Polymer Science—Recent Books

The death of Hermann Staudinger on 9 September 1965 brought to mind the tremendous advances that have occurred in the science of high polymers since 1920 when Staudinger began a vigorous effort, which lasted a decade or more, to gain general acceptance of the idea of the existence of linear macromolecules with normal covalent linkages. Books relating to polymers as such did not appear previous to the publication of *Der Aufbau der hochpolymeren organischen Naturstoffe* (Meyer annd Mark, 1930) and *Die hochmolekularen organischen Verbindungen* (Staudinger, 1932). Meyer and Mark's book appeared in two volumes in a second German edition (1939–1940) and in an English edition (1940–1942). Since that time the number of new volumes devoted to this field has increased almost every year.

Although the five books reviewed here are quite different in scope and coverage, they are some of the most important books on polymers published during 1965: **Polymers: Structure and Bulk Properties** [Van Nostrand, Princeton, N.J., 1965. 392 pp., $12.50], by Patrick Meares; **Aging and Stabilization of Polymers** [Consultants Bureau, New York, 1965. 375 pp., $25], edited by M. B. Neiman; **Condensation Polymers: By Interfacial and Solution Methods** [Interscience (Wiley), New York, 1965. 579 pp., $25], by Paul W. Morgan; **Crystalline Olefin Polymers**, pts. 1 and 2 [Interscience (Wiley), New York, ed. 2, 1965. pt. 1, 1017 pp., $32.50, and pt. 2, 689 pp., $22.50], edited by R. A. V. Raff and K. W. Doak; and **Metalorganic Polymers** [Interscience (Wiley), New York, 1965. 381 pp., $12.75], by K. A. Andrianov, translated by Scripta Technica and edited by D. C. Bradley.

Specialization, obviously necessary, has proceeded to such an extent that only one book (that by Meares) attempts to cover the structure and bulk properties of all polymers. Even here, many topics, including the properties of polymers in solution, can be given only passing reference. Of the other books, one deals with a single group of properties (aging and stabilization) of all polymers, while the other three books are concerned with the properties of a single group of polymers (condensation polymers, crystalline olefin polymers, and metal-organic polymers).

Meares, senior lecturer at the University of Aberdeen, with two decades of experience in teaching advanced students, has prepared a well-organized and coherent summary of knowledge in the fields he covers. Modern ideas regarding stereoregularity in polymers and chain folding in crystals are introduced at the outset. Chapters are devoted to basic methods of polymerization and microstructure, and then attention is given to molecular weight distribution and branching. Two chapters devoted to crystallization precede five chapters that deal with viscoelasticity and rubber-like elasticity, with attention to both the thermodynamic aspects and the practical aspects. The remaining chapters discuss flow, the glass transition, and the diffusion of gases and vapors in polymers.

The book is characterized by the unity and coherence made possible by single authorship and presentation in lecture form during several years. Individual chapters, each followed by literature references and a list of symbols, are understandable as separate articles by those who have a general familiarity with the field. The references themselves are detailed and well selected. Author and subject indexes are included. The previous books most closely related to Meares's *Polymers* in scope are those by Tobolsky (1960) and F. Bueche (1962).

Aging and Stabilization of Polymers, edited by M. B. Neiman, is an English translation of a Russian text (1964) written by 16 Soviet specialists in polymer degradation and stabilization. The most familiar names among the authors are those of V. A. Kargin, A. A. Berlin, K. A. Andrianov, A. S. Kuz'minskii, G. L. Slonimskii, and M. B. Neiman.

A discussion of the mechanism of thermo-oxidative degradation and stabilization precedes a treatment of inhibitors and their synthesis. The aging and stabilization of seven different types of polymers are then examined in detail. The types are polyolefins, polyformaldehyde, polyvinyl chloride, polyamides, several condensation polymers, polyorganosiloxanes, and unvulcanized and vulcanized rubbers.

The references number more than 1000, including patents. As one would expect, the Soviet literature is particularly well covered. There are many references to original work by American and British authors, but references to review articles and books are lacking. For example, in the field of rubber there is no mention of the book by Buist (1956), the A.S.T.M. Symposium on Aging (1949), the A.S.T.M. Symposium on the Effects of Ozone on Rubber (1958), the National Bureau of Standards Symposium on Polymer Degradation Mechanisms (1953), or Shelton's article in *Rubber Reviews* (1957). Where reference is made to books translated from English into Russian, the translators should have given the original references as well as the Russian references. The book is not indexed.

The Polymer Reviews Series was initiated to give an author an opportunity to present personal views and theories while a given field is in a state of development. Morgan, of the DuPont Company's Textile Fibers Department, is the author of volume 10 of this series, *Condensation Polymers*. He limits the subject matter to those condensation polymerizations and hydrogen transfer polymerizations that can be carried out below 100°C and lead to essentially linear polymers. The book deals with interfacial polycondensations in unstirred and in stirred systems, as well as solution polycondensations, before discussing the formation of specific polymers. More than 1200 different polymers have been prepared by these methods, and particular attention is given to polyamides, polyureas, polyurethanes, polysulfonamides and polyphosphonamides, and polyesters. The continuous formation of a polyamide by interfacial polymerization (sometimes called the "Nylon Rope Trick") was popularized by Morgan several years ago. This well-indexed book is a model of prompt publication, with a preface dated February

1965 and a 7-page appendix devoted to references that appeared in 1964.

