REVIEWS

The Theory of Laminar Boundary Layers in Compressible Fluids.

By K. STEWARTSON. Oxford University Press, 1964. 191 pp. £3. 3s.

Paraphrasing N. Wiener one might say that laminar boundary layers are common in theory—commoner indeed in theory than in practice. Prof. Stewartson has added yet another book to the burgeoning literature on this subject and the second in the series of Oxford Mathematical Monographs to deal with laminar boundary layers.

The main aim of the book is to present an account of analytical and numerical methods in laminar compressible boundary-layer theory. Real gas effects such as those involving chemistry and ionization are not discussed. Laminar stability theory is also omitted. The reader is assumed to have a basic familiarity with boundary-layer theory in incompressible flow. Thus the main focus is on the effect of variations in the viscosity coefficient and the coupling of thermal problems to flow problems.

The first chapter introduces the Navier–Stokes equations in a conventional way and tries to assess their validity. A somewhat misleading comparison of mean free path with boundary-layer thickness is used here. The second chapter introduces the idea of the boundary layer by considering the limiting flow as the viscosity coefficient $\mu \rightarrow 0$. The situation is remedied a little by a brief discussion of dimensionless variables and the asymptotic nature of boundary-layer theory. The next two chapters, which form the main part of the book, study the boundary layer without and with pressure gradient under a variety of thermal wall conditions. Extensive use is made of the idea of a model fluid with constant Prandtl number equal to one and $\mu \sim T$ so that the transformation to incompressible form can be carried out. The various classical transformations are all discussed and all the cases in which similarity permits reduction to ordinary differential equations are carried out. Numerical results of calculations for these cases are given as well as a little comparison with experiment. Some discussion is given on the effect of Prandtl number different from but close to one. Suction and injection are studied briefly without mentioning the inviscid boundary layers which occur with large injection or the quite different nature of the boundary layer for large suction. The strong effect on the skin-friction of the exponent in the viscosity law is illustrated by comparison with some exact calculations. Three-dimensional boundary layers are discussed in a brief chapter which surveys the work on separation, axially-symmetric flow, yaw and small cross-flow. The main emphasis is on transformation to equivalent incompressible flow and approximate methods. The next subject taken up is the unsteady boundary layer and the discussion deals mainly with the boundary layer in a shock-tube and Rayleigh's problem. The treatment of the latter problem for the case of a strong shock wave provides an excellent introduction to the strong-interaction theory for a boundary layer in hypersonic flow which appears in the final chapter on interaction. It is unfortunate that a more systematic asymptotic theory for matching the viscous and inviscid regions in the problems was not worked out. From a practical point of view the hypersonic régime of strong interaction is one in which laminar boundary layers are very important. The corrected versions of matching do not change the overall scaling laws but do affect the values of heat transfer and skin-friction as well as introducing an overshoot in velocity profile. This overshoot, due to heating near the wall, is mentioned briefly in the section on general fluids under pressure gradient. It is an illustration of a qualitative effect due to $\mu \sim T^{\omega}$ $(\omega \neq 1)$ and Prandtl number not equal to one. The problem of weak interaction of shock waves with boundary layers, based on a linearized theory, is also discussed in the last chapter. The last chapter ends with an inconclusive discussion of another practical laminar boundary layer, the stagnation point flow at hypersonic speeds.

As can be seen from the previous discussion the book provides a survey of a wide range of topics; the work reported paralleling very closely the original references. The book contains no index except an index of 212 names of authors cited. Very often these characters enter and leave the scene in a confusing manner and too often without a critical evaluation of their work. This makes it difficult to follow the thread of ideas although many penetrating comments are scattered throughout the text. There do not seem to be any new results in the book. Thus this monograph will probably be most useful to research workers in the field who want a survey of what has been done and to engineers who wish to look up an answer. Two recent books, the Oxford Mathematical Monograph on *Laminar Boundary Layer Equations* by N. Curle and the Fluid Motion Memoir on *Laminar Boundary Layers* edited by L. Rosenhead cover a good deal of the same ground for boundary layers with pressure gradient and heat transfer and also deal at more length with approximate methods. The article (soon to appear) by Lagerstrom in the Princeton *Handbook*, although written much earlier, contains more of a systematic account of the asymptotic nature of boundary-layer theory and the idea of matching viscous and inviscid regions.

