# Book Reviews

**A History of Technology.** vol. III. *From the Renaissance to the Industrial Revolution, c. 1500–c. 1750.* Charles Singer, E. J. Holmyard, A. R. Hall, Trevor I. Williams, Eds. Clarendon Press, Oxford, England, 1957 (order from Oxford Universtiy Press, New York). xxxvii + 766 pp. Illus. + plates. $26.90.

With the appearance of this, the third of five proposed volumes relating a history of technology to the beginning of the 20th century, readers of the first two volumes should carefully reread the earlier prefaces. For as this monumental project creeps ever closer to modern times, it becomes abundantly clear, as the editors had warned, that the extreme selectivity necessary even in five bulky volumes precludes all possibility of an ideal, definitive history. In the preface to volume II the editors wrote, "When completed, this *History* will provide a moderately comprehensive survey of the development of western technology." I feel that it is very important for all readers of these volumes, especially of the later ones, to realize that this statement reflects no false modesty on the part of the editors, but rather reflects their serious awareness of the dilemmas inherent to their undertaking.

Two difficulties are especially apparent in this third volume and will no doubt be felt even more keenly in the succeeding volumes. First, there is the anomaly in the historian's art whereby the "definiteness" of a historical picture is sometimes related by inverse proportion to the amount of available data. If one writes about, say, astronomical instruments in antiquity, where the amount of extant information is all too finite, the problem of creating a history of such instrumentation may be one of gathering even enough information to make meaningful statements. But, on the other hand, in such a case it is at least possible to accurately and exhaustively treat the available data and to make more or less plausible conjectures on the basis of them, and in this limited sense one might call such history definitive. The opposite extreme occurs when the historian must either catalog a near-infinite amount of data or attempt the type of value judgments involved in selecting "representative" data. Obviously the problem has a time dimension: in the vast majority of cases, the nearer history comes to the present, the greater the amount of available data, and hence the problem of digestion or indigestion.

One might recall here two recent examples of historians who directly faced this problem. When the late George Sarton regretfully ended his labors on his great *Introduction to the History of Science* (Williams and Wilkins, 1927–48), he found that it had taken almost as many pages to deal with the 14th century alone as with the entire period from Homer to Roger Bacon. It was his considered view that no one scholar working alone could hope to continue the project on such a scale, due to the sheer enormity of the data bearing on science in later centuries. Lynn Thorndike's half-century odyssey in the preparation of a *History of Magic and Experimental Science* (Columbia University Press, 1923–58) led him to similar conclusions, with the result that he has ended his history with the 17th century.

In the present case, the editors have been determined not to bog down in the Middle Ages but to face the problem by being "highly selective in their choice of topics for discussion, and have perforce imposed on authors restrictions of space that have rendered their tasks far from easy." Thus, we shall have a "moderately comprehensive survey," carrying the story down to our own century, through the process of choosing what appear at this time to be crucial or at least typical technological developments.

The second difficulty is not unrelated to the first. It is simply the fact that the historian synthesizing the story of our more recent technological past must do so with the benefit of far fewer detailed monographic studies. The reasons for this are perhaps not hard to find. The long tradition of classical and medieval studies, again with the seeming benefit of there being comparatively limited data for analysis, has encouraged the production of monographic studies of ancient technology. This is apparent in the earlier volumes of the present work, where, for example, the learned scholar R. J. Forbes essentially summarizes portions of his life's work of detailed study of ancient science and technology. Unfortunately the ground has not as yet been spaded very deeply in many areas of technology from the Renaissance to the present. This may result, I feel, in an unevenness in the real evidence behind the conclusions reached in this study, both in terms of areas of technological activity within a given time period and also from volume to volume representing different time periods. It might also result in an unwary reader assuming that the articles in the later volumes have an authoritativeness which the authors themsleves would hesitate to claim.

