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APPARATUS FOR TESTING ACIDITY

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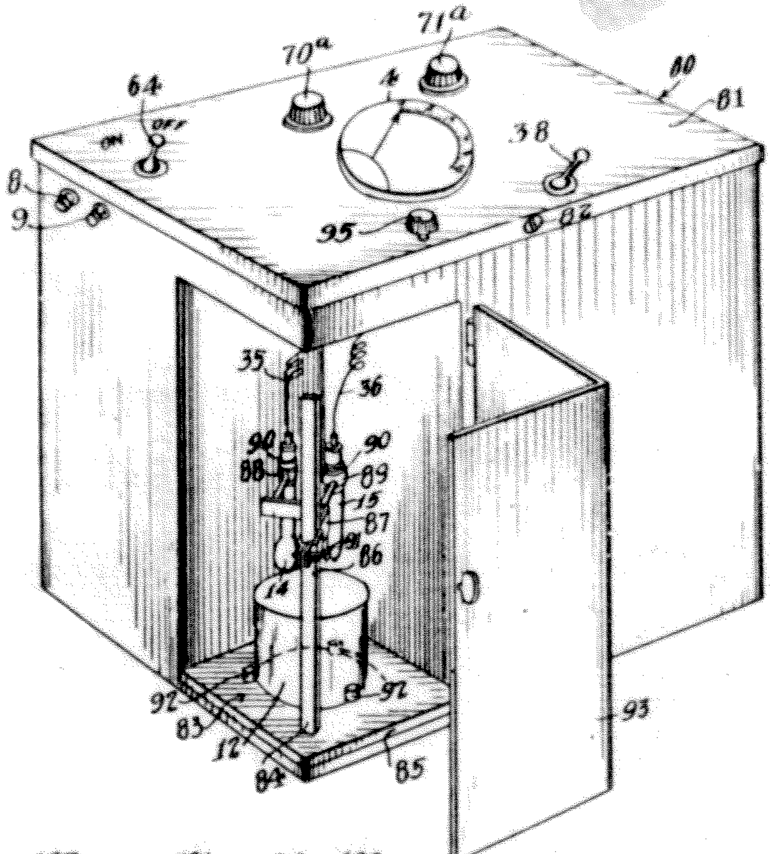
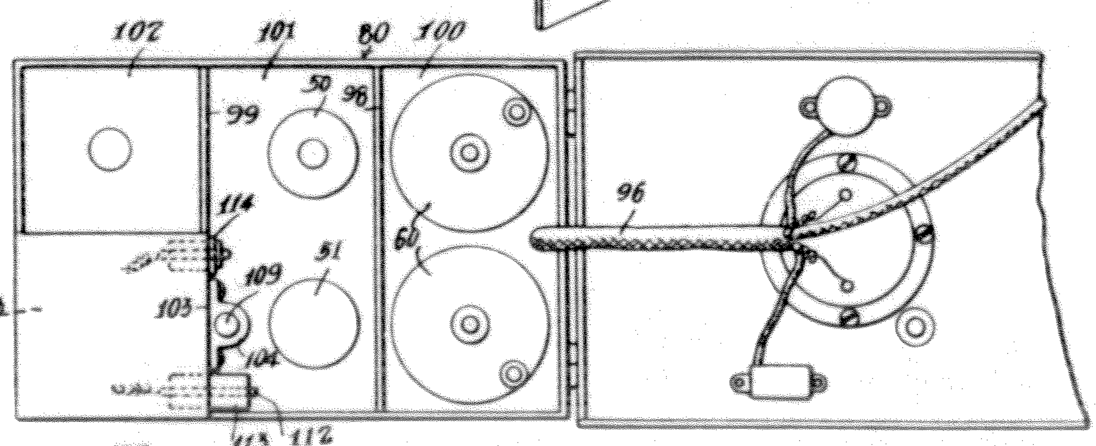


