Harold M. Agnew

1921–2013

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
Richard L. Garwin

NATIONAL ACADEMY OF SCIENCES

HAROLD MELVIN **AGNEW**

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By Richard L. Garwin

Harold M. Agnew was best known for helping to create the first "chain-reacting pile" with Enrico Fermi at Columbia University and the University of Chicago; for the photographs and motion pictures he took from a plane accompanying the bomber that delivered a nuclear weapon to Hiroshima; and for his leadership in developing postwar nuclear weapons—and their safety and use-control—at the Los Alamos National Laboratory. He was much loved as the third director of the lab, which he led for almost a decade.

Harold was born in Denver, Colorado, to Sam E. Agnew and Augusta Jacobs Agnew. Sam was a stonemason and later a roofing contractor. Augusta was a fastidious and hardworking homemaker, requiring Harold, their only child, to be neat and tidy around the house and to take care of his possessions; years later, Harold's own two children were able to play with his childhood games, still in their original cardboard boxes, with the box corners intact.

As a youth and in college

By Harold's account[1] he respected and admired his father, who in addition to practicing his craft was an avid grower of vegetables and a tinkerer as well. His father "graduated from Cooper Union and drifted west, as the West was being built, as a stonecutter. But with his training at Cooper Union he [also] did drafting and analyzed plants. I was always intrigued because he usually worked every night on some gadget and I got interested in doing things like that. Also he used his hands a lot, which [was] a part of [the] science and physics and chemistry that I later got involved in."

1 *Pioneers in science and technology series: Oral history of Harold Agnew.* 1983. Interviewed by Clarence Larson, filmed by Jane Larson, December 21. Transcribed by Jordan Reed. Online at http://cdm16107.contentdm.oclc.org/cdm/ref/collection/p15388coll1/id/451. The quotes in this section of the memoir are taken from this source.

Although money was scarce, Harold was given a chemistry set as a child and he soon developed an active interest in chemistry. Meanwhile, young Harold always had a job. In junior high school in Denver, he confirmed his attraction to:

> *math and science because it had a quantitative nature...in contrast to the social sciences and English, where I was never sure when I finished something whether it was really finished. There was no way of checking what one had accomplished. So I liked science from that standpoint very much.*

Graduating from junior high, Harold attended South Denver High School and was very interested in chemistry, which was "big then; physics wasn't very big then." He took no physics course in high school but was a lab assistant in chemistry. In high school, as in junior high, he always had a job, including school janitor, mucking stables (and walking "rich people's ponies") at the polo grounds, and lifeguard at the community pool.

1942 Kynewisbok of the University of Denver. The caption reads:
Scholar...is the word for Harold Agnew, Beta Theta Pi, and President of the Senior Class. Maintaining a straight "A" average, Harold upon premature graduation, was rewarded with a position assisting Dr. Stearns in a vital defense job. The well liked boy with the analytical mind was also President of Omicron Delta Kappa.
(PDF p. 135 of http://digitaldu.coalliance.org/fedors/respository/codu:59269)

Harold was encouraged in chemistry by a high school teacher. At the University of Denver, it was his major. He was an outstanding student; the Beta Theta Pi fraternity, aware of that, pledged him to raise its brothers' grade-point average and to help them with homework. Harold graduated with a B.A. because he was intent on making

Phi Beta Kappa: one couldn't be elected to that honor society from the B.S. program. At university he realized that he preferred the physics parts of chemistry to the other parts. He didn't like analytical chemistry or quantitative or qualitative analysis, either:

> *I lived in horror of doing something wrong and getting the wrong answer. I just didn't like that business, but physical chemistry I thought was very nice; I enjoyed that very much.*

"May Day in all its glory—Ambassador, Queen and Chancellor" (Beverly Jackson as Queen of the May; the next day to marry Harold Agnew.)

At Denver he met Joyce C. Stearns, who taught math and physics. Stearns had been a student of A. H. Compton and ran the High Altitude Observatory on Mount Evans; he advised Harold to get into physics and to study more mathematics.

Because Harold had skipped the third grade, he was at the same level at the University of Denver as his wife-to-be, Beverly Jackson, despite being 15 months younger. By January 1942, Harold had enough credits to graduate, but he did not formally receive his degree until June of that year, *in absentia*. Harold and Beverly had picked a wedding date of May 2, 1942.

Since the outbreak of war in Europe, many of Harold and Beverly's friends had been going to Canada to join the World War II effort, as the United States was not yet involved. After the attack on Pearl Harbor on December 7, 1941, and the U.S. entry into the war, both Harold and Beverly became intent on signing up for the Army Air Corps.

Joining the nuclear weapon program in Chicago —the Metallurgical Laboratory

Stearns had been asked to join a secret project at the University of Chicago. He asked Harold not to enlist in the Army, because if he did, Stearns would be unable to take him to Chicago to work on this important project. Harold heeded the advice and went off with Stearns to that university, where he found, to his surprise, the Metallurgical Laboratory—the Chicago branch of the Manhattan Project. The "metals" in question were revealed to be uranium and the artificially produced element plutonium, to be used for a new weapon that would release the energy of nuclear fission—a phenomenon that had been recognized only in December 1938. It was already understood that a kilogram of fission from plutonium would liberate the energy of 17,000 tons of TNT, and it was imagined that there would be little difficulty in assembling a critical mass of plutonium, once the new element had been produced, separated, and purified. However, all of this depended on the feasibility of a self-sustaining fission chain reaction that would use uranium to produce the plutonium.

From Chicago, Harold was sent early on to Columbia University to assist Fermi, who had worked there with his right-hand man Herbert L. Anderson since January 1939 on fission and (with Leo Szilard) on the realization of the chain-reacting pile. In a decades-later speech, Harold recounted going with Anderson to the U.S. Radium Corp. in downtown Manhattan to pick up a gram of radium, which they brought back to Columbia on the subway and then to Chicago on a plane, with totally inadequate shielding of the gamma rays from radium. In Harold's own words:[2]

> *In the spring of 1942 Anderson and I made the first compressed radium-beryllium source. The powdered beryllium was prepared by filing on a block of beryllium. The die and press for making the source were designed by Anderson, and we flew to New York City with them. We prepared the source[3] by pouring a solution of radium chloride on the beryllium powder, evaporating the mixture on a hot plate, pouring the dried powder into the die, [and] pressing the mixture to form a pellet, which was hand soldered into a brass capsule. The source was then wrapped in tissue, inserted into a small mayonnaise jar, and placed in a briefcase. We then boarded a plane and placed the briefcase under our seat and returned to Chicago.*

Within months, the work on the pile was transferred to a space under the west stands of Stagg Field, the football field at the University of Chicago, along with Fermi and his team.

2 Agnew, H. M. 1997. Herbert L. Anderson. *NAS Biographical Memoirs* 72:1–13.

3 More details are in Agnew, H. M. 1985. *The way it was, no regrets.* LANL DVD 85-031, August 6. The operation was performed in an open loft of the U.S. Radium Corp. in Manhattan using a Coors evaporating dish on a hotplate.

