REVIEWS

Fluid Mechanics for Engineers. By P. S. BARNA. London: Butterworths Scientific Publications. 1957. 371 pp. 57*s*. 6*d*.

To many people who teach elementary fluid mechanics to embryonic engineers, there falls regularly the responsibility of recommending a choice from a long list of textbooks all covering much the same ground. For a lecturer without a book of his own, the choice may be quite difficult. A survey of the booksellers' shelves shows the field to be indeed very full: there are about half a dozen possible winners and a much larger number of outsiders. Because some of these textbooks are very bad, and also because over all the correlation between value and price is not strong, a recommendation to students is an important undertaking.

When assessing any book written 'for engineers', it is necessary to apply a further criterion beyond the general standards desirable in scientific writing. The special requirement is of course that the book should meet the particular needs of engineering students, as distinct from those found by students of physics or applied mathematics approaching the same branch of science. Modern trends in engineering education have made this distinction much less clear than it used to be; but an essential difference must still be recognized. A good introductory textbook on fluid mechanics addressed to engineering students has to cover a wide range of topics necessarily somewhat superficially, emphasizing the utility of theoretical results rather than their rigorous logical justification and in general avoiding all but the simplest mathematical arguments; nevertheless, such a book must give an essentially *correct* account of underlying broad principles, even those which underlie mechanisms whose complete description is an extremely difficult matter—for example, boundary-layer separation and turbulent friction. It does not seem unduly rash to say that among the achievements of modern fluid mechanics there is no important physical result whose fundamental explanation could not be made clear to an intelligent final-year engineering student, provided of course that sufficient expository skill could be mustered. Thus, the scope of elementary engineering texts need never be restricted merely to what is easy mathematically, but depends rather on the ability of authors to extract essentials from the corpus of existing knowledge and present them in simple terms.

In the light of these rather stern generalities, it is pleasant to be able to write that Mr Barna's book is on the whole a fairly satisfactory one: certainly this book is among the better of its kind, and can be regarded as a welcome addition to the list deserving consideration for teaching purposes. Readers sensitive to style will suffer many minor irritations—e.g. equations are often introduced with needlessly clumsy wording—and there are a few blunders; but, after reading the book through, it is recognized that a wide range of material has been presented tersely yet for the most part explicitly. In his preface the author claims: 'Emphasis is laid upon the broad representation of fundamentals, leaving certain topics not included in the text for the choice of individual teachers.' This is a fair statement as to the character of the book, although the author's second remark does not in fact imply any serious gaps in the coverage. Many worked examples are given to illustrate the theory, and 67 problems are set for the student to work out.

Part I of the book contains ten chapters on topics primarily concerning incompressible fluids, the applications described being well balanced between problems of water flow and low-speed air flow. The short opening chapter outlines hydrostatics quite nicely. Then, unfortunately, at the important stage where the rudiments of fluid dynamics are to be introduced, the standard ebbs far below the good average of the book as a whole. Chapter 2, titled 'perfect fluids in motion', obviously was written without due care. The chapter makes a bad start, a discussion of pathlines and streamlines leaving much to be desired—for instance, no suggestion is made that these are in fact the same in steady flow. After this the usual simple derivation of Bernoulli's equation from Newton's second law is presented; but the author then repeats the common error of interpreting the terms in the equation directly as representing energies (introducing the awkward concept of 'pressure energy'). (Again in the later chapter on compressible flow, the absence of a proper derivation of the energy equation for steady flow seems an unfortunate omission: merely to add the definition of internal energy, $dQ = dE + p\,dv$, to Bernoulli's equation is unconvincing, to say the least.) Another disappointment occurs later in the chapter when momentum considerations are applied to calculate the force exerted by a deflected jet. A page and a half are given to discussing momentum changes of solid bodies, particularly the case of a ball bounced off a wall; and after this one rather expects that the case of a jet will be explained by analogy with a stream of particles, as it can be quite convincingly. But this is not done, the actual explanation being tentative and needlessly feeble for all the space allowed this topic.

To pass on to better things, Chapter 3 is mainly a short account, quite well done, of viscosity and the significance of Reynolds number. It is followed naturally by a chapter on the flow of real fluids in closed conduits. This presents a sensibly balanced mixture of fundamentals and practical data, such as graphs of friction coefficients and a short table of typical roughness lengths for engineering materials.

Chapter 5 deals briefly with steady flows in open channels. Though adequate, this is not one of the better chapters: it runs through the usual material, 'specific energy' and all that, and adds nothing new. An opportunity is missed, for surely the time is ripe for infusing some new ideas into the teaching of this part of hydraulics. It is a pity, for example, that the useful analogies between open-channel flow and one-dimensional compressible gas flow were not exploited. Thus, the Froude number based on local mean velocity and depth is not mentioned explicitly, despite its important role precisely equivalent to that of Mach number.

Then follows a chapter on 'Fluid metering', which gives brief but quite interesting descriptions of orifice meters and other types of flow meter, Pitot tubes, and various manometers. Next, Chapter 7 gives a careful account of dimensional analysis, explaining formally the details of its technique (e.g. Buckingham's pi theorem), but particularly emphasizing its *purpose* as a tool for the engineer. This chapter is one of the best in the book.

