

## Arnold Orville Beckman

*b. April 10, 1900, Cullom, Illinois, U.S.A.  
d. May 18, 2004, La Jolla, California, U.S.A.*



**Arnold O. Beckman was one of America's foremost inventors. Starting with the invention of the pH meter (the first accurate test for acidity) in 1935, Beckman went on to secure 14 patents and produce dozens of scientific instruments that have advanced the understanding of human biology and chemical measurement. He developed the helical potentiometer, a precision electronic component, and the quartz spectrophotometer, an instrument which pioneered automatic chemical analysis. Beckman was a founder of the megacorporation Beckman Instruments. Also known for his philanthropy, Beckman founded the Arnold & Mabel Beckman Foundation, which disburses millions of dollars to scientific endeavors each year.**



Arnold Orville Beckman came into a town of fewer than five hundred residents at the birth of a new century. Born April 10, 1900, he was the third son of George Beckman, one of three blacksmiths in the town of Cullom, Illinois. Arnold was the first child of George Beckman's second wife Elizabeth Beckman (*nee Jewkes*), who was a native of the small Illinois town. Soon Arnold lost his status as baby of the family with the birth of his sister, Wilma, in 1904. Arnold had also two older half brothers, Frederick and Roland.

*A wedding portrait of George Beckman and Elizabeth Ellen Jewkes, 1898 (left); Elizabeth Ellen Beckman (nee Jewkes), Arnold's mother (right)*

Beckman's childhood was idyllic after the manner of Twain's boy-heroes. At age nine, he fortuitously stumbled upon an old, dusty book that had belonged to his aunt. "*Fourteen Weeks in Chemistry*" was a basic instruction manual teaching simple home



experiments for children. Beckman was captivated. From this point forward, he managed to commandeer laboratory space in each of his family's houses, no matter how small. When the family moved to Bloomington, in 1915, Arnold set up not only a chemistry laboratory in the attic of the house, but also appropriated the basement for an electrical lab as well.

*Beckman's blacksmith shop in Cullom, Illinois*



*Arnold Beckman as a toddler*



*Arnold Beckman dressed as George Washington*



*The Beckman brothers: Arnold (center), Frederick and Roland*

### **Early Education and Military Service**

Once enrolled at University High School, the teaching school affiliated with Illinois State University, Arnold talked his way out of Latin courses in favor of an accelerated chemistry curriculum. A professor of chemistry at Illinois State University agreed to mentor the young chemist after observing his enthusiasm and aptitude for the subject. This professor, Howard Adams, enthusiastically fostered Arnold's interest in chemistry, guiding Beckman through six courses of college chemistry and driving the teenager fifty miles to Urbana each Saturday to give him access to the more fully equipped chemistry labs of the University of Illinois. Beckman and Howard Adams also subscribed to a correspondence metallography course after Adams observed Beckman's interest in the subject. Adams himself had no particular personal interest in metallography, as Dr. Beckman recalled many years later, but, like a good mentor, he wanted to encourage his student's inclinations. If all this was not enough

Adams found his student a customer to whom the young Beckman could market his skills as an analytical chemist: the Bloomington Gas Works. Arnold went so far as to have business cards printed bearing the name "***Bloomington Research Laboratories***" and listing Arnold Beckman as the "***Chief Scientist***." The seventeen-year-old was commissioned to run periodic analyses to determine the concentration of ferric chloride in the wood chips used to remove the noxious smell from coal gas.

An exemplary student, Arnold Beckman was released from high school half a year early, in order to join the American effort in the First World War. His skills in chemistry were put to good use: Professor Adams found Beckman a position as a chemist with Keystone Steel and Iron during the spring of 1918. His job was to analyze steel samples during the manufacturing process, to determine the content of carbon and other substances in the melt. The varieties and qualities of the metal depended upon the carbon content of the steel and the presence of other materials. Moreover, the precise timing of steps in the manufacturing process, as well as subsequent procedures for shaping and handling the steel, all hinge on this same measure of the steel's components. Arnold's ability to carry out his chemical analyses quickly and accurately was of paramount importance to Keystone, and he rose to the challenge. Beckman and the only other analytical chemist worked in alternating ten- and fourteen-hour shifts, two weeks on the first shift, two weeks on the second. Beckman was the sole person in charge while he was on duty. Dr. Beckman later painted the scene at Keystone thus:

*"This was an open-hearth plant, a hundred tons of glowing hot, molten steel in each furnace. When they're about ready to pour the melt, it is essential to know whether four elements of impurity are within acceptable limits. I'd reach into the open-hearth furnace with a long-handled ladle, get a sample of the molten iron and pour it into a mold about two inches square and six inches high. As soon as the test sample was solid-although still red hot-I'd pick it up tongs and run to the laboratory. After cooling it with water, I'd drill chips and weigh out four samples: one each for carbon, sulfur, manganese, and phosphorus analysis. On that they'd decide if they would pour that melt or refine it more. With a hundred tons of molten steel tied up, every minute costs a great many dollars; that's why it was so important to get the results back in a hurry. I'd race against the clock. I could run all four of these analyses in less than thirty minutes. I set a record for the lab, I remember."*

Arnold Beckman returned to high school for graduation after having worked at Keystone. He was valedictorian of his class in 1918, with his overall average of 89.41 — the highest in University High history. Despite the sober and serious impression that these records might leave, Arnold was an exuberant young man: his class spent graduation day playing at the park, and at the ceremonies that night, valedictorian Beckman had a bright red sunburned face as he stood up to give his speech.



***Arnold at Marine  
boot camp,  
1918***



***Mabel in Red  
Cross uniform,  
1918***

Though he had already had an opportunity to help the American war effort, the eighteen-year-old Beckman felt that a stint in the Marines would give him adventure outside the narrow parameters of his Illinois boyhood. He would never leave the United States while in the Marines; he made it as far as Brooklyn Navy Yard before the war ended in November 1918. That year, the young Marine found himself being served Thanksgiving dinner by a beautiful seventeen-year-old Red Cross volunteer named [Mabel Meinzer](#). It must have been love at first sight, because Mabel Meinzer and Arnold Beckman began to correspond regularly. In Mabel, Arnold found a life-long companion and partner who he would marry almost seven years later.



An accomplished pianist, Beckman formed his own dance band in high school. He also accompanied the silent movies at the local theater. After being discharged from the Marines in 1919, he headed west for the summer as an itinerant movie-house pianist before entering college.

Upon discharge from the Marines, Beckman very much wanted to further his education in chemistry. Too late to enroll for the spring semester of 1919, he decided to see some of the country before starting college in the fall of that year. His summer adventures, which took him all the way to Ashton, Idaho, taught the young Beckman a valuable lesson about self-reliance and an entrepreneurial spirit. A talented pianist as a result of his mother's discipline, Arnold Beckman had begun an amateur musician career in his early teens, practicing with the Cullom band, playing piano at one of the Bloomington movie theaters, and eventually starting his own orchestra in high school. He spent the summer playing as a movie-house pianist in the Ashton theater, and through this experience he convinced himself that he was equal to whatever task was laid in front of him. The summer that he "*bumped out west with a friend*" was truly formative, converting his confidence in his ability into an unshakable faith in his future: "*I learned I could take care of myself no matter what. So what my future life was going to be really never was of great concern to me.*" He could follow where his curiosity and his judgment where they might lead him, secure in the knowledge that he would always find his way in the world. "*I thought at that time I was going to be an organic chemist,*" Dr. Beckman once recalled, "*I was intrigued by thoughts of making all these fancy dyes and thing of that sort.*" He would later add: "*Keep in mind, I was a young lad in 1919 coming from a small rural community that had no contact with the industrial world at all... I wasn't worried about the future of the chemical industry at that time. I was interested in making some interesting chemicals, dyes, or things that smelled well.*" After an entertaining summer out west, Arnold made his way back to Illinois, where he began his freshman year at the University of Illinois at Urbana-Champaign.

### The University of Illinois

Because Beckman had done university-level course work in chemistry while at University High, he was allowed to pass over the regular sequence in the Illinois chemistry curriculum and begin with the advanced courses. One professor who made a great impact on Beckman during these formative years was his freshman-year organic chemistry teacher, Carl "Speed" Marvel (1894-1988). Speed Marvel was to become one of the nation's best-known and most respected organic chemists. He mentored generations of students during his long tenure at Illinois, served as president of the American Chemical Society, made path-breaking contributions to polymer science, and played a crucial role in the [synthetic rubber program](#) during the Second World War. When Beckman first encountered Marvel, however, he was a recent Illinois Ph.D. serving as an instructor in the department. Just six years older than Beckman, Marvel provided the freshman with an immediate example of how someone remarkably like him could make his way in the world of academic chemistry.

Beckman respected Marvel, and the respect was mutual. As Beckman had already studied a substantial amount of chemistry, Marvel assigned him a research project of his very own involving mercury

compounds. Beckman worked on synthesizing dialkyl mercury compounds, namely dipropyl and isopropyl mercury. Marvel proved to be both a mentor and a guiding model for Beckman as a chemist. In 1920, as Arnold Beckman began his syntheses in the organic chemistry laboratory, he did so in a way that would have caused shock and dismay in our more risk-conscious era. Mercury is one of the most hazardous and toxic of the elements, ranking just behind lead and arsenic. The smallest of exposures can cause poisoning, and even death. While Beckman and Marvel were aware of the dangers of mercury poisoning, they had good reason to be interested in mercury compounds. These compounds had an agricultural usefulness to match their dangers, in fungicides and preservatives, and were also key ingredients in many manufacturing processes.

Almost immediately, Beckman began to suffer from mercury exposure. His work was progressing, however, and he stuck doggedly to his bench. By the time that he left to return to his father's home for the Christmas holidays, the exposure was already more than his body could bear. At home, the symptoms of his poisoning lifted away. The holidays lasted nearly a month, but when he returned to his experiments the mercury symptoms returned with a vengeance. Marvel, like his freshman student, had also been afflicted by repeated mercury exposures. He, like Arnold, developed an extreme sensitivity to the organic mercury compounds, causing him to abandon this line of research. Marvel later remembered: "*If somebody opened a bottle of mercury compound two doors down the hall [in the laboratory], I'd get a headache.*" The organic chemistry laboratory became so hazardous for Beckman that he made a dramatic change of track in his chemical studies. He switched over from organic chemistry to physical chemistry, away from mercury and toward a whole new realm of fascinating chemical questions and puzzles.

Beckman's association with Marvel did not end with his switch to physical chemistry. The older man had another example to set for Arnold Beckman. From the time of Marvel's arrival at Illinois as a graduate student, the faculty and students of the Department of Chemistry had long had intimate connections to industrial enterprises. Summer work was available for the brightest of its organic chemistry students at what the Department then called "*organic manufactures*," the synthesis of rare and expensive fine chemicals in very limited quantities. This enterprise served a dual purpose: students learned the concepts and craftsmanship of chemistry by making dozens and dozens of compounds, and the Department obtained compounds for itself and financed the purchase of other research materials through sale of the compounds to others. Academic and industrial chemists alike had a growing thirst for greater quantities and varieties of exotic, pure organic compounds. They were the raw materials with which chemists expanded the bounds of chemical knowledge and developed new industrial products and processes. There were very few sources from which to purchase fine chemicals, and even fewer that could match Illinois's reputation for pure product. Marvel began working at these organic manufactures during his second summer as a graduate student and continued on through his next two academic years. This work, which combined the educational and the practical, allowed Marvel to earn a student's living and, in his estimation, truly become a chemist: "*That's how I learned my chemistry.*"

	By Arnold Beckman's freshman year, Marvel directed the organic manufactures work. It was he who made the decisions about which Illinois students would get the competitive positions in synthesis during the summer recess. Marvel gave Beckman a job after his second year on the basis of his precocious grasp of chemical concepts and his skills of hand, eye, and wit at experimental chemical manipulations. Despite the hazardous environment, Marvel provided Beckman with a powerful model. Marvel was an academic chemist possessing rural Illinois roots, ties to Bloomington, and a real delight at the fascinations and
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challenges of chemistry. Furthermore, Marvel, in partnership with a leading distributor of scientific goods, was making money and providing livelihoods through producing the basic tools with which fellow scientists could further the progress of science and technology. Consciously or unconsciously, Beckman drew on these experiences a decade and a half later as a relatively new professor of chemistry at Caltech.

