

REVIEWS

Introduction to the Theory of Compressible Flow. By SHIH-I PAI. Princeton: D. Van Nostrand Co., 1959. 385 pp. \$9.75 or 73s.

In writing this book Prof. Pai has attempted what is probably the most ambitious scheme by a single author in the recent history of fluid mechanics. He has tried to provide a comprehensive introduction to compressible fluid dynamics in all ramifications—subsonic flow, supersonic flow, hypersonic flow, viscous flow, flames, condensation, dissociation, electromagnetic effects, gas mixtures, small disturbance theory, etc. Such a programme, it might be thought, must lead to a book of encyclopedic proportions, particularly as it should contain a good deal of basic mathematical theory and extensive reference to experimental work. However, Prof. Pai has managed to get it all into less than 400 pages.

He begins with a short introduction and then discusses those parts of thermodynamics which he considers are essential for the reader to know. In the following twelve chapters inviscid compressible flow is discussed, beginning with one-dimensional theory including shock waves and continuing with a chapter on the fundamental equations. Then in chapter VI the method of small perturbations, which effectively means linearized potential theory, is discussed and is followed by chapters on subsonic flow, the hodograph method, and on the well-known exact solutions of the steady flow equations. He continues with a discussion of transonic and hypersonic flows, concentrating on the similarity laws, and then introduces the method of characteristics. In the last three chapters on the theory of inviscid flow, three-dimensional and rotational flows are considered. (It should be noted that in the chapter on rotational flows the author regards, without justification, rotational flow as identical with non-homentropic flow or, in his notation, anisentropic flow.) In chapters XV and XVI the effects of viscosity are discussed, and in the final chapter magneto-gas-dynamics is analysed.

Apparently Prof. Pai has drawn everything into his net. In the opinion of the reviewer, however, in doing so he has made nonsense of the title and the principal claim in the preface. The prime purpose of a text-book deserving the title 'Introduction' is to introduce new readers to the subject. Accordingly, in a book of this sort it is necessary for a reader to be aware of how much he is expected to know and, from that starting point, the author should give a connected and so far as possible a self-contained account of the way in which the subject develops. Unfortunately, this book cannot be said to have been a success in these respects.

First, it is not clear how much mathematics and physics the student must know before reading the book. To give an example, he is supposed to have the theory of tensors at his fingertips but is not expected to know what a vector is. Moreover, the reader is expected to see that temperature gradient is clearly a vector from its directional property, even though a finite rotation, which also has a magnitude and direction, is not a vector. Secondly, the argument is far

from self-contained. On almost every page appeal is made to the references, or else the reader is expected to undertake difficult and laborious calculations. Even so, the book would be of value in the way intended by the author if, by taking the gaps in the argument for granted, the reader was able to discover the more important features of the behaviour of the fluid, but unfortunately he is frequently left at a loss. Consider for example chapter XVI, entitled 'Boundary layer flow of viscous compressible fluids'. At the start of this chapter the reader is assumed to know nothing at all about boundary layers, but within the space of twenty pages he has been brought right to the frontiers of knowledge in this field in the discussions of hypersonic boundary layers and improvements to boundary-layer theory. The meal offered is, however, so rich and concentrated that a reader new to the subject would find it completely indigestible, and even if he knew something about incompressible boundary layers he might still find this chapter unfathomable. What in general terms are the effects on the boundary layer of Mach number, heat transfer, pressure gradient and Prandtl number? Why is the interaction of the boundary layer with the main stream taken more seriously in hypersonic flow than when the fluid is incompressible? On these and other questions which are vital to an understanding of compressible boundary layers the author is practically silent, preferring to fill the space available with an avalanche of formulae and equations which must in the end bewilder all but the most experienced aerodynamicist. This chapter is perhaps an extreme example and the topic discussed in it is certainly not an easy one, but the tendency exhibited is present almost every chapter of the book.

Another unsatisfactory aspect of the book is that the author does not have a point of view. He is most reluctant to criticize, even though it is clearly of importance to the reader to have the defects and merits of methods put to him. One of the best written sections of the book is concerned with the Kármán-Tsien method, of use in the theory of subsonic steady flow. The account is clearly and simply presented and the reader should have no difficulty in understanding it. However, there is no appraisal of the method; the reader must look elsewhere for a discussion of its advantages and disadvantages and of its relation to the less sophisticated Rayleigh-Jantzen method.

The book is designed primarily to give a theoretical introduction to the dynamics of a compressible fluid and, as is probably already clear, I do not consider that it is a success in this respect and cannot recommend it to new students of the subject. However, a secondary object is to serve as a reference book for research workers in the field, and here the author has had more success. The active aerodynamicist may well find it useful to consult the book and the extensive list of references, many of which were new to me at least. Nevertheless, he will regret the uncritical approach and the lack of the contact with the experimental results which is essential if the theoretical worker's due sense of obligation is to be maintained.

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