Ernie Wollan: Founder of health physics and neutron scattering

(As published in The Oak Ridger's Historically Speaking column on January 2, 2017)

Ann and Ed Frome, who attend the same church as Carolyn Krause, have long been interested in the career of the late Ernest O. Wollan, one of the most renowned physicists who worked at Oak Ridge National Laboratory. The Fromes bought his house at 107 Oneida Lane in 1977 when he decided to leave Oak Ridge for his home state of Minnesota to be near his daughter.

Ann spoke with him a few times. "He was a man of dignity," Ann told Carolyn after asking her to consider writing about Wollan for this *Historically Speaking* column. "He had the aura of Albert Einstein."

In the Wollan house, which has a glorious view of the Cumberland Mountains, Ernie and his wife Addie (Adelaide) raised a daughter, Katherine, and two sons, Tom and John. Ed Frome, a retired ORNL statistician, had an "impressive tie to Ernie," Ann said. "Ed used the statistical methods he developed to analyze the data collected by radiation workers' film badges based on Ernie's invention."

The Wollans were charter members of Grace Lutheran Church, and Ernie was instrumental in getting the original structure built. They were avid golfers and among the first members of the Oak Ridge Country Club. In 1959, Addie died of cancer, and in 1984 Ernie died of pneumonia in Edina, Minnesota, but he was buried next to his wife in Oak Ridge Memorial Park.

Last September, John Wollan, a former physicist at Los Alamos National Laboratory, was invited to the Oak Ridge National Laboratory for the official renaming ceremony for the Joint Institute for Neutron Sciences, managed by ORNL and the University of Tennessee. It is now the Shull Wollan Center: A Joint Institute for Neutron Sciences. Wollan and Clifford Shull together pioneered the field of neutron scattering using the world's first continuously operating nuclear reactor, the Graphite Reactor at ORNL.

After the ceremony, John Wollan stopped by the Oneida Lane house he grew up in and shared information with Ann and Ed. Below is Carolyn's article on Ernie Wollan, using information she obtained from the Fromes, Oak Ridge Associated Universities Consultant Paul Frame, a journal paper by ORNL Director Thomas Mason et al., The Oak Ridger, Wikipedia and John Wollan.
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Ernest Omar Wollan (1902-84) had one of the most distinguished résumés a scientist could have, except, because of an unfortunate delay, he did not win the Nobel Prize many thought he richly deserved. He pioneered the fields of health physics and neutron scattering research in the 1940s when the nuclear reactor was in its infancy. Today thousands of scientists are health physicists or use neutron beams from reactors and accelerator-based sources to determine the arrangements, motions and magnetic characteristics of atoms in materials.

Wollan visited James Chadwick shortly after the British physicist's discovery of the neutron in 1932; Chadwick won the Nobel Prize in physics for his discovery three years later. The free neutron is the key particle from the atomic nucleus that makes possible fission, research reactors, nuclear power plants, atomic bombs that ended World War II, nuclear medicine and neutron scattering research.

Wollan finished his doctoral work on X-ray diffraction in crystals at the University of Chicago under a Nobel laureate. He was Arthur Compton, who had won the Nobel Prize in physics in 1927, five years after he discovered the Compton effect using X-ray scattering. Wollan received his Ph.D. degree in physics under Compton in 1929.

In 1944 Wollan obtained permission to use the neutron output from the Graphite Reactor at ORNL to study the diffraction of neutrons in single crystals. Neutrons in a beam directed at a

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material being studied bounce off, or are scattered by, atomic nuclei in the sample, producing a diffraction pattern that shows the atoms' positions. Knowing where atoms are in a material and how they interact with one another is the key to understanding a material's properties.

Clifford G. Shull joined Wollan in the research in 1946. (One curious fact: Shull's middle name was Glenwood, and Wollan was a native of Glenwood, Minn.) But the Nobel Prize in physics for the researchers who pioneered neutron scattering was not awarded until some 50 years later, in 1994. Shull (1915-2001) was a recipient but Wollan was not – because he had died 10 years earlier, in 1984.

