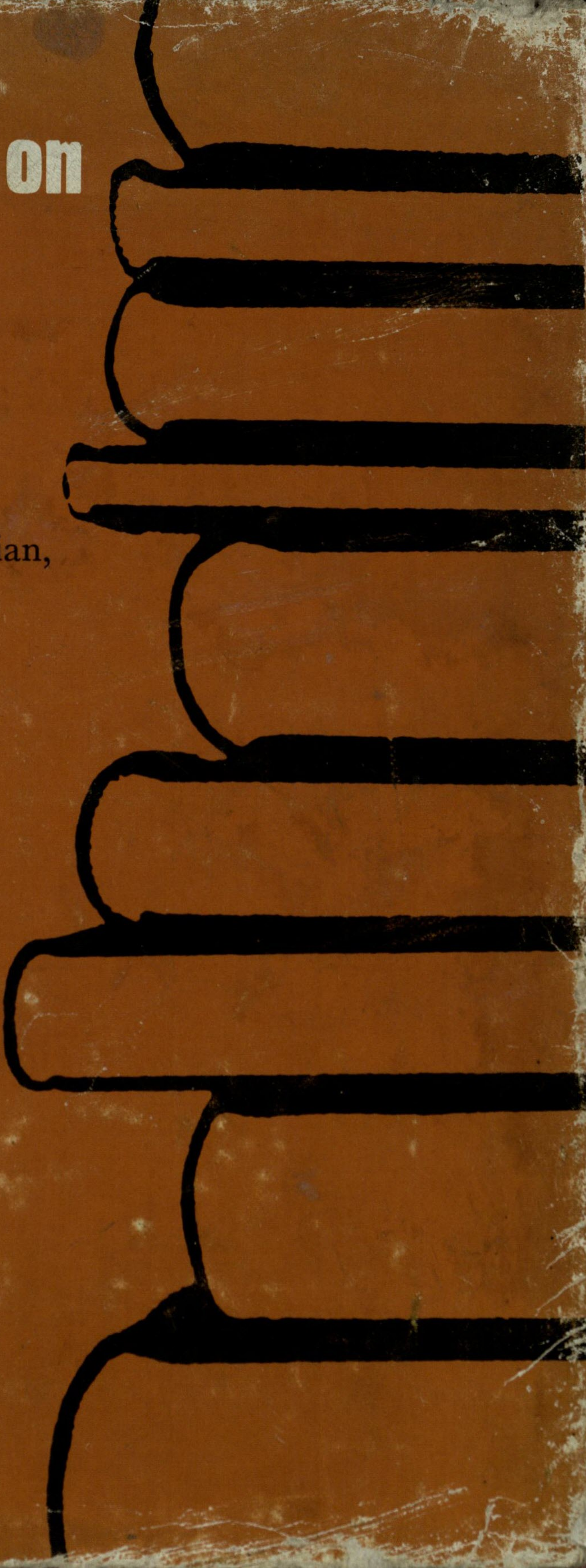
SOURCES OF INFORMATION ON THE RUBBER, PLASTICS AND ALLIED INDUSTRIES

E.R. Yescombe, Librarian,
Northern Polytechnic,
London



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Sources of Information on the Rubber, Plastics and Allied Industries

E. R. Yescombe, Librarian,
Northern Polytechnic, London

This monograph provides a detailed comprehensive annotated guide to the combined literature of plastics and rubber and the many organisations that originate polymer information. Many recent changes have taken place in the literature, which has undergone an explosive growth including computer and other information retrieval techniques, which are discussed in special and other chapters.

National, international and inter-government sources of information are discussed in detail, followed by published sources of information, including general, commercial, statistical and economic information; patents, trade marks and trade names.

A guide is given to the literature of polymer science, including polymer chemistry, physics and rheology; natural and synthetic materials, both for rubbers, plastics and also compounding ingredients and processing aids; plant, processing and treatment. Standards, testing, technical data and quality control. Examples of selected applications are given under headings of adhesives; use of plastics and rubber in building and engineering: mechanical rubber goods; packaging and paints and coatings.

Welfare and safety aspects are covered in the chapter on safety, fire hazard, toxicity and industrial health. A chapter for librarians deals with classification, coding and information retrieval. The book concludes with the general guide to education and training both in the United Kingdom and the United States in detail, with a review of education in Europe.

This is a field in which literature and sources of information are expanding and changing rapidly and the author's comprehensive and informed guide will prove invaluable.

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GENERAL EDITOR: G. CHANDLER

VOLUME 7

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SOURCES OF INFORMATION ON THE RUBBER, PLASTICS AND ALLIED INDUSTRIES

BY

E. R. YESCOMBE, F.L.A.
Librarian, Northern Polytechnic, London

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INTRODUCTION

The need has been felt for many years for a comprehensive annotated guide to the literature of plastics and rubber, and to the many organizations that originate polymer information.

Recently many changes have taken place in the literature, which has undergone an explosive growth, and computer and other information-retrieval techniques are now being used. The polymer educational front is undergoing extensive changes and a Rubber and Plastics Processing Industries Training Board is being formed. More and more people need to know about plastics and rubbers.

The present work began as lectures given to special librarians at the North-Western Polytechnic, and to tutorial groups of rubber and plastics students from the National College of Rubber Technology using the Northern Polytechnic Library. Some of the work originated in the form of technical information first-aid given to enquirers and users of the Library from the industry. In 1963 an exhibition of polymer literature was staged in the National College, and there was a considerable demand for the specially prepared catalogue. Over the years various polymer bibliographies were compiled including one for the "Plastics Centenary". The author's paper on Polymer Literature and Sources of Information attracted some attention at a Symposium on Chemical Literature (Borough Polytechnic, 1966).

