The book begins with the ancient history, where one learns that the value we nowadays associate with diamond is of fairly recent vintage, dating approximately from Roman times only. Then we have the epic story of the nineteenth-century struggles to synthesize diamond, culminating with the first genuine success when the General Electric team in Schenectady announced, in 1955, their development of a reliable, repeatable process, and when, in 1957, commercial sales of synthetic grits began. This story is buttressed by a clear, methodical exposition of the underlying thermodynamic principles and the phase diagram for carbon. The modern scene (*i.e.*, as of 1983) is then surveyed: one learns with some astonishment that a substantially greater amount of diamond is today made artificially [80 million carats (16 tonnes)] than is obtained by mining (50 million carats), although the production of gems, the principal money-earners, still rests solidly on mining. This leads to the central portion of the book, which is devoted to the uses of diamond.

The fact that some 25 tonnes of diamond are produced and used annually today (compared with, say, 1920, when less than one hundredth of that amount was available *per annum*, or even with the mid 1950's, when about 4 tonnes *per annum* were produced) testifies to the fundamental importance of diamond to modern industry in the developed world. In mass terms, engineering applications easily dominate. This means cutting, grinding and polishing; but there is nothing crude about these processes, considering that, for different materials and different sorts of cutting, the synthetic techniques employ distinctly different conditions, creating diamond particles of quite different characteristics, each optimized for a particular requirement. Beside engineering uses, however, there are a host of other contrasting and remarkable applications, often highly specialized, each exploiting some combination of the unique properties that diamond has. Most of us know that diamond anvils are invaluable for the achievement of very high pressures in research, and, in daily life, all of us know about the diamond stylus for record players (having a lifetime 20 times that of its closest rival), but I will mention just three other examples. First, since diamond is so hard it can be ground to an exceedingly sharp edge, and since its surface is strongly water-repellant ('oily') too, it makes a superb surgical knife; this can have a radius of curvature of only a few tens of atoms at its cutting edge and, as tissue falls away from it directly, the cut is clean and strain-free. Second, since diamond has so low a specific heat at low temperatures, it allows the construction of a heat sensor for the measurement of radiation (as from a star), capable of detecting rates of energy as minute as 10^{-15} W. Third, since diamond is so transparent to light, especially infrared, and so inert to chemical attack, and also so strong, it was used (as a disc of 18 mm diameter, 2·8 mm thick) for the spectrometer window of the Pioneer space probe, monitoring the acid atmosphere and red-hot surface of Venus, in 1978. This is all scientifically fascinating. Following the description of these and other specialized applications there is a section on the impurities and atom replacements that occur in diamond, where even more up-to-date physics is effortlessly brought in. It is interesting, and as yet unexplained, that fractional replacement of carbon by nitrogen, to the extent of 10^{-4}-10^{-3}, significantly improves crystal growth and strength.

Each of these extraordinarily different uses and features of diamond is explained by Dr Davies in terms of the structural, chemical and physical principles of matter, so that each becomes an illumination of these principles of physical science. Thus, the bolometric application above is tied in with the physics of atomic vibrations, with quantum theory, and with Einstein's paper of 1907. All this is done so intelligently and so readably, neither blinding the reader with jargon, nor patronizing, that there is educative value in the book far beyond what the title would lead one to expect. The quantity of information is considerable, enhanced by numerous footnotes and many references for further reading; yet the digestibility of all this is ensured by the style adopted, including, for instance, the use of distinct subsections within the chapter, and the unobtrusive summaries that crop up every now and then in the text, especially at the ends of chapters.

For the old-fashioned crystallographer in each of us, there is a special message. Yes, gem-quality diamonds *can* now be grown synthetically: to the size of a pea, crystal clear, tinted as desired, almost flawless, and with the most beautiful display of complex, symmetrical faces. But the conditions for this are fearsome: five days' continuous maintenance of the mass of nickel metal solvent-catalyst at 55 000 atmospheres pressure, at a temperature of 1400 °C, and with a 50 °C gradient between the raw-diamond feedstock and the growing implanted seed. This is simply too expensive to compete with what nature has provided, already manufactured in the depths of the earth's crust.

The final chapter on gemstones, including diamond fakes and simulants, is exciting in its own right but only one small part of a fascinating book.

This book can be recommended as an excellent gift for any reasonably intelligent lay person, sufficiently interested in physical science. It is good quality armchair reading for anyone, including even the ordinary crystallographer. It is not unduly expensive, by present-day standards.

J. H. Robertson

School of Chemistry
University of Leeds
Leeds LS2 9JT
England.