*Arnold Beckman in his 20s*

Beckman left Illinois in 1923 with a B.S. in chemical engineering and master's degree in physical chemistry. He left immediately for Pasadena, California to pursue a Ph.D. at the newly-formed California Institute of Technology. His choice was based on the quality of the program at the fledgling school, its small size, and Beckman's natural attraction to the West. It meant moving farther from Mabel, however, which must have been a difficult decision considering that their engagement had been announced that spring. He and his close friend William Hincke made the journey from Illinois to Pasadena in Hincke's Model T, an arduous journey over the mountains that served to renew Beckman's passion for the enchanting scenery of the West.

### Off to New York: Mabel and Bell Labs





Caltech was a stimulating environment, full of interesting scientists at the top of their fields, but Beckman grew restless over the course of his first year. Despite his love for California and Caltech, his attention constantly returned to Mabel Meinzer. She was gainfully employed in New York, and Beckman did not feel that he could ask her to come to California to share his uncertain life as a graduate student. Thus, in 1924, he drew deeply on the self-confidence he gained in his Western summers and left for New York to seek gainful employment. He took the cheapest passage he could find, by steamship through the Panama Canal, but the stateroom that his hundred-dollar passage bought was so uncomfortable that he spent most of the voyage on the deck.

*Arnold Beckman, 1925*

Beckman's first thought was to work as a chemist at Standard Oil of New Jersey's Bayonne refinery. He was offered the job almost immediately, but a friend from Caltech who was working for the newly-formed Bell Labs in Manhattan reportedly told him "*Oh, you don't want to work out in Bayonne, the mud flats. Why don't you get a job right here in New York with Western Electric?*" Almost immediately, Beckman became the first technical employee of Walter A. Shewhart, known as the father of modern statistical quality control. Even though his two-year career at Bell Labs is often treated as a sidebar in his life, he learned important lessons about electronic technology and quality control in manufacturing

as it was practiced in the most renowned of industrial research centers. Beckman learned the importance of intellectual integrity in business from Shewhart, as well as a commitment to scientific objectivity. But most of all, Beckman learned the awesome potential power of electronics when they were built to exacting standards of quality. The easy familiarity that he gained with the vacuum tube, a Bell Labs invention, would pay off significantly later in his life. His experience with electronics at Bell Labs provided important knowledge for the partnership of chemistry and electronics that he was later to make so successfully.

	<p>Beckman's relationship with his <i>fiancee</i> only deepened with his arrival in New York, and Arnold and Mabel were married in June of 1925. They took a honeymoon to Niagara Falls and the Great Lakes, and returned to New York to set up housekeeping. Despite the opportunity and variety offered by New York, Beckman was restless for California. When Arthur A. Noyes, the chairman of Caltech's chemistry division, arrived in New York and demanded a meeting with Beckman to convince him to come back and finish his degree, Beckman needed little prompting. Arnold and Mabel set out for California in the fall of 1926 in Arnold's Model T. The journey took six weeks, and Arnold set a personal record in the Badlands of South Dakota: nineteen flat tires in one day. This was all a new experience for Mabel, who had always been a city dweller, but she and they arrived safely at Pasadena.</p>	
<p><i>Arnold and Mabel's wedding, June 1925</i></p>		<p><i>Arnold and Mabel on their honeymoon, 1925</i></p>

### Caltech and a Family

At that time, Caltech was an unusual place. It was a college organized around a technological vision, that science and rationality would provide good things for all people. This strong vision attracted strong scholars, and Caltech quickly won a reputation for a distinguished faculty and progressive thinking. Beckman studied in Noyes's program at the Gates Laboratory, which was very forward-thinking in its emphasis on the interaction between chemistry and physics. By the time of Beckman's return, the lab was already a center for X-ray crystallography in the United States.

	<p>Beckman quickly settled in at Caltech, and the combination of classes, teaching, and choosing a subject for his doctoral dissertation kept him busy. He and Mabel lived close to the campus, and Beckman had a study partner in a cedar waxwing that the couple had adopted. Beckman remained true to his experimental background by choosing photochemical research for his dissertation. This choice placed him on the frontier of science under the tutelage of Roscoe Gilkey Dickinson, a respected experimental scientist at</p>
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Caltech. His research on the photochemical decomposition of hydrazine required a delicate experimental touch, and it was this unique combination of intellectual and mechanical skill that served him so well in his later career.

*Arnold and Mabel*

He made his first inventions while a graduate student at Caltech and was also issued his first patent, for a "signaling device" for automobiles that rang an alarm when a certain speed was exceeded. Beckman needed this device himself, as he had already gained his lifelong reputation as a fast driver. He furthered his interest, developed at Bell Labs, in the power of the vacuum tube by building radios for himself and his friends. His journals from his graduate school years contained ideas for many other inventions that were never fully worked out, such as an audio recording scheme for film and a proto-power window for an automobile.

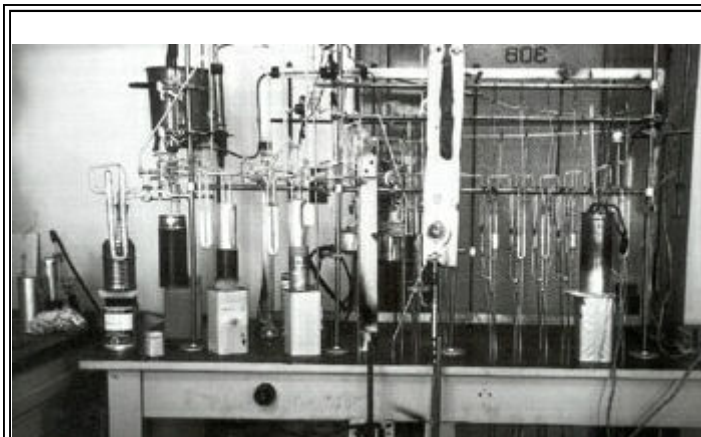


Beckman won his Ph.D. in 1928, and was immediately asked to join the faculty at Caltech. He does not remember investigating any other job options; he liked Caltech, he was invited to stay on competitive terms, and so he did. Both he and Mabel liked California and Caltech, and the transition from student to professor seemed simple at the time. He was promoted from instructor to assistant professor after only a year, at about the same time as the stock market crashed. Caltech and its faculty tightened their belts and marched on, however. Beckman continued his photochemical research with minimal budget cuts, but found that there was an increasing demand for his mechanical and technical skills as an experimenter. His research was never the central focus of his life at Caltech; instead, he took his duties as a teacher with the utmost seriousness and enthusiasm. He showed a good deal of inventiveness in the classroom, using laboratory devices of his own invention that allowed interesting and informative demonstrations.

Beckman quickly became responsible for freshman chemistry, a course that he enjoyed teaching immensely. His inclination towards practical problem solving led him to teach experimental techniques for chemical engineering and industrial chemistry as well. He quickly became the acknowledged faculty virtuoso in the lab, and much of his time was occupied with a stream of problems and requests from all over the university. His skills as a glassblower were especially in demand. His photochemical research suffered in this flurry of miscellany, but there was order to the chaos. The challenges that were most often presented to Beckman, as well as those that most often held his interest, were the construction of instruments and apparatus.

As the 1930s wore on, the chemistry department at Caltech became increasingly interested in pure, academic science. Beckman began to work more closely with William Lacey, the sole professor of chemical engineering, and soon became a primary resource for answering questions posed to the

institute by industry.



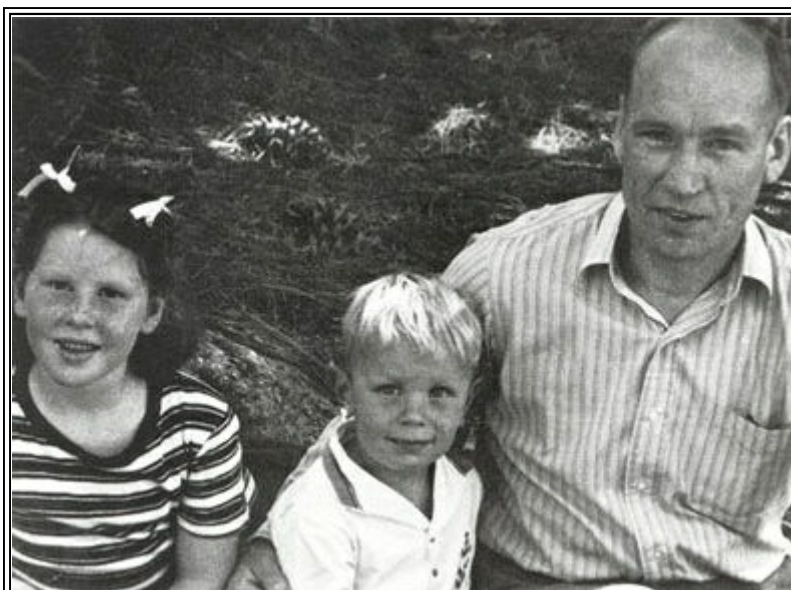
Beckman and Lacey paid close attention to what was going on outside Caltech in the world of applied chemistry. For example, he worked with inventor [Lee De Forest](#) on the early development of television by supplying him with a device that would place a uniform coat of metallic silver on a strip of film. His photochemical research continued to languish further under a tidal wave of practical, mechanical challenges.

*Part of Beckman's photochemical apparatus at Caltech*



*The Beckman' Altadena dream house*

Despite the Depression, the Beckmans thought themselves sufficiently successful to begin building their dream house in 1933. They had it built sturdily to their own design at the entrance to Eaton Canyon, in nearby Altadena. Their spare time was well occupied with activities that they enjoyed, such as camping and hiking, but soon they began to think about having a family. Mabel had learned early in their marriage that she was unable to have children and in her despair even suggested a divorce so that Arnold could have his own children, but Arnold flatly refused to hear of it.



They joined The Cradle, a new adoption agency operating out of Chicago, and in 1936 Mabel traveled there to adopt Gloria Patricia, or Patty, Beckman, then three years old. Less than a year later, they returned to adopt the newborn Arnold Stone, or Arnie, Beckman. By 1937, the family was complete in their new Altadena home. Mabel fought off an attack of tuberculosis around this time in order to dedicate herself completely to her new family.

*Arnold Beckman with his adopted children: daughter Patty (Patricia) and son Arnie (Arnold)*



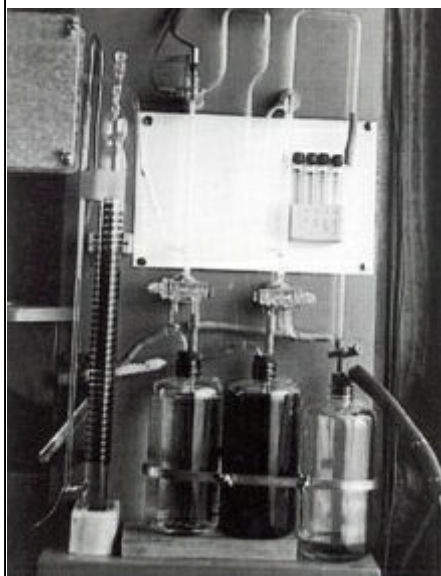
*Arnold and Mabel Beckman with daughter, Patricia, and son, Arnold, 1946*



*Arnold and Mabel Beckman in their home in the late 1940's*

### **The World of Business**

Beckman was being slowly drawn into the world of applied science outside of Caltech. In addition to fielding inquiries made to the University, he began to serve regularly as an expert witness and as a private consultant. Beckman worked extensively with a Los Angeles patent attorney named Leonard Lyon. Southern California was an exciting place at the time, experiencing rapid growth and great opportunity, and so Lyon and Beckman had more than enough to fill their plates. They were involved in proceedings all over the state of California, including one that almost implicated Beckman along with the defendants he was testifying against. A group of fraudulent entrepreneurs whom Beckman was testifying against attempted to debunk his testimony by claiming that he was their employee, but his meticulously kept diaries convinced the state otherwise. The extra income made the Beckmans very comfortable and eased their journey through the years of the Depression.