Fig. 3

Fig. 4



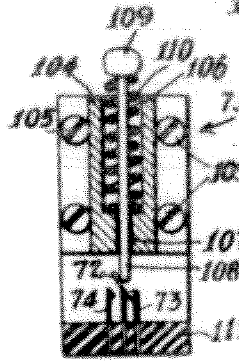


Fig. 5

Inventors

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Fifty Years of Beckman Instruments

Few would have predicted, 50 years ago, that the tiny company Arnold O. Beckman founded to provide him with "pin money" would grow to be one of the world's largest manufacturers of scientific and medical instrumentation. But that's just what happened to Beckman Instruments, Inc., a company whose early history is closely intertwined with that of Caltech. Beckman has discussed the history of his company for oral history projects run by the Caltech Archives and the Claremont Graduate School, and what follows is the story of Beckman Instruments, told largely in its founder's own words.

WHEN ARNOLD BECKMAN WAS AT CALTECH in the 1930s, Robert A. Millikan, chairman of the Institute's executive council, would often call on the young assistant professor to help outsiders who came to the Institute with technical problems in chemistry. "In this period of the early '30s, there was a lot of bunkum on colloidal gold," recalls Beckman. "Some prospectors would claim they'd found out in the desert a deposit of colloidal gold in a form that could not be measured by the ordinary fire assay techniques used for assaying gold ore, but they were sure it was there in colloidal form. Most were just rip-off artists that would come in; several of them were turned over to me and I had to debunk their claims. They'd bring in ultraviolet light or X-rays or whatnot . . . and try to mystify the uninitiated.

"But then other, legitimate people came in for help. One of particular interest was the National Postal Meter Company. They were one of the first ones in the metered mail business, and they had problems with their ink clogging up the machines." Beckman developed a formula for a non-clogging ink but no company would manufacture it. "Companies that made ordinary printing inks wouldn't make the special formula because we used a little butyric acid. Butyric acid is the substance that gives rancid butter its distinctive odor. I'd go home at night smelling like a tub of old butter."

In 1934 National Postal Meter helped Beckman set up the National Inking Appliance Company to manufacture the new ink. Since commercialism on campus was frowned upon, Beckman rented a corner of a garage at 3600 East Colorado belonging to Fred Henson, the chemistry department's instrument maker. There, with the help of two techers working part-time, Beckman mixed the ink. "But a few buckets full of ink will take care of an awful lot of meters, so that was not a major operation."

Later that year, however, Beckman was paid a visit by Glen Joseph, a former classmate of his at the University of Illinois, who was working for the Sunkist Fruitgrowers'

The drawing, opposite, is from the patent for the original pH meter. Experts assured Arnold Beckman that he'd saturate the market with 600 pH meters, but his company has sold hundreds of thousands of them so far. One of the latest models is pictured below.

Exchange. "Along in the end of '34, he came into my office . . . and said he was having a problem. He had to measure the acidity of lemon juice that had been treated with sulphur dioxide. He was making byproducts from lemon juice — pectin, citric acid, things like that. He couldn't use a hydrogen electrode or a quinhydrone electrode, and he couldn't use colorimetric indicators because the sulphur dioxide would react. So he had to use a glass electrode." But at that time, the only glass electrode available was one made by Leeds and Northrup, which was used with a galvanometer.