Acta Cryst. (1986). B**42**, 525-528

International tables for crystallography. Vol. A. Edited by Th. Hahn. Pp. xvi + 854. Dordrecht: Reidel, 1983. Price Dfl 385.00, US $165.00, £80.00; or, for individual crystallographers, Dfl 215.00, US $90.00, £45.00.

This book is a new version of the well known *International Tables for X-ray Crystallography*, Vol. I, *Symmetry Groups* (first edition 1952), familiar to every crystallographer. The difference in the titles of these two versions reflects the main aim of this new book - *IT*, Vol. A (1983), as we shall now refer to it - which, according to the editor's intention, is 'to provide data and text which are useful for all aspects of crystallography'.

The present volume deals with the symmetries of one-, two- and three-dimensional space groups and point groups in direct space without extension to 'generalized symmetry'. Its most striking feature is a considerable increase in size [854 pages, *i.e.* 53% more than in Vol. I (1952)], which is the result of an important extension of the contents. No wonder that such an impressive work had to be undertaken by an editorial team of experts three times larger than before.

A pleasant invitation to reading which we encounter immediately after opening the huge book, is a short explanation of the space-group data given inside the front and back covers.

IT, Vol. A (1983) consists of two parts. Part I, 'Tables for Plane Groups and Space Groups', is designed mainly for practical use. Part II, 'Symmetry for Crystallography', contains the necessary theoretical background for all the topics which appear in Part I.

In Part I there are five short sections which should be read before making profitable use of the plane- and space-group tables given in Sections 6 and 7 respectively.

Section 1 (Th. Hahn) gives definitions of the symbols and terms which occur throughout the whole of Vol. A. It has important tables which contain printed and graphic symbols for symmetry elements in a clear form, much extended in comparison with *IT*, Vol. I (1952). They involve graphic symbols applied in the newly introduced diagrams of the cubic space groups as well as useful detailed definitions of all glide-plane symbols. As reviewers, we would, however, feel better if the definition of the rotation operations given in Table 1.3 were supplemented with a remark about the way of looking at the designated rotation axis. Such a remark is given in Part II, Section 11.2 (p. 788), but no reference to it is made in Section 1. It would also be good if the entry 'rotation sense definition, 788' were given in the Subject Index before 'rotation, sense of, 789, 790'. In the same table a footnote concerning the usage of the letter **g** for glide reflections should be added with a reference to Section 11 [11.2 (v)].

Section 2 (Th. Hahn & A. Vos, with contributions from other members of the Editorial Committee) is a guide to the use of the Tables.

A lot of work has been carried out to acquaint the reader with the considerbly extended and completely revised symmetry tables. There are many novelties and some of them deserve special mention.

(i) In the classification of the space groups the term 'crystal families' has fortunately been introduced to good effect, especially in the case of the trigonal and hexagonal crystal systems and *hP* and *hR* Bravais lattices. It seems to be a nice solution of a long-lasting controversy between different schools of crystallographers.

(ii) The monoclinic space groups are treated with special care: synoptic descriptions of three cell choices are given with a complete demonstration of each of two settings. It seems to us that, for a practising crystallographer, of most importance are the three statements on the selection of the monoclinic cell on p. 38 which may be read as a summary of § 2.16.

(iii) Maximal subgroups and minimal supergroups are thoroughly described with many examples which help the reader to follow the rather difficult text.

(iv) No distinction has been made between 'independent' and 'included' reflection conditions which might be slightly disappointing for those who have become accustomed to these symbols.

Two slight changes we propose below could perhaps help in reading this section. In a paragraph about the symmetry elements not indicated in the full symbols of space groups (§ 2.4, p. 16), Tables 4.1.1, 4.1.2 and 4.1.3 containing additional symmetry elements should be mentioned, together with Tables 4.2.1 and 4.3.1 where extended full symbols are given. In § 2.7 (p. 21) instead of 'second description' ('second' in contrast to the 'first description' which corresponds to the centre of symmetry), we would prefer 'another description' because in the space-group tables the origin in the point of high site symmetry is always taken as origin choice 1.

We have some personal feelings about the newly introduced terminology for reflection conditions: we are not enthusiastic about 'integral' and 'serial' reflection conditions, though we fully accept 'zonal' ones.

Section 3 (A. Vos & M. J. Buerger) provides a discussion on the determination of space groups from diffraction patterns. Here the most important item is Table 3.2 which lists reflection conditions, diffraction symbols and possible space groups, and is much extended in comparison with that in *IT* (1952). The terms used in this table are briefly considered including possible sources of errors in the space-group determination, and some additional methods which give appropriate information about the space group of the crystal structure under consideration.