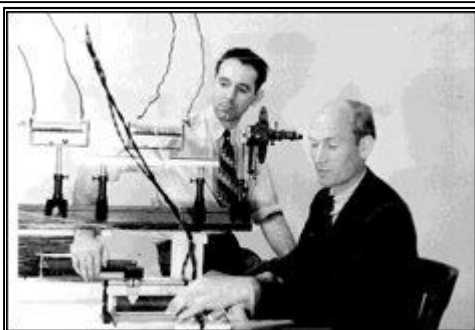
Another opportunity presented itself in 1934. National Postage Meter, a fledgling company in Los Angeles, was having trouble with ink clogging their postage printing machines. They consulted Beckman, who quickly developed an ink whose particles of pigment would not settle out in solution. His ink was effective, but it had an unpleasant odor and no established ink manufacturers would produce it. With characteristic self-confidence, Beckman decided to manufacture the ink himself. National Postage Meter set up a subsidiary company, National Inking Appliance Company, and put Beckman in charge. This new company manufactured Beckman's ink and also a pair of re-inking devices, also of Beckman's invention. The company was run out of a back of a garage belonging to a Caltech associate, and it employed graduate students part-time. The ink was a success, but the re-inking devices were not; Beckman quickly discovered that secretaries were not willing to get their hands dirty to save their bosses the cost of a seventy-five cent ribbon. Beckman learned an important lesson: no matter how ingenious an invention, it was worthless if it was not commercially

***Beckman's ink-making device***

viable. National Inking Appliance Company was the smallest of operations, but it was a significant step. Arnold Beckman was in charge of his own company. It was another step beyond the cloister of Caltech.

The next big change in Beckman's life came when he was asked by an old friend from the University of Illinois, Glen Joseph, to help solve a tricky experimental problem. Joseph worked for the California Fruit Growers Exchange, a proto-agribusiness that controlled more than three-quarters of California citrus production. They sold their prime quality fruit under the Sunkist label, but the lower-quality fruit was processed to make pectin and citric acid. These industrial processes needed a sturdy and reliable method of testing the fruit's acidity, but the sulfur dioxide that was added as a preservative made all traditional methods of testing untenable. Beckman hit on a novel solution built around a pair of vacuum-tube signal amplifiers that made the device both sensitive and rugged. Suddenly, his various experiences came together to put him in a unique position: his understanding of electronics, gained at Bell Labs, mixed with his knowledge of chemistry, his skill as an experimenter, and his enthusiasm for practical problem-solving to create a perfect solution to his old friend's problem.

Once Joseph's lab had demanded another device almost immediately, Beckman realized that there might be a wider market for his acidity-measuring devices. Beckman's real innovation was more fundamental, however. Electrical equipment was commonly used in chemistry labs by the 1930s, but integrated instruments were not yet available on the market. Experimental chemists were expected to have a working knowledge of electrical engineering in order to integrate the separate components of their experimental device. Beckman's original solution to Joseph's problem fit within this paradigm; he supplied the vacuum-tube amplifier that Joseph integrated with his own meters and electrodes. When Beckman began to think about the market beyond the California Fruit Growers Exchange, however, he envisioned an integrated instrument that would encase all the electronics in a neat box. A sample would be placed in one end, and a reading would appear on the top. It was simple, portable, precise, and did not require a deep understanding of electronics to operate. Thus, Beckman's solution was doubly revolutionary: it was built around vacuum-tube technology, and it was a completely integrated instrument rather than just a device.



***Beckman and McCullough  
with apparatus, ca. 1933***

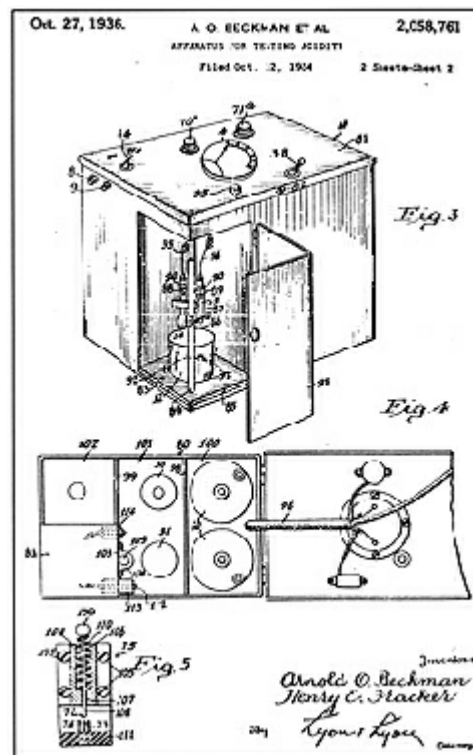
Although close control of acidity is critical in the manufacture of many industrial products, industrial chemists continued to use color tests well into the twentieth century and rarely used the pH scale. The first commercially successful electronic pH meter was invented in 1934 by Prof. Arnold O. Beckman. He tried to interest various companies in manufacturing the device, but they declined. As a result, he formed in 1935 National Technical Laboratories, based in Pasadena, Calif., which developed the first commercial pH meters and was the beginning of what is now Beckman Instruments, Fullerton, Calif.



*The Beckman G pH meter was produced from 1935 until 1950. At roughly 29 cm (~11") wide it is large by today's standards, but measuring pH had required an entire benchtop of equipment before Beckman's first pH meter was introduced in 1934.*



*This pH meter of 1934, highlights the development of the company that became Beckman Instruments and started a revolution in scientific instrumentation.*



*Patent drawing for the original Beckman pH meter (1936): Apparatus for Testing Acidity; Patent No. 2,058,761*

To make his original pH meter study, Beckman used the then recently invented vacuum tube. Although he was cautioned against starting up a company to offer a \$195 instrument to scientists struggling to keep laboratories going in the middle of the Depression, Beckman went ahead, and the firm was a success.

The pH meter invented by Dr. Beckman, a forerunner of modern electrochemical instrumentation, the scientific instrument simplified and expedited acidity and alkalinity measurements. It quickly became an indispensable tool in analytical chemistry and, in 1987, earned him a place in the National Inventors Hall of Fame. Over the years, Beckman, other companies, and academic researchers made great improvements in pH meters as they developed into their modern form, with higher stability glass electrodes, microprocessor control, and light-emitting diode readouts. Beginning in the 1950s, electrodes were also developed for other ions, such as  $F^-$ ,  $Na^+$ ,  $K^+$ , and  $Ag^+$ . The pH meter and ion-selective electrode have now become indispensable scientific tools.



*Arnold Beckman is shown with the "acidimeter" he constructed in 1934, which led to the formation of Beckman Instruments.*

In October 1934 Beckman, Henry Fracker, and Robert Barton, who constituted the complete staff of the National Inking Appliance Company, submitted a design for an "acidimeter" to the Patent Office. Beckman had decided to develop his instrument through his private business venture rather than through Caltech due to his respect for the ethical issues involved in using the resources of an institution of pure science for personal gain. In April of 1935 the National Inking Appliance Company became National Technical Laboratories [NTL] to reflect its diversified business interests.

NTL was not a subsidiary of National Postage Meter. It was an independent company, and Beckman owned ten percent of the stock. National Postage Meter and Jergins Oil Company, its parent, split the remaining stock in return for nine thousand dollars starting capital. Beckman was happy to give his private venture a new focus on instruments, because National Postage Meter was having problems that were not simply related to the Depression and the ink business was on uncertain ground. It shows what a novice businessman Beckman was at the time, however; as he said later, *"You see how stupid I was.... We made back that nine thousand dollars in the first year. They put peanuts into the thing and [eventually] made several million dollars.... I was so naive."*

In September of 1935, Arnold and Mabel traveled to the national ACS meeting in San Francisco with his newly perfected instrument in hand. The conventioners were fascinated by its simplicity, elegance, accuracy, and innovation, but they were unsure of its commercial success at \$195 apiece. This was not an insignificant sum of money, about the monthly salary of a starting chemistry professor, and the country was still in the Depression. The Beckmans left with the semi-encouraging advice and departed immediately on an ambitious national sales tour. They visited all the major national laboratory supply companies, on whose opinion the success of the instrument rested. He received a positive response from Ed Patterson, Jr. of the Arthur H. Thomas Company, an influential national house based in Philadelphia. He forecasted a 600-unit market, big enough for Beckman to move into production, but more importantly the presence of an NTL product in a major national catalog gave Beckman a legitimate entry into the instrument market.

Beckman returned to Pasadena encouraged and began the academic year at Caltech as usual. NTL moved from the back of the old garage that had housed National Inking Appliance Company to a new building on Colorado Street, then Pasadena's main street. Demand grew quickly, and NTL sold eighty-seven instruments in the last three months of 1935.



*A new building of NTL on Colorado Street*

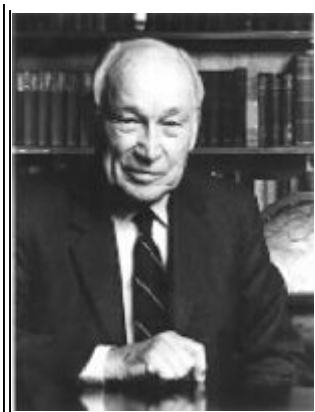
The company had no starting capital to speak of, and payment for each batch of instruments was used to buy the parts for the next. Production finally became well enough organized so that the instruments were produced in batches of twelve. NTL turned the handsome profit of \$2,000 that fiscal quarter, a remarkable start for any company, and especially impressive considering the economic conditions of the time. Soon the instrument was carried in the catalogs of all twenty-eight major instrument dealers in the United States, and it was sold as the "Beckman Glass Electrode pH Meter." Even from the beginning, Beckman's name was associated with high-quality precision instruments.

The success of late 1935 was not simply a fluke. Despite problems of supply that reflected the early stage of development of vacuum tube technology, Beckman's business grew to the point that he was forced to employ a "one-man sales force" to coordinate the flow of orders. Since the company was operating without any start-up capital to speak of, they were forced to use "imaginative economy" in as many ways as they could. Despite the company's emphasis on economical solutions, quality and aesthetics were never sacrificed; the early instruments even had walnut cases. Part of Beckman's genius was to balance the contradictory demands of economy and quality, a skill that he attributes to the company's Depression-era roots.

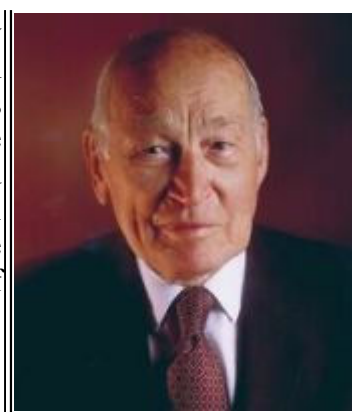
1937 brought the fledgling firm's first major obstacle. A professor at Stanford published a paper suggesting that the readings produced by Beckman's pH meter were influenced by the depth of the electrode in the sample. The NTL staff sought the cause of the problem, and found it in minute leaks in the glass electrodes. The glass electrodes were a key component in that they allowed the instrument to measure the pH of a wider variety of samples, but they were flawed. With typical confidence and energy, Beckman and his growing staff eventually secured a patent for their newly-invented factory-sealed electrodes that solved the problem. This gave NTL another advantage in the marketplace: not only were they marketing the most precise instruments available, they were also the sole manufacturers of the most error-free electrodes. They quickly specialized, producing electrodes made out of different compositions of glass that were optimized for different sample types. The company flourished, with 1937 bringing in record profits from the sale of instruments and accessories.

Beckman oversaw this period of expansion and innovation in his private enterprise while still remaining a full-time faculty member at Caltech. This is the same period in which he and Mabel were starting their family, and Beckman did not neglect his other research-and-development (R&D) projects, such as his inks for National Postal Appliance Company. He managed this full plate by hiring project leaders for each of his various pursuits and by managing them in the same way that a faculty member organizes graduate students. He presented each one with a problem and suggested possible solutions, and then let him come up with his own resolution. If it was different from Beckman's original idea, all the better. He and his growing organization were solution-oriented above all else.