Wollan was denied the prize he richly deserved because of a Nobel Prize rule and the Nobel Prize committee's commitment to political correctness. First, Nobel prizes are never awarded posthumously. Second, granting of the prize for neutron scattering, or diffraction, using a nuclear reactor was held up because it was politically incorrect.

Paul W. Frame, a former health physics instructor and now consultant for Oak Ridge Associated Universities, wrote: "The unusually long delay in awarding the prize was due to the politically incorrect association of neutron diffraction analysis with nuclear power, i.e., the method had been developed using a reactor. As Karl Larsson of the Swedish Academy of Sciences admitted (Strand 1994), 'Politics should not affect us, but we are only human.'"

According to a 2013 article on the early development of neutron diffraction by ORNL Director Thom Mason et al. in the Acta Crystallographica Section A journal, "the Nobel Prize in Physics was awarded to Shull and Bertram N. Brockhouse, who pioneered inelastic neutron scattering at Chalk River Laboratories in Canada in the 1950s and 1960s, 'for pioneering contributions to the development of neutron scattering techniques for studies of condensed matter.'"

"Shull, who was recognized specifically 'for the development of the neutron diffraction technique,' concluded his Nobel lecture with a tribute to 'the association, collaboration and close friendship' that he enjoyed with Wollan, who died in 1984, and expressed his deep regret that Wollan had not lived long enough to share in the honors that had come to him (Shull, 1995)."

So, what were some of Wollan's achievements? In January 1942, he joined the University of Chicago Metallurgical Laboratory at the invitation of Compton and Enrico Fermi. As a member of the Manhattan Project research team, he was one of the 50 scientists present on Dec. 2, 1942, when the first man-made self-sustaining nuclear chain reaction was achieved in Fermi's Chicago Pile-1 experiment.

Wollan's jobs were to determine if and when CP-1 went critical and to monitor the radiation flow around CP-1 to be sure the radiation levels were within the limits that had been set as allowable for the people in the area.

He was then tasked with measuring workers' radiation exposures to determine if they were in an unsafe environment. As head of a group of radiation protection specialists in Chicago, he was the first to use the title health physicists.

In 1942-43 he co-developed the first standardized film badge dosimeter that accurately measured the wearer's exposure to radiation. To ensure accuracy he added tiny cadmium filters to packets of dental film. The invention is the basis for the hundreds of thousands of film badges worn by workers for the Manhattan Project and at nuclear research labs (like ORNL) and other nuclear facilities ever since.

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From 1944 to 1955, Wollan investigated, with chemist Lyle Borst and then Shull, "the fundamentals of the diffraction of thermal neutrons by crystalline powders" of rock salt, gypsum and other materials. According to the journal article by Mason et al, Wollan and Shull reported in 1948 the results of diffraction measurements on diamond, graphite, aluminum, sodium and three sodium compounds.

With G. A. Morton and W. L. Davidson, they reported results on the diffraction of neutrons in compounds of sodium containing hydrogen or heavy hydrogen (deuterium). According to a 1948 paper by Shull et al., they developed "a promising method of obtaining information on the location of hydrogen positions in crystalline and molecular structures."

In an overview in Science magazine in 1948 that compared neutron, X-ray and electron diffraction, they pointed out the advantages of neutron diffraction, which include better understanding of hydrogen-containing biological materials.

In 1955 Shull left ORNL for MIT. Wollan remained a member of the ORNL research staff until he retired in 1967 and served as a consultant for 10 years. For much of his 23-year service at ORNL, he was associate director of the Physics Division.

But Wollan also was an accurate prophet when he predicted that neutron diffraction techniques would be "a very useful and simple physical tool." He would be pleased that ORNL, with its Spallation Neutron Source, High Flux Isotope Reactor and supercomputers, is the foremost neutron scattering research center in the world!