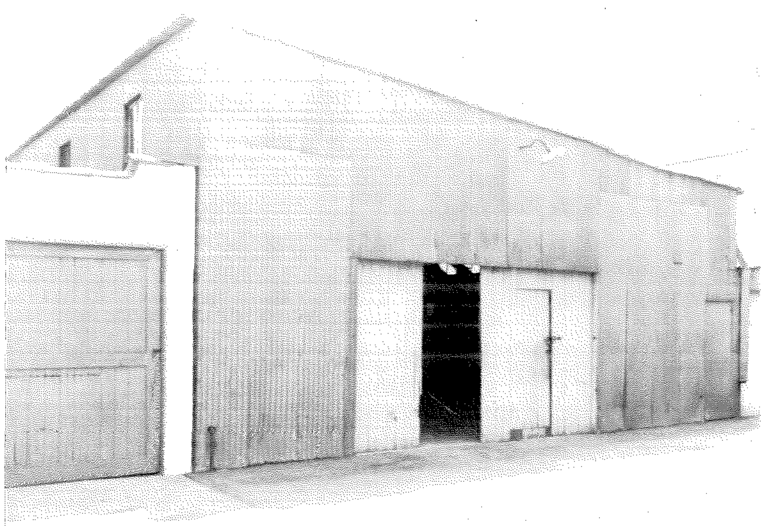
"Well, because of the poor electrical sensitivity of the galvanometer, the glass electrode had to be made . . . so large in diameter that it was very fragile. The glass electrodes were always breaking, and if it wasn't that, the galvanometer itself would break. So based on my experience at Bell Labs [Beckman worked there before returning to Caltech], I said, 'Use a rugged vacuum tube voltmeter. The grid impedence is so high that you can measure voltages with much smaller currents than you have to have for the galvanometer. That would mean that you could have a much more rugged glass electrode. You could make it smaller with a thicker wall.' So I built him an instrument in late '34, maybe early '35. He came back in two or three months, and wanted to know if I'd build him another one — others in the laboratory were using the first one, and he wanted to have one for his own use. So I did build him another. Then I thought, 'Gee, if he could use two of these in that little laboratory he has, maybe there's a market for them.' In September of 1935, the American Chemical Society was meeting in San Francisco, and I went up there. In the meantime, we'd developed the acidimeter into a nice looking thing in a walnut box.

"Well, I took this pH meter up there to show to a couple of my professors from the University of Illinois . . . to see whether or not there was a market. This thing would have to sell for $195, and in those days that was a terrific amount of money. It was competing with a ten-cent vial of litmus paper, you see. So I said, 'Do you think there's a market for it?' They didn't know. They were intrigued, and they suggested that I go around and talk to apparatus dealers. So Mrs. Beckman and I got on the train, and we went across the country." They stopped in at companies in Denver, Chicago, New York, Philadelphia, and Pittsburgh. "Well, the most optimistic estimate I got was from the Arthur H. Thomas Company . . . who thought we might sell as many as 600 over a ten-year period, to saturate the market.

"Fortunately, I was not a very good market researcher. Instead of saturating the market with 600 acidimeters, our company has made several hundred thousand of them and is still making them at a substantial rate."

Beckman's company, newly renamed National Technical Laboratories, soon outgrew its garage and moved into a former dry cleaning establishment at 3330 Colorado owned by Ernest Swift, then assistant professor of analytical chemistry. In 1935 the company sold 87 pH meters; in 1936 that number jumped to 444. "We were lucky because we came into the market at just the time that acidity was getting to be recognized as a very important variable to be controlled, whether it be body chemistry or food production or corrosion or growing of foods in the field. The term pH wasn't known then; chemists talked of hydrogen-ion concentration."

Beckman had been running the company part-time, working evenings and weekends when he could manage time away from his responsibilities at Caltech. But by 1939 the company needed a full-time manager. Recalls Beckman, "Well, by this time I was having so much fun in the business — dealing with customers, dealing with employees, raising money, and getting involved with the elementary bookkeeping — that it deserved my full interest. Furthermore, I found that I was still keeping in touch with science because the instruments were being used in scientific laboratories, and I was exposed to all sorts of



Beckman's company, then called the National Inking Appliance Company, started in a corner of this garage at 3600 East Colorado Boulevard.

new applications. I felt I was not divorcing myself from science. So I made the decision to leave Caltech and go into business."

At about this time the company moved into its own building — a 12,000 square foot plant at 820 Mission Street in South Pasadena. "We were aghast at the amount of space we had," says Beckman. "We seriously considered partitioning off part of it so we wouldn't waste time walking the long distances back and forth. Of course that didn't last long."

