Title
EARLY DAYS IN THE LAWRENCE LABORATORY

Author
McMillan, Edwin M.

Publication Date
1976-10-01

EARLY DAYS IN THE LAWRENCE LABORATORY

Edwin M. McMillan

October 1976

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

EARLY DAYS IN THE LAWRENCE LABORATORY

Edwin M. McMillan

October 1976

(This is based on a talk with the same title given on October 30, 1976, at a symposium held in connection with the celebration of the 45th Anniversary of the founding of the Lawrence Berkeley Laboratory, with some additional text and illustrations.)

Lawrence Berkeley Laboratory

University of California

Berkeley, California 94720

EARLY DAYS IN THE LAWRENCE LABORATORY

This will be a multi-media presentation. I will start with a more or less connected discourse and finish with a slide show. When I speak of the early days, I include only the period up to the end of 1940. By then many people in the United States had become deeply concerned over the war in Europe, some had left the Laboratory for war work, and soon the Laboratory itself became involved in war work. One major peacetime project was started in 1940, the 184-inch cyclotron, but it did not get back to its original purpose until after the war. The hill above the Big C was chosen for the site, and by the end of 1940 the magnet foundation was completed and the bottom yoke was in place. This started the first expansion of the Laboratory off the campus, a stage in growth belonging to a later period.

The Radiation Laboratory was the personal creation of Ernest Lawrence. It was his idea. He got the financial support, he pulled together the equipment and drew the people, and of course he supplied the key idea, the cyclotron. Many other people helped in essential ways. I could name President Sproul of the University, Leonard Fuller, of the Federal Telegraph Company and the University, who arranged the gift of the large magnet for the 27- and 37-inch cyclotrons, Frederick Cottrell and Howard Poillon of the Research Corporation and Francis Garvan of the Chemical Foundation who looked with favor on Ernest's requests for grants, Raymond Birge who became Chairman of the Physics Department in 1932, Don Cooksey from Yale, Stan Livingston, and many others, but it was Lawrence's laboratory.

Those of us who were there in the early days remember that Ernest was always "the boss". He could be very rough on people if he felt they were not giving their utmost efforts, but he made up for this by his generosity in giving credit and in sharing ideas. I never met Rutherford, but I have been told that he had the same kind of character, with an important difference: Rutherford favored the individual researcher working with simple apparatus, Lawrence believed in efforts so large that teamwork was necessary. In the very beginning there was a penalty for this. The drive for greater energy and beam current was so frantic that people hardly had time to think, and some important discoveries were missed and some mistakes were made, but this phase soon passed. On the whole, I think Lawrence was right; the rapid development of the cyclotron was more important to nuclear science than the question of who made which discovery.

The Laboratory was started in 1931, and when I came to Berkeley near the end of 1932 it was in full swing. There was not only the 27-inch cyclotron giving protons of around 2 MeV but also the Sloan X-ray tube, on which great hopes were placed for cancer treatment, and a couple of linear accelerators of the Wideröe type, which were built and operated by Dave Sloan, Wes Coates, and Bernard Kinsey. The Sloan X-ray tube was used clinically for several years, but the linear accelerator concept fell by the wayside, waiting to be revived by new ideas coming from wartime radar developments. It was certainly a busy place day and night, especially when Ernest was there, which was most of the time.

I started my research in Le Conte Hall on a molecular beam problem, but dropped that when the result I was seeking was obtained elsewhere, and entered the exciting world of the Radiation Laboratory in the Spring of 1934. Stan Livingston, the cyclotron expert, and Telesio Lucci, a retired Commander in the Italian Navy who was a beloved general helper and factotum, gave me sage counsel on how to comport myself, as my previous experience had been in working alone, and I needed to learn the art of teamwork. This was not obviously easy since no one was routinely coordinating the various tasks needed to keep the cyclotron going, and there were the twin dangers of neglecting what one should do, or getting in the way trying to do something that someone else should do.

Robert Oppenheimer was the chief theoretical advisor for the Laboratory, and he suggested that I study the gamma rays produced by proton and deuteron bombardment of light elements. This turned out to be an important experiment, because I found a 5.5 MeV gamma ray from fluorine bombarded with protons, with which I could check Bethe and Heitler's new theory of gamma ray absorption by pair production. The chief line of research then going on was the study of nuclear reactions by observing the protons and alpha

~~in which protons or alpha~~ particles which are emitted. These were detected by a thin ionization chamber connected to a linear amplifier, a device not suited for observing gamma rays.

Geiger counters were considered unreliable. Stan Livingston tells, in a paper presented in Texas in 1967, what happened on February 24, 1934 when the Laboratory learned of the Joliot-Curie discovery of artificial radioactivity. They were using a Geiger point counter, a device that now seems as exotic as the coherer, to count alpha particles. It was not the familiar cylindrical Geiger-Muller counter. The cyclotron oscillator and the counter circuit were turned on and off by the two poles of a double-pole knife switch, for convenience in timing. Within half an hour the switching arrangement was changed so that the counter could be turned on while the cyclotron was off, the counter voltage was raised so that it would count beta particles, the internal target wheel was rotated to bring a carbon target into the beam, and the activity of nitrogen-13 was there, produced by a different reaction than that used by its discoverers. The failure to see this first was a blow to the Laboratory, and there was a natural reaction against all Geiger counters.

So, the first thing I did was to go to Pasadena to learn from Charlie Lauritsen himself how to make quartz-fiber electroscopes. I had my first Lauritsen electroscope, which was mounted in a lead-walled chamber for detecting gamma rays, inside the laboratory for only a few days when Malcolm Henderson came to me in the middle of May with the news of the discovery of neutron-induced radio-activity in Rome, and he wanted to use it to look at some of those activities. It took only a short while to make a new chamber out of a tin can with a thin aluminum window, and the tin-can version of the Lauritsen electroscope became a valuable instrument for observing beta rays. Jack Livingood made one like it, which he used in a monumental survey, with Seaborg and others, of activities produced in many elements by deuteron bombardment, which resulted in a rate of discovery of radioisotopes that was comparable to that at Rome following Fermi's first neutron-induced activity. Some of those they found became very important in medical and other applications, like iodine-131, iron-59, cobalt-60, and technetium-99m.

There was a great surge of

activity in the field of artificial radioactivity. The names involved are too many to list completely. Stan Livingston and I found a radioactive form of oxygen, and Lawrence found sodium-24, which created a sensation because very strong samples could be made. Lawrence once had the cyclotron crews working around the clock to make a whole curie for a demonstration. That was a tough job. Jackson Laslett found sodium-22, the longest-lived artificial activity known at the time, but soon to be surpassed, Martin Kamen and Sam Ruben found carbon-14, probably the most important radioisotope of all, and so on. Also new types of activities were discovered. Van Voorhis found that copper-64 could decay by emitting either negative electrons or positrons, the first known example of that kind of branching in radioactive decay, and Luie Alvarez found the first case of decay by orbital electron capture, now a well-known process.

Among the new activities were some that had atomic numbers differing from that of any known element, and were therefore new elements. The first of these was found by Emilio Segrè and Carlo Perrier in 1937. They worked in Palermo with a piece of molybdenum that had been on the leading edge of the deflector plate in the cyclotron, where it got a lot of bombardment, and which Segrè had taken back with him after a visit in the summer of 1936. In it they found element 43, which they named technetium, after the Greek work for "artificial," as it was the first artificially produced element. Next was element 85, called astatine, from the Greek word for "unstable," found by Segrè, Dale Corson, and Ken MacKenzie in 1940.

A little later in the same year Phil Abelson, who had been a graduate student with Lawrence, came back to Berkeley for a short visit and supplied the missing link in the chemical identification of an activity induced in uranium by neutron bombardment, which had been puzzling me for some time. This was, as I had expected, the first transuranium element. I named it neptunium after the planet Neptune, just as uranium had been named after the planet Uranus.

After Phil left I continued the work, trying also the deuteron bombardment of uranium, which produced a different isotope of neptunium than the neutron bombardment, and found alpha particle activity in the neptunium samples, which suggested the presence of the next transuranium element. I did some chemical separations showing that the alpha activity did not belong to uranium or neptunium, but did not complete this investigation because I was persuaded by Ernest to go to the Massachusetts Institute of Technology for a few weeks to help set up a new laboratory for developing microwave radar (it was not called that then, the word was coined later). As a cover, the new laboratory was called the Radiation Laboratory. Two Rad Labs! That was sometimes a source of confusion. I left by train on November 11, 1940.