Agnew recounted[4] that in June 1942, at an outing to the Dunes in Indiana, he was overexposed to the sun and had a reaction—"sort of little blood vessels breaking out all over my skin, legs, torso." A radiologist suggested, "This is a synergistic reaction that sometimes people get if they've had a heavy dose of radiation and then the ultraviolet will cause this to happen. Have you had any radiation?" Indeed, Harold had been working with a gram of radium (in a radium-beryllium source) on a string at the end of a meter stick, together with a block of paraffin to measure the neutron albedo of CH2, and every half-hour he would remove the source from the paraffin and put it back after another 30 minutes.[5] He mused, "It's interesting that during that period we had really no radiation monitoring equipment whatsoever." As a result of his exposure, Agnew was sidelined from further contact with radioactive sources. He remained involved in the construction of CP-1, the pile under the football field, which under Fermi's supremely confident direction went critical on December 2, 1942. This constituted the first human-made neutron chain-reacting system and was to bring revolutionary change to warfare, science, and industry.

By Harold's account, he had no feeling for the enormity of the accomplishment, in part because of the methodical, no-nonsense approach of Fermi, so that achieving criticality and the indisputable evidence of the first man-made neutron chain reaction was "just another one of Fermi's experiments."

Harold's overexposure to radiation helped to determine his future. When he married Beverly in May 1942, she came to Chicago and began work as secretary to Richard L. Doan, director of the Metallurgical Laboratory. Doan, who had been a student of Compton, was in overall charge administratively, although he had a Ph.D. in physics.

Doan needed a secretary and because Beverly had graduated with a teaching certificate from the University of Denver it was felt that she could do the job; in those days, a secretary earned more than a teacher. So at 21, Beverly Agnew had the job of secretary to the boss of the project; she handled the payroll and helped to design the security system for safeguarding documents. A system of document classification had been created by

4 *Pioneers in science and technology series: Oral history of Harold Agnew.* 1983. Interviewed by Clarence Larson, filmed by Jane Larson, December 21. Transcribed by Jordan Reed. Online at http://cdm16107.contentdm.oclc.org/cdm/ref/collection/p15388coll1/id/451.

5 In a later presentation at the Los Alamos National Laboratory, Agnew recounted that he used a quarter-gram of radium and intervals of 15 minutes (Agnew, H. M. 1985. *The way it was, no regrets*. LANL DVD 85-031, August 6).

the scientists themselves, beginning in 1939, and with the formation of the Manhattan Project they chose Yale theoretical physicist Gregory Breit to write a two-page memo setting forth the secrecy rules. Breit proposed compartmentation of access to information within the laboratory, and left when Fermi rejected this approach, as did J. Robert Oppenheimer later at Los Alamos.[6]

Oppenheimer was a frequent visitor to the Metallurgical Laboratory and saw Beverly often in Doan's office. When Oppenheimer learned in the fall of 1942 that he was going to head a laboratory to be created at Los Alamos and discovered that Harold was "on ice for a while as far as exposure to radiation was concerned," Oppenheimer suggested that Harold and Beverly join him "in New Mexico outside of Santa Fe." According to Harold, "The real reason I got to Los Alamos was because Oppie wanted Beverly on his payroll and I was available because of this radiation problem."

A supporting role at Los Alamos

Los Alamos opened for business in March 1943 with housing and lab space furiously under construction. In that same month, Harold and Beverly left Chicago under strict secrecy rules, first going to Champaign, Illinois, to pack up John Manley's Cockroft-Walton generator and accelerator. Beverly recorded the details to guide reassembly. She then visited for two weeks with her brothers, who were leaving for overseas duty in the U.S. Army Air Forces,[7] so Harold arrived alone by train in Lamy, New Mexico, boarded a bus to Santa Fe, and showed up at 109 East Palace, a storefront office operated by Dorothy McKibbin. From there he rode a truck carrying equipment to Los Alamos and was assigned a place in the Lodge, at the time a bunkhouse.

Out for a walk in Los Alamos, he encountered Oppie and announced his presence, but "all [Oppie] wanted to know was where Beverly was. [He] could care less that I was there or not…so I understood the pecking order from the very beginning."

6 Oppenheimer chaired a summer study in Berkeley, CA, during June of 1942 on how to build a nuclear weapon from the highly enriched uranium to be provided by plants in Oak Ridge and from plutonium produced by reactors that would follow a successful demonstration of the neutron chain reaction. Leslie R. Groves, who had been elevated to brigadier general and head of the Manhattan Engineer District (the "Manhattan Project") in September 1942, chose Oppenheimer in October to head a laboratory to be established at Los Alamos, New Mexico. Its mission was to make nuclear weapons based on a fission chain reaction in plutonium or in isotopically enriched uranium.

7 The U.S. Army Air Forces (AAF), active throughout World War II, were the successor to the Army Air Corps and the predecessor to the U.S. Air Force.

Harold ‘s first work at Los Alamos was to assist in usi;ng the Cockroft-Walton as a neutron source in order to measure the scattering cross-sections of various materials in the form of one-foot-diameter disks of materials an inch thick. “We had platinum and gold and ultimately metallic uranium and tungsten, all the elements that were conceived to be useful materials in bomb construction,” he said. His work with the Cockroft-Walton generator lasted until early 1945, by which time the weapon program at Los Alamos had resulted in designs for the two options for nuclear weaponry—the U-235 gun-assembled weapon, which on August 6, 1945, destroyed Hiroshima; and the plutonium implosion weapon, to be tested in a full scale nuclear explosion of 20-kiloton yield at Alamogordo, New Mexico, on July 16, 1945, and used to destroy Nagasaki on August 9.

Deploying with the bombs and photographing their explosions

During Harold’s two years at Los Alamos (until spring 1945), his parents in Denver were having an increasingly difficult time with friends and neighbors whose sons were in the military or, especially, had been killed or wounded in the war. Those parents proudly posted photos of their sons in uniform and talked about their ranks and, to some extent, experiences. In contrast, Sam and Augusta could only say that Harold was away working on some secret project, they knew not what or where. Although Harold knew perfectly well the goal of the project at Los Alamos, he had no direct involvement with the bomb until Luis Alvarez showed up in spring 1944, having moved from the Radiation Laboratory at MIT, where he had played a key role in the development of radar.[8] Versed both in physics and electronics, and full of energy and ingenuity, Alvarez learned that the uranium gun, “Little Boy,” was to be used without having been subject to explosive test. While “Fat Man,” the implosion weapon, was scheduled for a full-scale test at Alamogordo there was not, in Alvarez’s view, an adequate plan for actually measuring its explosive yield when used in combat.

Talking with colleagues at Caltech’s Jet Propulsion Laboratory, Alvarez learned of technology that might be useful—the Firing Error Indicator (FEI) that had been realized by W. K. H. Panofsky and Alex E. S. Green. Mounted on a cloth target towed by a long line, the FEI would radio the acoustic pulse of nearby bullets fired by fighter pilots in training, thereby providing an objective score and help in improving performance. At Los Alamos, Alvarez formed a small group headed by Lawrence Johnston to develop, test,

8 Johnston, L. 1987. The war years. In *Discovering Alvarez*, edited by W. P. Trower. Chicago: University of Chicago Press, 55–71.

