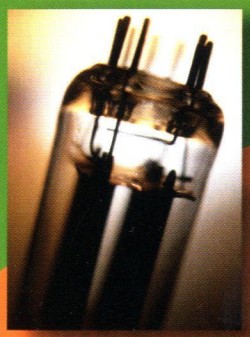
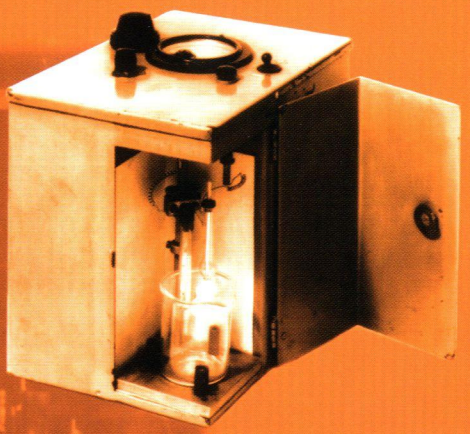
The Development of the Beckman pH Meter

March 24, 2004

A National Historic Chemical Landmark





AMERICAN CHEMICAL SOCIETY
SCIENCE THAT MATTERS

pH meter

"The pH meter was just a chance development that I did as a favor for Glen Joseph."

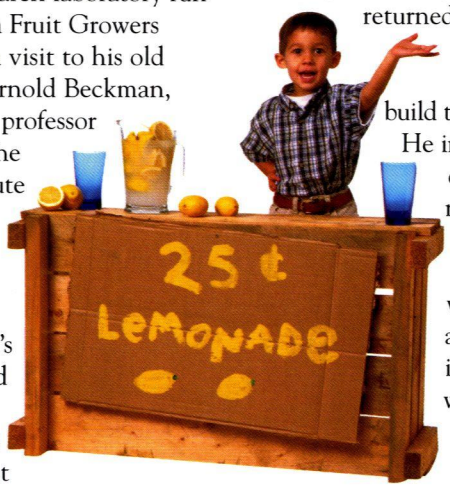
—Arnold O. Beckman, Interview by Jeffrey L. Sturchio and Arnold Thackray at University of Pennsylvania, 23 July 1985 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0014B), p. 13.

Celebrating Chemistry

The American Chemical Society designated the development of the Beckman pH meter a National Historic Chemical Landmark on March 24, 2004. For additional information see our Web site: www.chemistry.org/landmarks.

Measuring acidity

In the mid-1930's Glen Joseph, a chemist at a research laboratory run by the California Fruit Growers Exchange, paid a visit to his old college friend, Arnold Beckman, now an assistant professor of chemistry at the California Institute of Technology. The Exchange controlled more than three-quarters of California's citrus output, and it marketed its high quality fruit under the Sunkist label. Joseph sought Beckman's assistance in solving a problem: how to get an accurate and rapid measure of the acidity of lemon juice.



Chemists then measured acidity by several methods. The most prominent was the colorimetric method familiar to most high school chemistry students. Litmus-treated paper was dipped in a solution; if it turned red, the solution was acidic; if it turned blue, alkaline. A cheap test, but it is unusable in the citrus industry since sulfur dioxide, used as a preservative, bleaches out the litmus. Chemists also used electrochemical methods, relying on the pH scale which has values ranging from 0 (extremely acidic) to 14 (extremely alkaline). Again, sulfur dioxide caused problems for the measuring devices then available.

Joseph had tried using a hydrogen electrode and then a glass one to measure the acidity but his systems were fragile and the signals weak. Beckman suggested using the newly evolving technology of vacuum tube amplification of the weak electrical signal. Joseph left Beckman's office armed with a sketch showing two vacuum tubes to amplify and then re-amplify the signal. But he soon returned saying the device did not work.

Beckman offered to build the instrument himself. He included a newly developed and more rugged glass electrode as the measuring device combined with vacuum tube amplification. This instrument worked so well that Joseph soon asked Beckman whether he could make a second.

Significance of the pH meter

Chemists were just beginning to make use of electrical instruments in their research. This was usually done to meet a specific need and typically consisted of linking various devices together, which were then spread out on the workbench in a laboratory.

