existing EPR textbooks? For two reasons, that does not seem likely. First, the extensive information that other textbooks provide about the properties of paramagnetic centers such as organic radicals[2,3] or transition-metal ions[2,4] is something EPR spectroscopists cannot do without. Secondly, the theory is not easy to assimilate on one's first exposure to EPR. So, we hold our breath to see a new generation of students who, after "a month in a mountain hut" with the book (see preface), will come back with a working knowledge of pulsed EPR. Nevertheless, we may still be tempted to give them a copy of Atherton's book[2] as they leave.

[1] S. A. Dikanov, Y. D. Tsvetkov, *Electron Spin Echo Envelope Modulation (ESEEM) Spectroscopy*, CRC Press, Boca Raton, **1992**.
[2] N. M. Atherton, *Electron Spin Resonance*, Ellis Horwood, New York, **1993**.
[3] J. A. Weil, J. R. Bolton, J. E. Wertz, *Electron Paramagnetic Resonance*, John Wiley & Sons, New York, **1994**.
[4] J. R. Pilbrow, *Transition Ion Electron Paramagnetic Resonance*, Oxford University Press, Oxford, **1990**.

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Instruments and Experimentation in the History of Chemistry. Edited by *Frederic L. Holmes* and *Trevor H. Levere.* (Series: Dibner Institute Studies in the History of Science and Technology). MIT Press, Cambridge, MA 2000. xxi + 415 pp., hardcover $ 50.00.—ISBN 0-262-08282-9

Although, from the earliest beginnings of alchemy to the present day, chemistry has been and continues to be primarily an experimental science, historians have concentrated on the development of chemical theory rather than on the instruments and experimental techniques through which its theories have advanced. A notable exception is provided by *The History and Preservation of Chemical Instrumentation* (edited by John T. Stock and Mary Virginia Orna, published by D. Reidel, Dordrecht/Boston/Lancaster/Tokyo 1986), a collection of papers presented at a symposium on the subject held at the 190th National Meeting of the American Chemical Society, Chicago, Illinois, September 1985). A welcome addition to this sparse genre is another collection, consisting of 14 essays by 14 distinguished historians of science from the United States (7), Canada (2), France (1), and the UK (4), edited by Frederic L. Holmes, Avalon Professor and Chairman of the Section of the History of Medicine at Yale University, and Trevor H. Levere, Professor of the History of Science at the Institute for the History and Philosophy of Science and Technology, University of Toronto.

From its beginnings in the work of alchemists and practical artisans, chemistry has been defined by the instruments and apparatus which comprise a repertoire of laboratory operations that its practitioners have used to examine naturally occurring materials or the fabrications of human culture. Therefore historians of chemistry have always been concerned with activities involving instruments and experiments. However, that concern has usually been overshadowed by their primary attention to such subjects as the origins, structures, and transformations of theory or to the careers of chemists and the institutional organizations in which these careers were built. The aim of this book by Holmes and Levere is "simply to move the instruments and experiments into the foreground of our concern". The principal themes are stability and change, precision, the construction and transformation of apparatus, the dissemination of instruments, and the bridging of disciplines by means of instruments.

One of the main reasons for the historical neglect of chemical instruments and apparatus has been the lack of material evidence, for most of the items are disposable and have been made of breakable glass, earthenware, or stoneware. Furthermore, they are rarely signed or beautiful, so they seldom appeal to collectors, in contrast to astrolabes or microscopes. Consequently, whatever has been preserved in laboratory basements or museums is neither comprehensive nor representative. For example, from the laboratory of so eminent and historically significant a chemist as Lavoisier, less than one percent of its original 6000 items of glassware has survived.

The book is divided into three sections arranged chronologically. Section I, "The Practice of Alchemy" (74 pp., three chapters) considers material and iconographic evidence, the written record, and the question of reproducibility. In "The Archaeology of Chemistry" (30 pp.) Robert G. W. Anderson* (asterisks denote recipients of the Dexter Award in the History of Chemistry) explores the range of material evidence for chemical experiments and practices in the ancient and medieval world. In "Alchemy, Assaying, and Experiment" (20 pp.) William R. Newman uses the written and pictorial record to argue for the continuity of practice as Anderson does for the archaeological evidence. In "Apparatus and Reproducibility in Alchemy" (20 pp.) Lawrence M. Principe employs dramatic and apparently allegorical imagery to extend our understanding of the common ground between alchemy and chemistry.

