notably those by Néel and Stacey, dealing with the processes of acquisition of thermoremanent magnetization.

This text *Physical Principles of Rock Magnetism* is a much-needed attempt to fill the gap. The essential background and theory of the subject are competently presented but unfortunately in a way that conveys to the reader little of the flavour. A large part of this book is based on Stacey's 1963 review and his other publications. Fortunately for the authors, these are virtually unobtainable now because the extent to which they have been expanded and updated hardly warrants the expenditure of £10.

Only two chapters deal with the properties of magnetic minerals and in my opinion this is not enough to bring to the attention of the reader some of the most exciting developments which have occurred in recent years. While mention is made, for example, of cation distribution, impurities and oxidation of titanomagnetites, the data and theory are not developed sufficiently to discuss some of the interesting current problems being actively investigated. Had this been attempted, the book would inevitably have been larger, but not unduly so, for with 195 pages it can hardly be considered a large volume. At this size it is not possible to cover all important aspects of what has grown into a wide-ranging subject involving methods and techniques outside the field of magnetism itself.

How well does the book represent the current state of thought, interest and achievement in the subject? Both authors have been actively working in rock magnetism for many years and have made important contributions. These are covered well by the text but at the expense of achieving a well-balanced presentation overall. I would not advise a research student starting work in the subject to use this text as his only work of reference for I doubt whether it would lead him to the currently most fruitful areas of research. On the other hand, the text provides a good grounding in the areas covered especially if supplemented by a good text on basic magnetism. The authors have opted to use the e.m.u. system throughout, a decision which I commend. Although the use of S.I. units has been recommended by IAGA (International Association of Geomagnetism and Aeronomy) most research workers in rock magnetism have shown reluctance to adopt this system because of the difficulty of accepting that intensity of magnetization should have the dimensions of H (as recommended) rather than B (as, for example, proposed by Collinson, Creer and Runcorn in *Methods of Palaeomagnetism*, Vol. 3 of the series of which the book under review is Vol. 5). Stacey and Banerjee discuss their reasons for preferring the use of e.m.u. in their preface and their decision will, I trust, encourage the continued use of e.m.u. in research papers in rock magnetism.

In spite of its shortcomings, I am sure that Stacey and Banerjee's text will be accepted as the standard text in the immediate future, certainly until something better comes along.

K. M. Creer

Physics

System identification: methods and applications

By Harriet H. Kagiwada. *pp. 292. New York: Addison-Wesley/W.A. Benjamin Inc. US $16.00 (cloth), US $8.50 (paper).*

Away from the frontiers of science there are many areas of nature that have been successfully mathematized, that is, put into correspondence with standard equations. Further progress on these subjects then consists largely in studying the detailed structure of the solutions of the equations, and the relation of these solutions to initial conditions. A glance at the literature of mathematical physics or applied mathematics shows that the overwhelming majority of papers deals with what we can call 'direct' problems: a system is specified, together with some initial or boundary conditions, and questions are asked about the further development of the system, or the structure of certain fields. For example: A space craft is launched into a given gravitational field with a given velocity; what will be its trajectory? Or, a plane wave strikes a given array of diffracting objects; what will be the scattered wave at infinity?

In recent years, however, it has been realized that in practice there often arises a fundamentally different type of problem, where the mathematics must be put into reverse gear, to enable the nature of the system to be inferred from its history, or from measurements of certain fields. For example: by analysing radio echoes from a glacier bed, deduce its topography. Or, from irregularities in the path of a comet, deduce the position and mass of an invisible perturbing object. Or, from the arrival times of earthquake waves at seismic stations, deduce the distribution of elasticity inside the Earth. These are 'inverse' problems, often called problems of 'system identification', and the reason why they differ fundamentally from direct problems is in the matter of *uniqueness*: even when the direct problem is well posed, and has a unique solution, there may well be several different systems generating the same solutions; that is, uniqueness is often irreversible.