No guide of this kind can hope to be exhaustive, but every effort has been made to include all important sources and to describe them accurately up to the end of January 1967. No doubt there are omissions and errors, and the author would be glad to have these brought to his attention.

An attempt has been made to cater for the needs of those who are familiar with the industry and those who are not. Interpolations have been made in the text for the benefit of those who are not familiar with the industry, but these should not unduly distract the scientific or technical reader, who wishes to use the book as a straightforward guide to sources. The lack of accessible polymer literature collections has also been borne in mind, and annotations are fairly detailed and where possible prices have been indicated to assist librarians and others. Many of the works cited can be borrowed from the National Lending Library for Science and Technology, Boston Spa, Yorkshire, through approved libraries. It should be noted that some items are of a semi-restricted nature, but industrial membership of the Rubber and Plastics Research Association of Great Britain (RAPRA), the leading

PART 1

THE POLYMER INDUSTRY

CHAPTER 1

THE POLYMER INDUSTRY

THE materials which we know as plastics, resins, rubbers, natural and synthetic fibres, surface coatings and adhesives, can all be called *high polymers* or macromolecular products. They are all materials of high molecular weight of from 10,000 and upwards, and even one million. The most valuable properties of natural and synthetic polymers arise from their high molecular weights. The nature of the polymer, whether it is rubberlike, plastics or fibrous is determined by the detailed shape and chemical structure of the molecule.

The dividing line between these different members of the high polymer group is becoming less and less distinct as polymer science develops and illuminates the essential unity of the group. The technologies also have a great deal in common, and this is particularly so as between rubbers and plastics practice. Compression and injection moulding processes are used in both industries, as are extrusion and calendering, and the same polymeric materials serve as raw materials for both.

It may be said that the difference between rubbers and plastics is essentially one of temperature. Natural rubber at normal temperatures exhibits its well-known rubbery character. At low temperatures, say −40°C and below, it becomes hard, rigid and brittle. Polystyrene, on the other hand, is normally hard, rigid and brittle, but when heated to 100°C it becomes rubbery. Fundamentally then rubbers and plastics are the same type of material, but of course their differences are equally real and have in the past led to quite separate industries.

Plastics and rubbers are now dealt with collectively for the purpose of education, research and for many scientific and professional activities. Out of all this is emerging a new greatly extended *polymer industry* with added impact and prestige. The two industries, then starting from widely separated points, have extended their activities over a wide area, and in doing so find that not only do they overlap, but in some sectors they have become inextricably mixed. Rubbers and plastics are no longer rivals but are the raw materials of one great expanding industry.

The polymer industries of the world, comprising rubbers, plastics and synthetic fibres, have grown more rapidly this century than any other branch of the chemical industry. Already they are larger than the

PART 2

NATIONAL SOURCES OF INFORMATION (GENERAL) AND INFORMATION SOURCES IN THE BRITISH COMMONWEALTH

CHAPTER 2

INFORMATION SOURCES IN THE BRITISH COMMONWEALTH

General Note

In 1960 some 335 organizations in forty-four countries were recorded as being connected with the rubber, plastics and allied industries.[1] Some changes in name and scope have occurred since then, and some have ceased to exist. The *Rubber Red Book* for 1966[2] lists 121 leading technical and commercial associations and institutions in twenty-two countries of interest to rubber manufacturers. Details of some of these organizations now follow with details of their publications. Specialized organizations will be listed in later specialist chapters, and others can be traced in the various directories listed in Chapter 7.

In the U.K., and in some other countries, there is the difficulty of the rival attraction of specialist societies and associations in the polymer field. Amalgamation might well be the answer. The Institution of the Rubber Industry and the Plastics Institute have a Joint Steering Committee to consider closer collaboration and possibly an eventual amalgamation. Two U.K. trade organizations—the Rubber Manufacturing Employers' Association and the Tyre Manufacturers' Conference—may also become merged into one.

Information Sources in the

UNITED KINGDOM

BRITISH ASSOCIATION OF SYNTHETIC RUBBER MANUFACTURERS (BASRM), Alembic House, 93 Albert Embankment, London, S.E.1.

There are only seven synthetic rubber manufacturers in the U.K. and five are members, but they are large and powerful concerns.

BASRM formed in 1965 serves as a central body representing the whole industry, which at present has an annual turnover in excess of £40 million and a total capacity of 252,000 long tons, with a further 80,000 tons planned at the end of 1965.[3] U.K. consumption was divided into 100,300 tons for

CHAPTER 3

INFORMATION SOURCES IN THE UNITED STATES

AMERICAN CHEMICAL SOCIETY—DIVISIONS

1. DIVISION OF RUBBER CHEMISTRY INC., Box 123, University of Akron, Akron, Ohio 44304.

The Rubber Division was created in 1919 and is now the fourth largest of the twenty-five ACS Divisions. Membership (excluding affiliates) totals 2649, about 3 per cent of ACS membership.[1]

The Division has fifteen active Rubber Groups throughout the U.S.A. and two in Canada, and has a total income of $108,000. Education is an important function of the Division. Most Rubber Groups sponsor scholarships and lecture courses are held. The Division also holds correspondence courses ($30 each). The study text—Morton's *Introduction to rubber technology*[2] —was compiled from an earlier lecture course run by the Division.

The Spring and Fall Symposia Meetings are attended by 1000 members. A Best Paper award is made each year, and the Goodyear Medal award is presented after delivery of the Goodyear Lecture.

