REVIEWS

Turbulent Flows and Heat Transfer. (Volume v of **High Speed Aerodynamics and Jet Propulsion.**) Edited by C. C. LIN. Princeton University Press and Oxford University Press, 1959. 549 pp. £5. 5*s*.

I believe that, even in the present state of development, the results obtained from fundamental studies of turbulent flow can be useful in practical problems of fluid motion but I am unable to think of any book published in the last twenty years that provides evidence for this belief. The trouble is that most of the books belong to one of two distinct groups, the first describing experimental studies of highly specialized flows and relating them to mathematical theories based on insecure assumptions and the second providing design information for engineers. A typical book of the first group usually stops well short of being useful and, in spite of encouraging words on the jacket, makes little attempt to show how it could be useful. In a typical book of the second group, useful observational material is presented in the proper non-dimensional form and interpreted in terms of mixing-length theory, with a supplementary account of, say, the theory of diffusion by continuous movements which has no obvious relation to the rest of the book and confirms one's suspicion that the aim of the statistical theory of turbulence is full employment for mathematicians. To quote the preface to the volume under review: 'future developments in our knowledge should result in the merging of these two approaches into a comprehensive and unified treatment'. However the initiative lies with those engaged in fundamental studies and the cause of unity is not advanced by describing work interesting only to specialists. In this respect, this volume, or at least the part concerned with turbulent flow, is disappointing as one in my second group with a considerable amount of space allowed for description of basic theory.

The first section (by H. L. Dryden) is concerned with the phenomenon of transition from laminar to tubulent flow, for the most part in boundary layers, and it is a good account of present experimental knowledge related in a sensible way to the little theory that exists. Ample references are given as in all the sections and anyone needing information about the problem of transition should read this article. The next section on turbulent flow (by G. B. Schubauer and C. M. Tchen) must have been very difficult to write, and I am in complete sympathy with the authors in their desire to link theory and practice but I am most unhappy about the result of this mixture. The introductory chapter, discussing the general nature of turbulent flow, is good but the following chapters on equations of motion, compressible boundary-layers and wall-flow suffer from a lack of selection and organization of the theoretical background. Although the incompressible boundary-layer is used as the standard of comparison for compressible layers, the latter are described first and with inadequate forward reference. For example, two equations for the variation of skin friction with Reynolds number appear in chapter 3 as respective consequences of the Karman similarity hypothesis (12–17) and the Prandtl hypothesis for the

mixing-length (12–18) but, in chapter 4, they appear, more accurately, as a consequence of the 'law of the wall' and the 'law of the wake' (18–5) and as an explicit interpolation valid over moderate ranges of Reynolds number. Again, section 23 is a clear and accurate account of the effect of surface roughness, but the result that surface conditions can only cause a velocity shift is most relevant to the existence of the logarithmic velocity-distribution and should be mentioned when that is discussed. Some of the theory in this brief account is of very limited interest, e.g. the development of a modified form of the mixing-length theory from the Boltzmann equation; and the 'proof' that stagnation temperature and stream velocity are linearly related if the laminar Prandtl number is one (p. 91, § B.9) is just wrong. (The similarity of two equations is not established by similarity of their mean values.) Good selection of experimental material and very full references make this section useful but, on this evidence, meteorologists are far ahead of aerodynamicists in understanding wall flow.

The section on the statistical theory of turbulence (by C. C. Lin) has very little connexion with the rest of the book and it omits, or describes only very briefly those parts of the theory that are relevant to practical problems. The theory of isotropic turbulence is developed in some detail with brief reference to the Kolmogoroff theory of local similarity, and the various theories of the decay of isotropic turbulence are compared with experimental measurements. In the remaining 12 pages, we hear of the theory of diffusion by continuous movements, of temperature fluctuations in isotropic turbulence (with no mention of the more important topic of the spectrum in the range of local similarity), of turbulent motion in a compressible fluid and the production of sound, and of the effect of damping screens on homogeneous turbulence. Since this group of subjects includes nearly all those parts of the statistical theory that may be used with profit in the study of practical problems, some of the previous 45 pages should have been diverted to their use.

The other sections on flow problems, on convective heat transfer in liquids (by R. G. Deissler) and in gases (by E. R. van Driest) correlate experiment with theory in a way which should be useful to the experimentalist and which is not unduly disturbing to the theoretically minded. The remaining sections, on heat conduction, on boiling heat-transfer and on radiative transfer, are of less interest to hydrodynamicists.

