J. Fluid Mech. (1985), *vol.* 156, *pp.* 532–535
Printed in Great Britain

REVIEWS

The Earth's Magnetic Field: Its History, Origin and Planetary Perspective. By R. T. Merrill and M. W. McElhinny. Academic, 1983. 401 pp. £39.50 hb, £17.50 pb.

The authors of this book have set themselves a difficult task – that of bringing together palaeomagnetists on the one hand and on the other theoreticians working on problems of the origin of the Earth's magnetic field and its secular variation. There are few people better qualified to undertake such a daunting task. Palaeomagnetists are generally experimentalists, collecting data in the field and analysing it in the laboratory: their knowledge of higher mathematics and physics is often not very deep. Theoreticians, on the other hand, tend to concentrate on highly mathematical studies of magnetohydrodynamic problems including dynamo theories, not only for the Earth, but for the Sun and other planets. They often have little knowledge of the properties of the magnetic minerals that can contribute significantly to the remanence in rocks and of the problems that may be encountered in the field. There have been a number of special sessions in the past arranged at various conferences with the same object in view and they have generally been disappointing – each side tending to address his remarks only to his side or, on occasion, descending to too low a level of scientific discussion to be really worth while. However, these authors have on the whole succeeded in their aim and are to be congratulated.

The first chapter gives a brief historical account of geomagnetism and palaeomagnetism and sets the stage for the later chapters. The second chapter gives the conventional account of the description and analysis of the present geomagnetic field based on historical observations. Some palaeomagnetists may find the mathematical treatment still a little beyond them – but there is no alternative. At least it is hoped that they will appreciate that a spherical harmonic analysis is but a convenient mathematical description of the field and not proof that such a representation physically exists. The section on uniqueness and other mathematical problems is very welcome. The third chapter attempts to compress the fundamentals of palaeomagnetism into 35 pages. It is perforce brief but covers most of the ground and the interested physicist can probe deeper.

The next three chapters present the results of palaeomagnetic and archaeomagnetic studies and are followed by three chapters on dynamo theory. This is the heart of the book and the time of reckoning for both sides. The first set of three chapters (4, 5 and 6) are devoted to three main topics: studies of the Earth's magnetic field back approximately 50000 years; reversals of the geomagnetic field; and studies of the field on a longer timescale – 50000 to hundreds of millions of years. These three chapters are not mere compilations of data – many particular points are discussed in detail (e.g. the geomagnetic power spectrum, marine magnetic anomalies, analysis of reversal sequences, palaeosecular variation) and mathematical treatment is not spared.

It is then the turn of the theoreticians to give an account of dynamo theory. Chapter 7 gives an introduction and physical insight into the problems of the origin of the Earth's magnetic field. Mathematics is kept down to a minimum, but there is still enough to give an excellent summary of the state of the art (and perhaps deter the timid!). Chapter 8 gives a good introduction to advanced dynamo theory, but would probably be beyond the average palaeomagnetist. Chapter 9 is devoted to two particular problems – the origin of the secular varation and reversals of the geomagnetic field. Chapter 10 is then an attempt to bring the two sides together and reconcile theory and experiment. Only individual readers of the book can decide whether the authors have been successful – this reviewer believes they have. The two final chapters deal with the magnetic fields of other heavenly bodies. Chapter 11 reviews the enormous literature in lunar magnetism, whilst chapter 12 discusses the magnetic fields of the Sun, planets, and meteorites. These last two chapters, necessarily brief, are nevertheless sufficient to whet the appetite of the interested reader to seek further. The book is well written, with good illustrations and a very comprehensive bibliography. It is a worthy addition to the International Geophysics Series published by Academic Press.

J. A. Jacobs

Hydraulic Pumps and Motors. By R. P. Lambeck. Dekker, 1983. 154 pp. SFr. 67.
Hydraulic Valves and Controls. By J. J. Pippenger. Dekker, 1984. 256 pp. SFr. 99.
Fluid Power for Industrial Use – Hydraulics. By O. A. Johnson. Krieger, 1983. 251 pp. $14.50.

The editor of the Dekker series of textbooks on Fluid Power and Control states that the objective is to provide an overview of fluid power products, their construction and their application, and to reflect the current state of the art. Such texts are directed in the first instance to component designers and systems or applications engineers. They are also valuable in the education and training of young engineers, since they illustrate good design practice and provide material for discussing the application of theoretical principles to the solution of practical problems. A basic limitation of this series is the lack of theoretical analysis, which means that there is little scope for discussion of the steady-state performance characteristics and little reference to dynamic effects.

The first book in the series, Hydraulic Pumps and Motors by R. P. Lambeck, is very well presented. After an interesting historical introduction, the author gives a comprehensive review of the types of hydraulic pumps, motors and controls currently used in industrial and mobile fluid power systems. The advantages and limitations of the different designs of gear, vane and piston units, fixed capacity and variable capacity, are considered and limited steady-state performance data are presented. The illustrations are good and the text is lucid, even to an non-specialist.

There is a useful chapter on pump controls and systems in which many alternative circuits are described with a discussion on the system efficiency for a range of load conditions. Another chapter of interest to the systems engineer is devoted to the various forms of hydrostatic transmission, with sections on operating efficiency, installation and control. The latest forms of split-power transmissions and microprocessor-controlled engine-transmission systems are only mentioned in the closing paragraph.

There is emphasis on American rather than European practice. In Europe the external gear pump has been developed rather more than the vane pump and is more popular in both industrial and mobile applications. Numerical values quoted are a useful guide to current practice and S.I. Units have been added in parenthesis.

