Book Review

Wing Theory

Robert T. Jones, Princeton University Press, Princeton, NJ, 1990, 207 pp., $35.00.

Wing Theory, by Robert T. Jones, is a most worthwhile and gratifying book that should be of great interest to anyone concerned with the real foundations of the subject. There are numerous excellent texts on fluid-dynamic lift, but Jones' book is unique among them in the sense that it is permeated with a profound understanding of the real consequences of what a wing does; of the eternally fascinating topic of that elusive, essential, and almost magical force called lift, by which a more or less flat surface moving in the fluid continuum creates a force roughly at right angles to the relative flow. We must note at the outset that this is really quite an eccentric volume, and immediately qualify this epithet to stress that the adjective is intended to be a very warm compliment. The book is both elementary and profound, basic and yet specific. In short, it encapsulates the grand and simple vision of the author. It is a book that should be studied by anyone really interested in the subject. Like other seminal works, it is of value to both the neophyte and the expert, but takes effort to fully digest.

The author has made marvelous contributions to the science of aeronautics. In all of his papers his concepts have been characterized by both practicality and depth, and by a point of view that is aimed at developing useful results while simultaneously extracting the essence of the fluid-mechanical principles involved. This work epitomizes his method of handling fluid dynamics and covers the aerodynamics of lift, ranging from a brief survey of the early theories of lift to modern theoretical developments, treating both high and low speeds as well as the effect of viscosity in modifying the results of ideal theory. Portions of the book have been adapted from the Princeton Aeronautical Paperbacks publication, *High Speed Wing Theory*, by Jones and Doris Cohen. The adapted material is information of importance and depth and may not be readily available, so this is a sensible and worthwhile duplication. The presentation in the new book seems to be more balanced and wider ranging than in the earlier volume, published more than 30 years ago.

In the preface, the author notes that he has tried to bring out the important elements of classical wing theory and to make more explicit the physical basis of its various components. In this goal he has succeeded most admirably. He also draws attention to the increasing reliance of the modern aeronautical engineer on the awesome power of the computer, and notes, modestly enough, that power has been known to corrupt! The author continues his argument by commenting that computer fluid-dynamic calculations can create a false impression of high accuracy when, in fact, the basic physical assumptions are often not given adequate treatment. These sentiments are strongly supported by the reviewer. This book is certainly not about computation, it is not about methods of estimating wing performance, nor is it about theoretical analysis. It *is* about the most important issue of any subject—the underlying basics—in this case, the fluid-mechanical processes that give rise to the really fundamental results and consequences of lift in fluids.

The book is quite short, consisting of 10 chapters, starting with the fundamentals of fluid flow over wings and concluding with the fundamental theorems of minimum drag for wings and bodies in supersonic flow. The subjects covered include fundamental considerations leading to two-dimensional flows over elliptical shapes and airfoils (thick and thin), with a brief but excellent discussion of the influence of the boundary layer on the performance of low-speed airfoils. The fluid-mechanical basics are restricted to cover only the features of fluid mechanics that directly affect the behavior of airfoils, thus preserving a clarity and sparseness in the theoretical treatment. Compressibility and sweep are treated in a basic but entirely accurate manner. Finite wings are very well presented and the concept of induced drag treated with wonderful clarity and succinctness, while the extreme cases of high- and low-aspect ratio are handled with elegance. Optimal loading distributions for flat, nonplanar, and flapping wings are treated with appealing simplicity and directness and the global theorems of stagger and interaction very clearly expressed. It has always been the reviewer's somewhat idealistic opinion that fundamental theorems should not require more complex proofs than the expressions embodying their final enunciation, and that the use of significant logical verbal argument to establish a basic result should always be preferred to algebra. After all, the behavior of a physical system is not really a consequence of the particular mathematics used to describe it! Jones establishes the optimal theorems of wing-induced drag using exactly these principles, and does so with his usual style and grace. Finally, the book deals with the somewhat more complex optimal theorems of supersonic wings and wing-body combinations, again with the minimum of mathematics and the maximum of well-chosen words, although in this case some fairly complicated analysis seems to be unavoidable.

This book is not a college text, because the assumptions and mathematical developments required to prove the results are not spelled out but presented in the tantalizing form usually annotated in more pretentious tomes

with the comment that "the proof is left to the reader." It would serve, however, as an excellent enrichment resource for fluid-mechanics courses at any level, provided the instructor had the courage and skill to prove or explain to the class the many interesting results that Jones quotes without providing rigorous support. Nor is the book a research document, since the author wisely manages to avoid succumbing to the temptation to digress or expand on the finer details of any particular topic. The volume is replete with wonderfully simple but global results. In each chapter this reviewer found valuable and powerful statements that were new to him, or of a generality that he had not appreciated. The volume is also loaded with other intriguing results that appear reasonable, consistent, and useful, and which the author could not quite see how to establish, but believed.

This book is heartily recommended to everyone interested in how wings work and who cares enough about the topic to wish to have an understanding of this subject. It gives an insight into the visionary assumptions and simplifications developed by Jones over half a century, which continue to provide new physical insights and powerful approximate analytical methods.

The format of the book is very charming. It is set in an elegant Sabon format and contains numerous well-drawn and clear figures and graphs, making it a pleasure to read, study or skim. It is most certainly "lovely to look at and delightful to know." The reviewer did not notice any typographical errors, and his only minor criticism of the layout is that the stunning dust-cover photograph of the MIT human-powered airplane, Daedalus, was not reproduced and credited in the main text. Now that really was a wing, one of which every dreamer of that ancient dream—Flight—would be proud. It is a fitting frontispiece for this book. Robert Jones, a "Grand Master" of the wing business, has produced a book on aerodynamic lift that is a tour de force of excellence by all standards of clarity, elegance, precision, and style.

P.B.S. Lissaman
AeroVironment, Inc.