As an example of the need for further monographic studies before a survey of this sort is completely feasible, we might look at page 345 of A. P. Usher's otherwise splended article "Machines and mechanisms." This section was certainly written before he was acquainted with the *History of the Gear Cutting Machine*, one of the series of monographs undertaken by my colleague Robert S. Woodbury to provide the scholarly basis for his history of tools. In the light of Woodbury's evidence, the last two paragraphs of this section (as I am sure Usher would be the first to admit) need complete revision.

The clock- and watchmakers were in only a very few cases interested in scientifically correct shapes for their gear teeth, and even those who knew the theoretical results, such as Thomas Reid of Edinburgh, felt the design of such teeth to be too complex to be worth the trouble. In any case, the results of the mathematicians' work were generally published in Latin and often appeared in erudite scientific journals unknown to clockmakers. Thiout made no new contributions to the theory at all and only reprinted Camus' paper of 1733. Although Camus' work began in 1733 and not in 1735, it certainly was far less important than the analysis of de La Hire, upon which Camus admitted he had based his own contributions. Actually, the theory of gear teeth was not in a form which practical men could use before the appearance of John Issac Hawkins' *Teeth of Wheels* (London, 1806), although there were a number of rule-of-thumb handbooks, such as Jacob Leupold's *Theatrum machinarum generale* (Leipzig, 1724).

Woodbury also shows in detail, in an article to appear in an early issue of *Isis*, that Desargues, and not Roemer or de La Hire, was the first to advocate epicycloidal teeth for gears, probably as early as 1644–49. Huygens never claimed to have orginated this theory and gave the credit both to Roemer and to Desargues.

The men who developed the mathematical theory of gear teeth were, if anything, more interested in improving efficiency and reducing wear in gearing for various types of mills than for clocks. To be sure, the theory had little effect in industrial practice until after Hawkins (in 1806) and Willis (in 1841), but neither were the machine tools and the knowledge for precision and complexity "fully worked out on this small scale" of clocks and watches in the early 18th century. Yet Polhem's gear-cutting machine dates from 1729, and Rehe's gear-cutting machine, first described in 1783, had probably been used for cutting wheels for the silk-reeling works built by Boulton about 1780 for the East India Company. The gears for Rennie's Albion Mill (built during the period 1784–88) had epicycloidal teeth carefully chipped and filed to shape.

In short, the very able scholars who wrote the articles in this volume in many cases simply do not have—because they do not exist—the adequate monographic studies on which to build a scholarly history of technology.

Nevertheless, it would be worse than invidious were I not to point out the excellent qualities everywhere apparent in this difficult-to-write volume. It is organized into five parts, essentially matching the divisions of volume II, each of which contains numerous articles with short but useful bibliographies. As in the preceding volumes, the illustrations are accurate and germane, and the plates at the end of the volume are nothing short of magnificent. The reader will at once realize that much thought and searching has gone into the selection of the illustrative material, so important in conceiving of the history of man's relation with material things and objects. Perhaps the dominant theme throughout the work—or at least the notion most strongly reinforced for me—is that during these fertile two and one-half centuries, the period of the scientific revolution, what we often call pure science affected technology very little. This was still a craftsman's age, despite the tremendous conceptual upheaval that attended the downfall of scholasticism and the birth of modern science. Repeatedly our authors conclude that science, as we know it, began seriously to instigate technological changes only at the end of the 18th and beginning of the 19th centuries. This is perhaps a truism to which everyone would agree, but the authors in this project can do a great service by teaching us more of the details of this transition. For this and similar reasons we anxiously await the concluding volumes.

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**Ionographie.** Les émulsions nucléaires. Pierre Demers. University of Montreal Press, Montreal, Canada, 1958. 835 pp. + plates. Illus. $20.

*Ionographie* (which deals with the self-inscription of the path of fast charged nuclear particles traversing photographic emulsions) can be said to be the first comprehensive work on this important tool of modern nuclear physics. The title selected for this monumental work by Pierre Demers is perhaps apocalyptical, in view of the disturbing and restless age we are living in—"The Moving Finger writes; and, having writ,/ Moves on." In the English-speaking world the subject is usually referred to as nuclear emulsions, in an effort to differentiate the specially tailored photographic emulsions useful in the recording and discrimination of the tracks produced by the diverse fast-moving nuclear particles from the more common optical emulsions.