Since 1947 the Division has been sponsoring the development of a collection of rubber literature at the Bierce Library of the University of Akron. A *List of bibliographies* and a polymer abstract computerized retrieval service is sponsored by the Division and produced by the Center for Information Services, University of Akron, and a weekly *Current Awareness Bulletin* is produced (see Chapter 6, references 29–31 and 6).

The main publication of the Division is *Rubber Chemistry and Technology*, which includes reprints of theoretical and technological papers of special value, specially commissioned translations; reports of original research, and critical reviews. *Rubber Reviews* consist of invited papers. The *Bibliography of Rubber Literature* has been issued at irregular intervals since 1937 (see Chapter 6, references 58, 59 and 10).

A membership list directory for the Rubber Division is available.[1] Joint meetings of the Division have been held with the Chemical Institute of Canada.

2. POLYMER CHEMISTRY DIVISION. Secretary: Professor William Cass, Department of Chemistry, Northeastern University, Boston, Mass. 02115.

CHAPTER 4

INFORMATION SOURCES IN OTHER COUNTRIES

FRANCE

Information on French plastics and rubber organizations appears regularly in two journals—*L'Officiel des Plastiques et du Caoutchouc* and in *Revue Générale du Caoutchouc et des Plastiques, Générale Édition* (see Chapter 6, Appendix).

CENTRE D'ÉTUDE DES MATIÈRES PLASTIQUES (CEMP), 21 rue Pinel, Paris 13^{e}.

CEMP was founded in 1943 as an association of three committees covering Chemistry, Electrical Construction and Various Industries. It changed in 1945 to a professional association and is financed from producer syndicate subscriptions, Interprofessional Action Group (GIACE)* subscriptions and from revenue from Quality mark issues, gifts and special research charges.

Programme activities are worked out by various Commissions covering Thermosets, Thermoplasts, Agricultural Plastics, etc., whilst research is carried out on a joint basis for producers and main processors. It also functions as a testing and Standards Bureau (1952–), and as a Documentation Centre. Its Library, open to the public (9 a.m.–12 and 2 p.m.–5 p.m.), includes forty plastics journals and 500 books on plastics. A card index and punched card retrieval system is employed. Technical consultations are given to GIACE members free of charge, but are also free to the public if they require only a short interview.

Its equipment and laboratories (including some outside associated laboratories) are also used for educational and research purposes. The Director, M. M. Pierre Dubois, holds the Chair of Plastics of the Conservatoire National des Arts et Métiers. Courses at the Centre include practical work (evening courses), a 1-week holiday course for 120 to 150 engineering students and some five to eight engineers prepare each year theses for Engineer Doctorates of the University. The Association for Organizing Courses for Overseas Technologists in French Industry send engineer students of various nationalities for holiday courses to the Centre for periods of from 4 to 6 months. The Chair also contributes to the organization of colloquia on plastics, including "Plastics in agriculture".[1]

* GIACE = Groupement Interprofessionnel d'Action.

PART 3

INTERNATIONAL AND INTERGOVERNMENT SOURCES OF INFORMATION

CHAPTER 5

INTERNATIONAL ORGANIZATIONS

SOME of the National societies and organizations have achieved an international reputation. In addition there are a number of international and inter-government organizations:

INTERNATIONAL INSTITUTE OF SYNTHETIC RUBBER PRODUCERS, INC.

54 Rockefeller Plaza, New York, N.Y. 10020.
European Office for the five European Members: 49, square Marie-Louise, Brussels 4, Belgium.

The rapid development of the synthetic rubber industry throughout the world in the 1950's established the need for this organization formed in 1960, to promote and further the interests of manufacturers of synthetic rubber polymers, and also the interests of the general public in manufacturing, engineering and other aspects of the synthetic rubber industry. Membership includes twenty-one companies in seven countries. Sponsored research is being carried on at Osaka University, Japan; at the University of Mainz; at the Rubber Research Institute at Delft, and at the University of Akron, Ohio.

The Nomenclature Group has taken over from the American Society for Testing Materials the assignation of numbers to new SBR polymers, and also for new stereo and related rubbers.[1]

A $2500 Bancroft W. Henderson scholarship is awarded by the International Institute of Synthetic Rubber Producers.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO), GENEVA

The work of this branch of the United Nations Organization is discussed in Chapter 15.

INTERNATIONAL RUBBER RESEARCH AND DEVELOPMENT BOARD

19, Buckingham Street, Adelphi, London, W.C.2.

PART 4

PUBLISHED SOURCES OF INFORMATION

THE published literature on polymers is widely scattered through a very large number of books, journals, conference proceedings, pamphlets, technical trade literature and catalogues, standards, specifications and other documents, since many more subject fields are now involved.

In recent years the Niagara of books on rubbers, plastics and man-made fibres has continued unabated, the flow, in part reflecting the growing body of knowledge relating to the fundamentals of the subject, the new emergent materials, and the ever-growing applications of old and new polymer materials. More and more people are finding it necessary to have a working knowledge of what plastics and rubbers are, and what they can do. Hence books at various levels and for various requirements are being produced.

There is evidence of unnecessary duplication and dispersal of effort resulting in a confusing array of overlapping services. Some fifteen years ago there was an acute shortage of text-book literature, and technical trade literature was often used as a substitute. Today many of the post-war literature gaps have been filled, but some are not yet adequately covered, or are poorly served, especially those concerned with the manufacture of products.

To keep track of developments is difficult enough for the polymer specialist, whilst those who are not so skilled in the art, the position appears more of jungle than an orderly field.

