario; Said Elghobashi from CHAM; and David Pratt from the University of Utah. All the authors are recognized authorities in the field of combustion and all of them discuss problems related to turbulent flow with chemical reaction.

Libbey's major contribution is in the improved understanding of the effects of variable density and reaction on turbulent shear flows. He has become well known for his use of a two sensor probe for measuring correlations between temperature and concentration in nonreacting flows. He shows the importance of Favre averaging, according to which the density is not decomposed but all