In 1940 Arnold Beckman gave up his faculty



position at Caltech, but he remained deeply involved with education and research, serving on Caltech's board of trustees from 1953—as chairman from 1964 to 1974—and on the governing boards of several other colleges and universities. Through the Arnold and Mabel Beckman Foundation, the Beckmans have contributed substantially to the advancement of education and research nationwide.



### **National Technical Laboratories Comes Into Its Own**

By 1939, the four-year-old company was so successful that its board of directors created the new position of "President" for Beckman. This new acknowledgment of Beckman's role required that he leave his old position as professor at Caltech. Not only were the demands placed on him mutually exclusive in terms of time, Beckman sensed an ethical conflict as well. At Caltech in the 1930s, it was no light thing to mix pure science with the workbenches of business. Despite Beckman's fear that he was sacrificing his scientific training by using it for profit, he ultimately found peace with the decision through rigorously ethical conduct of his affairs and through the pleasure that he got from solving practical problems. Beckman stepped into his new role of head of a successful company brimming with confidence. Ever since his years at the University of Illinois he had constantly been creating ideas for of new inventions; finally he was going to have a chance to try some of them out. And the business could only benefit now that he was giving it his full attention.

Chemical instrumentation was profitable in 1939, so much so that Beckman began looking for a new home for NTL. Such was his optimism that he did not look for another rental; rather, he sought a loan to build according to his own plan.



NTL moved into their new 12,000-square-foot facility at 820 Mission St. in South Pasadena in 1940. Beckman was initially dismayed at the enormous amount of space that his company had to fill, but soon the outbreak of the Second World War filled it faster than he could imagine.

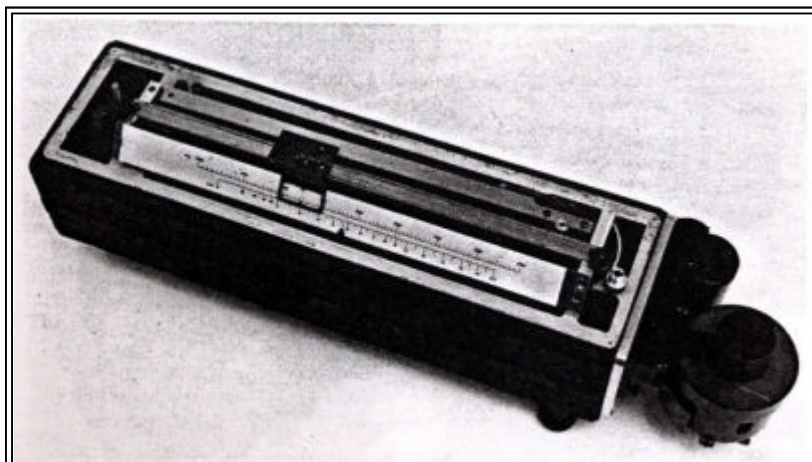
*NTL's Mission St. headquarters*

The competition did not stand still for long, and by 1940 Coleman Instruments had offered a pH meter that was just different enough to stand up to direct patent infringement attacks. Even worse, Coleman developed the instrument one step further with an add-on component that allowed the pH meter to be used for ultraviolet spectrophotometry. This assembly of optics and phototube developed a weak electrical signal based on the absorption of the sample, which the user could then feed into the pH meter for amplification and readout. Even though this was a cumbersome and less than ideally accurate system, it was better than the earlier options. Before the Coleman system, a chemist had to assemble a

huge, complex, and expensive network of individual components if he wanted to read absorption from the ultraviolet spectrum. Beckman, needless to say, was immediately intrigued, and immediately began work on a solution that would best Coleman's. The eagerness of many chemists to work with ultraviolet-absorption spectrophotometry guaranteed a market, so Beckman put his vice president for development, Howard Cary, in charge of the project.

NTL initially approached Bausch and Lomb, a renowned maker of optical instruments, to make the optics required for the spectrophotometer. Bausch and Lomb was not interested, because their factories were facing a capacity crisis due to their role as supplier to the armed forces for the war effort. They did not realize how crucial Beckman's spectrophotometer would later be in maintaining the armed forces' competitive edge. With characteristic confidence, Beckman decided to manufacture the optics himself. After much trial and error, the company developed a superior design based on a quartz prism and a highly accurate control mechanism. The beauty of Beckman's design as it evolved was that it all but eliminated the need for a skilled operator through its precision engineering. Beckman continued to follow Coleman's scheme, however, with a separate optical unit that could be attached to the electronics of the pH meter.

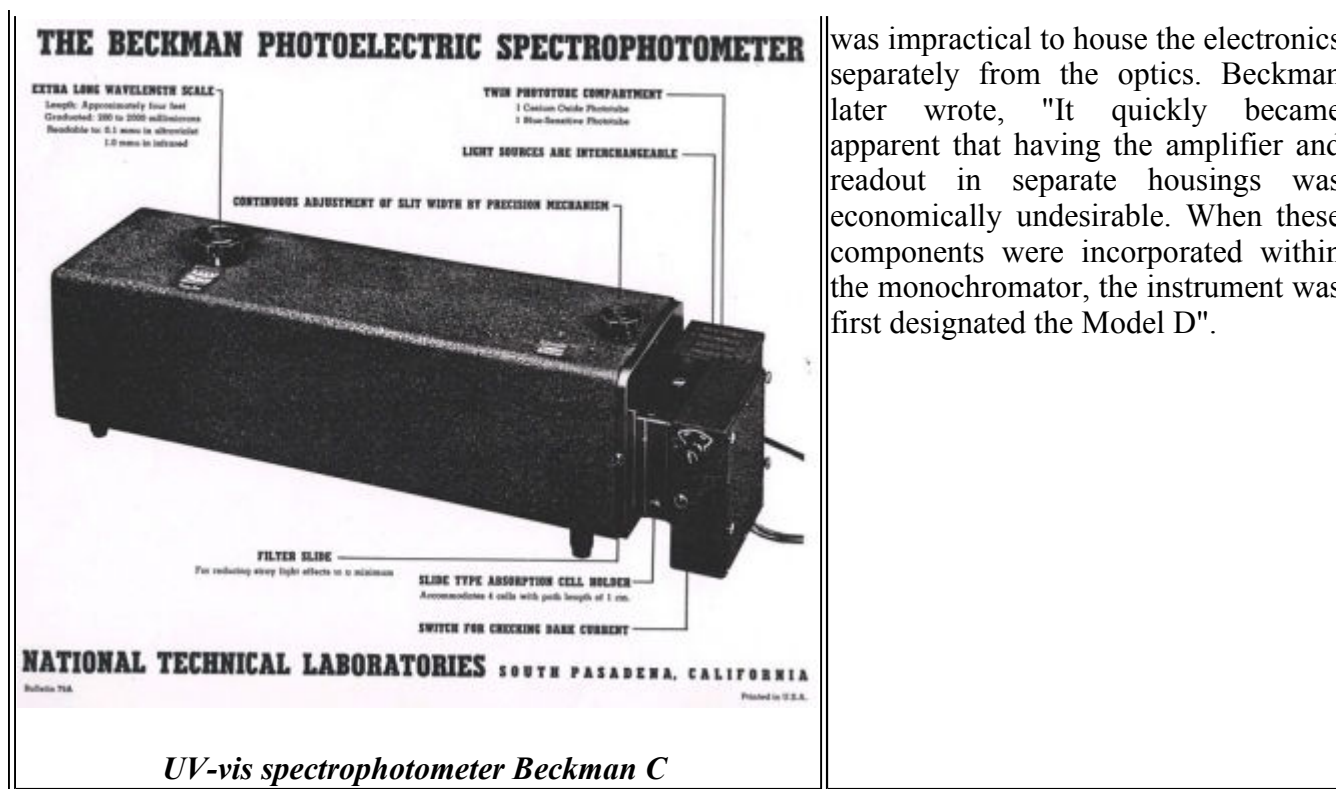
The first prototype UV-vis spectrophotometer, dubbed the Model A, was developed in 1940. The Model A used a tungsten source and glass Fery prism monochromator until it was discovered that glass was unsuitable for use in the UV.



*UV-vis spectrophotometer Beckman B*

The Model B prototype replaced the glass Fery prism with a quartz prism, greatly improving its usefulness in the UV. The Model B also utilized a tangent bar mechanism to adjust the monochromator. This mechanism was almost linear in wavelength, but too compressed and sensitive, particularly in the UV, for general use. A sure hand, skill, and considerable concentration were prerequisites for operation of the Model B. The Model B, like the Model A before it, used an external Beckman pH meter for readout.

The sensitive tangent bar mechanism of the Model B was replaced in the Model C by the scroll drive mechanism that would be used in all later Beckman quartz prism instruments. The model C also abandoned the rotary cell compartment of the Model B in favor of a linear sample chamber, but still used an external Beckman pH meter for readout. The end of the Model C was brought about by the realization that it



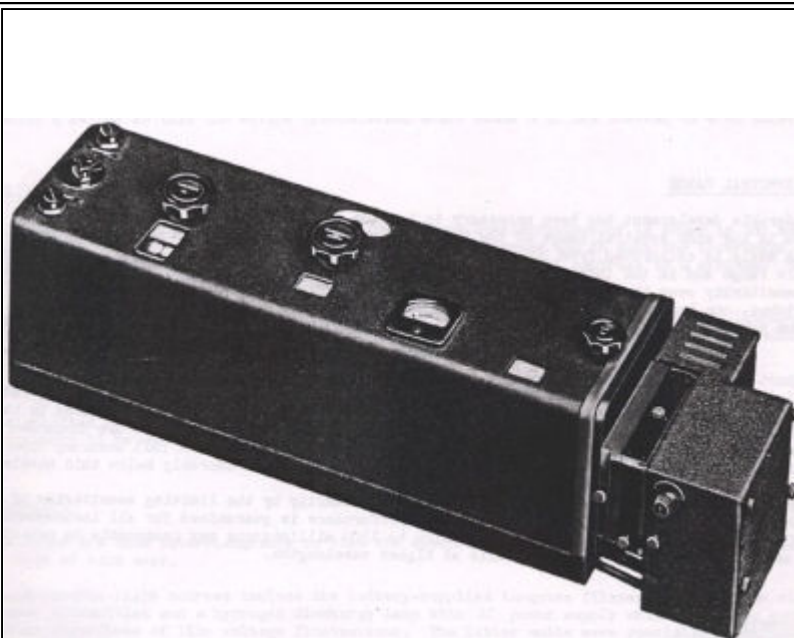
was impractical to house the electronics separately from the optics. Beckman later wrote, "It quickly became apparent that having the amplifier and readout in separate housings was economically undesirable. When these components were incorporated within the monochromator, the instrument was first designated the Model D".

The Model D incorporated the vacuum tube amplification system of the Beckman G in the empty space in the casing surrounding the quartz prism monochromator of the Model D. Finding the raw material for quartz prisms presented its own challenges. The large, high optical quality quartz required by the Model D could only be obtained from Brazil. Quartz was an essential part of radio oscillators, however, and any quartz shipped from Brazil was rapidly purchased by radio manufacturers for their wartime efforts. Because of the importance of UV spectroscopy to vitamin research, Beckman was able to convince the government of his need for quartz prisms, but "only after establishing a wartime priority listing and paying a premium price was it possible to get access to the stores of large, uncut crystals from which prism blanks Écould be cut".

Two more challenges had to be overcome before the Model D could enter production. The first was the design of a suitable UV light source. Tungsten light sources were widely available because of their use as automotive headlamps, gave excellent results in the visible, but had little power in the UV. In fact, Cary and Beckman's original paper describing the model D listed "a standard 32-candlepower automobile headlamp (Mazda No. 2331)" as the tungsten source (1941). Hydrogen lamps were known to produce UV radiation, but in 1940 there were no manufacturers of hydrogen lamps suitable for spectroscopic work. By 1941, National Technical Laboratories had developed and started production of a new type of hydrogen lamp with an enclosed anode and thin blown-glass window.

