REVIEWS

Fluid Mechanics with Engineering Applications. 6th Ed. By R. L. DAUGHERTY and J. B. FRANZINI. McGraw-Hill. 1965. 574 pp. $9.95 or 80*s*.

Fluid Dynamics. By J. W. DAILY and D. R. F. HARLEMAN. Addison Wesley. 1966. 454 pp. $12.50 or 94*s*.

These two books, both written by civil engineers, represent the opposite ends of the scale. The first stems from the traditional hydraulic engineering approach, was first published in 1916, and is now appearing in its sixth edition with the claim that it is sufficiently rigorous to appeal to all engineering students. The second book is completely new and is written in a more mathematical style. Both books are very well printed, contain some excellent diagrams and photographs and are generously supplied with problems after each chapter.

Daugherty and Franzini's book is strongly biased towards civil engineering applications with many pages devoted to the behaviour of turbines, pumps and associated waterworks. The reviewer would not recommend it for students of mechanical, aeronautical or chemical engineering as it lacks adequate treatment of some basic phenomena. If the book is regarded as being primarily for civil engineers, it could be expanded with advantage to include discussion on ocean waves, sediment transport and forces generated by bodies at a free surface.

Chapter 1 deals with properties of fluids and is well written. Chapter 2 is on fluid statics, and includes a useful discussion on aspects of pressure. In the beginning, the tacit assumption that the body force is due to gravity is not as neat as the equation of the surface forces on the element to the body forces with gravity as a special case. The authors' obsession with gravity fields is exemplified by their continual use of specific weight throughout the book, even when the situation calls for the use of density in appropriate units, usually the 'slug'. They are forever having to divide terms by g, to the ultimate confusion of the student. Chapter 3 is concerned with kinematics, and introduces the equation of continuity. The discussion, while correct, does not bring out the possibility of unsteadiness as clearly as a control volume approach. However, the introduction of conservation of fluid weight is a poor one and shows up the book's ancestry. There is some worthwhile discussion on flow nets.

In chapter 4 the energy equation is introduced. Hydraulic gradient is discussed as well as free and forced vortex motions. The next chapter deals with basic hydrodynamics and covers the usual material in a satisfactory manner up to the stage where flow around a circular cylinder is derived. Circulation around the cylinder is considered in a later chapter, but complex potentials and the method of images are not treated at all. Chapter 6 covers momentum and dynamic forces. The derivation of the momentum equation is too simple and is in a form which is applicable only to the steady flow of liquids. Later in the chapter when the authors evaluate the thrust from a jet engine, they write down without explanation an equation which bears no resemblance or seeming relation to the one initially derived. Here is a chapter that needs urgent revision and the authors might care to look at Daily and Harleman's book for an alternative approach. This chapter is also full of 'fluid weights' and contains a number of small mistakes. The next seventeen pages deal adequately with similitude and dimensional analysis.

The steady flow of incompressible fluid in pipes is covered in chapter 8. The subject matter is quite wide and includes articles on laminar and turbulent flow, critical Reynolds number, entrance conditions, turbulent velocity profiles, roughness, non-circular ducts, losses in various geometries and finally various pipeline arrangements. No recent work on pipe roughness is mentioned. Secondary flows are dismissed too briefly. Chapter 9 treats the steady flow of compressible fluids. Here the momentum equation is stated in a form which has not previously been derived despite the authors' claim to the contrary. First, constant area flow is considered followed by the usual nozzle flow. Oblique shocks receive bare mention while expansions are not treated at all. This is altogether inadequate for students other than those of civil engineering.

At this stage we are halfway through the book and it is a pleasure to read chapter 10 on open channel flow, on which matter the authors are obviously experienced. They treat the effect of channel slope, the Manning formula, velocity distributions, different cross-sections, specific energy and critical depth, varying flow and surface profiles, hydraulic jump and finally flow in bends. On the matter of nomenclature for the velocities in a channel, could I refer the authors and other hydraulic engineers to the proposal of A. M. Binnie? To correspond with subsonic and supersonic velocities from aerodynamics he proposes the words 'subundal' and 'superundal' respectively replacing the words 'subcritical' and 'supercritical', which latter two are used in too many varieties of situations to have proper relevance here.

