15. J. Penington, *Common Diary from July 14, 1790 till Oct. 1 of the same year*. This unpaginated manuscript, located in the Library of the Historical Society of Pennsylvania, is in three parts and continues until 14 August 1791.

16. Reference 7, p. 22.

17. A.L.S., J. Penington to B. Rush, 3 August 1790. Library Company of Philadelphia.

18. *Gazette of the United States*, Wednesday, 3 July 1793. The entire announcement is reproduced in W. Miles, "Benjamin Rush, Chemist," *Chymia*, **1953**, *4*, 37-77. The Hopkins process, dated 1 July 1790 and signed by George Washington, was the first patent issued in the United States. See H. M. Paynter, "The First U.S. Patent", *Amer. Heritage Invent. Techn.*, **1990**, *6(2)*, 18-22.

19. L. H. Butterfield, *Letters of Benjamin Rush*, American Philosophical Society, Vol. 2, Princeton, 1951, pp. 672, 698.

20. *The Federal Gazette*, **1793**, *(20 September)*. Quoted in Miles, reference 18.

21. W. Miles, reference 18, pp. 72-75.

*William D. Williams is Professor of Chemistry at Harding University, Searcy, AR 72143. He collects and studies early American chemistry texts. Wyndham D. Miles, 24 Walker Avenue, Gaithersburg, MD 20877, is winner of the 1971 Dexter Award and is currently in the process of completing the second volume of his biographical dictionary, "American Chemists and Chemical Engineers".*

## CHEMICAL ARTIFACTS

### The Apparatus Museum at Transylvania University

*George M. Bodner, Purdue University*

In March, 1775, Colonel Richard Henderson purchased 20 million acres from the Cherokees in an unsettled region of the British colony of Virginia then known as "Kan-tuck-ee" and hired Daniel Boone to mark a permanent trail into this territory (1). In May of the same year, the legislature that was assembled to organize a government for the new country voted to name it "Transylvania" (literally: across the woods), perhaps because the Romans had used this name to describe a region of eastern Europe that also lay beyond a great forest (2).

When news of this purchase reached the Virginia assembly, it was declared illegal because this body had reserved the right to extinguish Indian title to lands within its borders. Between 1775 and 1800, however, 150,000 people crossed through the Cumberland Gap and traveled down Boone's Wilderness Road into the region that the Virginia assembly eventually established as "Kentuckee county".

One of the problems colonists faced was that of preserving

Dr. Robert Peter

their British cultural heritage. To do this, they turned to the schools (3). This might explain why the Virginia assembly took time in May, 1780 - during a period when their highest priority was the threat of British invasion following the fall of Charleston - to charter the establishment of Transylvania Seminary, which would serve as a spearhead of learning in the wilderness (1). Transylvania thereby became the 16th college established in the United States and the first established west of the Allegheny Mountains.

In 1789, the school was moved to Lexington, the commercial center of the region, and on 22 December 1798, it was merged with the Kentucky Academy to form Transylvania University. At their first meeting, the board of trustees of the new university established several colleges, including a Medical Department staffed by Doctor Samuel Brown, Professor of Chemistry, Anatomy, and Surgery, and Doctor Frederick Ridgely, Professor of Materia Medica, Midwifery, and Practice of Physic.

In 1799, Professor Brown was authorized to use $500 to import books and other items for instruction in the Medical College. Another $800 was allocated in 1805 for the purchase of apparatus for teaching natural philosophy, which included chemical apparatus and a galvanic battery. The Board of Trustees, in a public announcement that fall, proudly proclaimed the arrival of this apparatus, as well as additions to the college library, which now totaled some 1300 volumes.

In 1816, the trustees made an offer to Dr. Thomas Cooper to become the first professor of chemistry. The salary, however, was purposefully set so low that he would refuse the offer, which he did. In 1818, Professor Charles Caldwell arrived from the Medical School at the University of Pennsylvania.

Two years later, Caldwell convinced the legislature to give him \$5000 for the purchase of books and apparatus for the Medical Department. At the same time, the city of Lexington loaned another \$6000 to the college for the same purpose and an additional \$2000 was raised from physicians throughout the South. In 1821, Caldwell went to Europe to purchase books and apparatus that formed the core of one of the finest medical libraries in the country. Caldwell wrote (4):

> ... the time of my arrival in Paris was uncommonly and unexpectedly propitious to that purpose ... Toward the close of that catastrophe (the French Revolution) the libraries of many wealthy and literary persons ... had ultimately found their way onto the shelves of the booksellers. ... I was appraised of the ... very precious repositories ... and purchased, at reduced prices, no inconsiderable number of the choicest works of the fathers of medicine from Hippocrates down to the revival of letters - works which in no other way, and perhaps at no other time could have been collected so readily and certainly, and on terms so favorable ... Hence the marked superiority of the Lexington Library, in those works, to any other ... in the whole United States.

