REVIEWS

High Speed Aerodynamics and Jet Propulsion. Volume X: Aerodynamics of Turbines and Compressors. Edited by W. R. HAWTHORNE. Oxford University Press, 1964. 616 pp. £7.

A review of one of the books in the Princeton series is a difficult task. A galaxy of international stars is assembled to cover the vast field that is allocated to the editor of any one volume. It follows that a reviewer can be expert in but limited parts of the resulting book, which will in effect be several books in one.

The present volume on the aerodynamics of compressors and turbines is no exception. Professor Hawthorne's short editorial introduction traces the history of compressor and turbine development, and indicates the areas allocated to his contributors. Before discussion of these separate contributions, it may be useful to attempt to define the purpose of a book such as this.

The only clue in the foreword, prefaces and introduction lies in Donaldson's note. This appears in all the volumes of the Princeton series. 'The need for a comprehensive and competent treatment of the fundamental aspects of aerodynamic and propulsion problems of high speed flight...has been long felt in research institutions, universities and private industry and its potential reflected importance in the advanced training of nascent aeronautical scientists has also been an important motivation in this undertaking.'

It appears then that the volume is written for research workers in establishments, designers in industry and engineers and scientists on graduate courses. Certainly the book is far too advanced for undergraduate work, and, I would judge, for most graduate courses. Parts of it form excellent reference material for doctoral students, but it is unlikely that many industrial workers will use it much (see Pearson's aggressive review in the *Journal of the Royal Aeronautical Society*).

Weinig's section on two-dimensional flow through cascades is valuable; much of the material on flow through flat plates and cambered thin aerofoils is either unpublished or difficult to obtain. The treatment is thorough and logical —conformal transformations of increasing complexity, the method of singularities, flux plotting, the hodograph plane and the effects of compressibility, boundary layers and wakes. Unfortunately the now widely used Martensen method (distributed vortices on the blade profile) is not mentioned, presumably because this section was written several years ago. (This is true of much of the book; I was unable to find a reference later than 1958, and much work on turbomachinery has been done since then.) The omission of Merchant and Collar's exact solution to the potential flow through cascades (1945) is also surprising.

Marble's review of three-dimensional flow in turbomachines is of similarly high scholastic standard. A comprehensive statement of the equations of axially symmetric flow is followed by linearized solutions. Marble's classic comparison of the isolated actuator disk solution with that of the blade with distributed loading (1948) is included, and an elegant analysis of the effect of variable hub

and tip radius is given—to my knowledge for the first time. The emphasis is on the flow through a single row, although the simplified exponential approximation for a multistage machine is described. Numerical methods of solving the equations of motion are now widely used, but are not described.

Erwin's description of experimental techniques is, as one would expect, a mine of information, especially the section on instrumentation. The only flaw here is the limited information on the most difficult of experimental problems, the measurement of static pressures with probes inserted between the blade rows. This is probably because a person with Erwin's high standards has doubts about the accuracy of any such measurements. The effect of unsteadiness in the flow on static pressure readings is but briefly mentioned. To anyone setting up a new laboratory or test facility, Erwin's chapter will be extremely valuable.

Howell's review of flow in cascades reflects his flair for design which, through his 1945 paper, established the basis of axial compressor design. Probably Howell would agree that the effects of varying axial velocity through the cascade are more important than he suggested 8–10 years ago, and that the academic analysis of secondary flows is of limited value as it ignores the effect of streamwise vorticity at entry.

The emphasis given to supersonic compressors—again excellent reviews of early work by Erwin and of aerodynamic fundamentals by Ferri—is surely now out of balance, for the whole body of work on transonic compressor development by the N.A.S.A. and others (*Trans. A.S.M.E.*, 1961) is omitted. While Hawthorne refers to the recent progress on transonic compressors in his introduction, it is perhaps here that the gap between writing and publication has proved most serious. The reviewer omitted the same material in his book published in 1958, but this was at a stage when it was classified and there was no alternative. Such an omission should have been avoided in a book published in 1964.

Rannie's account of the axial flow compressor stage is perhaps the most up-to-date chapter in the book. It is original in outlook, covering the effects of choice of vortex flow, secondary effects, tip clearance, propagating stall and off-design performance. Duncombe's section on turbines is similarly closer to the designer's interests than much of the book and would form a useful basis for a graduate course. Radial machines get relatively little space—presumably because of their limited application in modern aircraft engines, but again the sections by Taylor (compressors) and Von der Nuell (turbines) will be of value to designers. The book concludes with a thoughtful little section by Kraft on unsteady flows, emphasizing that the large transient pressure variations that occur in turbomachines make steady flow analyses and experiments of doubtful value.

A wide range of readers will find some sections of the book valuable. The academic will be interested in the work by Weinig, Marble, Ferri and Kraft. The intending designer and the graduate student (nascent aeronautical scientists?) will find the sections by Howell, Rannie, Duncombe, Von der Nuell and Taylor of use, but they will have to look elsewhere for information on transonic compressors. The experimental worker will use Erwin's chapter as a reference.

Perhaps the man least satisfied will be the engineer actually concerned with design and performance now. The academic work will be advanced and remote for him, and the design sections too elementary. The emphasis recently has been upon comprehensive numerical solutions (e.g. the Martensen solution for potential flow and the streamline curvature calculations of L. H. Smith and others) and the book provides no information on this work.

The standard of writing, editing, printing and reproduction is high. Inevitably with a number of authors some duplication occurs (secondary flow analyses by both Howell and Rannie, actuator disk solutions referred to by Marble and Rannie, radial equilibrium solutions given by Marble, Rannie and Duncombe, and identical plots of supersonic compressor performance given by Erwin and Ferri in the same chapter), but these do not detract from the value of the book. The balance between British and American work is good, and has been ensured by an editor who has worked in both countries, but German work is not given its full recognition.

From the academic point of view a stimulating book, yet enigmatic in its balance. From the point of view of 'the man on the job', I suspect it will not meet his immediate needs.

J. H. HORLOCK

Mechanics of Incremental Deformations. By MAURICE A. BIOT. John Wiley, 1965. 504 pp. £6. 12*s*.

This is almost entirely an account of Dr Biot's own work over a period of more than thirty years. The first chapter is an introductory account of the statics and kinematics of incremental stresses and strains. The following three chapters are concerned with various aspects of elasticity theory of initially deformed media; most of these are concerned with problems of stability and wave propagation. Fluids appear for the first time in Chapter 5 as elastic solids with zero rigidity. The final and longest chapter of the book is the one most likely to interest workers in fluid mechanics. This treats viscoelastic and viscous behaviour; again stability and small-amplitude wave propagation are the main topics considered.

The author's approach is intuitive rather than rigorous, and many would wish to see the results established on firmer foundations. (The reviewer thought that the claims to rigour made in the preface were not substantiated; to quote one example, the formulation of constitutive equations for viscoelasticity is based on one-dimensional mechanical models.) However, Dr Biot makes no secret of his view that in recent years progress in continuum mechanics has been retarded by an excessively formal approach, and it must be said that his methods lead to some interesting solutions.

The book may be of interest to readers with a sound knowledge of non-linear continuum mechanics in that it presents a rather unconventional view of some aspects of the subject. It is not, and makes no claim to be, a balanced account of the mechanics of incremental deformations, and should be read in conjunction with other work on the subject.

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