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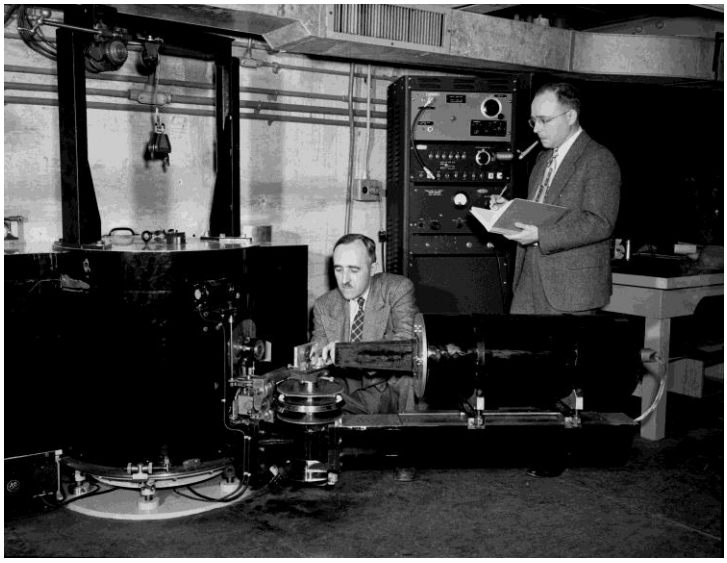
Thanks Carolyn for bringing Ernie Wollan's contributions to health physics and neutron scattering to light. Next Carolyn will bring us John Wallon's memories about Oak Ridge and his father Ernest Wollan.



Wollan (left) and Shull take data on a double-crystal neutron spectrometer, installed on the south face of the ORNL Graphite Reactor in 1949. Built to Wollan's specifications, this instrument was, according to Shull, "the first prototype of present-day neutron spectrometers, having components that were built for specific neutron use rather than being improvised from X-ray units."

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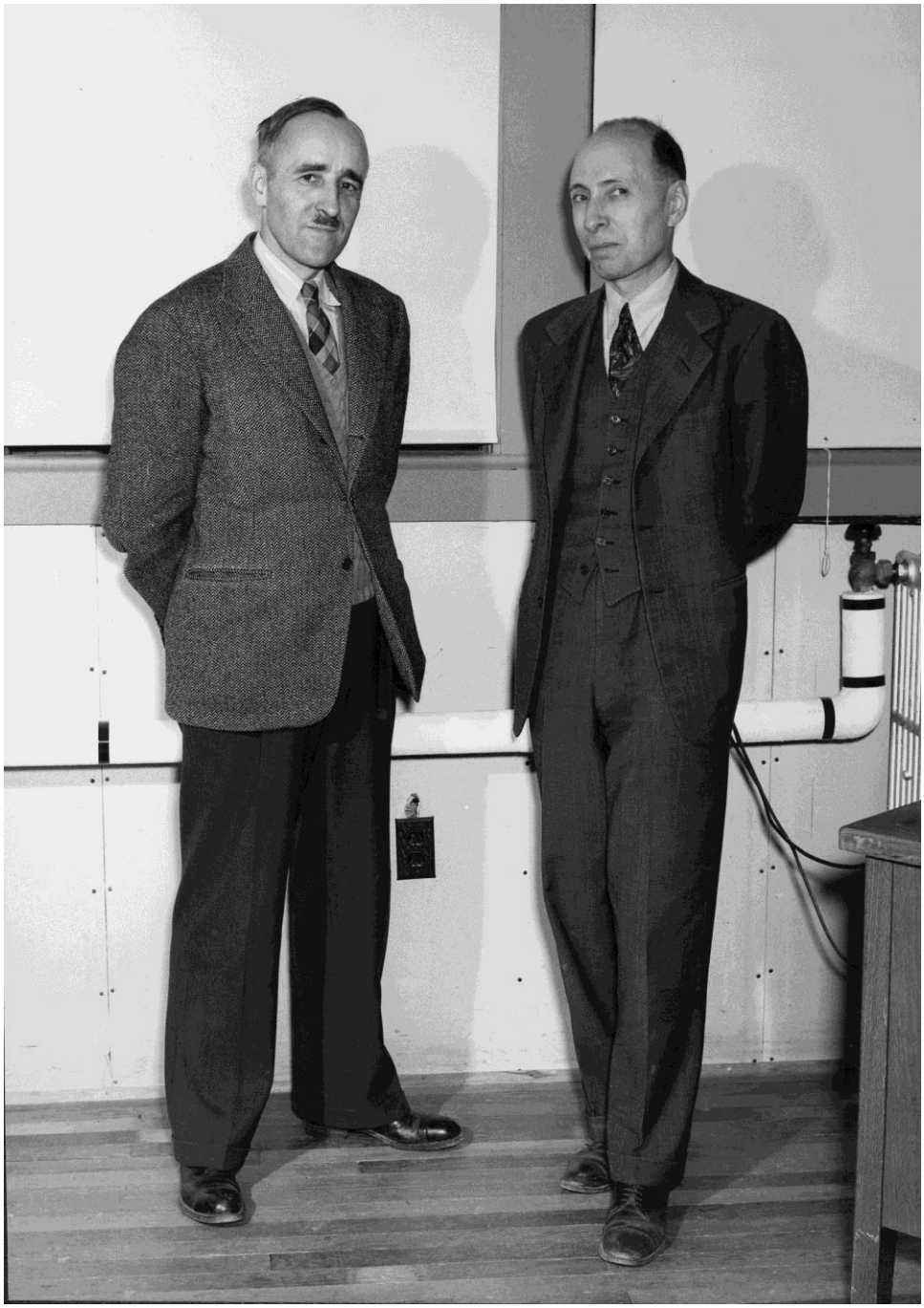

