Book Reviews

The Organisation of Science in England. D. S. L. Cardwell, Heinemann, London, 1957, ix + 204 pp. 18s.

At a time when many nations are giving increased attention to the development of an adequate supply of well-trained applied scientists, Cardwell has supplied a well-documented and highly relevant case history of the development of a class of professional scientists in England. The telling of this story provides an opportunity for analyzing the developments of education in applied science in England, and for comparing those developments with parallel ones on the Continent.

Formal training in applied science was late in getting started in England. The Ecole Polytechnique was established nearly a century before anything comparable existed in England, and the great technological schools of Germany and Switzerland were frequently cited models in efforts to improve science education in England. There were, however, antecedents to the great growth of science at Cambridge, the founding of Imperial College, and the development of other now prominent centers of technological education. Cardwell gives some of the antecedent and parallel developments from the 18th century into the 20th: the Mechanics Institutes, the changing character of the universities, the origin and course of development of the Cambridge Natural Science Tripos, the founding of University and Kings Colleges in London and the University of London, and other significant events such as the impact of the Great Exhibition of 1851 and the later establishment of the Exhibition Fellowships.

These individual histories are used to document two major themes which run throughout the book. One is the argument that to have a flourishing scientific industry requires the existence of a class of professional scientists, and that to have a class of professional scientists requires both an educational system designed to train them and an adequate number of positions in which their vocation can be practiced. An organized system of technical education provides the solution to this apparent circle. It offers professional training. It also provides jobs for those who have been trained. Only after a sufficient number of teaching positions become available can industry begin to employ scientists, either by taking some from teaching posts or by engaging new graduates.

This is the major theme of the book, and it provides the framework for considering individual developments and comparing English with Continental experience. For example, when the International Exhibition of 1862 was held in London, there was much enthusiasm over Perkins' recent discovery of mauve. The official handbook of the exhibition promised, ". . . we shall soon become the great colour exporting country. . . ." The promise failed of fulfillment. Seventeen years later, Germany had 17 color works to England's five, and was producing coal tar colors of over four times the value of those manufactured in England. True enough, England was exporting, but primarily coal and coal tar rather than the finished dyes. Germany's leap ahead was attributed to the existence of a group of professional chemists, something England did not have.

The second recurring theme is the still fresh problem of the merits of specialization in education. Cardwell gives the arguments, pro and con, of many of the leading British scientists of the past century, and shows the relations between these arguments and the developing aspects of technological education. It is on this topic that the author closes. The achievement of professional science he recognizes as a desirable advance in social organization, but the high degree of specialization that now characterizes English education, even in the later secondary years, may well, he contends, hinder the progress of science itself by increasing the difficulty of communication and cross-fertilization among the interdependent branches of science.

Appropriately, the publisher classifies this work in the field of sociology. It is a thoughtful, useful contribution to the sociology of science.

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The Hypercircle in Mathematical Physics. A method for the approximate solution of boundary value problems. J. L. Synge. Cambridge University Press, Cambridge, 1957 (order from Cambridge University Press, New York). x + 424 pp. Illus. $13.50.

One of the more beautiful *objets d'art* in mathematics is surely that of Hilbert space. Here geometry and analysis meet and enrich each other. It comes as somewhat of a shock to realize, under J. L. Synge's prodding, that one of the possible avenues wherein geometry could help in analysis has simply not been used. The chain—Euclidean concept to Hilbert space to analysis—has not been exploited. To be sure, the concept of distance has traveled this road. But the concepts of the plane, the sphere, the circle, and so on, have not.

This book undertakes to remedy this situation. Various geometrical constructs with which we are familiar in three-dimensional space are generalized to the infinite number of dimensions of Hilbert space. The insight, which comes from having a geometrical understanding, automatically suggests theorems and their proofs. In particular, an application to problems of boundary values suggests itself. In these geometrical terms, a boundary-value problem resolves itself into finding the intersection between the subspace composed of functions which satisfy the differential equation involved and the subspace composed of functions which satisfy the boundary conditions. For example, in electrostatics, upper and lower bounds to the capacity can be found, and a method of successive approximations can be set up.

The book is a model of clarity. The author starts slowly, reviews often, and gives many examples. One should not, however, think that it reads like a novel. The reader has to do some work too! Applications are made mostly to the Laplace equation, although the biharmonic equation, as well as the equations of acoustics, electromagnetism, and elasticity, is treated.

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Handbuch der Physik. vol. 32, *Structural Research.* S. Flügge, Ed. Springer, Berlin, 1957. 663 pp. Illus. $27.50.

Perhaps no other volume of the new *Encyclopedia of Physics* shows the changes which have taken place in physical research so clearly as does the volume on structural research. Even in the second edition (1933), the classical article by P. P. Ewald was barely 200

pages long and was just a portion of the volume on x-rays. The new volume, with indexes, has 663 pages!