There are two approaches to inverse problems. The first is *analytical*: the exact inversion of a simple problem is sought, and this is used as a basis for the approximate inversion of complicated problems with similar structure. Most analytical inversions (certainly in wave and ray theory) are based on Abel's integral equation or Fourier's theorem. The second approach, of which the book under review is an extreme example, is *computational*.

The author takes the view that inverse problems are essentially numerical. From a given set of numbers representing the observations, another set of numbers can be computed, representing the system. A fairly systematic procedure is used in which the equations governing the phenomenon are assumed known, and are considered as determining the system numbers when the observation numbers are put in as 'initial conditions'. An initial guess for the structure of the system is used as a basis for iteration. The equations are usually nonlinear, and they are 'quasilinearized' by treating the differences between successive iterates as first-order small quantities. This process is often found to converge, but there is no method given for choosing the initial guess so as to ensure convergence, and no discussion of the uniqueness of the answer thus found.

To help derive equations suitable for inversion, it is often helpful to regard the dimensions of systems as variables rather than constants. Thus in discussing reflection of neutrons from a rod of length x, the rod of length $x-dx$ is also considered. This simple principle is given the rather inflated name of 'invariant embedding', although it is surely second-nature to physical scientists trained in the analytical methods that this book eschews.

There is superficially a reasonable case to be made for regarding analytical inversion techniques as obsolescent. As the author says of the equations for a neutron transport problem; 'The analytical solution is of no import, since we wish to consider . . . more complex processes for which a computational treatment is mandatory'. Or in connection with the inversion of orbit data: 'Since we are virtually forced by our modern computers to take a fresh look at old problems, we shall not be concerned with conic sections. A new methodology, based on high speed digital computers, is developed.'

Unfortunately the examples presented do not live up to this worthy philosophy. In almost all cases the problem is simplified at the outset by assuming *ad hoc* that the unknown system can be represented by a simple function characterized by a very small number of parameters. Thus the elaborate numerical techniques really amount simply to curve fitting. In these circumstances it is not obvious that analytical methods are slower. For example, in the case of reflection from a slab, the refractive index profile $n = a+b(x-1)^2$ is assumed; but the reflection coefficients for this case can be calculated *exactly*, in terms of the well-understood parabolic cylinder functions, and a and b determined without solving the reflection equations. (Further, the author's inversion scheme will converge very slowly, if at all, in cases where n has a zero, as in the ionosphere.) This is not to say that computational techniques—even curve fitting—are not useful. Of course they are, but they complement rather than supplant theoretical analysis of the equations.

Noisy measurements are a thorn in the flesh of all inversion problems, and the author rightly tests her numerical techniques with noisy input data. Sometimes noise has surprisingly little effect on the accuracy of the inversion; in other examples noise completely ruins it. These are presented here as unexplained phenomena, whereas a study of simple 'model' systems for which explicit analytic inversions are possible would at least give some idea of when an inversion will be stable under noise, and when not.

Even within its self-imposed limitations this book omits two important examples where inversion techniques have been particularly useful: the deduction of crystal structures from X-ray diffraction data, and the reconstruction of three-dimensional objects from their projections along different axes.

Anyone faced with a practical inversion problem should certainly study this book. The price is reasonable, the collections of references are useful, and the author's exposition is lucid. It should not be forgotten, however, that the methods presented here are severely limited in their applicability.

MICHAEL BERRY

Biology

Introduction to molecular embryology

By JEAN BRACHET. *pp. xii + 176. (Heidelberg Science Library Volume 19). London: The English Universities Press, 1974. £2.45.*

For over 10 years now, molecular biology has been acclaimed as one of the major growing-points in science, providing information about the synthesis of macromolecules and how these control events in living cells. Ten years ago, however, one could question whether a science of 'molecular embryology' existed. Biochemical work on eggs and embryos up to the 1960s had so far served mainly to fill in descriptive detail rather than to explain developmental mechanisms. Investigators were not yet able to see precisely how the materials and macromolecules that they found in embryonic cells functioned