Wollan and Eugene Wigner, research director at ORNL in 1946-47 and later a Nobel Laureate

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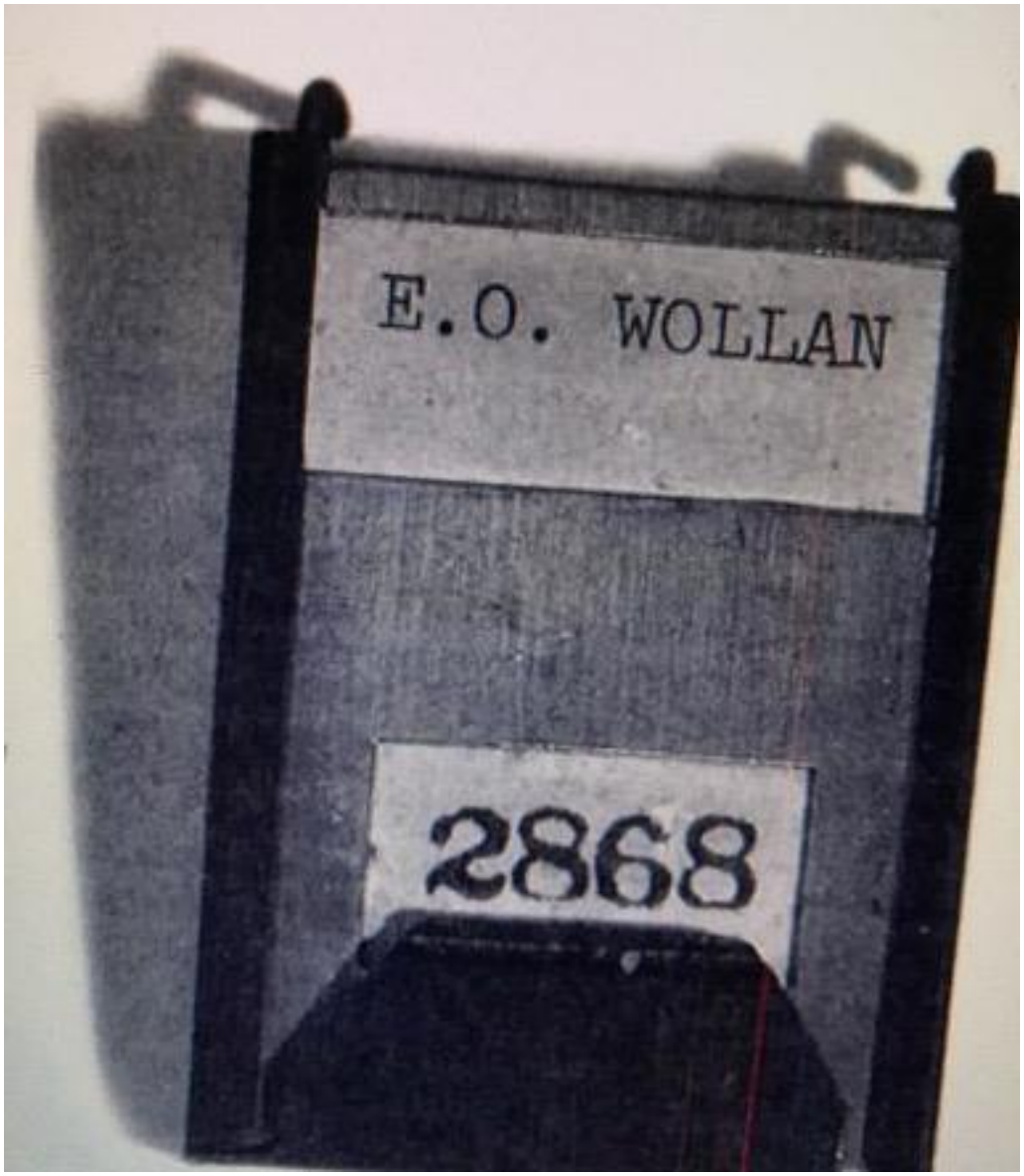

