J. Fluid Mech. (1968), *vol.* 32, *part* 4, *pp.* 823–827
Printed in Great Britain

REVIEWS

Fluid Dynamics. By R. H. F. PAO. Merrill Books, 1967. 497 pp. $15.65.

Fluid Mechanics. By A. G. HANSEN. John Wiley and Sons, 1967. 531 pp. $9.95.

Mechanics of Fluid Flow. By P. A. LONGWELL. McGraw-Hill, 1966. 433 pp. £5. 18*s*.

Recent years have seen the publication of a very considerable number of text-books on fluid mechanics, particularly in the States, and one cannot help but wonder whether the market is not approaching saturation. However, there is presumably always room for the book that is illuminated by a new and fruitful approach or that introduces subject-matter associated with newly developing and important growing points. The authors of the three books under review can claim some justification under one or other of these counts.

The books by Prof. Pao and Prof. Hansen can most readily be compared and related since both are aimed at the general needs of the undergraduate engineer. Prof. Longwell's book is intended for the first year graduate chemical engineer who has already had some introduction to hydraulics. As might be expected the mathematical background required for the reader of this last book is somewhat more extensive than for the readers of the other two books but the differences are not great.

Prof. Pao's book begins with the usual topics of the conservation of mass flow, momentum and energy and in each case treats them in integral form derived for a control volume before developing the relevant differential equations. Non-inertial frames of reference (i.e. moving axes) inevitably receive some prominence, because of current interest in space vehicles, but the reader is expected to refer to a mechanics text-book for the necessary vector transformations or otherwise take them on trust. Two-dimensional and axisymmetric potential flows are next considered, and the discussion includes conformal transformation methods and their application to simple Joukowski aerofoils. The next three chapters deal with the effects of viscosity and the derivation of the Navier–Stokes equations, turbulence and simple boundary-layer theory. The treatment here is adequate if uninspired and in parts over-simplified. One notes that bulk viscosity is not referred to and the thermodynamic pressure is implicitly equated to minus the mean normal stress without comment. It is incorrectly stated (p. 383) that in the absence of flow separation from the surface of a body the total drag is only the friction drag. The treatment of compressible flow that follows is also somewhat limited in scope, being largely devoted to one-dimensional flow with a brief discussion of linearized perturbation theory in two dimensions. The final chapter breaks new ground in a book of this kind in so far as it provides a useful introduction to magnetofluid mechanics. The book is liberally supplied with worked examples and exercises.

One's general impression is that the undergraduate engineer might find the

mathematical treatment rather heavy going and the physical treatment sometimes less than adequate in scope or understanding. He would not be able to rely on this book for all his needs in the subject but given good guidance in his reading he could extract much of value from the book.

Prof. Hansen's book is at a slightly more elementary level than Prof. Pao's book but it covers much the same ground except that it does not deal with magnetofluid mechanics. The mathematical treatment is generally simpler and more likely to appeal to the undergraduate engineer whilst the discussions of basic physical phenomena are on the whole helpful and clear. Prof. Hansen like Prof. Pao develops the conservation laws initially in integral form for control volumes, then applies them to one-dimensional flow problems, and it is relatively late in the book that the differential equation forms are presented. Prof. Hansen argues that this is a natural sequence in increasing difficulty and that it is this sequence that is followed in practice in attempting to solve a problem, a further stage being appeal to experiment. Thus, apart from an introductory section the book is in three parts, viz. integral analyses, differential analyses and empirical analyses. This last part covers dimensional analysis, internal flows, external flows including boundary layers, with the briefest of references to compressibility effects. This approach is interesting but its merits are debatable. It is questionable whether engineering students do not find it easier to learn from the particular to the general and if this is so then simple one-dimensional treatments might with advantage come first before the integral relations. One can also dispute whether the material labelled empirical analyses is given its rightful importance or position by this treatment; certainly the reader gets little guidance as to how far he needs to use both inviscid flow analysis and boundary-layer analysis to form an adequate model of a real flow situation.

