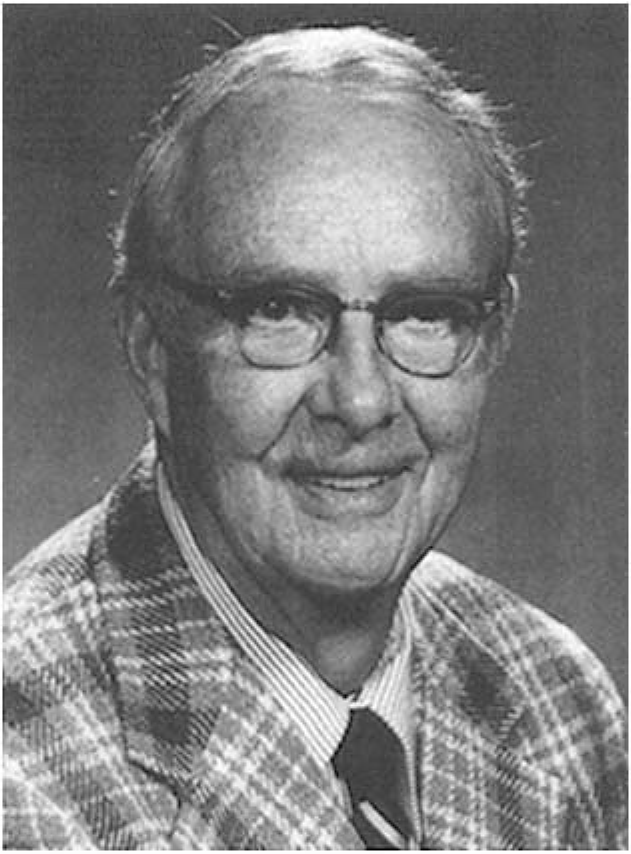

Courtesy of Lawrence Berkeley Laboratory, University of California.

Luis W. Alvarez

1911–1988

By Richard L. Garwin

Luis W. Alvarez was outstanding as scientist and engineer. It is a challenge to his friends and biographers to do justice to the breadth and depth of Luis's accomplishments. His bare-bones biography does provide a hint:

Physicist, born in San Francisco June 13, 1911, son of Walter C. and Harriet Smyth Alvarez, married (1936) Geraldine Smith-wick, with whom he had two children, Walter and Jean. In 1958 married Janet L. Landis—two children, Donald and Helen. Luis[1] Alvarez earned a B.S., M.S., and Ph.D. in physics from the University of Chicago in 1932, 1934, and 1936, respectively. Beginning in 1936, his entire career was spent at the University of California, Berkeley, as professor of physics from 1945 to 1978, and professor emeritus from 1978. He was associate director of the Lawrence Radiation Laboratory from 1949 to 1959 and from 1975 to 1978. He did radar research and development at the Massachusetts Institute of Technology (MIT) from 1940 to 1943, and then worked at Los Alamos in 1944 and 1945.

Luis Alvarez was a consultant over the years to numerous agencies of the United States government and was a member of the President's Science Advisory Committee in 1973. He was a

[1] Pronounced in the Spanish fashion as "Loueese," but almost everyone called him "Louee," for his nickname, Luie.

long-time member of the IBM Science Advisory Committee and a director of the Hewlett-Packard Company.

His talents did not go unrecognized. He was a fellow of the American Physical Society (and president of the APS in 1969), a member of the National Academy of Sciences and the National Academy of Engineering, of the American Philosophical Society and the American Academy of Arts and Sciences, of Phi Beta Kappa and Sigma Xi. He was also an associate member of the Institut D'Egypt.

He received the Collier Trophy (aviation) in 1946, the Medal for Merit in 1948, the John Scott Medal in 1953, the Einstein Medal in 1961, the National Medal of Science in 1964, the Michelson Award in 1965, the Nobel Prize in Physics in 1968, the Dudley Wright Prize (Interdisciplinary Science) in 1981. He was named California Scientist of the Year in 1960 and named to the National Inventors Hall of Fame in 1978.

Luis Alvarez presented a fascinating view of his life and involvements in his autobiography,[2] and the flavor of his scientific activities is available in a recent book subtitled *Selected Works of Luis W. Alvarez, with Commentary by his Students and Colleagues*.[3] Luis's father was a physician in San Francisco, where he worked each morning on research in physiology, and as a private practitioner in the afternoons to support his family. Although Luis showed no interest in the biological aspects of his father's work, by the time he was ten he could use all of the small tools in his father's shop and wire up electrical circuits.

