

stock". It "is intended primarily for students of vocational agriculture and other youths on farms and ranches who are assuming new responsibilities in raising livestock". These purposes are well served. One author is skilled in animal husbandry, the other in education. Their joint authorship provides a model of a sensible, direct and logical exposition of principles and practices. The whole field is adequately covered, from the broad economic and business aspects, through judging, feeding, housing and handling livestock, the maintenance of health, breeding and the intelligent use of records, to marketing stock and products, and preparing and processing the products for use (including quick-freezing). The book is profusely and aptly illustrated; there is a useful index and, in addition, an annotated list of films and film-strips suitable as visual aids. Few errors have been noted, though that on p. 344, which implies that selected daughters should be used in computing a sire index, is regrettable, and the index given is for Sire A, not B; also, p. 288, it would be scarcely fair to accept for British conditions that pasture rotation offers the only control measure for liver fluke in sheep.

In their preface the authors express the hope that the book "should also be useful to adults . . . who are interested in securing better returns from livestock enterprises". For British readers this could well be extended to those who are concerned with the presentation of instruction in the many aspects of animal production, at all levels of the existing agricultural education system.

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PIEZO-ELECTRICITY

Piezoelectricity

An Introduction to the Theory and Applications of Electromechanical Phenomena in Crystals. By Prof. Walter Guyton Cady. (International Series in Pure and Applied Physics.) Pp. xxiii+806. (New York and London: McGraw-Hill Book Co., Inc., 1946.) 45s.

IN 1921 W. G. Cady proposed the use of quartz vibrators piezo-electrically excited at their resonance frequency for stabilizing radio installations, and thus originated the new industry of piezo-electric engineering which has employed thousands of workers on the manufacture of millions of stabilizers and oscillators. Cady had been interested in piezo-electricity before, and had studied in particular the piezo-electric properties of Rochelle salt, and ever since, he and his school at Wesleyan University have never ceased investigating the subject. This treatise, long awaited by his numerous colleagues and friends, embodies the experience not only of the author and of his school, but also of other workers in the field, and will earn him the gratitude of all interested in crystal physics.

The book starts with a relation of the discovery of pyro- and piezo-electricity and of the parts played by the brothers Curie, by Kelvin and by Voigt in the study of the phenomena and the development of theory. From the outset the enthusiasm of the author for his subject is evident, and may account in a large measure for the thoroughness and elegance of presentation. A concise yet adequate introduction to crystallography is followed by chapters on crystal physics, including elastic and dielectric properties, and a treatment of thermodynamic potentials, which

are used afterwards in the exposition of the theory of piezo-electricity. Valuable formulæ and tables for transformation to rotated axes are given, and indeed wealth of data and references are special features of the work. From a critical survey of all available experimental data, Cady has assigned "most probable values" to the elastic, dielectric, piezo-electric and other constants of quartz, tourmaline and Rochelle salt. This evaluation must indeed have been a laborious task; but it will prove of immense value to all workers in this field.

In the theory of piezo-electricity given by Voigt, piezo-electric strain is expressed in terms of applied electric field. Measurements show, however, that in the case of Rochelle salt the quotient of strain to field varies greatly with temperature, as also does the permittivity, whereas if the piezo-electric strain is expressed in terms of electric charge or electric displacement, the quotient is almost independent of temperature. Although Cady remarks that experimental results taken by themselves lead to the expression of piezo-electric strain in terms of displacement, "nevertheless, one should not confuse that which is most easily measurable with that which is most fundamental; and if the proportionality of stress with field has to be abandoned, it appears fundamentally more logical to assume proportionality with polarization than with a parameter that involves both P and E". Since, however, it is always charge rather than polarization which is observed, might it not be held that expression in terms of charge is preferable?

As was to be expected from the author, the chapter on the piezo-electric resonator bears the stamp of thoroughness. Cady has long been interested in the effect of air gap on response frequency, to which he devotes a considerable proportion of this and subsequent chapters, but certain discrepancies between measured and predicted effects of gap still appear to defy explanation. Various types of cut designed to yield vibrators of negligible thermal coefficient of frequency are described, and the account of the piezo-electric valve-maintained oscillator, with clear, concise physical explanations of stabilizer and oscillator action, is a welcome contribution to the subject.

The Seignette electrics, of which Rochelle salt is the best known member, stand in relation to quartz or tourmaline very much as iron to paramagnetic substances, and Valasek, Kurchatov, Fowler, Mueller and Cady have worked on interaction, polarization and other theories in an endeavour to explain observed phenomena. The part of the book devoted to this aspect is possibly the least easy to read, but the reason may lie in the inherent complexity of the subject. The same reason may account for the impression left that the explanations given are very imperfect, and that, as with ferro-magnetism, much experimental and theoretical work remains to be done.

There are numerous lists of references, the bibliography at the end has more than 650 entries, and the data interspersed throughout the text will be found most valuable; for this reason, and because of the excellence of the general treatment of piezo-electricity, the book will be in demand in every scientific library. The printers are to be congratulated for the presentation, while the paucity of misprints bears witness to the meticulous care taken by all who have been concerned in the preparation of an excellent treatise.

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