Section 4 (E. F. Bertaut) contains the synoptic tables of space-group symbols, extended with respect to older versions of *IT*. They are completed with the tables of additional symmetry elements [suppressed in *IT* (1952)] and many examples which show how to use them. These examples are easier to follow when Section 12 from Part II is taken into account and this should be pointed out in a footnote.

This section also gives instructive examples of group-subgroup relations in the cases when maximal subgroups can be recognized from extended and full space-group symbols.

We noticed on p. 60 two printing errors which might be confusing for some readers, namely symbols: '$\begin{array}{c}P2_1\,2\,2(51)\\ mma\end{array}$' instead of '$P\ 2_1/m\ 2/m\ 2/a$ (51)' and '$P2_1/n11$ ($P2/c$)' instead of '$P2_1/n11$ ($P2_1/c$)'.

Section 5 (H. Arnold) deals with transformations in crystallography emphasizing transformations of coordinate systems, while the detailed description of the symmetry operations themselves is given in Section 11. Some important invariants are also considered. As an illustration of rules for the coordinate system transformations the very good example of the relation between low-cristobalite and high-cristobalite structures is presented. A useful list of selected transformation matrices and their inverse matrices makes up Table 5.1, complete with diagrams.

Sections 6 and 7 were prepared with the use of a computer. All the programs for crystallographic calculations and the computer typesetting of the tables were carried out by D. S. Fokkema while the other authors supplied such data for each of the 17 types of plane group and 230 types of space group as headline, Patterson symmetry, origin description, asymmetric unit indication, list of symmetry operations, generators, oriented site-symmetry symbols, maximal non-isomorphic subgroups, maximal isomorphic subgroups of lowest index, and minimal non-isomorphic supergroups. Many of these are new features of the space-group description. Extremely valuable are new types of diagrams for triclinic, specially treated monoclinic, and orthorhombic space groups. Also, cubic space groups are provided with elaborate diagrams including stereodiagrams for the general positions. No wonder that a standard layout requires two pages per space-group type. As reviewers we are delighted by the results of the efforts made to modify the plane- and space-group tables: they are much more informative than the previous versions of *IT*.

Part II consists of sections 8 to 14 and it seems to be important for a more profound understanding of what is going on in the space-group tables.

Section 8 (H. Wondratschek) gives basic concepts and terms used in the modern approach to crystallographic symmetry as well as to classifications of space groups, point groups, lattices, and group–subgroup relations.

Of this useful section the most elegant, clear and instructive chapter is that which treats the coset decomposition of a space group and shows how it can be used in establishing the relations between space and point groups. In connection with this chapter we would like to remind crystallographers of the work of Opechowski and coworkers (Opechowski & Guccione, 1965; Opechowski & Dreyfus, 1971) whose contribution on the application of the coset decomposition formalism in classifications of magnetic structures seems to us quite remarkable.

It is worth mentioning that the definition of such terms as space-group types, arithmetic and geometric crystal classes, Bravais classes of matrices and Bravais types of lattices, Bravais flocks of space groups as well as crystal families, which were not given in *IT* (1952), are presented in a very thorough manner. It is good to have them collected in one section in case one needs a reliable source for this part of crystallographic theory.

The relationships between crystal systems and Bravais systems are well described, which is especially important in the case of the hexagonal family of space groups.

Among other topics, the discussion of sub- and supergroups, with many examples, deserves the special attention of those who study structural relationships and phase transitions.

There are, however, some misleading fragments concerning the definitions of vector space, point space, vector lattices and point lattices (in § 8.1.3) which might cause confusion rather than build a bridge between mathematicians and theoretical physicists on one side and crystallographers on the other. One of the troublesome notions seems to be the concept of 'finite number of interpenetrating infinite point lattices' which, according to the author, may be used for a description of a crystal structure. It is difficult to infer from the text whether this concept has an old, often-criticized meaning (*e.g.* Fischer, Burzlaff, Hellner & Donnay, 1973) or whether it concerns the lattice complexes introduced in *IT* (1983) in Section 14. We also wonder if the term 'linear part', used for the rotation part of a motion or transformation, here and throughout the whole volume (*e.g.* Section 5), should not be replaced by 'homogeneous part' for the sake of mathematical precision. For the same reason we would suggest adding in a footnote a remark that the 'augmented matrix' can be described as a semiproduct of rotation and translation.

