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EDWARD LEONARD GINZTON
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A Biographical Memoir by

ANTHONY E. SIEGMAN

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EDWARD LEONARD GINZTON

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BY ANTHONY E. SIEGMAN

EDWARD L. GINZTON'S MULTIFACETED career spanned an era of immense technological advances in physics, electronics, and microwaves—and of important advances in social and political issues. Throughout his long and productive life his remarkable combination of scientific skills, leadership qualities, technological foresight, and community concerns enabled him to make distinguished technical contributions and to build enduring institutions in which others could make such contributions as well.

Ginzton's scientific career began in the late 1930s when he helped develop the understanding of feedback in early vacuum tube amplifiers and worked with the pioneers who invented the klystron. It continued through his leadership in developing modern microwave technologies and megawatt-level klystron tubes during and after World War II, and in helping make possible the development of linear electron accelerators both as mile-long "atom smashers" and as medical tools still in use worldwide for cancer radiation therapy. His abilities eventually led him to take distinguished roles in both the academic and industrial worlds and in local and national community service as well.

By the end of his career Ginzton held some 50 fundamental patents in electronics and microwave devices, had received the 1969 IEEE Medal of Honor "for his outstanding contributions in advancing the technology of high power klystrons and their applications, especially to linear particle accelerators," and had been elected to the National Academy of Sciences (1966) and the National Academy of Engineering(1965). Beyond this, to borrow from the words used by photographer Carolyn Caddes in her *Portraits of Success: Impressions of Silicon Valley Pioneers*, "Ginzton [also] contributed to the growth of Silicon Valley as scientist, educator, business executive, environmentalist, and humanitarian."

1915 TO 1929: EARLY YEARS IN RUSSIA AND IN EXILE

Ginzton was born on December 27, 1915, in the Ukrainian city of Ekaterinoslav to Natalia Philapova, a Russian physician, and Leonard Ginzton, an American medical student. So far as can be determined from the confusing records available even to Ginzton himself, his father was born in Russia but as a young man emigrated first to Germany and then to America, where he became a U.S. citizen and participated in the Klondike Gold Rush of 1897. After some success in finding gold, Leonard Ginzton traveled back to Switzerland, began his first real period of formal education, and after a few years returned to Russia to study medicine and to marry Ginzton's mother in 1905.

During the following two decades Ginzton's parents, idealistic medical students and eventually doctors, were caught up in the birth of six children, only two of whom survived infancy, and in the turmoil associated with World War I, the final years of tsarist Russia, and the rise of the new Soviet state. As Ginzton later recalled in an informal autobiography:

> Since both of my parents participated as medical officers on the Eastern Front, my early childhood consisted of rapid migration with the tides of war, revolution, and other similar events. Until I was 8 we did not live in any one place for more than six months, and I was not exposed to formal education until I was 11. As I was supposed to have had tuberculosis, I was [at one period] sent to the Black Sea by myself, with only occasional visits by my relatives.

In 1927 Ginzton's parents decided to leave Russia, partly in response to the tragic death two years earlier of Ginzton's only surviving sibling, Leonard. As revolution swept through the Russian empire, the Ginzton family sought refuge in the distant city of Harbin, Manchuria. Still lacking any formal education, Ginzton had a private tutor there for a period of a year, during which he learned just enough to catch up with the requirements of the Russian school in Harbin.

1929: ARRIVAL IN THE UNITED STATES AND STUDIES AT BERKELEY

In the autumn of 1929 Ginzton's father arranged for the family to emigrate from Manchuria to the United States. On his arrival in San Francisco the 13-year-old Ginzton, "knowing not a word of English," was placed in the first grade in the public schools. Less than four years later he graduated from San Francisco's Polytechnic High School and in the spring of 1933 entered the University of California, Berkeley, to study electrical engineering. In addition to his studies Ginzton joined the Reserve Officers Training Corps, hiked in the High Sierra, enjoyed amateur photography, played chess at a competitive level, and organized an intramural water polo team. His ROTC participation eventually led to a commission as a second lieutenant in the Army Reserve, but he was never called to active duty.

Graduating from Berkeley three years later in the middle of the Great Depression, Ginzton, unable to find employment, chose to continue with graduate work at Berkeley. During the following year he took further courses, did independent research on the theory of electronic circuits, and invented the "balanced feedback principle." "It was not much of an invention," Ginzton later recalled, but the circuit analysis and experimental work were enough for an M.S. degree from Berkeley in 1937 and a publication in the *Proceedings of the Institute of Radio Engineers* (1938).

1937: FIRST ARRIVAL AT STANFORD UNIVERSITY

Ginzton's subsequent application for a graduate fellowship together with his work on negative feedback at Berkeley led to a meeting with Frederick Terman, who had been working for some time to build a radio electronics curriculum at Stanford. Terman immediately offered him a teaching assistantship and Ginzton moved to Stanford in 1937 to enroll in Terman's graduate program in electrical engineering. Ginzton later recalled that in doing this,

> I became a member of a graduate class of about 15. This group was of unusually high caliber [one of Ginzton's closest friends in the group was William Hewlett] and we learned as much from each other as from formal c1asswork. We organized seminars on topics which were not being taught but which appeared to us to be of importance. We became fascinated [with] the principle of negative feedback, and much of the experimental work in this field, as well as the theory, evolved from the research of this group of students.

The students helped revise and expand an early edition of Terman's *Radio Engineering* textbook and lectured to each other from papers in the *Bell System Technical Journal.* Ginzton's research on feedback eventually led to an engineer degree thesis on applications of feedback at radio frequencies in 1938, and a Ph.D. dissertation on stabilized negative impedances in 1940.

