Book Reviews

The Creation of a Technique

The Beginnings of Electron Microscopy. PETER W. HAWKES, Ed. Academic Press, Orlando, FL, 1985. xx, 633 pp., illus. $88. Advances in Electronics and Electron Physics, supplement 16.

The origins of electron microscopy have never commanded the respect as a breakthrough in science that has been accorded, for example, the first observations of x-ray diffraction by von Laue's students Friedrich and Knipping in 1912 or the first evidence of electron diffraction in the experiments of Davisson and Germer and Thompson and Reid in 1927. There was no fundamental principle of physics involved. There was no immediate promise of insight into the atomic structure of matter, even though the more far-sighted participants may have had high hopes.

The wave nature of electrons proposed by de Broglie in 1923 had been clearly demonstrated in the electron diffraction experiments. The fact that electron wavelengths could be very much shorter than those for light suggested that an electron microscope could in principle have a resolution very much better than the light microscope. However, this was little more than a philosophical concept, with little relevance for the practical experimental concerns of those struggling to produce the first magnified images with electrons. It would be many years before the wavelength of the electrons would be at all significant for interpreting what was seen. The electron microscope grew, in fact, through a series of technical advances from a background of experience in the development of cathode ray oscilloscopes. The theoretical basis was limited to the purely classical considerations of the bending of electron beams by magnetic and electrical fields. The practical aim was to make a better microscope.

Without the drama of a major scientific advance, the beginnings of electron microscopy have remained relatively unfamiliar. Peter Hawkes has earned our gratitude for a volume that goes far to reveal the more personal and intellectual dramas of the scientists who created the new technique and brought it to the stage where its future as one of the major tools of modern science became evident.

Like *Fifty Years of X-ray Diffraction*, edited by the late P. P. Ewald, and *Fifty Years of Electron Diffraction*, edited by Peter Goodman, the present volume takes advantage of the fact that many of the originators of the subject are still alive and able to contribute their recollections. In the same way it must be noted with regret that for some the compilation has come too late. The accounts by colleagues or science historians, though valuable for filling some gaps, do not have quite the same flavor. One regrets in particular that Otto Scherzer could not contribute before his death and that health reasons prevented a contribution from Hans Boersch and limited that from R. W. G. Wyckoff.

Perhaps "flavor" is an apt basis for description of the contents of this volume. Each person has contributed in his own style, with his own viewpoint on what is significant. The result is a collection with the widest possible variation of flavorings—enough to provide a rich banquet for the historian and many tasty tidbits for the general scientific reader. There are the careful, systematic records of step-by-step progress through painstaking construction of increasingly complicated instruments. There are the intensely personal reminiscences of the struggle for progress in wartime Europe. There are the gossipy accounts of who was who and how the characters interacted. There are also the unabashed exercises in personal aggrandizement. The variety of styles and of interpretations of the purpose of the compilation is especially entertaining and informative to those of us who have had the pleasure of personal contact with many of the writers.

A notable absence from this book is the personal history of the work of Ernst Ruska, who, more than anyone else, may be regarded as the father of the electron microscope. The absence is explained by the 1980 publication of Ruska's own book, *The Early Development of Electron Lenses and Electron Microscopy*, in the English translation of Thomas Mulvey. In this Ruska has given an excellent and detailed account of how he and his asscciates made their first efforts to produce an electron imaging system, developed the iron-shrouded magnetic coil with pole pieces to concentrate the magnetic field, and achieved the first images having better resolution than could be achieved in an optical microscope. It was Ruska's book that spurred Hawkes into action to collect these contributions from other scientists involved in the early years of electron microscopy. Here Ruska writes only a short preface.