Harold Agnew in 1945 holding the plutonium core of the Nagasaki bomb. Tinian Island.

and field an electronic gauge that would telemeter the time profile of the acoustic wave it received, having descended by parachute from a chase plane as the bomb itself was dropped on its target.

At first, the plan was to train military personnel to operate the recording equipment, but the project's leaders realized that unpredictable events might require more operational flexibility than could be expected of quickly trained military personnel. So they decided that scientists would fly on the observing missions in order to operate the equipment.

In this way, Harold actually got into the war. He was deployed with the equipment to North Field on the Pacific island of Tinian, where he and his colleagues awaited delivery of the atomic bombs to be used against Japan. Although up to that time involved essentially as a technician, Harold was not short on initiative and guts. He had brought a 35-mm camera and a 16-mm home movie camera with (then-rare) color film for filming the actual drop, and he used both successfully when he flew on the chase plane *Great Artiste* that accompanied *Enola Gay,* the bomber piloted by Col. Paul Tibbets, to Hiroshima.

The yield gauges, on parachutes, were dropped as planned from the observation plane (a third aircraft), and their radio signals were acquired by manually tuning the receivers. The signals were then displayed on small oscilloscopes in the aircraft and photographed by "gun cameras." The developed film was later interpreted at Los Alamos by Bill Penney and Klaus Fuchs to obtain a yield for the explosion.

Alvarez, who already enjoyed international recognition as a physicist for his discovery of tritium and He-3, had the idea that the gauges could also serve as a means of urgent communication with Japan's science community and the emperor. Accordingly, he persuaded Oppenheimer to allow him (together with Philip Morrison and Robert Serber) to hand-write a personal letter to be attached to the gauges and addressed to his Japanese colleague, Prof. Ryokichi Sagane. [9] It read as follows:

> *Headquarters*
> *Atomic Bomb Command*
> *August 1945*
>
> *To: Prof. R. Sagane*
> *From: Three of your former scientific colleagues during your stay in the United States.*
>
> *We are sending this as a personal message to urge that you use your influence as a reputable nuclear physicist to convince the Japanese General Staff of the terrible consequences which will be suffered by your people if you continue in this war.*
>
> *You have known for several years that an atomic bomb could be built if a nation were willing to pay the enormous cost of preparing the necessary material. Now that you have seen that we have constructed the production plants, there can be no doubt in your mind that all the output of these factories, working 24 hours a day, will be exploded on your homeland.*
>
> *Within the space of three weeks, we have proof-fired one bomb in the American desert, exploded one in Hiroshima, and fired the third this morning.*
>
> *We implore you to confirm these facts to your leaders, and to do your utmost to stop the destruction and waste of life, which can only result in the total annihilation of all your cities, if continued. As scientists, we deplore the use to which a beautiful discovery has been put, but we can assure you that unless Japan surrenders at once, this rain of atomic bombs will increase many-fold in fury.*

The letter was written after the Hiroshima destruction, attached to the yield gauges for the second bomb—planned for the city of Kokura but diverted, because of the weather,

9 Guide to the Luis A. Alvarez letter to Ryokichi Sagane 1945 August 9. Cage 1603. Pullman, WA: Washington State University Libraries. Online at *http://ntserver1.wsulibs.wsu.edu/masc/finders/cg1603.htm.*

to Nagasaki—and delivered by parachute. After the bomb exploded over Nagasaki the gauge was found and Alvarez's note was sent to Professor Sagane, who met with the emperor. What influence this had on Japanese surrender following the country's second nuclear explosion is not known.

Although the "historical record," including Lawrence Johnston's book chapter "The War Years," has Harold onboard a B-29 test plane for the ground-based explosion at Alamogordo of July 16, Harold had already deployed to Tinian, where he and Johnston were AAF captains and Luis Alvarez was a colonel. The three planes comprising the mission flew in line as they neared Hiroshima. First was Tibbets's *Enola Gay*, which carried the bomb and Captain William S. Parsons, who armed the bomb. *Great Artiste*, the second plane, flew 300 feet behind, piloted by Charles Sweeney and his crew. Onboard as well were Alvarez, Agnew, and Johnston. The third plane carried Bernie Waldman of Los Alamos with a high-speed Fastax movie camera intended to take pictures of the expanding fireball.

Johnston[10] gave details of the flight, noting, for example, that Harold had the foresight to give his movie camera to the tail gunner, given that *Great Artiste* would be flying away from Hiroshima when the bomb went off and the tail gunner would have the best view. Waldman's Fastax did not give any images, so Agnew's home movie camera produced the only movie of the explosion.

For the follow-up mission to deliver the implosion weapon, it was decided that enlisted men would handle the job. But because they had not been fully trained in the use of the onboard recording equipment for the yield gauges, Johnston accompanied Sergeants Walter Goodman and John Kupferman. The only movies of the Nagasaki explosion were taken by Goodman, again with Harold's home movie camera, given that a plane loaded with officials and cameras never made rendezvous with the mission.

Cat-and-mouse with the Hiroshima films

Although later crediting General Groves with superb performance in running the Manhattan Project,[11] Harold felt that the photographs from his still camera and the movie film of the Hiroshima explosion would be seized by Groves and never make it to the project's scientists. So in somewhat devious manner, Harold arranged to have

10 Johnston, L. 1987. The war years. In *Discovering Alvarez*, edited by W. P. Trower. Chicago: University of Chicago Press, 66.

11 Additionally, Harold observed, "if Groves were 6-foot-4 and lean and trim he would be a national hero." (Agnew, H. M. 1985. *The way it was, no regrets.* LANL DVD 85-031, August 6).

these items sent by courier directly to Oppie at Los Alamos. He was there with Oppie to receive them, as was Julian Mack, in charge of all things photographic at Los Alamos during the war. Mack left by the back door of Oppie's office, traveled to California, where there was a facility to develop color film, and the pictures were soon back in Harold's hands, with copies for the scientists and ultimately for Groves. In 1980, Harold chose the Hoover Institution at Stanford as the recipient and caretaker of these historic visual records; the Agnew atomic bomb footage is the most requested motion picture film in the Hoover's collections.

Fermi had come to Los Alamos in early September 1944, having remained hard at work in Chicago after bringing in the first CP-1 chain-reacting pile in December 1942. The pile operated at a nominal level of 2 watts thermal output, limited in power because of its location on the university campus with no shielding at all. To obtain the 6 kg of plutonium needed for an implosion weapon would require a nuclear reactor enormously (but to a physicist, not unfathomably) larger, and Fermi, Eugene Wigner, and Manson Benedict at Chicago set to work, with excellent engineers from Du Pont, to design the Hanford production reactors at a power level one hundred million times that of the CP-1. With plutonium production fundamentally of the order of one gram Pu per megawatt-day of reactor operation, the Hanford pile at 200 MW would produce about 0.2 kg of Pu per day, and so could make 10 kg of Pu in about 50 days. And it did, by means of the enormously complex Purex process devised for separation of the plutonium from the highly radioactive solution that was obtained by dissolving uranium-metal fuel in acid.

Fermi remained in Los Alamos with his wife Laura and two young children Nella and Giulio until Christmas 1945, when he returned to the University of Chicago physics department that was preeminent by his presence and that of other excellent physicists. Harold and Beverly now had a daughter, Nancy, born at Los Alamos, among hundreds of other children who were born in "P. O. Box 1663, Santa Fe, NM."