During his first week at Stanford, Ginzton also enrolled in a course in modern physics taught by William W. Hansen, a young but very highly regarded faculty member in the Stanford Physics Department. In 1939 as Ginzton neared the end of his Ph.D. work, Hansen, with Terman's encouragement, invited him to join the Varian brothers Russell and Sigurd in continuing the development of the klystron tube, a pathbreaking microwave device invented two years earlier by Russell Varian. Ginzton explored the characteristics and potential applications of the new tube and developed new methods for making microwave measurements—activities that set him on a path to several of the major accomplishments of his subsequent career. Ginzton thus had the good fortune during his student years at Stanford to develop lifelong relationships with many microwave and electronics pioneers, including William Hewlett, David Packard, and Karl Spangenberg in Terman's laboratory, and the Varians and others in Hansen's group. He also married Artemas A. McCann on June 16, 1939. The couple subsequently had four children: Anne, Leonard, Nancy, and David.

1941 TO 1946: WAR YEARS AT SPERRY GYROSCOPE

Stanford had entered into an agreement in 1938 under which the Sperry Gyroscope Company acquired ownership of the klystron patents and opportunities to participate in continuing klystron development at Stanford in return for the promise of future royalties to the Varian brothers and Stanford. In late 1940 as World War II broke out in Europe and American involvement came to be seen as inevitable, most of the Stanford klystron group, including Hansen, Ginzton, and the Varian brothers, transferred to the Sperry plant in Garden City, New York, to continue development of the klystron for microwave radar applications.

Very soon after arriving at Sperry, Ginzton, still in his late twenties, began to demonstrate his leadership abilities, and by 1946 he was directing a staff of some 2,000 people working on klystron microwave tubes, microwave measurement techniques, and Doppler radar systems. As Ginzton later noted, "[During these] six years I invented some 40 or 50 devices, some of which were relatively important." The Doppler radar techniques developed under Ginzton's direction at Sperry introduced the basic features of many sophisticated civilian and military radars today. Even as they devoted long working hours to these developments, however, Ginzton, Hansen, and the Varian brothers continued to think about the research plans that the war had forced them to leave behind at Stanford. In Ginzton's own words, during what free time they had, the four colleagues all "dreamed together, had lots of ideas we wanted to pursue" when the war was over—including the idea of founding a company whose directions and objectives would be set by scientists and not by businessmen.

1943: STANFORD'S POSTWAR PLANS

Others back at Stanford had similar thoughts about postwar opportunities. In the late 1930s some of Stanford's academic leaders had come to recognize that their university, though a respected regional institution, was not one of the top 10 among American universities. A 1938 article in the *Atlantic Monthly* ranked Stanford with Penn, Illinois, Iowa, and Ohio State as competing for twelfth place in national rankings. A group of senior academics led by Donald Tresidder, the unusually young and energetic president of the Board of Trustees, thus began around 1940 to formulate plans for bringing Stanford to a stature on the West Coast comparable to Harvard, MIT, and other major universities on the East Coast.

These plans resonated with Frederick Terman, who had struggled to develop his own radio research laboratory activities at Stanford in the late 1920s and 1930s with very meager resources before heading east to head the Radio Research Laboratory at Harvard during World War II. When Tresidder became president of Stanford in 1943, he along with Terman and others, set out to build postwar "steeples of excellence" (Terman's phrase) at Stanford, taking advantage of new technologies and new government and industrial funding that would become available as an outcome of wartime experiences.

Hansen, spending the war years in East Coast laboratories, had also proposed to his widely dispersed Physics Department colleagues that following the war Stanford should set up an interdisciplinary laboratory to continue the advances that had grown out of the prewar invention of the klystron and wartime developments in microwave technology, and to exploit these for both scientific and technological purposes. Felix Bloch, who first came to Stanford as a refugee from Hitler's regime in the early 1930s and was back after serving in a variety of wartime positions, agreed that Hansen's microwave laboratory was a good idea scientifically as well as technologically. He was equally eager to bring Hansen, whom he greatly respected as a physicist, back to Stanford. The Stanford Board of Trustees responded to the urgings of Tresidder and Terman, who had returned from Harvard to become dean of engineering, and in 1945 approved the creation of a microwave research laboratory as part of Stanford's School of Physical Sciences, with close ties to the School of Engineering. Hansen, already back at Stanford since 1944, and Ginzton, still at Sperry, were appointed as director and assistant director of the new laboratory.

1946 TO 1949: LOADED WAVEGUIDES AND MEGAWATT KLYSTRONS

By March 1946 Hansen had returned to his faculty position in physics, and Ginzton to a new junior faculty position in the same department. Because of concerns by some over his purely engineering background, Ginzton was appointed assistant professor of applied physics rather than physics, with a parallel appointment in electrical engineering. He was promoted the following year to associate professor of applied physics. Marvin Chodorow, who had become a colleague at Sperry, also joined them as a physics faculty member.

As part of his initial teaching and research activities Ginzton developed a comprehensive family of microwave measurement tools, "making our laboratory the best of its kind in the world," while Chodorow developed course and research activities in microwave electronics. But most of all, Ginzton, Hansen, and Chodorow were seeking to accelerate electrons using those microwave tubes. The Stanford Physics Department's interest in X rays and in generating energetic particles to explore nuclear physics dated back to the 1920s and early 1930s. Hansen's invention of the microwave cavity resonator in 1936 had been partly motivated by a desire to find a cheap method of obtaining high-energy electrons. This motivation remained strong and was shared by Ginzton following World War II. Others around the world had similar goals, though many of these groups thought the more interesting results in nuclear physics would come from accelerating heavier particles, such as protons or ions.