In 1832, Doctor Robert Peter came to Lexington to help run The Kentucky Female Eclectic Institute. He soon became an adjunct professor at Transylvania and in 1838 was elected to the chair of chemistry at that institution. In 1839, he and Doctor James Bush spent most of the summer in London and Paris purchasing books and apparatus for instruction in the Medical Department. In his correspondence, Peter wrote (5):

> We have bought a great many fine books and a great deal of excellent apparatus and anatomical and other models. Transylvania will shine. No other institution in our part of the world will be able to compare with her in the means of instruction. In fact, I have seen none in Europe that is more completely prepared to teach *modern* medicine.

As a result of these purchases, in 1841 the Transylvania Medical Department was described as the "best endowed medical school in America" (1). Between 1817 and 1859, 6456 students enrolled in the Medical Department at Transylvania and the degree of Doctor of Medicine was conferred on 1881 of them. Transylvania thereby provided the foundation for the practice of medicine throughout much of the South. The Medical College was closed in 1859 as a result of a combination of political, social and economic forces as students and faculty drifted to other institutions in cities that had grown larger than Lexington.

The third major source of apparatus for the school was the purchase of the Philip S. Fall collection in 1857. Dr. Fall was the founder of the Eclectic Institute mentioned previously, for which the apparatus had originally been purchased.

A significant fraction of the apparatus purchased for use in the Medical Department can still be found in the Museum of Early Philosophical Apparatus in Old Morrison Hall on the Transylvania University campus at 201 W. 3rd Street in Lexington. A few of Caldwell's purchases have survived, including a vacuum pump and an Atwood's Machine purchased from Pixii in Paris and a portable Sassure hygrometer. Most of the collection, however, traces back to Doctor Peter's visit to Europe in 1839 and Doctor Fall's purchases for the Eclectic Institute.

The collection, as it now stands, is a tribute to the efforts of Professor Leland Brown, who died on 30 August 1989 at the age of 91. Brown joined the faculty in 1932 as a professor of biology, was acting president from 1942 to 1945, and retired in 1965 as vice president for academic affairs. As early as 1910, part of the collection was stored in a museum, but the majority was either in use or stored in various departmental basements and storage shelves. The preservation of the collection became especially uncertain in 1933, when the museum was dismantled and stored in an attic.

Over a period of years, beginning in 1949, Professor Brown cleaned, assembled, and identified the apparatus - when possible - and prepared it for display in its permanent home. In 1959, a catalog describing the collection was published (6), copies of which can be obtained by contacting Professor Monroe Moosnick at Transylvania University or Carolyn Palmgreen, curator of the library special collection at Transylvania. A few items described in that catalog are missing: the Watkins and Hill balance, the blowpipe and double bellows, the camera lucida, the Daniell's hygrometer, the electromagnetic machine, the pith-ball electrometer, the eolipile or Newton's engine, the goniometer, the Hope's apparatus for measuring the density of water at different temperatures, the Marcet's steam apparatus for showing the relationship between pressure and temperature, and the safety lamp developed by Davy. In spite of these losses, the collection is both extensive and in excellent condition.

Dr. Leland Brown

A general view of the museum

The collection includes a variety of items of chemical interest, including a balance purchased from Charles Chevalier; a voltaic pile 23.5" tall and 3" wide that contains 58 separate metal disks; an eudiometer designed by Robert Hare of the University of Pennsylvania; an eudiometer designed by Volta; a large (10-qt. capacity) copper still; a small (1-qt. capacity) copper still; two large, three-neck Woulfe bottles, 5.5-6.5" in diameter and 8.5-12" tall; three small, two-neck Woulfe bottles, 3.5" in diameter and 6.5" tall; two tubulated retorts, 3" wide, 4.25" tall, with a 13" neck; one untubulated retort, 6" wide, 8" tall, with a 20" neck; a precipitation glass about 6" tall on a solid glass base that tapers from a 4" width at the mouth to 1.25" at the bottom; a 1-pt. capacity apothecaries' vessel calibrated with both 1 oz. and 1/4 pt. gradations; a demonstration cylinder 2" wide and 10.5" tall with a ground surface at the top; a 500 cc graduated cylinder with 5 cc gradations; a 100 cc graduated cylinder with 1 cc gradations; a 1000 cc gas collection bottle with 10 cc gradations; three lime-glass 1-L volumetric flasks, one of which is calibrated at 1000 cc; 12 assorted bell jars, 4-8.5" diameter and 7-14" tall; three receivers to be used with vacuum pumps, each equipped with two barometer tubes; and two tapered flasks, 3" diameter and 6.5" tall that can be sealed by inserting a glass sphere into the narrow mouth.

