REVIEWS

Gas Dynamics, by Klaus Oswatitsch; English version by Gustav Kuerti. New York: Academic Press Inc., 1956. 610 pp. $12.00.

The original German version of this book was published in 1952; the English version under review bears the date 1956 and one's first and immediate reaction is to ask whether or not the subject has grown to such an extent in the intervening four years as to make profitable this reissue in translated form. Quite obviously in such a rapidly growing subject it is not every book that can stand up to such a time lapse.

In an attempt to decide whether Professor Oswatitsch's book has withstood it, one must examine in some detail its objects and scope. These are set out in prefaces to the translated edition. As far as the objects are concerned, Professor Kuerti says, in his preface, "There is still a place in the literature of the English language for a book of moderate length on gas dynamics, combining a thorough and imaginative account of the fundamentals with a survey of the advanced methods of analysis that are beyond the scope of the usual textbooks of aeronautical engineering". As far as the scope is concerned, Professor Oswatitsch says "Gas dynamics deals with the flow of compressible media. It represents the *general* form of hydrodynamic theory and includes as a special case the classical hydrodynamics of liquids.... In this book the flowing medium will be treated as a continuum; considerations that belong to the field of kinetic theory of gases will be omitted. Even so the range of topics remains very large indeed.... This makes further restriction necessary, arbitrary to the extent that a clear cut boundary between gas dynamics and its neighbour sciences cannot be drawn.... The *typical problems of gas dynamics* always involve considerable changes of density" (author's italics).

In fact the subject as presented is perhaps more restricted than even this last sentence suggests, for the emphasis is very largely on inviscid flows, as will emerge when we go on to consider the detailed contents. In addition to the publisher's agreement to the references being brought up to date, one final quotation from the preface is relevant; Professor Oswatitsch says "In preparing the English text improvements have been made and many formulations have been rendered more precise. Thus the substance of the book has in my opinion profited by the translation."

The first chapter entitled thermodynamics is perhaps too short to be really successful. It is difficult to avoid feeling that it raises in the reader's mind more problems than it answers and does not pay enough attention to dynamical processes which should after all be the prime concern here. Even at the time it was first written, the ideas of the classical thermodynamics of media at rest had been successfully extended in part at least to gases in motion by such writers as Tolman and Fine (see for example *Rev. Mod. Phys.* **20,** 1948, 50–77), but I suspect that the passage of four more years has made the omissions seem more glaring.

The next two chapters are devoted to steady and unsteady one-dimensional flows respectively and here one feels that the book can stand up to any examination. Although the author makes no claim to an encyclopaedic completeness the accounts here are full and illuminated by appropriate and interesting examples, including, for instance, the effects of combustion, detonation and condensation, as well as an account of Lagrange's problem in internal ballistics.

Two chapters follow on general equations and theorems and on the application of the integral theorems in particular cases. Here the general differential equations of motion and energy are derived and from them similarity rules are obtained. Perhaps rather more would have been said about the second coefficient of viscosity had the book been written today, but this is not a serious criticism. An interesting point of nomenclature arises. The word homentropic as originally suggested by the Fluid Motion Sub-Committee of the Aeronautical Research Council has been adopted for flows in which the entropy is constant in a region of space and the word isentropic for a process in which the entropy of an individual element remains constant, as for example in some steady flows along a streamline. However, when it comes to energy considerations, where again the same distinction can usefully be drawn between regions in which the energy is constant and processes in which the energy of an element remains constant, the corresponding nomenclature homenergic has been spurned in favour of isoenergetic.

The integral theorems are primarily concerned with the forces experienced by bodies immersed in streams, and their application to specific problems show the book at its best.