In developing the pH meter, National Technical Laboratories invented a new type of rheostat — an electrical component, also called a potentiometer, that's much like the volume control on a radio. "The ones we could buy in the market just weren't very good; they would not hold up in the field. So we decided that to get a better rheostat we would have to make our own. In developing it, we hit on the idea of getting a very wide range of motion by using a helical multi-turn resistance element. Thus a ten-turn coil would provide 3,600 degrees of rotation, whereas single-turn potentiometers provide less than 360 degrees. So we could get wide range with fine sensitivity adjustment over the whole range. Well, we patented that, and made it originally just as a component item for our pH meter, under the name Helipot."

Several years later, during the war, Beckman received a mysterious telephone call from someone named Rosenberg, who wouldn't identify himself further, but who said that it was important for the war effort that Beckman come to Boston immediately. Rosenberg turned out to be Professor Paul Rosenberg of Columbia University and he was in charge of potentiometer development for the radar program. "I'd never heard of radar," notes Beckman. "It was not even permitted to use the word in conversation in those days. It was a secret, very hush-hush thing. In radar, for range finding you have to have a precise linkage between mechanical movement and electrical output. That's where accurate potentiometers are involved. It was found that our Helipots were far more precise than anything else on the market. We didn't know this, for we had never measured the linearity, because we didn't use the Helipot with a dial of any kind. All we wanted was the fine adjustment and wide range. Well, to make a long story short, Professor Rosenberg wanted to know whether we'd make Helipots to military specs, and I said we would.

"When I came back, I found that ours was absolutely worthless from a military standpoint, because if you hit the Helipot sharply, the sliding contact would spring off of the coiled resistance winding causing a momentary open circuit, which they couldn't permit. So it meant that we had to start from scratch. We had the helical winding all right, but we didn't have shock-proof contacts. . . . I began getting calls from the military, particularly from the Navy: 'Where are the Helipots? We have ships ready to go, but the radar gear is incomplete because we don't have this potentiometer.' . . . One sleepless night I conceived of a design using a solid rotor with a groove; the contact would slide up and down in the groove so it couldn't get displaced. . . . In two days, we had a working model of this Model A Helipot potentiometer, of which we've made tens of millions."

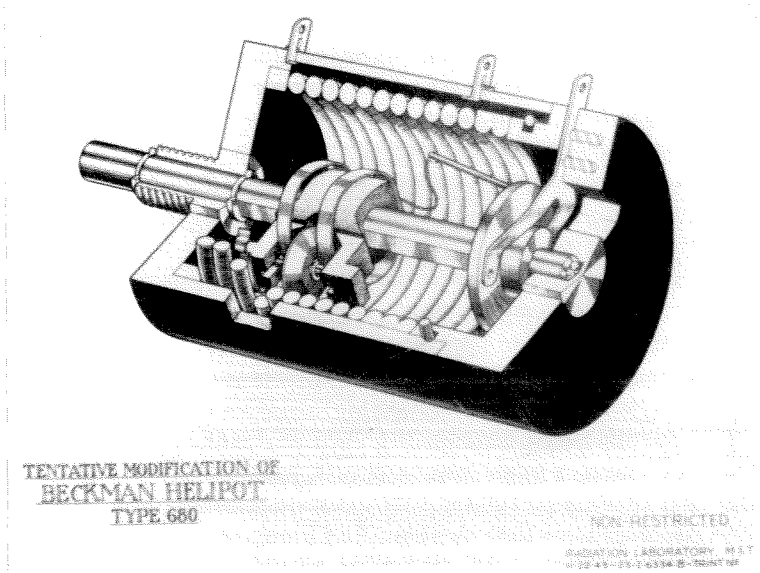
But the Helipot potentiometer was not the only spin-off of the pH meter — the meter also led to the development of ultraviolet/visible and infrared spectrophotometers. (A spectrophotometer measures the amount of light that is absorbed and transmitted by a chemical sample. This information can be used to determine the sample's composition and concentration.) "The pH meter . . . consisted of a vacuum tube amplifier with a very high input impedance," said Beckman. "Well, that meant that it would be suitable for working with a vacuum-type photoelectric cell. I mention that because the vacuum-type photo cell gives a linear response with light flux: the amount of current that comes out is directly proportional to the light flux going in. The gas-filled photo cells, which are more common because they are much more sensitive, do not give a linear response. So I recognized that this circuit we had would be