JULIAN D. COLE

Lectures on Gas Theory. By LUDWIG BOLTZMANN. Translated by Stephen G. Brush. University of California Press, 1964. 490 pp. $10.00 or 80*s*.

'This is one of the greatest books in the history of exact sciences' proclaims the dust-jacket. And so indeed it is; for like Newton's *Principia* and Maxwell's *Treatise* it was written as a textbook by the man who had played a large part in the original development of the subject, and at a time when it was still fresh, and even controversial.

In this translation, the two parts of the original are bound in one book. The first part deals with what we should now call the classical kinetic theory of a dilute gas, including discussion of the velocity distribution, collisions, the H-theorem, and calculations of transport coefficients insofar as this was practicable at that time. The second part, which naturally appears somewhat more dated, concerns the extensions of the work to dense gases, changes of state, compound molecules and physical chemistry. It also (in Chapters III and VII) makes considerable progress towards abstract statistical mechanics and ergodic theory.

One feels it would be presumptuous to review the book itself; one ought, however, to review the translation and book-production. Fortunately, these are both excellent. Dr Brush has done his work well, and has furnished a useful introduction, footnotes, and an index. The University of California Press has produced a handsome volume. Our thanks are due to them both for making this classic available in English.

J. P. Dougherty

Handbook of Supersonic Aerodynamics. Published by Bureau of Naval Weapons, U.S. Navy, and for sale by U.S. Government Printing Office, Washington, D.C.

In an earlier review (*J. Fluid Mech.* **10**, 1961, p. 156) a general account of this *Handbook* and its aims was given, together with a discussion of the first eleven sections to be published.

Three further sections have now been published, as follows:

Section 8. *Bodies of Revolution*, by D. Adamson, E. A. Bonney and I. D. V. Faro, 335 pp. $2.50. 1961.

Section 17. *Ducts, Nozzles and Diffusers*, by Aerodynamics Handbook Staff, Johns Hopkins University, 423 pp. $3.25. 1964.

Section 20. *Wind Tunnel Instrumentation and Operation*, by R. J. Volluz, 485 pp. $3.00. 1961.

Section 8 starts with a brief outline of theoretical methods for slender bodies at small angles of attack, followed by an account of cross-flow theories for high angles of attack. The application of these theories to the calculation of pressure distributions, force components and moments is then explained for specific shapes of body and results are presented in an extensive set of diagrams. Methods of estimating skin friction and base drag are also included. In the chapter on base drag the omission of recent work is noticeable; the date of publication was 1961 and no references later than 1959 are included.

In Section 17 the chapter on the theory of duct flow covers the essentials of one-dimensional flow, both steady and unsteady. Later chapters deal with useful configurations and design calculations for supersonic inlets, wind-tunnel nozzles and diffusers, and propulsion nozzles.

Sections 8 and 17 both satisfy excellently the declared aim of the *Handbook* which is to provide useful data and methods of calculation for designers of supersonic vehicles.

Section 20 is different in character, since it is concerned almost entirely with experimental methods. It is an excellent and authoritative account of the principal measuring instruments and methods used in supersonic wind tunnels. The user of low-speed wind tunnels will also find much useful material here. Although there is some overlap, the work does not supersede the excellent book by R. C. Dean *et al.*, *Aerodynamic Measurements*, since some topics are covered in greater detail in Dean's book. There is a comprehensive list of references, including the complete list taken from Dean's book, but the index is poor.

W. A. Mair

Optics of Flames. By F. J. Weinberg. Butterworths, 1963. 251 pp. £2. 15*s*.

This unusual monograph will be of considerable interest to those engaged in experimental work on combustion, although it lies a little outside fluid mechanics. In the first half of the book the author provides accounts of elementary optics, the refractive indices of gases under different conditions, and flame processes and their optical properties. The second half discusses the various optical methods used in the study of flames, including 'schlieren' techniques, shadowgraphy, deflexion mapping, and interferometry. Some of these methods have application in aerodynamics, as is evident from the photographs in the book.

