Book Reviews

Works intended for notice in this column should be sent direct to the Book-Review Editor (M.M. Woolfson, Physics Department, University of York, Heslington, York, England). As far as practicable books will be reviewed in a country different from that of publication.

Graphic prints and drawings of M. C. Escher: set of 35 35mm colour slides. Hilversum: Polygoon. Price Dfl. 20, $ 5.50, £2·7*s*.

Many crystallographers will be familiar with the fascinating work of the Dutch artist M. C. Escher. One of Escher's preoccupations is the filling of two-dimensional space with objects that can be recognized as, or associated with, living creatures and many of his drawings are truly periodic. It is not surprising that X-ray crystallographers are interested in Escher's work when they are concerned with the ways in which nature solves the same problem of packing identical objects in periodic patterns. Escher's drawings are sufficiently complicated to illustrate most of the rules of plane group symmetry without presenting too many difficulties for the beginner. They are certainly superior to patterns of little circles, thinly disguised as atoms or molecules, which appear on the blackboards of crystallography classes and the reviewer has found Escher's drawing an admirable aid to the teaching of symmetry.

Out of the 35 slides in the set under review, 11 are of periodic patterns nearly all of which exhibit colour symmetry. The remainder form a good cross-section of Escher's work and include reproductions of such famous lithographs as 'Belvedere' and 'Waterfall' which depict impossible buildings and play tricks on our concept of the three-dimensional world. Also present are pictures which show a transition from a flat two-dimensional to a spatial three-dimensional world and others that use perspective in the cunning fashion so typical of Escher.

It is easy to think of works that one would like to see included in this set of slides, but very difficult to decide which of the reproductions already present they should replace. The quality of reproduction is satisfactory and if one can judge from the success of an evening showing the slides at a Department of Physics get-together at York, they are well worth buying.

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Hydrogen bonding in solids. By Walter C. Hamilton and James A. Ibers. Pp. xv+284. New York: Benjamin, 1968. Price $ 13.95.

Every year it becomes more difficult to write a good scientific book. The crazy tempo of the accumulation of experimental data, the continuous birth of new investigational methods, the rapid change in theoretical points of view and – perhaps the main thing – the unavoidable growth of several kinds of hybrid scientific topics – all this makes the problem of the successful selection of material and the scope and logical sequence of its exposition a matter of high scientific skill.

Surely there are subjects which do not require the author to make a choice between a lot of possible sections in a multidimensional space of science. This is so in the case of books about crystal symmetry, or the dynamics of material points, but such is not the case for a book dealing with hydrogen bonds.

Why hydrogen bonding in solids? Are the bonds in solids different in principle from bonds in the melt or in solution? Surely not. But the authors ingeniously give their book a secondary title – 'Methods of Molecular Structure Determination'. It is written with small letters but this is a mere formality since it is not customary to give a book such a long title. If we want to understand the principle of construction of the book, however, we must read the two titles together.

Our previous question – why in solids – was quite legitimate if one bears in mind the *nature* of bonding, but we agree with the authors that the methods of investigation of hydrogen bonding in solids are multifarious and there is some specificity which deserves attention and knowledge.

The second title is surely very important because the methods topic plays the first fiddle in the book. The title reflecting most truly the book content is the following: 'The methods of determining the structure of solids which are appropriate to the investigation of hydrogen bonds and exposition of some results of these investigations'.

My opinion that the authors are more interested in methods than in results is based on the fact that there are very few pages in the book dedicated to the crystallography of hydrogen bonding. The results are given as an aggregate of abstracts. We find practically no attempt to give any classifications of bonds, based on their very interesting geometry. (The brief and naive discussion on pages 18–21 does not count.) Physical, not chemical, classification of the crystallographic data is badly needed, but unfortunately is lacking in the book. The anisotropy of physical properties caused by hydrogen bonding is also outside the scope of the book. All things which are done with love and with enjoyment are done well; therefore I find the first 160 pages of the book much more interesting than the last 100 pages, where the description of hydrogen bonds in organic substances is given.