The fourth book in the series, Hydraulic Valves and Controls, is written by J. J. Pippenger, who has worked for leading American manufacturers of fluid power components for over 40 years. The book shows the development of valve controls from simple two or three position devices to load-sensing controls designed to give economic operation and electro-hydraulic servo systems designed for high accuracy and good dynamic response. It contains a wealth of experience, invaluable both to the circuit designer and also to the potential user. The language is sometimes confusing and the mass of detail may sometimes be overwhelming to the non-specialist.

Following a cursory and rather unsatisfactory introduction, there is a lengthy chapter explaining the symbols used to represent fluid power components, symbols used in the circuits throughout the remainder of the book. The various types of pressure-control valves, direction-control valves and flow-control valves are then described with the aid of a large number of photographs, drawings and performance characteristics. The illustrations have been reduced to rather a small size but they are generally clear; all drawings are to U.S. standards and American units are used throughout. Applications are considered in detail in order to illustrate the use of particular valves and to bring out practical aspects of installation and operation. A fair knowledge of fluid power terminology and practice is required if one is to follow much of this work.

The chapter on servo control systems is quite different in style to the remainder of the book. Following a preliminary discussion on closed-loop, position-control systems, the author sets out the important parameters in the design of an electrohydraulic system. By applying basic linear control theory, he shows how these parameters may be determined. The numerical values which he quotes on the basis of his experience are a valuable guide to those with less expertise. The final chapter on load-sensing circuits, describes important recent developments aimed at improving power economy and control sensitivity in relatively simple systems.

The text by O. A. Johnson, is interesting for its historical and autobiographical content rather than for the technical material presented. The author commenced work for an American machine tool manufacturer in 1937 and the book reflects his range of interests in the application of hydraulics over a period of some 30 years.

Early chapters on theoretical aspects of the subject are unsatisfactory and should have been ruthlessly edited. The treatment is theoretically superficial, but the numerical work is laboured and the choice of non-standard units is unfortunate. In a book on fluid power it is quite inappropriate to devote twenty pages to the calculation of static pressures and forces on reservoir tank walls.

The pumps described by the author are generally outdated; the valves described are limited to those of the simplest design. However, Mr Johnson has shown considerable ingenuity in applying theoretical principles to the solution of some practical problems.

D. McCandlish

Elements of Hydrodynamic Propulsion. By J. A. Sparenberg. Nijhoff, 1984. 281 pp. Dfl. 140.00, $52.00, £35.00.

This is an unusual book, in several respects. It does not easily fit into any of the accepted categories of textbooks, monographs or engineering handbooks and could probably be best defined as a progress report, by a leading authority on mathematically oriented hydrodynamics. As such, it sums up the contributions of Professor Sparenberg and his group, over a period of 25 years.

The book starts off with an unconventional approach to inviscid flow fields by defining force fields which drive the motion. This technique is well established for creeping ($Re \ll 1$) flows and is reminiscent of the irreversible thermodynamics approach, which deals with all transport phenomena as products of forces, and the fluxes they cause. This is an interesting and useful way of looking at the problem of producing forces and motions in an inviscid medium and one implicit advantage is the possibility of including dissipative effects in the future.

The first chapter of the book sets the scene for the applications described later on. It is a mix of basic theorems and points dealing with the force-field method and quotations from standard textbooks on vorticity production and propagation, thus blending portions including rigorous proofs and sections which are descriptive and intuitive. This causes some disjointedness and logical leaps, which to my mind would preclude using *Elements of Hydrodynamical Propulsion* as a textbook except in some advanced graduate courses. For example, the sections on 'Singular force perpendicular to its velocity', and 'Singular force in the direction of its velocity' (1.6 and 1.7 respectively) do not mention the physical significance of these models and the differences between them. In all fairness it must be said that the author does not claim this to be a textbook (although the publisher does – on the rear cover).

The next part, comprising chapters 2 through 4, treats actuator disk theory, with applications, mainly to marine propulsion. A useful distinction is made between pseudo-steady (screws) and essentially unsteady propulsors such as oscillating plates. The latter are defined as 'when the fluid flow relative to its lifting surfaces is time dependent and this time dependency is essential to its functioning' (p. 114). While this definition is, to quote the author, 'vague to some degree', it does point out a genuine difference which has not been stressed enough in the past. The treatment here is rather rigorous from a mathematical point of view, but presented clearly enough so that this part can serve as a basis for course work. This reviewer would have preferred seeing some more emphasis on multiple blade propeller theory. Chapter 4, which deals with what Professor Sparenberg defines as unsteady propulsion, is a very useful review of the theory of oscillating thin profiles as propulsors. It is rather a pity that detailed results are given mainly from the author's own work, while other studies are only mentioned briefly, in the style of a journal paper.

The most interesting part of the book, in this reviewer's opinion, is the third and last part, including chapters 5 through 7. This deals with optimization theory and its application to lifting surfaces, in the context of inviscid hydrodynamic forces. Examples include the Voith–Schneider propeller, sails and oscillating foils, single and multiple. Not less significant are the results in chapter 7 which define wide classes of realistic problems for which no optimum solutions can be obtained. There are some minor inconsistencies, such as on p. 147 where one of the problems suggested is the minimization of energy left behind when both lift and thrust are prescribed. On p. 148 it is stated that efficiency, defined as above, does not apply to lift. Nevertheless, the methods described here will prove useful to the understanding of the limits achievable in hydrodynamic propulsion and as such should be familiar to researchers in the field.

This book is a useful addition to a sparsely covered field and should be of interest to theoretical hydrodynamicists at postgraduate level.

D. Weihs