On November 28 Glenn Seaborg wrote me that Art Wahl had been making some strong neptunium samples, and said: "if you are too busy to carry on the work alone we would be glad to collaborate with you." In my reply, on December 8, I say: "It looks as if I shall not be back in Berkeley for some time, and it would please me very much if you could continue the work on 93 and 94." (The "some time" stretched out to 5 years before I came back to stay. I never did believe Ernest's estimate of a few weeks.) On March 8, 1941, Glenn wrote to me describing the final chemical proof that the alpha activity belonged to the next element up the periodic table, plutonium. In this correspondence we did not use the names for the new elements, which were not yet official, but referred to 93 and 94, and the March letter was marked "Confidential." Secrecy was creeping into nuclear research.

Luie Alvarez came from Chicago in 1936, with a lot of clever ideas. He was the originator of the method of getting what is effectively a beam of very slow neutrons by pulsing the cyclotron and gating the detector so that it is only sensitive at some chosen time after the pulse of neutrons has been emitted. With Ken Pitzer, he used this method in an investigation of neutron scattering by the two kinds of molecular hydrogen, ortho and para hydrogen, and with Felix Bloch of Stanford he made the first measurement of the magnetic moment of the neutron. One of the questions of that time was the relative stability of the nuclei hydrogen-3 (called tritium) and helium-3, both of which had been observed by Mark Oliphant at the Cavendish Laboratory as products of the bombardment of deuterons by deuterons. Alvarez and Bob Cornog first showed that helium-3 is the stable one by detecting it in atmospheric helium, using the cyclotron as a mass spectrometer; then, knowing that hydrogen-3 must emit beta-particles, they looked for activity in deuterium gas bombarded by deuterons and found it, establishing tritium as a radioactive isotope.

Gilbert Lewis of the U. C. Berkeley Chemistry Department played a very important role in the Laboratory's history. As soon as the discovery of deuterium was announced, he set up equipment to make heavy water by electrolysis and furnished a sample of heavy water to the Laboratory, and in March, 1933, the first beam of deuterons was produced by the cyclotron. From then on a major part of the work was with deuterons, which are much more prolific in producing nuclear reactions than are protons or alpha particles. Lewis, like many associated with the Laboratory, was a colorful character. He liked to tell how he fed some of his first heavy water to a fly, and it rolled over on its back and winked at him. One day at lunch at the Faculty Club he heard some professors in the department of education arguing about whether children should be taught to add a column of figures from the top down or the bottom up. Lewis said, "The way I do it is, first I add them down and then I add them up, then I take the average."

I could go on and on. There were many visitors to the Laboratory who stayed and worked there for considerable periods of time, like Jim Cork from Michigan, Jerry Kruger from Illinois, Lorenzo Emo, a Count from Italy, Harold Walke and Don Hurst from the Rutherford Laboratory, Wolfgang Gentner from Germany, Maurice Nahmias from France, Sten von Friesen from Sweden, Ryokichi Sagane from Japan and Basanti Nag from India. The working visitors were very important to the Laboratory. They not only contributed to the research program but they carried back the cyclotron art to their own institutions. Lawrence actively promoted this diffusion of knowledge, Don Cooksey wrote "cookbooks" of cyclotron lore which were mailed to interested institutions, and many Laboratory people went out to help design and build cyclotron laboratories. Milton White went to Princeton, Henry Newson to Chicago, Hugh Paxton to Joliot's laboratory in Paris, Jackson Laslett to Copenhagen, and Reg Richardson and Bob Thornton to Michigan.

Many of the physicists took part in the running and maintenance of the cyclotron. There were regular crews assigned to this task. I remember being on the owl crew for a while, which did not bother me as a single man with rather nocturnal habits, but was hard on some others. If anything went wrong we had to pull the cyclotron apart and try to fix it. The greatest problems were vacuum leaks and the burnout of filaments in the ion source inside the cyclotron tank, and in the demountable oscillator tubes built by Dave Sloan. When the ion-source filament went out, the vacuum tank of the cyclotron had to be rolled out of the magnet gap, then the wax joint between the lid and tank broken and the lid removed, and the filament replaced; then it all had to be put back together again. Physicists did more than just operate the machine. For example, Art Snell and Ken MacKenzie built oscillators, Bob Wilson made the first theoretical study of orbit stability, and I designed the control system for the 60-inch cyclotron. This was in 1938, and a new concrete building, the Crocker Laboratory, was under construction to house the new larger cyclotron. The Laboratory was starting to expand.

Bill Brobeck came in 1937 as the first professional engineer hired by the Laboratory. That created a real revolution. No more waxed joints that leaked, no more equipment that fell apart in the middle of an important experiment. Or, at least, less than before. The "string and sealing wax" school of physics still has a nostalgic appeal to some oldtimers like myself, but it is not suited to large efforts where many people are depending on the reliability of apparatus. Win Salisbury and Bill Baker, both electronic geniuses, took over the designing and building of oscillators and other electronic equipment. Charlie Litton came for a while and taught us many techniques in radio frequency engineering. He had a small company in Redwood city which he later sold to some entrepreneurs from Texas who used it as the nucleus for the giant conglomerate called Litton Industries. Charlie retired to Grass Valley where he spent the rest of his life happily working on various inventions.

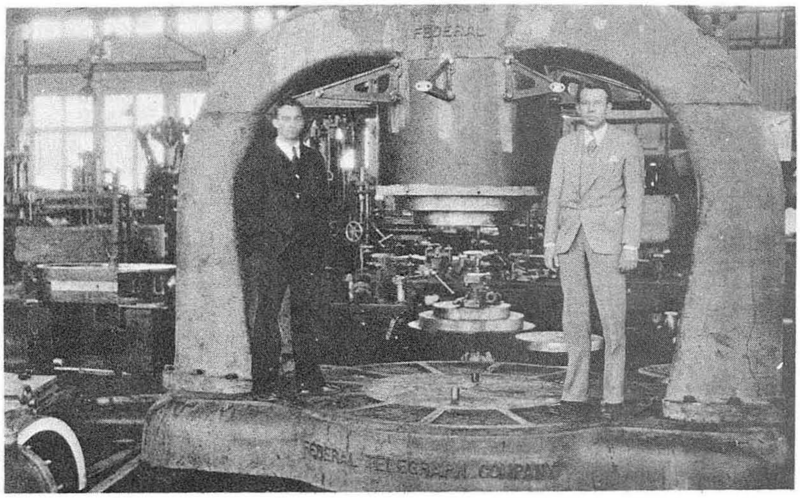
Interest in biomedical applications started very early. Ernest's brother, John, is a physician, and Ernest always had an attraction to the field of medicine. I have already spoken about the Sloan X-ray tube, which went into medical use in 1934. The next year John came to Berkeley for the summer and made the first observations of the effects of neutron rays on a living organism, finding the effects greater than those of other forms of radiation and, therefore, very interesting, and in 1936 he came to stay. Paul Aebersold became the chief physicist for the biomedical group, making the arrangements for irradiation and measuring the dosage. The first cancer patient was treated in September, 1938, with sufficiently encouraging results that the Crocker Laboratory was dedicated to medical research, although the physicists and chemists got to use it too. There were working visitors in the biomedical field: Frank Exner from New York, Isidor Lampe from Utah, Raymond Zirkle from Pennsylvania, Al Marshak, Lowell Erf, John Larkin, and many others. Dr. Joseph Hamilton had a separate group studying the distribution of radioisotopes administered to animals and humans. To the smells of hot oil from the cyclotron were added those of animal colonies. As Laslett said in his "Cyclotron Alphabet", "M stands for mice whose smell makes us moan."

We went through the WPA period. It was during the great depression, and the WPA was a scheme by which unemployed people were hired by the Government and assigned to governmental bodies or other institutions to perform useful work. I have a 1934 letter from Lawrence to the University office handling this program, requesting, for a period of 1 month, "(1) One physicist, with Ph. D. and several years' subsequent research experience; (2) one carpenter; (3) one machinist, with several years' experience in general shop work." Some of those who came were real characters. I remember particularly Murray Rosenthal who was an amateur magician, a Swedish draftsman named Hallgren who was so profane that we tried to keep him away from Don Cooksey who objected to his language, and a man who had been with the telephone company, very distinguished looking, who liked to go around checking the strength of soldered wire joints by pulling at the wires with a buttonhook. Some, who were only temporarily down on their luck, stayed on and became valuable members of the Laboratory staff. Some idea of the financial scale of that time is given by the cost estimate made by Wally Reynolds in 1931 for the installation of the 80-ton magnet. This includes moving the magnet from San Francisco and setting it in place, four transformers, a 50 kilowatt motor-generator set, a 10-ton crane, concrete piers, labor, engineering, and contingencies, all for $5,300!