With all the demobilization of the war effort, Harold's prospects were not clear. Somehow, by virtue of his various contacts at Los Alamos, he was offered a tuition fellowship for graduate work at Yale but was relieved when Fermi obtained for him a fellowship at Chicago. It paid $125/month in living expenses—just enough for Harold, Beverly, and Nancy to live on—if they could find a place to live.

To Chicago for graduate work

Chicago in 1946 had a severe housing shortage. Fortunately, Laura Fermi, who had not seen her sister in Rome since 1938, decided to go on a trip of some months' duration. The Fermis had bought a large house near the University of Chicago and invited the Agnews to live there while Laura was away in Italy. Beverly did the cooking and cleaning and took care of the children while Harold did whatever else needed to be done around the house—mowing the lawn and fixing things, for example. With a degree in chemistry, Harold was ill prepared for the instructional graduate program in physics at Chicago, composed of fellow students who for the most part already had master's degrees in physics. Adding to this pressure was the notorious Chicago examination system, which Harold characterized as follows:[12]

Agnew's house in Chicago, 1949. (Charles W. Cushman Photograph Collection, Indiana University Archives.)

> *Chicago had an open enrollment system for graduate studies but required a three-day written examination to decide one's future. Choices were: flunk and out; pass with a master's degree and out; or pass with option for going on for a doctorate—if you could find a faculty sponsor. I was terrified about taking the exam because I felt my peers were much smarter than me.*[13]

Harold's inclination was to study for five years so that he could be confident of passing the exam. Laura Fermi had other ideas, however, urging him to take the exam as soon as it was offered. She said, "You will take it; you just do it!" Harold took her advice and

12 Agnew, H. M. 2001. Documents on Fermi's life. In *Proceedings of the international conference "Enrico Fermi and the universe of physics."* Rome, September 29–October 2, 289–294. Online at http://old.enea.it/produzione_scientifica/pdf_volumi/V2003_AttiFermi.pdf.

13 The author of this memoir took the exam at the same time in 1947 and agrees with this characterization.

he passed and was admitted to the Ph.D. program. One of his classmates, eventually a Nobel Prize recipient, failed the exam and had to take it again the next year.

Harold's thesis topic, suggested to him by Fermi and Herb Anderson, was an experimental study of the electron spectra from the beta decay of several radioactive isotopes. Meanwhile, in a city with little space and costly housing, there remained the crucial problem of where to live. Ultimately, Harold walked the streets and found a house with an outside porch that he could convert to a suitable abode for the three of them at 932 East 50th Street. Harold paid for the materials, enclosed the porch on two levels, and installed a spiral metal staircase so that there was a self-contained apartment.[14]

For his Ph.D. thesis work, Harold competently designed a two-coil beta-ray spectrometer, as specified by a paper in the literature, and he added the capability of accelerating the electrons at the detector in order to be better able to study the low end of the spectrum. He used thin lacquer (zapon) films for supporting the sources and a thin nylon film for separating the gas-filled Geiger counter from the vacuum.

This writer now enters the picture. Most of the physics graduate students were unmarried, but both Harold and I had wives and very little money, so we each brought a brown-bag lunch and routinely had lunch together sitting next to Harold's Leeds and Northrup potentiometer at one end of the spectrometer. Looking back, it would have done both of us more good to have had lunch in Hutchinson Commons with Fermi and the other graduate students, but wisdom sometimes comes late and the choice doesn't seem to have impaired Harold's career or achievements.

Back to Los Alamos as a Ph.D. physicist

In any case, there was clear sailing for Harold after he passed the exam and defended his thesis in 1949.[15] Having grown up in Denver and having had a taste of Los Alamos, he couldn't wait to leave Chicago for points west. He was offered a position at Los Alamos that involved working with the Van de Graaff accelerator under Dick Taschek. Now he could explore nuclear reactions at higher energies than with the Cockroft-Walton.

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14 When Harold received his Ph.D. in November 1949 and was soon to return to Los Alamos with Beverly and Nancy, he told his landlord that I (the author of this memoir) would be a good tenant and could fix anything that went wrong in the house, so it turned out that Lois and I and our newborn son happily occupied these quarters. And we much appreciated the stability—during our first year in Chicago we had moved 13 times, unable to find long-term housing. See photo of the house in February 1949 at h*ttp://webapp1.dlib.indiana.edu/cushman/results/detail.do?pnum=P04170*.

15 Agnew, H. M. 1950. The beta-spectra of Cs 137, Y 91, Pm 147, Ru 106, Sm 151, P 32, and Tm 170. *Physical Review* 77(5):655–660.

Indeed, he might have continued on that course, but back trouble caused him to consider some other activity at the lab that didn't involve lying on the floor under the target-end of the Van de Graaff. While he was still on this project, the group accelerated tritium, which their oil diffusion pumps absorbed when trying to recover it. As a consequence, the physicists were contaminated by breathing tritium, and in order to remove it from the body as quickly as possible, they were instructed to drink beer all day at the Van de Graaff. Their urine samples were tested daily for tritium and one day Harold submitted a sample of beer rather than urine. Tom Shipman, head of the medical group, sent Jerry Kellogg, the Physics Division leader, a note saying that with that level of alcohol in his urine, Harold was probably dead;[16] Kellogg wanted Harold fired, but the incident blew over.

On January 31, 1950, President Truman directed the Atomic Energy Commission to develop a hydrogen bomb, despite the fact that no one really knew how to do it—the only option on the table being the "classical Super," a long cylinder of liquid deuterium with as little containment as possible, ignited at one end by a fission explosion and perhaps seeded with tritium at that end to make the fusion reaction proceed more rapidly. At Los Alamos, the only U.S. nuclear weapon laboratory at that time, augmented effort was put into the exploration of the classical Super. I shared an office during the summer of 1950 with Fermi, who worked with mathematician Stan Ulam in that office. Every day they would fill out the first few lines of an accountant's spreadsheet, propagate the variables in time from one interval to the next down the page, and then hand off the detailed calculation to a "computer," Miriam Caldwell. The next morning Fermi and Ulam would plot the results and decide the next case to be studied.

But the classical Super was at best marginal and was never implemented. The situation changed in February 1951 at Los Alamos, when Ulam went to Edward Teller with the idea to compress the deuterium fuel—a concept that Teller had considered many years before but discarded because of a "theorem" that he had worked out in his mind: Given that all of the energyproducing and energyloss reactions were "bimolecular" (two-particle), both energy generation and energy loss rates per unit volume would be proportional to the square of the compression, and "if you couldn't make the Super work at normal density, it wouldn't work at 100-fold density either," as Teller summarized.[17] However, the result of their February meeting was the publication of a secret memo

16 Personal communication from John Hopkins, December 23, 2014.

17 From the transcript of a "testament" by Edward Teller, recorded by Jay Keyworth, concerning an important question in the wartime history of Los Alamos—"How the idea of the implosion emerged." September 20, 1979.

by Teller and Ulam[18] in which an oversight in Teller's theorem was revealed. They now recognized that while a space heated to a certain temperature could accommodate only a finite energy density of electromagnetic radiation (X-rays), the amount (proportional to the fourth power of temperature) would be vastly greater than what humans are accustomed to—exceeding the radiation pressure and energy density in the interior of stars.