CHAPTER 6

RUBBER AND PLASTICS IN GENERAL

ABSTRACTING SERVICES

For those who endeavour to keep up to date by reading technical articles, much of the burden can be eased if use is made of the abstract journals. These serve as a means of locating information in original literature for retrospective searching and to alert readers to the latest developments. In the polymer field there is a variety of such services in English and in other languages. These fall roughly into three groups, those covering the whole of the polymer field, those covering the broader chemical and scientific field, and those covering selected parts of the polymer field. In addition, many polymer journals include a selection of abstracts, and some include a summary of their own articles in three or four languages.

The longest continuing specialized service covering rubbers and more recently plastics now appears as twin monthly abstract journals—*Rubbers: RAPRA Abstracts*[1] and *Plastics: RAPRA Abstracts.*[2] *Plastics Abstracts*[3] has appeared weekly since 1959, whilst *Polymerics*[4] provides a select monthly coverage concentrating on commercial and industrial matters.

Resins–Rubbers–Plastics[5] provides detailed "graphic" abstracts, first in fortnightly loose-leaf form with a monthly *Title list of world polymer literature*, and later in selected bound annual yearbook form with indexes.

Two polymer abstract computer retrieval services have begun, and two more were scheduled to start for January 1967. The CIS Center for Information Services, the University of Akron, Ohio, provides a weekly *Current Awareness Bulletin*[6] for the Division of Rubber Chemistry of the American Chemical Society. Engineering Index Inc., in co-operation with the Society of Plastics Engineers, has begun a pilot study computer retrieval system producing *Engineering Index Plastics Section.*[7] A similar project is being carried out for the electrical–electronics field. The project receives partial support from the National Science Foundation and the Engineering Foundation.

Polymer Science and Technology POST[8] is the new polymer-information service announced by Chemical Abstracts Service. The new computer-based service appears in two parts: POST-J, covering journals and government report literature, and POST-P, covering patents from twenty countries (see Chapter 8, reference 6). These appear alternately on a bi-weekly basis in both printed form and on magnetic tape suitable for machine searching.

CHAPTER 7

COMMERCIAL AND ECONOMIC INFORMATION

SOURCES of technical information have been described in some detail, but there is also an equal, if not greater need for commercial and economic information required for "market research" and other purposes vital to modern industry. Many of the organizations already listed also answer commercial enquiries from their members, and some from non-members including the general public.

DIRECTORIES

Directories form one of the most frequently used quick-reference sources of information, although few libraries cover the range required for rubbers and plastics. RAPRA issued a list in 1962 of *Directories for the rubber and plastics industries*,[1] and lists were formerly issued by the British Plastics Federation before its Library closed.

International Directories

The *International Plastics Directory*,[2] together with its counterpart *International Rubber Directory*,[3] are the most used international directories. *European Plastics*[4] has less coverage and is differently arranged. *Plastics international*[5] is a desk handbook, covering both technical information and a directory. Others with international coverage include Rousset's *Recueil international du caoutchouc, des matières plastiques*[6] and *Annuaire de l'industrie du caoutchouc et de ses dérivés.*[7]

United Kingdom Directories

The *British Plastics Yearbook*[8] is the principal annual directory covering the British plastics industry. It covers technical terms and properties; materials and suppliers; addresses of firms, associations, organizations and consultants; overseas addresses; who's who; technical data and an index. The *Rubber directory of Great Britain*[9] "blue book" covers over 950 companies and has many similar features, but its revision is much less frequent. The

CHAPTER 8

PATENTS, TRADE MARKS AND TRADE NAMES

THE purpose of patents is to secure the commercial advantage of monopoly. Patents specifications form an important source of information. Some 6000 patent specifications are published weekly by the most active Patent Offices in the world, about one-half having been already published in another country.[1] Many specifications published are difficult to locate solely from their titles, which are often vague or deliberately misleading. Many abstract journals contain abstracts of the more important patents in their area, even though the coverage may be by no means exhaustive. Often abstracting services are working in arrears, so much valuable time will be lost as there is only a relatively short period during which claims can be contested if infringement seems probable. Many large polymer firms have patent information sections often quite separate from their library service. There is also a need for specialized patents services. The polymer patents situation is quite complex as the industry embraces the machine manufacturer and the raw-materials supplier on the one hand, and the moulding and fabrication end-user on the other, covers many different technologies in which inventions arise. It is an industry in which patents can be valuable commercial assets. The problems of characterization and definition of polymers are also difficult.[2]

PLASDOC—Plastics and Polymers Patents Documentation[3] service started in 1966, based on the same principles as the *FARMDOC* (*Pharmaceuticals Patents*) scheme introduced by Derwent Publications Ltd. in 1963. PLASDOC speedily reports on new patent specifications of plastics and polymer interest throughout the world. It includes the five major issuing countries: U.S.A., U.K., West Germany, France and Japan; three quick-issuing countries—Belgium, Netherlands and South Africa; and Canada, Australia, the Irish Republic, U.S.S.R., and East Germany. Coverage was extended to Italy in 1967.[4] An average of 630 patents are dealt with each week in the *PLASDOC Abstracts Journal*, of which over 400 are "basic" or first-issue specifications. These receive full treatment in a 350–450-word abstract, and then are coded according to a 400-class manual classification, which forms the basis of a weekly subject index. *Company Code Cards*, consisting of IBM punch code cards, are made available for tracking down "equivalent"

CHAPTER 9

POLYMER SCIENCE

ONE reason for the amazing explosive growth of the polymer industry is due to the intense research which has in the past 30 years elucidated the mechanism of the formation of polymeric molecules from basic units, and the understanding of the relationships between structure and properties. This must be coupled with the development of technologies and machines for processing polymers for the production of goods.

The early growth of the rubber industry owed little to pure science in its development, but it reached a highly creditable level by patient empiricism. In contrast, the rapid development of the synthetic rubber industry has benefited from fundamental scientific knowledge relating to the nature of polymerization reactions and the structure of the polymers.

