Book Review

Instruments and Experimentation in the History of Chemistry.

Edited by Frederic L. Holmes and Trevor H. Levere. xxii + 415 pp. The MIT Press, 2000. $50.

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Humphrey Davy held the early "world's record" for discovering chemical elements – six. In *Elements of Chemical Philosophy*, he modestly attributed his success to the voltaic pile-a new instrument in the chemist's armamentarium – rather than to his own acumen, stating that "The active intellectual powers of man in different times are not so much the cause of the different successes of their labours, as the peculiar nature of the means and artificial resources in their possessions."

Histories of chemistry usually trace the evolution of great ideas or the interplay between great scientists. The essays in this collection examine the evolution of the field through its apparatus. This presents an interesting challenge since, unlike the attractive and robust microscopes, telescopes and astrolabes of earlier centuries, chemical apparatus was more modest, even homely, and especially more fragile and, therefore, highly disposable and disposed of. Its more valuable parts (such as metal rings) were stripped and recycled. Thus, little ancient alchemical glassware exists today; for example, the number of true pelicans (glassware for recycling distillation) that have survived is quite small. We rely on ancient manuscripts containing highly stylized figures and on the texts of the 16th and 17th centuries, which were often stylized versions of these stylized pictures, in some cases probably describing apparatus fabricated only in the mind of the author.

Following a helpful introduction by the editors are 14 contributed chapters organized chronologically into three sections: The Practice of Alchemy; From Hales to the Chemical Revolution; and The Nineteenth and Early Twentieth Centuries. The editors also introduce each section with a brief explanatory essay. The chapters, 20 to 40 pages in length, are uniformly well written and well edited, and most are well illustrated. They are written both for chemical historians and for a more general readership, since unfamiliar terms are defined, and often the workings of unfamiliar apparatus are explained. Each chapter ends with an extremely useful summary.

The first chapter ("The Archaeology of Chemistry"), by Robert G.W. Anderson, summarizes the discoveries of fragments of ancient chemical glass- ware from Egypt, Arab lands, India, early Europe and Renaissance Europe. Four important early books are scrutinized for details of Renaissance chemical practices. It is both humbling and reassuring to note the relative "stability" of chemical glassware and "continuity" of change through the ages. However, Anderson cautions us not to take these texts at face value, noting that much more may eventually be learned from careful study of the archaeological fragments.

In "Alchemy, Assaying, and Experiment," William R. Newman makes a case for the very early use of the blowpipe for chemical investigations – well before its employment by Johann Kunckel in the 17th century. Quantitative accuracy in alchemical investigation, commonly unanticipated, is implied by the famous glass-cased balance in Elias Ashmole's 1652 *The- atrum Chemicum Britannicum* (the plate is a virtual copy of the illumination from Norton's 15th-century manuscript *Ordinal of Alchemy*) [*The color illustration could not be reproduced, ed.]*. The glassware in the figure suggests alchemy, not simply the assaying or weighing of gemstones. Thus the quantitative analytical work of alchemists may have been more sophisticated than is generally assumed.

Lawrence M. Principe (in "Apparatus and Reproducibility in Alchemy"), arguing against Jungians who attribute alchemical imagery to psychic states, makes a case for precise chemical apparatus as an indicator of the reproducibility desired by chrysopoeians (alchemists devoted to making gold). Evidence includes a discussion of the symbols in the keys of Basil Valentine, presumably readily decipherable by any true adept. One very interesting feature of this chapter is Principe's experimental recreation of a "Philosopher's tree" inside a glass flask.

In "Slippery Substances," Maurice Crosland neatly explains how and why chemists were so unconcerned with gases until the work of Stephen Hales and thoroughly depicts the evolution of studies of gases through the 18th century.

Trevor H. Levere (in "Measuring Gases and Measuring Goodness") treats the long-forgotten eudiometer, initially developed by Joseph Priestley as a volumetric instrument for measuring the purity of "dephlogisticated air" as well as the "goodness of air" through reaction with nitric oxide. This instrument quickly evolved to include sparking wires and in other ways to make it suitable for testing other gaseous reactions. The illustrations of gasometers, which fed measured amounts of gases into reactions, include the elaborate apparatus of Antoine Laurent Lavoisier.

Lavoisier's wealth and precision afforded him a laboratory of unrivaled apparatus. Frederic L. Holmes ("The Evolution of Lavoisier's Chemical Apparatus") quotes Jan Golinski's observation that "To Priestley and his followers, expenditure on this scale was not only undesirable but reprehensible, because it foreclosed the possibility of Lavoisier's experiments being replicated by others who lacked his wealth." A key insight offered to the reader is that most of Lavoisier's great works were actually accomplished using relatively simple apparatus, often adapted or "jerry-rigged" from earlier pieces.

Bernadette Bensaude-Vincent ("The Chemist's Balance For Fluids") treats hydrometers and their cousins areometers. Thought initially to have great potential as scientific instruments, hydrometers were useful for measuring the "goodness" of wine, among other commercial liquids.

Jan Golinski ("Fit Instruments") reminds us of the important role Herman Boerhaave played in transforming the thermometer from an instrument used to quantify our senses (a "cool" breeze has the same temperature as motionless air) into a scientific instrument both used on its own and incorporated into more complex apparatus.

In "Platinum and Ground Glass," William A. Smeaton describes Louis Bernard Guyton de Morveau's exploitation of these innovations in his portable laboratory. The agronomist Arthur Young visited Guyton in Dijon in 1789 and found "such a variety and extent of apparatus, as I have seen nowhere else." This apparatus was the standard for other such chemistry "kits" on both sides of the Channel and across the Atlantic during the early 19^{th} century.

The final section begins with an insightful essay by Melvyn C. Usselman ("Multiple Combining Proportions") that analyzes the experimental work associated with the law of multiple proportions. John Dalton, whose experiments verified his theory, did not provide experimental support as strong as that of William Hyde Wollaston, who had no theoretical bias. The strongest experimental evidence was contributed by Jacques Étienne Bérard, who received the least recognition, because the theory was already generally accepted.

In "Organic Analysis in Comparative Perspective," Alan J. Rocke provides an excellent description of Justus Liebig's development of the Kaliapparat, which permitted the gravimetric measurement of carbon dioxide from large quantities of organic compounds, thus revolutionizing the accuracy of carbon, hydrogen and oxygen analysis. His accounts of Liebig's interactions with Jacob Berzelius, Friedrich Wöhler and Jean Baptiste Dumas are informative and entertaining. Liebig was skeptical of Dumas's "French chemistry," but Dumas ultimately perfected the difficult analysis of nitrogen.

“Chemical Techniques in a Pre- electronic Age,” by Colin A. Russell, treats the ingenious chemical apparatus designed by Edward Frankland in the latter half of the 19^{th} century. Trying to trap the radical “ethyl,” Frankland made pyrophoric diethylzinc instead and ushered in the era of organometallic chemistry.

The theme of Seymour H. Mauskopf’s “Bridging Chemistry and Physics in the Experimental Study of Gunpowder” is the use of physics to determine the ballistic force of gunpowder.

The final chapter, “Laboratory Practice and the Physical Chemistry’ of Michael Polanyi,” by Mary Jo Nye, provides a wonderfully focused description of the Hungarian Jew who left the continent in the stormy and dangerous aftermath of World War I to make seminal contributions to x-ray crystallography in Manchester in the 1920s. His polymathic interests led him eventually to exchange the title of professor of physical chemistry for a chair of “social studies” at Manchester.

This book is a must for all institutional libraries and for anyone even mildly interested in the history of chemistry.