The concept was given concrete form in a four-page memo of July 25, 1951,[19] and the laboratory quickly decided to test the radiation-imploded liquid-deuterium-fueled two-stage thermonuclear design, which was indeed fired as the MIKE test on November 1, 1952.

Rising in the weapons program at Los Alamos

With the new approach of radiation implosion thus demonstrated in a full-scale test explosion, laboratory director Norris Bradbury created a small group under Marshall Holloway—"DIRX"—to weaponize the concept. According to Harold,[20] the large high-yield weapons prepared for the CASTLE series of 1954 included JUGHEAD, a liquid-deuterium-fueled deliverable model, of which some small number had actually been fabricated and were being flown for practice on B-36 aircraft; and versions that used "salt," a convenient brief term (and cover name) for lithium deuteride (LiD). The version with salt enriched in Li-6 was named SHRIMP, and two with normal-lithium deuteride were RUNTs.

Harold was project engineer for RUNT and played an active role in its design and engineering. When tested, the energy yield of the LiD tests was unexpectedly high, because, it turned out, the design had neglected the highly reactive tritium formed by "breeding" from the influence of fast-fusion neutrons on Li-7—a (n, 2n) reaction. The solid-fueled two-stage thermonuclear designs were far more practical than the model fueled with liquid deuterium, so JUGHEAD, although deployed as an "emergency capability weapon," was never tested.

Not yet head of the weapon division at Los Alamos, Harold argued that it was important to make the weapons lighter, even at considerable sacrifice in yield; he thought it ridic-

18 Teller, E., and S. Ulam. 1951. On heterocatalytic detonations 1: Hydrodynamic lenses and radiation mirrors. *LAMS-1225* (SECRET RD), March 9.

19 Garwin, R. L. 1951. Some preliminary indications of the shape and construction of a sausage, based on ideas prevailing in July 1951. *LAMD-7416* (SECRET RD), July 25.

20 Palevsky, M. 2005. *Interview with Harold M. Agnew. Nevada Test Site Oral History Project,* October 10.

Agnew and a large barracuda, caught at Eniwetok during the 1954 Pacific nuclear test campaign. (Photo courtesy Los Alamos National Laboratory archives.)

ulous that an aircraft could carry only a single hydrogen bomb. Harold persuaded Hans Bethe to sign the letter he had written to Bradbury that advocated the development of two-stage weapons of lower mass. This risky tactic was vindicated by Bradbury's approval of such a program. Harold later recalled[21] that his boss, Max Roy, told him it was Bethe's signature on the letter that carried the day and that Harold would have been fired had Bethe not cosigned.

Harold later maintained that but for him, Holloway and the establishment that had built the extremely heavy test items—MIKE, SHRIMP, and RUNT (and the deployed emergency-capability weapons, JUGHEAD)—would have been perfectly happy continuing to make those large weapons.

Harold was placed in T-Division (Theoretical Division) for a year, where he saw his job as getting the theorists to curtail their calculations and define specific models that could be tested and fielded. Otherwise, he thought, they would be pursuing small improvements, effectively slowing the deployment of the new, lighter capability.

Gregarious and well liked, Harold was also public spirited. Los Alamos after the war became the 32nd county of New Mexico, with very special status: a single employer (the federal government) made voluntary contributions to support the community and the schools. Thus there were no local taxes. As a member of the school board, Harold learned that New Mexico law forbade counties to have professional school superintendents; the state instead required elections so that a community resident would be its school superintendent. This posed difficulties for Los Alamos, as all professionals there were employed in the laboratory. But Harold felt that the special circumstances of Los Alamos required

21 *Ibid.*

special action. He ran for election to the state legislature, and once in office he was key in passing a bill that allowed a county in a special category to have an employed official of the county as school superintendent.

Beverly also held office, as a member of the New Mexico Board of Education.

Throughout their postwar stay at Los Alamos, Beverly would visit the weekly laboratory "salvage" sales, buying technical items for their appearance as art objects, and Harold would transform them for display in their home. He would copy a Calder mobile or cast silver jewelry in hand-carved and polished graphite molds. When he wasn't working, he hunted, fished, skied, played tennis, and, like his father, built things big and small for their home.

Harold was impatient to advance at Los Alamos, so it was with great trepidation that he accepted a position in Paris as scientific advisor to the Supreme Allied Commander Europe—SACEUR—who at the time was General Lauris Norstad. To take that job, Harold felt, risked being forgotten at the lab. However, colleagues in the Department of Defense urged him to take the NATO position in order to overcome NATO opposition to PAL (see below). Far from being forgotten, on his return from the 1961–64 stint in Paris, Harold was appointed head of the weapon division at Los Alamos.

Harold and Beverly greatly enjoyed their time in Paris and made the most of it, such as in visiting the flea market and acquiring many minor pieces of art. Daughter Nancy spent the school year at Stanford but the summers with her family in Europe, and son John was plunged immediately into the local French school system; Harold maintained that this was better for John, and besides, Harold said, he was too stingy to pay tuition. Within four months, John was fluent in French and able to graduate from Stanford a year early. On this basis, he persuaded Harold to pay for a year's residence at the traditional Cordon Bleu cooking school in Paris. John became an accomplished chef.

Harold hoped to become director of the Los Alamos National Laboratory, which had been ably directed by Bradbury since 1945. Harold had the highest regard for Bradbury, saying:[22]

> *I thought he was first-rate. Absolute integrity. Almost too honest. But absolutely a first-rate person. No pretentiousness. Very fair. Put up with terrible bureaucrats in Washington. [But he] stayed too long....If you take a leadership job, if you can hack it you ought to stay five years but no more*

22 *Ibid.*

than 10, because there are things you want to do and you've either done them or you haven't done them in 10 years. [If the latter,] you're never going to get them done and you're out of ideas. So let somebody else [take] over.

Yet in Los Alamos by 1954 Bradbury had already served only nine years and if he retired would have to move out of his government-owned house. Foresight spurred Harold to campaign to include the director's house in the government sale of residences in Los Alamos, with existing occupants getting the first opportunity to buy. In 1955 Bradbury and his wife indeed bought their government-owned house, and Harold expected Norris to retire soon after. But when Harold returned from Paris in 1964, Bradbury had still not retired, despite Harold's having removed what he felt was the principal bar to the director's retirement.

Nuclear weapons safety and use-control

In November–December 1960, Harold went to Europe with some members and staff of the Joint Committee on Atomic Energy (JCAE) on an inspection trip of U.S. nuclear weapons at NATO bases. The party in general, and Harold in particular, were appalled by the lack of security provided there for these weapons. Many of them deployed at foreign bases were loaded on foreign-owned fighters piloted by foreign nationals, as was the case for quick-reaction-alert planes in Germany. The security against takeoff by a rogue German pilot with the intent to carry out a self-initiated attack, perhaps against the Soviet Union or targets in Eastern or Western Europe, was a lone U.S. soldier with an automatic rifle at the end of the runway. His job was to shoot to prevent the takeoff of any aircraft loaded with a U.S. nuclear warhead.