Section 9 (H. Burzlaff, H. Zimmermann & P. M. de Wolff) is a description of crystal lattices and their properties. It also gives the rules for selection of the conventional crystallographic bases on one side and of reduced bases on the other, as well as the relationships between their metric tensor coefficients. Two tables, very helpful in everyday practice, deal with the 44 lattice characters and are a guide for immediate recognition of the lattice symmetry and Bravais type from the reduced basis, and also for the transformation to a conventional basis.

Section 10 (Th. Hahn & H. Klapper) on point groups and crystal classes is remarkably rich both in size and in content. A new feature of the presentation of the point groups is a treatment similar to that for the space groups, *i.e.* each of the 10 two- and 32 three-dimensional point groups is characterized by its Hermann–Mauguin and Schoenflies symbols, a pair of stereographic projections (one displaying a general form and point form and the other with the framework of the symmetry elements), matrix representation of the group-symmetry operations, as well as general, special and limiting forms classified into Wyckoff positions; even the symmetries of special projections are added. There is also a useful table which reviews the 47 face forms and point forms, taking into account their eigensymmetries and occurrence in the crystallographic point groups. Subgroups and supergroups of the crystallographic point groups are also discussed and depicted in the form of family trees for two and three dimensions. As an extension of the concept of geometric crystal classes the 'general classes', *i.e.* the classes of non-crystallographic point groups, are considered and classified into systems for two and three dimensions. For one of these systems, icosahedral, two of its point groups are tabulated in the same manner as the crystallographic point groups. This section is concluded with a brief but informative survey of the relation between point-group symmetry and physical properties of crystals with two very clear and elegant tables: one on the occurrence of specific physical effects and the other on polar and non-polar directions in the 21 non-centrosymmetric crystal classes.

The whole of Section 10 seems to us very important in view of the recent revival of crystal morphology in connection with the development of crystal physics.

The only confusing fragment is that on p. 766 (in the right-hand column below the diagram of the 23 point group). It concerns the block arrangements of the Miller indices for the cubic point groups. The text suggests that for each of these groups four blocks can be found, but in fact all four of them are present only in the groups $\bar{4}3m$ and $m\bar{3}m$. Only two blocks are in 432 (left and right block) and $m\bar{3}$ (upper and lower block) while in 23 only one block exists. It seems to us that the description of this arrangement should start with the group type of the highest symmetry and then the blocks in each of the groups should be enumerated.

We also noticed a kind of inconsistency in regard to the names of the prismatic point forms given in Table 10.2.2. The statement on p. 767 that prisms are among the open forms seems to contradict the next sentences ('A point form is always closed') because some point forms are listed in the table as 'prisms'. Accordingly, we think that the name of a prismatic point form, such as the *tetragonal prism* of

$8c1$ in $4/m$ (p. 754), should be completed with 'cut off by pinacoid', as given for other point forms; or a statement should be added that in the case of point forms the term 'prism' means a closed form.

As to the references in this section, we would prefer, instead of the mention of 'the well-known books by H. S. M. Coxeter', a few chosen references to the newest editions of these books.

Section 11 (W. Fischer, E. Koch & H. Arnold) sums up the matrix approach to symmetry operations with many examples and a very convenient table which collects all matrices for point-group symmetry operations taking into account the orientation of corresponding symmetry elements referred to in the seven Bravais coordinate systems.

Section 12 (H. Burzlaff & H. Zimmermann) reveals the information hidden behind the space-group symbols, among them the properties of international symbols in comparison with other notations such as those invented by Schoenflies, Shubnikov, Hermann and Mauguin. The most impressive is the huge table which consists of standard space-group symbols in different notations and of the symbols given in 1935 and present editions of *IT*, with useful comments. An interesting novelty is the remarks on the formal matrix approach to the systematic absences.

However, in one case the authors do not follow the notation adopted throughout the whole volume and given in Section 5 (p. 70) for the matrix $\mathbf{w} = (w_1/w_2/w_3)$. Instead they use $(w^1/w^2/w^3)$, which seems rather infelicitous. We would also replace the sentence (p. 796): 'For centred cells the vectors to the centring points are given first' by 'For centred cells the centring vectors are given first'.

Section 13 (Y. Billiet & E. F. Bertaut) gives a detailed discussion on isomorphic subgroups of space groups. For each plane- and space-group type the explicit forms of the transformation matrices from the conventional unit cell to the basis vectors corresponding to an isomorphic subgroup are given. This is arranged in two steps: the first reveals the restrictions imposed on the matrix coefficients by the space-group symmetry and the other lists the derived matrices according to the order of the space-group numbers in *IT*.