Cryogenic Engineering. By J. H. Bell. Prentice-Hall, 1963. 411 pp. £4. 16*s*.

All about how to handle and make use of solid, liquid or gaseous material at very low temperatures. The scientific standard is not high.

Les Liquides Simples. By Arnold Münster. Gauthier-Villars, 1964. 77 pp. 14 FF.

This little book in French records four lectures delivered by the author in Paris on present understanding of the liquid state.

Lectures in Theoretical Physics, vol. vi. University of Colorado Press, 1964. 516 pp. $7.00.

A volume containing eleven separate articles and recording lectures given at the sixth annual Institute for Theoretical Physics held at the University of Colorado. Chandrasekhar writes on the equilibrium and stability of rotating configurations, and there are articles on statistical mechanics (by Ruelle) and superconducting fluids (by Parry and by Valatin).

Stress Waves in Anelastic Solids. Edited by H. Kolsky and W. Prager. Springer-Verlag, 1964. 342 pp. DM 67.50.

The proceedings of a symposium held at Brown University in April 1963 under the auspices of the International Union of Theoretical and Applied Mechanics. The texts of twenty-three papers are printed in full. In accordance with the general policy of IUTAM for specialized symposia, participation was by invitation. As a consequence, this well printed volume is an authoritative statement of current work, both theoretical and experimental.

Proceedings of the 1964 Heat Transfer and Fluid Mechanics Institute. Edited by W. H. Giedt and S. Levy. Standford University Press, 1964. 275 pp. 70*s*.

This latest and seventh volume of the series contains seventeen papers on many diverse problems. The blurb on the cover says that 'The papers are selected on the basis of their fundamental character'. Hm.

Relativistic Fluid Mechanics and Magnetohydrodynamics. Edited by R. WASSERMAN and C. WELLS. Academic Press, 1963. 241 pp. 68*s*.

Those who are wondering what connexion there is between relativistic fluid mechanics and magnetohydrodynamics will still be wondering when they have finished reading the four invited papers on the former subject, four on the latter, and five contributed papers on one or the other, all of which were presented at a symposium at Michigan State University in October 1962.

Hydraulics and Fluid Mechanics. Edited by R. SILVESTER. Pergamon Press, 1964. 503 pp. £5.

The Australians have now joined in the conference game, and the meeting held at University of Western Australia in December 1962, the proceedings of which are recorded in this volume, is said to be the first of a triennial series in Australasia. The thirty papers suggest the conference was a good one. But as usual it is difficult to see what purpose is served by publishing them in a special book rather than in the relevant journals.

CORRIGENDUM

'On free-surface oscillations in a rotating paraboloid', by JOHN W. MILES and F. K. BALL, *J. Fluid Mech.* **17**, 1963, pp. 257–266.

The shallow-water equations for a rotating paraboloid admit steady, axisymmetric solutions with the free-surface displacement [$s = \sigma = 0$ in (2.11)]

$$\zeta(r) = A_{0j}F[j, 1-j; 1; (r/a)^2] \quad (j=2, 3, ..) \tag{3.5a}$$

and the purely tangential velocity field

$$u = 0, \quad v = (g/2\omega)\zeta_r. \tag{3.5b}$$

We gave only the solution for $j = 2$ in our original (3.5) and stated that the solutions for $j \neq 2$ were trivial. In fact, these solutions are non-trivial for $j \geqslant 2$; on the other hand, the only solution that conserves volume for either $j = 0$ or $j = 1$ is $\zeta \equiv 0$.

The additional angular momentum (relative to that of the rigid-body rotation) implied by (3.5*a*, *b*) is zero for $j \geqslant 3$ but finite for $j = 2$ (as previously noted). The additional vorticity is non-zero for $j \geqslant 2$, however, in consequence of which the modes can be generated only by processes that create or destroy vorticity.

Each of the foregoing modes is of the type mentioned by Lamb (1932) in the last paragraph of his §207, in reference to which the footnote on p. 201 of our paper should be deleted.