Chapters 6 to 10 inclusive, rather more than half the bulk of the book, are devoted to inviscid flows steady and unsteady, subsonic, transonic and supersonic in two and three dimensions. Whilst it is true, as Professor Oswatitsch himself comments in the preface, that much has been achieved since the original version appeared, particularly in linearized theories, yet even faced with complete freedom in 1956 some drastic selection would be necessary to keep the book within its avowed limits. Professor Oswatitsch's original selection was weighted very much towards discussion of the basic physical phenomena and typical results rather than on mathematical techniques for dealing with specific problems. It is an over-simplification to say that all the recent developments have taken place in this latter field, but certainly the book has been saved by its approach from being as outdated as some of its contemporaries. This is not to say that the passage of four years has left the book unscathed; one would imagine that the area rule would have been seized on by Professor Oswatitsch had he been writing today and that he would have said more about transonic flows, for example. However, the fact remains that chapters of the book have still much to offer and my most serious criticism is that more has not been made of the permission to bring references up to date.

Chapter 11, devoted to viscous and turbulent flows, is the one where in your reviewer's opinion it least measures up to its task. There is so much more that should be said even accepting the exclusion of all flows in which the density changes are small. It might, one feels, have been better to limit the stated objectives even further and to omit this chapter altogether rather than give the impression of such an unbalanced treatment. Here again many more references might have been added.

Chapter 12, the final chapter, gives a brief account of experimental methods and is open to the same type of criticism as those levelled against Chapter 11.

The final conclusion I reach is that apart from the first chapter, and the last two particularly, which unbalance it, the book has much to commend it. A detailed study of it will reward any serious student and lead, as Professor Oswatitsch states as his intention, to an insight and understanding of many of the fundamental aspects of gas dynamics.

L. HOWARTH

Wing Theory, by A. ROBINSON and J. A. LAURMANN. Cambridge University Press, 1956. 569 pp. 75*s*. or $13.50.

The publication of a new book on wing theory by the Cambridge University Press is surely an important event for many of us, especially when we reflect that the same Press published Glauert's *Aerofoil and Airscrew Theory* some thirty years ago, and that that famous volume has been almost the only book on the subject in all the intervening years. One is led to speculate on whether the new work will be as useful to new generations of aerodynamicists as ' Glauert ' has been. To do so, it would have to combine as effectively the physical explanation and the mathematical development.

The content of the new book is impressive, representing as it does the increased scope of the subject: aerofoils in two- and three-dimensional flow at low speeds, aerofoils in compressible flow (subsonic, transonic, and supersonic), and aerofoils in unsteady motion. All this is preceded by an introductory chapter entitled " Foundations " in which the fundamental ideas of fluid mechanics are reviewed, with emphasis on such concepts as source, doublet, and vortex distributions, particularly useful in wing theory. This chapter also includes a concise discussion of viscosity and of the assumptions of the Navier–Stokes equations. This provides the basis for some dimensional analysis and the boundary-layer approximations, including the momentum-integral equation. Turbulence is also described, Reynolds' equations are derived, and the turbulent boundary layer briefly discussed. These real-fluid phenomena are to prepare the reader for the subsequent discussions of wakes and trailing-edge conditions that are central to the subject of wing theory, but so often glossed over in textbooks.

Two-dimensional aerofoil theory for low speeds is, of course, largely a matter of complex-variable techniques and the thin-aerofoil theory. These matters seem to be handled competently. There is a purely mathematical section on conjugate functions. Theodorsen's method for arbitrary profiles is given, and so are Lighthill's procedure for prescribed pressure distribution and Goldstein's approximate calculations. Cascades of aerofoils are also treated briefly, and there is an explanation of profile-drag determination by Pitot-traverse methods. The latter includes discussions of boundary-layer calculations (turbulent and laminar) and the Pohlhausen procedure.

The chapter on three-dimensional aerofoils in low-speed flow begins with considerable generality, for singular behaviour of the velocity at the leading edge is assumed from the beginning and the force formulas are accordingly complicated. Lifting-line theory appears as a special case; the reviewer remarks that present authors do not seem able to recapture the clarity of Prandtl's original presentation. Among other computational schemes, the one attributed to Multhopp (but actually originated by I. Tani) is given. The theory of minimum induced drag for general multiplane arrangements is included. The lifting-surface approximations of Falkner, Weissinger, and others are presented, and then R. T. Jones's theory for small aspect ratios. Wind-tunnel-wall interference is calculated in detail, for open, closed, and slotted boundaries.