It is hard to convey the atmosphere of that time. The world was in a deep depression. There was a general strike in San Francisco in 1934. Some people on the campus took sides, and friendships were broken over this. There was a lot of leftist agitation which later had dire consequences for many scientists. There was not much money around; for 7 months, between the end of my fellowship and my appointment to the faculty as an instructor, I was a research associate without pay. But we all managed somehow, and the Laboratory kept going. Lawrence was the driving force, and the spirits inside the Laboratory were kept high by the excitement of discovery. There was very little organization; Lawrence was the boss, and that seemed to be enough. What a change has taken place since then! The eager youth has grown into an adult with the increased powers and problems that come with maturity.

Slides

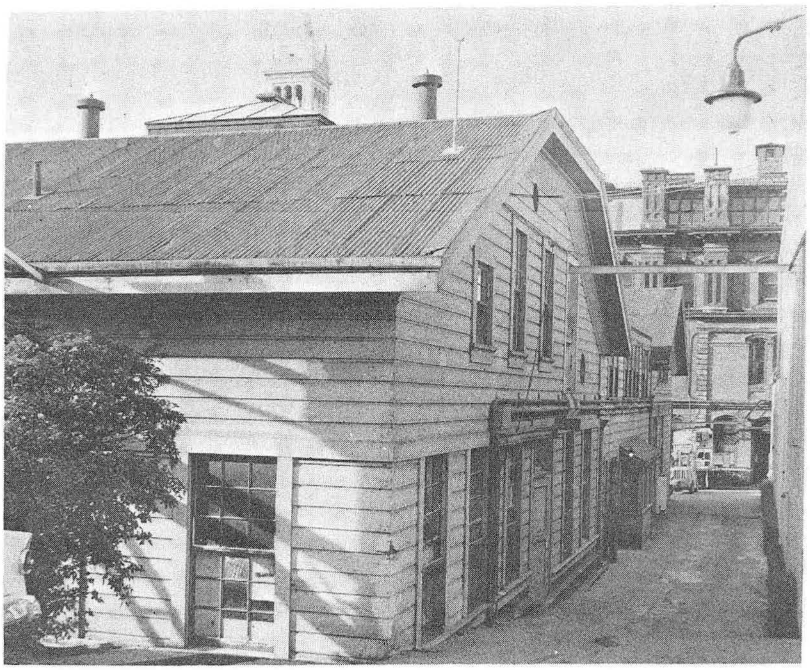
Slide 1. This is Ernest Lawrence, taken on September 19, 1930, just after he had given the first scientific paper on the cyclotron at a meeting of the National Academy of Sciences on the Berkeley campus. He is holding a glass, brass, and wax apparatus with which he and Neils Edlefsen had obtained evidence of ion resonances in a magnetic field, encouraging Ernest to go on with the development of the cyclotron idea. From his expression, you can see that he has hopes for the future.



Slide 2. Here are Stan Livingston and Ernest Lawrence standing beside the big magnet, in the shop of the Pelton Water Wheel Company in San Francisco. The magnet had been built by the Federal Telegraph Company of Palo Alto for use as part of a Poulsen-arc radio transmitter ordered by the Chinese government, but it was never delivered, and

Leonard Fuller, a vice president of the company, arranged for it to be given to the University. The core and poles of the magnet had to be changed before it could be used as a cyclotron magnet, and that is being done here, in late 1931.

Stan Livingston made the first cyclotron that worked. He found a beam of 80,000 electron volt hydrogen molecular ions on January 2, 1931, in a 4-inch cyclotron. Then he made an 11-inch cyclotron, with which, in 1932, Milt White confirmed the lithium disintegration results of Cockcroft and Walton. This work was done in Le Conte Hall, but the big magnet needed a larger place to house it. As you all know, Stan was one of the discoverers (or inventors) of strong focusing, without which most of high-energy physics could not have been done.



Slide 3. This shows the Old Radiation Laboratory. It had been a civil engineering testing laboratory and was scheduled to be torn down, but Ernest persuaded President Sproul to let him have it for his experiments. This occurred on August 26, 1931, in President Sproul's office. At that time Ernest had the promise of financial support and a formal offer of the magnet, so if one wants to choose a day for a birthday this could be it. Early in 1932 the name

"Radiation Laboratory" was painted on the doors. The magnet was installed in ~~December, 1931~~ January, 1932, and the 27-inch cyclotron first operated in June ~~of the next year~~. Six years later the magnet poles were enlarged and the 37-inch cyclotron was installed. In the crew record for November 10, 1937, I found the following poem by Martin Kamen:

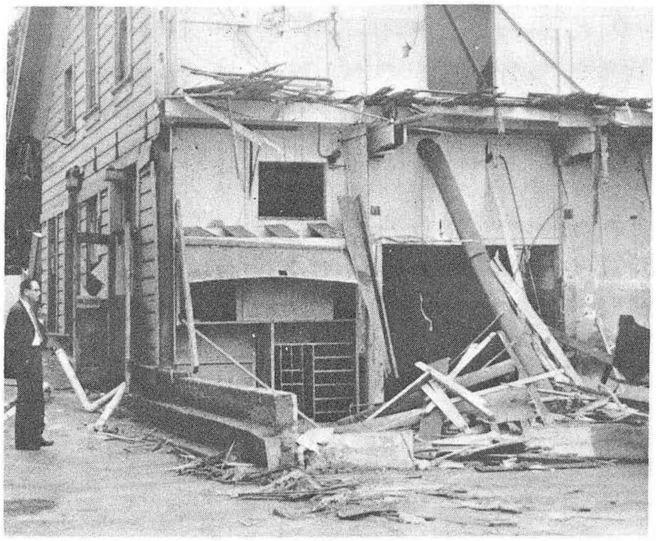
"The cyclotron is a noble beast
It runs the best when you expect
    it least
Of all the pleasures known to man
The greatest is a good tight can"

by which he meant the vacuum tank. You remember what I said about the misery of leaks.

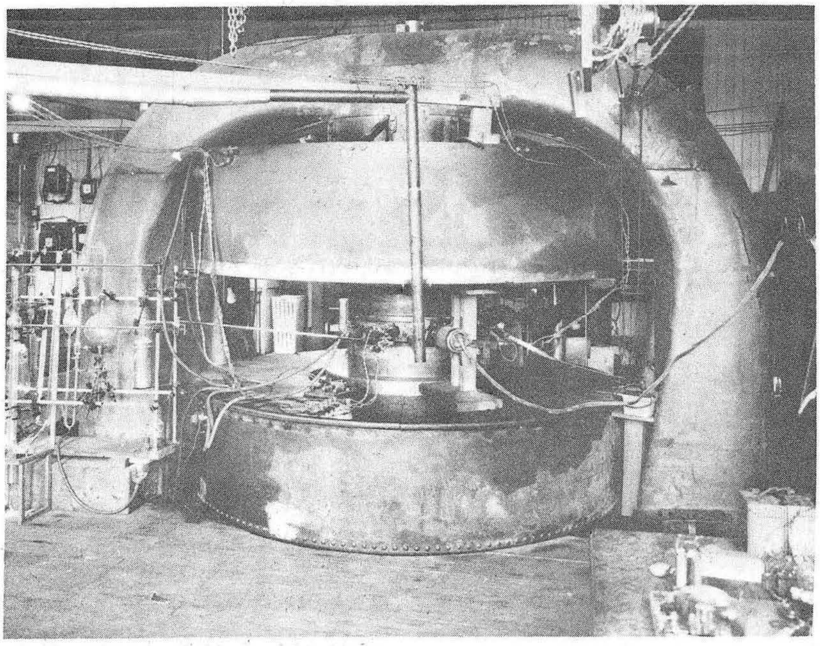
In this building there was a large room for the cyclotron and its controls, an open court for transformers and switchgear, a machine shop, and some office space. Whenever there was trouble with the commutator of the generator that supplied the magnet current, I was called in to fix it. I was considered an expert at soldering with a torch in those days. Once Franz Kurie, when starting the motor generator, threw in the breakers in the wrong order and turned out the lights in all of Berkeley.