Polyethylene, a book by Raff and Allison, was published in 1956. Developments since that time have been so extensive that the version which supersedes the earlier book is the work of 38 authors, appears in two parts, and is entitled *Crystalline Olefin Polymers*. The first part contains eight chapters devoted to polymerization and an equal number to structure. The second part contains chapters on brittleness, stress-cracking, electrical properties, and permeability, as well as chapters on chemical modification, degradation and stabilization, processing, and applications. Polyethylene in its various forms receives the major emphasis of course, since it has received by far the greatest commercial development.

This monumental treatise should prove to be of the greatest value to all who are interested in these polymers. As a group effort of American research workers (one chapter is by Dutch authors) it demonstrates the intense activity, and the importance, of the recent developments in this area. On the whole it is well organized and well written. Extensive indexes, arranged by authors, by subjects, and by patents, are provided for each part.

Polymers containing both metallic and organic groups are the subject of *Metalorganic Polymers*, an English translation of a Russian book by K. A. Andrianov of Moscow's Institute of Elemento-Organic Compounds (the name given these polymers in the Soviet Union). The author is well known as the holder of a Soviet patent (1937) relating to organosiloxane polymers. From literature published up to 1961, he has reviewed the synthesis and properties of polymers in which the backbone is formed by coupling the electronegative elements oxygen, nitrogen, or sulfur with elements of slightly lower electronegativity such as silicon, germanium, tin, lead, boron, aluminum, phosphorus, arsenic, antimony, or titanium. Carbon, if present, is only in side groups and not in the main chain. Of these polymers, the polyorganosiloxanes are by far the most highly developed and receive the greatest attention. The polyaluminoxanoorganosiloxanes (based on a skeleton of aluminum, silicon, and oxygen atoms) are next in importance. Most of the remaining polymers considered also contain silicon and oxygen with the other inorganic elements just mentioned replacing the aluminum in the skeleton.

The book is particularly complete in its summary of the work of Andrianov and his collaborators, which has previously been available only in several hundred separate papers. Like the book edited by Neiman, it includes many references to non-Russian papers but very few to books or reviews, and it is not indexed.

As a group, these books demonstrate the remarkable diversification and specialization that has occurred in the field of polymers during the past 30 years. Staudinger could hardly hope to have comprehended, or even to have been interested in, all the details covered in these books, but he should have been deeply moved by the massive structure of scientific knowledge that has developed from the fundamental ideas that he introduced 40 years ago.

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History of Technology

A Short History of Machine Tools. L. T. C. Rolt, M.I.T. Press, Cambridge, Mass., 1965. 256 pp. Illus. $7.50.

Although the standard symbols of the Industrial Revolution are the steam engine and the textile machine, it is evident to those who have a technical background that machine tools are required to build machines of metal. It can be argued fairly that machine tools are of central importance to an industrial complex and that in order to understand how we came to be where we now are we should be well informed about the development of machine tools. Nevertheless, this book is the first comprehensive history of machine tools to appear since Joseph W. Roe's pioneering book *English and American Tool Builders*, which was published in 1916. Rolt, an English author who has written more than a dozen competent books on technological history and who served an apprenticeship in a machine shop, has brought together in this book practically all significant published findings of scholarly work in the field. The work is one of synthesis, and with few exceptions it is based on books and articles.

The modern conception of a metal-cutting machine tool appeared unmistakably in 1775 in the boring mill of the Englishman John Wilkinson. By making possible the boring of the first satisfactory steam cylinder, this mill supplied the crucial ingredient to the success of the Boulton and Watt steam engine. The steam engine, as it hastened the industrialization of the United Kingdom, helped to encourage the development during the first third of the 19th century of the modern lathe, planing machine, milling machine, and drill press. During this period nearly all of the significant developments that we know anything about occurred in England.

This early period, which occupies half of the book, lends itself to biographical treatment of the tool builders. For example, Henry Maudslay, a craftsman of exceptional skill, dominated English tool building until his death in 1831. Some of his pupils, most notably Joseph Whitworth, who became the leading English tool builder of the following generation, adopted and extended Maudslay's ideas on precise measurement, standardization of screw threads, and general integrity of design and workmanship. In following the lives of the builders, however, Rolt never strays from his central subject, which is the internal development of the tools.

In the latter half of his book Rolt turns his attention, for the most part, to American contributions, which included the turret lathe, grinding machine, and many special-purpose machine tools especially adapted to the sequential operations required for mass production of interchangeable parts.

The book is well written, but the reader who does not have full command of mechanical nomenclature will find it heavy going in the many detailed descriptions of machine elements and assemblies. Such details are necessary, but simple sketches, keyed to the text, would have made the reader's task easier. Unfortunately, text descriptions are not keyed to pictures even when the latter are provided. On page 172 there is a long description of a machine and a photograph of that machine is given on page 185, but on neither page is there a reference to the other. At the very least, an illustrated glossary should be supplied.

In spite of the author's unusual qualifications, he has not questioned a considerable number of conclusions that for years have needed examination. It is disconcerting to have so able an author repeat standard phrases which, although not completely wrong, are far from