Billmeyer's *Textbook of polymer science* (see Chapter 6, reference 128) forms an excellent general introduction, whilst Naunton's *The applied science of rubber*,[11] and Bateman's *The chemistry and physics of rubber-like substances*,[10] are both in the more advanced category. The *Encyclopedia of polymer science and technology* (see Chapter 6, reference 94) supplements all readings. Polymer science journals are also available.[90–7]

POLYMER CHEMISTRY

The science of polymer chemistry is relatively recent. Initial pioneering work was carried out in the 1920's by Staudinger and others, but the preparation and characterization of large molecules by Carothers did not become a part of organic chemistry until the 1930's. The main reason for this was ignorance of the chemical nature of macromolecules as well as inapplicability of standard methods for their characterization.

Flory's *Principles of polymer chemistry*[1] provides the classical textbook on modern polymer chemistry theory. Numerous elementary introductions to polymer chemistry are available.[2–8] Moore's *Introduction to polymer chemistry* [9] is intended as an introduction for honours degree students to more specialized works. Besides the more advanced works already mentioned [10, 11] there are Wakeman's *Chemistry of commercial plastics*[12] and Martin's *Synthetic resin chemistry for students*.[13]

CHAPTER 10

MATERIALS, PART I: RAW MATERIALS AND INTERMEDIATES FOR SYNTHETIC POLYMERS

THE choice of raw materials from which carbon compounds can be made lies between coal and petroleum or natural gas.

PETROCHEMICALS

In the last 30 years petroleum has gradually replaced coal as the raw material for synthesis, and now most of the basic materials for synthesis are produced by the petrochemicals industry. The stupendous growth of the petroleum-chemicals industry has been possible only by a parallel growth in the polymer industries. Solvents, detergents, thermoplastics and synthetic rubbers are now manufactured from petroleum on a large scale.[1, 2, 5]

NATURAL GAS

North Sea gas is unlikely to be an economic starting point for the big tonnage thermoplastics in the foreseeable future, but the gas is likely to act as source of basic materials for the manufacture of synthetic resins (phenolics, urea and melamine) and plasticizers. The Chemicals Industry Association claims that the U.K. chemicals industry would receive great benefits from cheap natural gas used in both synthesis of materials and as a fuel—benefits almost certainly greater than would result from its use in any other industry. The methane gas can be reacted in steam to produce carbon monoxide and hydrogen, which can then be synthesized into methyl alcohol, from which formaldehyde and then synthetic resins can be made.

MONOMERS

Some fifty monomers are used industrially for the synthesis of an even larger number of polymers and copolymers. Synthetic rubber production is based on the polymerization and co-polymerization of a limited number of monomers. The monomers in principal use are the hydrocarbons, butadiene,

CHAPTER 11

MATERIALS, PART II: RUBBER—NATURAL, SYNTHETIC AND LATICES

NATURAL RUBBER

Although rubber was harvested in the Western Hemisphere long before the time of Columbus,[1] cultivated plants did not become the main source of rubber until after 1912. Seeds of the wild *Hevea braziliensis* tree were taken from Brazil in 1876 and, after germination in Kew Gardens, they were introduced by the British into the Far East. Natural rubber is generally regarded as the product of the *Hevea* tree, although many other sources exist including bushes of the *Guayule* species and the *Kok-saghyz* dandelion.[4] The general chemical nature of the hydrocarbon harvested from these sources is that of a chain polymer of isoprene.

Further contributions to cultivated rubber were the discovery of a suitable plantation system, and suitable methods of coagulating the *latex*.[66] The first half of the century saw a complete revolution in rubber cultivation.

Recovery after the Japanese invasion of the Far East in World War II has been rapid especially in Malaya, which is now the world's largest producer of rubber. In 1965 world production expanded from 2,220,000 tons to 2,330,000 tons. The 2,375,000 long tons produced in 1966 fell short of the 2,460,000 long tons which the industry had hoped to turn out. In the last 5 years the consumption of natural rubber actually grew by 228,000 long tons. In the same period, synthetic consumption rose by 1,056,000 long tons (see Fig. 2). Production has been increasing at the rate of $2\frac{1}{2}$ per cent per annum for some years compared with a total of 5 per cent for total rubber consumption. It has been shown that increasing the yield per acre from 500 to 1000 lb a year reduces cost by one-third, and yields of well over 2000 lb/acre/annum are now possible.[2]

Traditional methods of preparing raw rubber are now slow and labour consuming. Methods of improving this include mechanically comminuted rubbers (*Dynat, Nat 601* and *Peptorub*) whilst another method is the *Hevea-crumb* process.

CHAPTER 12

MATERIALS, PART III: PLASTICS MATERIALS

GENERAL

Brydson's *Plastics materials*[1] is a comprehensive study of the history, development, structure and properties of plastics materials available commercially, and their processing. The *Modern plastics encyclopedia*;[2] *The plastics manual*;[3] "*Plastics*" *International*;[4] "*Design Engineering*" *Handbook plastics*;[5] and *Plastics materials guide*[6] all give good coverage of plastics materials and include data. Manufacturers' literature and data are also reproduced on *DATAMATIC Thermosetting polymers*' edged notched cards. [145]

INDIVIDUAL GROUPS OF PLASTICS

ABS Plastics

Acrylonitrile–Butadiene–Styrene

ABS plastics are thermoplastic materials formed from the copolymerization between styrene, butadiene and acrylonitrile.[7] There is also a SAN (styrene–acrylonitrile) version of this family of plastics.