That building was the scene of frustration and elation--human as well as scientific drama. Many anecdotes have been told about happenings there, like the times that Ernest fired Bill Baker, and on another occasion Bob Wilson, only to recant and take them back again. But on the whole, relations were remarkably harmonious considering the many different temperaments of the people.

After the war, the first tests of the synchrocyclotron principle were done here, and in it Melvin Calvin did his pioneer work on the carbon cycle in photosynthesis.

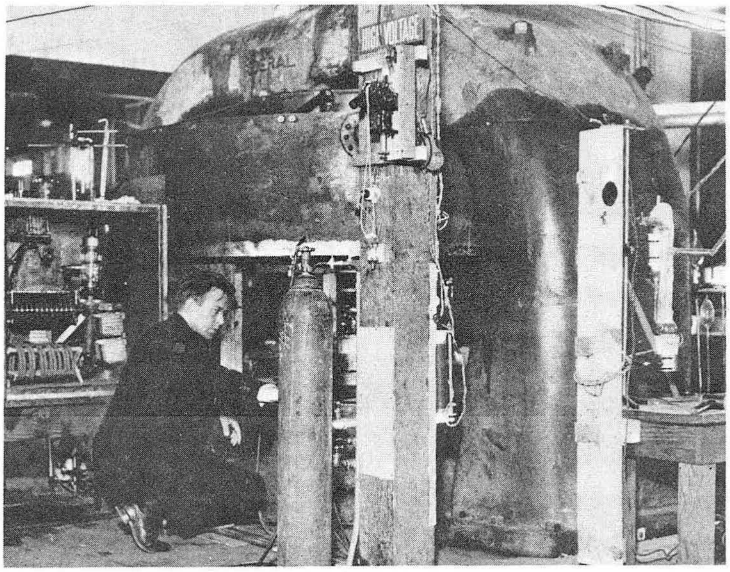


Slide 4. This is another view, taken in 1959. The demolition is proceeding toward you in the last view, and not much is left. I am standing there, sadly viewing the end of an era. Later, Crocker had to go too; the Chemistry Department needed space for more buildings.



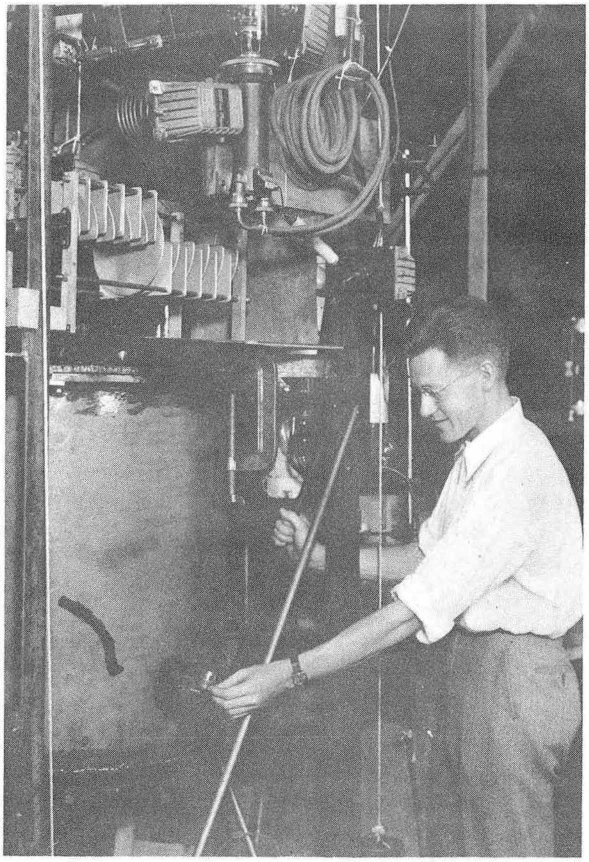
Slide 5. This is the 27-inch cyclotron in 1932. The vacuum chamber sits between the poles of the magnet, covered with wax. The stovepipe going up in front has a wire strung down the middle which

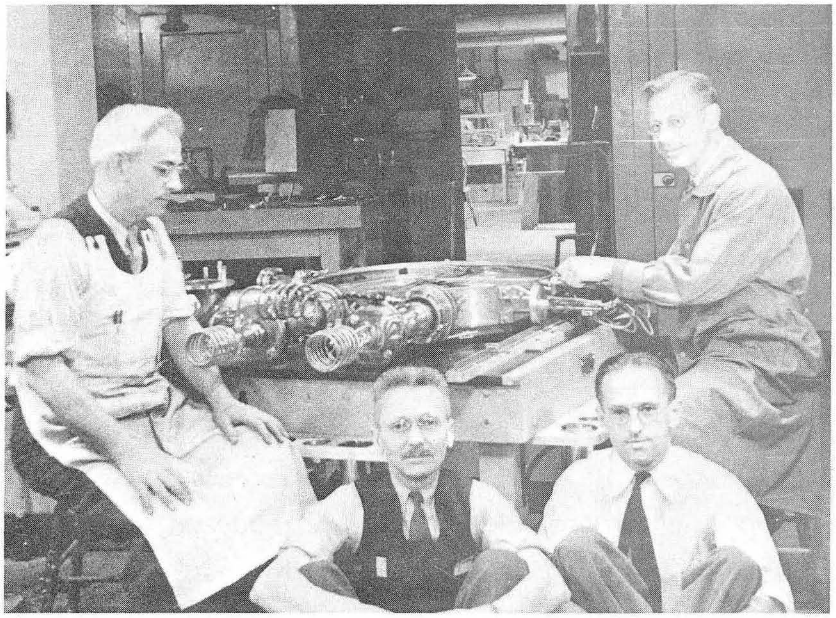
carries the collected beam current to a galvanometer on the control table out of the picture at the left. Sticking out in front is the linear amplifier built by Malcolm Henderson, which was used to count protons and alpha particles. The magnet windings were cooled by oil in the big circular tanks, and there was oil all over everything. One time Luie Alvarez neglected to close a valve after turning off the oil circulating pump and a whole tank of oil ran over and went through the cracks in the floor into the basement.



Slide 6. This shows Ernest at the other side of the cyclotron, also in 1932. This photo contains its own date. It is written in chalk on the hydrogen tank. Behind Ernest is the oscillator that supplied high-frequency power to the cyclotron. You can see that it used a commercial vacuum tube, but these were expensive, and for a while home-made tubes designed by Dave Sloan were used. Ernest is recognized as one of the world's great experimental physicists, but he was not particularly adept with his hands, and contributed his share in the breakage of apparatus. When some delicate task was to be done, he would turn to someone else and say: "Here, you do this." His ideas and enthusiasm were the important things.

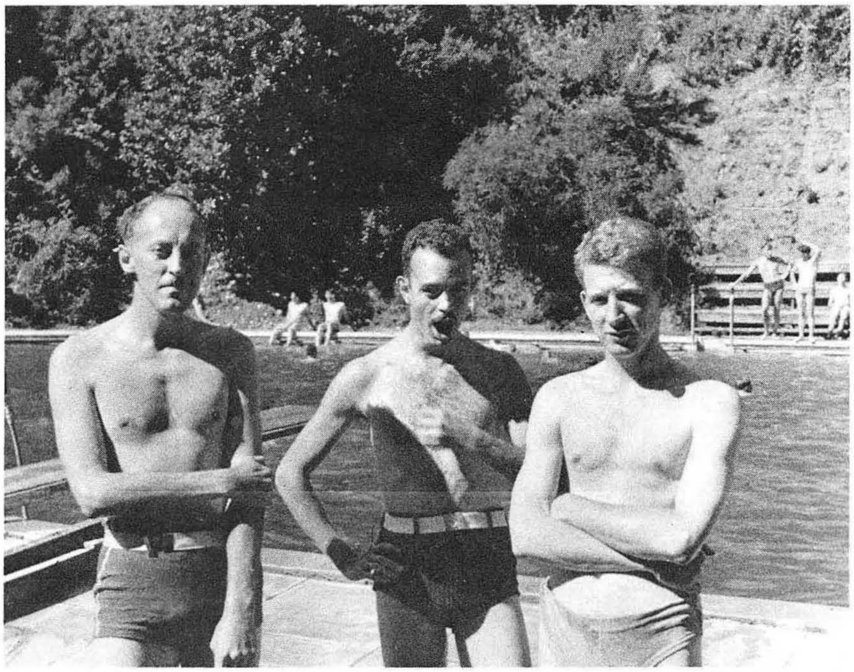
Slide 7. This shows Dave Sloan with his X-ray tube, which was essentially a Tesla coil in a vacuum tank. Dave was very important to the Laboratory. He could build anything, and was full of ingenious ideas. He built large oil-diffusion pumps when such items were not obtainable commercially, and made demountable oscillator tubes in which the filaments could be changed by taking apart a wax joint. One time he tried to make a diffusion pump using bismuth vapor. This did not work very well, but it was an interesting idea. He is still active at Physics International, working with high-current accelerators, a natural continuation of what he did here.