The Stanford group was focused, however, on the acceleration of electrons using "loaded waveguide" linear accelerator structures with a diameter of a few inches, down which microwaves and electrons could travel in perfect synchronism at just infinitesimally less than the velocity of light.

The electrons, surfing on the crests of the microwave cycles and continually pushed forward by the microwave fields, thus gained energy, and converted this energy into mass as they traveled. Linear accelerators offered two great advantages over other schemes for accelerating particles: Since the electrons traveled in straight lines rather than curved paths, they did not continually lose energy to synchrotron radiation; and the accelerator itself could be built in the form of individual modules perhaps 10 feet in length, which could then be cascaded to almost unlimited lengths and energies. Such a linear accelerator, perhaps 200 feet in length and driven by sufficient microwave power, could be made to accelerate electrons to a billion electron volts (1 GeV), and these electrons could then be used as probes to study the still largely unknown interior structures of the nuclei of atoms.

They already had the waveguide structure they needed: a cylindrical copper pipe 3.5 inches in diameter containing transverse copper disks 1/4 inch thick and 1 inch apart with a 1-inch hole in the center of each disk for the electron beam to pass through. The microwave fields in this structure were analyzed by E. L. Chu and Hansen in early 1947, and later that year Ginzton, Hansen, and W. R. Kennedy prepared a remarkably prescient 20-page paper describing exactly how a few hundred feet of this pipe, driven by several hundred megawatts of microwave power at 3 GHz, could be used to accelerate electrons up to 1 GeV. There would be no problem in steering the electrons through thousands of such holes in succession, they found; to the relativistic electrons the whole pipe would appear to be only a few inches long. Their paper, submitted in November 1947 and published under the title "A Linear Electron Accelerator" in the February 1948 issue of the *Review of Scientific Instruments*, laid the foundation for several generations of electron linear accelerators that continue in operation today and that have provided the primary tools for at least half a dozen Nobel Prizes.

Still unsolved at this point, however, was the problem of how to generate the hundreds of megawatts of microwave power required to drive such a linear accelerator. As a result of intensive development during the war years, pulsed magnetrons that could generate peak pulse powers of at least a few megawatts were widely available by the end of the war. Distributed injection at multiple points along a lengthy accelerator pipe required, however, that the injected microwave signals originate from a single weak but very stable master oscillator and then be amplified to multimegawatt levels by individual microwave amplifiers at each injection point. This was something that magnetrons could not do. They could function very well as small, powerful, and highly efficient pulsed oscillators—just the thing, it was later realized, for microwave ovens—but not as clean and stable amplifiers.

It was Ginzton who realized early on that the klystron could potentially provide the needed megawatt power levels. As of 1946 most klystrons produced power outputs from a few tens of milliwatts to a few tens of watts, although during the war years Ginzton had seen in England a few klystron amplifiers with pulsed power outputs of 20 kilowatts. Ginzton had the bold vision that klystron amplifiers could be made to deliver not just tens of kilowatts but tens of megawatts from a single tube—and moreover that he could make the required leap of 1,000 times or more in power output in a single step, rather than a lengthy sequence of many smaller steps. Success in achieving this goal would very likely make possible Hansen's linac (linear accelerator) and its goal of GeV electrons. None of the necessary components for Ginzton's klystrons existed at the time, however, much less the klystrons themselves, and many believed that they could not be made.

"WE HAVE ACCELERATED ELECTRONS"

Pulsed magnetrons, although fundamentally unsuitable for longer linacs, could be and soon were used for the first tests of the group's linac concept. By the time the linear accelerator analysis was completed in 1947, Hansen working with three students, had already assembled a single 10-foot section of his pipe, later known as the Mark I linac. Using a single 750-kilowatt magnetron he and his assistants generated 4.5-MeV electrons. His subsequent contract report to his Office of Naval Research sponsors is said to have contained just four words: "We have accelerated electrons."

Based on these results, together with Ginzton's initial designs for megawatt klystrons, in March 1948 the group submitted a detailed proposal to the Office of Naval Research for what would eventually became the Stanford Mark III accelerator: a building some 220 feet long containing an accelerator 160 feet long, with one of Ginzton's still nonexistent 20-MW klystrons every 10 feet along its length, all to be completed in two and a half years by a staff of five key people and for a budget of $951,000. Their audacious proposal was accepted, and active development of the accelerator and the klystrons went into full swing later the same year.

Megawatt power outputs required not only klystron tubes scaled up by factors of between one thousand and one million times but also power supplies that could deliver several hundred kilovolt volt pulses with peak currents of tens to hundreds of amperes, and associated structures that could stand these voltages and currents—components that simply did not exist at the time. Ginzton's team of students and technicians failed on their first two tries: Vacuum windows failed and insulators were unable to stand up to the megawatt peak powers. In March 1949, however, on their third try one of their klystrons operated as planned, delivering 14 MW. Succeeding tubes delivered steadily higher powers and more reliability, and by October 1949 one of Ginzton's klystrons was used to operate a Mark II prototype linac that delivered 40-MeV electrons from a 14-foot section of the loaded waveguide.

Just as success for the Mark III project came in sight, however, Hansen died very suddenly and unexpectedly, in May 1949, only a few weeks after learning of his election to the National Academy of Sciences. Hansen had struggled with serious lung disease for many years, and had worked throughout the preceding few years with an oxygen tank at his side and wearing an oxygen mask that he had built himself. It suddenly became Ginzton's responsibility to complete the entire project, taking over as director of the Microwave Laboratory with full responsibility for both the accelerator and the klystron aspects of the work.