That alpha particles produced individual tracks in fine-grained emulsions, readily resolvable with the aid of the microscope, was known on the Continent as early as 1909. The technique, however, did not gain favor with experimentalists in the field of radioactive measurements until after the discovery of the neutron. This massive uncharged projectile racing through an emulsion will collide with the hydrogen nuclei of the gelatin and, at a given angle of incidence, will impart enough kinetic energy to the ionized nucleus so that it records a "proton-recoil track" in the recording medium.

The emulsion became an important competitor with the Wilson cloud chamber as a means of visualizing the path of charged particles during the early days of the Manhattan Project, when it became necessary to discriminate and elucidate the properties of the newly discovered fission fragments from the alpha particles emitted in the spontaneous decay of the uranium isotopes. Demers, as a member of the Canadian group, was particularly active in this field and was able to demonstrate, with the aid of his improved laboratory-made emulsions, that the normal binary fission process also occurred in an alternate mode, in which a high-energy alpha particle accompanied the two massive fragments originating from the neutron splitting of the uranium atom. Demer's researches on the preparation of concentrated emulsions containing as much as 90 percent of silver bromide, by weight, stimulated interest in the large-scale industrial manufacture of early nuclear emulsions such as the Eastman NTA plate and the Ilford series of B, C, D, and E plates.

The ready availability of these new recording media at the end of World War II led to a series of revolutionary discoveries by cosmic-ray workers, which in turn have altered our picture of nuclear structure. This simple tool led to the discovery of the pi mesons, the heavy primary component of the cosmic radiation, trident formation in the electromagnetic cascade, and the production of heavy "strange particles" in high-energy interactions. More recently it proved instrumental in elucidating the mode of annihilation of the antiproton and demonstrating lack of conservation of parity in $\pi$-$\mu$-$e$ decay processes.

This new volume, of virtually encyclopedic proportions, not only is concerned with the preparation and development of nuclear emulsions but also presents a lucid description of almost all applications in the field of nuclear physics and radiochemistry. Over 100 pages are devoted to a bibliography covering several thousand entries, with cross reference to points in the text where the subject matter is discussed. In general, the style of writing is reminiscent of Mellor's *Comprehensive Treatise on Inorganic Chemistry,* in which an effort is made to cover the literature completely. The bibliography appears to be complete to 1957, and Demers must have made considerable effort to extend his work even when it was in galley form, as some of the more important current papers of 1958 are also listed.

The first section of *Ionographie* is devoted to the manufacture of nuclear emulsions on a laboratory scale. While most readers will probably not attempt to "roll their own," a knowledge of the factors governing sensitivity will be helpful in understanding the shortcomings of commercially available products. This section of the book also describes the new Russian type P emulsions, which achieve a grain density of 60 per 100 microns of track produced by singly charged relativistic particles at the minimum of ionization. This is some three or four times greater than the sensitivity currently available in emulsions of American or British manufacture.

The volume covers the methods of normal and discriminatory development of both plates and stripped emulsions up to 600 microns in thickness. A more thorough treatment of specialized techniques permitting the processing of 2-millimeter-thick slabs would have been a useful addition to the book. Needless to say, the diverse ailments inherent in the technique—such as fading of the latent image, track distortion, gelatin blistering, and surface silver image corrosion—are given detailed treatment. A large section is devoted to the geometrical problems of plate exposure and evaluation of results. As an indication of the thoroughness of the treatment, even ancillary techniques, the details of which are often difficult to locate in the literature, are described in detail. Thus, the cosmic-ray worker will find methods for the measurement of atmospheric depth, details on the fabrication and launching of balloons, and meteorological data on wind directions for facilitating the recovery of the emulsion stacks. Demers can write authoritatively on these matters as he performed these operations in the field.