The company's rent increased by a factor of 10 when it moved into this former dry cleaning establishment at 3330 Colorado in 1935.

suitable for working with the vacuum-type photo cell, which would give us a linear response, and then we could make a spectrophotometer.

"I was familiar, of course, with visual spectrophotometers, and I realized that even in the visual spectrum there would be advantages if we could use a photo cell instead of the eye, because the eye gets tired. But also, we could extend the spectral range into the ultraviolet, where the eye doesn't respond. And so we started working on a spectrophotometer. The result was Model DU — the first commercially available quartz photoelectric spectrophotometer. It used crystal quartz prisms, because quartz is transparent in the ultraviolet as well as in the visual range.

"We're very proud of the DU. It played a role in the field of chemical analysis comparable to that of the DC-3 in aviation. We produced more that 21,000 DUs before the product line was superseded in 1964." And since that time the instrument's successors have continued to be an important part of the company's business.



Beckman Instruments has made tens of millions of these Helipot potentiometers.

The DU came on the market just before World War II. The war effort required infrared as well as UV/visible spectrophotometers. "When our country's sources of natural rubber were shut off, we had to go into the manufacture of synthetic rubber in a hurry. The basic raw material needed was butadiene, which is formed in the cracking of petroleum products. So there was a problem of analyzing refinery gases containing C_3, C_4, or C_5 hydrocarbons. The butadiene molecule has four carbon atoms with two double bonds. We had to analyze it in a mixture of other hydrocarbons quite similar in chemical composition. And that was a chore by conventional analytical procedures; it took an excellent chemist maybe two or three days to carry out one analysis. When you're controlling a refinery, it doesn't do you any good to learn two days from now how you should have the controls set today. So there was a need for rapid analysis. And infrared was shown at that time to be a suitably fast way for analyzing hydrocarbon mixtures, but nobody was producing infrared spectrophotometers. [There were] maybe a half a dozen or eight hand-built spectrophotometers in the whole country. The Office of Rubber Reserve decided it wanted to standardize on infrared analysis for the synthetic rubber program. There was a meeting in Detroit at which that decision was made, and we were given the job of making infrared spectrophotometers for the entire synthetic rubber program."

The war years also marked Beckman's entry into medical instrumentation. Scientists at Caltech had developed a meter to measure a gas's oxygen content and the Navy wanted to put these oxygen analyzers aboard submarines. The Caltech scientists asked Beckman to manufacture the instruments, which he did, selling a few each year. When the instrument was still in development, an anesthesiologist at Huntington Memorial Hospital heard about it and asked to borrow it over a weekend because his prematurely born granddaughter was in an incubator and doing poorly. Using the analyzer, he discovered that she was not getting enough oxygen. Supplemental oxygen saved her life.

But the oxygen analyzer did not become a big seller until the mid '50s, when an article appeared in the *Saturday Evening Post.* "The article told about a marvelous piece of medical detective work by doctors at Johns Hopkins," remembers Beckman. "They found that the incidence of a disease called retrolental fibroplasia, which causes blindness in infants, was highest in our best hospitals. Pursuing further, they found that this was caused by excess oxygen: These hospitals had fancy incubators with elevated oxygen levels. The doctors found that when the oxygen got over 40 percent, retrolental fibroplasia set in. After the article appeared, we were deluged with orders for the oxygen meter. From then on it was a good little business."

