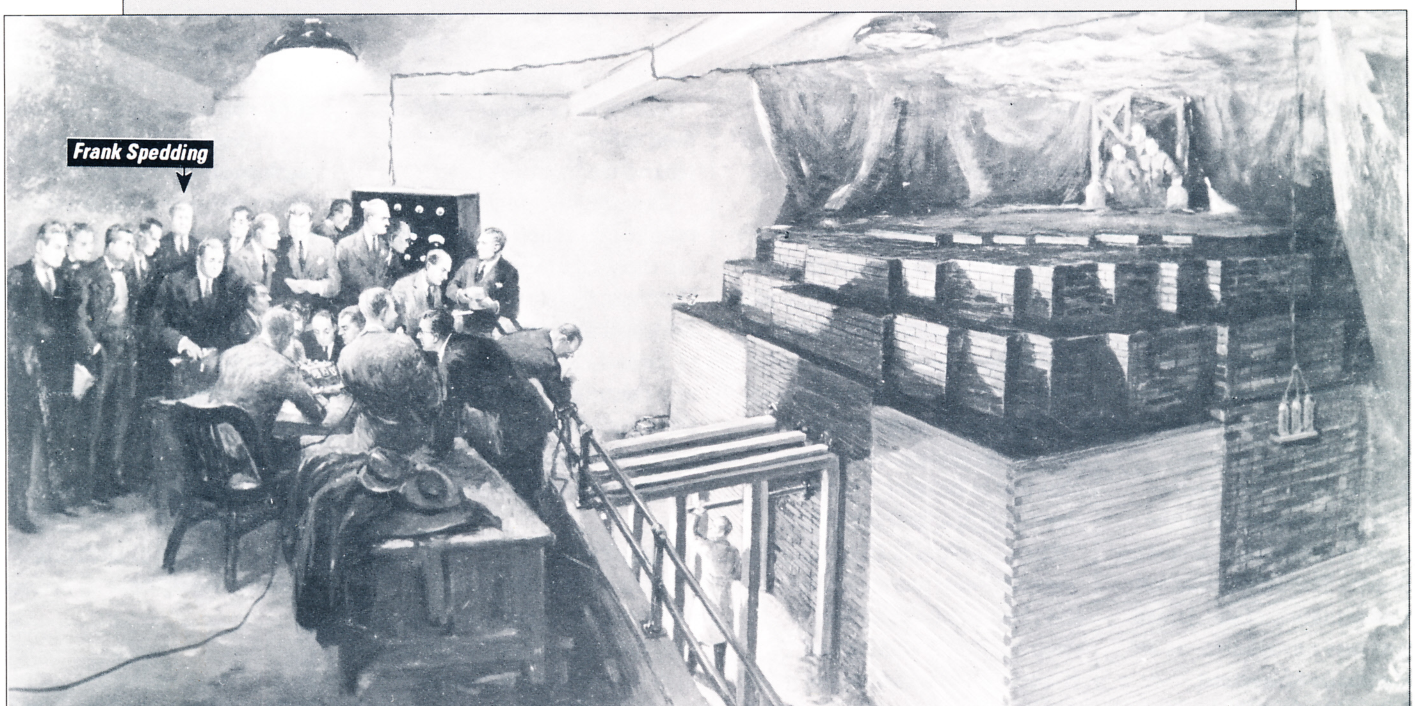
Highlights

INSIDER

Newsletter for the Employees of Ames Laboratory ■ Volume 3, Number 11 ■ December 1992

50th Anniversary of the Manhattan Project



On December 2, 1942, a cold, wintry Wednesday, Frank Spedding and a group of scientists gathered in the squash court under the west stands of the Stagg athletic field at the University of Chicago to witness a secret, critical experiment. Across the room was a massive pile of graphite blocks embedded with uranium in which the scientists hoped to produce a controlled nuclear chain reaction.

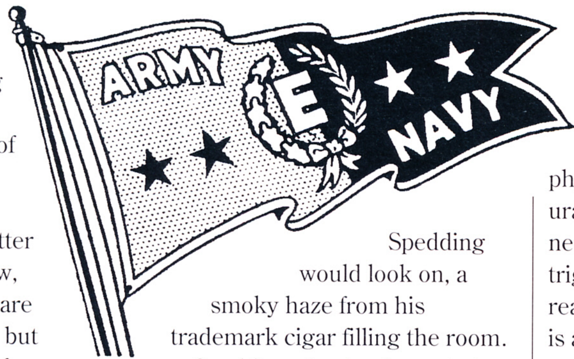
On the floor below was a man responsible for the control rods that regulated the chain reaction. In a corner above the pile were three men, jokingly called "the suicide squad." If the reaction could not otherwise be stopped, it was their responsibility to throw buckets of cadmium solution over the pile. Another person was ready with an ax to cut the rope holding a safety rod if the reaction began to grow with sudden violence. Behind two concrete walls was another group that was ready to throw the safety rods by remote control if anything had happened to the people inside the reactor.