Under Ginzton's direction the first few sections of the Mark III operated in the accelerator's new building a year and a half later, delivering 75-MeV electrons from 30 feet of waveguide driven by three klystrons, each operating at 8 MW. By April 1951 as more klystrons were produced, the accelerator had been extended in successive 10-foot steps to 80 feet and was delivering 180-MeV electrons—enough to begin serious research.

1948: FOUNDING OF VARIAN ASSOCIATES

During this same period, as Sigurd Varian became the last of the Stanford klystron group to return to the West from Sperry, Ginzton joined with the Varian brothers and others from the Stanford and Sperry groups in founding their long-planned enterprise. Varian Associates was established with $22,000 of capital and six full-time employees, and its first board meeting was held in April 1948. Besides Ginzton and the Varian brothers, the initial board members were William W. Hansen, Paul Hunter, Richard Leonard, Stanford physics faculty member Leonard Schiff, H. Myrl Stearns, and Russell Varian's wife, Dorothy; other associates were Marvin Chodorow as a consultant and employees Don Snow and Fred Salisbury. The group chose the name Varian Associates because Russell Varian was well known in the scientific community as the inventor of the klystron, adding the term associates to indicate that the group wanted to create a science-based company, managed by scientists, where the decisions would be made by the scientists and engineers who carried out the work.

In addition to his membership on the new venture's board of directors, a position he would retain until 1993, Ginzton worked to establish the objectives and help guide the activities of the new company. Five years later, in 1953, Varian moved from its initial leased facilities in San Carlos to a new building on Stanford land, becoming the first tenant in what would later become the Stanford Industrial Park. A decade later Ginzton was to take over full direction of the company's growth and development.

During this same period, Ginzton also developed one of the first graduate courses in the art of microwave measurements, teaching it full time from 1946 through at least 1953 and intermittently thereafter, and publishing his widely recognized text on *Microwave Measurements* through McGraw-Hill in 1957. Harried faculty members from any era may appreciate a quote from Ginzton's memoirs, recalling for his children and grandchildren those first years as a new faculty member:

I was teaching my first class in microwaves. I was building a house. I was consulting with Hewlett-Packard. I was supervising about a dozen graduate students. Supervising the construction of a building [for] the Microwave Laboratory, the new building. Seeking money from the government and from industry to continue the work. Teaching Litton and Varian and Eimac and GE and RCA how to build microwave tubes.

THE EARLY 1950'S: THE MARK III LEADS TO A NOBEL PRIZE

In the early 1950s as the success of the Mark III linac began to appear more certain, attention turned to the physics that could be done with Hansen and Ginzton's machine. In 1950 Robert Hofstadter joined the Stanford physics faculty then led by noted theoretician Leonard Schiff, and the two physicists began a serious examination of how they could study atomic nuclei by observing the scattering of the high-energy electrons that would be generated by the evolving accelerator. In 1951 the University of California became embroiled in a faculty-administration confrontation when the university's Board of Regents yielded to the state's conservative legislature and insisted that an oath of loyalty be required of all university staff. The promising young particle physicist and skilled experimenter W. K. H. Panofsky, who had at that point spent several years at Berkeley helping Luis Alvarez build huge proton accelerators out of surplus radar transmitters, was willing to sign the oath himself. Panofsky insisted, however, that rights of nonsigners must be respected, and viewed the dismissal of nonsigners as a violation "of all that is true about academic freedom and tradition in the European sense." When this nonetheless happened, Panofsky felt he could no longer stay at Berkeley, and elected to try his hand at the rival university across the bay.

Not long after Panofsky arrived, the basic structure of the Mark III accelerator was completed, and in November

1953 the Mark III generated 400 MeV electrons along its full length, with 14 out of 21 potential klystrons operating. Hofstadter was by then already carrying out pioneering measurements of nuclear scattering, using 150 to 200 MeV electrons that were siphoned out of the accelerator at a midstation halfway along the pipe. By the end of 1953 Panofsky and Ginzton had also worked out new organizational and physical solutions to the Mark III's needs and difficulties. Together they created an umbrella W. W. Hansen Laboratories of Physics within which Ginzton continued as director of the Microwave Laboratory, concentrating on klystron development and on his emerging interests in high-power traveling wave tubes, while Panofsky, as director of a new High Energy Physics Laboratory, or HEPL, assumed leadership of accelerator development efforts and plans for particle physics research using the Mark III. The original goal of 1 GeV was ultimately achieved by the Mark III in 1960 and extended to 1.2 GeV in 1964. The most notable contribution of Ginzton and Panofsky's Mark III was its use by Professor Robert Hofstadter to measure the size and charge distribution of the proton, the neutron and several heavier nuclei, fundamental results for which Hofstadter was awarded the 1961 Nobel Prize in physics. Within less than a decade the Mark III, as pioneering and productive as it was, became only the infant from which ultimately grew the very much larger and even more productive 2-mile Stanford Linear Accelerator Center.

LINEAR ACCELERATORS FOR CANCER THERAPY

In addition to his leadership of the Mark III project and the related klystron developments, Ginzton also supervised the construction of some 10 other microwave linear accelerators during this period. As early as 1953 Ginzton had recognized the potential application of linear electron accelerators for radiation therapy, and had joined with physician Dr. Henry Kaplan of the Stanford Medical School to explore the use of energetic electrons for the treatment of cancer. In 1954 as the Mark III accelerator became increasingly dedicated to physics experiments, Ginzton began construction of a 20-foot, 80-MeV Mark IV accelerator intended for experiments on improved accelerator components. Studies of beta-ray cancer therapy using this machine were immediately successful, and the first clinical medical linac, a 6-foot, 5-MeV accelerator, went into regular use soon afterward in the university's hospital in San Francisco.