The reader of this review will recognize from what has been said already that the scope of the book is ambitious. The chapter on aerofoils in compressible steady flow is comparable in size and in scope to some of the monographs on the subject that have appeared. Almost everything is included : source-sink methods, conical flow, Evvard's technique, higher-order approximations, transonic similitude, the shock polar—even hodograph theory. It is surprising, in view of this thoroughness, that the energy equation of compressible flow is never mentioned; the isentropic equation of state appears as an unexplained assumption, and the generalized Bernoulli equation then follows, of course, from the equations of motion.

Finally, there is the chapter on aerofoils in unsteady motion. This begins with an exceptionally fine introduction, and proceeds to the classical theory of two-dimensional thin aerofoils. The usual vertical-gust cases, however, are contained in a rather complicated section devoted to " motions with non-uniform average velocity ". The subject of three-dimensional wings in unsteady flow is handled principally by discussion and some references. For two-dimensional compressible flow the Lorentz transformation is used, following Küssner, to set up elementary solutions; this leads to Possio's integral equation, approximate solutions of which are discussed briefly. Supersonic unsteady aerofoil theory is a somewhat simpler affair, and here, for oscillating aerofoils, the solution is actually carried out. The chapter includes a considerable portion of new material, previously unpublished.

This book has been carefully planned and written. The authors' attention to the published literature, both old and new, is very impressive; it includes, incidentally, an appended bibliography of over 100 more recent titles. The index seems complete and well organized. The character of the book, it seems to this reviewer, is something like this. After a clear, physical, but concise introduction of each new subject, the mathematical argument appears and often becomes rather elaborate and, especially, lengthy. Conclusions are reached, graphs are sometimes provided, and experimental confirmation and references to literature are not omitted. But one wonders whether a graduate student (for whom, among others, the volume is intended) may not get lost in the intervening analysis. One therefore feels somewhat more confident in recommending this volume as a reference book for engineers and research workers than as a textbook, even for graduate students. It may be argued that wing theory is naturally a highly mathematical subject—practically a minor branch of mathematical analysis, once the fundamental assumptions are set down and the boundary conditions established—and that a textbook of this character is therefore appropriate. Perhaps the correct answer depends on whether we intend our students to become masters of the mathematical art of applying established theories or the successors of Prandtl, Munk, Ackeret, and R. T. Jones, who originated the theories but whose greatest contributions to wing theory were not essentially mathematical. If the latter is our goal (and admittedly it is a ridiculously optimistic one!) we might prefer a textbook with a slightly different emphasis. But this is not a severe criticism of Robinson and Laurmann, especially since the other textbooks, with slightly different emphasis, are non-existent. Their volume will be widely used and much appreciated.

W. R. SEARS

CORRIGENDUM

"On the hydrodynamic stability of two viscous incompressible fluids in parallel uniform shearing motion", by S. FELDMAN (*J. Fluid Mech.* **2**, 1957, 343).

Page 358. In the second line below figure 3, replace $F = W = 0$ by $F = W = \infty$.

Page 368. The expressions within large round brackets in equations (88) and (89) should read as

$$\frac{\phi^{\text{iv}}\bar{\phi} - 2\alpha^2\phi''\bar{\phi} + \alpha^2\phi\bar{\phi}}{U-c} + \text{complex conjugate.}$$

The expression within the first pair of square brackets on the right-hand side of equation (91) should read as

$$\phi^{\text{iv}}\bar{\phi} + \bar{\phi}^{\text{iv}}\phi - 2\alpha^2(\phi''\bar{\phi} + \bar{\phi}''\phi) + 2\alpha^2\phi\bar{\phi}.$$