REVIEWS

The Theory of Electromagnetic Flow-Measurement. By J. A. SHERCLIFF. Cambridge University Press, 1962. 146 pp. 27*s*. 6*d*.

The principle of Faraday's classic attempt to measure the voltage induced in the River Thames by its movement through the earth's magnetic field has since been used by many others. Oceanographers and hydraulic engineers have used it to measure local fluid velocities, and research workers and nuclear engineers have measured the rates at which fluids (varying from blood to sodium) flow through pipes. In many instances the magnetic field does not affect the fluid motion, but in other instances, notably when measuring the flow of liquid metals or ionized gases, the flow and magnetic field interact and the motion is governed by the magnetohydrodynamic equations.

This is the only book devoted entirely to the subject and is the work of an expert. Dr Shercliff has made a close study of the electrodynamics and magnetohydrodynamics of magnetic flow-meters and most of the theoretical information available to flow-meter designers is due to his work. Much of the book is concerned with the voltages induced at the electrodes of pipe-type flow-meters when the effects of pipe geometry, of pipe and liquid electrical conductivity, and of contact resistances are accounted for. The author mentions, but does not deal with, ionic effects in electrolytes nor does he concern himself with instrumentation problems. Although the scope of this book is thereby reduced, its authoritativeness is greatly increased.

Instead of writing down the magnetohydrodynamic equations on the first page Dr Shercliff engages the reader with the simplest model, but one which at the same time displays the most important phenomena. He states clearly the principal engineering requirements, namely to obtain a configuration in which the flow-meter sensitivity is predictable or, failing that, is unaffected by constructional tolerances. He then investigates systematically the effects of different geometries, boundary conditions, and entry and exit conditions. In doing so he gradually develops an increasingly sophisticated treatment. This way of approaching the subject naturally involves a certain amount of repetition, but has the great advantage that the non-specialist can easily learn a great deal from the book. Chapter 3 introduces the various magnetohydrodynamic effects which occur in liquid metal flow-meters. This chapter in particular will appeal to the fluid dynamicist, especially the section on the entry effects which arise when a conducting fluid enters a transverse magnetic field. A first-order approximation to the disturbance of the velocity profile is found by neglecting viscosity in the immediate entry regions and taking an eigenvalue expansion of a perturbation stream function satisfying the momentum equation.

In the final chapters several ingenious devices are discussed and magnetic flow metering is related to other flow metering techniques. The book concludes with an invaluable 15-page classified bibliography. A book on this subject could easily have become an ill-digested assortment of facts and equations. The author is to be congratulated on welding his material into a sound coherent monograph, one which can be recommended to instrumentation engineers and to fluid dynamicists.

W. MURGATROYD

Theory of Ion Flow Dynamics. By DEMETRIOS G. SAMARAS. London: Prentice-Hall International, 1962. 636 pp. 75*s*.

Dr Samaras has produced a text of very wide scope. The first two chapters contain summaries of basic physics material on electromagnetic fields, charged particle motion, gas ionization and recombination, gas and plasma kinetics, and radiation. The next chapter treates the dynamics and thermodynamics of gases and plasmas, with inclusion of relativistic effects. Then a chapter is included on transport properties of gases and plasmas. Dimensional analysis and similarity are discussed. Steady and unsteady gas and plasma flows are described for various geometries and applied conditions. The next chapter is on waves, boundary layers, and turbulence, and the final chapter is on plasma oscillations and waves.

Theory of Ion Flow Dynamics is a misleading title for a book on plasma physics, but this would be forgiven if the book could stand as a student text, as a handbook, or as a viewpoint of a master plasma physicist. In fact, the book stands as none of these.

The student will find the book has too much scope without enough depth. For example, in the treatment of unipolar flow (space-charge flow) in electric fields, only the most elementary material is presented. No reference is made to the work of Meltzer and Rosenblatt, so the student is left without the concept of action function and its importance in curvilinear motion. As another example of lack of depth, Buneman's work on the decay of plasma oscillations is ignored. In addition to omissions, some of the basic physics in the book are misleading. For example, the section on thermionic emission is purely phenomenological; the student is left without a fundamental description of the process. While it is true that good texts on solid-state physics do exist, none are referenced at this point. Another misleading section is that on transport properties. The ancient expressions due to Maxwell are used for viscosity and slip flow, with no mention of modern expressions due to Chapman–Enskog and Present, respectively. As still another example, it is not stated, in the section on combined thermal and electrical conduction, that the expression for the coefficient of thermal conduction, equation (5.4.59), obtains only for zero current density. Not only is this failing of the book injurious to the student, but in addition places the practising scientist in a doubting frame of mind.

While the fundamental equations are listed as in many other books, the final equations developed by the author leave much to be desired. In fact, this reviewer and his associates find the book to be of little use in applied problems.

Finally, the book also fails as a viewpoint of a master plasma physicist. The reader may liken the book to an assemblage of notes from many lectures and a few personally solved problems (really only partially solved) laced together with excerpts from standard texts. Any feeling or philosophy the author may have is lost in the over-ambitious scope of this book. The welter of equations should have been replaced by succinct expressions with a surrounding text to carry the point at hand.

This reviewer intends to keep on with Spitzer, etc., until a better book comes along. The reader is advised to look carefully at the book before deciding to use it as a companion reference to his other books.

W. R. MICKELSEN

Introduction to Plasma Physics. By W. B. THOMPSON. Pergamon Press, 1962. 256 pp. £3. 10*s*.

For a time, magnetohydrodynamics was out of fashion in the thermonuclear fusion camp. It was felt that it provided too crude a model for the complex behaviour of a hot laboratory plasma, and that nothing but Boltzmann's equation could provide a valid description. The greater generality of the Boltzmann approach is inevitably associated with a very much greater complexity that hinders, if not halts, significant progress. For this reason the pendulum has recently been swinging back to the continuum approach, and strenuous efforts have been made to define circumstances under which the continuum description of a plasma may be valid.