Slide 8. Here is another side of the Laboratory, the machine shop in the old Radiation Laboratory.

Without shops a laboratory could not operate. We used our own shop, the Le Conte shop, and large jobs were sent out to commercial shops. On the left is George Krause and on the right Eric Lehmann, working on a cyclotron tank, or at least looking as if they were contemplating working on it. Sitting in front are Don Cooksey, who made the shops one of his primary concerns, and Jack Livingood, the great hunter of radioisotopes. Three men who worked in that shop in the early days, Don Stallings, Jack Kroll, and Paul Wells, are still with the Laboratory.



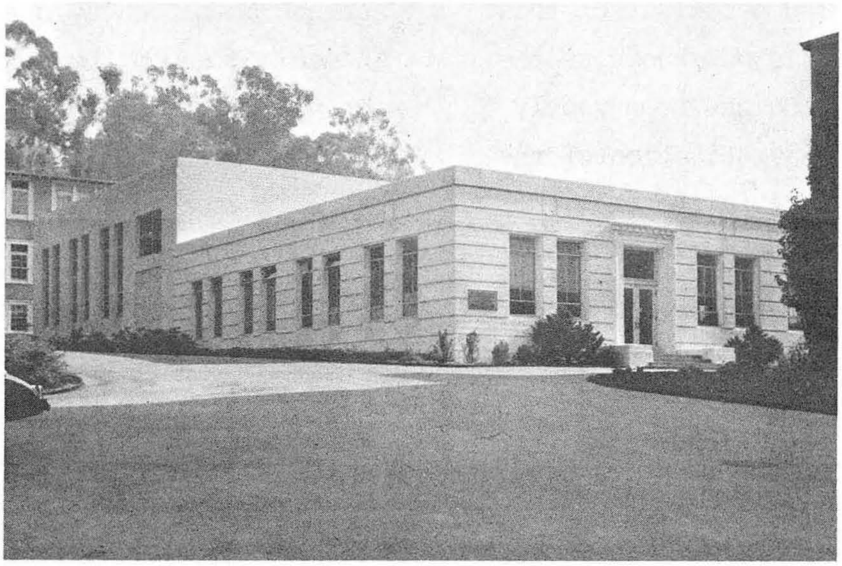
Slide 9. This shows Art Snell, Franz Kurie, and Bernard Kinsey, who were, I think, in the Strawberry Canyon pool when this picture* was taken. Art came from Montreal in 1934, later went to Chicago, and is now in Oak Ridge. He was famous as the poet laureate of the Laboratory; he would make limericks for all occasions. When Lawrence was awarded the Nobel Prize in 1939, he sent a wire that said: "Congratulations. Your career is beginning to show promise." He built an oscillator and discovered radioactive argon, among other things.

Franz Kurie from Yale seems to be giving a Tarzan yell, but he was actually a very gentle person. He introduced the cloud chamber technique into the Laboratory. He made measurements of the energy distribution of beta rays and invented a method for presenting the data that made it easy to

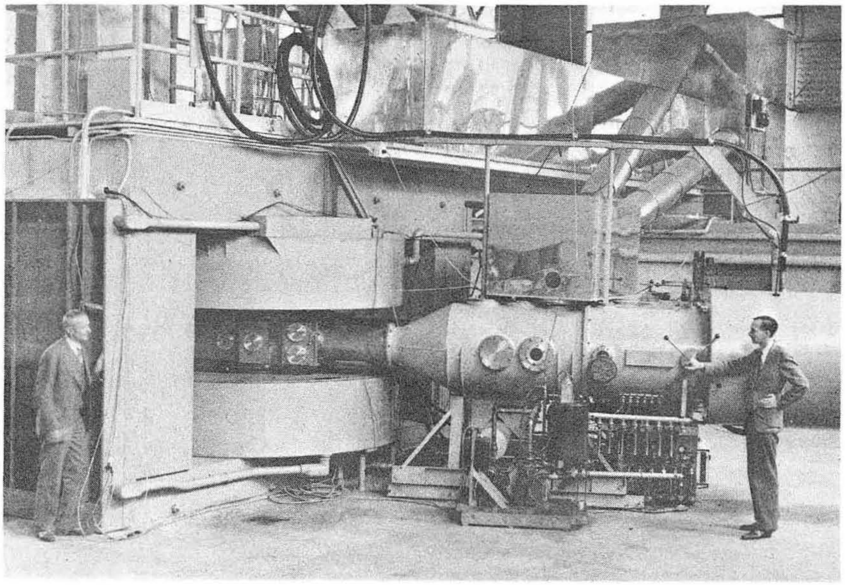
*The picture is reversed.

determine the upper limit of the energy. This is now known as the "Kurie plot" and has been widely used. In an investigation of the disintegration of nitrogen by neutrons, he found some unusual tracks which could be interpreted as being due to the capture of slow neutrons and the emission of protons, resulting in the formation of carbon-14. This served as a clue in finding the best method of making carbon-14 which, as you might guess from what I have said, is the capture of slow neutrons by nitrogen. I had a bottle of ammonium nitrate sitting near the cyclotron target for a long time, hoping eventually to separate out carbon and see if it was active, but this got knocked over and broken and I never put another one back. As I remember, people thought it was a nuisance and were afraid it might explode. There had been some large explosions involving ammonium nitrate. When carbon-14 was eventually identified in carbon bombarded by deuterons, Kamen and Ruben then tried neutrons on nitrogen, and they never went back to the carbon bombardments, in which the yields were smaller and the active carbon was diluted by all the ordinary carbon. Franz later was the director of the U. S. Navy Radio and Sound Laboratory in San Diego.

Bernard Kinsey was a Commonwealth Fellow from England, who built a linear accelerator for lithium ions. There are many stories about Bernard. He had a high temper and a very complicated and colorful form of swearing, really a high art. He is here at this celebration, and perhaps he might be persuaded to give us an example. There was another Commonwealth Fellow at the University named Brown, who was probably the laziest man I ever knew. I don't think he ever did anything, but I saw him around the Faculty Club, where I was living at the time. He obviously was not in the Laboratory; Ernest would have thrown him out.



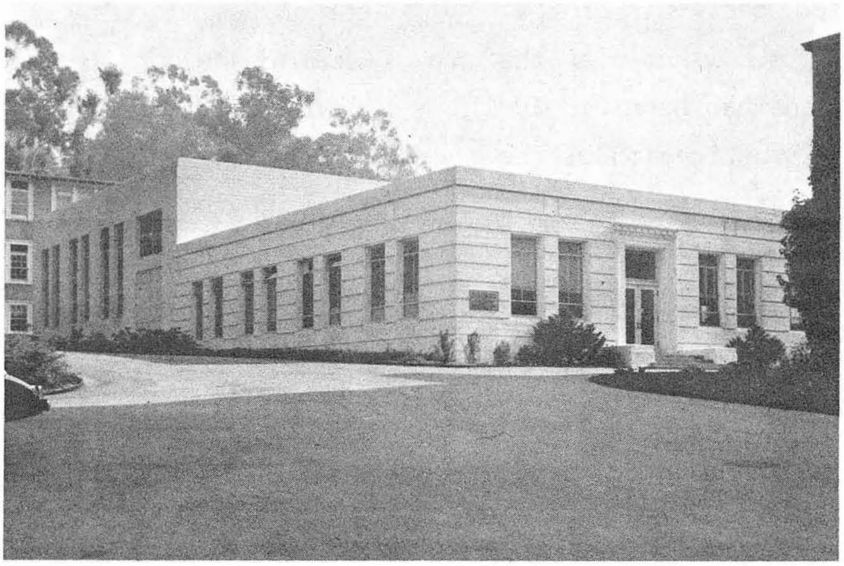
Slide 10. This is the Crocker Laboratory that I mentioned earlier. The Old Radiation Laboratory is off to the right across an alley, and the 60-inch cyclotron resided in the high bay at the rear. This was called the medical cyclotron, but as I have said, others used it. It went into operation in 1939, giving deuterons of about 8 MeV. Under the supervision of Dr. Joseph Hamilton it was used extensively for making radio isotopes for medical and tracer uses.