In 1925 Walter Alvarez left his very successful practice as an internist in San Francisco to join the staff of the Mayo Clinic in Rochester, Minnesota, as a research physiologist, resuming his

[2] *Alvarez, Adventures of a Physicist*, by Luis W. Alvarez, Basic Books, Inc., New York (1987). All unattributed quotations in this tribute are from this book.

[3] *Discovering Alvarez*, edited by W. Peter Trower, the University of Chicago Press, Chicago and London (1987). This volume contains a complete list of Alvarez publications and patents through 1986, to which should be added U.S. Patent 4,911,541, *Inertial Pendulum Stabilizer* with Stephen F. Sporer issued on March 27, 1990.

career there as a clinician a few years later during the Depression. On his retirement, he had a third career as a syndicated newspaper medical columnist, gaining fame as "America's Family Doctor."

During two high school summers, Luis added to his experimental skills as an apprentice in the instrument shop of the Mayo Clinic. Enrolling in the University of Chicago in chemistry, he discovered instead a real talent and passion in physics, beginning with a fascination for optics in which his native talent was nourished by Albert Michelson's optical technicians. Studying optics, working with Michelson's own instruments, taking twelve physics courses in five quarters, Alvarez soon read in the physics library every word Michelson had published. Thus he began his long and tremendously facile acquaintanceship with the literature, exercising an excellent memory for the substance, presentation, and even the location of articles he had read many years before.

In 1934 Luis began his long involvement with aviation, soloing "with just three hours of dual instruction. "He flew for fifty years, logging more than a thousand hours as a pilot before deciding at the age of seventy-three that it was time to put away that demanding and delightful avocation.

In 1936 Ernest O. Lawrence invited Alvarez to join the Berkeley Radiation Laboratory. Luis's older sister, Gladys, worked for Lawrence in Berkeley as a secretary, and on a visit to Chicago, Lawrence (then thirty-two) invited Luis to tour the Chicago Exposition with him, the beginning of a close and productive friendship.

At Berkeley Luis spent almost a year "reading *everything* that had been written on the subject" of nuclear physics. He also soon knew the contents "of every drawer and cabinet in the Radiation Laboratory," resurrecting the first small cyclotrons from oblivion. Key to his evolution as a scientist was Ernest Lawrence's journal club, meeting every Monday night at 7:30—a tradition that continued for decades in Luis's home. Also influential was the "Bethe Bible," three articles published by Hans Bethe in *Reviews of Modern Physics* in 1936 and 1937. Luis's highly developed competitive spirit was stimulated by these 468 pages—"If he (Bethe) said a phenomenon would never be observable, I wanted to prove him wrong, which would make both of us happy. In several significant instances over the next four years, I did."

Luis's discoveries in physics are treated at length in his autobiography and in *Discovering Alvarez*, cited earlier. The discovery of the K-capture process, of He^3, the extraordinary development of the liquid hydrogen bubble chamber, and the work on the comet-impact origin of the extinction of species are evidence of a person of extraordinary experimental talent. But Luis was much more, in driving himself to find the most important application of his capabilities.

Luis recounts his father's injunction "to sit every few months in my reading chair for an entire evening, close my eyes, and try to think of new problems to solve. I took his advice very seriously and have been glad ever since that I did."[4]

Those who lack perfection in educational opportunity might take heart in his further words, "By almost any standard, my training at Chicago had been atrocious.... From another point of view, though, my training had been extraordinarily good. I could build anything out of metal or glass, and I had the enormous self-confidence to be expected of a Robinson Crusoe who had spent three years on a desert island. I had browsed the library so thoroughly that I knew where to find the books I needed to learn almost anything I wanted to know." And Alvarez characteristically would disappear for days into the library at Berkeley, emerging with ideas, plans for experiments, explanations for puzzling results.

Time after time, Luis showed that dogged but imaginative persistence that forced him not to stop with the first idea because there might be a better one. Repeatedly he would leap to a conclusion and then strive to find evidence that would refute it. Alvarez was perpetually surprised to find individuals who do not challenge their own results, and who do not immediately accept even the strongest contrary evidence.

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[4] This tribute draws upon my review of "Alvarez: Adventures of a Physicist," published in *Physics Today*, pp. 83–84 (December 1987).

During World War II, Alvarez played a key role at the MIT Radiation Laboratory, working on radar and other systems. There he invented Vixen, which permitted radar-equipped aircraft once again to destroy surfaced German submarines. After an early success, radar had become ineffective in this role because the submarine's radar warning receiver indicated the increasing signal as the aircraft approached on its attack run. Alvarez thought of reducing the radar power output inversely as the *cube* of the range to the submarine. As the aircraft approached, the submarine would detect *decreasing* radar signal and have no fear of impending attack, while the aircraft would receive a continuously *increasing* radar reflection (returned signal energy goes as the inverse *fourth* power of range).