This trend is reflected in this much-needed book, the core of which (chapters 4–6) is mainly devoted to the ideal magnetohydrodynamics of an inviscid perfectly conducting fluid. These (and the other) chapters are written with an originality of approach and a vigour that will be recognized as characteristic of Dr Thompson by all who have heard his lectures. The central chapters on magnetohydrodynamics are preceded by three introductory chapters that lead the reader gently through the simplest properties of a cold plasma, and they are followed by two marathon chapters that drive the reader mercilessly through the increasingly complicated properties of a hot plasma. The last chapter occupies more than a quarter of the whole book, and seems to afford the most comprehensive account of plasma kinetic theory yet given in book form; it will be of undoubted value to seasoned workers in this field.

Two attractive features are immediately apparent on reading the early chapters. First, the diagrams and sketches of plasma processes have a three-dimensional vividness that makes them attractive and easily understood. And secondly, theory makes persistant contact with reality—no sooner, for example, is the plasma frequency or the Debye length defined than it is immediately evaluated for plasmas of widely varying properties, both astrophysical and terrestrial. Not much space is devoted to experimental plasma physics, and only those crucial experiments that have demonstrated the nature of basic plasma phenomena are briefly described.

As the book progresses, and as the difficulty of the subject-matter increases, another feature makes itself felt, and that is that the style is at times terse to the point of obscurity. This is of course a matter of taste; it is extremely difficult to steer the course between the Scylla of tedious explanation and the Charybdis of leaving too much to the reader; but here, a little more Scylla and a little less Charybdis might have been welcome. This terseness is associated with a tendency to assume knowledge in the reader that may not be justified. For example

Maxwell's equations are not formally written down until chapter 4, although the transmission equation for transverse waves, which can only be deduced from Maxwell's equations, is used earlier in chapter 2. And again, equations governing steady one-dimensional compressible flow are stated without justification in § 5.4.

The chapters on magnetohydrodynamics are mainly oriented towards the plasma containment problem: various magnetohydrostatic equilibria and thermonuclear devices are described in chapter 4 and the stability problem is considered in some detail in chapter 6. Attention here is focused on ideal fluids, and a minimum energy principle is developed. The power of this principle is reflected in the demonstrations of the instability of a plasma supported against gravity by a magnetic field and of the stability of the 'hardcore' cylindrical confinement scheme. Further topics treated in this chapter include such esoteric matters as Suydam's necessary condition, and Newcomb's necessary and sufficient condition for stability. There is also a treatment by normal modes of the problem of thermal convection in a magnetic field.

Other chapters are equally ambitious. Chapter 5 covers Hartmann flow, plasma propulsion, magnetosonic waves, and shock waves, both normal and oblique. Alfvén waves are dismissed rather briefly; the fact that these waves are represented by solutions of the full *non-linear* equations surely deserves some discussion. Chapter 7 is mainly concerned with the motion of individual particles in an electric and a magnetic field, with adiabatic invariants, and with the plasma equations derived by summing over a large number of particles. In particular the Chew–Goldberger–Low equation of state, applicable when the field gradients are small, is derived. The author's absorption in thermonuclear work is again underlined, in his description of the role of adiabatic invariants in the mirror containment of a plasma, although he then makes a slight concession to astrophysics with a qualitative account of the Fermi mechanisms for the acceleration of cosmic ray particles.

In the eighth and last chapter the kinetic theory of a plasma is formally developed by Boltzmann's equation. The dielectric properties of a hot plasma in the absence of a magnetic field are discussed by means of the collisionless Boltzmann (or Vlasov) equation, and the phenomenon of Landau damping is thoroughly treated. The effect of collisions is then considered and the Fokker–Planck equation is derived. Electrostatic instabilities (in particular the two stream instability), and self-consistent solutions of the Vlasov equation (in particular the Bennett pinch) are treated. Expansion procedures for determining transport coefficients are described, and the detailed procedure based on large gyro-frequencies is developed. The subject-matter of this chapter is concentrated and difficult; it is self-contained and could easily be expanded to fill a complete book. The volume as a whole is impressive in its range, and its author is to be thanked for making this treatment of a wide variety of advanced topics accessible in book form to students and researchers in plasma physics and magnetohydrodynamics.

H. K. MOFFATT

Proceedings of the 10th International Congress of Applied Mechanics. Edited by F. Rolla and W. T. Koiter. Amsterdam: Elsevier Publishing Company, 1962. 370 pp. Dfl. 50 or £5.

The 10th of the series of International Congresses of Applied Mechanics—*the* Congresses for workers in the mechanics of fluids and solids—was held in 1960 at Stresa, on Lake Maggiore, Italy. Accounts of this gathering of 740 scientists have already been published, and need not be repeated. This volume of proceedings has now appeared, somewhat belatedly, but welcome nevertheless as a permanent, definitive and concise record of the work reported at the Congress.

The volume contains three groups of material: first, the names of participants, the texts of opening and closing addresses, and a brief report on the Congress by the Secretary of the International Committee; second, the full texts of the four general lectures, namely,

Méthodes analytiques de la théorie des oscillations non-linéaries, by N. Bogolioubov and I. Mitropolsky;

Some heat transfer problems near stagnation region of blunt bodies at hypersonic speed, by A. Ferri;

Non-linear effects in hydrodynamic stability, by J. T. Stuart;

Non-linear deformations of solid bodies, by G. Colonetti;

and third, the abstracts of the 188 contributed papers, arranged according to the session in which they were read.

The 11th Congress will be held at Munich in 1964.