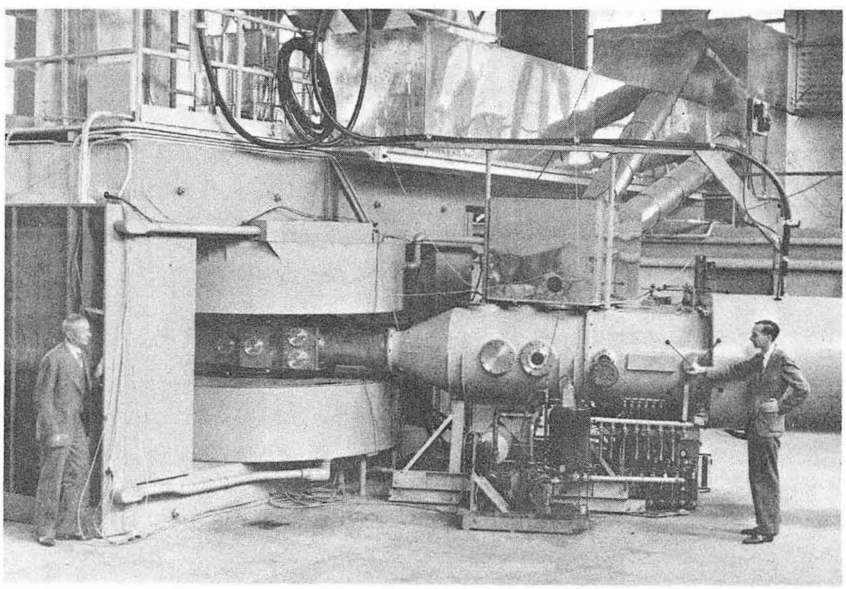
Slide 11. Here is the 60-inch cyclotron, with Don Cooksey and Ken Green. You see that it is much neater looking than the earlier cyclotrons. Bill Brobeck had had his influence. The structure pro-

determine the upper limit of the energy. This is now known as the "Kurie plot" and has been widely used. In an investigation of the disintegration of nitrogen by neutrons, he found some unusual tracks which could be interpreted as being due to the capture of slow neutrons and the emission of protons, resulting in the formation of carbon-14. This served as a clue in finding the best method of making carbon-14 which, as you might guess from what I have said, is the capture of slow neutrons by nitrogen. I had a bottle of ammonium nitrate sitting near the cyclotron target for a long time, hoping eventually to separate out carbon and see if it was active, but this got knocked over and broken and I never put another one back. As I remember, people thought it was a nuisance and were afraid it might explode. There had been some large explosions involving ammonium nitrate. When carbon-14 was eventually identified in carbon bombarded by deuterons, Kamen and Ruben then tried neutrons on nitrogen, and they never went back to the carbon bombardments, in which the yields were smaller and the active carbon was diluted by all the ordinary carbon. Franz later was the director of the U. S. Navy Radio and Sound Laboratory in San Diego.

Bernard Kinsey was a Commonwealth Fellow from England, who built a linear accelerator for lithium ions. There are many stories about Bernard. He had a high temper and a very complicated and colorful form of swearing, really a high art. He is here at this celebration, and perhaps he might be persuaded to give us an example. There was another Commonwealth Fellow at the University named Brown, who was probably the laziest man I ever knew. I don't think he ever did anything, but I saw him around the Faculty Club, where I was living at the time. He obviously was not in the Laboratory; Ernest would have thrown him out.

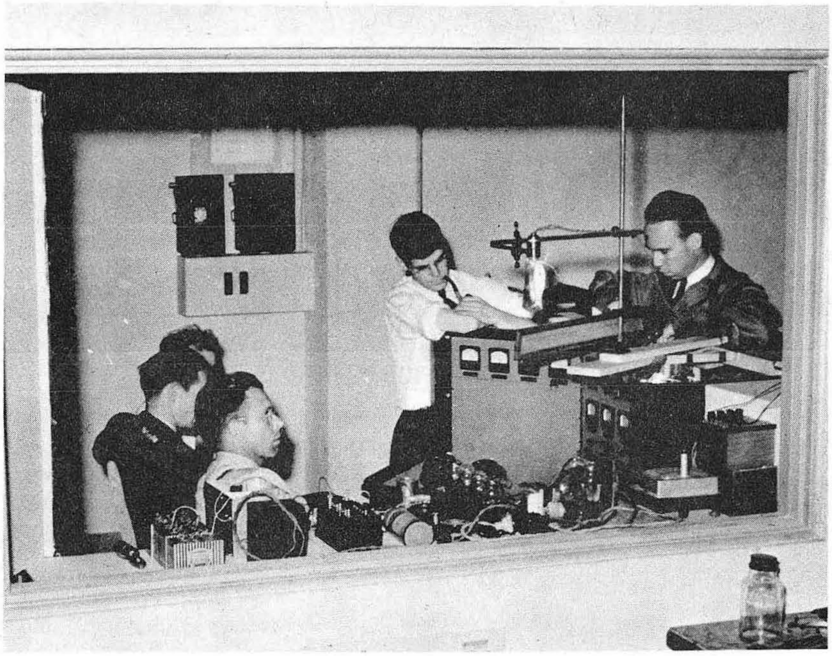


Slide 10. This is the Crocker Laboratory that I mentioned earlier. The Old Radiation Laboratory is off to the right across an alley, and the 60-inch cyclotron resided in the high bay at the rear. This was called the medical cyclotron, but as I have said, others used it. It went into operation in 1939, giving deuterons of about 8 MeV. Under the supervision of Dr. Joseph Hamilton it was used extensively for making radio isotopes for medical and tracer uses.



Slide 11. Here is the 60-inch cyclotron, with Don Cooksey and Ken Green. You see that it is much neater looking than the earlier cyclotrons. Bill Brobeck had had his influence. The structure pro-

jecting at the right is a pair of tanks that held the dee stems, which formed a resonant system. The oscillators were on the balcony at the right. You will notice the coil of heavy cable at the top. This carried high voltage to the deflector plate from the rectifier built by Ed Lofgren. The reason for the coil is that high voltage cables usually fail at the ends, and are very hard to splice. The coil gave plenty of slack for making repairs.



Slide 12. Looking through the window into the 60-inch control room. Bill Brobeck is there, Bob Wilson smoking his pipe, Ernest Lawrence, and a couple of other characters. Bob Wilson follows me on this program, and his introducer will tell you about his achievements. The temporary setup that mars the neatness of the control table was a breadboard model of an automatic magnet current regulator that was being tested.

Slide 13. Ernest, Dale Corson, Winfield Salisbury, and Luie Alvarez, in 1939. I don't recognize the man on the extreme left. Corson participated in the discovery of astatine, and is now the President of Cornell University. Salisbury has had a distinguished career in industry and the academic world since leaving the Laboratory; he made very valuable contributions to radar countermeasures during the war. Luie, as you know, went on to win the Nobel Prize in physics and is one of the introducers on this program.

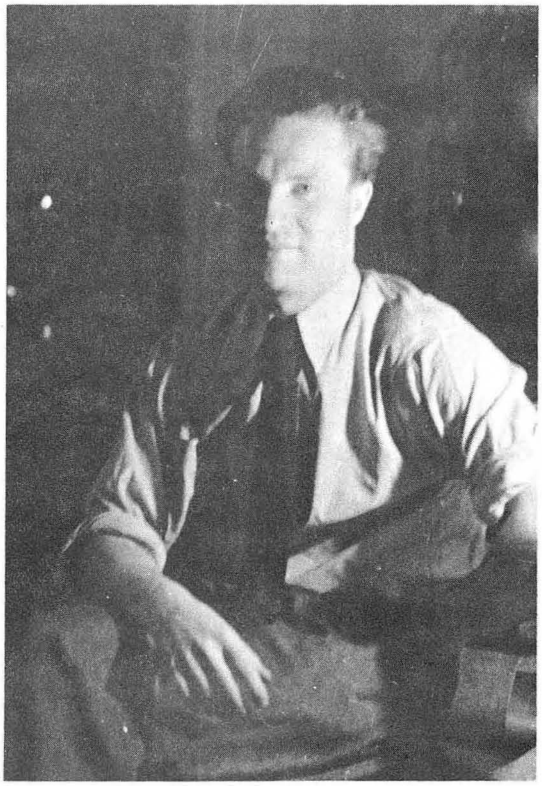
Slide 14. This shows John Lawrence in 1936, with rows of mouse cages in the background, a proper setting for a biomedical researcher. I will not say any more about the biological and medical research, which will be covered by Dr. Alpen later on in this program.

