REVIEWS

Advanced Mechanics of Fluids. Edited by HUNTER ROUSE. New York: John Wiley, 1959. 444 pp. $9.75 or £3. 18*s*.

Prof. Hunter Rouse's *Elementary Mechanics of Fluids*, which was published in 1946, has become firmly established as one of the best text-books on fluid mechanics suitable for engineering students at the undergraduate level. With the special merits of this earlier volume in mind, one is quite likely to be disappointed with the present book, which stands as its sequel by providing, for the graduate student with some basic knowledge of the subject, a fairly comprehensive introductory survey of the theory of incompressible flow. It would have been gratifying to have found that the 'advanced' mathematical aspects covered in this book were presented in the discerning and concise manner familiar from Prof. Rouse's elementary text; but these aspects seem largely to have eluded, perhaps inevitably, the model treatment he could give when dealing with the basic physical principles of fluid motion and their engineering applications. To dwell on this comparison would be unfair, however, in view of the much wider scope of the present book. Another difference is that the book is a joint enterprise shared by eight present or past colleagues of Prof. Rouse at the Iowa Institute of Hydraulic Research: these are Drs D. W. Appel, P. G. Hubbard, L. Landweber, E. M. Laursen, J. S. McNown, T. T. Siao, A. Toch and C. S. Yih, each of whom contributed a chapter on a topic in which he had specialized, though evidently all collaborated on the preparation of the final draft. Prof. Rouse directed the project and contributed an introductory chapter including an account of dimensional analysis.

The result of this intricate undertaking is a volume which, despite its shortcomings, is written in a remarkably consistent and attractive style—really an editorial triumph. This is especially creditable considering its wide coverage, which is seen at once from the titles of its eight chapters: Introduction to research in fluid motion (26 pp.), Fundamental concepts and equations (35 pp.), Principles of irrotational flow (69 pp.), Conformal representation of two-dimensional flow (53 pp.), Laminar motion (59 pp.), Turbulence (40 pp.), Boundary layers (51 pp.), Free-turbulence shear flow (44 pp.). Compressible flow, water waves and heat transfer are not covered, though the last two subjects are touched upon briefly.

To blame a book for falling short of its publisher's extravagant claims is always rather unjust; but the subtitle, 'A thorough treatment of the latest developments and research techniques in the field', which appears on the wrapper is so misleading as to be definitely harmful. Although the later chapters naturally make a good number of references to recent work, the book is essentially a primer in the miscellaneous mathematical procedures which have been applied to fluid mechanics, most of them long ago; and though it goes a long way towards filling in the necessary background, it will scarcely by itself equip a student for original research. For instance, 122 pages are devoted to perfect-fluid theory, though

covering only the basic material which can be found in a great many of the older text-books; the approach here is indeed more rudimentary than in some of these other books, since much of the space is given to preparatory accounts of elementary potential theory, general methods for solving Laplace's equation, Cauchy's theorem, and other incidental mathematical topics. Thus, the main purpose served by the book is to instruct the student in the relevant analytical methods, the development of his powers of physical reasoning being only a secondary objective.

It is very doubtful, however, that this is a satisfactory line of approach to the training of graduate students for research; and on this score the book will be found inadequate by some readers. Physical understanding is a more important requisite for creative work in modern fluid mechanics than sheer analytical ability; and in any case the latter is probably best gained in the first place by study of mathematical texts, rather than of *ad hoc* developments of theory in the context of particular hydrodynamical problems. A really helpful introduction to theoretical fluid mechanics would emphasize the essential physical explanations of flow phenomena to a far greater extent than in the present book and would present a more concise and utilitarian account of the analytical methods, relying on the many existing sources for much of the mathematical detail.