It is desirable for every student of fluid mechanics to make measurements of flow, and the authors include a long chapter (56 pages) on fluid measurements. There is a good discussion of Pitot tubes and the measurement of viscosity and static pressure. However, the hotwire anemometer is dismissed in 11 lines while orifices, nozzles, jets and venturi tubes with all their empirical constants cover the next 28 pages. The last 10 pages of this chapter are devoted to weirs and their discharge. There is no mention of towing tanks or wind tunnels as experimental facilities nor of the measurement of temperature. Chapter 12 is titled 'Unsteady flow problems' and deals with two hydraulic problems. The first one follows from head variations in reservoirs. The second problem is concerned with water hammer and valve closing in pipelines. The discussion is knowledgeable.

Dr Ingersoll, the co-author of the fifth edition, is largely responsible for writing chapter 13 on forces on immersed bodies. Very correctly he starts with discussion on the boundary layer and proceeds through some analysis to articles on separation and pressure drag. Following drag he treats lift and circulation, first on a cylinder and then on the aerofoil, and then induced drag and lift-drag diagrams. The following comments apply to this chapter. A power-law description of the turbulent boundary-layer velocity profile which he uses is very primitive. Even if space is limited one should include discussion of the log law, velocity-defect behaviour, Cole's wake function, roughness, eddy structure and intermittency, to mention but a few points. The discussion on form drag implies that this occurs only on a body with separation forward of the theoretical rear stagnation point; but even a streamlined body has form drag due to displacement thickness of the boundary layer. In the article on the effects of gravity and compressibility on drag, gravity effects are treated first. For a body operating at a free surface the reader is referred to a previous chapter seven; but in chapter seven one finds seven lines on the matter and a reference to the present article for more details. Compressibility effects are covered in two paragraphs which include the statement: 'Fortunately, by the time the velocity is high enough for compressibility effects to become important, it is so high that viscous effects are altogether negligible and Reynolds number does not enter the picture'. But shock waves cause boundary layers to separate and the transonic drag problem is still with us! The Prandtl–Glauert law is not mentioned nor is any law of supersonic behaviour discussed such as that due to Ackeret.

The last five chapters cover turbo-machines and are entitled. 'Similarity laws and factors for turbomachines', 'Impulse turbines', 'Reaction turbines', 'Centrifugal and axial-flow pumps' and 'Fluid couplings and torque convertors'. They are well written, contain much useful practical information and are by far the best chapters in the book. What is omitted is a chapter on propellors, fans, jets and windmills.

This sixth revised edition has still not caught up with the present state of fluid mechanics. The subject matter is unbalanced and many of the fundamentals are poorly treated. When the authors move away from their home ground then the standard of the treatment makes a rapid decline. It is the opinion of the reviewer that they have failed in their attempt to provide a suitable text for engineering students. The merits of the book lie in its civil engineering applications.

Having laboured through the vintage book it was with some pleasure that the reviewer turned to the new text by Daily and Harleman. In the words of the authors, 'it is designed for a first course in fluid dynamics for engineering students—having increased relevance to the educational process in modern engineering curriculum and to the needs of engineers of the future'. The material is here rearranged. The Navier–Stokes equations of motion are introduced at an early stage and followed by their application to a variety of special cases. This raises the question often argued by educationalists; whether it is better to teach from the general to the particular or vice versa. The authors point out that their approach saves time and allows more material to be included. The real question to be answered is whether the students absorb the ideas better with this approach. Whatever the result, this book represents an interesting change from the traditional.

The first eight chapters are concerned with fundamental concepts, while the remaining eight are devoted to specific topics and applications. Chapter 1 discusses properties and states of fluids, and some tables of physical properties are included. Chapter 2 discusses kinematics at a superior level. The inclusion of rotating and accelerating co-ordinate systems in these days of space craft is most topical.

Chapter 3 is titled 'Dynamic features and methods of analysis' and, which, in the reviewer's opinion is the authors' Achilles heel. They attempt to relate a rate of transport to the gradient of the transport quantity. As an example of momentum transport, laminar Couette flow is shown and the analysis leading up to the relation of shear stress to normal velocity gradient is in error. It may be possible to derive this relation but a much more sophisticated argument would be needed. The flavour of the book is unfortunately spoilt by this mistake.