They are available as powder or granules for injection moulding extrusion and calendering, and as sheet for vacuum forming. Strong and tough, heat and chemical resistant and with good electrical qualities, they are used for radio cabinets, camera and flash-unit cases, fans and for a range of household goods, car fascias, seat adjusters and exterior trim. Electroplated ABS shows a saving in cost over zinc alloy die castings in light engineering applications.[8]

Acrylics

Acrylic, or *polymethacrylate* plastic, is a thermoplastic material, which offers clarity, toughness and outstanding resistance to U/V and weathering. Commercial polymethacrylate sheets include Perspex, Oroglas and Plexiglass.[9, 10]

Uses include lighting fittings, windscreens for cars, aeroplanes and motorcycles, roof lights and canopies, number-plates, goggles, machine guards, oxygen tents, illuminated signs, bar and kitchen fittings, baths, splash backs and many other items.

CHAPTER 13

MATERIALS, PART IV: COMPOUNDING INGREDIENTS AND PROCESSING AIDS

THE mixture of rubber and ingredients used in a particular manufacture is known as a *compound* or *mix*. The plastics industry frequently uses the term *additives*. Most plastics need to be mixed with other ingredients before they can be put through further converting processes. It is usually necessary to incorporate stabilizers into the polymer. Other additives, including lubricants, plasticizers, fillers and pigments, are often necessary and the process of incorporating these into the polymer is known as compounding.

The invention of the "mill" or "pickle" by Hancock inaugurated compounding. The discovery of vulcanization, the accelerating effect of lime and litharge, and of a reasonable solvent, were of major importance to nineteenth-century compounders. The development of the tyre industry in the twentieth-century saw further developments including organic accelerators (1906), abrasion-resistant blacks, antioxidants, the development of synthetic rubbers. Occasionally compounding ingredients have been discovered having entirely new functions—antirads with increased resistance to atomic radiation and anti-fatigue agents.

The growth of the polymer industry during the last 25 years has resulted in a growing diversity of raw materials employed in producing rubbers and plastics. In 1950 the choice of ingredients for rubber totalled 1665; by 1957—2200 and over 2500 by 1961.

Most requirements for rubber manufacturers can be met by Wilson's *British compounding ingredients for rubber*, 2nd edn.;[1] for U.S. materials—Rubber World's *Materials and compounding ingredients for rubber and plastics*, 4th edn.;[2] and for the Continent—Van Alphen's *Rubber chemicals*[3] may be consulted. Foreign (non-Russian) polymer materials are also covered in Semenov and Polyakova's *Zarybezhyne promyshlennye polimernye materialy i ikh komponently*, Academy of Science U.S.S.R.[4] RAPRA have issued a translation entitled *Auxiliary substances for polymeric materials*, of a recent Soviet handbook.[69]

Commercially available accelerators produced in France, U.S.A., U.K., West and East Germany, Holland, Italy and Spain are grouped under twelve categories in a loose-leaf data service by LABORATOIRE DE RECHERCHES ET DE CONTROLE DU CAOUTCHOUC, *Accelerateurs de vulcanisation.* [5]

CHAPTER 14

TECHNOLOGY: PLANT, PROCESSING AND TREATMENT

INFORMATION on plastics and rubber machinery is available both in general works, in more specialized works and in manufacturers brochure literature. General information can be obtained from the *Encyclopedia of plastics equipment*[1] consisting of 220 brief articles by leading authorities. *Machinery and equipment for rubber and plastics*[2] gives short descriptions of U.S. and Canadian machines based on brochure literature. There are various guides for the U.K. including the British Plastics Federation *Buyers' guide*;[3] *Plastics machinery handbook (machinery available in the U.K.)*[4] and annual feature articles in the commercial rubber and plastics press, often coinciding with exhibitions. *Plastics* produced a special directory number of *Plant availability*.[5]

"*Plastics*" *International* (see Chapter 6, reference 102) gives world-wide coverage of plant, materials and processes. *International Plastics Engineering* (1961–6) catered for engineering aspects and machinery, but later reverted to a supplement of the monthly *British Plastics*. *Processing machinery*[7] is a loose-leaf binder data sheet service by Plastic Data Services. *Kunststoffkunde für Ingenieure*[8] includes plastics machinery and engineering properties of plastics.

Manufacture of plastics, vol. 1,[9] written by technical staff of American companies, is a survey of published information on polymer plant engineering. Published information in this field is difficult to assess as the practice of polymer manufacturers may not even be disclosed in patents. Du Bois and John's *Plastics*[9] surveys the whole field with emphasis on processing technology.

PROCESSING—GENERAL

A variety of conversion techniques are available for processing plastics and rubbers. These include: compression moulding and transfer moulding; injection moulding; extrusion; blow moulding; vacuum or thermoforming; calendering; laminating; powder processing; fabrication from plastic pastes and liquids (casting); fabrication of expanded plastics; and reinforced plastics. Vulcanization is a process exclusive to rubber processing. Preliminary processes: mastication, mixing and dispersing must also be considered.

Much of current processing technology is still empirical. The increasing complexity of polymer processing has made it essential to approach the

CHAPTER 15

STANDARDS, SPECIFICATIONS, CODES OF PRACTICE, TESTING OF POLYMERS, TECHNICAL DATA AND QUALITY CONTROL

THE terms *Standard* and *Specification* are frequently misused. All documents issued by the British Standards Institution are termed British Standard, but only those laying down minimum property requirements and/or composition are termed Specification, which features in the full title. *Methods of Test, Recommended Practices* and *Glossaries* are similarly distinguished.