The most powerful UV lamp is useless without an appropriate detector, and finding a suitable phototube for the Model D was the last major challenge of its development. In 1941, RCA produced phototubes suitable for use from 350 nm to 600 nm and from 600 nm to 1200 nm, but nothing in regular production for use below 350 nm. RCA was also developing an experimental phototube useful to 220 nm, but the batches of this phototube were small and quality was irregular. Despite these problems, the Model D spectrophotometer was introduced at the Summer Conference on Spectroscopy at MIT in July 1941, with the experimental RCA phototube.

The Model D was a success, and demand quickly drained the supply of experimental RCA phototubes. RCA was unwilling to produce regular batches of the UV-sensitive phototubes, so Beckman and Cary frantically set about designing their own UV-sensitive phototube before the success of the Model D became its demise. Within months, production began on a new UV-sensitive phototube designed by Howard Cary and Warren Baxter. Instruments equipped with the new phototube were designated DU to signify their enhanced UV performance.



*UV-vis spectrophotometer Beckman DU*

With the advent of the DU Beckman introduced an instrument which "had higher resolution and lower stray light in the ultraviolet than any other commercial instrument, and it quickly enjoyed a good market". By the end of 1941, 18 DU spectrophotometers had shipped at a price of \$723; in 1942, 54 were sold. The first publication written on work using a Beckman DU was published in *Industrial and Engineering Chemistry, Analytical Edition* in September 1942. Beckman later wrote about the delay between the introduction of the DU and publication, "Those decrying the present delays in publication will be interested to know that the instrument upon which this paper was written was not shipped from Beckman Instruments until June 5, 1942! In subsequent years thousands of technical papers concerning DU applications have been published."

The Beckman DU has proven to be one of the most enduring instrumental designs in the history of analytical instrumentation. From its introduction in 1941 to the end of production of the cosmetically-altered DU-2 in 1975, over 35,000 instruments using the optical design of the original DU were sold. Major changes along the lifespan of this instrument have been the shift from DC to AC power, the introduction of the DU-2 with its cosmetic freshening and slightly altered control layout, and the production of numerous Beckman and other aftermarket accessories. The introduction of AC power to the DU line was more complicated might be expected because of the necessity to design a single power supply that would work with all existing DU spectrophotometers as well as their accessories, each of which had different voltage and current requirements. The modular design of the DU permitted accessories to be added easily. Some of the more popular, influential accessories were the flame photometry and automatic point-by-point recording accessories, both of which heralded new classes of instruments.

Even though the spectrophotometer had important long-term effects on the rate of scientific progress, its effect on the war effort was large and immediate. Scientists had already discovered the importance of vitamins to proper nutrition, but methods for determining the presence of vitamins in food remained elementary. For example, the presence of vitamin A



in foods was determined by feeding rats on the test substance and then analyzing the strength of their tailbones. This method was imprecise, tedious, and extremely time-consuming.

*A technician running an infrared analysis of penicillin*

Since vitamins have unique absorption patterns in ultraviolet light, however, Beckman's spectrophotometer could determine their presence quickly and with a high degree of reliability. This instrument became the standard so quickly that the National Bureau of Standards stipulated its use in large and important projects that required measurements to be absolutely interchangeable between labs. This official government endorsement of Beckman's invention sealed NTL's reputations for reliability and excellence.

Beckman's invention helped the war effort in other critical ways. It assisted in the mass production of penicillin, the miracle drug that decisively assisted an Anglo-American victory. Once penicillin had been discovered, the challenge of mass production remained. In order to synthesize the chemical, its structure had to be analyzed. The spectrophotometer played a crucial role in the research that led to this "miracle". The Model DU also assisted in the analysis of crude oil for two new substances crucial to the war effort. In addition to gasoline, oil, kerosene, and other traditional products, Beckman's instrument helped researchers find benzene and toluene in crude oil. Benzene is an important ingredient of synthetic rubber, and toluene is the second T in the critical explosive TNT. The orders that poured in from petrochemical companies for the Model DU opened a whole new market that Beckman had never considered.

The success of ultraviolet spectroscopy in the war effort convinced the government to make the development of infrared spectroscopy one of its wartime campaigns. Infrared spectroscopy had existed since the early twentieth century, but these measurements were qualitative rather than quantitative. It was only in the late 1930s that chemical scientists made infrared spectroscopy quantitative as well as qualitative. Norman Wright, a researcher at Dow Chemical, was the first to make a delicate electronic instrument out of a table full of equipment, in much the same way that electronic pH measurements and ultraviolet spectroscopy were conducted before Beckman's innovations.

In early 1942, the government held a top-secret meeting in Detroit to facilitate the production of reliable infrared spectrophotometers that had been deemed crucial to the mass production of synthetic rubber for the war effort. Robert Brattain, from Shell Development Company, had developed a working prototype based on a single-beam design. The Office of Rubber Reserve asked Beckman to manufacture a hundred instruments on Brattain's design. By September 1942, less than half a year after the Detroit meeting, NTL shipped the first infrared spectrophotometers, dubbed the Model IR-1. It worked, but Beckman and his colleagues could not help seeing many ways to improve it.

It was clear that the use of rugged vacuum-tube amplifiers instead of the testy galvanometer specified by Brattain would be a significant improvement. Therefore once production had begun on the promised one hundred IR-1s Beckman began work on an instrument of his own design, the IR-2. It was based on the design of the DU ultraviolet spectrophotometer, and it was endowed with a similarly substantial housing

and similarly simple controls.



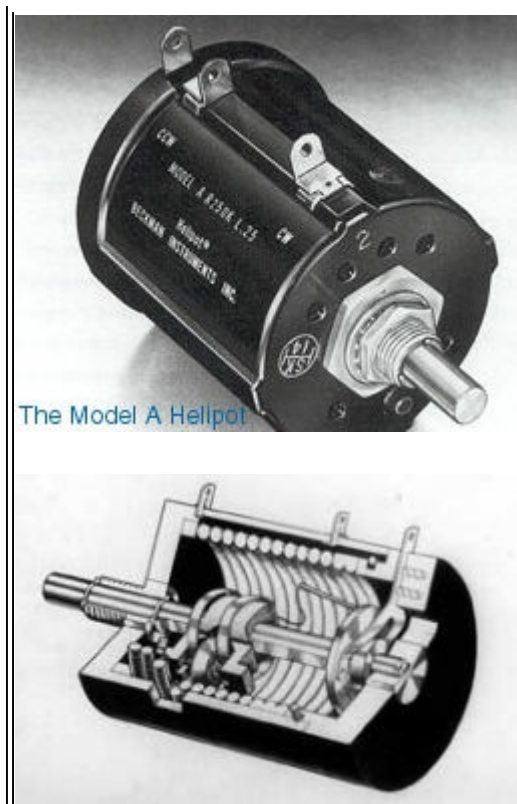
Beckman's team developed a new, highly responsible device for detecting infrared light, just as it had developed its own phototube for the Model DU. The IR-2 went into production in 1945. Despite its advanced design, the IR-2 was never as easy to use as the DU due to the inherent difficulty of infrared spectroscopy. It sold for upwards of four thousand dollars, and NTL sold over four hundred of them in the next eleven years. This was an unqualified success by the standards of the NTL of 1935, but it was modest at best compared to what was to come.

*Steve Murphy works on the IR-2A in the later 1940s*

The war left NTL with a mixed bag of advantages in infrared spectrophotometry. They had gained much experience and become a much larger company thanks to their involvement in the Office of Rubber Reserve project. Indeed, they had made more infrared spectrophotometers by the end of the war than any other American firm. However, they were forbidden to publicize this fact, and research conducted on their instruments could not be published. Bowling Barnes, a scientist from American Cyanamid who had been to the fateful meeting in Detroit in 1942, launched a commercial instrument with Perkin-Elmer based on a more sophisticated double-beam design. It was launched around the same time as the IR-2, and no one in the scientific community knew anything about Beckman's wartime experience with infrared spectroscopy. Beckman was not content with an inferior product; he still had that old Caltech spirit in him. He did not want to be involved in something unless he was going to be the best. He posed himself a direct question in 1953: would his company be involved in infrared spectroscopy or not? He decided that yes, the field was important and sufficiently cutting-edge for his company, and so he poured massive resources into the development of the instrument that would regain NTL's position as a leader in its field: the IR-4.

The IR-4 was introduced in 1956, and it became the archetype of an evolutionary family of spectrophotometers that ultimately spanned some seventeen years of production. It was radically redesigned and had many advanced features. Users could switch between single- and double-beam scanning modes with a simple switch, and in either mode it was a sophisticated, high-performance instrument. Once again, Beckman's commitment to excellence played a significant role in furthering the progress of chemical and life sciences research.

Immediately after the 1942 meeting in Detroit, Beckman received an urgent and puzzling call from Paul Rosenberg at MIT's Radiation Laboratory. Rosenberg arranged for Beckman to fly directly from Detroit and then back to Pasadena; to Beckman, this kind of arrangement could only mean another secret meeting for military purposes. Sure enough, once at MIT Beckman was initiated into the top-secret world of microwave radar, the real purpose behind MIT's Radiation Lab. The radar project had a desperate need for strong, reliable, and accurate potentiometers, otherwise known as control knobs. The best they had been able to find had been those on Beckman's pH meter. Early pH meters had used off-the-shelf components that were used by their manufacturer as volume and tuning controls for commercial radios, but Beckman's precision instruments soon outstripped their accuracy level.



In typical style, NTL developed their own potentiometer, called the Helipot (for "helical potentiometer"), with a radical new design that made them the most accurate and reliable on the market. Rosenberg asked him if he could create a new class of Helipot that would live up to military specifications. Beckman remembers answering an enthusiastic "of course," despite, as he admitted forty-three years later, "not realizing what I was getting into". The Helipot from the pH meter was accurate, but it was not able to withstand much shock.

***Beckman's Helipot (helical potentiometer): photo of the device and a scheme of the shockproof internal construction.***

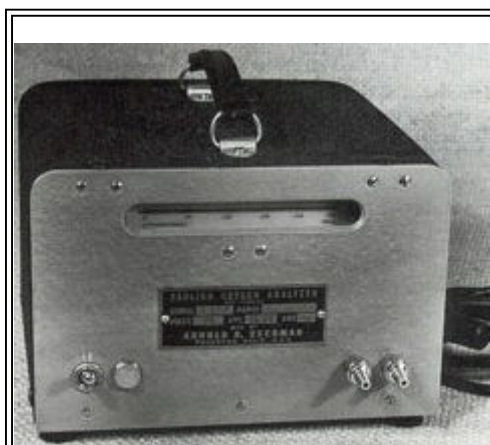
This was understandable, as Beckman's instruments were made to be used in a relatively peaceful laboratory, but the Helipot that they were to make for aircraft radar needed to be much more robust. A complete redesign was called for, but back at NTL, not everyone was so enthusiastic. The firm was just gearing up to make the infrared spectrophotometers for the Office of Rubber Reserve, and some of the engineers seemed to find the task of engineering a mere component distracting or even insulting. After all, NTL was in the business of making scientific instruments, not electrical components. What was even worse, Beckman could not inform his staff what the new Helipot was for; radar was so highly classified that the concept and even the word were top secret. His insistence on the new component seemed a mere whim to them, and he was almost faced with an "in-house mutiny". Caught between the demands of the military and the revolution among his staff, Beckman set out to redesign the Helipot himself.

The new design came to him one sleepless night, and he bypassed his disgruntled engineers to have the machinist make a prototype for him directly. The new Model A Helipot was exactly what the military ordered, and immediately NTL was deluged with orders. Within its first year of production the Model A was responsible for 40% of NTL's total profit. Its success was troubling, however. If the military was to declare the Helipot a military priority, they could force NTL to do nothing but produce them for the duration of the war, which would derail all of NTL's other more interesting projects. To address this problem, Beckman convinced the directors of NTL to allow him to set up a separate subsidiary corporation, the Helipot Corporation, to produce the components. The new company leased space in NTL's Mission Street headquarters, so Beckman was able to simultaneously direct the two companies. It was an important step for two reasons, however: it gave Beckman his first company of his own, and it allowed him to maintain a dual focus on instruments and components. When Helipot was reintegrated back into its parent organization in the mid-1950s, its reputation served to maintain for decades Dr. Beckman's position as an important electronics manufacturer. The Model A Helipot is still manufactured to Beckman's design. The Helipot, originally developed as a component of the pH meter, became an essential component in the then-secret RADAR systems used in World War II, and today is

used in products ranging from control systems to electronic games.