Chapter 4 covers continuity, energy and momentum equations and uses the control volume concept. For some odd reason the usual convention, having a normal to a control surface pointing outwards, is reversed in this text. The energy equation is shown in two forms, per unit mass and per unit weight. It would be even clearer if units were defined as 'pound force' or 'pound mass' and written 'lbf' or 'lbm' respectively. Chapter 5 is an innovation. Stress–strain relations for an elastic solid are taken and applied to a Newtonian fluid. Chapter 6 presents the stream functions, the Navier–Stokes equations, Bernoulli and simple vortex motions.

Dynamic similarity is discussed in chapter 7. The Buckingham pi theorem is not presented; instead emphasis is laid on physical understanding of the forces involved. Again there is a minor discord, caused this time by reference to that part of the static pressure which responds to dynamic behaviour as the 'dynamic' component and later in the book as the 'dynamic pressure'. Dynamic pressure is the term normally used to signify the quantity $\frac{1}{2}\rho v^2$. The next chapter is concerned with laminar and turbulent flow, the boundary layer concept and the notion of drag and lift, while chapter 9 covers creeping motions. Some of the explanations could be improved, such as that for form drag. Chapter 10 gives an excellent account of laminar boundary layers, while chapter 11 covers the origin of turbulence and turbulent shear stress. In chapter 12 the authors present an obviously knowledgeable account of turbulent boundary layers. They might consider in the future the simplicity and greater rigour of both Millikan and Rotta type arguments showing the existence of the log law. In the discussion on roughness they do not mention that type whose action depends only on boundary-layer thickness or pipe diameter. Nor do they consider the advantage of using an equivalent kinematic viscosity for collapse of all results on to a unique curve. The problem of the location of the effective origin for the rough surface is not mentioned. Chapter 13 covers turbulent flow in uniform conduits and ranges from the usual pipe flow through to open channel flow.

Chapter 14 is titled 'Non-uniform flow in conduits'. This covers changes in fluid properties brought about by changes in geometry, compressibility and surface wave effects. Some of the streamlined flow patterns shown may be misleading to the students. For example, from the diagrams of a sudden enlargement and of an orifice plate in a pipe it might be inferred that the central flow region remained streamlined, whereas it does not. It may be possible to find mean streamlines but the idea of breakup of the jet into turbulence is not shown.

Chapter 15 covers the drag and lift on bodies. It is a pity that in discussing the drag of a circular cylinder the work of Roshko, done in 1960 has not been used. There is a worthwhile article on the effects of cavitation which is followed by a rather naïve discussion of ship drag. There is no discussion of the crude assumptions made for the Froude theory nor of the interactions between the wave drag and the skin friction drag. A photograph purporting to show only a ship's bow waves shows also the diverging stern waves, and the transverse bow and stern waves as major features; wave interactions are not discussed at all. As with the previous book, compressibility effects on drag are not well treated. Nowhere is there mention of compressible expansion waves. The last chapter is titled 'Turbulent jets and diffusion processes'.

On the whole it is a very creditable piece of writing, with only a few lapses in presentation. It could be argued that more engineering applications should have been included, as with the first book. Certainly a chapter on fluid measurements appears to be called for.

P. N. Joubert

Magnetohydrodynamics. By A. Jeffrey. Oliver and Boyd, 1966. 252 pp. 13*s*. 6*d*. (paperback), 17*s*. 6*d*. (hard-cover).

Books on magnetohydrodynamics appear to be in fashion and many of them share the same simple title. This volume is published in the series of University Mathematical Texts. I expected a concise introduction to the subject, based on fluid mechanics but leading up to both astrophysical and engineering applications. Unfortunately, my hopes were disappointed.

Of the seven chapters, three are devoted to magnetohydrodynamic waves, with the emphasis on finite-amplitude effects and the propagation of discontinuities and shocks. Thus 114 pages (45 % of the total) are concerned with one branch of the subject. It is not clear whether one should regard the book as an introductory text with a swollen appendix or simply as an account of nonlinear magnetohydrodynamic waves. I shall try to discuss these two aspects separately.