Many fascinating stories emerge, directly or indirectly, from the various chapters. Illuminating accounts are given of the controversial patenting of the electron microscope by Rudenburg, whose contribution to the subject was, at best, conceptual. The war years find the various groups in Germany, France, the Netherlands, and Britain, necessarily in isolation and frequently in danger, struggling with the same problems, which would be crucial for the postwar developments. The stories from England reveal the enormous impact of the six RCA microscopes arriving unannounced from the United States in 1942 under the lend-lease agreement, appearing in chosen laboratories with no instructions, no manuals, and in some cases no one on hand with any knowledge of electron microscopy. There are also accounts of the important contributions of early workers in the United States, Japan, Czechoslovakia, and Venezuela. Unfortunately it was not possible to get contributions from the Soviet Union, but Hawkes does his best to make amends for this deficiency in his careful bibliography and summary chapter.

This book is not a textbook of electron microscopy: for many parts, it is assumed that the readers know the significance for the present-day science of the work described. It is not a history. It is a collection of personal accounts, often overlapping and sometimes contradictory in detail. It is a valuable resource and fascinating reading for all those with an interest in electron microscopy or the history of science.

J. M. COWLEY
Department of Physics, Arizona State University, Tempe 85287

A Technological Innovation

The Continuous Wave. Technology and American Radio, 1900–1932. HUGH G. J. AITKEN. Princeton University Press, Princeton, NJ, 1985. xviii, 589 pp., illus. $67.50; paper, $19.95.

As the foundation of some of the 20th century's most significant technological achievements, early radio and the industry associated with it have attracted significant interest from many quarters. For the period 1890 to 1935, technical development and applications, industry infrastructure, patent policy, issues of global communications, the rise of broadcasting, and the role of government have all been analyzed separately. As a result, the general outlines and many details of the development of radio have been known for some time. But Aitken's recounting in *The Continuous Wave* provides an unprecedented cohesiveness, many new details, and a few challenges to older interpretations. During the period covered, business and government were learning which organizational forms and managerial techniques worked best for technological innovation. Because radio makes a revealing case study in this process, this book is important for a wide range of readers.

Wireless communications came out of the laboratory into the commercial sphere in the 1890's. Several spark systems, based on the work of Heinrich Hertz, were developed to send signals across the airways. By 1910, they were effective transmission systems for long-distance radio messages. (The development of these systems and the industry that grew around them was described in Aitken's 1976 book *Syntony and Spark*.) But with spark systems sharp tuning and transmission of voice were impossible. As the number of stations increased, the elimination of interference through better tuning became critical; voice transmission would make the system accessible to those without specialized training.

Over the first two decades of the 1900's, radio men searched for a continuous-wave system that would allow them to overcome the weaknesses of spark systems. Three devices developed were the oscillating arc, the alternator, and the vacuum-tube oscillator. In the United States the oscillating arc had an exciting history. Sponsored by the Federal Telegraph Company of California, the arc became the basic unit in a chain of U.S. naval stations for global communications. The arc came from nowhere to compete successfully with the spark systems of the National Electric Signaling Company (NESCO) and the Marconi companies. NESCO was one of several companies to develop the alternator, a design modified and constructed by General Electric (GE). Before the end of World War I, alternators were operating in several stations, all taken over by the U.S. Navy for use in war communications. Both the arc and the alternator technologies were mature upon installation. Their immature cousin, the vacuum tube, was not used in continuous-wave systems until after the war.

In these days of the transistor, it is difficult to appreciate the versatility of the vacuum tube that came before. Engineers investigated several kinds of use for the tube, patenting each along the way. By the time an effective transmission system using tubes became available, patents for tube design and use were numerous and widespread among companies. And with the advent of commercial broadcasting transmitters and receivers and test instruments in the 1920's, the market for tubes—small, simple-to-manufacture devices—grew dramatically as compared to the market for arcs and alternators.