During the mid-1950s Ginzton and his colleagues also constructed a 10-foot, 35-MeV accelerator for cancer therapy at Michael Reese Hospital in Chicago, a 20-foot, 60-MeV linac for cancer research at Argonne National Laboratory, and several research accelerators including a 6-foot, 5-MeV linac for medial research at General Electric. After taking over the leadership at Varian six years later, Ginzton continued to crusade for the use of small accelerators in cancer treatment and steadfastly supported many years of related but unprofitable development work, which ultimately led to a line of small electron linacs called Clinacs. By the time of Ginzton's death, some 4,000 of these had been installed in hospitals around the world and were treating over 1 million patients annually. These machines were a source of great satisfaction to Ginzton because his father had died of cancer.

1953: AN UNPLEASANT ENCOUNTER WITH SECURITY CONCERNS

In 1951 Ginzton along with a dozen others at Stanford received a Secret clearance for his government-sponsored work on high-power microwave tubes. In September 1953—some eight months after Joseph McCarthy opened his campaign alleging massive Communist subversion in the U.S.

government with a fiery speech in Wheeling, West Virginia—Ginzton applied for a similar clearance for his expanding responsibilities in the same area at Varian. Five days later the Western Industrial Personnel Security Board denied Ginzton's application, citing his alleged unreliability in handling classified documents, his alleged omission of names of relatives residing in the Soviet Union, and his "close associations with [unnamed] individuals identified with Communistic or related movements." Two weeks later the board revoked Ginzton's existing Stanford clearances as well, based on the same charges.

The first of these charges apparently stemmed from a series of confused events in the handling of Hansen's belongings and his personal and classified papers by Hansen's family and the Stanford Physics Department following Hansen's sudden death four years earlier. With regard to the second charge, Ginzton had in fact listed his only relative—an elderly aunt—known to be still alive in Russia. As regards the third, since no specific individuals were identified by the security board, Ginzton could only reply that the only individuals known to him that could possibly be characterized in this fashion were Frank Oppenheimer, an instructor with whom Ginzton had shared an assigned office as a graduate student in 1939, but whom he had not encountered since; a Stanford physics M.S. student and anti-Korean-War activist with whom Ginzton had had a few brief interactions in his faculty role during 1946-1949; and the noted San Francisco artist Emmy Lou Packard, also known as an early acquaintance of Diego Rivera and Frida Kahlo and as a social activist. The Ginztons had met Packard on a few occasions through their long-standing interest in modern art, and had purchased some of her paintings.

These actions greatly hampered Ginzton's ability to carry out his responsibilities both at Stanford and at Varian. To protect Varian's interests Ginzton immediately resigned from its board of directors, along with Schiff and Terman, who faced similar accusations. To assist Ginzton in his appeals against the clearance denials, Stanford brought in its noted attorney and alumnus Robert Minge Brown, who would later become president of its Board of Trustees, and Fred Glover, the widely respected administrative aide to Stanford's president, Wallace Sterling. Under Brown's guidance Ginzton and Glover testified at a daylong appeals board hearing in San Francisco on November 19. During Glover's testimony it emerged that Glover himself was a commander in the Naval Reserve with five years active experience in naval intelligence, including three years in counter-intelligence in San Francisco and two years as director of naval intelligence in Europe. Four days later the hearing board, possibly outgunned, responded: "The Appeal Division has determined that . . . the granting of clearance to you for access to classified security information is clearly consistent with the interests of national security."

THE MID 1950'S: PROJECT M

By the middle of the 1950s with the Mark III's high-energy physics program well underway, Hofstadter, Panofsky, Ginzton, and a number of their colleagues began to consider the possibility of building a very much larger electron linear accelerator at Stanford. The concept of such a machine apparently originated in 1954 when Robert Hofstadter, sitting in Leonard Schiff's living room with Felix Bloch, Ginzton, and Schiff, proposed building a multi-GeV linac to provide electrons of shorter wavelengths, which could probe still deeper into the nucleus. Panofsky and Ginzton quickly took leading roles in exploring the feasibility of building a 2-mile-long multi-GeV electron accelerator—20 to 30 times larger than the Mark III in both size and energy output, and initially referred to as "the Monster"—on the Stanford campus. These numbers were determined in part by their assessment of the energies needed to do significant nuclear studies, along with the capabilities of the linac technology, but as Ginzton later recalled, "The length was 2 miles simply because that was the longest straight path we could identify on the map of the Stanford lands." Ironically, as the administrative and organizational problems associated with building and operating such a facility in an academic setting began to emerge, Hofstadter elected to divorce himself both from the project itself and from making use of the resulting accelerator for scientific work, and eventually redirected his own efforts into other areas of physics.

The formal birth of Project M took place in April 1956 when a group of some dozen Stanford physicists and staff members gathered at Panofsky's home to discuss the possibilities and implications of such a project. Ginzton was named as director of the new project, a position he retained from 1956 through 1960, with Panofsky as deputy director, and Schiff and Hofstadter as consultants. An augmented and largely volunteer group of Stanford physicists and engineers then began to study the practicality, usefulness, and costs of an accelerator 2 miles in length. During subsequent months Ginzton led the efforts to lay out the design of the accelerator, while Panofsky formulated the research program it would be intended to accomplish. In April 1957 these efforts led to a formal \$100 million proposal by Stanford to the Atomic Energy Commission, the National Science Foundation, and the Department of Defense for the construction of the proposed accelerator on Stanford land.