Beckman's instruments played another crucial role in the scientific aspect of the war program. The Manhattan Project, the almost superhuman effort by a broad range of American scientists to develop an atomic bomb, needed a reliable supply of plutonium. In order to ensure this supply, Dupont's plutonium works in Hanford, Washington needed to be running at full capacity. In order to determine full capacity, a micro-microammeter was needed to measure the amount of radiation being produced. Radiation could produce a weak electrical current in an ionization chamber, but scientists did not have a reliable instrument for measuring this current. After wasting much time and money trying to develop an instrument, a group of MIT scientists realized that once again Beckman's pH meter could do the trick. Beckman instantly adapted his pH meter to develop a whole line of micro-microammeters that were used in the Manhattan Project and beyond.

Beckman established yet another company to manufacture yet another instrument for the Manhattan Project. Arnold O. Beckman, Inc., made the "dosimeter", a miniaturized ionization chamber and meter based on a miniscule quartz fiber. The entire device could fit in the breast pocket. This allowed researchers to assess the level of radiation that they were being exposed to at any given moment. Beckman was especially proud of this neat little self-contained instrument.



*The Pauling Oxygen Analyzer*

As one of the nation's leading scientific and technical universities, Caltech was deeply embroiled in the war effort as well. The military needed an instrument for measuring the amount of oxygen in a sample of mixed gases; this device was needed on submarines and high-flying aircraft to ensure the safety of the servicemen. Linus Pauling contracted with the government to design and produce one in 1940. Pauling's assistant, Holmes Sturdivant, came to Beckman to ask him to build cases for the one hundred instruments they were manufacturing. Beckman agreed, but soon after the Caltech faculty came back and asked Beckman to manufacture the instruments in their entirety. Apparently they had underestimated the difficulty of mass-producing highly accurate instruments. In March 1942, Beckman agreed to manufacture the Pauling Oxygen Analyzer.

Beckman had already convinced the board of NTL to take on one top-secret project without knowing any of the details, that of the IR-1 infrared spectrophotometer. He was unable to convince them to produce the classified Pauling Oxygen Analyzer on faith as well. Instead, he produced it under the auspices of Arnold O. Beckman, Inc., the company he wholly owned that was already producing the dosimeter. The Pauling Analyzer relied on a set of tiny glass barbells suspended on an almost-microscopic quartz fiber, an arrangement that proved very difficult to manufacture quickly in large quantities as the war effort demanded. Beckman was forced to make several advances in manufacturing techniques, including what was probably the world's smallest glassblowing machine.

Arnold O. Beckman, Inc., produced only meters of Pauling's design during the war, but after the war they branched out with several improved varieties, including recording meters, meant for military, scientific, industrial, and medical use. By 1955 Beckman Instruments had integrated the oxygen analyzer technology with its infrared analysis and other technologies in the Mark II Atmosphere Analyzer, which was used on the U.S. Navy's submarine fleet.

## The Post-War Boom



*A Beckman Instruments trade show display from the 1950s*

Despite the horrible reality of the war, it gave Beckman's business an important boost. Not only did it force NTL and its allied companies to boost production, it also introduced Beckman to a much wider potential market, in science, engineering, business, and the military, for his expanded line of instruments. His business grew exponentially in the 1940s, augmented by the postwar business and science boom and by NTL's first foray into direct advertising. The size and energy of NTL caused the board of directors concern, however, because many of them were not nearly as adventurous as Beckman himself. Beckman controlled a minority share in the company, a unique position for a man whose technical expertise was the reason for the company's existence.

In order to remedy this situation, Beckman struck a deal with John J. Murdock, the man who had originally asked him to consult on non-clogging inks for National Postage Meter. Murdock was a major shareholder in NTL, and he agreed to sell Beckman his shares upon his death. But by 1947 other, more conservative shareholders had begun to gang up on Beckman. In a characteristically bold move, Beckman entered into merger negotiations with Minneapolis-Honeywell Regulator Company, an electronics corporation that had its roots in the thermostat industry. This would have given him control of his own enterprise as well as a significant role in the larger corporation. In 1948 Murdock died, however, and Beckman was able to purchase his shares and thus gained control of his own company. He immediately broke off negotiations with Minneapolis-Honeywell, because his goal had always been control of his own ideas rather than big business.

Change came quickly once Beckman controlled the board. In 1950, the name of the corporation was changed to Beckman Instruments in order to reflect the name that had become associated with high-quality, precision instruments. Beckman Instruments was introduced as a publicly-traded company in 1952, giving it a much-needed injection of capital. Beckman Instruments had been capitalizing new ventures out of the previous years' retained earnings, which although sufficient stifled much of the company's exuberant innovation. The new money would allow Beckman to pursue avenues of research that had previously been too expensive. It also allowed the company to buy potentially advantageous technology. Indeed, Beckman Instruments purchased Berkeley Scientific that same year.

From its modest beginning, [Beckman Instruments](#) grew to become one of the world's leading suppliers of instruments and related scientific products used widely in medicine, science, industry, environmental pollution control, education, space exploration, and many other fields. In 1982, Beckman merged with SmithKline Corporation of Philadelphia to form Smith Kline Beckman Corporation. In 1989, Beckman became independent again.



Even with the astronomical growth of the early 1950s, Beckman worked hard to ensure that the close-knit, loyal, familial feel of his company was not lost. He continued his early habit of hand-delivering each employee's paycheck long past the point of feasibility; he only stopped when there were so many employees that the task would have taken more than a day. Beckman valued loyalty, and expected the commitment to go both ways. His first two directors of research and development, Howard Cary and Roland Hawes, both left to start their own firms, decisions that left much bad feeling on both sides. Even though there was eventually a reconciliation, these splits were indicative of a major trend in American industry in the later twentieth century. Especially in technology companies, the old model of corporate loyalty was sacrificed to the entrepreneurialism that kept the industry vital. Beckman's company was a true pioneer of this new model of business.

During this exciting period in the history of Beckman Instruments, the children of the Beckman family were growing up. Mabel worked hard to maintain their house in Altadena as a haven for the family, and she insisted that Arnold take some time out of his busy schedule for their children. The family remained very closely knit for this reason, spending every Sunday and every vacation together.



Camping remained a Beckman favorite, but it was increasingly supplemented with sailing trips aboard the Lady Pat, a 37-foot sloop that the Beckmans co-owned with their friend Gray Phelps. Later, the Beckmans owned their own boat, the Aries. Beckman's roots in the Midwest and in the Great Depression kept the family from luxurious excess, and their modest life in their old home in Altadena belied Beckman Instrument's remarkable success.

*The Beckmans aboard the Lady Pat*

Beckman Instruments pursued a number of growth strategies in the 1950s. First, they worked to increase the sensitivity and precision of the instruments they had. The company constantly pushed for the cutting

edge thanks to its founder's unique drive. Secondly, they worked to make cheaper and simpler instruments. Recognizing that not every user needed the sensitivity or could afford their top-of-the-line instruments, Beckman developed a line of lower-cost, easier-to-use instruments that sold particularly well to industry. The third strategy, which often helped serve the second one, was that of acquisition. Now that it was a widely-respected and publicly-traded company, Beckman Instruments could afford to purchase technologies that they did not have the time or inclination to develop in-house. Beckman followed a somewhat untraditional route to acquisitions, however. He preferred to buy entire companies rather than merely purchasing patents, which would have been cheaper and easier. This habit underlines his belief that the most important thing in a technology company is the talent behind the product.

The fourth strategy followed by Beckman Instruments was suggested by their experience with MIT's Radiation Laboratory and the Helipot. They pursued a policy of aggressive development of their component business, first within the Helipot Corporation, and then within the Helipot Division of Beckman Instruments. Military use of Beckman's devices helped to spur their development, especially that of high-performance ceramic/metal blend materials. The division also moved beyond potentiometers to the productions of other electronic components. In 1958, Beckman Instruments opened a Helipot factory in Scotland, signaling its global ambition.



Beckman pursued a number of government contracts in the same years. Government contracts were not profitable in themselves, due to the small run and strict specifications, but they helped Beckman's staff retain their position on the technological cutting edge. A prime example was their agreement to build a series of mass spectrometers for the Atomic Energy Commission (AEC) in 1953. Even though Beckman Instruments had decided not to enter the mass spectrometer market, due to the already-established preeminence of several other firms, they built other instruments that incorporated the technology they developed for the AEC, including a super-sensitive leak detector and a portable gas analyzer. The industrial purpose of both of these instruments reflects the expanding horizons of Beckman's market.

*Beckman Instruments executives examine mass spectrometer in 1953*

Despite Beckman's busy business schedule, he still found time to be involved in the Los Angeles Chamber of Commerce. Southern California was growing exponentially at this time, and in 1943 smog entered the regional consciousness as a problem. Since Beckman was a member of the scientific advisory group, he quickly attacked the problem. He motivated the research that identified the probable cause of smog, ozone, and chaired the Special Committee on Air Pollution that released its findings in the "Beckman Bible" in 1953. This study set Los Angeles and statewide pollution control measures for years to come. In November 1953 Beckman was also active in founding the Air Pollution Foundation, a not-for-profit founded to support research into the smog problem. Beckman's leadership on the smog issue won him an invitation to join the board of directors of the Chamber of Commerce in 1954. He was named vice president in 1955 and president in 1956. Beckman became a strong spokesman for his adopted Los Angeles, and emphasized two issues during his tenure: fighting smog and fostering the scientific-technical-industrial-educational nexus that was growing in the area. His concern for smog won

him a place on the Federal Air Quality Board in 1970. He received a further opportunity to address these concerns when he assumed the leadership of the California Chamber of Commerce in 1967.

As president of the Los Angeles Chamber of Commerce, Beckman became the region's representative to the world. The American economy was undergoing much change that could be classified under the heading of "globalization" in the 1950s, and the technology-fueled Los Angeles area was no exception. This new international focus in Beckman's civic life was reflected in his professional life, as well.



He opened his first overseas factory in Munich, Germany, in 1953. Even though a majority of his international orders originated in Great Britain, he was reluctant to open a facility there due to its long tradition of strong unions. The management of Beckman Instruments had always believed in non-union factories, and treated their employees well as a matter of principle. The German subsidiary was a success, leading to similar arrangements in Scotland, France, Austria, the Netherlands, Sweden, South Africa, Mexico, and Puerto Rico. Beckman established sales and service networks in many more countries, excepting only Soviet allies.

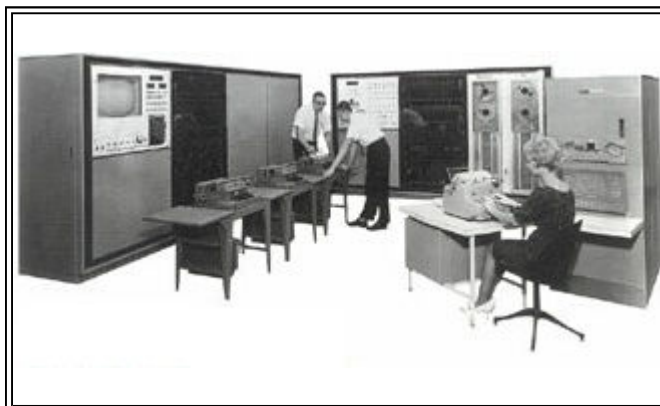
***Beckman subsidiary in Cape Town, South Africa***

All of this new activity in the 1950s seriously taxed Beckman Instruments' available space facilities. The company was spread out through two factories and countless smaller spaces in South Pasadena, and Beckman wanted to unify his operations under one roof. Real estate in South Pasadena had become prohibitively expensive, and so in 1953 the company broke ground on a massive complex in Fullerton, California. It was designed as a marvel of flexibility and expandability, and it continues to house Beckman Coulter, the descendent of Beckman's operations, to this day.