After the war, National Technical Laboratories' business boomed. Between 1941 and 1947, annual sales multiplied by a factor of

10 to over $2.6 million. And by 1951 that figure had increased to $8.5 million. The company's operations had expanded to the point that it occupied no fewer than 16 locations in Pasadena and South Pasadena.

The '50s was a decade of change for Beckman's company. On April 27, 1950 its name was changed to Beckman Instruments, Inc. The company went public and began a program of acquiring other, compatible companies. The most important of these acquisitions took place in 1954 with the purchase of Spinco, a Belmont, California, company that designed and manufactured centrifuges and instruments for electrophoresis. Spinco formed the nucleus of Beckman's medical instrumentation activities, ventures that were eventually to form two-thirds of the company's business.

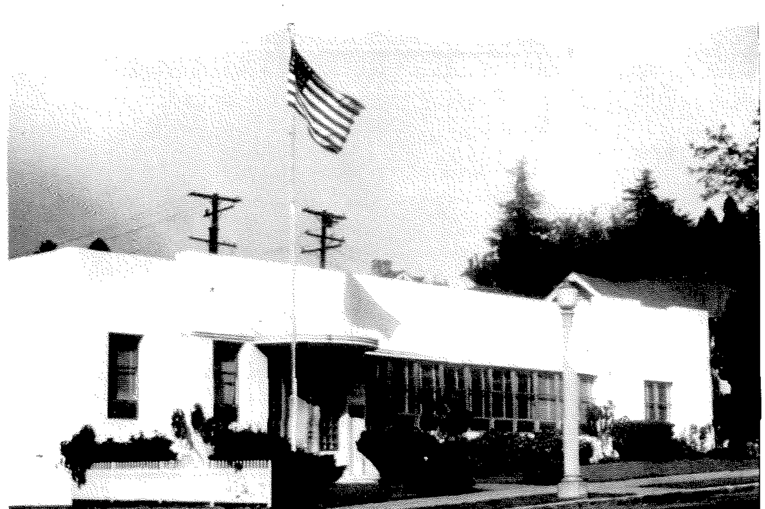
The company expanded overseas, building plants in several European countries. "There are many factors to be considered in establishing plants in other countries," says Beckman. "Once sales get above a certain level, it makes sense to have a source of manufacture near our customers. Also, we have a policy of not wanting to build up too large an operation in any one location. Having too many employees is undesirable. We like to split up into manageable groups." But the start of Beckman's first overseas plant, in Munich, was fraught with difficulties. First of all, U.S. government approval was required before any parts could be sent there for assembly. "I just couldn't get approval from the State Department or from the Commerce Department or from anybody back in Washington, and we couldn't get anybody to tell us why," says Beckman. The answer had to do with Beckman's German lawyer, one Dr. Bastian, and the anti-communist hysteria engendered by Senator Joseph McCarthy.

"Our people in Washington would not tell me that we had a Communist for a lawyer over there, but this is what they thought," says Beckman. "It turned out that Dr. Bastian was the first lawyer allowed to resume his practice after the war. He was given that privilege because he had established that he was not a Fascist by showing his membership card in the Communist Party. As a student . . . he had joined the Communist Party and still had the card. He was no more a Communist than I am, but nevertheless that was still on his record. So finally I had to say to Dr. Bastian, 'I'm sorry, but that's the way the situation is in our country, and we'll have to get another lawyer.' We paid him off rather handsomely. . . . Think of the months of delay and thousands of dollars of needless expense incurred just because our State Department wouldn't come out and tell us what the story was." But that wasn't the end of Beckman's problems with the Munich plant. In excavating the site, a steam shovel scooped up an unexploded, 250-pound American bomb. Fortunately, specialists were able to remove and defuse it, and construction proceeded without any other serious incidents.