Other problems showed up. For example, there was an arming wire that had been pulled from the bomb casing and then partially reinserted, but not far enough to prevent the small arming propeller shaft from rotating in the high-speed airflow under the wing of the aircraft if the aircraft had taken off on practice or an alert run. That precaution against premature arming of the weapon on the wing of the aircraft was supposed to be enforced by the pullout of the safing wire by a lanyard as the weapon dropped from the aircraft wing. With the safing wire removed and wrongly reinserted, if the weapon had been dropped in a hard landing it was much more likely to have produced a nuclear explosion.

The weapon in question was an Mk-7 single-stage fission bomb, and Harold soon got together with the Sandia Laboratory (Albuquerque) program manager for the Mk-7, Donald R. Cotter, to supplement the safety features for that weapon—and for all other nuclear weapons deployed on foreign soil—by a "use-control device" initially called the "preventive action link" (PAL).

The concept, and in particular, the name, aroused a lot of opposition on the part of the military. But this concern was largely overcome by a change of name so that "PAL" stood for "permissive action link." An Air Force commander recognized that with PAL he could deploy his weapons more widely, and with improved safety, because PAL required the pilot, while in flight on the way to the point at which he would drop his weapons on the target, to enter a 4-digit (and later a 6-digit) code via an electro-mechanical unlocking device. No code, no unlock. Too many false-code tries, and the weapon would lock up permanently and would need to be remanufactured.

This was the origin of the PAL for U.S. and probably for all other nations' weapons, although Agnew was to learn in 2012 that Fred C. Iklé, at the RAND Corp. in 1958, had written a report[23] calling for such a PAL that would require the insertion of a correct code for the weapon to function at all.

Regarding the Mk-7 nuclear bombs deployed on NATO F-84 fighter aircraft, PAL became a reality after Rep. Chet Holifield of the JCAE[24] arranged for Harold to meet with Jerome B. Wiesner, science advisor to President John F. Kennedy. Wiesner, together with his assistant Spurgeon M. Keeny and the author of this memoir, then put PAL on a fast track in the White House, and only later calculated for President Kennedy that this $20,000 add-on to 7,000 weapons in Europe was a $140-million program.

In 1960–1961, while Harold was in the weapon division, he was also responsible for the one-point safety tests, proposed by Robert Osborne, at TA-49.[25] Harold needed to persuade his superiors that it was necessary to test existing nuclear weapons during the U.S.-Russian moratorium of October 1958 to April 1962, but without nuclear explosions. The purpose was solely to ensure that detonation of the high explosive surrounding the Pu "pit" at a single point would not create a significant nuclear yield. The design of fission weapons had evolved from the earliest days, in which the fissile material of the "pit" was kept separate from the explosive assembly system ("in-flight insertion"), to a

23 Iklé, F. C., G. J. Aronson, and A. Madansky. 1958. *On the risk of an accidental or unauthorized nuclear detonation. RM-2251*. RAND Corp.

24 From 1946 to 1977 the Joint Committee on Atomic Energy had exclusive jurisdiction over military and civil nuclear energy.

25 Technical Area-49, an outlying site at Los Alamos.

"sealed pit" design that would function when the explosive was symmetrically and intentionally detonated but also that would be "one-point safe"—it would give essentially no yield if detonated at any single point on the explosive. Analysts realized that simulation of the system on a computer was not capable of providing the necessary assurance, but that intentional detonation at one point with a sequence of pits diminished in amount of plutonium, in the presence of a strong neutron source ("creep-up tests"), could safely be carried out in shallow boreholes at the lab to establish one-point safety.

Harold was also responsible for the definition of the one-point-safe criterion—namely that the nuclear explosive yield in energy terms would be less than the yield of four pounds of high explosive, and further that over the normal life of an individual nuclear weapon the probability of a yield exceeding the yield of four pounds of high explosive would be less than one per billion, and in an accident less than one in a million.

Harold's one-point-safety criteria were promulgated by Carl Walske when he was assistant to the secretary of defense for atomic energy. The "four-pound yield" limit arose from calculations that at such a yield the likelihood of a person in the neighborhood being killed by radiation would be less than the likelihood that he or she was killed by the detonation of the high explosive itself.[26]

Later, as Los Alamos director, Harold continued his efforts to make nuclear weapons safer and better controlled—beyond his involvement with one-point safety and permissive action links. With all U.S. nuclear weapons meeting the one-point-safety requirement, the possibility of an accidental nuclear explosion was essentially eliminated. But concern remained regarding accidents that would result in detonation of the high explosive in a nuclear weapon, with the resultant scattering of plutonium that would need to be cleaned up at multi-million dollar cost. Proposals from the weapon labs included the separation of the plutonium "pit" from the high explosive until the weapon was armed, as had been done manually on the Nagasaki weapon and with mechanical in-flight-insertion devices in the deployment of early weapons.

Sandia proposed a "supersafe weapon" that weighed about 10,000 lb and included a 1000-lb "physics package."[27] Harold responded that this was "the stupidest idea we've ever heard, and unless you really want this we'll design a better approach." Los Alamos proposed instead to use an explosive (TATB) with somewhat lower performance than the

26 See "Minutes of the 133rd meeting of the fission weapons committee" of December 30, 1957 (dated January 9, 1958), paragraph 3, regarding a presentation by Harold M. Agnew.

27 Personal communication from Robert Peurifoy, November 11, 2014.

conventional plastic-bonded explosive (PBX 9501) but that would not detonate if struck with a high-velocity rifle bullet or if exposed to a fire.

In a competition with the Lawrence Livermore Laboratory, which proposed a "flying foundry," Los Alamos won and in August 1974 conducted the PUYE test—an underground explosion of an implosion device using "insensitive high explosive" (IHE, PBX 9502). The intention was to use it in the B77 two-stage thermonuclear bomb. Harold approved a modification to the B61-3 and -4 bombs, then in development, to use IHE. Both bombs entered the stockpile in 1979, and the W80 warhead designed by Livermore and Sandia entered the stockpile in 1981. The first Livermore-designed IHE weapon, the B83 bomb, entered stockpile in 1983 as a derivative of the B77 program.

Harold Agnew as director at Los Alamos

Norris Bradbury retired in 1969, and Harold was widely supported in the national security community as the best candidate to succeed him at Los Alamos. He became director of the lab in 1970 and served until 1979. Despite his high regard for Bradbury, Harold felt that major changes were in order because his predecessor had been arbitrary and restrictive in several ways. For example, although he had been a naval officer, Bradbury had ruled that no military personnel could stay overnight in the town of Los Alamos. They had to commute from off "the Hill"—a restriction that surely impeded cooperation between the lab and the military organizations that deployed the weapons.

Bradbury had also established a rule against laboratory employees doing consulting outside the lab, which Harold promptly changed; he argued,[28] "If no one else wants you, why do I?" And Harold abandoned the rule against hiring people who had served fellowships at the lab.

As laboratory director, Harold was loved, and affection for him grew in retrospect, as he was succeeded by others less highly regarded by the staff. Although Harold loved directing Los Alamos, he detested being called a "manager," or even "excellent manager." In his view, he was a leader, not a manager.