One of the more intriguing items of chemical interest is a "2nd edition" of an "Improved Scale of Chemical Equivalents", or chemical slide rule, which was constructed by Lewis C. Beck and Joseph Henry and manufactured in Albany in 1828. This chemical equivalents scale contains the following inscription:

The Scale of Chemical Equivalents, the invention of which is due to Dr. Wollaston ... to facilitate the general study and practice of Chemistry. The present scale differs from the original one, in the assumption of Hydrogen, as ... unity ...

Under the heading "Mathematical Construction," the inscription goes on to state:

It will be observed that the slider of the scale is graduated into divisions and sub-divisions continually ... in length, from 8 at the top to 330 near the bottom. These divisions correspond in relative lengths to the differences of the logarythms [sic] of the numbers placed opposite them.

It then goes into a protracted discussion of the mathematics of "logarythms" and notes that the distance between any two numbers on the scale is equal to the distance between any other pair that give the same ratio.

Under the heading "Chemical Explanation", the inscription states:

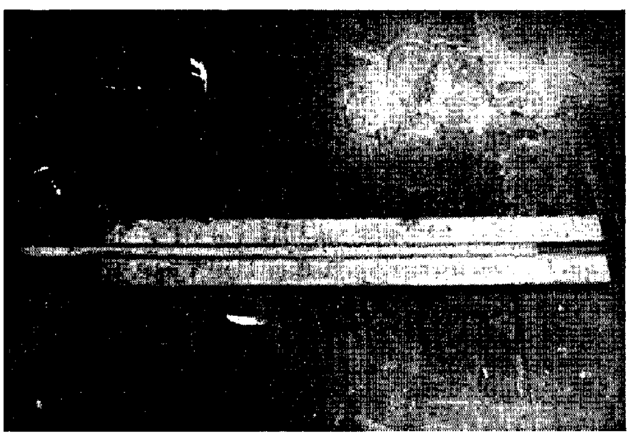
The application of the logametric scale to Chemistry is founded on the most important fact in this science; which is, *that all bodies whether simple or compound that enter into Chemical combination, always unite in weights or in multiples of weights that have the same constant ratio to each other*. And as these relative weights have the same effect in forming neutral compounds and in producing other chemical changes they are called chemical equivalents, and may be expressed in numbers referable to a common standard taken as unity*. (*These have also been called atomic weights, because philosophers have supposed that in all cases of chemical combination an union takes place between the ultimate atoms of bodies. This is the basis of the Atomic Theory.) On this scale the least combining quantity of hydrogen is taken as the unit; and as eight times as much oxygen by weight enters into combination with hydrogen to form the chemical compound water, oxygen will be expressed by 8, and water by 9. If, therefore, the slider be so placed that 8 near the top of it coincides with the upper oxygen, the whole scale becomes a synoptical table of these chemical equivalents, having hydrogen as its radix. Thus 16 for the equivalent for Sulphur, 17 for Ammonia, 24 for Sodium, 70 for

A selection of the chemical apparatus, including Woulfe bottles, gas-generating bottles, flasks, retorts and a precipitation glass

Barium, 110 for Silver, &c. &c. ... In order to diminish the length of the scale ... it commences with oxygen at 8, instead of Hydrogen 1, and 10 atoms of hydrogen are placed opposite 10 on the slider. For the same reason, 2 carbon, the atomic weight of one atom of which is 6, is placed opposite 12. Again, as water and oxygen enter into combination in several definite proportions, 2 oxygen is placed opposite 16; 2 water opposite 18; 3 ox. opposite 24; 3 water opposite 27, &c. &c.

A series of "Examples and Illustrations" are then presented (In some cases, for greater clarity, I have inserted modern formulas or equations in square brackets):

1. Without moving the slider, the scale shows us that 50 is the equivalent number for carbonate of lime [$CaCO_3$]; this substance consisting of carbonic acid [$CO_2$ not $H_2CO_3$] and lime [CaO], we find the equivalent of the former to be 22, and of the latter 28 = 50. Any denomination may be given these numbers, as ounces, grains, parts, &c. But if we wish to ascertain the constituents of any number of ounces, grains, or parts, as 100 for example, we have only to place 100 on the slider at carbonate of lime; and carbonic acid is then opposite 44, and lime 56; which are the proportions of these ingredients in 100.