Specifications can assume a number of forms, but, broadly they can be regarded as falling into two categories: the first is the *dimensional specification*; the second is the *performance* or *quality specification.* A standard *code of practice* sets out recommended practices for the design, installation and maintenance of equipment, construction and service. Standards on *nomenclature* have been considered separately (see Chapter 6, references 142–6), and are necessary as words are hazardous for conveying thoughts, especially where quality of precision is required. *Draft standards* are liable to modification before adoption and issue.

In several industrialized countries, the national standards body has been encouraged to set up a system of *certification marking* on goods made to its standards.

UNITED KINGDOM STANDARDS

BRITISH STANDARDS INSTITUTION (BSI), British Standards House, 2 Park Street, London, W.1. Sales Office: Newton House, 101/113 Pentonville Road, London, N.1.

The approved body for the preparation and promulgation of standards in the U.K. is the British Standards Institution.

Standards relating to plastics and rubber are prepared by committees of representatives from manufacturing and user trade associations, professional institutions, Rubber and Plastics Research Association and Government Departments. The *Annual Report*[1] gives details of these Committees and the work in hand.

CHAPTER 16

SELECTED APPLICATIONS

Polymeric materials find many applications such as structural components, adhesives, flexible sealants, fibres, lubricants, heat exchange fluids and mechanical damping media.

Ever since the rise of synthetic rubber it has become evident that there are a great many products where rubber and elastomeric plastics such as plasticized PVC are interchangeable. The field of overlap has widened due to the advent of rubber-modified high impact plastics, resin-reinforced rubbers, and the use of rubber–resin blends in certain applications. Rubber injection moulding and the discovery of the thermoplastic rubbers, are a recent addition. These can be processed and given their final shape by methods normally used by plastics.

ADHESIVES

An adhesive may be defined as a substance capable of holding together other materials by surface attachment. The use of adhesives date back to antiquity, and some examples of adhesive bonding have survived for many centuries. Systematic improvement of adhesives dates only from the 1930's, when it was discovered that natural adhesives are macromolecular, and therefore polymers could be designed and synthesized with superior adhesive properties. The industry is highly competitive, which has led to secrecy and suppression of publication of much basic information.

The growth of metal adhesives in World War II led to the formation of a Ministry of Supply Panel-Advisory Council on Scientific Research and Technical Development, which produced a report on adhesion in 1961.[1] A *Financial Times* supplement[2] forms a useful introduction to the subject, and a preview of adhesives of tomorrow is available.[3]

The British Rubber and Resin Adhesives Manufacturers' Association, c/o A. C. Palmer & Co., Court Chambers, Friar Lane, Leicester, is one of the special associations concerned with this field. Other organizations are listed in the *Adhesives Directory*.[4] The *American Adhesive Index*[5] is a market report directory for 400 U.S. manufacturers and with 700 trade names. The *Adhesives guide*[6] is a much-used handbook users' guide and directory issued by the British Scientific Instrument Research Association.

CHAPTER 17

SAFETY, FIRE HAZARD, TOXICITY AND INDUSTRIAL HEALTH

EMPLOYEES are a company's greatest asset. Production, accident prevention and industrial health care cannot be separated. Toxicity factors may also concern the use of the products, including contact with foodstuffs.

The *Annual report of H.M. Chief Inspector of Factories*,[1] issued by the U.K. Ministry of Labour, includes statistics on accidents reported in the synthetic resins and material industry; in plastics moulding and fabricating; and also for the rubber industry.

All aspects of safety, accidents, fire and health hazards, general and specific, are dealt with in the SPI *Plastics safety handbook*.[2] The National Joint Industrial Council for Rubber Manufacturing have made an outstanding contribution to safety in the rubber industry. Their booklet of reprints of leaflets on *Industrial safety*[3] gives many points to think about. The British Safety Council has issued a *Safety code for using synthetic resins*.[4]

The British Plastics Federation;[5–7] Institut National de Securité;[8] and the National Joint Industrial Council for Rubber Manufacturing Industry, who led the world in making machines safe, have issued recommendations for the guarding and safe working of plastics and rubber machinery.[9–12] The American Standards Association has issued a *Safety code for mills and calenders in the rubber industry*.

Accidents in rubber factories together with the appropriate devices and drills are explained and illustrated in a German article.[13]

FIRE AND DUST HAZARDS

The manufacture of polymers involves in many instances the storage and handling of both flammable and toxic gases, liquids and solids. The hazards associated with such materials may be reduced to acceptable proportions only by the proper design and installation of plant together with sound operating procedures and adequate supervision. A check list shows where the main fire hazards arise in plastics moulding shops.[14] Fire Protection and Insurance Associations have issued reports and fire surveys.[15, 19, 20] The Society of the Plastics Industry Inc. issues *Fire Prevention Bulletins*.[16] The National Industrial Council for the Rubber Manufacturing Industry

PART 5

FURTHER SOURCES OF INFORMATION

CHAPTER 18

CLASSIFICATION, CODING AND INFORMATION RETRIEVAL FOR POLYMERS

THE large increase in the number of basic types of polymer materials in a short time, has greatly increased the problems of classification. Although solid high polymers may be classed as thermoplastic, thermosetting, rubbery, film forming or fibre forming, these groups are not necessarily mutually exclusive. A thermoplastic may also be film forming or fibre forming, and with suitable plasticization it may become flexible plastic or rubbery. A material may be rigid at low temperature and rubbery at a higher one.

Not long ago all plastics had an organic backbone and could be classified reasonably as thermoplastics or thermosetting. Today we speak of organics, semi-organics, inorganics, semi-conductors, pyrolites, stereoregular polymers, biopolymers, ion-exchange polymers, ladder polymers, cross-linked thermoplastics and extrudable thermosets. There is a big "twilight" area of "elastoplastics", where a material can be both a rubber and a plastic, and which you choose depends from where you start from. This situation has increased the difficulties of classification and also retrieval of polymer information on a systematic basis.