Beckman made one move towards the technological cutting edge that would have great ramifications for the entire world even though it was essentially a failure for Beckman Instruments. William Shockley, a scientist at Bell Labs, had invented the semiconductor in 1947, and it promised to revolutionize the world of electronics as a far superior replacement to the vacuum tube. He was interested in commercializing his invention, and Beckman convinced him to come on board at Beckman Instruments. From the beginning Shockley was a creative prima donna, but Beckman followed his usual policy of indulging technological talent for the sake of innovation. The Shockley Transistor subsidiary was located in Palo Alto, California, at Shockley's request. It quickly became clear that the division was not following its mandate, which was the efficient mass production of silicon semiconductors, and that Shockley was in fact abusing his position to follow his personal interests in creating a four-layered diode, an exceptionally complex transistor. Beckman was faced with a mutiny in the ranks of Shockley's research team, and eventually eight scientists left to form their own company. Beckman Instruments eventually marketed the four-layered diode, but Shockley's managerial problems turned out to be more trouble than they were worth, and Beckman sold the subsidiary to Clevite Transistor Company in 1960, ending his involvement with semiconductor manufacture. Fairchild Semiconductor, the company founded by the splinter group of researchers, went on to develop integrated circuits, the basis for all modern information processing technology. Fairchild spawned Intel and many other important companies. Beckman Instruments was thus present at the very birth of Silicon Valley, and was perhaps the earliest victim of the legendary entrepreneurial inclination of its technological innovators.

Beckman made an early venture into the exciting realm of information processing with his purchase of

Berkeley Systems in 1952. After that, his company became increasingly involved in processing the information that its instruments produced.



The expanding scale of science and industry, as well as the increasing ease of making measurements, combined to make automated data processing essential. Beckman Instruments had formed a Systems Division by 1957 to develop appropriate devices, and Beckman built a \$1.25 million addition to his Fullerton facility to support the work.

*The Systems Division's products of the early 1960s*

Although his data collection systems were originally designed for oil refineries, they were popular with the military and aerospace industry, and their construction made Beckman Instruments a major military contractor. Each system was custom-built, like an organ: they were all made of the same basic parts, but each application required a unique assembly. They worked, but they were ahead of their time. Beckman's salesmen were selling products that most people could not even imagine existed. The Systems Divisions was busy and successful, but never profitable.

In 1955, Beckman Instruments acquired Spinco, short for Specialized Instruments Company, a Bay Area producer of ultracentrifuges. Until the rise of Beckman's medical and clinical instruments business in the 1960s and 1970s, Spinco was the most profitable division of Beckman Instruments. The company also manufactured Moore-Stein amino acid analyzers and ion-exchange chromatography instruments, and it counted several firsts, such as commercial peptide sequencing and synthesizing, Tiselius electrophoresis, and paper and capillary electrophoresis. Spinco remained Beckman Instrument's storehouse of technical know-how in the life sciences, especially molecular genetics and biology. As such, it laid the groundwork for much of Beckman Instruments' future preeminence in clinical instrumentation, the central mission of the company today.

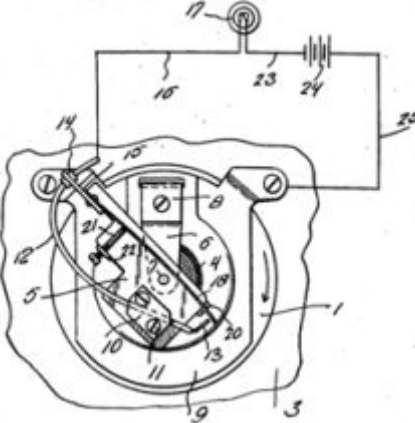
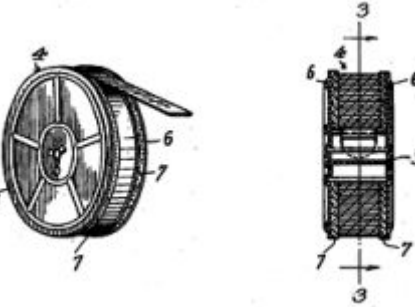
In 1956 Beckman Instruments acquired the Watts Manufacturing Company of Ronceverte, West Virginia, which had been one of the first firms to produce gas chromatographs, especially for industrial customers. Later that same year, Beckman Instruments came out with its first gas chromatograph, the GC-1. It was an inexpensive yet high-performance instrument targeted at an industrial market. Like Spinco, Beckman Instrument's gas chromatograph division was highly successful and developed a long line of instruments. Commercial competition was extreme in the field of gas chromatographs, however, and Beckman was faced with the same decision he needed to make over the infrared spectrophotometer. His company would only enter into the market if they could be at the top. Since true leadership in gas chromatography eluded Beckman Instruments, the decision was made to withdraw.


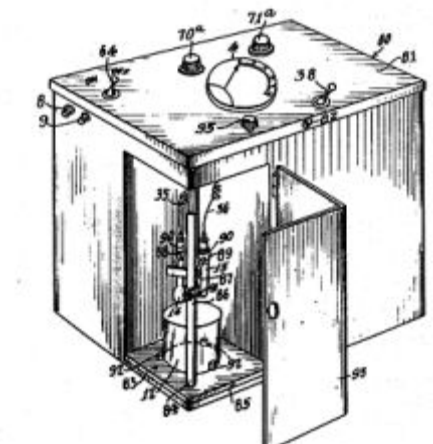
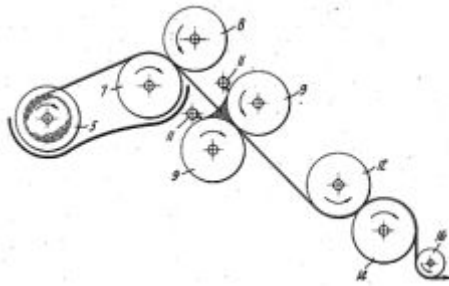
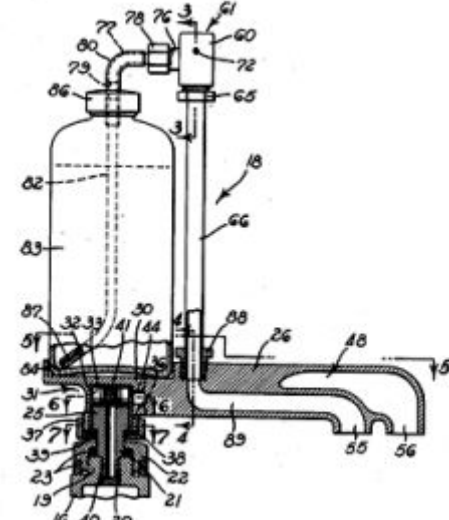
Beginning in 1955, Beckman positioned his company at a prime spot of opportunity, namely, the technologies that would underpin the growth of biotechnology in the 1970s. The developments that began with Spinco put Beckman Instruments in a unique position to be true leaders in the field. Luckily for the company, another significant trend followed the growth of biotechnology: the field of hospital diagnostic tests and clinical care. In a sense, the hospital market was to biomedical research what industry was to chemical research. In both cases, Beckman Instruments was able to fulfill the needs of both constituencies and thus expand their markets.


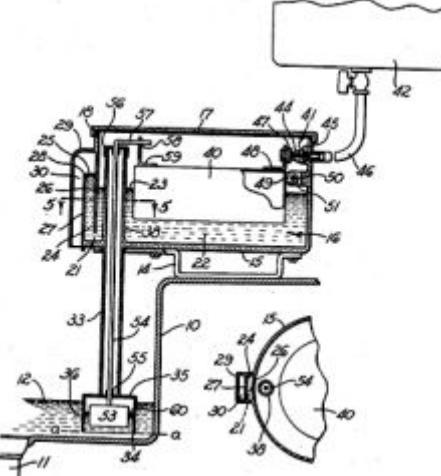
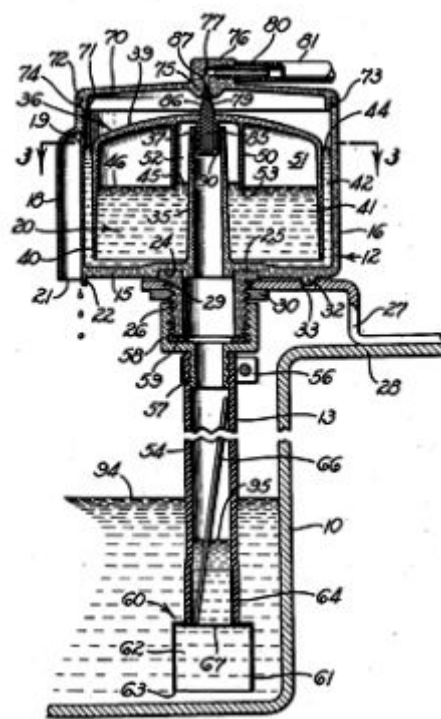
Beckman Instruments' rapid expansion began to take its toll in the late 1950s. In 1958, the company posted its first and only loss. The problems lay with Arga, a hastily-acquired company that manufactured high-precision rotating equipment. Its founders had taken on more than they could handle, and they lost over \$1.7 million in 1958. Shockley's transistor group and the Systems division were also drains on profitability. The problems with the company ran deeper, however. Beckman had continuing difficulty managing his company that had grown so rapidly. His personal style of management, which relied to a great extent on loyalty given and received and his own personal instincts for innovation, was no longer suited to the corporate reality of Beckman Instruments. Arnold Beckman was still Professor Beckman, leading graduate students, rather than President Beckman, leading employees. Luckily he was wise enough to recognize this fact, and a series of reorganizations and reforms quickly returned the company to profitability.

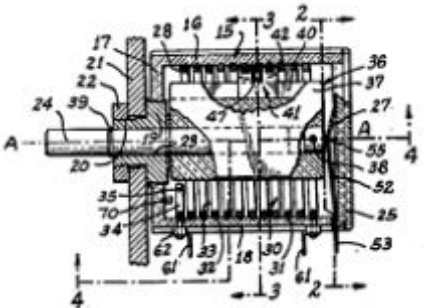
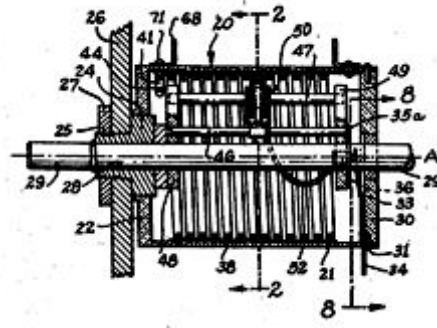
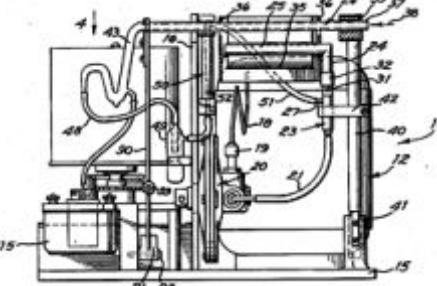
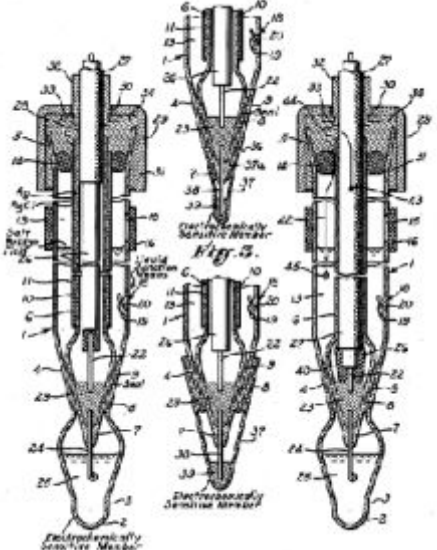

In 1963, Beckman instruments made a radical change in their distribution and sales scheme. They had relied on instrument dealers ever since the 1930s when Arthur H. Thomas Company of Philadelphia had agreed to sell Beckman's pH meter. These catalog merchants had no reason to push Beckman's instruments over those of any other manufacturer. Furthermore, Beckman had relied on these distributors to service his equipment, but its increasing sophistication often exceeded their ability. Thus in 1963 Beckman Instruments announced the establishment of their own network of sales and service representatives. It cost the company some \$2 million, but it paid off handsomely in the end: it only took the new system nine months to exceed the record sales total of the old system. There was a personal cost as well, however. Ed Patterson, Beckman's loyal ally at Arthur H. Thomas who had originally pushed for the national marketing of the pH meter, never spoke to Beckman again.