Wollan's film badge dosimeter. It's an example of one of the mass-produced film badges based on the wearable dosimeter he co-developed.

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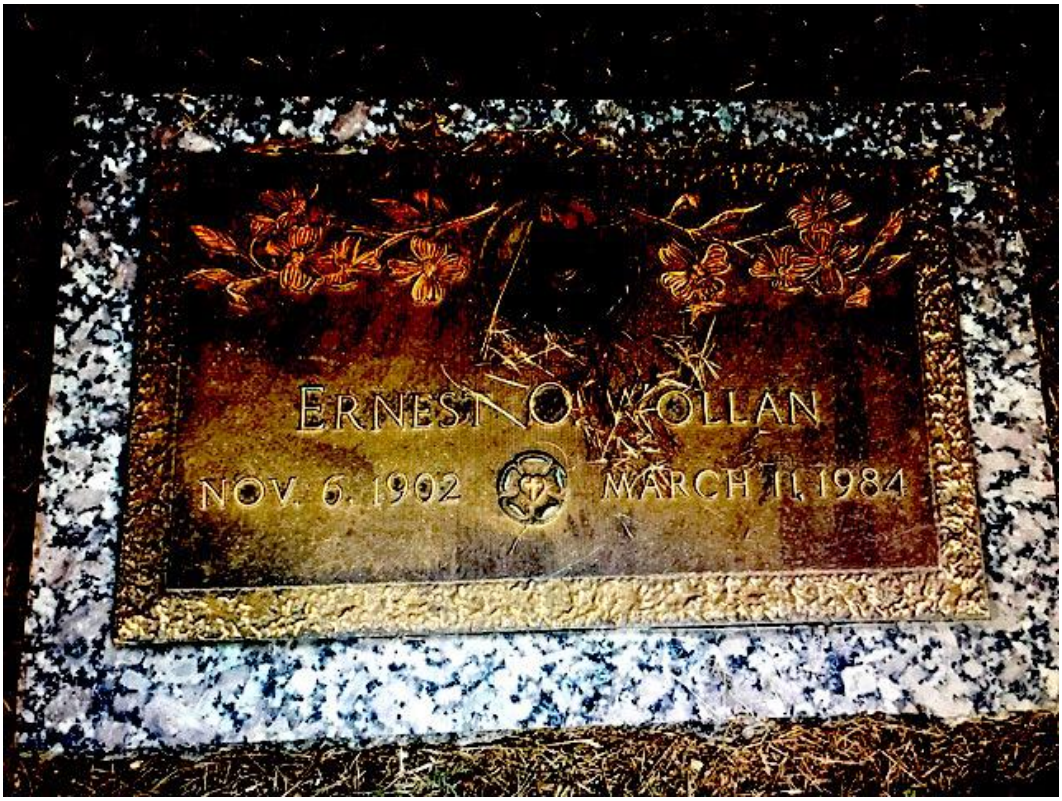

Wollan's grave in Oak Ridge Memorial Park