Taken as an introduction to the subject as a whole, the book seems rather short. In the first chapter, after a brief description of plasmas, the continuum equations are derived; the magnetohydrodynamic approximation is carefully discussed; the magnetic Reynolds number is defined; Alfvén's theorem is proved and transverse Alfvén waves are introduced. The second chapter is concerned with boundary conditions, discussed with discontinuities as well as rigid boundaries in mind. Chapter three is about incompressible flow and treats parallel steady flow ($\mathbf{v} \wedge \mathbf{B} = 0$), Hartmann flow and Couette flow. Steady compressible flow is considered in the last chapter, for the situation where the equations are hyperbolic and flow round obstacles can be described by characteristics. The final section, entitled 'Discontinuities in the static case', discusses magnetohydrostatic equilibria; plasma containment is dealt with in the last five pages.

Now the most remarkable magnetohydrodynamic effect is the freezing in of magnetic fields in a perfectly conducting fluid. This lends power to the concept of lines of force, which can provide a simple description of hydromagnetic interactions. Any book should therefore include a discussion of kinematic problems and solutions of the induction equation,

$$\frac{\partial \mathbf{B}}{\partial t} = \operatorname{curl}(\mathbf{v} \wedge \mathbf{B}) + \frac{c^2}{4\pi\mu\sigma}\nabla^2\mathbf{B}.$$

Dr Jeffrey hurries by: frozen-in fields only receive two mentions in the text; Ferraro's law of isorotation and Cowling's anti-dynamo theorem do not appear at all.

The account of flow in ducts is short. Magnetohydrodynamic instabilities and turbulence are omitted. The basic material is really inadequate for anyone interested in astrophysics or in plasma containment. Occasionally the discussion is misleading: on p. 73, vanishing of the normal component of **B** is given as the magnetic boundary condition on a perfect conductor; but this component need only remain constant. It may have been there from time immemorial. Again, on p. 78 it is stated that the condition for incompressibility is $\operatorname{div} \mathbf{v} = 0$ *and* $\mathbf{v}\,.\operatorname{grad}\rho = 0$. Yet it is only necessary that the total derivative $\mathrm{D}\rho/\mathrm{D}t$ should vanish, which implies that $\operatorname{div} \mathbf{v} = 0$. The second condition holds for steady flows only.

The whole book has been written with magnetogasdynamics very much in mind. Chapter four introduces characteristics and uses general methods to describe fast and slow magneto-acoustic waves. Then there is a discussion of non-linear simple waves and of the piston problem. Shocks appear in chapter six. The jump relations are derived, the shock front is described and various types of shock wave are then classified. This discussion is fairly comprehensive.

The treatment of non-linear waves in terms of characteristics is certainly interesting. However, it is a rather specialized topic and I am not convinced that it is suited to the constraints imposed by an elementary book of this form. In particular, it is a pity that the conventions of the University Mathematical Texts do not allow references except to other members of the series.

The emphasis on compressible flow leaves the book inadequate as an introduction to incompressible magnetohydrodynamics. Certainly it does not compare with those by Cowling and by Shercliff. On the other hand, the condensed treatment of finite-amplitude waves seems inappropriate to me. Indeed, the same author has already given a better account of the subject elsewhere (Jeffrey and Taniuti: '*Non-linear Wave Propagation*', Academic Press, 1964). I cannot recommend this book.

N. O. WEISS

Descriptive Micrometeorology. R. E. MUNN. Academic Press, 1966. 245 pp. $9·75 or 78*s*.

This book is intended to serve the dual purpose of being both a text-book for a graduate course and a review of micrometeorology covering mainly recent literature. The term 'descriptive' is to indicate that proofs and derivations are rarely given but not that equations are entirely omitted; it also serves to distinguish the book from O. G. Sutton's *Micrometeorology*.

