Oak Ridge National Laboratory's Miles Leverett: The Graphite Reactor's unsung hero

(As published in The Oak Ridger's Historically Speaking column on February 15, 2016)

It is a pleasure for me to often share the content of the Historically Speaking column with Carolyn Krause. She often provides subjects that I might not have otherwise gotten for you readers to enjoy.

This column is a departure from her usual approach in that she has relied on Bill Yee, a retiree from Oak Ridge National Laboratory who is a member of ORNL's History Room team and has only edited his input. Bill has contributed this two-part series on Miles Leverett. Yee conducted research and then wrote two articles on this innovative engineer, superb manager and unsung hero who worked at the Graphite Reactor, ORNL iconic symbol, during its early years. Carolyn Krause is also an ORNL History Room team member. Enjoy Carolyn Krause's edited version of Bill Yee's input!

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Armed with a freshly minted Ph.D. degree in chemical engineering from MIT, Miles Leverett joined Humble Oil (now Exxon-Mobil) in 1938. His job was to conduct research on mixtures of fluids. He was 28 years old.

Fast forward four years. One day his boss, Thomas V. Moore, seemed to have disappeared. Then, just as suddenly, Moore called Leverett from an undisclosed location to enlist him for a "war project."

And so it was that Leverett joined the Manhattan Project at the University of Chicago in May 1942. Six months later, Leverett was present when a group of scientists led by Nobel Laureate Enrico Fermi demonstrated a sustained nuclear chain reaction at the world's first nuclear reactor, Chicago Pile-1, or CP-1. Leverett had abruptly changed from "oil man" to "nuke man."

Subsequently, Leverett was assigned to the Clinton Laboratories in Oak Ridge to form what was ultimately the Technical Division. Engineers in this group were responsible for designing the air-cooled, graphite-moderated X-10 reactor.

The purpose of this pilot plant (or semi-works), later called the Graphite Reactor, was to demonstrate the production of plutonium-239 (Pu-239) from uranium-238 (U-238) by neutron bombardment in the reactor and the chemical separation of Pu-239 from U-238 and fission products. The Pu-239 was meant as fuel for one type of atomic bomb. The information gained guided the scale-up to three water-cooled, 250-megawatt plutonium production plants in Hanford, Washington.

The Graphite Reactor began operating just 10 months after its construction started on Feb. 2, 1943, at the X-10 site. On Nov. 4, 1943, at 5 a.m, the pile reached a sustained chain reaction. The reactor continued operating throughout the month. Then the first irradiated uranium slugs were pushed out of the reactor, moved by underground canal to Building 205, and processed chemically by remote equipment to separate the plutonium. By the end of the year, 1.54 milligrams of plutonium were sent to Chicago.

The Technical Division that Leverett headed was the precursor to two long-standing divisions of ORNL: The Chemical Technology Division and the Reactor Division. (However, these divisions no longer exist today as identified organizations.)

Leverett led the translation of the results of crude laboratory experiments in the new science of nuclear fission into engineered systems that would yield "mass"-production quantities of nuclear fuel for use in the atomic weapon that hastened the end of World War II.

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At the University of Chicago, T.V. Moore and Leverett worked in Glenn Seaborg's group. Seaborg was a co-discoverer of plutonium and other elements at the University of California at Berkeley and later became a Nobel Prize winner and chairman of the Atomic Energy Commission. Seaborg's chemistry group selected the bismuth phosphate separation process to separate and recover Pu-239 from natural uranium at the Graphite Reactor.

Leverett and colleagues were specifically credited with designing horizontal channels in the Graphite Reactor that enabled the production of "macro" amounts of plutonium in a "continuous" manner for the first time. Slugs of natural uranium were inserted into the configuration, exposed to a neutron field to produce plutonium, and pushed out of the reactor. Then the slugs were chemically treated to separate Pu-239 from the dissolved uranium slugs.

Up until that time, the only way to access the exposed slugs was to dismantle Fermi's radioactive "pile"--the configuration of the CP-1 that demonstrated sustained nuclear fission. Dismantling this pile that produced only micro quantities of Pu-239 in "batch" form would have been quite a risky operation because of the resultant exposure to radiation and radioactive contaminants, (For Pu-239, "micro" means on the order of micrograms and "macro" means on the order of milligrams or more.)

For this work Enrico Fermi and Miles Leverett received two patents: U. S. Patent 2,813,070 (Method of Sustaining a Neutronic Chain Reacting System), E. Fermi, M. C. Leverett, November 12, 1957; and U. S. Patent 2,837,477 (Chain Reacting System), E. Fermi, M. C. Leverett, June 3, 1958.

After moving to the Clinton Labs, Leverett was assigned to work with DuPont engineers on designing, constructing, and operating a scale-up of the Chicago pile that would demonstrate the production of "macro" quantities of plutonium.

General Leslie Groves, who was in charge of the Manhattan Project, ordered Leverett and others in the Chicago group to provide nuclear technology guidance to the DuPont chemical process-oriented group working on the Graphite Reactor at Oak Ridge. This experience enabled the DuPont group to take full responsibility for building and operating the production-scale plutonium works at Hanford.