Beckman concluded that the vacuum tube amplifier, the measuring electrode, and the data meter should not be separate devices but part of an instrument in which all components were integrated. Initially called an "acidimeter," this one box unit enabled the chemist to purchase the instrument, provide a power source, and immediately begin collecting data. It was no longer necessary to assemble the requisite components and the chemist did not require much knowledge of the electronics. This basic but innovative approach to instrument design provided the basis for the subsequent development of modern instrumentation by Beckman and others.

Marketing the pH meter

Beckman created National Technical Laboratories, an outgrowth of a company with which he was previously involved, to manufacture and distribute the acidimeter. By September 1935 Beckman had a marketable instrument housed in a wooden box with a handle and a latch, just in time for the fall national meeting of the American Chemical Society in San Francisco. Beckman took the acidimeter with him. "In particular," he later said, "I asked some of my former professors, whether, in their opinion, there would be a market for such an instrument. To put things in perspective, I should point out that our instrument was priced at $195, and it would be competing to some extent with litmus paper which cost only a few cents a vial."

Beckman's professors suggested he show the instrument to laboratory apparatus dealers. "Their most optimistic estimate," he learned, "was that 600 might be sold over a ten-year period before the market would be saturated. Not a very great sales potential, but I decided to go ahead. After all, it was only a spare-time activity." To help boost sales, the name was changed from "acidimeter" to "pH meter" to emphasize the scale that measures acidity and alkalinity.

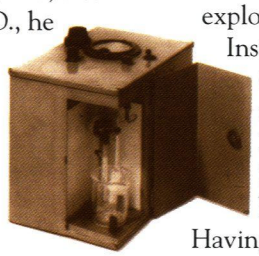
In 1936, the first full year of sales, NTL sold 444 pH meters, with a gross income of $60,000 and a net profit of $2,358. By 1939, 1,995 pH meters had been sold and the profit for that year was $22,160. Success meant that soon the "Beckman Glass Electrode pH Meter" was featured in the catalogs of all the major U.S. instrument dealers. Business was so good that in 1937 NTL introduced the Model G pH meter, eventually selling thousands of this version.

Arnold O. Beckman: Inventor, businessman, philanthropist

Arnold O. Beckman was born on April 10, 1900, in Cullom, Illinois, a town of about 500 people. As a nine-year-old, Arnold stumbled on J. Dorman Steele's *Fourteen Weeks in Chemistry*. Steele was a teacher who loved developing new scientific lectures and experiments, relating them to household objects and materials. Beckman devoured Steele's lessons, leaving him with a life-long love of chemistry. For his tenth birthday his father gave Arnold a small "shop," an 8-by-10 foot shed that stood behind the family home, in which he could conduct his "experiments." For chemicals, Arnold scoured his mother's pantry and shopped at the local druggist. When the family moved in later years, Arnold always commandeered laboratory space.

At age 17 Beckman started a consulting business as an analytical chemist. He had business cards printed and the little laboratory in his home became the "Bloomington Research Laboratories" with him as "Chief Scientist." Beckman's consulting work for Union Gas and Electric in Bloomington, Illinois, was to run analyses of woods chips soaked in ferric chloride to determine whether the concentration was high enough to remove the noxious smell that came from burning Illinois coal. Before graduating from high school, Beckman aided the American war effort in the First World War when he landed a post at the Keystone Steel and Iron Company in Pekin, Illinois, analyzing steel samples to determine their carbon content.

After a stint in the Marines, Beckman attended the University of Illinois, earning a B.S. degree in chemical engineering and a master's in physical chemistry. Beckman then entered the new California Institute of Technology in Pasadena to pursue a Ph.D. but after a year he took a job with Bell Labs in New York, where he learned about vacuum tubes, which he made good use of ten years later. In 1926 he returned to graduate school, and, after completing work on his Ph.D., he joined the Caltech faculty.



Beckman easily settled into life as a university professor, continuing his research and teaching college freshman chemistry. But the commercial success of the pH meter forced Beckman in 1939 to make a major career decision. For four years he had been running NTL but had only the formal title of vice president. Beckman understood that NTL had grown to the point where "somebody had to run the show full-time. It was a case of whether I tried to do that or whether I went out and hired a professional to do it." So "with great reluctance" Beckman resigned from Caltech to become president of NTL.