With the company expanding rapidly, Beckman's American operations required new facilities as well. A new 220,000-square-foot plant, with manufacturing and office space, was built in 1954 in Fullerton, California, which remains the company's world headquarters. But the company soon outgrew even this space; additional construction on the Fullerton site has brought the size of the plant to 771,000 square feet. And this is just the main headquarters; Beckman Instruments has built large plants in Brea, Irvine, and Palo Alto, California, as well as in a number of other locations around the world.

At the start of the '60s, Beckman Instruments had sales of over $54 million, 4,260 employees, and was spending more than $4 million a year on research. The number of Beckman products was increasing rapidly; in some years the company released an average of one new product each week. Among these products were analog computers, decimal counting units, gas chromatographs, ultracentrifuges, liquid scintillation counters, amino acid analyzers, digital volt-ohm meters, precision potentiometers, telemetering systems, switching diodes, and computer control sys-

When the company outgrew the dry cleaning establishment, it built its own plant at 820 Mission Street in South Pasadena.



tems. In 1965, Arnold Beckman became 65 years old ("the age of statutory senility," as he calls it) and he relinquished the presidency of the company to William F. Ballhaus (PhD 1947), becoming chairman of the board of directors. By the end of the decade, the company's sales had increased to $132 million, and it was employing over 7,500 people and investing $11 million yearly on research.

The 1970s was Beckman Instruments' most successful decade yet. The company continued its program of acquisitions. But, as Arnold Beckman said, "We have a policy. We're not a conglomerate. We won't go out and buy a grocery store, for example. We have to buy a company whose product fits into our operations in some way." Individual products, too, must complement existing products, but sometimes they lead to whole new businesses. "A good example was liquid crystals," says Beckman. "We decided we wanted a liquid crystal display with our battery-operated pH meters because liquid crystals use virtually no current, and a battery would last for a couple of years or more, left on continuously. We developed production techniques that were good. We got some good patents. Well, electric crystal displays were also of interest to wristwatch makers. We became the world's largest manufacturer of liquid crystal wristwatch dials. Now, this is completely foreign to our analytical instrument field, but that's one of these fallouts. We developed a technique that was useful in applications other than the one we had. That's been the history of our company in many ways." But a few years later, "a Japanese manufacturer just dumped the price. It came down from 87 cents to 27 cents — something like that — below production costs. . . . We decided we could use our resources better in other ways and sold the business."

Toward the end of the decade, Beckman Instruments expanded its overseas market to the People's Republic of China. This came about when Arnold Beckman happened to read that the president of Beijing University, Chou Pei-Yuan, had been put in charge of modernizing China's higher education system after the dark years of the Cultural Revolution. Beckman remembered Chou from their days as Caltech graduate students: both received their PhDs in the same ceremony in 1928. Beckman wrote to Chou, offering to set up a scholarly exchange program. Chou, in turn, invited Beckman and nine others from Caltech to tour China. As a result of this, Yu Wen, the general secretary of the Chinese Academy of Science, visited Beckman Instruments to learn how an instrument manufacturer was organized. "We gave him an eight-hour course leading to an MBA degree," notes Beckman. "When he got back he invited three of us to be his guests and to continue the discussion. Eventually we developed an office over there. It has been picking up a good deal of business. Luck has played an extraordinary role in my life, and that was another example."

In 1978, Beckman Instruments released an instrument that had the most rapid and widespread acceptance of any in the company's history. This was the ASTRA, the Automated Stat Routine Analyzer. The ASTRA is used in hospital clinical chemistry departments — given a single small sample of blood serum, cerebrospinal fluid, or urine, the ASTRA performs many standard physiological measurements very rapidly.

By 1979 Beckman Instruments was approaching $500 million in sales and had increased its work force to 12,400 employees. As the company entered the '80s, it continued to enter new markets. In testing its newly developed peptide synthesizer, for example, the company produced small test quantities of various peptides. "Well, it occured to us, why don't we produce larger quantities of peptides and sell them?" says Beckman. "So we're now in the chemical business, making highly specialized peptides, particularly enkephalins and endorphins. . . . We are making a great many of these highly specialized research chemicals for the larger pharmaceutical companies. It's cheaper for them to have us do it for them than it is for them to disrupt their research organization to make some of these rare chemicals."

