

Society (47 Belgrave Square, London S.W.1, England), and The Polycrystal Book Service (P.O. Box 11567, Pittsburgh, Pennsylvania 15238, U.S.A.). As it contains many figures and much tabular matter, it may be expected to be of use even to those with only a rudimentary knowledge of Russian.

Although the subject appears rather abstract, it has a very wide application in connection with the properties of magnetic materials, and the Shubnikov groups have been much studied by scientists in the USSR from 1951 onwards. This monograph is the first to give a general account in a form

convenient for practical purposes. It contains the full group-theoretical and geometrical description of the 1651 space groups of anti-symmetry. For 1191 of them it gives drawings of symmetry elements and general positions in two colours, table of coordinates and symmetries of equivalent sets in magnetic unit cells, tables of subgroups, and other information. It is claimed that the tables make it as simple to work with Shubnikov groups as with the classical groups, and that the book will be invaluable to research workers in the fields of solid-state physics, magnetic properties of solids, and crystal-structure determination.

Book Reviews

Works intended for notice in this column should be sent direct to the Editor (A.J.C. Wilson, Department of Physics, The University, Birmingham 15, England). As far as practicable books will be reviewed in a country different from that of publication.

Symmetry aspects of M. C. Escher's periodic drawings. By CAROLINE H. MACGILLAVRY. Pp. xi + 84. Utrecht: Published for the International Union of Crystallography by A. Oosthoek's Uitgeversmaatschappij NV, 1965. Price F. 24.

The Song of Solomon speaks of certain things 'for delight', and no phrase could be more appropriate when applied to this beautifully produced book. The late Professor G. H. Hardy considered aesthetic content to be essential for the most creative work in mathematics, indicating a fundamental grasp of form and rhythm. Here, in the periodic drawings of M. C. Escher, a Dutch artist, this principle is plain to see. By itself alone, however, it might be a trifle inaccessible, and so we are given the services of a distinguished cicerone in the person of Professor C. H. MacGillavry of Amsterdam. Under her sure guidance the reader is skilfully conducted through such regions of the theory of symmetry as are necessary for a tolerable grasp of the full significance of these patterns, several of them produced in full colour.

It is well to recollect at once that those designs are all two-dimensional, and are close-packed in the sense that there is no redundant amorphous background, the whole effective area being filled with meaningful shapes, in fact animals and flowers. At first sight this presents, as might be expected, a problem in *Gestalt*; it is not always easy to grasp immediately the existence of visual forms in the matrix, if the primary grouping is very strong. This in itself is an interesting psychological effect often used in the testing of visual acuity, coupled with brain reactions of the observer. But having overcome this temporary hazard, the reader will soon find himself engrossed in these examples of symmetry, translations, glide-lines, rotations, and all the rest. Individual *motifs* are analogous to large organic molecules, partitioned, as in formal crystallography, into unit cells of greater or lesser complexity.

The volume is divided into three main sections: I, patterns with classical symmetry, II, patterns with black-white symmetry, and III, patterns with polychromatic symmetry. (Class II is actually composed of two-colour symmetry, reduced to black-white for convenience.) In addition, there is an index of crystallographical expressions which,

by the way, are in full accord with those of the International Union (Fifth Congress, Cambridge, 1960). We are reminded that, using these notations carefully, there is much to recommend these plates for teaching purposes as at least as instructive as the conventional arrays of balls and wires constituting our stock-in-trade of crystal models. It is intriguing to compare them with the 'appearance' of any one layer in a *Schichtengitter* such as graphite, and then to enlarge one's conception to a much diversified unit of pattern. In one respect at least the artist has the advantage over nature; there are no *Lockerstellen* with which to contend, nor the deformations resulting from slip planes. How all this would have delighted the late Sir George Beilby in his pioneering research on crystal gliding!

There is a profound element of epistemology to be noticed here, and that is that the draughtsman has been able to select at will any configuration which consciously or unconsciously leads the eye to satisfaction; an example of the law of *Prägnanz*, uninhibited by considerations of mechanical or electrical stability. This is the type of morphogenesis which may prove the harbinger of future developments in theoretical biophysics – the need for a major breakthrough to some new phase of quantum mechanics applicable to living systems, even perhaps to those of the stylized creatures displayed in this volume. D'Arcy Thompson's *Growth and Form* was not a great distance away in conception.

Two other matters remain for comment, and a third for passing reference. The first is the important reminder that X-rays are 'blind' to the difference between certain centres such as K^+ and Cl^- set in a row, as also to the orientation of magnetic moments, whereas these finer points are picked up by neutron scattering. Our author notes this one in plate 14, where a 'colour-blind' observer, who could distinguish contour but not shade, would probably class the black and white Pegasus beasts as a true translation, whereas in strict geometry this is not so.