There are of course parts of the book which deal squarely with the realities of the subject, particularly in the chapters on turbulent flow where appeal to the observed facts becomes a continual necessity. But other parts seem unduly formal and sometimes remote from real problems, and it is the over-all emphasis that is under criticism. In the chapter on conformal representation, for example, a good outline of Kutta-Joukowsky wing theory depends on the statement of the basic hypothesis that 'the circulation on a two-dimensional foil adjusts itself so that the velocity at the trailing edge is finite'. An intelligent student will naturally inquire why this should be so; and even a brief explanation of the physical mechanism whereby the circulation develops to this extent would be of greater potential value to him than a large measure of complex-variable theory. But none is given anywhere in the book. In the chapter on laminar flow, a brief account of hydrodynamic stability concentrates on presenting a few items from perturbation theory, e.g. derivations of the Orr-Sommerfeld equation and Synge's sufficient stability conditions, and Squire's theorem—generalized by Yih—concerning the relative effects of two- and three-dimensional disturbances. This is all well done as far as it goes. But in the small space allowed it might have been more generally useful to concentrate on some of the interesting considerations that relate to the physical mechanism of instability, perhaps discussing the evidence that an inflexion in the primary velocity profile has a strong destabilizing effect, and perhaps repeating Prandtl's illuminating explanation of the role of viscosity in causing instability of boundary-layer flows.

Aside from this general criticism, it must be recognized that a very wide variety of material has been presented accurately and lucidly. There are very few omissions of any importance within the range suggested by the chapter headings and the introductory character of the book, although the absence of a mention of the Kármán vortex street seems one unfortunate case. That no

chapter stands out for special praise is testimony to the uniformly high standard of presentation; but chapter 2, on fundamental concepts, may be mentioned as being an attractive alternative to the various well-known presentations of the basic kinematical and dynamical equations. To note a further point in favour, which to some extent excuses the main criticism made above, the preface remarks that the volume as a whole has been planned for use in formal classes; obviously in these circumstances the deficiency of physical interpretations of the theory may not be so important, since the instructor may develop this side of the subject.

On the whole the text is attractively laid out, the diagrams are well done, and the mathematical printing is of high standard. A minor irritation is that the equations are unpunctuated. A valuable feature is the large number of problems set for the student. Many of these are remarkably searching and realistic, and they go a long way towards correcting the balance of the book. It is likely that very few of the problems could be solved by an average student without further help, although they all provide excellent examples for class instruction.

This can be recommended as a useful text-book to supplement a lecture course on incompressible flow, during which the lecturer could concentrate on presenting a well-balanced over-all account of the subject, referring to the book for many of the mathematical details and in particular clarifying the physical aspects. Thus, the book seems most appropriate to the American method of graduate training, which relies largely on formal lecture courses. Prof. Rouse in fact writes in his preface that the material has been taught as a two-semester course at the Iowa Institute. For the more casual British method, however, where the student has to depend more on private reading, the book is far less suitable; nevertheless, it might still be recommended if read in conjunction with books, such as Prandtl's *The Essentials of Fluid Dynamics*, which show clearly the status of the theory in relation to physical problems. Taking into account the specific purpose for which this book was written, it cannot be denied that Prof. Rouse and his co-authors have achieved it fairly successfully; and in any case they deserve to be congratulated on a most attractively written account.

T. Brooke Benjamin

Aerodynamik des Flugzeuges. Band I. By H. Schlichting and E. Truckenbrodt. Berlin: Springer-Verlag, 1959. 455 pp. DM. 52.50.

This first of two volumes on *Aerodynamics of the Airplane* contains the complete part A dealing with 'Fundamentals of fluid mechanics', and two chapters of part B on 'Aerodynamics of wings'. Part B will be completed in the second volume, which is to be published soon, and the review of part B can be postponed until then.

In part A, which is based on lectures by Dr Schlichting, the authors attempt the task of writing on almost the whole field of fluid mechanics, which is rather unusual in these days of the monograph. Their aim, however, is restricted and clearly stated in the foreword: they intend to given an introduction to fluid mechanics for the student of aeronautical engineering which is up-to-date.

There is certainly a need for such a book; the main problem, in view of the burgeoning knowledge accumulated in each field, is to know where to stop with the introduction. The authors are eminently successful in solving this problem; they have a sound and sober judgement of what has to be known by the student of the general field and what can be left out and relegated to special studies (which are encouraged and helped by a good bibliography).

The material is presented in four chapters: 'Introduction to the physical properties of the atmosphere,' 'Incompressible inviscid flow', 'Compressible inviscid flow' and 'Viscous flow'. Throughout, the authors favour simplicity and directness of the presentation over lengthy analysis. This does not mean a sacrifice in rigour, as every incompleteness of proof is clearly stated. The authors intend primarily to show what important results can be obtained by simple means (like momentum methods) and experience has shown that the gain in simplicity and clarity benefits not only the engineering student, but also those who later turn to the theoretical study of fluid mechanics. A large number of excellent illustrations enhance the value of the book, particularly for the beginner.

