13.22 g; in Milan, 9.8 g; in Venice, 0.20 g. Or consider the market weight called the stone. In Amsterdam it was 3.95 kg; in Berlin the heavy stein was 10.28 kg and the light stein was 5.14 kg; in Sweden it was 13.56 kg; in Vienna it was 11.20 kg. In England the stone for fish or meat was 3.63 kg; the stone for glass was 2.27 kg; the stone for wool was 6.33 kg. There was the pharmaceutical pound of 12 ounces and the market pound of 16 ounces, and so on, for all the various units of weight of different commodities and places.

Vital to the exchange of goods and money were the master weighers and the money changers. Attempts to fix exact weights appear in most of the great lawgiving documents of history. For example, the Bible repeatedly admonished that the merchant should not keep a heavier set of weights for buying and a lighter set for selling; the Magna Carta declared that weights and measures should be uniform and in accordance with the law, as had Charlemagne so decreed. To establish such uniformity standard weights were kept, in ancient times, in the temple, and in medieval times and later, in the town hall. The master weigher of the Middle Ages several times a year would compare the merchant's weights with the standard city weight. Makers of balances and weights also were members of the organic medieval society: they had a guild of their own, with, at least in Paris, St. Michael for their patron.

The money changer, who was just as much money weigher, set up his booth in the marketplace, with his own kind of scales for the rapid evaluation of true weight. In some communities it was forbidden for anyone else to have such scales, with heavy penalties imposed (up to the loss of a hand) for violators of the law. A sharp-eyed changer, besides detecting clipped money, could also detect coins that might be too heavy, which excess would go into his own coffers. Money changers were apt to become embryonic capitalists; money would be deposited with them for temporary keeping, and one account of the de Medici family points to such a beginning of their wealth.

During the 18th century the scientific revolution was bearing its first fruits. New uses for balances were finally discovered by experimenters, and instead of being made by guild members, balances were increasingly made by instrument makers. Physicists more and more were turning their attention to improving the efficiency of the instrument. By that time, the descendants of the gnomon were in turn being replaced by the more efficient telescope. Then in the 19th and early 20th century the balance became the fundamental instrument of the laboratory, and it was exploited as never before. Today it is only one of the many instruments in the arsenal of the experimentalist.

Regrettably, only patches of the rich history of scales and weights appear in the book under review. The subtitle of the work—*A Historical Outline*—is misleading. The author makes few attempts to undertake the historian's task—that of resolving and evaluating conflicting opinions so as to give to the reader a neatly sewn fabric in which the relevant historical facts are matched and integrated into a pattern of causes and effects. Instead, the author has presented only fragments of the whole story, and mostly for the merchant's balance from the period before the 19th century. Although the reference apparatus is excellent—the book is well and profusely illustrated, and there is a 14-page bibliography—the text of the book is incompletely organized and, at times, vaguely written. However, the book can provide entertainment and pleasure for the browsing reader with an antiquarian interest who wishes to learn something of the art of weighing in past times.

CRYSTALS FOR STUDENTS

CRYSTALS PERFECT AND IMPERFECT. By Allan Bennett, et al. 237 pp. Walker, New York, 1965. $5.95.

by H. M. Otte

"Our understanding of crystals will not be complete until we can predict the properties of a crystalline system from first principles, and until we have the technical ability to produce a theoretically possible crystal struc-

PHOTO BY JOHN MCKENZIE FOR WESTINGHOUSE RESEARCH LABS

SCREW DISLOCATION AND GROWTH SPIRAL ON A SiC CRYSTAL. From CRYSTALS PERFECT AND IMPERFECT.

ture whenever we want or need it." This view, summing up the attractive little book by scientists of the Westinghouse Research Laboratories, presents the ambitious goal of much current research in materials and solid-state physics. The hope is that it may be achieved one day.

The authors have placed emphasis throughout the book on the single crystal in the belief that an understanding of it is a necessary preparation for greater problems, such as the study of aggregates of single crystals and the behavior of impurities in crystals.

The initial part of the book deals with the morphology of crystals and associated symmetry properties. This part of crystallography was extensively developed by 18th- and 19th-century mineralogists such as Haüy (1743-1822) and Miller (1801-1880). With the discovery of x rays at the turn of the last century, the discipline became also the domain of physicists who made numerous important contributions involving the diffraction and scattering of x rays and other radiations (electrons and neutrons) by crystals. This is presented in a simple but effective way in the third (and last) part of the book, as is the treatment of lattice vibrations (chapter 9). From physicists came also the concept of crystal (or lattice) imperfections, perhaps the single most important concept in the study of crystals today. A well illustrated description of this concept is included in the first part of the book.

The middle part of the book is concerned with theories and techniques of crystal growth. The importance of this activity is expanding dynamically. It has progressed a long way from the simple experiments of growing alum crystals to the sophisticated procedure required for making synthetic diamonds or preparing electroluminescent SiC crystals. (A color photograph of some of these crystals is on the jacket of the book.)

At the back is a comprehensive index, as well as portraits and thumbnail biographies of the five authors who contributed to the book. They are Allan Bennett, Donald Hamilton, Alexei Maradudin, Robert Miller and Joseph Murphy. The contents page at the front clearly indicates who wrote which chapters.

The Appendix also contains a list of addresses from which can be obtained information pertaining to mineral sources, geological surveys and maps; it includes a short list of books for those who wish to dig deeper; and a few pages give six-line descriptions of "certain scientists" who have been associated in one form or another with advances in crystallography and related fields. Such biographical "footnotes" add human interest and are a most pleasant asset, even in an erudite scientific treatise. However, with essentially the last two centuries to draw upon, and with fewer than forty names included, the authors have been, needless to say, highly selective. The omissions of many names, such as that of Sir G. I. Taylor, are easy to cite.

The text is on the whole elementary, and all the drawings are in general well done and clear. Many of the photographs, however, especially those of crystals, suffer seriously in effectiveness and appeal by not being in color, as a comparison between the photograph in color on the jacket and the same in black and white opposite the title page clearly demonstrates. Undoubtedly the price of the book would have had to be increased substantially to correct this.

The volume is one in a series of Westinghouse Search Books designed to go beyond the scope of standard textbooks, supplementing in an introductory fashion conventional courses in the physical sciences and emphasizing the interrelationship of the scientific disciplines. The objective is achieved with commendable style and a vigor that should enlist many a young enthusiast in this dynamic new branch of science.

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H. M. Otte is a member of the staff of the Martin Company's Materials Research Center at Orlando, Fla.

A STUDY OF NEAREST SPACE

SOLAR SYSTEM ASTROPHYSICS. By John C. Brandt and Paul W. Hodge. 457 pp. McGraw-Hill, New York, 1964. $12.50.

by E. J. Opik

With our rapid progress in the exploration of nearest space, a textbook of solar system astrophysics on an intermediate university level is highly welcome. Students with a background

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Professor Opik is a member of the Department of Physics and Astronomy at the University of Maryland and is on the staff of the Armagh Observatory in Northern Ireland.