The author has succeeded in making an attractive and balanced outline of the subject which in itself is not easy to do because of its heterogeneous nature. But he has partly failed in the detailed execution of it. The second half of the book is rather reminiscent of Geiger's text on *The Climate Near the Ground*. It is perhaps better organized, but it inevitably contains much less information. The treatment is uneven. Some sections are virtually void of information, for example § 6·3 on 'Precipitation and fog', and other sections are loaded with it, for example § 9·2 on 'The Monin–Obukhov length and the Richardson number', where the uninformed reader will encounter a major hurdle.

The 'descriptive' character of the text combined with the use of equations sometimes degenerates into a list of recipes and recommendations which are quite controversial and irritating. For instance, the use of the aerodynamic method to obtain the turbulent heat flux is discouraged, but no satisfactory alternative is given and in further discussion the author himself refers to and makes use of the aerodynamic method without hesitation.

There are numerous comments and criticisms which one might make on the text. These are usually minor, but their cumulative effect leaves one with a negative impression. Some examples are: (1) the statement that ozone protects man from cosmic radiation is wrong (p. 10); (2) 'dimensional analysis and similarity theory' are considered the 'fundamental principles' from which 'the whole theory of the surface boundary layer is derived' (p. 56); (3) the Lagrangian correlation function is used but not defined (p. 78); (4) the erroneous impression is given that before Ellison's (1957) paper it was generally believed that 'the ratio K_H/K_M was constant and probably equal to unity' (p. 83); (5) the statement, 'In the absence of evaporation, Ovey...has calculated that cooling of a meter-deep layer of water by 0·1 °C would raise the temperature of 30-meter thick layer of air by 10 °C' is a roundabout and inaccurate way of saying that the heat capacity of water is about $3 \cdot 10^3$ times that of air (p. 168); (6) the statement that 'horizontal advection (of heat) by ocean currents is usually small' does not do justice to the effect of the Gulf Stream (p. 176). It seems that the book has not been seriously edited.

The list of references is extensive and valuable, but nevertheless rather arbitrary, and a number of pertinent papers and books have been omitted.

Although in view of the above-mentioned criticisms the book is unsuitable as a text, it contains interesting and useful information, particularly the last eight chapters.

J. A. Businger

Fluid Flow in Bends of Conduits. By A. K. Ananyan. 1965. 259 pp. £5. 17*s*.; **Theory of Stream Run-off.** By N. P. Chebotarev. 1966. 464 pp. £5. 8*s*.; Israel Programme for Scientific Translations Ltd.

These two books are published as part of a programme of translating books from Russian. In both cases the translation has clearly not been done by one skilled in fluid mechanics, and many passages are difficult to follow. The editor's footnotes attempt to redress the balance. Neither book has an index, but each has an extensive bibliography almost entirely of Russian works; there are few references to work in the West, and the non-Russian references are notably old-fashioned. Many parts of the books are diffuse, long-winded and difficult to follow.

The book by Ananyan is rather like a Ph.D. thesis. The author works out a theory of secondary currents, in conduits of rectangular cross-section, using some assumed velocity distributions and eddy viscosity profiles to give his frictional forces. He applies the theory to bends in rivers making the width of stream much smaller than the radius. His own experiments are described together with several other peoples' work, and he concludes that his velocity profiles in the bend are in fair agreement with the theory, assuming an elliptical velocity distribution at the entry. Nowhere is the phrase 'secondary current' used, and the original (published in 1957) has no references to similar work done in other countries. It is, nevertheless, a useful book for anyone trying to understand the effects of curvature in rivers and canals. Subsections deal with the problems of branched channels and the distribution of turbidity of particles in bends. The instrumentation of the experiments seems somewhat crude.

The book by Chebotarev is quite different since it is claimed to be a text-book for river engineers. There has clearly been a great deal of effort expended in the U.S.S.R. in collecting hydrometric data and this book attempts to correlate some of it by empirical methods. However, the sophistication is of a low order, judged by western standards, there being no discussion of such fundamental topics as the unit hydrograph of flood routing. Thus the scientific (as opposed to empirical) content is low. There has been little attempt to make the essence of the treatments of data general for a wide range of rivers and catchments.

Both books are of interest to students, if only as a realization that other ideas are possible, and that there is a great deal of new information available in the Russian scientific literature which has not yet been translated.

J. R. D. FRANCIS, T. O'DONNELL