The modernized superstructure of the book is actually built on well-proven traditional foundations. In the chapter on incompressible inviscid flow, the presentation is made to fit the usual engineering curriculum by using first the real potential in plane flow; the paragraphs on complex potential are written without presupposing any knowledge of the theory of functions. The paragraph on the momentum theorem is a good example of the strong side of the book, as it contains material on over-all momentum balances which is often omitted by authors with purely theoretical interests.

The chapter on compressible flow does not appear to be as polished and well-balanced as the rest of the book. In particular, this reviewer found the presentation of the Prandtl–Glauert rule to be old-fashioned, even obsolete. A pure theoretician will consider all formulations of the Prandtl–Glauert rule as different only in trivial respects. Some modern text-books adopt this point of view, and the whole subject is dismissed by a one-line formula, which is all that is needed in principle. But an amazing number of papers (by distinguished authors!) containing erroneous results are to be found in the older literature on this subject; this should serve as a warning against considering the problem as completely trivial, particularly in books written for engineers.

Schlichting and Truckenbrodt choose to follow the historical presentation and give a derivation of the Prandtl–Glauert rule, in two 'different' formulations, for plane flow; the general three-dimensional (Göthert) rule is promised for the second volume. The derivation also contains the traditional mistake, an error of omission only, but nevertheless the same error which caused the confusion of the earlier writers; it is not pointed out that the results in two dimensions hinge on the proportionality between the potential and the body thickness in plane flow. This reviewer thinks that the exclusive use of the general and foolproof procedure given by B. Göthert would have been preferable.

The chapter on viscious flow appears to be essentially a condensed version of Dr Schlichting's own well-known book on boundary-layer theory, and is far

superior to the usual treatment of this subject in books on airplane aerodynamics.

Although the authors have clearly stated a restricted aim, it will be inevitable that their work will be criticized from the viewpoint of the present and future trends in the education of engineers in fluid mechanics. Many students to-day would like to be well prepared for work on missile aerodynamics in addition to aeronautical engineering, and for this purpose the introduction offered by Schlichting and Truckenbrodt is not adequate. In particular, an elementary presentation of the kinetic theory of gases in parallel with the foundations of continuum mechanics would be useful. A special chapter on hypersonics is a second requirement, although perhaps it is not important to find this section under the same cover with the rest. But the possibility of a schism between aeronautical and missile engineering is indicated by these omissions, which is regrettable. In the past the unified teaching of fluid mechanics for all engineering applications has not been achieved in most universities, and the outlook is that future developments will probably increase the division. This means that there may be students specializing from the beginning in traditional aeronautical engineering. For them, the use of Schlichting and Truckenbrodt's 'Fundamentals' is an excellent choice.

N. ROTT

Journal of Nuclear Energy. Part C: Plasma Physics—Accelerators—Thermonuclear Research. London: Pergamon Press Ltd. £7 or $20 per volume.

This journal has been set up to help cope with the prevailing spate of work on plasma physics, with Dr J. V. Dunworth as Editor-in-chief, a number of executive editors in U.K. and U.S.A., five general editors, and an imposing list of names on an editorial advisory board. The first part appeared in October 1959 and subsequent parts are to appear quarterly. Half of the eight papers in the first part are from the Atomic Energy Research Establishment at Harwell, although the editorial list suggests that later papers will be more diverse in origin. The emphasis appears to be on the field of applied nuclear energy, and there is unlikely to be any overlap with journals concerned with fluid mechanics, space flight or astrophysics. The inclusion of 'accelerators' within the journal's scope seems to be sensible. As well as original papers, the journal is apparently to contain two useful regular features, viz. translations of selected papers from the Russian journal *Atomnaya Energiya*, and a list of authors, titles and sources of recent papers published elsewhere on plasma physics, accelerators and thermonuclear research. The printing of the first part is of reasonable quality, but there is need for more care in the general editorial work; for instance, the address of the Editor-in-chief should be made known to intending authors.

So far as can be inferred from the information on the back cover, two volumes will be published each year. Evidently two parts like the one available for review (labelled 'Numbers 1/2' and containing 104 pages) will comprise a volume. £7 or $20 for a volume of about 208 pages is quite a price.