There are several slips which should be corrected:

(i) instead of the determinant symbol $|\mathrm{Det}\ \mathbf{S}|$ (p. 810, left column) we would suggest 'det ($\mathbf{S}$)' as *e.g.* in Section 11 (p. 789) or '$|S_{ij}|$';

(ii) the missing number '(3)' for the general expression of the matrix $\mathbf{S}$ (p. 810, the top of the right column) should be added, because there is a reference to it on p. 811 (right column, line 9 from the bottom);

(iii) the space-group symbol, $P4/mmc$ (p. 812, left column, line 2 from the bottom) should be changed to $P4/mcc$.

Section 14 (W. Fischer & E. Koch) introduces for the first time the idea of lattice complexes into *IT*. This is very important for many applications such as the study of the geometrical properties of point configurations and relationships between different crystal structures. Characteristic features of lattice complexes are discussed and their descriptive symbols are given in each plane- and space-group type. The descriptive symbols of lattice complexes look rather complicated, but the authors point out several useful properties of these symbols.

In the text describing Tables 14.1 and 14.2 (p. 844, left column) we read '...the Wyckoff letter (column 1), the multiplicity (column 2)...', which contradicts the layout of this table where the Wyckoff letter is in column 2 and the multiplicity in column 1.

Taken as a whole *International Tables for Crystallography*, Vol. A, *Space-Group Symmetry* (1983) is an excellent well of information organized in a clear and coherent manner, with a great deal of internal consistency. It seems to us that the misprints are remarkably few considering the size and complexity of this volume of *IT*. The references to the literature contain the titles of papers which is very helpful for users. The thoroughness with which they have been prepared is quite impressive. In the Subject Index one can find, without much difficulty, most of the terms used in the book. Last but not least, the creamy background of the print and its good quality makes reading easy except for the 'heights' above the projection plane indicated on the cubic space-group diagrams, which are very faint. Unfortunately, the cover of the book, of beautiful blue colour with golden letters, does not seem to be joined well enough to the heavy bulk of almost 900 pages, so it is not too suitable for frequent use.

Thinking about future editions of *IT*, (i) we feel a necessity to consider a symmetry treatment suitable for describing the phases intermediate between nematic and crystalline, *i.e.* the cholesteric, blue and smectic phases [a complete classification through the combination of the continuous and discrete groups has been published by Kléman & Michel (1978)], (ii) we suggest the introduction of a uniform mathematical approach to ordered media with the use of rigorous definitions of vector space, point space, and their transformational properties [it seems to us that the concept of condensed matter could be further developed on the basis of papers by Michel (1980) and Thom (1981)], and (iii) it might also be fruitful to take into account the possibility of derivation of the space groups from Lie groups as their discrete subgroups, as was done by Raghunathan (1972).

KATARZYNA M. STADNICKA
BARBARA J. OLEKSYN
KRZYSZTOF Z. SOKALSKI

Jagiellonian University
Kraków
Poland

Editorial note: A list of some twenty errata is supplied by the publishers with the book; a table listing other typographic errors is obtainable from the authors of this review.

References

FISCHER, W., BURZLAFF, H., HELLNER, E. & DONNAY, J. D. H. (1973). *Space Groups and Lattice Complexes. Natl Bur. Stand.* (*US*) *Monogr.* No. 134, p. 1. Washington, DC: National Bureau of Standards.

KLÉMAN, M. & MICHEL, L. (1978). *Spontaneous Breaking of Euclidean Invariance and Classification of Topologically Stable Defects and Configurations of Crystals and Liquid Crystals. Phys. Rev. Lett.* **40**, 1387–1390.

MICHEL, L. (1980). *Symmetry Defects and Broken Symmetry. Configurations. Hidden Symmetry. Rev. Mod. Phys.* **52**, 617–651.

OPECHOWSKI, W. & DREYFUS, T. (1971). *Classification of Magnetic Structures. Acta Cryst.* **A27**, 470–484.

OPECHOWSKI, W. & GUCCIONE, R. (1965). *Magnetic Symmetry.* In *Magnetism*, Vol. IIA, edited by G. T. RADO & H. SUHL, pp. 105–165. New York: Academic Press.

RAGHUNATHAN, M. S. (1972). *Discrete Subgroups of Lie Groups.* Berlin–Heidelberg–New York: Springer-Verlag.

THOM, R. (1981). *Mathematical Concepts in the Theory of Ordered Media. Proceedings of* XXXV *Summer School Session, Les Houches*, 1980, edited by R. BALION, M. KLÉMAN & J.-P. POIRIER. Amsterdam: North-Holland.