The Henry-Beck chemical slide rule

2. Suppose we wish to ascertain the constituents of 100 parts of nitrate of ammonia. Move the slider so that 100 is at nitrate of ammonia, which we find has 1. *W.* before it, indicating one proportional of water. Then 1. water on the scale is opposite 11.3, on the slider; ammonia opposite to 21.2, and dry nitric acid to 67.5. The constituents of 100 parts of nitrate of ammonia are, therefore, 11.3, water; 21.2, ammonia; and 67.5 dry nitric acid, = 100.

3. When oxygen at the top is at 8 on the slider, sulphate of potash [$K_2SO_4$] is at 88, which is therefore its equivalent number. In order to decompose this, we may take nitrate of barytes [$Ba(NO_3)_2$], the barytes having a greater affinity for sulphuric acid, than the potash. [$Ba(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s) + 2KNO_3(aq)$] The quantity requisite for the decomposition is 132, being the number at nitrate of barytes; and the amount of sulphate of barytes resulting from this decomposition will be 118. We can also ascertain the quantity of nitrate of barytes necessary to decompose 50, 100, 150 or any other number of parts or grains of sulphate of potash, by placing either of the above numbers on the slider opposite to sulphate of potash and then finding the number of nitrate of barytes.

4. To find the composition of the metallic salts, we ascertain the amount of acid and *oxide* of the metal. Thus nitrate of silver is equivalent to 172, and consists of dry nitric acid, 54, and oxide of silver, 118, = 172. So also we find 100 parts of sulphate of barytes to consist of dry sulphuric acid, 34, and baryta or oxide of barium, 66. And in all cases where *W* is not prefixed to the salt it is then supposed to consist of a base united to a dry acid.

As might be expected, the scale gives good results for predictions that can be confirmed experimentally, such as the weight of $BaSO_4$ produced from given weights of $Ba(NO_3)_2$ and $K_2SO_4$ or the weight of $AgNO_3$ that can be produced from a given weight of $Ag_2O$.

Faraday described the scale as follows (7):

There is a small instrument, the invention of Dr. Wollaston, which though not directly concerned in the actual performance of chemical operations, is of great and constant use in the laboratory, either in supplying the information requisite previous to an experiment, or afterwards in interpreting and extending its results...

The scale only fails when applied to theoretical questions based on inaccurate or inappropriate theories. Within the limits of experimental error, for example, it correctly calculates the percent by weight of $NH_3$ in $NH_4NO_3$. It errs, however, when nitric acid is assumed to contain one equivalent of water mixed with "dry nitric acid" and the percent by weight of water and dry nitric acid in ammonium nitrate is calculated.

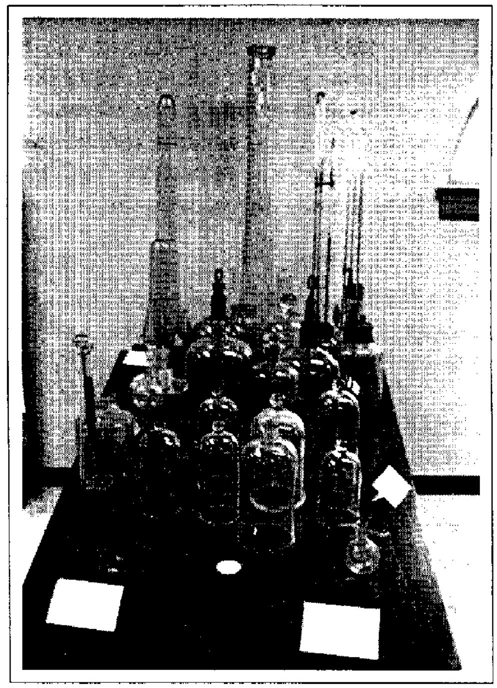
An impressive collection of apparatus purchased to demonstrate the basic laws of physics can also be found in the Transylvania Museum. This apparatus can be divided into two categories: mechanical and electrical. Some of the items in the first category include an Archimedes screw; an Atwood's machine; a black glass or landscape mirror; an apparatus for demonstrating collisions between bodies; a set of equilibrium tubes to show that water will fill interconnecting tubes of any size or shape to the same level; water and mercury fountains to be used with vacuum pumps; a set of friction blocks; glass models to demonstrate crystallographic forms; a heat conduction apparatus; three sets of heat reflectors; a heliostat, a hydrometric balance manufactured by Chevalier; a hydrostatic paradox apparatus; a set of Magdeburg spheres; an Oersted's apparatus for measuring the compressibility of liquids; a planetarium; a planetary path model to demonstrate Kepler's laws; a set of glass prisms on brass stands; a variety of vacuum pumps manufactured by Chevalier, including one that stands over 5' tall and is 3' wide that was originally purchased by Dr.

