Int. J. Heat Mass Transfer. Vol. 2, pp. 268–270. Pergamon Press 1961. Printed in Great Britain.

BOOK REVIEWS

High-speed Aerodynamics and Jet Propulsion: Vol. V: Turbulent flows and heat transfer data. Edited by C. C. LIN, Princeton University Press; London, Oxford University Press. 1959, 105*s*.

THIS book, like the others in the series, is by a panel of distinguished Americans. Its scope and authority are sufficiently indicated by the following contents list: Transition from laminar to turbulent flow by Dryden; Turbulent flow by Schubauer and Tchen; Statistical theories of turbulence by Lin; Conduction of heat by Yachter and Mayer; Turbulent heat transfer and friction in smooth passages by Deissler; Survey of problems in boiling heat transfer by Sabersky; Convective heat transfer in gases by van Driest; Cooling by protective fluid films by Yuan; Physical basis of thermal radiation by Penner; and Engineering calculations of radiant heat exchange by Hottel.

The book is presumably intended, among other aims, to help engineers to predict frictional and heat transfer phenomena arising in jet propulsion. The reviewer has therefore attempted to judge the quality of the book from the point of view of an engineer wishing to solve a common engineering problem; that of calculating friction and heat transfer on the gas side of the wall of a rocket nozzle. The results of this study will now be reported briefly.

The problem is not discussed directly in the book, which does not set out to be a handbook for designers. However, the section by Schubauer and Tchen deals with the turbulent boundary layer of a compressible fluid. Here we find theoretical and experimental data on the recovery factor in Perfect Gases and on the relation between skin friction and heat transfer. The latter section is short, and rather confused by the fact that Stanton number is defined in the text (but not, it seems, in the accompanying figure) by dividing the heat flux by the temperature difference between the wall and the free stream (rather than the adiabatic wall temperature); however, readers who have read more elementary textbooks will soon surmount this obstacle.

Since our problem involves a flow with pressure gradient, we need the von Kármán momentum equation in its general form. This equation is found on page 134 of the Schubauer–Tchen section, by which time the authors have restricted further discussion to incompressible flow; the fact that the shape factor H depends upon Mach number and temperature ratio appears not to be mentioned, either here or anywhere else in the book. Our engineer is therefore forced to ignore the influence of the pressure gradients in the rocket nozzle on H and on the local shear law, and to use flat-plate relations. These may be found in the section in question, which gives a brief review of procedures for calculating the turbulent velocity profiles starting from the alternative Prandtl and von Kármán differential shear hypotheses; solutions of the equations are not given and the reader is referred to (a great many) original papers for further study. (Incidentally, why do so many authors, these included, make discouraging noises about the difficulty, tediousness, elaborateness, and approximate character of the solution of an equation simply requiring numerical quadratures? One would think that digital computers had never been developed.) However, experimental data are presented concerning the relation between drag coefficient, Mach number and Reynolds number; these are shown to agree fairly well with an empirical formula which indicates that "incompressible" formulae can safely be used if the density and viscosity are inserted with values appropriate to the arithmetic mean of the stream and the wall temperatures. However, before the design engineer puts this formula down in his notebook, two remarks should be made—firstly, although the authors do not say so, it appears that all the cited experimental data are for *adiabatic* surfaces; secondly, van Driest in a later section discusses the whole matter at greater length and specifically warns the reader against using calculation procedures which, like that of Schubauer and Tchen, would indicate no effect of Mach number on skin friction coefficient at fixed Reynolds number, when the wall temperature is held constant. The alert reader may at least notice the first of these two points and will then look further for aid.

The next chapter having relevance to the rocket-nozzle problem is that of Deissler, who uses the von Kármán hypothesis as a starting point for his velocity and temperature profiles. This rather laconic author is certainly not cowed by numerical quadratures; indeed the reviewer was sorry not to find a more complete set of graphs or tables representing the calculations which have been performed. However, although Deissler presents Nusselt–Reynolds relations for variable-property air in tubes, these are in any case inapplicable to our problem; for this we need *momentum thicknesses* rather than pipe diameters, and there appears to be no way of extracting these from the data presented by Deissler.

Balked once again, we move on to van Driest's section, where perhaps we should have started in the first place. Once more we find theory and experimental data for recovery factor and for the relation between drag coefficient and Stanton number, which is here defined in a more sophisticated way than by Schubauer and Tchen, i.e. by reference to the *adiabatic-wall enthalpy*. Van Driest gives pride of place to the Prandtl hypothesis in deriving the velocity profiles in turbulent compressible boundary layers with heat transfer, and achieves analytical integration. However, because he is solely interested in the ubiquitous flat plate, he omits to present relations between drag coefficient and momentum–thickness Reynolds number, and jumps straight to (an approximate) one between this coefficient and length Reynolds number.