#### PATENTS ISSUED TO ARNOLD O. BECKMAN

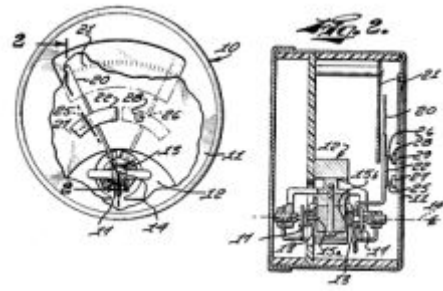
US Patent No	Issued on	Title	One of the patent figures
<a href="#">1,684,659</a>	September 18, 1928	Signaling Device	
<a href="#">2,038,706</a>	April 28, 1936	Inking Reel	

<p><a href="#">2,041,740</a></p>	<p>May 26, 1936</p>	<p>Inking Device</p>	 <p>The diagram shows a rectangular block of a porous material. A label 'Porous Body' points to the top surface. Below the block, a wavy line indicates the 'Liquid Absorption' within the porous structure.</p>
<p><a href="#">2,058,761</a></p>	<p>October 27, 1936</p>	<p>Apparatus for Testing Acidity (pH meter)</p>	 <p>The diagram shows a rectangular metal cabinet with a door on the right side. Inside, a glass electrode is mounted on a vertical stand. Various numbered components are labeled, including the electrode (35), a scale (38), and other parts of the measurement system.</p>
<p><a href="#">2,277,287</a></p>	<p>March 24, 1942</p>	<p>Coating Materials such as Paper Bread Wrappers</p>	 <p>The diagram illustrates a mechanical system for coating materials. It features a series of rollers (5, 7, 8, 9, 10, 11, 12) and a drive mechanism (13, 14, 15) that rotates the rollers to pass a material through a coating station.</p>
<p><a href="#">2,302,097</a></p>	<p>November 17, 1942</p>	<p>Swing Spout Device for Dispensing Liquids</p>	 <p>The diagram shows a detailed cross-section of a swing spout device. It includes a main body (18) with a reservoir (62) and a spout (19) that can swing outwards. Numerous numbered parts are labeled, such as the spout (19), body (18), and various internal valves and seals (e.g., 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82).</p>
<p><a href="#">2,348,103</a></p>	<p>May 2, 1944</p>	<p>Soil Surveying for Oil Deposits</p>	<p></p>

			
<p><a href="#">2,351,579</a></p>	<p>June 20, 1944</p>	<p>Method and Apparatus for Proportioning</p>	
<p><a href="#">2,351,580</a></p>	<p>June 20, 1944</p>	<p>Method and Apparatus for Proportioning</p>	

<a href="#">2,454,986</a>	November 30, 1948	Variable Resistance Device (Helipot)	
<a href="#">2,473,048</a>	October 22, 1945	Variable Resistance Unit	
<a href="#">2,613,126</a>	October 7, 1952	Recording Apparatus for Recording Gas Concentrations in the Atmosphere	
<a href="#">2,755,243</a>	July 17, 1956	Electrochemical Electrode Structure	
<a href="#">3,234,540</a>	February 8, 1966	Meter Pointer Position Monitoring Means Utilizing Heat Absorbing Vane	

and Thermistors



### Beckman the Citizen



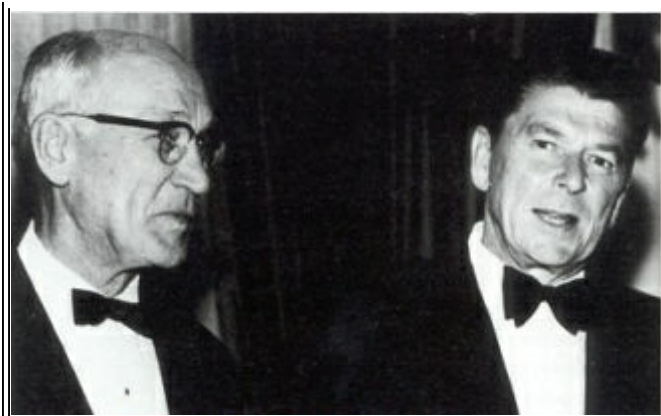
A more personal change came in 1960, when the Beckmans left their old house in Altadena. The children had both left home, and Mabel was looking for a change. When she found a good deal on a beautiful ranch house overlooking the sea in Corona del Mar, she convinced Arnold to leave the site of so many happy memories. Their new house was well built and had stunning views of the ocean, and the fact that the Beckmans acquired it in an auction for half of its asking price appealed to their Depression-era mentality. They would live in this house together until Mabel's death in 1989, and Arnold continues to reside there.

*The back of the Beckman's new house in Corona del Mar*

The years 1964 and 1965 brought even more momentous change for Arnold Beckman. In 1964, he became chairman of the Caltech Board of Trustees. His increasing involvement in community organizations led him to contemplate his successor at Beckman Instruments. At a meeting of state industrial leaders in Sacramento, Beckman had met William Ballhaus, a young executive vice president of the Northrup Corporation, a major defense contractor. In 1965, Beckman retired as president of Beckman Instruments and passed the job to Ballhaus, but he assumed the position of chairman of the board. As such, he remained in a position of stewardship at the broadest level of the company he founded, but was freed to pursue new avenues in the next stage of his long, productive life.

Beckman had been engaged with fundraising efforts at Caltech since the 1940s. He had chaired their first formal fundraising campaign in 1958. As a member of the board of trustees, he had helped the school re-negotiate its relationship to the government and to society in the new postwar world and had helped it to survive the ravages of McCarthyism. He and Mabel marked his assumption of the chairmanship of the board in 1964 by giving \$1 million to build the Beckman Auditorium, a concert hall designed to rival Caltech's laboratories in excellence. In 1974, when he resigned from the chairmanship, they again gave money, this time \$6 million, to build the Mabel and Arnold Beckman Laboratory of Behavioral Biology. In addition to his financial contributions to the school, he offered his wise guidance that helped Caltech rise to become one of the most respected universities in the world.

Political activity became a more prominent part of Beckman's life in these years as well. He only made one political campaign speech in his entire



life, during Richard Nixon's 1962 bid for governor of California. Nixon lost, despite Beckman's strong support, and Beckman decided to do something about that. He organized the Lincoln Club of Orange County, a private political club of prominent businessmen who organized fundraising efforts in support of selected candidates.

*Arnold Beckman and Ronald Reagan, 1978*

This club was instrumental in the election of Ronald Reagan as governor of California in 1966 and of Richard Nixon as President of the United States in 1968. Even though the club was nominally unaffiliated, they almost uniformly supported conservative Republicans. Even though Beckman and his associates preferred to remain "behind the scenes", at times being almost secretive, his club and its financial power was immensely influential in local, state, and national politics.

Beckman Instruments evolved significantly under Beckman's tenure as chairman. Ballhaus turned out to be a highly competent president, able to evaluate the company objectively and chart a solid and profitable course of action. From 1965 to 1971 Ballhaus realigned Beckman's business portfolio to emphasize its strengths and downplay its weaknesses. Gone was the systems division, because Ballhaus shared Beckman's conviction that the company did not belong in a field where it could not excel. Ballhaus continued to support the instruments division, because they represented the bread-and-butter of Beckman Instrument's profitability. The growth area, as he saw it, was in the biotechnology and medical realms. An observation that quickly became a Beckman Instruments mantra was that for every thousand research labs in the United States, there are ten thousand clinical labs, all clamoring for equipment. Profitability was further ensured by the insatiable demand of these facilities for the reagent chemicals and other supplies needed to operate the instruments. Much of Beckman Instruments' R&D budget in this period was directed at this huge potential market.



Beckman Instruments introduced the glucose analyzer in 1969 and the blood urea nitrogen analyzer in 1971. Both were cutting-edge instruments that measured levels of associated substances to infer the level of the substance they were intended to measure. They allowed doctors to make quick diagnosis in emergency situations. Following their time-tested technique, Beckman engineers simplified and integrated their medical instruments, making them more sophisticated and yet easier to use. In the early 1970s, they began to market the STAT Lab, a combination of instruments linked to a central computer that could perform rapid diagnosis in the emergency room. This device went through several evolutions but was wildly popular and revolutionized the practice of medicine.

*Beckman Instruments' blood/urea nitrogen analyzer*

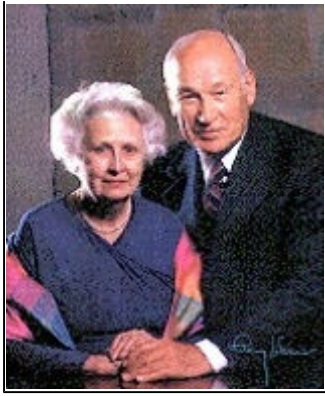
Arnold O. Beckman, founder-chairman emeritus of Be



Instruments, Inc., is recognized worldwide as a scientist, an inventor, and an educator, a philanthropist, and a business and civic leader. From President Bush, he received the 1989 National Medal of Science for his leadership in the development of analytical instrumentation, and for his deep and abiding concern for the welfare of the Nation's scientific enterprises. In recognition for exceptional deeds of service to fellow citizens, Dr. Beckman was presented by President Reagan with the 1989 Presidential Citizens Medal, and a 1988 National Medal of Technology for outstanding contributions to the United States through technology. In 1999 he received the National Welfare Medal from the National Academy of Sciences, Washington, D.C. Dr. Beckman has received numerous awards including the Achievement Award from the University of Illinois for "leader in the field of precision instruments" (1960), and the Harvard Business School of Southern California's Business Statesman Award for Outstanding Achievement in Business Management (1974). He has been honored with Pepperdine University's Private Enterprise Award (1979), the Americanism Education League's Distinguished Community Service Award (1981), the Hoover Medal (1981), the National Medal of Science Award and the Golden Plate Award (1982). He was named the California Industrialist of the Year in 1971. Dr. Beckman is one of the largest private benefactors of American scientific research. Through the [Arnold and Mabel Beckman Foundation](#), he has given away more than \$170 million, mostly in major grants to universities for scientific research.



Mabel's passing in 1989 was very difficult for Arnold; she had been his best friend, closest companion, and confidante for sixty-four years. Beckman personally administered the foundation until his final retirement in 1993. He has dedicated his time since his retirement to his extended family.



*Arnold O. Beckman in the rose garden dedicated to him on the occasion of his 100th birthday. At Beckman Coulter, Fullerton CA, 27 July 2000 (left). Sculpture portraits of Arnold O. Beckman and Mabel Beckman (below).*



Arnold Orville Beckman died on May 18, 2004, in his sleep at Scripps Green Hospital in La Jolla, California, where he lived for the past 15 months. He was 104. Beckman was buried in his birthplace of Cullom, Ill., with his wife Mabel who died in 1989. Arnold O. Beckman is survived by his son, Arnold Stone Beckman, daughter Patricia Beckman, two grandchildren and three great-grandchildren.

See the best web-site about A.O. Beckman: [The Man and His Instrument](#) and [Collection of photos from Caltech Archives](#)



*This text has been compiled from the biographies of Beckman available in the Internet:*

( [1](#), [2](#), [3](#), [4](#), [5](#), [6](#), [7](#), [8](#), [9](#), [10](#), [11](#), [12](#), [13](#), [14](#), [15](#), [16](#), [17](#), [18](#), [19](#), [20](#), [21](#), [22](#), [23](#), [24](#), [25](#) )

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*(updated & corrected on September 15, 2004)*