Fall for $1070; a horizontal pyrometer; a sextant and a quadrant; a 5'4" aperture, achromatic refracting telescope; a thermoscope of Rumford or differential thermometer; a Wedgwood's pyrometer; and an apparatus to show Newton's rings.

Electrical apparatus includes an aurora tube; a condenser of Aepinus; several electric batteries consisting of sets of Leyden jars; a cannon that could be fired with an electric spark; several electric machines for generating static electricity; including one in excellent condition that uses a 33" diameter glass plate; an electroscope; several glass piercers that could be used to pierce a card with the discharge from a Leyden jar; a Kinnersley thermometer to show the expansion of air when an electric spark is passed through it; induction cylinders for storing electric charge; a revolving armature engine; a revolving bar magnet; a sparking column and flyer for demonstrating the passage of an electric charge; several thunder houses to demonstrate the use of lightening rods to protect buildings; a series of electric discharge tubes with adjustable spark gaps that could be filled with different gases; an electrophorus and a Zamboni's apparatus purchased by Dr. Peter from Deleuil in 1839.

One item of physical apparatus of historical interest is a camera allegedly purchased by Dr. Peter during his visit to Paris in 1839, the year Daguerre introduced his photographic process. This camera has often been described as the source of the first Daguerreotype taken in Kentucky (8) and what may have been the first medical photograph (4). Brown (6) rejects the notion that this is one of Daguerre's cameras and identifies it as a Fox-Talbot camera - or an early copy of one - similar to one on display in London dated 1835. The curator of the photographic archives in the special collection at the University of Kentucky has presented cogent arguments suggesting that the camera was not purchased in Paris in 1839, but constructed by or for Dr. Peter in Lexington (9).

Wright has noted that the procurement of corpses for dissection was a challenge for medical students, who often turned to midnight expeditions to graveyards or commercial resurrectionists (1). Thus, it is no surprise that a major fraction of the collection at Transylvania consists of models to teach anatomy, which includes a pair of artificial eyes to demonstrate near and far sightedness; life-sized wax models of an arm, the human head, and the colon; plaster models of pathological conditions; a set of fetal skeletons illustrating development month-by-month; numerous plaster models of various organs mounted in wooden frames; and papier-mâché models of pregnant uteri. The collection also contains a set of 40 canvasses painted by A. Chazel in Paris of medicinal plants in the Jardin des Plantes in Paris, which were purchased by Dr. Peter in 1839. Because Peter's visit to Europe coincided with the publication of Schwann's cell theory, he included among his purchases a number of microscopes, including both aquatic (Raspail's) microscopes and cal-oxyhydrogen projection microscopes equipped with numerous slides of zoological and botanical specimens. It should be noted that the original medical school library has also been preserved intact, including nearly 760 volumes on chemistry spanning the period 1790-1850 (10).



A selection of bell jars and receivers

In his catalog, Brown (6) comments on the problems he encountered in identifying apparatus in the collection. One item he could not identify was described as follows:

> Figure 87 represents a small (9 and 5/8 x 5 x 4 inches) well-made box which is divided into eight compartments. In each velvet-lined compartment there is a small belljar receiver. These receivers are not all precisely of the same shape. Their brass tops appear to be made to fit into some receptacle. They have no obvious musical tones when struck.

Considering the reaction I receive whenever I mention that I had the privilege of spending a month as a Distinguished Professor at Transylvania University, it is intriguing that one of the few items that Brown could not identify was a set of blood-letting cups.

**References and Notes**

1. J. D. Wright, Jr., *Transylvania: Tutor to the West.* Transylvania University, Lexington, KY, 1975.

2. R. Peter, *Transylvania University: Its Origins, Rise, Decline, and Fall,* Morton, Louisville, KY, 1896.

3. B. Bailyn, *Education in the Forming of American Society,* University of North Carolina Press, Chapel Hill, NC, 1960.

4. "The Medical Museum at Transylvania University", *Scope*, 4(10), Upjohn Company, Kalamazoo, MI, 1956.