Our last hope of calculating the wall-friction and heat transfer in a rocket nozzle has now vanished. Though this hope may revive when, in Yuan's chapter, we find once more the differential equation based on the Prandtl hypothesis, the temperature–velocity relationship for a compressible fluid, and the appropriate integral expressions, it is soon dashed; for these expressions are only evaluated for the case of zero Mach number and isothermal flow.

This account of an unsuccessful journey through the book should not be read as a complaint: perhaps the problem which the reviewer chose was not one to which the authors attach importance; and probably other engineering problems could have been chosen which the book would have been more helpful in solving. However it seems fair to draw certain incidental conclusions about the nature of the book. Thus, it will have been remarked that there is considerable overlapping between the contributions of the various authors. This is to be expected; indeed it is to be desired. However anyone who has never tackled such a job will be tempted to say that the editor might have arranged for more cross-referencing and greater uniformity of treatment.

It will also be apparent that notable gaps remain; in particular, the book fails to present the important advances which have been made in recent years in the study of compressible boundary layers with pressure gradients, diffusion and chemical reaction. Even in those areas which are treated, the value of the book would have been greatly increased if reasonably extensive tables had been included of the more important and useful functions [(e.g. $c_f(Re_\theta, M, T_w/T_e, \rho_w v_w/\rho_e u_e)$)].

Finally, the very length of this review will have indicated that this volume contains plenty to get one's teeth into. It will be indispensable for several years to everyone concerned with aeronautical heat transfer problems. This reviewer welcomes its appearance heartily.

D. B. SPALDING

Evaporation and Droplet Growth in Gaseous Media. N. A. FUCHS. Pergamon Press, London, 1959, 67 pp. 30*s*.

THIS short book (67 pages) is a translation from the Russian of a scholarly and thorough literature review by an author who himself has made early and notable contributions to the field. Apart from a brief and non-theoretical mention of the work of Godsave, processes involving chemical reaction are excluded. Vaporization is given the greater attention and the author presents the quasi-steady theory for spherical and ellipsoidal droplets in stagnant media and media in relative motion, with discussion of the effects of surface tension and large mean free path; unsteady effects are dealt with in a short final chapter. Wherever possible the author adduces experimental data, describes the experimental method and critically examines their accuracy; he is not afraid to state on occasions that the experimenters must have made a mistake of measurement or calculation.

The English translation by J. M. Pratt is excellent, and the setting, though non-letterpress, admirably clear. Though the price is high, research workers concerned with the subject will find it entirely worth while.

D. B. SPALDING

Tables of Thermodynamic and Transport Properties of Air, Argon, Carbon Dioxide, Carbon Monoxide, Hydrogen, Nitrogen, Oxygen and Steam. Pergamon Press, Oxford, 1960. pp. 478 + xiii, 140*s*.

THIS book contains a collection of tables which was first published in 1955 by the United States Department of Commerce as National Bureau of Standards Circular No. 564, under the title: "Tables of Thermal Properties of Gases". The tables give values of gas constant, compressibility factor, density, specific heat, specific enthalpy, specific entropy, specific-heat ratio, sound velocity, viscosity, thermal conductivity, Prandtl number, ideal-gas thermodynamic functions and coefficients for the equation of state for the gases listed; in addition vapour-pressure data for the pure substances are included. Broadly the range of pressure covered is 0·01 atm to 100 atm and the range of temperature 50 to 5000°K. Each group of tables is preceded by discussions on the sources, the correlation and the reliability of the data; the bibliography is extensive.

The present edition appears to have been produced from the original by a photo-copying process. In general reproduction is good; the only defect worthy of mention is the rather poor definition of the grid on a few of the graphs.

This book is published as a revised edition. The revisions noted are some minor typographical corrections and the omission of ten pages of unit conversion tables from the appendix. The latter change is not a serious one since the conversion factors relevant to each group of tables have been retained in the main text.

The tables represent an important contribution to the property data required in the fields of heat transfer and mass transfer. The publication of revised editions of data books, outside the country of origin, increases the the availability of the data and is to be welcomed in general. In the case of this British edition, however, this advantage is somewhat offset by its very high price.

E. H. COLE

Conduction de la Chaleur en Régime Variable. G. RIBAUD, Gauthier-Villars, Paris, 1960, 90 pp. $3.78.

THIS monograph is intended for young physicists and engineers who are studying the problems of conduction of heat in the unsteady state for the first time.

The first chapter deals with steady-state conduction, as an introduction to the main body of the work, developing the equations from Fourier's law in the usual fashion. Several unfortunate features mar the treatment. When dealing with variable thermal conductivity a mean conductivity is defined rather than allowing the mean value to define itself by straightforward integration of the