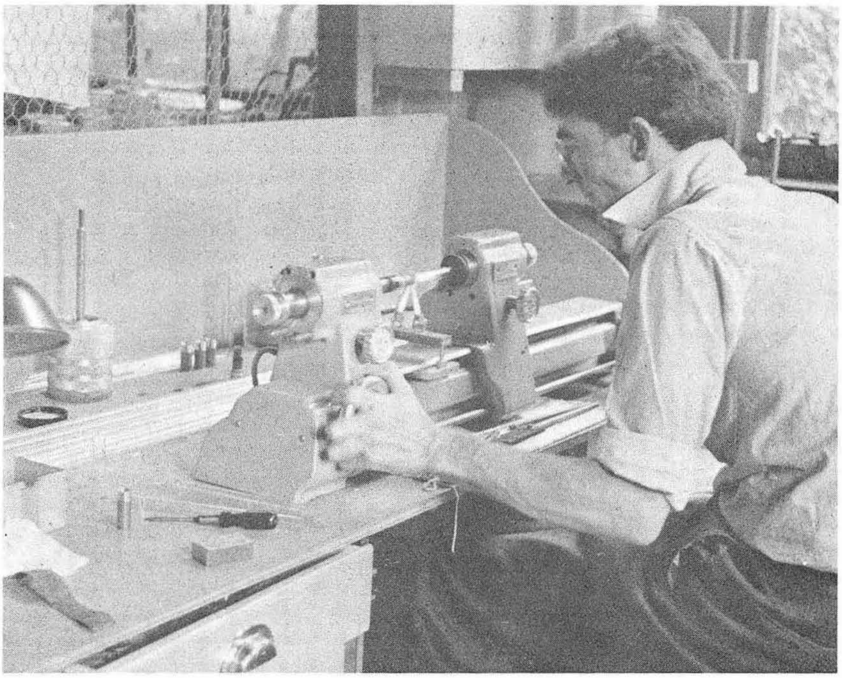
Slide 15. Again mouse cages, with mice, but a later date (1939) and a different person, Dr. Joseph Hamilton. Joe had a setup in Crocker where he worked with radioisotopes in medical and biological studies. Joe's table at the Faculty Club was noted for the interesting conversations on many subjects at lunch time.

Slide 16. All was not hard work; we had fun too. The Di Biasi parties were famous yearly affairs, at an Italian restaurant in Albany (Albany, California, that is.) Paul Aebersold had an irrepressible sense of humor and was always the master of ceremonies. This party in 1939 was in celebration of the 60-inch cyclotron, and Paul was presenting a cake in the shape of a cyclotron, with the words: "8 billion volts or bust." That was supposed to be a wild exaggeration, but the Bevatron had not been invented yet. Lawrence and von Friesen are in the forground.

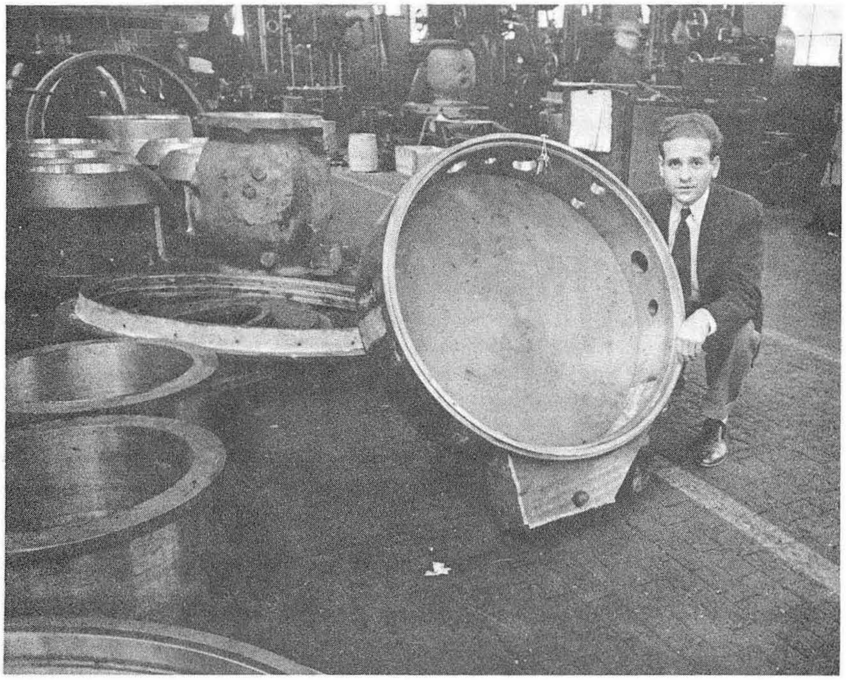
Slide 17. At the same party. At the left is Martin Kamen, looking puzzled, then come Sten von Friesen from Sweden and Bob Cornog. Ken MacKenzie is in the left background, and on the right is Molly Lawrence, flanked by two distinguished visitors, Vannevar Bush and Alfred Loomis. Alfred was a great friend of Ernest's and the Laboratory, and helped in many ways.

Slide 18. Lorenzo Emo Capodilista, the Count from Italy, came to the Laboratory in 1935 and stayed several years. He did not use the last name, which means "head of the list" and is a name of great antiquity in Italy.

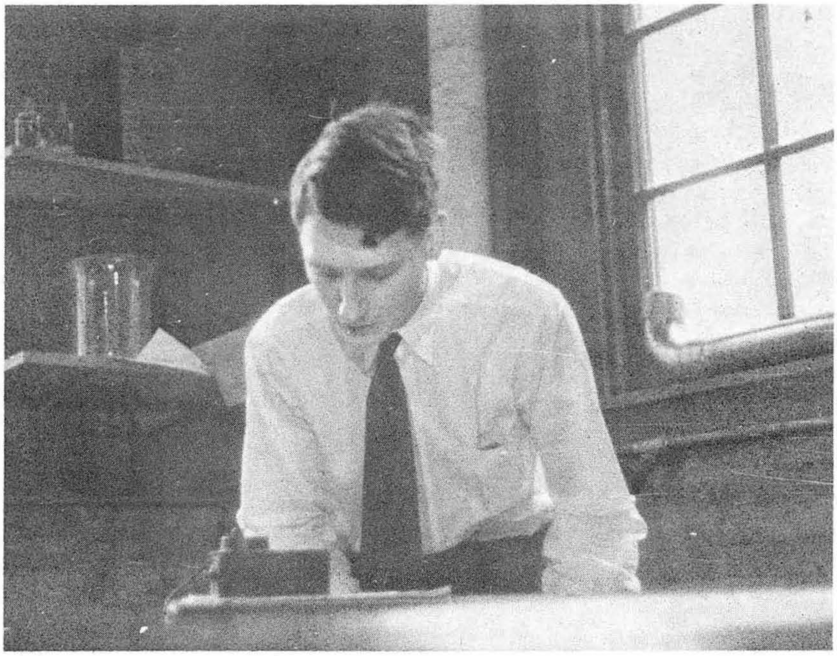




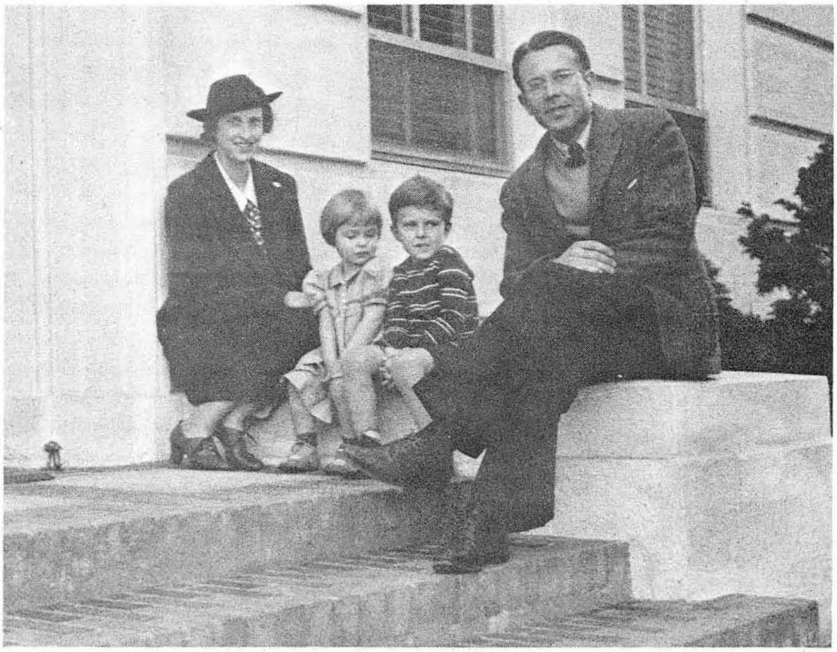
Slide 19. Charlie Litton in 1936, working with one of the glass lathes that he made.