Leverett also played a role in the engineering aspects of remotely separating Pu-239 from bulk quantities of irradiated natural uranium. This work involved solving unique problems such as the design, fabrication, and operation of equipment for remotely handling highly radioactive materials and dealing with large quantities of radioactive materials on a scale never before attempted.

All of this was incorporated into Building 205 (later designated as Building 3019 at ORNL), where five-foot-thick concrete walls were built to surround "hot cells" to shield workers from intense radioactivity. Remote controls were installed to operate the equipment. Banks of instruments that monitored the performance of the equipment were added. The operations were remotely observed using television, periscopes, mirrors, and other equipment.

The first plutonium shipment to Los Alamos was In February 1944. Within a few months 90% of the plutonium in the slugs was being recovered. The Graphite Reactor and separations plant produced a total of 326.4 grams of plutonium, a substantial contribution to nuclear research and ultimately to weapons development.

The air-cooled pilot plant at Oak Ridge had demonstrated the feasibility of the process so it was used as the design basis for the larger, water-cooled, plutonium production plants in Hanford, Wash. These units soon produced plutonium in amounts useful for the atomic bomb.

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Because the Graphite Reactor had fulfilled its mission, it could have been shut down. Fortuitously, however, Leverett's horizontal channels enabled the Graphite Reactor to become the world's first facility to make production quantities of radioactive isotopes for nuclear medicine and research that employ radioactive tracers. A broad spectrum of isotopes was produced, purified, packaged, and shipped all over the world for 20 years until the Graphite Reactor was shut down in 1963.

It became a National Historic Landmark in 1966. It is already one of the most important tour stops for the present Department of Energy Public Tours. It is an icon of Oak Ridge National Laboratory history. It will likely receive even more visitors in the future as more and more visitors spend time at the Oak Ridge part of the new Manhattan Project National Historical Park.

Alvin Weinberg, director of ORNL from 1955 to 1973, said, "If at some time a heavenly angel should ask what the laboratory in the hills of East Tennessee did to enlarge man's life and make it better, I daresay the production of radioisotopes for scientific research and medical treatment will surely rate as a candidate for the very first place."

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Next Bill Yee and Carolyn Krause will bring us the details of Miles Leverett's other accomplishments at ORNL after World War II.

Miles Leverett, one of the original Manhattan Project scientists

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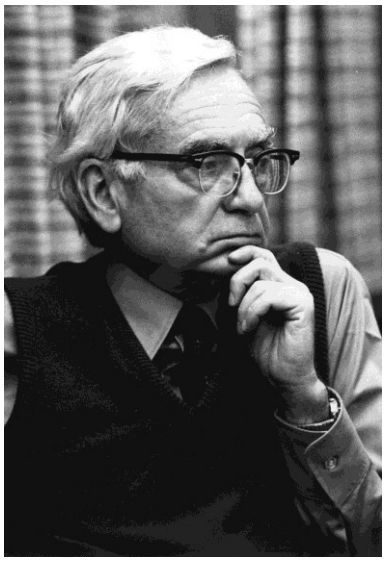
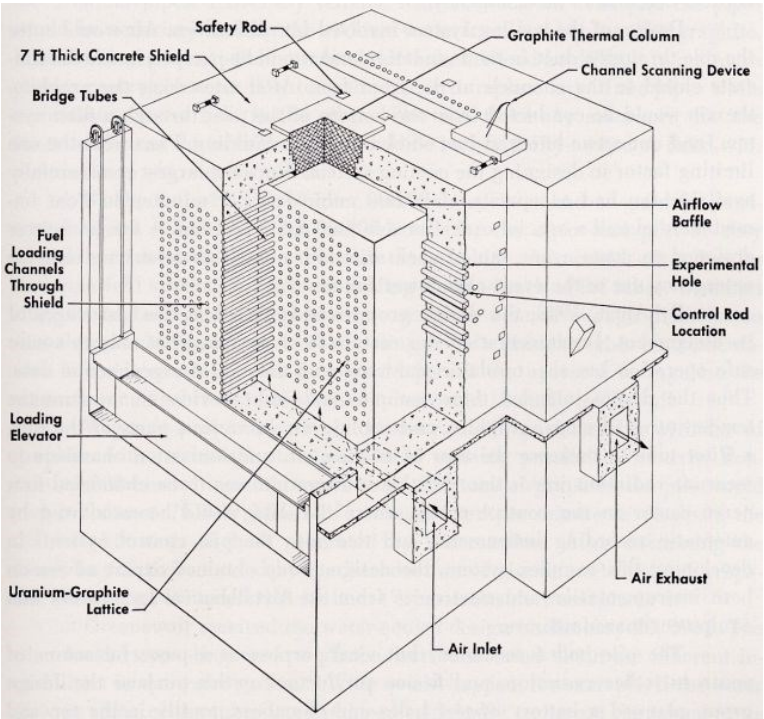


Alvin Weinberg, a peer of Miles Leverett who not only saw the value of radioisotopes but also had a keen insight into the future of nuclear power



Workers pushed new uranium slugs into the horizontal channels on the face of the X-10 pile, forcing irradiated ones at the rear to fall into an underwater bucket, where they underwent radioactive decay for several weeks. Then the slugs were moved by underground canal into the chemical separation facility (Building 205), where the plutonium was extracted with remote control equipment. (photo from DOE website)