With the proposal off to Washington, Ginzton was able to spend a long-delayed sabbatical year in Geneva in 1957-1958, during which he visited many electronics laboratories in Europe to give lectures on microwave technology and on accelerator design. Working in an office at CERN, Ginzton was also able to complete his McGraw-Hill book on *Microwave Measurements*. Also of importance were visits to hospitals in London to discuss the treatment of cancer with electrons and X rays. In 1958 advisory panels convened by the National Science Foundation and the Atomic Energy Commission recommended that the project be funded, the first step in an approval process that was eventually to take almost four years. Ginzton and Panofsky then testified in several rounds of congressional hearings in 1959 and 1960, attempting to obtain congressional approval for construction on the Stanford campus of the world's highest-energy electron accelerator. After Ginzton stepped down as project director in 1960 to assume full-time leadership of Varian Associates, Panofsky took over as director of the renamed Stanford Linear Accelerator Center, or SLAC. Following lengthy and sometimes contentious debates both in Washington and on the Stanford campus, the proposal to establish SLAC and build the accelerator under Panofsky's direction was approved by Congress in September 1961. Once the accelerator itself was completed, essentially on time and within budget, in February 1966, Ginzton and Panofsky's machine became the source of many new discoveries in high-energy physics, and by the time Panofsky retired as its director in 1984, SLAC could log two Nobel Prizes earned "on his watch," with several others to come in later years.

THE 1960'S: TRANSFER TO THE LEADERSHIP OF VARIAN

Throughout the 1950s even while carrying heavy responsibilities at Stanford, Ginzton had continued as a member of the Board of Directors and of the Executive Committee of Varian Associates, and had become increasingly active in its management. In 1959 Russell Varian, who was chairman of the Varian board, died suddenly, and Ginzton was immediately elected to take his place as chairman and chief executive officer. Ginzton, who at the time was the director of both the Microwave Laboratory and the emerging Project M, felt a deep commitment to both of these projects, especially the completion of the proposed SLAC machine. His colleague "Pief" Panofsky, however, possessed highly regarded capabilities both in guiding the construction of large research facilities and in the basic physics to be done using them. After much soul searching, Ginzton made the choice to resign from his Stanford positions and accept the responsibilities at Varian, rather than continuing to lead Project M at Stanford. He continued on, however, as a special consultant to the president of Stanford on the construction of SLAC from 1960 until 1966, and until 1968 as a professor of applied physics on leave.

Following his transfer to Varian, Ginzton became active both in management and in developing longer-range objectives for the company, holding the title of president from 1964 to 1968 and of chief executive officer until 1972. Under Ginzton's leadership, Varian continued its success in the commercial development of new areas of basic physics, notably in analytical products, such as mass spectrometers, atomic absorption instruments, gas and liquid chromatographs, and visible and ultraviolet spectrometers. It also expanded its partnership role with overseas companies and explored new areas in medicine and in solar energy. Ginzton retired as chairman of the Varian board in 1984, but remained as a member and as chair of its Executive and Nominating committees until 1993.

Ginzton particularly supported the continuing development of nuclear magnetic resonance technology, or NMR, at Varian. NMR was another fundamental new area of physics that had germinated during Ginzton's early years at Stanford. The first experimental observations of NMR were independently carried out during the immediate postwar period by Felix Bloch's group at Stanford and Edward M. Purcell's group at Harvard, leading to a shared Nobel Prize in physics for Bloch and Purcell in 1952. In their earliest observation of this phenomenon as published in 1946, Bloch and Hansen in fact apparently, although quite unwittingly at the time, became the first researchers ever to observe a man-made population inversion and the associated phenomenon of stimulated emission—the physical phenomena underlying all subsequent developments in masers and lasers.

Even before the founding of Varian Associates in 1948, Russell Varian, occupying a cramped desk as an unpaid research associate in the Stanford Physics Department, had foreseen the possibilities of nuclear induction and NMR both for chemical analysis and for the precision measurement of geomagnetic fields, and had persuaded the Stanford researchers to obtain patents on their new technology. He also acquired commercial rights in these patents and in additional improvements that he himself made. Varian Associates even in its first year of operation had begun to develop nuclear magnetic resonance spectroscopy and nuclear induction magnetrometry as future commercial products, thus laying the foundation of what eventually became the Varian Instrument Division. Under Ginzton's leadership this early venture into NMR eventually became one of Varian's most profitable divisions and made Varian the leading manufacturer of NMR instruments worldwide.

LATER YEARS: CIVIC AND COMMUNITY LEADERSHIP

In addition to his leadership roles in technical and business affairs, Ginzton had strong interests in bettering his community and played a major role as a leader in championing fair housing and clean air before they became fashionable. He was founder and cochair with David Packard from 1968 to 1972 of the Stanford Mid-Peninsula Urban Coalition, an organization that helped launch minority-owned small businesses, and continued as a member of its Executive Committee until 1974. As a member of the Board of Directors of the Mid-Peninsula Housing Development Corporation beginning in 1970, Ginzton worked on community education and health issues and supported efforts to meet the need for affordable housing.