While these tube developments were in progress, nationalistic concerns about control of global communications led to actions that shifted control of the airways from one corporate group to another. On the part of the Navy there was a perception that the British Marconi Company, and hence the British government, had the capacity to control global communications. Negotiations between Marconi and Federal and between Marconi and GE offered the Navy an opportunity to step in. Naval officers asked GE to form a new company that would become the "American radio company" and would "advance and protect American national interests in world communications." This they did, with the help of AT&T, American Marconi, and Westinghouse, by forming the Radio Corporation of America. These facts essentially formed the basis for the views of radio developments presented in most histories and congressional and Federal Communications Commission hearings since the mid 1920's.

What we have in Aitken's book is a new treatment of the problem faced by the radio men and the industrialists. This history illuminates how the technical feasibility of the new technologies was proved, how the new technologies, beginning as laboratory devices managed by technical personnel, came to be supervised and managed by corporate-level authorities, and how, through politicization, they became early instruments of telecommunications policy. Moreover, Aitken describes how "broadcasting" was impossible without the previous development in continuous-wave technologies. This was not obvious, because these technologies emerged from undertakings with different objectives.

Aitken has made use of a wider range of sources, many of them unavailable until recently, than any previous investigator. Moreover, he has used his sources in more effective ways. Documents isolated in small archival collections become important evidence for the larger picture. Large corporate collections, such as those of Owen D. Young, a principal actor in the RCA drama, provide vital new perspectives and facts. The story of RCA's formation is told and assessed better and more accurately here than elsewhere. In fact, Aitken's research provides a challenge to previous writing on this subject. He demonstrates that GE management's assessment of the needs of the industry might very well have led them to a path similar to that proposed by the Navy. In addition, he presents some evidence that the Navy's view may have been manipulated by GE to achieve the company's own ends.

Those who know the model of interaction of science, technology, and the economy and the concept of "translators"—individuals who act at the interfaces of these sectors—from Aitken's *Syntony and Spark* will find that the model has undergone considerable modification in this book. In the more complex case of continuous-wave development, it was necessary to consider perspectives developed in formal, bureaucratic organizations. Since the later phase of radio development involves business and government at least as much as technical people, Aitken has been forced to soften the boundaries so sharply defined in the earlier book. The dramatic tension in the story itself and the broadening of the analysis make the book interesting and useful to a broad range of historians, economists, technical managers, and policy-makers.

ARTHUR L. NORBERG
Charles Babbage Institute,
University of Minnesota,
Minneapolis 55455

Animal Behavior

Experimental Behavioral Ecology and Sociobiology. In Memoriam Karl von Frisch 1886–1982. BERT HÖLLDOBLER and MARTIN LINDAUER, Eds. Sinauer, Sunderland, MA, 1985. xiv, 488 pp., illus. $55; paper, $30. From a symposium, Mainz, Germany, Oct. 1983.

It is difficult to think of a concise title that would capture the essence of this book. Its given title does not, somehow, do it justice. Although about half its 28 chapters are primarily experimental, many are based on observational field studies, theoretical models, or reviews of literature. Nor is the content of the book restricted to the particular interpretative slant suggested by "behavioral ecology and sociobiology," although that field is well represented here by some of its most distinguished practitioners (Wilson, Krebs, Markl, Bradbury, Emlen and Vehrenkamp, Sherman and Holmes). The contributions are in fact highly varied in style, from a warm biographical essay on von Frisch by Lindauer, through accounts of ingenious laboratory and field studies of army ants (Franks), desert isopods (Linsenmair), and ground squirrels (Sherman and Holmes), to reports of remarkable detailed laboratory research on the mechanism of orientation in honeybees (Wehner and Rossel) and their complementary opposite—ruminations (Griffin) on "cognitive dimensions of animal communication." The book is a memorial tribute to Karl von Frisch, who revolutionized the public image of insects with his ingenious work on the sensory physiology and dance-communication of honeybees. Perhaps it could have been titled "Modern, Exemplary Studies of Animal Behavior that Karl von Frisch Would Have Liked." Keywords indicating its primary content and emphasis (number of chapters in parentheses) are: honeybees (nine), communication (nine), behavior evolution (nine), social insects (15), forag-