To sum up, Prof. Hansen's is a useful if elementary book whose great virtue lies in its clarity and lively style rather than in the particular mode and order of treatment chosen by the author. Illustrations, examples and exercises are plentiful and very good. As with Prof. Pao's book, an undergraduate engineer (particularly one studying aeronautical engineering) would need to supplement the book by further reading in external fluid mechanics and boundary-layer theory.

As might be expected Prof. Longwell's book is somewhat more extensive in scope than the other two books and it gives even greater emphasis to internal flows. The mode of treatment is perhaps more conventional but it is none the less effective, and it has a rigour in its discussion of physical concepts that is unusual and which the discerning reader will find very rewarding. For example, in the derivation of the Navier–Stokes equations there is no evasion of that 'skeleton in the cupboard', bulk viscosity; instead it is fully discussed and the reason why its effects can safely be ignored in many practical problems is made clear. The conservation laws are derived from the general concept of fluxes and there is no hesitation in deriving them in differential form; however, integral relations and one-dimensional flows provide important illustrations. Before the energy equation is discussed the momentum equation is fully developed and

applied to inviscid and viscous flow, to flow in pipes and channels and flow in porous media, and after a full discussion of the Navier–Stokes equations a number of solutions of practical interest are presented. The derivation of the energy equation is illustrated by a number of problems of heat transfer for flows in pipes and ducts. The next two chapters deal with laminar and turbulent boundary layers including thermal boundary layers, but with constant physical properties, and the boundary layer on a flat plate in natural convection. The discussion is mainly confined to boundary layers on a flat plate with zero external pressure gradient or in a pipe, but the basic concepts and assumptions involved are presented in a full and illuminating fashion. The final chapter deals with non-Newtonian fluids, and discusses the behaviour of the main categories of such fluids and their mathematical representation, laminar flow in pipes, methods of assessing transition, friction factors and velocity distributions for turbulent flow in pipes. As with the other two books the text is illustrated with a good supply of examples, and exercises are appended to each chapter.

Prof. Longwell's book seems to be the most successful of the three books under review in meeting the needs of the reader to whom it is directed. At the same time it has much of interest for the general reader of final year undergraduate or postgraduate level who is concerned primarily with internal flow problems.

A. D. YOUNG

Thermodynamique Appliquée aux Machines. By R. VICHNIEVSKY. Masson & Cie, 1967. 412 pp. 60F.

Turbo-Machines, Hydrauliques et Thermique, Tome 1. By M. SÉDILLE. Masson & Cie, 1966. 368 pp. 60F.

It is always interesting to read foreign language text-books for there is a good chance that their approach may be different. Professor Vichnievsky's book, which is one of a French series of monographs on thermo-fluid mechanics, is no exception. It bridges the gap between thermodynamics and heat engines more completely than most English language books and devotes considerable space to the practical and theoretical considerations of many types of cycle. It comprises three main sections, thermal machines for a perfect gas, two-phase fluid prime movers, refrigerators and heat pumps. As the title suggests, the emphasis is on machine applications and after briefly outlining basic thermodynamic principles it dwells on the practical aspects of many heat engine cycles. It assumes a prior knowledge of thermodynamics and, in going further than most undergraduate courses in Britain, has more of an engineering flavour. It is suitable for senior undergraduate and research students specializing in heat engines. The object of the book is to encourage the reader to apply his existing thermodynamic knowledge, and the many numerical examples provided by the author give an idea of the orders of magnitude encountered in practical problems. This is very necessary for anyone proceeding to study the practicability of complex cycles. Throughout there is an emphasis on optimum thermal efficiency and the many reduced scale thermodynamic charts specially produced

for the book enable the reader to evaluate cycles and to gain a sense of proportion. A useful bibliography for further reading is provided.