Under Harold's leadership, Los Alamos collaborated much more closely with the military leaders who were the source of the "military requirements" for the weapons designed and developed at Los Alamos; and, after 1952, with its sister weapon-design laboratory—the Lawrence Livermore Laboratory (now the Lawrence Livermore National Laboratory). Harold was also a member of many committees in Washington, including the General

28 In-person communication at the Agnew home, June 25, 2013.

Harold with Edward Teller in 1973.

Advisory Committee (which he chaired) of the State Department's Arms Control and Disarmament Agency (ACDA) and the President's Commission of Advisors on Science and Technology (PCAST). During the 1960s and early '70s Harold was a member of the Military Aircraft Panel of the President's Science Advisory Committee, which I chaired. In 1973, he was offered the directorship of ACDA by two secretaries of state—William P. Rogers and then by Henry Kissinger—but Harold declined; Fred C. Iklé took the position, which had been vacant for three months following the dismissal of Gerard Smith.

As director of Los Alamos in the 1970s and head of the weapon division before that, Harold found it far more efficient to work with government through the JCAE than was later to be the case after the JCAE was dissolved and Congress replaced it. In fact, Harold never did accept the premise that the nuclear weapon enterprise could operate effectively with the multiple jurisdictions in Congress.

Among Harold's first acts when he became director in 1970 was to invite Edward Teller to come to Los Alamos for the summer. Having known Edward during the war, when he came to recognize Edward's warmth, imagination, and intelligence, Harold thought that it would be beneficial for laboratory personnel to be exposed to his ideas and criticism. The younger staff had had no contact with Edward, who left Los Alamos in late summer 1952. Harold wanted also to show him how good Los Alamos was, because Edward had known only Livermore for 18 years.[29]

According to Harold, "Edward needed a keeper," by which he meant that Edward needed somebody to show him around, to schedule appointments with people, and to ensure that laboratory scientists felt fully authorized to meet with him. As Edward's keeper Harold appointed Los Alamos Physics Division leader George A. ("Jay") Keyworth,[30]

29 H. M. Agnew, speech at Los Alamos National Laboratory, December 4, 2012.

30 "[Harold] told me many times, including just before his death, that he invited Edward back because he viewed him as one of the finest, most creative minds he'd known and he wanted Edward to stimulate young people at Los Alamos." Personal communication from Jay Keyworth, January 14, 2015.

who got along very well with Edward, as most people did. Edward was by now a major player on the national scene, associated with news about civil defense against nuclear attack, nuclear weaponry, and space defense against Soviet nuclear weaponry. When Ronald Reagan later became president in 1981, his staff requested Edward's advice about candidates for White House science advisor. Quite naturally, Edward advanced the name of Jay Keyworth, who in fact was appointed.

"Spouting Baloney" Harold kept this bust in the Director's office at Los Alamos.

During Harold's tenure as director, Los Alamos grew from 4,000 to 8,000 employees and became a truly national laboratory. He tried to avoid bureaucracy and largely succeeded, at least locally. He opined to the National Science Board in 1976, "The ever-increasing bureaucracy, composed of managers who require more and more detail, justification, and guaranteed schedules, will in the not too distant future completely eradicate our nation's world position in research and technology."

Among Harold's innovations was the creation of a "spook shop" at the lab, conceived not just to provide nuclear weapon knowledge from Los Alamos but also to provide general laboratory expertise on questions that might be totally unrelated to nuclear weapons. This activity thrives to this day and has contributed to some very interesting and useful things. In addition, Harold introduced several other innovations as director, including the appointment of Laboratory Fellows.[31] Early fellows were Herbert Anderson, Richard Garwin, Gian-Carlo Rota, Bernd Matthias, and Anthony Turkevich.

Harold's resignation as director of Los Alamos came abruptly over his proposal to pay some of his most valued staff members a salary higher than the $60,000 that he was paid. From its inception in 1943, all Los Alamos staff were employees of the University of California, which operated lab under a contract with the U.S. government. The president of the University of California system, David Saxon, phoned Harold in Salzburg, Austria,

31 *Los Alamos Science.* 1983. The times they were a changing' (The Agnew years), Winter/Spring, 73–79. Online at *http://library.lanl.gov/cgi-bin/getfile?00416612.pdf.*

to tell him in person that his request would not be approved; Harold responded, "Fine. I quit!" And that was it.

Upon retiring in 1979 Harold proudly stated[32] that Los Alamos had developed every strategic warhead in the U.S. stockpile. The reality was somewhat more complicated.[33] Of the country's strategic force in 1979, Livermore was responsible for four types (W56, Q58, W62, and W68) while Los Alamos had provided the W53, W69, W76, and W78. More accurately, however, Harold believed that he had done his part in building "a real competition between the two laboratories [Los Alamos and Livermore] and that they and Sandia are the three best laboratories in the world. No question."

In addition to his principle of a limited term for laboratory directors, Harold felt strongly that the ex-director should not hang around the lab. Accordingly, he found a position as head of the General Atomics Corp. of La Jolla, CA, which was an entirely different responsibility from heading a government-financed national laboratory.

Harold Agnew as president of General Atomics

In December 1978, Harold was named president of General Atomics, a distinguished technological company based in La Jolla, CA. Harold was familiar with GA, in view of the fact that many of his Los Alamos colleagues had gone there or spent time there; the company was founded by Fred de Hoffmann, who had worked with Edward Teller at Los Alamos 1944–46 and from 1948–1955.

De Hoffmann, recruited to General Dynamics in 1955, persuaded that firm's president to create General Atomics for the purpose of commercializing nuclear reactors. With de Hoffmann as president, GA developed and sold TRIGA, a versatile and safe nuclear reactor used for training, research, and industrial applications.

Other Los Alamos scientists who joined or worked at GA included Theodore B. Taylor and Marshall N. Rosenbluth; Freeman Dyson also played a key role.

GA's first projects in the 1950s were TRIGA and Project Orion—a highly ambitious program to develop a rocket propelled by hundreds of small nuclear bombs. GA later developed and sold a few large commercial power reactors that used TRISO fuel, encapsulated in tiny spheres of carbon and silicon carbide, and that were cooled by pressurized helium.

32 Pioneers in science and technology series: Oral history of Harold Agnew. 1983. Interviewed by Clarence Larson, filmed by Jane Larson, December 21. Transcribed by Jordan Reed. Online at *http://cdm16107.contentdm.oclc.org/cdm/ref/collection/p15388coll1/id/451*.

33 Personal communication from Robert Peurifoy, November 11, 2014.

When Harold joined GA it was 50 percent owned by Royal Dutch Shell, and he felt that foreign ownership limited what GA could do for the U.S. government. He was pleased when in 1982 Gulf Oil bought out Royal Dutch Shell and renamed the firm GA Technologies, Inc. After Chevron merged with Gulf Oil in 1984, GA was owned by Chevron; and in 1986 it was sold to a company owned by the brothers Neal and Linden Blue. Neal Blue characterized Harold's successful contributions to GA as due in part to his "fiscal conservatism and intolerance for bureaucracy."

