a centre of symmetry, by the $\pm$ signs. If this problem were answered, the determination of the mass distribution in the crystal would be reduced to a merely computational operation. Recent years have seen much progress, the first general advance beyond the method of heavy atoms being given by Harker & Kasper's inequalities. After this breach the approach has been widened by Mac-Gillavry, Karle & Hauptmann and Goedkoop, as reported at the conference. In order to obtain phase-determining relations, point atoms are assumed in the crystal; to this sharpening of the atomic peaks there corresponds in Fourier space the reduction of the observed F values by an assumed atomic factor common to all atoms; furthermore a 'unitary structure amplitude' U_h or $|\hat{F}_h|$ is introduced by dividing F_h by F_{000}. The first source of relation between the U_h is the limited number (N) of atoms in the cell. Banerjee showed in 1933 that as a consequence there exist linear equations between any $N+1$ successive U_h values on any lattice row passing through the origin of the reciprocal lattice. Goedkoop generalized this equation to det $U_{H-K}=0$, where the vectorial orders H and K form any two different or identical sets of $N+1$ lattice vectors in the reciprocal lattice. By a proper choice of these sets the U values appearing in this relation can be adapted to the ones known from observation; this makes his relations more supple than the original ones of Banerjee. As is the case for the latter, symmetry reduces the number of orders involved (Avrami).

The second source of relations is the positiveness of the density in the crystal. This leads Harker & Kasper and later Karle & Hauptmann to their inequalities. By their present contributions Karle & Hauptmann show how both equalities and inequalities can be obtained from the same form of determinant, according to whether its order is greater or smaller than the number, N, of atoms in the basis.

Altogether this new development of the theory of structure analysis has at present a rather forbidding mathematical aspect; it is, however, quite likely that this will mellow by more intensive discussion.

It is well known that according to the general scheme of Fourier transformation the Fourier series formed with the observable $|F|^2$ values (Patterson) represents the convolution or 'fold' of the density $\rho(x)$ of the crystal with $\rho(-x)$. The transition from $|F|^2$ to F in Fourier space finds its geometrical counterpart in crystal space in the 'unfolding' of the Patterson diagram. In attempting this process it is important to clear the way by recognizing the effects caused in the Patterson diagram by the presence of symmetry elements in the crystal, or even in single groups of atoms of the basis (e.g. the symmetry $3/m$ of a CO_3 group). A. L. Patterson showed how such symmetry elements could be brought out on the fold by a suitable superposition of the fold on itself.

Altogether the impression left by this meeting is that the advance in the systematic tackling of the problems of structure determination has been very rapid along the three lines of computational aids, of algebraic approach and of understanding the relations contained in the theory of Fourier transformation. The X-RAC stands in a class by itself as, apart from its proficiency as a computing device, it permits, as it were, mathematical experimentation on two-dimensional Fourier series on a hitherto unknown scale.   P. P. EWALD

Book Reviews

Works intended for notice in this column should be sent direct to the Editor (P. P. Ewald, Polytechnic Institute of Brooklyn, 99 Livingston Street, Brooklyn 2, N.Y., U.S.A.). As far as practicable books will be reviewed in a country different from that of publication.

Einführung in die Mineralogie (Kristallographie und Petrologie), By CARL W. CORRENS. Pp. 414, with 405 figs. Berlin: Springer. 1949. Price DM. 38·00; bound DM. 41·60.

We are accustomed to seeing books entitled 'Introduction' turning out to be nothing but ordinary text-books at a rather elementary level. The traditional type of a mineralogical text-book, initiated by Wallerius in 1749, consisted of a bare description of mineral species arranged in some sort of order.

To this original skeleton there were added by successive stages an introductory chapter, including the structure of crystals as well as the general physical and chemical properties of minerals, and a chapter dealing with the genesis of minerals in their natural setting—involving petrogenesis. The emphasis, however, was still overwhelmingly on the descriptive sections. The progress made during the last fifty years in the field of crystallography on the one hand, and in the field of petrogenesis on the other, has prompted Prof. Correns to discard the old type of mineralogy text-book and to produce a book which is completely novel both in its scope and in the arrangement of material, a book in which the purely de-

scriptive part is reduced in the main to tables and occupies a bare 73 out of a total of 414 pages. This new type of 'Introduction to mineralogy' represents a very daring and radical attempt to get away from the traditional scheme and to outline the 'shape of things to come' in the field of mineralogy teaching.

The plan and structure of this book are based on two fundamental ideas: that minerals, with trifling exceptions, are crystalline substances, and that minerals are constituents of rocks. Thus the book is divided into (1) crystallography (150 pp.), (2) petrology (130 pp.), and (3) an appendix containing various tables, bibliography and indexes (129 pp.). This logical foundation scheme is not obtrusive. The novice will find no difficulty in following the text, while the specialist will find the factual material well and clearly arranged.

The first part is rather boldly entitled 'Crystallography'. It is true that it deals with crystals, but an English reader may think that the term 'crystallography' in the present case covers a very wide field. In a logical fashion this part is subdivided into (*a*) geometrical crystallography (*Kristallmathematik*), which includes crystal morphology, indices, projections, space lattices, point groups and space groups; (*b*) crystal chemistry (*Kristallchemie*), which in-

cludes structural types of chemical compounds, nature of chemical bonds, atomic and ionic dimensions and co-ordination; (c) crystal physics (*Kristallphysik*), in which cleavage, hardness, density and optical properties are discussed, often, when possible, in the light of crystal chemistry. A separate chapter on crystal growth and solution completes this part.