Production of other instruments soon followed. NTL's next major advance was the DU spectrophotometer, which used some of the technology first applied in the pH meter. The DU spectrophotometer simplified laboratory procedures for making and recording the ultraviolet spectra of compounds. By helping to determine their molecular structure, the DU has assisted in the development of drugs and foods. For example, during the Second World War the instrument helped researchers understand the chemical structure of penicillin.

NTL grew rapidly in the 1940s. In 1948 Beckman was able to purchase enough stock to gain control of the company. In 1950 the company changed its name to Beckman Instruments and two years later it became a publicly traded corporation. Sale of stock brought an infusion of capital that Beckman Instruments used to buy new, expensive technology and to pursue costly lines of research.

Beckman Instruments continued to grow and diversify throughout the last decades of the twentieth century, developing into a leader in the manufacturing of instruments used in the daily operations of medicine and industry and in research, even space exploration. In 1997 Beckman Instruments became Beckman Coulter, a multinational company with offices in 130 countries and sales in 2002 in excess of two billion dollars

Having made a fortune, Beckman decided to give it away. In 1977 he and his wife Mabel created the Beckman Foundation with a mission to support basic scientific research with an emphasis on chemistry. The Beckmans initially were the staff and the office was their dining room table. The Beckman Foundation gave substantial gifts to the Scripps Clinic and to the University of Illinois. In the 1980s the Beckmans created five Beckman Institutes in the United States devoted to cutting-edge research in the molecular sciences. In addition, Beckman gave two million dollars to the Chemical Heritage Foundation in Philadelphia for the Beckman Center for the History of Chemistry.

National Historic Chemical Landmark

The American Chemical Society designated the development of the Beckman pH meter at the California Institute of Technology a National Historic Chemical Landmark on March 24, 2004. The plaque commemorating the event reads:

Arnold O. Beckman developed the first commercially successful electronic pH meter while a member of the faculty of the California Institute of Technology. This rugged and portable "acidimeter," which had all necessary components housed in a single unit, allowed scientists to measure acidity accurately and rapidly. It immediately met an important need of the California citrus industry: how to measure the pH of lemon juice. The innovative features of the pH meter, including an early use of integrated electronic technology, were the basis for subsequent modern instrumentation developed by Beckman and Beckman Instruments.

About the National Historic Chemical Landmarks Program

The American Chemical Society, the world's largest scientific society with more than 159,000 members, has designated landmarks in the history of chemistry for more than a decade. The process begins at the local level. Members identify milestones in their cities or regions, document their importance, and nominate them for landmark designation. An international committee of chemists, chemical engineers, museum curators, and historians evaluates each nomination. For more information, please call the Office of Communications at 202-872-6274 or 800-227-5558, e-mail us at nhclp@acs.org, or visit our web site: www.chemistry.org/landmarks.

A nonprofit organization, the American Chemical Society publishes scientific journals and databases, convenes major research conferences, and provides educational, science policy, and career programs in chemistry. Its main offices are in Washington, DC, and Columbus, Ohio.

Acknowledgments:

Photo Credits: Pictures of acidimeter and Arnold Beckman holding an acidimeter are courtesy Beckman Coulter, Inc. All other photos: Getty Images

Other Credits: Chemical Heritage Foundation for the transcripts of Arnold O. Beckman interviews by Jeffrey L. Sturchio and Arnold Thackray at University of Pennsylvania, 23 April 1985 and 23 July 1985 (Philadelphia: Chemical Heritage Foundation, Oral History Transcripts #0014A and #0014B). California Institute of Technology, Oral History Project for Arnold O. Beckman, Interview by Mary Terrell, 16 October and 4 December 1978 (California Institute of Technology, Oral History Project, Caltech Archives, 1981).

Written by Judah Ginsberg

The author wishes to thank Mary Ellen Bowden, Paul Jones, and Frankie Wood-Black of the National Historic Chemical Landmarks Committee for reading the text and correcting inaccuracies. He also wishes to thank Dr. Stanley Pine of the ACS Board of Directors for also reading the text. Needless to say, any errors are the author's alone.

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