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REVIEWS

The Electromagnetodynamics of Fluids. By W. F. HUGHES and F. J. YOUNG. John Wiley, 1966. 648 pp. £6. 12*s*.

The first quarter of this book is intended to be a comprehensive introduction to electromagnetic phenomena in fluids. Principles of special relativity and the electrodynamics of moving media receive special attention. Then, in formulating the equations of motion and energy, the authors consider the effects of magnetic and electric polarization as well as those of current of free charge. The remainder of the book is devoted to particular topics in magnetohydrodynamics under the influence of $\mathbf{j} \times \mathbf{B}$ forces only. They are mostly familiar and include incompressible viscous flow, plane waves, shock waves, magneto-aerodynamics, etc. The whole package is aimed at graduate students taking a two-semester course.

The plan for the start of this book is ambitious, and a good discussion of wider scope than the usual introduction to magnetohydrodynamics would have been welcome. Whether a really general approach provides good course material for students is perhaps questionable. A more elementary treatment is adequate for the description of non-relativistic MHD, and attainment of a proper understanding of such a treatment is sufficiently taxing for most students. However, the general approach has value for research and reference purposes, and it is unfortunate that the execution of the plan has not been satisfactory. There are too many statements which are either wrong or misleading because they are not properly qualified. An example from one of the earlier chapters is: 'In metallic conductors ρ_e is zero...' (ρ_e is the volume charge density in the rest frame). Derivations can be inadequate and the reader has to be satisfied with quotations from other sources. An example of this is the writing down of the body force after reference to *Electrodynamics of Continuous Media* (by Landau and Lifschitz) in spite of the fact that the derivation involves only energy expressions which are required later.

The chapter on discontinuities and shock waves is representative of the way in which the book fails in general. The authors begin by distinguishing between discontinuities where there is no flux of fluid and shock waves where there is. A sentence which stands out is 'Such contact surfaces occur, for example, at the trailing edge a supersonic airfoil'. (Contact surfaces have been defined as discontinuities in temperature and density, but not velocity.) MHD shock waves with zero normal component of magnetic field are discussed first (the so-called normal shocks). Conservation relations are derived by integration of the equations of motion, energy, etc., through the shock layer. Thus an important point is missed at the start, although it is clarified later, namely, that the conservation relations are independent of the nature of the dissipative processes. In carrying out the integration, it is shown correctly that $\mathbf{v} \times \mathbf{B}$ has the same value on either side of the shock wave. This is then taken as sufficient justification for integrating the energy equation as if $\mathbf{v} \times \mathbf{B}$ were constant throughout the layer.

Thus, we can only arrive at the usual relations for the conservation of energy by taking $\int j^2/\sigma dx$ as negligible through the layer provided σ is large enough—whatever that means. A little more thought would have shown that the integral has a fixed value in terms of properties on one side of the wave when the resistivity and other dissipative coefficients are reduced proportionately. Nowhere is it shown that normal shocks must be compressive, and it is only by implication from a phrase in parentheses that we learn of the impossibility of rarefaction shocks. The section on normal shocks ends with a warning about the return path for currents. That is a good point, but it could be emphasized that the position of the return is important and also that there may be a problem of magnetic-flux return. And so to oblique shocks and the representation of shock states with the Rayleigh line on a (T, S)-diagram, but the point of using the latter diagram is entirely missed. Enough has been said.

M. D. Cowley

The Phenomena of Fluid Motions. By Robert S. Brodkey. Addison Wesley, 1967. 737 pp. $22.50.

There is no dearth of text-books on fluid mechanics. The reviewer of any new one is therefore inclined to look for something original. This one has an original and arresting title, though it contains basically familiar material presented in a familiar way. It is longer and more comprehensive than most and is aimed at graduate chemical engineers, so includes a lot of discussion of complex flows. A great number of references are given; using four test topics, it appeared to be up to date on all of them.

The book is split into three parts. The first, short part leads up to the Navier–Stokes equation after a chapter (yet another) on vector and tensor notation. The second, 170 pages long, presents what it calls the applications of the basic flow equations, and covers the material that usually appears in courses on fluid mechanics: ideal flow, laminar viscous flow at low and high Reynolds number and compressible flow. The third and longest part gets into the thick of real phenomena as they affect the chemical engineer—extensions of the basic flow equations, the author calls them: turbulence and mixing, non-Newtonian and multiphase phenomena.