Section II, "From Hales to the Chemical Revolution" (163 pp., the largest section, 6 chapters) shows how chemists sought to distance themselves from discredited alchemical practice although they continued to use instruments, apparatus, and operations that they had shared with alchemy. By the end of the 18th century the chemical laboratory, which had remained relatively unchanged for more than two centuries, was evolving into a rapidly changing workplace. In "Slippery Substances: Some Practical and Conceptual Problems in the Understanding of Gases in the Pre-Lavoisier Era" (26 pp.) Maurice Crosland* argues that, although Stephen Hales's invention of the pneumatic trough in 1728 was a turning point in enabling chemists to deal with "airs" and vapors, its manipulation alone could not lead to the identification of the gaseous state. In "Measuring Gases and Measuring Goodness" (36 pp.) Trevor H. Levere discusses the advent and refinement of early eudiometers and gasometers.

In "The Evolution of Lavoisier's Chemical Apparatus" (16 pp., the shortest essay) Frederic L. Holmes* shows that the experiments by which the "father of modern chemistry" developed his new and revolutionary theories were carried out with relatively simple appa-

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ratus. In "'The Chemist's Balance for Fluids': Hydrometers and Their Multiple Identities, 1770–1810" (31 pp.) Bernadette Bensaude-Vincent* argues that the hydrometer, an instrument long used commercially to measure the specific gravity of liquids, did not fulfill the hopes of Lavoisier and some of his contemporaries for quantifying chemical properties. In "'Fit Instruments': Thermometers in Eighteenth-Century Chemistry" (26 pp.) Jan Golinski illustrates the ways in which the meaning of a measurement can change and become problematic, even when the measuring instrument itself has become relatively stable. In "Platinum and Ground Glass: Some Innovations in Chemical Apparatus by Guyton de Morveau and Others" (27 pp.) the late William A. Smeaton* discusses some of the changes and improvements introduced by one of the more inventive chemists of the time.

Section III, "The Nineteenth and Early Twentieth Centuries" (162 pp., five essays) shows how, during the first half of the 19th century, chemistry grew to become the first large-scale modern scientific discipline. Each of the essays describes either the development of a given apparatus or the application of contemporary methods to a particular experimental problem, with full attention to the contexts within which the methods and apparatus were devised or used.

In "Multiple Combining Proportions: The Experimental Evidence" (29 pp.) Melvyn C. Usselman focuses on the experimental data that were crucial to the support and acceptance of Dalton's atomic theory. In "Organic Analysis in Comparative Perspective: Liebig, Dumas, and Berzelius, 1811–1837" (38 pp., the longest essay) Alan J. Rocke* shows how Justus Liebig's combustion apparatus, which reduced the analysis of organic compounds to a simple, routine procedure, changed the manner in which chemists practiced organic chemistry. He also explains its role in the rivalry and contrasting styles of contemporary French and German chemistry. In "Chemical Techniques in a Preelectronic Age: The Remarkable Apparatus of Edward Frankland" (24 pp.) Colin A. Russell* portrays Frankland's great experimental skill and ingenuity in using several new technical innovations and also illustrates the many special experimental problems that researchers encountered and the many modifications of basic methods that they devised to deal with these problems.

In "Bridging Chemistry and Physics in the Experimental Study of Gunpowder" (31 pp.) Seymour H. Mauskopf* describes experiments from physics as well as chemistry that were used to determine the force of gunpowder, and he contrasts laboratory research with military-style field research. Finally, in "Laboratory Practice and the Physical Chemistry of Michael Polanyi" (34 pp.) Mary Jo Nye* describes Polanyi's career, including his role in the adaptation of X-ray crystallography, a technique that had originated in physics, to chemical problems. According to the editors, her essay "reminds us that our concentration in this volume on the role of experiments and instruments in the history of chemistry should not cause us to lose sight of the very human condition of those who deploy such means in the quest for new knowledge."

Each essay is scrupulously documented with extensive notes (more than a hundred in two chapters) and, in five chapters, bibliographies as well. The volume contains 78 figures, many of full-page size (woodcuts, line drawings, photographs, and illustrations or title pages from historical books), one color plate, and two tables, and its index of 15 double-column-pages makes it user-friendly. I recommend this scholarly but readable volume to historians of chemistry and of science, practicing chemists, and anyone interested in instruments and their development and evolution.

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