Ginzton was supported in these efforts by his wife, Artemas, who was active in her own community and conservation efforts, especially on behalf of trails, hostels, and the preservation of unrecognized architectural masterpieces. With an appreciation for the land, an eye for the unusual, and an unconventional sense of opportunities, she worked on projects including the Santa Clara County master plan for trails, a system of bicycle trails along California aqueducts, and the conversion of abandoned Pacific coast lighthouses into hostels.

Ginzton also served as a director of the locally founded Stanford Bank from 1967 to 1971, a member of the Advisory Board of the Mid-Peninsula Region of the Union Bank from 1971 to 1973, and a member of Northern California Advisory Board of the Union Bank from 1973 to 1981.

In his later years Ginzton also responded to both of the universities at which he had studied, serving on the Advisory Committee for the School of Business Administration at the University of California from 1968 to 1974 and the

Lawrence Berkeley Laboratory Scientific and Educational Advisory Committee from 1972 to 1980. At Stanford he served as chair of the Advisory Board for the School of Engineering from 1968 to 1970; as a member of the Board of Directors of the Stanford University Hospital from 1975 to 1980; a member of the board of the university's National Bureau of Economic Research from 1983 to 1987; and a member of the Stanford Synchrotron Radiation Laboratory's Science Policy Board from 1985 to 1990. He also served for two terms as a member of the university's Board of Trustees from 1977 to 1985.

HONORS AND AWARDS

Ginzton had been a member of the Institute of Radio Engineers, or IRE (now the Institute of Electrical and Electronics Engineers, or IEEE) since his student days in 1936 and was elected a fellow of the IRE in 1951. He received the Morris Liebmann Memorial Prize from the IRE in 1957 for his contributions in the development of megawatt-level klystrons, and the IEEE Medal of Honor in 1969 for his overall accomplishments in the development of microwaves. He subsequently served as a member of its Board of Directors from 1971 to 1973, and chaired its Awards Board from 1970 to 1972 and its Long Range Planning Committee in 1973 and 1974. He was also a member of the U.S. National Committee of the International Union of Radio Science (URSI) from 1958 to 1968.

Ginzton was elected to the National Academy of Engineering in 1965, the National Academy of Sciences the following year, and the American Academy of Arts and Sciences in 1971, and subsequently gave extensive service to all of these groups. This included serving as a member of the NAE Council from 1974 to 1980, and chairing, from 1971 to 1972, the NAS Committee on Motor Vehicle

Emissions, a group created to advise Congress on the technological feasibility of the Clean Air Act of 1970. From 1973 to late 1974 he served on the Coordinating Committee for Air Quality Studies of the NAS, and in 1975 was a member of an NAS committee to advise the U.S. Environmental Research and Development Agency, or ERDA, on the creation of the Solar Energy Research Institute. Later that year he became cochair with Harvey Brooks of the Committee on Nuclear and Alternative Energy Systems, charged with recommending to ERDA plans and strategies for the energy future of the United States.

Ginzton also traveled with National Academy of Sciences delegations to Hungary in 1966, Bulgaria in 1972, and the U.S.S.R. in 1973 and 1975, and served on NAS Committees on International Relations from 1977 to 1980, on Scientific Communications and National Security from 1982 to 1984, and on the Use of Laboratory Animals in Biomedical and Behavioral Research from 1985 to 1988.

THE EDWARD L. GINZTON LABORATORY

By the mid-1970s Stanford's Microwave Laboratory, the direct descendent of Hansen and Ginzton's initial efforts, had become well established in many new areas of applied physics under the direction of Marvin Chodorow, with widely recognized accomplishments in quantum electronics, lasers and nonlinear optics, acoustic and scanning microscopy, fiber optics, and superconducting materials. In 1976 the laboratory was formally renamed the Edward L. Ginzton Laboratory in recognition of Ginzton's many contributions to its earlier history and to the developments at Stanford that his accomplishments had made possible. Two decades later its sister laboratory, the High Energy Physics Laboratory, or HEPL, was renamed the Hansen Experimental Physics Laboratory.

AVOCATIONS

During his active years Ginzton devoted his leisure time to outdoor activities, including skiing, sailing, and hiking, all of which he shared with his children, and to avocations that included a deep and lifelong personal interest in photography and the restoration of vintage automobiles. At the time of the Carolyn Caddes portrait mentioned below, he had three Model A Fords in his garage awaiting restoration, although his ultimate pride and joy was a 1929 Packard Phaeton sedan, a car of the same vintage as his own arrival in California.

With various members of his family he also traveled widely, including flying over Africa in a hot-air balloon and attending a banquet in the Saudi Arabian desert. Other round-the-world journeys took them to Machu Picchu, the Great Pyramids and the Sphinx, the Great Wall of China, and down the Glen Canyon of the Colorado River.

His interest in photography began in childhood when he prepared his own chemicals and even coated his own photographic printing paper. These early interests were strongly reinforced during the 1940s, when his wife, Artemas, presented him with a course of studies at the Museum of Modern Art in New York under Ansel Adams. This led to a longtime friendship with Adams and an extensive collection of Adams prints. As a photographer, he was a classicist, preferring black and white to color and large-scale-view cameras to 35 mm. He continued to maintain a personal darkroom in his home in retirement, spending many hours on printing to produce the effect that he originally thought would be most satisfying for each image.

PHILOSOPHY AND BELIEFS

Ginzton's continuing accomplishments during his lifetime clearly stemmed not only from his outstanding technical abilities and his devotion to his work but also from his ability to attract others to join with him in important enterprises, his remarkable foresight and vision, and his social concerns. In the interview that accompanied his retirement portrait Ginzton told Carolyn Caddes, "Grow and become educated, but do not equate professional training with education. Try to learn how to think. Attempt to do what you want to do. Making a living is not enough."