5. R. Peter, *The History of the Medical Department of Transylvania University*, Morton, Louisville, KY, 1905.

6. L. A. Brown, *Early Philosophical Apparatus at Transylvania College (and Relics of the Medical Department)*, Transylvania College Press, Lexington, KY, 1959.

7. M. Faraday, *Chemical Manipulation; Being Instructions to Students in Chemistry on the Methods of Performing Experiments of Demonstration or of Research, with Accuracy and Success*, Philips, London, 1827.

8. R. Taft, *Photography and the American Scene*, Dover, New York, 1938.

9. G. J. Munoff, *The Kentucky Register*, Summer, 1980, pp. 208-218.

10. *Catalogue of the Transylvania University Medical Library*, Transylvania University Press, Lexington, KY, 1987, pp. 316-347.

---

*Dr. George M. Bodner is Professor of Chemistry and Education at Purdue University, West Lafayette, IN 47907, and has served as a Visiting Professor at Transylavania University, where he had the opportunity to study its museum collection first hand.*

---

## BOOK NOTES

*Out of Thin Air: A History of Air Products and Chemicals, Inc., 1940-1990.* Andrew J. Butrica with the assistance of Deborah G. Douglas, Praeger, New York, NY, 1990. 336 pp. Cloth (Typeset). $39.95.

Despite the significant role industrial gases have played in the development of the U.S. chemical industry, it's easy for historians to overlook them. Gases may be important, but they just don't seem glamorous. In this history of the Air Products and Chemicals Company, Andrew Butrica uses the company archives and interviews with many of the men involved to prove that there's more excitement in this story than one might suspect.

50 years ago, even industrial users that required large amounts of oxygen depended upon gas delivery in cylinders. Leonard Pool, who founded Air Products, planned to fill a market niche by building small, on-site oxygen generating plants. This proved to be a good idea in the long run, but it was difficult to get started. During much of its history, Air Products was at a severe disadvantage because it was competing with much larger, well-established companies, and it was perennially short of capital. Air Products was successful because its leadership combined a tenacious determination to make this idea work with the flexibility to take advantage of whatever opportunities the market offered.

The character of the company was established by its response to its initial disadvantages. Since the company had little money available for research and development, in some cases it would offer to provide a customer with new technology at a low price, then use the job as an opportunity to develop the expertise that it needed to compete. Butrica comments that Pool assumed that if he could sell a product, his engineers could build it. Fortunately Pool made sure that he hired engineers who were good enough to make his promises stick.

The list of the challenges the company faced is a summary of the changing uses of industrial gases in the past 50 years. Providing oxygen for high altitude aviation in World War II, supplying oxygen for the steel industry, liquid oxygen and liquid hydrogen for NASA, and liquid nitrogen for a variety of applications (including quick freezing of McDonald's hamburgers) are only some of the applications that contributed to the growth of Air Products.

As it grew, the company diversified, sometimes into new areas that complemented the basic business, and sometimes into areas - like agricultural chemicals or welding gases - that were less successful. Two of these initiatives have become permanent divisions of the company (specialty chemicals and environmental/energy services) but industrial gases are still the main business. Despite the growth in size, the company continues to show a willingness to take calculated risks, sometimes with poor results, such as synfuels development, but more often leading to profitable new directions.

Writing an authorized company history can place a historian in the uncomfortable position of choosing either to describe setbacks and adverse decisions frankly or else keep the sponsor happy. Butrica seems to have done a good job of balancing these considerations. He presents the special difficulties of Air Products, such as labor disputes, research policies, and unsuccessful expansion, in a concise and diplomatic way. It's perhaps inevitable that the company founder, Leonard Pool, receives special and extensive consideration, but it would have been equally interesting to know more about the personalities and contributions of others who played key roles in the establishment of the company, such as George Pool, Ed Donley, and Dexter Baker.

In this book, Andrew Butrica not only restores industrial gases to their rightful place in the story of the chemical industry but also provides a fine 50th anniversary commemoration of a company that played a major role in that development. *Harry E. Pence, Chemistry Department, SUNY-Oneonta, Oneonta, NY 13820*

*Physical Chemistry from Ostwald to Pauling: the Making of a Science in America.* John W. Servos, Princeton University Press, Princeton, NJ, 1990. xxii + 402 pp. Cloth (Typeset). $49.50.

This superb monograph by John Servos delivers both more and less than its title might indicate. More in that it encompasses