amplitude, pulse duration and pulse position modulation, and finally there are two chapters on pulse code modulation systems. The treatment is clear, and simplifications and assumptions are stated with exceptional care. It is the chapters on pulse code modulation which form the most interesting single section of the book, for these furnish an outline of the principles of a system which must be expected to have a profound effect on the future development of long-distance communication. In addition to explaining the principles of multi-channel pulse code modulation, a description is given of a twelve-channel system which employs electron-beam coders and decoders. The final chapter of the book, Chapter 20, deals with the problem of 'distributed' channels, that is to say, systems in which a multiplicity of transmitters has access by a common transmitting medium to any of a similarly numerous group of receivers. The special problems associated with this type of transmission are illustrated by reference to a mobile system.

This book gives a comprehensive treatment of the whole problem of modulation in communication systems, and the treatment is based on the fundamental concepts of information theory. The standard of mathematics required is well within the scope of a university undergraduate course in physics or engineering. It is an especial merit of the work that the subject has been treated on a very general basis, and at the same time investigated in detail in its various branches, without recourse to mathematical methods of a standard beyond that of undergraduate courses. The very success of the treatment evokes the question as to whether it would not have been possible to give an outline of the derivation of Shannon's central formula in the theory of information. This volume is a worthy addition to the series of distinguished text-books which are associated with the Bell Laboratories.

JAMES GREIG

PLASTIC DEFORMATION OF CRYSTALS

Dislocations and Plastic Flow in Crystals

By Prof. A. H. Cottrell. (International Series of Monographs on Physics.) Pp. x+223+8 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1953.) 25s. net.

PROF. A. H. COTTRELL'S book is an admirable account of the theory of dislocations as applied to the plastic deformation of crystals, and is a valuable starting-point for students of this subject. It is written in an easy and attractive style, with the mathematical treatments outlined but not given in detail; and if there is occasionally a tendency to treat as fact things which have been assumed, or are suggested by somewhat imperfect experiments, this is generally done for the purpose of simple exposition, and the reader need not be misled.

The book begins with an account of the deformation of crystals by slip, and the way in which it is described in terms of the movement of edge and screw dislocations. It then deals with the theory of dislocations in a perfectly elastic isotropic and structureless medium, from which are derived the equations governing the stress field of a dislocation, its strain energy, and the forces between dislocations. The periodic structure of the crystal is next introduced,

leading to a discussion of the forms taken by dislocations in crystals, the forces necessary to move them, and the special forms of dislocation that may exist in face-centred cubic, body-centred cubic and hexagonal crystals. Growth spirals in crystals, the Frank-Read source, and the grain boundary, considered as an assemblage of dislocations, are dealt with in this chapter. This chapter and the preceding one are the most permanently valuable part of the book, and will frequently be referred to.

On proceeding to the explanation of the observed behaviour of actual crystals, the book tends inevitably to include a number of speculations, some of which may prove to be short-lived. The number and distribution of dislocations in unworked crystals are considered, with results that direct attention to the uncertainty of present knowledge of these basic facts. The piling of dislocations behind an obstacle, the grain boundary as an obstacle to moving dislocations, the action of dissolved atoms and precipitated particles, and the explanation of the sharp yield-point in some metals in terms of the influence of atmospheres of solute atoms around dislocations are described; but it becomes clear that the mathematical development of the theory has run far ahead of knowledge of the values of the terms appearing in the equations.

In the final chapter, which deals with work-hardening, annealing and creep, great stress is placed on the phenomenon of easy glide. This prepares the way for the author's view that work-hardening is primarily due to the mutual interference of dislocations moving in intersecting planes. This view is plausibly and effectively argued, without neglecting other views that have been expressed. The phenomena of recovery, polygonization and recrystallization prove to be too complex to be more than briefly described, and in selecting for discussion mainly those investigations in which quantitative treatments of the processes have been attempted, the author has produced a picture that appears rather strange to the practical metallurgist. The treatment of creep, on the other hand, is very acceptable, for while it presents a picture of the right general kind, it avoids the temptation to set up a master equation from which all things can be deduced, and keeps a proper balance between the deformation of the crystal and that of the grain boundary. Possibly too much importance is given to exhaustion theories of creep, and the reader is allowed to escape with the impression that, but for the presence of regions of exceptionally easy slip, materials would creep at a uniform rate, which is almost certainly not the case.

Dislocation theory moves so fast that, in spite of efforts to incorporate the results of new investigations up to the time of writing, some things are missing that would have to be included if the book were re-written to-day. Vacancies are mentioned; but little indication is given of the importance they have assumed, rightly or wrongly, in all recent discussions of processes in crystals, and no attention is given to the influence of vacancies formed during plastic deformation on the speed of diffusion processes, and their consequent influence on many of the phenomena discussed in the book. Nevertheless, all workers in solid-state physics will find Prof. Cottrell's work an invaluable guide, fair in its treatment of alternative points of view, stimulating and informative, but not to be regarded as final. Rather it will raise innumerable questions and suggest new investigations to improve the understanding of the strange behaviour of crystals.

N. P. ALLEN