Harold was an intensely personal leader and would drop in during the day or at the close of business to talk with staff members.[34] He did so with Sid Karin, who was in the High-Performance Computing group at GA, and as a result of their interactions Karin came to be elevated in the hierarchy and placed in charge. Later, Karin told Harold about the supercomputing initiative of the National Science Foundation, which aroused Harold's enthusiasm and his risking of a few hundred thousand dollars to propose that GA create a supercomputing center in La Jolla with Karin as director. Jay Keyworth, as President Reagan's science advisor, was initially skeptical of the NSF initiative, but Harold persuaded him.

Harold was GA president until his retirement in December 1984. In 1988 he became a member of the GA board of directors, on which he served for a quarter century until his death in October 2013, during which time GA also became known for a new line of business—its development of the Predator series of remotely piloted military aircraft. John Parmentola, GA's senior vice president for energy, has said[35] that as a GA board member Harold was "the most insightful and profound. He always got to the point quickly, and frequently came up with good suggestions. He always spoke his mind.…He was a warm and generous person and…helpful and generous with his time."

Later national security activities and views

In 1979 Harold went to China and in 1982 he was invited back. He accepted the second trip, on condition that he visit the Chinese nuclear weapon test site at Lop Nor and that he could take his wife Beverly with him on the trip. She was not allowed to go to the test site but spent those couple of days at Turfan in northwest China.

Harold was impressed by the detailed Chinese knowledge of the U.S. literature and amused when he was asked for the formula for "skinny steel." After he responded that

34 Harold had done this too at Los Alamos and not only talked but also listened. He did not kill the messenger of bad news (Personal communication from John Hopkins, December 23, 2014).

35 Personal communication from John Parmentola, June 17, 2014.

there was no such thing as skinny steel, he was shown an issue of the *LANL Weekly* that indicated that instrumentation was "emplaced downhole on a skinny steel tower."

Harold was invariably forthright and blunt. He opined that "NIF [the National Ignition Facility at the Lawrence Livermore National Laboratory] "is crazy" and so was Project Orion—the bomb-propelled spacecraft project at General Atomics. In a 2008 email he wrote to James R. Schlesinger that the RRW (reliable replacement warhead) "was a scam" and that "anyone who would put a warhead in the stockpile without full-scale testing is either ignorant or up to no good."

He believed, however, that Los Alamos's Project Rover (a nuclear reactor cooled by gaseous hydrogen that was then to be ejected through a rocket nozzle) was important because of its development of the pumps for liquid hydrogen that were key to the Apollo mission, the Space Shuttle, and the like. Rover was tested at the NTS(Nevada Test Site, now The Nevada National Security site) but never flew.

As indicated above, Harold was adamant[36] that "you should not put a bomb into the stockpile unless you have tested it." When President Jimmy Carter was considering a Comprehensive Test Ban Treaty, he consulted the directors of Livermore and Los Alamos and was persuaded by them that a permanent ban on nuclear weapon testing would be undesirable, and that at most he should declare a moratorium for three or five years. In my opinion, this decision was unfortunate and unjustified, and I made a special trip to Los Alamos to discuss it with Harold. His expressed view was that nuclear testing was unnecessary to maintain the reliability of existing nuclear weapons; they could simply be remanufactured and were sure to work. However, even though the NEPA (National Environmental Policy Act) had exemptions for national security reasons and programs, Harold thought that such exemptions would not be forthcoming. Therefore it would not be possible to remanufacture nuclear weapons that contained beryllium or other materials that were considered threatening to worker safety. This despite the fact that beryllium was being used for brakes on the prototype commercial Supersonic Transport and on other applications.

In 1979, Harold wrote:

> *After a few key nuclear tests are conducted, it is the judgment of the laboratories, based upon 30 years of design experience, that the nuclear performance is guaranteed if the nonnuclear components function as*

36 Harold expounded on this view at considerable length in response to a question from a young nuclear-weapon designer (Heritage Lecture Series, LANL DVD 2007-053, November 16, 2006).

> *desired and the nuclear components are maintained in their as-built condition. A very important conclusion, therefore, is that there has been no reduction in nuclear weapon reliability as a result of the TTBT [Threshold Test Ban Treaty] and that there will be none under the CTBT [Comprehensive Test Ban Treaty] if we utilize current nuclear systems [that] have been tested or utilize previously tested nuclear components as subsystems.*

In a 2006 Los Alamos Heritage talk, Harold indicated that under the CTBT and the ban on underground testing of nuclear explosions, "working on weapon design is fine. But don't put into the stockpile a weapon that had not been tested." Instead, he advocated, "rebuild the old weapons."

Harold pointed out that the myth of the lack of weapon utility of reactor-grade plutonium (i.e., plutonium extracted from the reprocessing of power reactor fuel, typically with 40 percent Pu-240, as compared with weapon-grade plutonium in which Pu-240 is less than 7 percent of total plutonium) began because of the focus at Los Alamos on gun assembly of the HEU (the Hiroshima bomb) and the plan until 1944 for gun assembly of plutonium from the Hanford reactor. But when Pu from Hanford became available, even though it had low irradiation compared with later power-reactor plutonium, a team under Emilio Segre discovered that there was sufficient Pu-240 with a high spontaneous fission rate that "pre-initiation" was certain; thus a gun-assembled Pu weapon would in most cases provide negligible explosive yield. This finding forced Los Alamos to change direction totally—in order to use the more plentiful fissile Pu rather than HEU from Oak Ridge—and consider much more rapid assembly via an enclosing explosive shell. The result was the "Christy gadget," a solid sphere of 6 kg of Hanford Pu, which was assembled from sub-critical state to its maximum supercriticality in a short enough time that the pre-initiation probability of any reduction in yield was of the order of 12 percent.[37]

Harold was elected to the National Academy of Engineering in 1976 and to the National Academy of Sciences in 1979. He was, inter alia, a member of the Council on Foreign Relations and a fellow of the American Physical Society.

37 Oppenheimer, J. R. 1945. Memorandum for Brigadier General T. F. Farrell and Captain S. Parsons, USN, July 23.

Beverly Agnew died in Solana Beach on October 11, 2011. For many years she had endured macular degeneration with equanimity and good humor, reading the *New York Times* and doing crossword puzzles with the aid of a magnifying reading machine. She also suffered a stroke and other afflictions, the consequences of which Harold helped ease as a loving spouse, cook, and caretaker, while ensuring that the two of them continued to enjoy concerts and plays together.

I can do no better than to use these borrowed words:[38]

> *Agnew was a man capable of great tenderness. At the time of Beverly's death in 2011, Agnew and Beverly had been married nearly 70 years. Beverly's decline, as both were approaching age 90, was more rapid than her husband's. Still spry, Agnew would meticulously disassemble, pack in the car, and then reassemble Beverly's wheelchair so that she could accompany him to social events, where he would never leave her side. Hollywood, when next in need of new scripts about old love, should option the story of the Agnews.*

Harold died at home on September 29, 2013, while watching football on television. He will be remembered for his contributions to small thermonuclear weapons, to their safety and use-control, for his leadership of the Los Alamos National Laboratory, and as a warm and complete human being. He is survived by his daughter Nancy, son John, and their families.

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39 Courtesy of Matthew F. Hopkins, Research Library of the Los Alamos National Laboratory (Personal communication from Alan B. Carr, September 17, 2014).

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