Ginzton's commitment to cooperation with others might be symbolized by the second word in the original name of Varian Associates. Throughout Ginzton's career his associates first at Sperry, then at Stanford, and finally at Varian spoke of his collegial management style, which encouraged and stimulated those around him to work at a high level of accomplishment. His vision and his technical foresight are exemplified by a brief but remarkably comprehensive summary of the future applications of microwaves in both basic science and technology that Ginzton wrote in 1956, in which he noted:

> Many of us are so immersed in the ever-narrowing branches of electrical engineering that it is difficult to take stock of the accomplishments in the field as a whole or to visualize the possibilities and limitations of future developments. For those of us engaged in teaching and research . . . such an assessment is necessary if we are to guide our students properly and anticipate the probable roles of our own specialties . . .
>
> It is evident that the applications of present microwave knowledge will continue to grow, both in number and diversity; but despite the daily invention of novel applications, we must not become complacent. Every field of research has a finite half-life . . .

Keeping the importance of basic research in mind, those of us who have specialized in this field must anticipate either more prosaic engineering applications or a change to some other branch of science. Many will remain to explore and exploit the possibilities for which the foundation is now laid; but some will think of exploring the higher regions of frequency lying beyond the microwaves.

The study and generation of still shorter wavelengths appears as fascinating and promising today, as the microwave region appeared in 1936. Now, as then, there are many practical difficulties, challenging to the imagination and ingenuity of human skill but which offer, for the scientific adventurer, unknown rewards.

Those of us who have had the good fortune to participate in the opening up of 22 infrared and optical regions "beyond the microwaves" made possible by the invention of the laser—an invention that occurred only four years after these words were written—can only admire their wisdom.

At time of his death on August 13, 1998, Ginzton was survived by his wife of 59 years, Artemas McCann Ginzton, and his children, Leonard of La Canada, California; David of Sandpoint, Idaho; Nancy of Los Altos Hills, California; and Anne (Cottrell) of Berkeley, California. It seems appropriate to close this memorial with the same words as in Edward Barlow's National Academy of Engineering memorial tribute to Ginzton: "He was truly a man of broad interests and large and persistent vision, who enjoyed life to the fullest and cared about his family, his associates, and his community."

The results of that vision and that caring persist today, in major institutions and in smaller personal memories, across the Silicon Valley landscape and around the world.

NOTES AND REFERENCES

Much of the biographical information in this memoir (and inevitably some of the wording as well) has been taken from various press releases and biographies in the files of the National Academies and Varian Inc.; from an IEEE Legacy profile of Ginzton in a booklet distributed at the IEEE Annual Banquet in 1969, when Ginzton was awarded the IEEE's Medal of Honor; from Ginzton's 1984 interview with the Oral History project of the IEEE and a brief autobiographical sketch prepared by Ginzton himself in April 1989; from an obituary in the January 1999 issue of *Physics Today* prepared by Ginzton's longtime colleague Karl L. Brown of SLAC; and from the NAE memorial tribute for Ginzton prepared by Edward J. Barlow and published in *Memorial Tributes: National Academy of Engineering* (vol. 10, pp: 100-105, National Academy Press, 2002). A brief but rewarding biographical note accompanying a notable black-and-white portrait of Ginzton in retirement can also be found in Carolyn Caddes's *Portraits of Success: Impressions of Silicon Valley Pioneers* (Palo Alto, Calif.: Tioga Publishing, 1986).

A large amount of archival material related to Ginzton and his career can be located (though not directly accessed) through the *Online Archives of California* (OAC) at www.oac.cdlib.org/, including links to material in the Stanford University Archives and the Special Collections of the Stanford University Library and the Varian Associates Records in the Bancroft Library of the University of California at Berkeley. Carolyn Caddes's interview notes and negatives for her volume are also stored in the Stanford University archives. Reminiscences of Ginzton in interviews by several of his professional colleagues, including Marvin Chodorow, Bill Rambo, and Mike Villard, along with the IEEE Legacy and Ginzton's own 1984 interview mentioned above, can be accessed online by searching on "Ginzton" at the IEEE Web portal (www.ieee.org/portal/index.jsp).

More detailed information on Ginzton's career at Stanford, especially the postwar developments that brought Hansen and Ginzton back to Stanford, the subsequent founding of SLAC, and the controversies over academic and science policies that ensued, can be found in C. Stewart Gillmor's definitive history *Fred Terman at Stanford: Building a Discipline, a University, and Silicon Valley* (Stanford University Press, 2004) and to a lesser extent in Rebecca S. Lowen's very inaptly titled *Creating the Cold War University: The Transformation of Stanford* (University of California Press, 1997). Much of the information relating to Ginzton's collaboration with W. K. H. Panofsky comes from a tribute to Panofsky presented by Sidney Drell at the 26th Annual Awards Dinner of the San Francisco Exploratorium held on April 30, 2003, the full text of which is available on the Exploratorium website. More detailed accounts of how the original Mark III linac evolved into Project M and then SLAC can be found in a May 1966 Technical Report "The Story of Stanford's Two-Mile-Long Linear Accelerator" by Douglas Dupen and in a 1983 contribution by Ginzton himself, both available on the SLAC website (www.slac.stanford.edu/history/.)

Preeminent over all of these, however, are Ginzton's own very personal reminiscences as recorded in his 1995 volume *Times to Remember: The Life of Edward L. Ginzton*, edited by his daughter Anne Ginzton Cottrell and Leonard Slater Cottrell and published by the Blackberry Creek Press in Berkeley, California.

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