From the MIT Rad Lab, Luis and his group invented, perfected, and fielded Ground-Controlled Approach (GCA) to allow aircraft and pilots to land at night and in poor visibility. Also at MIT, Luis contributed greatly to the MEW (Microwave Early Warning System) and the Eagle blind bombing system, although he left MIT before MEW or Eagle were complete. Like GCA, these important systems used the Alvarez invention of the first microwave linear arrays that were "electrically scannable," the phased array.

After his six weeks in England to transplant GCA, Luis left MIT where he was head of Special Systems (also known as Luie's Gadgets) to work with Enrico Fermi at the Metallurgical Laboratory at the University of Chicago.

Luie soon moved to Los Alamos. Among his major contributions was the invention and development of capacitor-discharge bridgewire detonators for simultaneous initiation of the multiple high-explosive "lenses" in the implosion system of the plutonium bomb. With a detonation wave speed in high explosive of some 8 km/s, 10 nanoseconds (one "shake" as it was called at Los Alamos) timing uncertainty would cause about 0.1 mm asymmetry in the shock wave; normal blasting caps demonstrated 10,000-times greater timing variation. Typical of Alvarez, the first trial of his invention involved firing a normal "bridgewire" with a 15-kV capacitor rather than the typical 6-volt battery. The necessary improvement in timing accuracy was accompanied by improve ment in safety because of the elimination of the more sensitive primer explosive.

Returning to Berkeley after World War II, Luis designed the first proton linear accelerator and headed the team that brought it into operation. He also provided the first published proposal for charge-exchange accelerators, doubling the energy available in electrostatic acceleration and (no small matter) allowing the ion source and the target region *both* to be at laboratory potential.

After World War II, Alvarez was swept up in an E. O. Lawrence passion to build a large deuteron accelerator for the production of plutonium for nuclear weapons; for once Alvarez did not himself look at the data, which would have convinced him that there was plenty of uranium for the reactor production route. Recognizing that he had drifted far from experimental physics, he recast himself as research assistant to two of his own research assistants. This discipline and redirection obviously bore fruit—in the Alvarez work on particle physics with hydrogen bubble chambers for which he won the 1968 Nobel Prize, and in his commitment to technical work and avoidance of formal management roles. His intellectual curiosity and talent for experiment led him to conceive and to execute the "x-raying" of the pyramid of Khephren by the use of cosmic-ray muons, establishing that this pyramid had no hidden chamber.

In Alvarez's long and broad history, it is striking to observe how some of his best and most practical ideas were only very much later brought to fruition by his own efforts, despite his early patents that would have been available to profit-minded industry at relatively low cost. The stabilized optical system for binoculars or cameras that Luie invented in 1963 while his wife, Jan, lay ill with malaria in Kenya has only in the late 1980s been sold (by a company of which Jan is president) as a stabilizing zoom lens for shoulder-held video cameras, despite working systems twenty years earlier. The same lag is found with the variable-power lens he invented and demonstrated to Polaroid in the 1960s. It first appeared on the consumer goods market (in the Polaroid Spectrum camera) in 1986.

The life of an inventor (even one in the Inventor's Hall of Fame and winner of the Collier Trophy in Aviation) may be a lot of fun, but it is not always profitable; Alvarez realized the first profit from *any* of his forty-some inventions just a few years before his death.

Luis Alvarez was very much aware of himself and carried into his physics the constructive competitive spirit he had learned early in athletics. He was quick to judge, but also very much open to reason and to his own challenge of the validity of his judgment. "The most," "the best," "the first" were important to Luis, in others as well as in himself, and throughout his life he rejoiced in being associated with the very best in physics, in industry, and in government. He wrote "Heroes have been important to my development as a scientist.... In aviation my two principal heroes are Jimmy Doolittle and Chuck Yeager." Luis wrote, frankly and perceptively, "Valuing honors myself, I've worked hard to see to it that my favorite candidates win them as well," and he could point to successes in that field.

Luis enjoyed the broad spectrum of intelligent laymen at the summer encampment of the Bohemian Club and gave illuminating, enjoyable, and well-prepared talks there. Luis's love of the unique shows itself in his description of his work in 1957 with a panel involved with the "Supersecret National Security Agency.... We were the first outside panel with access to NSA secrets.... I especially enjoyed learning in great detail from William Friedman how the United States broke the Japanese diplomatic codes before World War II."

Luis W. Alvarez was a consummate engineer and technologist who contributed greatly to the evolution of productive and effective civil and military aviation. His knowledge of technology was essential to his outstanding achievements in physics, and his clever and deep inventions in the field of optics may yet have the major impact that they deserve.