Professor Sédille's book is one of a series sponsored by the Conservatoire des Arts et Metiers, a distinguished institution for further education founded in 1819, which now has 22,000 students and a great teaching tradition. Typical of the system on the continent, the author is not only a professor but also a director of Societe Rateau, the well known turbo-machinery firm. This is the first of two volumes on thermodynamics applied to machines and is concerned entirely with basic incompressible fluid mechanics. It is admirably lucid and unusually comprehensive covering mechanical, aerodynamic and civil engineering aspects. One is conscious from the many names quoted of the distinguished contribution made to fluid mechanics by French scientists in the eighteenth and nineteenth centuries. There are some surprises however, for example, the theoretical loss in a sudden expansion is ascribed to Borda-Bellanger, and not to Carnot, as often suggested in English language books. The Buckingham theorem is now apparently the Vaschy–Buckingham theorem. Strange to say, in the bibliography Hunter Rouse appears as Roux, so perhaps we should not dwell too much on names. The eight chapters cover hydrostatic, energy and impulse equations, similitude, potential flow theory, viscous and laminar flow, turbulent flow and flow in conduits, free surface flow in channels, and experimental fluid mechanics. For an elementary text, it is unusually comprehensive and the sections on potential flow, turbulence, pipe-flow and losses in ducts and experimental apparatus are particularly useful. As the author rightly points out, it is essential in this first volume for the student to understand basic fluid mechanics before proceeding to machine applications. It is a first-class introduction to the subject, concisely written, very clearly set out and diagrammatically illustrated, and containing much practical information in addition to basic theory.

Both books are printed quite adequately and have robust flexible covers. They have a detailed list of contents which is helpful, but a rather inadequate index. Both can be recommended for those wanting a change of air.

S. P. Hutton

Stossrohre. By H. Oertel. Springer–Verlag, 1966. 1030 pp. $80.00.

This is a monumental work, with 621 illustrations and 3687 references, and the author actually apologizes for not having been able to include details of measuring techniques! These, we are told, will follow in a separate volume. The author, who has worked in the field of gas dynamics for over 20 years and who is well known internationally for his work on hypersonic shock tubes and on the physics of heated air, sets out to provide an account of all types of shock tubes and their applications. One of his objects is to familiarize more physicists, chemists, aero-space engineers, mining engineers and defence scientists with the possibilities of research using shock tubes and to turn them into shock-tube enthusiasts. He aims also to give full information on shock-tube techniques, and to present the methods for calculating events in the shock tubes.

I feel that he has succeeded admirably in his tasks. Whether the reader is interested in shock-wave attenuation, relaxation effects, diaphragm thicknesses, safety measures, electrical properties of gases, mounting of glass windows, to select but a few items, the required information will be found in the book in enough detail to be of practical use and with sufficient references to enable him to go into the subject more deeply if necessary.

Rather more than the first third of the book deals with the physics of gases and with the relevant steady and unsteady gas dynamics including boundary-layer theory. In the next part of the book follow a number of sections on shock tubes and shock tunnels and on their construction and operation.

The last part of the book is devoted to the application of the shock tube to research problems in gas physics and aerodynamics. A particularly useful feature is the large number of comprehensive tables itemising research in the various fields likely to interest shock-tube users, and giving the corresponding references. In his introduction the author mentioned the desirability of new workers in the field avoiding duplication of work done many years before, and there is no doubt that the clear presentation of this part of the book will help this aim.

The author has perhaps somewhat overstated the case for shock tubes when he deals with their use for aerodynamic research; experience has shown that this is restricted to relatively simple tests. For instance, for the complete testing of complicated hypersonic aircraft models with their control surfaces and engine intakes requiring many thousands of measurements under carefully controlled test section conditions, it is still preferable to conduct the tests in continuously running wind tunnel facilities where these are available. Gun tunnels, which are used in preference to shock-tube tunnels in many laboratories, have not, as stated by Dr Oertel, been developed primarily to obtain higher stagnation temperatures, but to give much longer running times than those obtainable in shock tunnels to enable complex tests to be made at Reynolds numbers higher than in continuous tunnels.

Altogether, though, this is a well-balanced and comprehensive account of the shock tube field up to 1964. There are too few books of this scope and scholarship in fluid dynamics, and this volume will stand as a classic reference for many years to come.

R. N. Cox