It was in late 1981 that one of these pharmaceutical companies, the SmithKline Corporation of Philadelphia, Pennsylvania, approached Beckman Instruments and asked its officers to consider a merger between the two companies. "Dr. Ballhaus and I talked it over," Beckman says. "Our major obligation was to the shareholders; we were their representatives. Personally, I'd have preferred not to sell. After all, I had my whole life tied up in the company. I was still the boss, and liked being the boss with all the independence that carried. But the merger with SmithKline would have advantages for our shareholders. For the employees there would be new opportunities in being associated with SmithKline. We were developing products such as peptides for which we had no adequate sales force in place. SmithKline did. Also, we could see that being associated with a health-oriented company would help us in our development of instruments for the health-care industry. We had research products we'd like to develop but couldn't because we were spending about as much on research as we could carry — about $60 million that year. Being associated with SmithKline would enable us to get on with some research that otherwise might never get done or at least would be subject to a long delay. And being part of a larger company would open up advancement possibilities for our employees."

Beckman and Ballhaus finally decided to agree to the merger. They shook hands on the deal with Robert Dee, chairman of SmithKline's board, and Henry Wendt, its president, on the evening of November 23, 1981. "I didn't sleep that night," says Beckman. "There was something bothering me, and I finally figured out what it was. It was the loss of the Beckman name in the marketplace. That was our corporate identity."

Beckman phoned SmithKline the next morning and said that the name "Beckman" had to appear in the name of the merged company. SmithKine agreed. The merger was finalized on March 4, 1982 with overwhelming votes of approval by the shareholders of the two companies. Arnold Beckman attended a meeting of SmithKline managers from around the world just four days later. "Everything they put on there was 'SmithKline Beckman' — pads on which to take notes, pens, everything," recalls Beckman. "On the same trip I visited the headquarters in Philadelphia, and was amazed to find that building signs and lettering on glass doors already had been changed to SmithKline Beckman. Their speedy action made a very favorable impression on me." Dr. Beckman is now a vice-chaiman of the SmithKline Beckman board.

Dr. Ballhaus retired from Beckman Instruments, Inc. in 1983 and Louis T. Rosso, a long time Beckman manager, assumed the presidency. Much of Caltech's current technical interactions with Beckman Instruments is facilitated by Dr. Richard A. Nesbit, vice-president — research and development. Dr. Nesbit sees an exciting future for Beckman Instruments. "We have made huge advances in instrumentation under Dr. Beckman's leadership. Our future should be even more exciting. We've greatly enjoyed Beckman Instruments' past relationship with the professors and students of Caltech and look forward to continued close contact."

In the years since the merger, Beckman Instruments has concentrated increasingly on the technology of health care. Arnold Beckman expects soon to see many changes in this field. "One factor will be the rising cost — the intolerably high cost — of health care. I think you're going to see both diagnosis and treatment moving away from being done mainly in hospitals, with highly skilled doctors and technicians, into the drugstores and into the home. You're going to see home diagnostic kits, for example. And the pharmacists will begin to function between the level of a skilled physician and an untrained person in the home. That's already taking place here in California; some pharmacists are now permitted to write prescriptions of certain types. . . . Diagnosis is going to go farther and farther down the line toward the patient. I think there will be some simplified instrumentation in the home. . . . The time has come, and I see Beckman Instruments in the midst of this development."

The company is also heavily involved in the development of genetic engineering and the biotechnology industry, which will require radically new types of instruments. "Facts such as these give merely a hint of the excitement the future holds for research, both basic and applied, an excitement that will surely lead to new instruments and new instrumentation," says Beckman. And he expects the next 50 years to "eclipse any comparable period in the world's history with respect to progress in instrumentation." □

Beckman Instruments' current world headquarters are at 2500 Harbor Boulevard in Fullerton.