The second part begins with a chapter dealing with the application of physical chemistry to mineralogy and petrology: crystallization from melts, phase rule and thermal-equilibrium diagrams illustrated by systems involving common rock-forming minerals. The next chapter deals in a compact but comprehensive way with magmatic rocks, including their classification, texture, composition, and genesis. The role of volatile constituents, especially in the formation of pegmatites and mineral veins, is very clearly discussed. A chapter on weathering forms a prelude to the chapter on sedimentary rocks, and these in turn are followed by a chapter on metamorphic rocks, in which there is also a very good account of ultra-metamorphism and petrotectonics. A very brief chapter on geochemistry concludes the second part. The third part, headed 'Appendix', consists of tables. The crystallographical tables include tables of the 32 classes, the 230 space groups and ionic and atomic radii. The mineralogical tables, compiled by S. Koritnig, contain over 300 common minerals, for each of which the following data are provided: space group and dimension of unit cell, dominant faces, cleavage, hardness, density, colour, streak, optical constants, and mode of occurrence. The petrological tables consist of chemical and mineral analyses of selected typical rocks (51 igneous, 23 sedimentary and 18 metamorphic). The list of literature is well selected, but the important book of Vernadsky, *La Géochimie*, mentioned in the text, should have been given in the list of books. Subject and author indexes are satisfactory, and at the very end of the book a detachable Wulff's stereographic net is appended.

The book is very well printed and the diagrams, drawings and photographs are well reproduced. The factual material is well selected and arranged, and with the help of the tables, as well as data dispersed throughout the text, the book can serve as a very valuable reference source. The style is pleasing and clear even to a non-German reader, and what is especially striking is the beautiful balance achieved between the factual material and the explanatory text. Speculations are discreet and set in a critical light. In its comprehensiveness, abundance of data and clarity this book is of value not only to students but also to teachers and research workers.

Of course this book, like many other good books, has some trifling faults as well as deep qualities. Some of them are in the nature of misprints, like that of Gottlob Abraham Werner (p. 200 *et al.*) instead of Abraham Gottlob Werner, or slightly imperfect figures (Figs. 20, 156) or the omission of the name of Barlow as co-discoverer with Fedorov and Schoenflies of space groups (p. 44). Other faults, in the reviewer's opinion, lie in the method or order of presentation of certain parts of crystallography. This, however, must be considered as a matter of opinion. One of such faults is probably due to the transition between the old and the new systems of representation of point groups and space groups and the use of certain elements of symmetry in preference to others. For example, in giving a list of elements of symmetry the author does not discuss the inversion-rotation axes, but he later gives the Hermann–Mauguin symbols some of which include inversion-rotation axes. It would seem that neither Schoenflies nor Hermann–Mauguin symbols are adequately discussed at the beginning, and in neither of the tables are they properly explained. The use of letter p for polar axes is also given at the very end of tables and not at the beginning as it should be. Another difficulty is created by the employment of figures for the number of axes used in conjunction with the Hermann–Mauguin symbols for the axes. In this way the full symmetry of class $m3m$ is given as 3.4 $4.\bar{6}$ 6.2 $3m$ $6m$, which is most confusing. It would probably be better to use the old-fashioned symbols for axes, such as $3A_4$ $4A_3$ $6A_2$, etc. Another small point: electron-density maps are really incomprehensible without some explanation of them in terms of Fourier analysis, but four of such maps are given (pp. 55, 57, 67, 68) before Fourier analysis is even mentioned (p. 138). A clear presentation of modern crystallography is not an easy task, especially considering the necessity of adjusting new points of view and new symbols and nomenclature to the old, well-established ideas. Probably every new book on crystallography at the present time suffers from 'growth pains' of this kind, and one cannot really blame Prof. Correns for these small defects in an otherwise first-class book.

Prof. Correns has covered such a vast range of topics—from structural parts of crystals to geospheres—that his book provides an excellent introduction not only to mineralogy as such but to crystallography, petrology and to geochemistry if this be considered in its widest sense. For a work of such compass and erudition the book is quite compact, and it is this compactness combined with the excellent arrangement of the material which makes it so useful.

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Materiewellen und ihre Interferenzen. By M. VON LAUE. Pp. viii+392, with 156 figs. Leipzig: Akademische Verlagsgesellschaft Geest und Portig K.-G. 2nd ed., 1948. Price DM. 34·00.

This practically unchanged edition of Prof. Laue's book, which was first published in 1944, is a companion to his recent book on X-ray diffraction (*Röntgenstrahlinterferenzen*, Leipzig, 1941). The present work consists mainly of an extensive and admirable account of the purely theoretical aspects of the diffraction of electrons by matter, especially crystals, together with a short description of the diffraction of molecular rays and neutrons.

A detailed treatment on these lines is not generally called for in the practical applications of electron-diffraction techniques to the study of the structure of surfaces and thin films; nevertheless, to appreciate fully the physical principles of the processes involved and to ensure clarity in the interpretation of the phenomena, such a theoretical background is essential.

An excellent, brief, but broad introduction to the subject is provided by Chapter i, which describes the paths of electrons and other corpuscles in matter, the