There are over 130 different classification schemes—both general and special that include the polymer field. Some twenty-seven were discussed briefly and arranged in four categories in a review prepared for the Plastics and High Polymer Division of UIPAC.[1] The needs of patent documentalists, librarians, manufacturers and consumers were considered. The critical comparison divided the twenty-seven schemes into five groups: (A) based on the chemical structure of the polymer; (B) based on the origin of the polymer (or on the chemical structure of the monomer(s)); (C) based on properties or on quality specifications; (D) classifications especially for use of patent documentalists; and (E) alphabetical classifications. Group B was considered best for the needs of librarians. These included the well-known Universal Decimal Classification (UDC),[2] but no major revision of the *Macromolecular Materials (Rubbers and Plastics)* section has taken place since 1955 (except for German addenda 1960,[3] and to date there seems no possibility of a major revision that is now required.

The Dawson system as described in the review[1] has since been drastically

CHAPTER 19

EDUCATION, TRAINING AND ACADEMIC RESEARCH

THE rapid rate of growth in the polymer industries needs increasing numbers of trained technical and commercial workers. This young science-based, explosive industry, whose technology is developing as fast as its commerce, sets high standards and a hot pace. Prospects of advancement are good for those who will accept this challenge.[1] It is no use talking of the importance of research and education, unless we convince more youngsters in the schools of the great future offered by the polymer industry. "It is clear that existing technical and supervision strengths in the (U.K.) rubber manufacturing industry indicate a replacement or annual restocking of between 600 and 1000 technically trained men and women . . . we may well find that a requirement of 5000 in the 5 years to 1970 will fall short of the rubber industry's needs, let alone those of the plastics industry", (see Chapter 7, reference 32).

POLYMER EDUCATION IN THE U.K.

Plastics and rubber training and education has reached a high level in the U.K. and is now undergoing many changes. It is complex in its organization and is spread over many establishments (see Appendix).

A new industrial revolution—in the organization and development of training—is taking place in Britain. The Industrial Training Act of 1964 now makes it obligatory for every branch of U.K. industry to organize its training and education through its Industrial Training Board. A Board has been set up for the Rubber and Plastics Processing Industries.* There is also a Man-made Fibres Industry Board, a Chemical and Allied Industry Board and a Petroleum Industry Board. The Boards will raise money by compulsory levies based on the salary bill, and from this source training grants will be made. It is anticipated that the Industrial Training Board will pay particular attention to the training of lower levels of skilled manpower in industry. In the past more attention has been paid to high levels and not enough to the training of foremen and equivalent ranks. Meanwhile the technician course for Plastics organized by the City and Guilds of London now has a lower entry level, and is lowering its general level to that of a lower technician for

* *Industrial Training (Rubber and Plastics Processing Board) Order 1967.* H.M.S.O. London, 1967. 10 pp. (*SI 1967 No. 1062*).

SUBJECT INDEX

INDEX TO ORGANIZATIONS

AUTHOR INDEX

The index excludes authors of periodical references cited

INDEX TO PERIODICALS AND DIRECTORIES

Information Storage and Retrieval

The Journal provides a medium for the publication of advances in theory and techniques relating to information storage and retrieval, with special consideration of scientific information and the intellectual problems involved. On the theoretical side, research includes new departures in indexing, classification and notation, recording and disseminating information, and the application of such disciplines as experimental psychology, somantics, linguistics, logic and information theory. The techniques include methods of recording and transmitting information, punched card methods, mechanical and electronic selectors, and mechanical translation. Articles therefore deal principally with theory and techniques, but may include illustrative results.

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Write for an Information and Index Leaflet giving full details and subscription rates.

International Series of Monographs in Library and Information Science, Volume 8

University and Research Library Studies

Edited by W.L. Saunders
Director, University of Sheffield Postgraduate School of Librarianship

The studies in this volume are concerned with specialized aspects of university and research libraries. They draw on experience from many parts of the world and are expected to be of interest both to practising librarians and students of librarianship. Two of the contributors are leading figures in the world of academic librarianship, the others are former Postgraduate students of the University of Sheffield Postgraduate School of Librarianship and Information Science. The scope of the volume covers: Australian university libraries; Instruction in the use of academic libraries; The history of the library of the School of Oriental and African Studies; A comparative history of the libraries of Manchester and Liverpool Universities up to 1903; The functions of the university library and the organization of research in library science in Eastern Europe.

International Series of Monographs in Library and Information Science, Volume 6

Technology For Underdeveloped Areas

An Annotated Bibliography

Jack Baranson

This bibliography brings together in a comprehensive form theoretical concepts and practical considerations for the design of, and transmittal of information relating to technology for developing countries. It deals with economic criteria, cultural constraints and organizational aspects, and provides concrete examples of required products and production systems. The titles have been collected from over 2000 sources and annotated with a view to identifying the major relevant concepts and models.

The bibliography is interdisciplinary. It brings together several previously disassociated aspects of the problem of technology for developing economies. These include, for example, commercial considerations (Role of Foreign Enterprise) and major aspects of economic theory (Choice of Techniques, Factor Proportions, Growth Models and Trade Theory). The bibliography forms the basis for a systematic approach to the field of technological design as a self-contained discipline and outlines the body of knowledge pertaining to its theory and practice. It provides for practitioners involved in technology programmes a catalogue of pertinent ideas and useful models.

The bibliography will prove extremely useful to professional people involved in the provision of technical information or advice and it will also be valuable as a reference book for graduate courses in economic development or concerning the socio-economic aspects of product design and production engineering.

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Headington Hill Hall, Oxford
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