# Alvin Weinberg's recollections on Eugene Wigner on 100th anniversary of Wigner's birth

(As published in The Oak Ridger's Historically Speaking column on June 20, 2016)

In 2002 Alvin Weinberg, director of Oak Ridge National Laboratory from 1955 to 1973, was invited to speak about his good friend and colleague Eugene Wigner (1902-95) during a celebration of the 100th anniversary of Wigner's birth in Budapest. Weinberg, however, was not feeling well enough to travel to Hungary, but said he would send a video of his remarks to Budapest. Carlos Bamberger, a retired ORNL chemist and an amateur videographer, agreed to make the video.

Carolyn Krause heard about the video and recently obtained a copy of the DVD master from Carlos. She has been searching for other perspectives on Wigner, research director of ORNL's predecessor, Clinton National Laboratory, for a year (1946-47). She recorded Weinberg's remarks, as heard on the DVD, and transcribed a selection of his words for the following article.

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When most physicists hear the name Eugene Wigner, they think of the famous theoretical physics genius who won a Nobel Prize for physics in 1963 for predicting a phenomenon few people understand. But Alvin Weinberg, a mathematical biophysicist and nuclear physicist before becoming a scientific administrator at ORNL, told his Hungarian audience in 2002 that Wigner was also a genius as a chemical engineer and as almost the world's first nuclear engineer. Weinberg called him the founder of the nuclear engineering profession.

Wigner and Weinberg collaborated on a book entitled "The Physical Theory of Neutron Chain Reactors," published in 1958. Weinberg followed Wigner as research director of ORNL.

"Ordinarily, when physicists think about Eugene Wigner, they think of him as a genius in theoretical physics. They do not realize that he first was a chemical engineer. He had a doctoral degree in chemical engineering from the university in Budapest.

"And he used the knowledge that he gained from his studies in chemical engineering in the leather tanning factory in Budapest where his father was plant manager. The factory had many chemical problems that Wigner worked on.

"This comes as a big surprise to many people who think of Wigner primarily as a physicist. Wigner was almost the first person who devoted himself entirely for a period to nuclear engineering. In fact, he was the inventor of the very first large-scale nuclear reactor."

In early 1940, various groups were working on the uranium reactor as a source of plutonium-239 for an atomic bomb. "The question was not could you make a chain reaction work but could you engineer a large-scale chain reaction that would produce enough plutonium to make an atomic bomb," Weinberg said. Early in 1942 when the University of Chicago's Metallurgical Laboratory was organized under Arthur Compton (who won the Nobel Prize in 1937), "the physicists pointed out to the engineers that the coolant ought to be helium. The reason helium was regarded as a proper coolant was that helium absorbed no neutrons. A good deal of engineering was done on a large helium-cooled reactor moderated by graphite and using natural uranium as the fuel.

"Applying his background knowledge in chemical engineering, Wigner objected strongly to this decision. The reason was twofold. First, if you use helium as a coolant, the device would have to run at a very high temperature (400 to 500 degrees Celsius) and this would mean you'd have immense materials problems that could not be solved quickly. Secondly, he viewed the project as immensely important for the outcome of World War II.

"Using his engineering judgment, he said if you depend on helium as the coolant, it would take many years to get a reactor that would produce 100,000 kilowatts and 100 grams of plutonium per day. Wigner was always worried that the Germans would beat us to the atomic bomb. And therefore, he said, instead

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of using helium at high temperature, let us cool the reactor with ordinary water. This was a brave thing for Wigner to do.

"He began designing a water-cooled reactor before it was demonstrated that any chain reaction was possible. He had much confidence in the accuracy of his calculations, later backed by the results of Enrico Fermi's experiment. You could make a reactor of modest size with uranium rods in a block of graphite.

"Wigner's ideas were found attractive by Compton. He instructed Wigner to design a complete reactor that would produce 500 kilowatts plus 500 grams of plutonium per day; that would be cooled by water, and that would use only 200 tons of uranium for fuel. That was a big deal because uranium was thought to be in short supply. When Compton told Wigner he could use only 200 tons of uranium; that put strictures on the design of the reactor. Wigner with a small group (including Weinberg and Leo Szilard, a Hungarian friend of Wigner's) proceeded to design the Hanford reactors.

"The argument that Wigner had with the DuPont people was the question of who was in charge. DuPont said they were in charge. They didn't realize that Wigner was a Ph.D. chemical engineer plying his trade as a nuclear engineer. However, when the first Hanford reactor was turned on in 1944, it reached only 30,000 kilowatts (it was designed for 250,000 kw). Then the neutron chain reactions slowly decayed, and the Hanford project hung in the balance.