The second point is more speculative, and refers to the coloured designs in section III. Here is portrayed the great, and fairly novel, subject of colour symmetry: some basic examples, attractive to the eye, are before us. But there must be some connexion, albeit only a circumscribing one,

with the four-colour map problem originally noticed by Möbius in 1840, relating to the fact that, mathematically, five colours are needed in the general case to distinguish regions sharing common boundaries, whereas in practice four colours satisfy all maps at present known or devised. Of course, the lower number is a conjecture, but has been proved for the special case of maps containing up to thirty-eight significant areas, so the task is not altogether easy. The question therefore is whether we have a limit (or possibly, in reverse, a self-denying ordinance) upon two-dimensional arrays of polychromatic figures. Here, for the moment, we have deserted group theory for topology.

And finally, for a trivial remark. The text is clear, but there are nevertheless a number of instances wherein idiomatic English has not been achieved, and there are one or two spelling mistakes. Neither mislead, but they are little blemishes on so fair a landscape.

In conclusion, it is tempting to ask where, on the bookshelves of those who appreciate form at its best, will they tend to put this book? A fair guess would be, close to Birkhoff's *Aesthetic Measure*, Weyl's *Symmetry*, and Speiser's *Theorie der Gruppen von Endlichen Ordnung*. More than that one cannot say.

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Mechanical twinning of crystals. By M. V. KLASSEN-NEKLYUDOVA. Translated from the Russian by J. E. S. Bradley. Pp. xiv+213. New York: Consultants Bureau, 1964. Price \$19.50.

It may be doubted whether the recent flood of translations from Russian always provides valuable and useful contributions to the scientific and technological literature. It appears to be beyond doubt, however, that the translation of the present book was worthwhile, both because of the qualifications of its author and her collaborators and because of the lack of a comparable modern work in one of the western languages. Although the 'classical' crystallographic aspects of twinning are not neglected, the outlook of the book is very modern. It discusses the relations to such subjects as martensitic transitions, recrystallization twins, lattice rotations in inhomogeneous deformations, fracture, ferroelectricity, ferromagnetism, and covers (in contributions by V. L. Indenbom) both the macroscopic and the microscopic (dislocation) theory of twinning. The book contains extensive tabular material and is well suited as a reference work.

The translation has been done expertly apart from occasional, but nevertheless irritating, misspelling of names (the same proper name may even be misspelled in two different ways).

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The structure of glass. Vol. 3. Catalyzed crystallization of glass. Editor: E. A. PORAI-KOSHITS. Translation from the Russian by E. B. UVAROV. New York: Consultants Bureau, 1964. Pp. 208. Price \$20.00.

Der vorliegende Band enthält einen Teil der auf dem dritten Leningrader Glaskongress gehaltenen Vorträge. Er behandelt vor allem die Probleme der Entstehung der 'Glaskeramik' und der Vorgänge in den lichtempfindlichen Gläsern. Dabei steht die Frage der Primärvorgänge bei der Kristallisation bzw. der Entmischung und der Methoden zu ihrer Erkennung und Verfolgung mit im Vordergrund.

Die insgesamt 44 Vorträge sind in vier Kapitel zusammengefasst, denen ganz kurz die wichtigsten Diskussionsbemerkungen folgen. Das erste Kapitel beschäftigt sich mit den allgemeinen Gesichtspunkten der Glaskristallisation. Unter diesen durchweg interessanten Berichten ist besonders der von Filipovich 'Initial Stages in the Crystallization of Glasses and Formation of Glass-Ceramics' zu erwähnen. Auf ihn wird in den Diskussionen wieder Bezug genommen. Porai-Koshits hebt in den Schlussbetrachtungen zum Kongress hervor, dass die Übereinstimmung dieser Kristallisationstheorie mit vielen experimentellen Resultaten eine der wichtigsten Erkenntnisse des Symposiums gewesen sei.

Das zweite Kapitel 'Two-Component Systems' enthält fünf Vorträge, das dritte 'The Lithium Aluminosilicate System' 18, das vierte 'Other Three-Component and Multi-component Systems' 14 Vorträge. Auf Einzelheiten einzugehen ist bei den zahlreichen behandelten Themen nicht möglich.

Der Band gibt eine Vorstellung von den energischen Anstrengungen der russischen Glasforscher, wissenschaftliche und technische Erkenntnisse auf dem wichtigen Sektor der Kristallisations- und Entmischungsvorgänge im Glas zu gewinnen. Den Vorstufen wird dabei besondere Beachtung geschenkt. Die Bedeutung der Glasstruktur und damit der Vergangenheit des Glases für die ablaufenden Prozesse wird hervorgehoben; ebenso sind die Schwierigkeiten, die sich der Deutung der experimentellen Ergebnisse entgegenstellen, klar erkannt.

Das Buch bringt die Ansichten und Ergebnisse der russischen Glasforscher zur Zeit des Kongresses (1961?), der vielseitige und anregende Bericht ist aber auch heute noch aktuell. Der Band ist wichtig für jeden, der sich mit diesen und ähnlichen Problemen befasst, er verdient aber auch sonst das Interesse der Kristallographen.

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Borides, silicides, and phosphides: A critical review of their preparation, properties and crystal chemistry. By B. ARONSSON, T. LUNDSTRÖM and S. RUNDQVIST. Pp. 120. London: Methuen, 1965. Price 25s.

This little monograph will serve as a simple introduction to an interesting field of research even though the title is mis-