The author has on the whole chosen his material well. He has taken care to master it himself and has evidently been at great paints to present it as objectively as possible to his readers. Most of us would be delighted to display one-half even of his knowledge. He writes well. But yet I found the going a little flat: the fact that so many approaches are given equality of treatment means that none is developed very fully, and the unenlightened reader may be in some doubt as to which of them should be investigated more fully. I suspect that the author has chosen his self-effacing role deliberately; here and there he sets his references aside and writes fluently and pithily in general terms. I liked, for instance, the introduction to turbulence on p. 227:

The Navier–Stokes equation of motion should be valid for turbulent flow, since the size of the smallest eddy is generally much greater than the mean free path of the molecules in the system. The turbulent motion can be considered macroscopic rather than molecular. The difficulty in applying the equations directly to the turbulence problem lies in the fact that the variables in the equations refer to instantaneous values at the point under consideration. These values vary to such a degree that little information can be gained by direct application of the basic theory, and thus some form of modification or extension is necessary. Reynolds modified the Navier–Stokes equation so that the variables would be time averages. When this is done, however, additional terms are introduced to account for the fluctuations in the flow. Two main areas have been studied: The first is the study of the equations as they were before modification. The purpose of this study is to gain some insight into the stability of laminar flow and to estimate the critical Reynolds number. The second area is concerned with an understanding of, and the obtaining of expressions for, the additional terms introduced in Reynolds' modification of the basic equations. This involves two main subdivisions: phenomenological theories and statistical turbulence. Mixing is an application of the latter.

The intention of the book seems to be to lead the reader towards a series of analytical, semi-empirical or purely numerical results, carefully derived, carefully explained and carefully delineated in terms of applicability. They are chosen to cover situations likely to be important to practising engineers. This is a worthy aim; the author has succeeded as well as I would have dared to expect, and his book may join the better known classics of the subject on most reading lists. Its merits (for the engineer) make it less attactive to the applied mathematician though the range of information contained could make it very useful. The physicist will sense perhaps a lack of personal involvement with the fluids or the phenomena described. I suppose we are a long way from the days of the last century when papers could begin: 'Whilst watching the wind blowing over the surface of the pool outside my window...' Have we lost something in the process—communicable enthusiasm, perhaps?

J. R. A. Pearson

Turbo-Machines, Hydrauliques et Thermiques. Tome 2. By M. Sédille. Masson et Cie, 1967. 571 pp. 99 F.

This is the second volume of Professor Sédille's book, the first of which has been reviewed in the *Journal* (vol. 32, p. 825). Despite the word 'thermal' in their title both volumes are concerned predominantly with hydraulic and incompressible flow machines.

This volume describes mainly the design of pumps (radial, axial and mixed flow) but contains two chapters on water turbines. It is an admirable comprehensive survey for students of idealized design theory collected from many sources and presented logically and scientifically. However, there is not much new information which would be of direct use to designers. For instance, practically important problems such as impeller–volute interaction are ignored and, although impeller design for finite blade number is described, much reliance is placed on existing cascade literature by Howell and Horlock for axial-flow machines. It is also surprising that there is no mention of actuator disk theory. Nevertheless, it is an extensive collection of published data. Here and there the approach differs from English language text-books and it is refreshing to find the Euler equation derived also for the flow relative to a rotating impeller. Special problems such as scale effects, cavitation and related thermodynamic effects, pumping slurries and suspensions are also described. Useful chapters are those on the influence of installation upon pump performance, including series–parallel operation of pumps, and on special applications of pumps and mechanical design problems.

As one might expect from the fact that the author has not been so intimately concerned with them, water turbines are covered more briefly. Nevertheless, there is a good introduction to water turbines, storage pumps and reversible pump-turbines and finally a chapter on water hammer and hydraulic transients using the Bergeron method.

The book is lucid, comprehensive, clearly set out and illustrated, and suitable for engineers interested in a review of the state of the art and for engineering students specializing rather more in hydraulic machinery than is usually the case in Britain.

S. P. Hutton