"Was there something going on that was not understood? It turns out that xenon-135 was being produced and was absorbing a lot of neutrons (free neutrons are the key to keeping uranium fission going). Xenon poisoned the reactor but fortunately it has a half-life of nine hours. If you waited for 18 hours, the reactor would recover.

"It is to the everlasting credit of John Wheeler and Fermi that they were able to identify xenon-135 as the culprit. Would Wigner's original design be able to counteract the xenon problem?

"He acceded to the DuPont request that the reactor have 250 tons of uranium. Times had changed and more uranium was available. There was enough uranium for three Hanford reactors, each of them having 250 tons. The fact that Compton had told Wigner to design a reactor that has only 200 tons of uranium is not generally known."

Weinberg said that Wigner had 37 engineering patents on various types of reactors, including an air-cooled reactor built at Brookhaven National Laboratory, the liquid metal fast breeder reactor (designed to create plutonium fuel from uranium, then considered scarce) and the design of the Materials Testing Reactor (MTR) at ORNL when Wigner was research director. One of his patents is on his redesign of the fuel element plates, from flat and parallel to curved, so as to prevent heat-caused buckling that could block the flow of water needed to cool the fuel elements.

The MTR was fueled by uranium enriched in 235 and cooled and moderated by ordinary water, as suggested by Wigner. According to Weinberg, the MTR was the prototype for the "Nautilus" reactor built for the U.S. Navy as requested by Captain Hyman Rickover. The USS Nautilus, which was christened in 1954, was the world's first operational nuclear-powered submarine.

NEXT: Memories of Eugene Wigner by another Oak Ridge scientist

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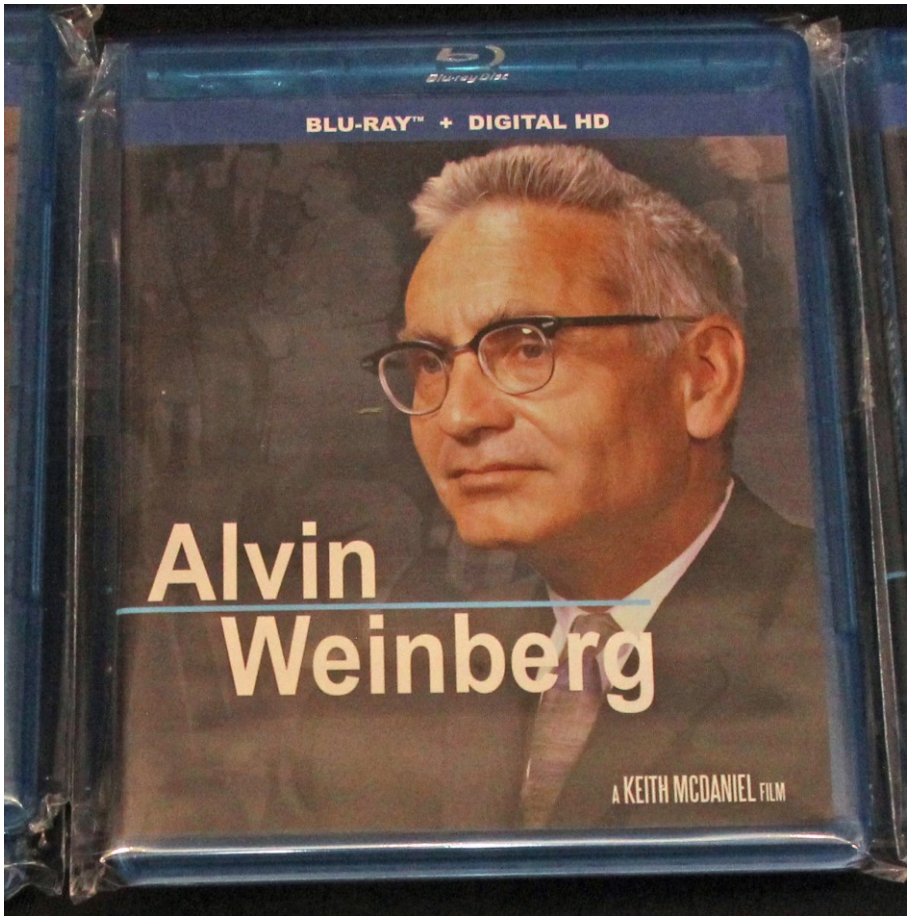


Alvin Weinberg as depicted on the cover of the documentary film by Keith McDaniel