I think that the first chapters, *i.e.* Chap. 2, 'Diffraction Methods'; Chap. 3, 'Spectroscopic and Diffraction Studies'; Chap. 4, 'Rotation Motion in Solids and Neutron Spectroscopy', make the Hamilton–Ibers book a very valuable contribution to the literature of physical methods of investigation of the structure of matter. These chapters are written with a perfect and deep understanding of a very important thing – the interrelation of different methods. The whale cannot be caught with a fishing rod and nobody goes trout fishing with a harpoon. We have very few books, if any, discussing the possibilities of different structure methods in the same book and with the same high competence.

Therefore the book is interesting not only to the scientist interested in hydrogen bonding but extremely useful to every member of the crystallographic family.

In Chapter 2 all concepts of diffraction methods are vividly and concisely described: the Bragg equation, the reciprocal lattice, the structure amplitude, the scattering density and the principles of structure determination. The next step is to discuss the scattering amplitudes in all three usable diffraction methods – X-ray, neutron and electron. After that the peculiarities of each diffraction method branch are treated briefly but all important things are stated clearly.

In this short exposition very valuable remarks are spread here and there about the physical meaningfulness of different techniques so often used somewhat blindly in different structure investigations.

Systematic errors in structure determinations are fully discussed in a special section. Perhaps a half page is lacking to warn the reader of unexpected trouble with which he can be faced if the crystal contains a comparatively small per cent of impurities. I cannot help repeating my opinion that the inner consistency of the structural result is sometimes more important than the R index. The 'clever' structure with R equalling say 0·11 is better than a 'silly' structure with $R=0{\cdot}10$. The importance of introducing structural reasoning as an element of structure determination is, from my point of view, not claimed with sufficient firmness.

Chapter 3 introduces us to optical vibration spectroscopy. Perhaps it would be worth giving a little more place to the Urey–Bradley field. Spectroscopic manifestations of hydrogen bonding are described briefly and I think this is right bearing in mind the book of Pimentel & McClellan.

The sections dedicated to neutron magnetic resonance methods are to be highly welcomed. At the moment no one method (I ask the optical spectroscopists not to be angry with me) has a comparable value as a partner of the diffraction methods. The n.m.r. method, as is clearly shown in a special section of the book, is well suited to the determination of proton–proton (or F–F *etc.*) distances. In the next chapter it is shown that without n.m.r. techniques we have no means of investigating the reorientation movements of molecules and this is especially valuable as in many cases even we did not suspect the presence of such movements.

But let us return to Chapter 3. Here we get acquainted with potential functions used for describing hydrogen bonding. It is shown quite clearly that the potentials can be checked with different diffraction and spectroscopic experiments. Some examples of using both techniques are given at the end of Chapter 3. But the importance of the n.m.r. method is insufficiently stressed. One of the n.m.r. applications is buried in a section on diffraction and optical spectroscopy. The other (reorientation problem) is dealt with in the neutron spectroscopy section en passant.

So Chapter 4 is in the first instance an exposition of neutron inelastic scattering. I would be happier if this chapter occupied another 5–10 pages, at the expense of the last part of the book if necessary.

In Chapter 5 we find information about hydrogen-bonded organic and biological molecules; in Chapter 6 are discussed the hydrogen bonds in hydrates and other inorganic crystals. (Why 'other'? There are plenty of organic hydrates.) Chapter 7 is dedicated to the hydrogen bonded ferroelectrics. The last chapter (two pages) has a title – 'Outlook for the Future'.

Summing up I can say that the Hamilton–Ibers book is certainly a happy occurrence. The reading of the methodical parts is surely stimulating. The pages where hydrogen-bonded structures are described give the reader a lot of useful information.

The book is illustrated with stereoscopic drawings. It is amusing and instructive to search for a three-dimensional view of the structure.

The references are voluminous. So, from all points of view the book is a good introduction not only to the hydrogen-bond problem but to the methods of crystal structure investigation.

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