The volume consists of monographs on "The Experimental Methods to Determine the Crystalline Structure by X-rays," by Gerard von Eller and André Guinier (Paris) (in French); "The Theoretical Principles of Structural Research by X-rays," by J. Bouman (Delft) (in English); "The Investigation of the Structure of Liquids and Amorphous Substances by Means of X-ray Diffraction," by Gerard Fournet of Paris (in French); "The Size of Particles and Lattice Defects," by W. W. Beeman, P. Kaesberg, and J. W. Anderegg (University of Wisconsin) and M. B. Webb (General Electric Research Laboratories) (in English); "Electron Interferences," by H. Raether (University of Hamburg) (in German); and "Neutron Diffraction and Interference," by R. Ringo (Argonne National Laboratory) (in English). The large amount of information on neutron diffraction now available did not exist at the time of publication of the second edition. The interferences from liquids and electron diffraction were briefly mentioned in two places; now each of these subjects forms the background for a detailed monograph.

The level of the book is entirely different from that of Ewald's. Whereas Ewald's book was written in such a way that it could be given to the beginning graduate student as an introduction to structural investigations with x-rays, the monographs in this volume are written for more advanced workers, and the bibliography takes into account only investigations of recent years. There are brief references, in the article by Bouman on theoretical principles of structural research by x-rays, to the elementary theory of diffraction, but otherwise most of the references deal with papers which have come out since the 1933 handbook appeared. This is quite justifiable in view of the fact that there is a large amount of material in the structure reports, which are now edited by the crystallographic societies.

One might feel that Bouman's article should really be the first one in the volume, for it lays the theoretical foundation, giving a detailed discussion of space groups, which is necessary for understanding of the experimental determinations that are discussed by Von Eller and Guinier.

The article by Von Eller and Guinier is quite complete; altogether, this volume is the only one in which all this information could be found, with the exception perhaps of Guinier's own book, *Theorie et technique de la radiocristallographie* (in French). The arrangement in the present text is sufficiently different to make the reading stimulating even if one is familiar with the former volume. The standard methods of Fourier analysis are discussed, as is the method of x-rac used by Pepinsky. The latter method seems to have been treated too briefly, for it is so far superior to anything that is otherwise available. The detailed discussion of the phase problem, by Bouman, will be welcomed by all workers in the field, as will be the discussions that follow of the various methods which have been used to solve this problem.

The article by Fournet on the structure of liquids and amorphous substances is perhaps the most complete monograph on the subject in existence at the present time.

The article by Beeman, Kaesberg, Anderegg, and Webb is divided into two subsections, one on the effect of particle size and the other on lattice defects. The latter, in particular, will be of great interest at the present time, now that imperfections in crystals have been studied so widely and have been recognized to be of such importance in many fields of solid-state physics. The last few paragraphs of this chapter, on x-ray microscopy and microbeam experiments, will be of interest to the investigator who is concerned with thin layers. On combining this information with the information supplied by Raether in his chapter on electron diffraction, one gains a good insight into what can be done nowadays with a combination of various diffraction methods. Some of the figures in Raether's article, in particular, are very beautiful. The detailed discussion of applications to electrolytically polished metal surfaces and to the structure of mechanically polished surfaces will be of great interest not only to the physicist but also to the engineer, and so will be the chapter on thin layers and their structure. This monograph closes with a brief description of the diffraction of electron waves, which have become more useful in recent years. The complete discussion of all the problems which are involved in neutron diffraction, now that reactors are becoming widely used all over the world, is of great importance. The advantages and disadvantages of the methods are discussed in detail; the discussion covers not only simple diffraction theory but also the various techniques which have to be used for interpretation and the experimental techniques which are necessary to get monochromatic neutron beams, as well as good detectors.

This is a very valuable book and will be indispensable not only to the physicist and physical chemist but also to the biologist who wants to learn more about the structure of materials. If I have one criticism, it is that there is, unfortunately, no really good index; the present one does not do justice to the amount of material which is actually available in the volume itself.

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Economic Backwardness and Economic Growth. Studies in the theory of economic development. Harvey Leibenstein. Wiley, New York; Chapman & Hall, London, 1957. xiv + 295 pp. Illus. $6.75.

This book employs the tools of traditional economic theory to produce an abstract analysis of economic backwardness and economic growth. The central thesis consists of two parts: (i) Economic backwardness involves a condition of quasi-stable equilibrium such that any small growth in per capita income sets up forces, such as population growth, which operate to reduce per capita income and reverse the initial growth. (ii) In order to achieve sustained growth, the initial impetus to growth must exceed some critical magnitude necessary to overcome the reversing effect of the income-reducing forces.

This thesis involves much more than the obvious statement that, in order to raise per capita income, production must outrun population growth. On the one hand, the possible forces operating to reverse growth include not only population increase stimulated by higher incomes but also overconsumption, the exhaustion of particular limited resources, and institutional rigidities. On the other hand, these forces are of a limited magnitude, so that an initial growth above some critical rate will not be reversed but will tend to lead to further growth.

Possible patterns of quasi-stable equilibrium are examined analytically and used to explain some of the known characteristics of less-developed countries. The minimum effort necessary for sustained growth is considered analytically, and abstract models for growth are developed. Finally, an analysis is made of rates of population growth, of investment, and of appropriate investment policies.

The central theme of the book presents a promising hypothesis to be tested, and the detailed analysis constitutes useful pioneering in a field that is underdeveloped. At the same time, the analysis is likely to leave the reader with a sense of unreality. There is no evidence that the author has had any actual experience with underdeveloped countries. The application of market analysis to countries