REVIEWS

An Introduction to Magneto-fluid Mechanics. By V. C. A. FERRARO and C. PLUMPTON. Oxford University Press, 1961. 181 pp. 25*s*.

Five years ago, magneto-fluid mechanics was in its infancy; the few books that had appeared by that time were in the nature of research monographs, and, while not attempting to cover systematically every aspect of the subject, they did convey a sense of the excitement associated with the opening up of a new subject. Well-known among such books were the two Interscience tracts, *Magnetohydrodynamics* by T. G. Cowling and *Physics of Fully Ionised Gases* by L. Spitzer, Jr. Since then there has been a phenomenal increase in interest in the subject, a considerable body of knowledge has emerged, and the basic principles of the subject have been consolidated. The time is ripe for a sound introductory account of the subject that will concentrate on the basic principles and touch on the applications, astrophysical, geophysical, thermonuclear or otherwise, only by way of illustration. It is this type of account that Professor Ferraro and Dr Plumpton have set out to give; and they have set themselves the unenviable task of covering the fundamentals of both plasma physics and magnetohydrodynamics in a book of less than two hundred pages.

It is perhaps no surprise that the result is not as exciting as one might have hoped. A very large proportion of the book covers topics treated in the tracts of Cowling and Spitzer and little additional insight is conveyed in this presentation. It is perhaps unfair to judge a book by the standards set in previous works; and it is true that a student who approaches the subject for the first time through this book will meet a few topics that may not have appeared in book form before, for example hydromagnetic shocks, Alfvén waves in a stratified medium, and waves in a collision-free plasma. But he will also meet, and may be misled by, defects which were not apparent in the earlier treatments.

The chief of these defects is perhaps the awkward use that is made of dimensional analysis in simplifying the governing equations when the fluid properties and the length and velocity scales of a phenomenon under consideration are known. For example, equation (1.14) includes two terms $\sigma q/\epsilon$ and $q\,\mathrm{div}\mathbf{v}$; the second of these is small compared with the first if $L\sigma/v\epsilon \gg 1$, where L and v are length and velocity scales; but in order to 'prove' this, the first term is assumed comparable with a third term of the equation, $\mathrm{div}[\sigma\mu(\mathbf{v} \wedge \mathbf{H})]$, in order to estimate q, whereupon $q\,\mathrm{div}v$ is estimated and at last found negligible. Further on, it is stated without qualification that 'the order of magnitude of the ratio of magnetic and inertia forces is given by the number $S = \mu H^2/\rho v^2$'. This is true only when the magnetic Reynolds number is large compared with unity. The use that is made of dimensional analysis in §5.4 to estimate the hydromagnetic shock thickness is unconvincing, and the most significant dimensionless parameter in this context, η/ν (where η is the magnetic diffusivity of the fluid and ν its kinematic viscosity) is not mentioned.

The first five chapters deal with what should correctly be described as magneto-fluid mechanics, and the last three with plasma physics. Chapter 1 is concerned with basic principles—the equations of magnetohydrodynamics (as so often, presented without comment as sixteen scalar equations for fifteen unknown quantities), Alfvén's theorem (on the 'freezing' of lines of force in fluids of infinite conductivity), and the magnetic stress interpretation. A section is devoted to the law of isorotation (which follows immediately from Alfvén's theorem). The law still holds in fact in fluids of finite conductivity, although by Cowling's theorem, batteries are then necessary to maintain the steady axisymmetric situation. Mention of Cowling's theorem is relegated to the bibliography (a useful appendix which summarizes the content of some important papers). Chapter 2 on magnetohydrostatics is clear and simple, but the attempt to describe the stability theory of Berkowitz, Grad and Rubin is unsatisfactorily simplified; a simple statement of their result together with a reference to the original paper would have been preferable. (Detailed references are not given in general.) Chapter 3 is devoted to Alfvén waves, clearly and adequately described. Chapter 4 is essentially an attempt to summarize Batchelor's theory of the turbulent dynamo; the crucial (and rarely satisfied) condition for growth of the magnetic energy density, $\eta/\nu < 1$, is overlooked, but the speculation that this density may increase to the level of the kinetic energy density of the small-scale motion is recorded. Incidentally the statement in the historical introduction that this speculation 'was confirmed by Chandrasekhar by detailed analysis (1950–51)' is incorrect. Indeed Chandrasekhar, in his most recent work on the subject (*Proc. Roy. Soc.* A, **233**, 1955, 330) favours equipartition of energy at all length scales. In chapter 5, the effect of a transverse magnetic field on a plane shock wave is analysed.

The approach in the second part of the book is more original and the result more successful. It contains the essence of a lecture course given by Professor Ferraro at the Varenna School of Physics in 1958, and covers the motion of a charged particle in a magnetic field (chapter 6), the kinetic theory of a highly ionized gas (chapter 7) and waves in a plasma (chapter 8). The methods of chapter 7, based on binary encounters, are debatable, but it is interesting to see how the transport coefficients can be thereby simply derived. The equations of motion and Ohm's law in a plasma are derived from Boltzmann's equation, and some interesting plasma vorticity theorems are included. In the last chapter the three types of plasma waves considered by Spitzer are again described and the concluding section considers the possibility of waves in a collision-free plasma.

The book might have been more successful had the authors concentrated entirely on the second part and given a more fully developed account of plasma dynamics. But in attempting to cover magnetohydrodynamics as well they give an impression of superficiality and the overall result is disappointing.

H. K. Moffatt

Magneto-fluid-dynamics: Current Papers and Abstracts (AGARD Bibliography I). Edited by L. G. NAPOLITANO and G. CONTURSI. Pergamon Press, 1962. 251 pp. 70*s*. or $10.00.

This book is primarily a list of the authors, titles and publication references for 2038 papers on magnetohydrodynamics and plasma physics and related subjects. The list is in alphabetical order of authors and appears (no statements are made) to cover a period of about 25 years up to the middle of 1960. The entries seem always to give the year of publication, usually although not always the volume number of the journal concerned, often the part number, and occasionally the number of figures and tables in the paper.

Following this list is a collection of abstracts, of variable length, language and quality, of some (about one-third in total) of the papers in the list. The abstracts are mostly taken from the paper itself or culled from one of the reviewing or abstracting journals. At the head of each abstract is the name of the author and the title of the paper, although not its date or origin, and also a pair of numbers. The reader is able to find by trial that one of these numbers is the serial number of the same paper as entered in the bibliographical list, the other being a new serial number for the paper in the sequence of abstracts.

At the end of the volume are three lists. The first, a short one, is of numbers entitled 'List of the entries included in bibliography no. 1'; bibliography no. 1 is apparently what *this* bibliography used to be when it was issued informally by AGARD in February 1960. The second is an index to authors, which presumably serves to identify the number of a paper written by a known author who is one of several joint authors and not the first named, the latter alone being used in the bibliographical list. The last is a subject-index, in which there are seven main divisions, like 'magnetohydrodynamics' and 'magneto-gas-dynamics', with a few sub-divisions for each. The value of the subject index will be limited by the fact that the subheading 'General' swallows up about half the entries in four of the main divisions.

It is obviously useful to prepare and disseminate an up-to-date and ordered list of papers on this important subject, and the initiative and work contributed by AGARD have been widely appreciated. But why print a second time, publish, and sell at a substantial price, a bibliography which pays little attention to the ordinary principles of fact-gathering and indexing? As well as being rather wasteful, the book does not maintain accepted standards in scientific publications.

G. K. BATCHELOR