The remaining chapters of Part I are also good. The 52 pages of Chapter 8 give a review of boundary-layer theory whose scope is quite ambitious for a book of this sort. The topics covered include a general description of laminar and turbulent boundary layers, thickness and skin-friction calculations for the laminar boundary over a flat plate, properties of turbulent boundary layers deduced from the $\frac{1}{7}$-power law, separation and form drag, the deduction of the 'law of the wall' from Prandtl's mixing length hypothesis, and the idea of rough or smooth turbulent boundary-layer flows. The author has been fairly skilful in reducing these complex matters to essentials, and this chapter makes an attractive introduction to the subject. As a minor complaint, figure 8.9 is a terrible bungle: about everything possible is wrong with this figure, which fortunately is not an important one. Chapter 9 is a brief but pithy exposition of the elements of wing theory.

In the single chapter on compressible flow comprising Part II, the usual basic topics (e.g. frictionless adiabatic flow in nozzles, flow in uniform ducts with friction, normal shocks, together with a mention of reflected shocks, expansion fans, etc.) are covered fairly adequately; but the chapter could have been greatly improved by added explanation of the fundamental thermodynamic considerations involved. For example, the entropy change across a normal shock is calculated without explaining the meaning of entropy or the significance of its increase through a shock.

The three chapters of Part III give a very readable account of the operation of the main types of rotary pumps and turbines, the emphasis being of course on fundamentals rather than technical detail although there is a reasonable measure of the latter. Rational methods of impeller design, dimensional analysis of machine characteristics, and cavitation are included in the topics discussed. The value of this part of the book is greatly enhanced by a series of excellently reproduced photographs and sectional drawings of machines, just sufficient in number to bring the realities of the subject home to the student without in any way giving the book the character of a technical manual. As an instance of the value of the photographs, the view of a Francis turbine runner on p. 361 conveys in an instant the essential layout and mode of operation of this intricate device, whereas to explain these in words or with simple sketches is very difficult.

The book shows some signs of hasty preparation, particularly of careless proof-reading (e.g. the equation preceding (2.8) looks all right on a cursory glance, but the misprint there could seriously confuse a student); and there are a few bad instances of careless writing. On p. 33, for example, there appears the wholly misleading statement, 'When liquids are in motion, surface tension effects are negligible; they may not be ignored, however, when they are at rest...'. Again, on the previous page, the author writes about the 'modulus of elasticity, E' where the *compression modulus* is implied, although surely he knows that all over the world engineering students learn to associate the symbol E with Young's modulus.

Nevertheless, the overall impression is a favourable one, even allowing for the fact that this book is unduly expensive. It can be recommended for teaching whenever a broad coverage of fundamentals is needed together with a small yet encouraging taste of engineering practice.

T. Brooke Benjamin

A Textbook of Fluid Mechanics. By J. R. D. Francis. London: Edward Arnold (Publishers) Ltd. 1958. 332 pp. 24*s*.

This book is presented, at a price which students should be able to afford, as an attempt to provide a simple yet up-to-date textbook for the earlier years of an engineering degree course.

There is certainly a place for sound but simple books treating fluid mechanics from a broader point of view than the older textbooks of hydraulics and omitting any very detailed treatment of the applications. But an author who embarks on such a book does well to consider carefully his choice both of the subject-matter and of a balance between the teaching of basic principles and the teaching of methods for solving engineering problems. Should the whole of a degree course be covered, or should the more advanced parts of hydraulics, for example, be left to be read elsewhere? Should any attempt be made to deal with high-speed aerodynamics at this stage, or, even briefly, with border-line subjects such as heat transfer or the flow of liquids through permeable media?

The main object ought to be to expound and illustrate the principles of fluid mechanics and to give a clear physical picture of the behaviour of real fluids. The actual range of the book is not so important, except in so far as it may have to cover the requirements of particular examinations. The illustrations of fundamental ideas should of course be drawn from engineering applications whenever possible, so as to be satisfying to a student with his mind on practical matters. Physical principles should be inculcated both overtly and by stealth. If the ideas of dynamical similarity can be driven home a little further in the course of a short chapter on, say, heat transfer, that may be sufficient justification for including such a chapter.

The book under review covers rather more ground than might be expected in view of its declared emphasis on the early part of a degree course. The author begins with two short chapters on hydrostatics. In the course of the introductory chapters on fluid motion which follow, he describes the use of stream function and potential function to describe inviscid two-dimensional incompressible flow. He then deals at some length with Bernoulli's equation and the momentum theorem as applied to a control volume, incompressible flow being assumed. A chapter contributed by Mr G. Jackson provides a substantial introduction to the compressible flow of a perfect gas, including a brief account of the flow about aerofoils at high subsonic and supersonic speeds. Dimensional analysis is treated next, from the point of view of experimental work. The properties of boundary layers are then described. Chapters on the flow in pipes and in open channels follow, and the book ends with chapters on hydraulic machines and some unsteady-flow topics. At the end of each chapter a selection of engineering problems, with solutions, is provided as an exercise for the student.