Although the contributors to this volume were allowed less space, it is natural to compare it with a classic work in fluid dynamics, *Modern Development in Fluid Dynamics*, edited by Goldstein, and also the result of collaboration. Today, much of the value of this latter two-volume work lies in its comprehensive account of experiment and the simple theoretical interpretations. The greater part of *Turbulent Flows and Heat Transfer* shares these qualities. The exceptional unity and organization of the older work is missing but, if the reader wants practical information, he will find it here. For the basic theory of turbulent flow, he must wait or work it out from the literature.

A. A. Townsend

The Atmosphere and the Sea in Motion. Edited by B. BOLIN. Oxford University Press, 1960. 105*s*.

This volume is a collection of articles prepared as a tribute to Carl-Gustaf Rossby, the Swedish–American meteorologist and oceanographer whose personality and scientific contributions have played a unique role in the spectacular growth of our knowledge of geophysical fluid systems during the past forty years. The collection was originally planned in honour of Rossby's sixtieth birthday, but following his death in Stockholm in August 1957, it was reorganized as a memorial volume.

The roster of distinguished contributors—a selection of Rossby's colleagues, collaborators, and students—is itself an impressive testimonial to the extraordinary role Rossby played in the development of many phases of modern geophysics. Virtually every aspect of physical meteorology, and much of physical oceanography, is represented. Articles in theoretical meteorology are interspersed with essays emphasizing synoptic or climatologic techniques of analysis. Discussions of laboratory experiments with rotating or stratified fluids are followed by articles on numerical methods in meteorological research and forecasting. Contributions also on geochemistry, cloud physics, atmospheric radiation, the mechanics of convection and many more fields are to be found in this scientific potpourri.

Unfortunately, the result is a collection of scientific papers lacking any semblance of organization or direction. Everyone with an interest in meteorology or oceanography can find something of interest in the Rossby memorial volume; few will find it a reference which they will frequently consult in their research.

This conclusion is not based solely on the wide variety of subjects discussed. The volume suffers also from the sheer number of contributions—thirty-nine in all—and the resulting raggedness of quality. Several of the articles are of trivial interest; others, by individuals well known for their research, are below the expected high standard of originality and competence. The number of significant articles is unfortunately low. One feels instinctively that many authors, finding themselves without a contribution of substantial importance, chose whatever topic was readily available in order to participate in the venture.

Nevertheless, it is difficult to blame either the individual contributors or the group of five meteorologists and oceanographers whose decision to solicit such a large number of contributions from such a heterogeneous group of scientists set the tenor of the volume. More than most leading scientists of our time, Rossby was a citizen of the world. His winning personality, flair for organization, and peripatetic restlessness—combined with his catholic interests and originality—led him to develop close associations with geophysicists throughout the world. Despite the fact that there were almost fifty contributors to the memorial volume, the five organizers (Bolin, Charney, Eliassen, Platzman and Stommel) find it necessary to apologize in their brief Preface for 'the number of colleagues or former students...we were forced to exclude in order to satisfy the rather stringent requirements of economy'.

This attitude is understandable. Yet the reviewer cannot help but regret the decisions which led to a volume of this nature. The array of talent available was formidable. A rigorously controlled number of major contributions, each devoted to a topic of substantial interest, might have proved a more enduring memorial to a great man.

The collection of articles in the volume is loosely grouped into six sections. The first is biographical in nature, and includes a major article by Rossby, translated from Swedish, which appeared in *Svensk Naturvetenskap* in 1956. The reviewer found this article to be one of the most interesting of the entire volume. Although it is written for the non-specialist, the paper illustrates the breadth of Rossby's interests and his comprehensive grasp of the atmosphere as a geophysical system. Those of us who knew Rossby only in his later years will also appreciate 'The young Carl-Gustaf Rossby', by Tor Bergeron.

The remaining sections are entitled: 'The Sea in Motion': 'Distribution of Matter in the Sea and Atmosphere'; 'The General Circulation of the Atmosphere'; 'Characteristic Features of Atmospheric Motion'; and 'Weather Forecasting'. It would be pointless to review individual contributions in detail. Articles of greatest interest will vary according to the background of the reader. The reviewer would like to call attention, however, to 'Ein numerisches Experiment mit dem primitiven Gleichung', by Von K. Hinkelman. This paper summarizes a substantial research effort, and holds considerable promise for the successful use of the primitive equations of motion in numerical research and forecasting.

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