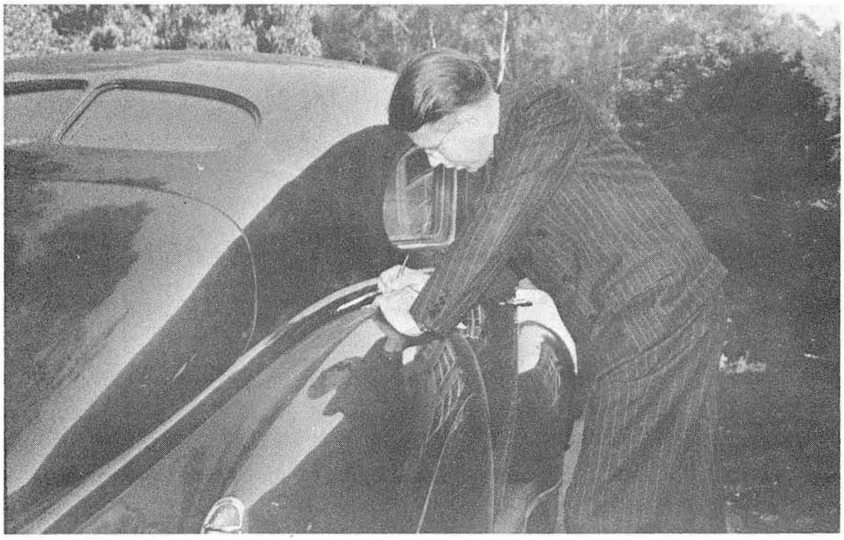
Slide 20. Maurice Nahmias from Joliot and Curie's laboratory in France, with the vacuum chamber of the 37-inch cyclotron in 1937.



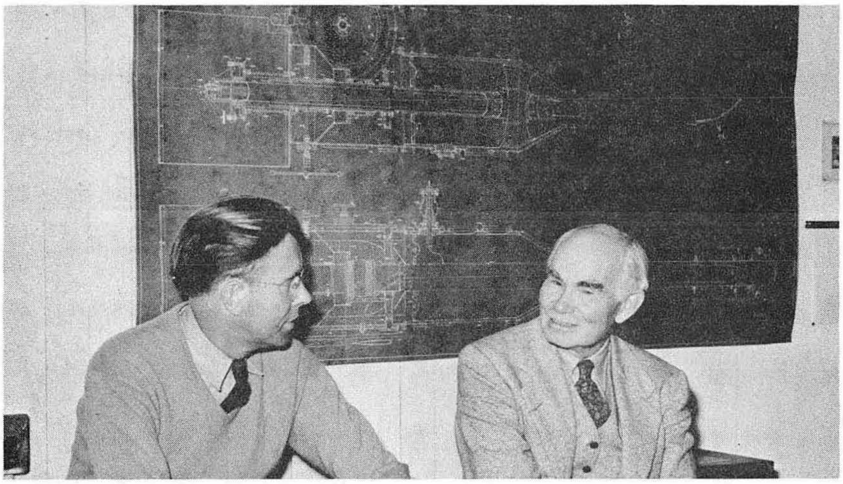
Slide 21. Henry Newson came from Chicago in 1934 with a Ph. D. in chemistry and turned into a physicist, doing some very ingenious experiments using the recoil of artificially produced radioactive nuclei. This picture was taken in 1938.



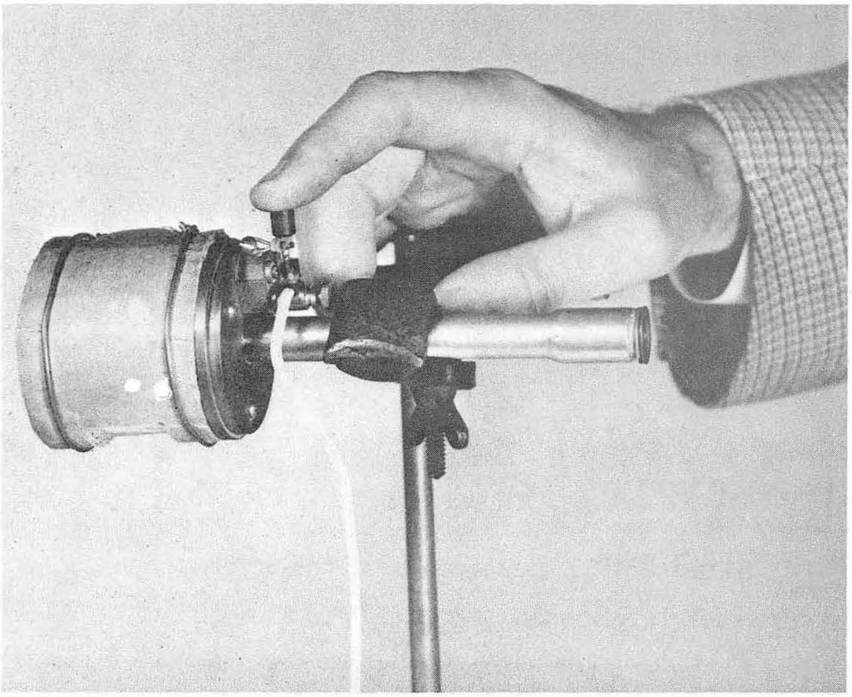
Slide 22. Ernest and Molly Lawrence with Eric and Margaret, on the steps of Crocker Lab in 1939.



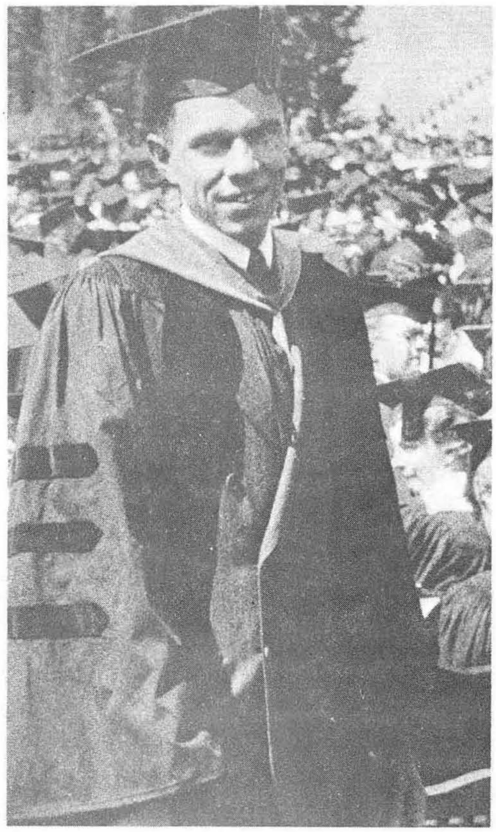
Slide 23. Ernest writing the script for
a movie about his Nobel Prize in 1939.



Slides 24 & 25. Distinguished visitors in 1940: Lee de Forest and Diego Rivera.



Slide 26. One of the original 1934 Lauritsen electroscopes that has survived.



Slide 27. Glenn T. Seaborg on the occasion of receiving his Ph. D. at Berkeley in 1937.

Slide 28. Your speaker, at a press conference in Crocker Laboratory on June 8, 1940, at the time of the announcement of the discovery of neptunium.

Slide 29. I found this in the archives, and couldn't resist putting it in to end the slide show. I call it "on the beach." Somewhere in the Sacramento River delta John Lawrence, Paul Aebersold and I are enjoying the sun with some girls.