As the control rods were gradually pulled out, calculations and tests were completed. During the final minutes of the experiment, the Geiger counters registering the neutrons from the reactor began to click faster and faster until their sound became a rattle. Then there was silence; the intensity was too great for the counters to follow. The scientists couldn't hear anything or feel anything, but they knew a dangerous activity was mounting rapidly. Everyone's eyes were on Fermi. "Throw in the safety rods," came Fermi's order. The plotter moved back to zero and the rattle died down. They had done it. Everyone sighed with relief and a small cheer went up. At 3:25 p.m., the first atomic power was produced, kept under control and stopped. Wine from the now famous flask of Chianti was poured into a paper cup and passed around. No toast, no remarks, nothing. It was very dramatic. Spedding had observed the first self-sustaining chain reaction— the dawn of the nuclear age.

Story page 2.

Looking Back

Ames Lab Played Key Role in the Manhattan Project



Behind a glass display cabinet outside 201 Spedding Hall is a singularly representative piece of Ames Laboratory history.

The large, white letter E has turned to yellow, and the blue and red are not so brilliant today, but the Army/Navy Flag for Excellence in Production, presented to Iowa State College (ISC) on October 12, 1945, symbolizes the crucial and dedicated efforts that gave Ames Lab its beginnings.

Responsible for the production of more than 1,000 tons of uranium at its pilot plant, Iowa State helped advance wartime efforts to uncover the secrets of atomic power and protect national security. Demonstrating excellence in production five separate times over a two-and-one-half-year period, Iowa State became the only college to ever receive the Army/Navy Production Award for Excellence. The events that led to the presentation of the Award are many and remarkable, as are the individuals who found themselves involved in the essential milestones of what ultimately became known as the Manhattan Project.

Frank H. Spedding

Iowa State College became involved in the Manhattan Project largely due to the unique qualifications of Frank Spedding, who came to ISC in 1937 to take over the physical chemistry section.

Spedding was well known for using the seminar method of preparing graduate students for careers as scientists. The infamous Sunday and Thursday "Speddinars" (as they came to be known) required students to recount their research results under the scrutiny and examination of their peers and superiors. Spedding would look on, a smoky haze from his trademark cigar filling the room.

Spedding also implemented a teaching philosophy that would eventually prove crucial to the success of the Ames Project during the war years: good scientists tackle tough problems whether or not they know anything about them.

Spedding was given the chance to do exactly that. Early in 1942, Arthur Compton, head of the Metallurgical Project at the University of Chicago, invited him to participate in the atomic bomb project.

"They had vastly underestimated the amount of chemistry that had to be done," recalled Spedding in a 1967 interview. "When I arrived at Chicago, they were allowing two rooms for the chemists to do all the chemical work. I informed [Compton] that two rooms would be woefully inadequate. ... I told him that we had a metallograph and a furnace here at Ames, and that we could get some of this work going."

Frank H. Spedding

Enrico Fermi

While in Chicago, Spedding had learned of Enrico Fermi's work with uranium. The great Italian physicist was bombarding the uranium nucleus with "thermal" neutrons, with the goal of triggering a self-sustaining chain reaction. The uncharged neutron is an ideal missile for entering the positively charged atomic nucleus. Fermi knew that neutrons slowed to thermal energies were almost invariably captured by uranium nuclei and then split into two other nuclei plus some electrons.

The uranium nuclei that perform this capture and fission are those of uranium-235. However, uranium-235 accounts for less than one percent (0.71%) of natural uranium, which occurs as a mixture of isotopes (nuclei of the same elements with different neutron counts). The bulk of uranium consists of uranium-238.

Stagg Field

Because the proportion of uranium-235 in natural uranium is low, the total amount to be used in demonstrating the chain reaction had to be very large, and the experiment required a great deal of space. That is why a squash court under the west stands of the Stagg field was made to serve as a laboratory.

In that squash court, Fermi started to build a code-named "pile," an array holding cylinders of uranium embedded in blocks of graphite. The configuration of the uranium and graphite was calculated to conform to a specific geometric lattice designed to achieve a chain reaction. The carbon nuclei in the graphite gently bounced neutrons back and forth, moderating their initial high speeds to the correct low thermal energies for capture by the uranium nucleus.

Once the uranium-235 atom captured a neutron, its nucleus would split into two smaller fragments, losing some mass and ejecting two neutrons as it did so. If prevailing conditions permitted the freed neutrons to split more uranium-235 nuclei, a chain reaction would proceed exponentially.

Fermi was having difficulty getting an experimental reaction to go because impurities in the uranium and in the graphite he was using captured too many neutrons. The pile's neutron economy demanded that certain impurities, especially elements such as boron and cadmium, which are very good neutron capturers, be kept at exceptionally low levels.

Harley A. Wilhelm

On February 21, 1942, the day after Spedding's official induction into the Metallurgical Project, he took the train back to Ames. Spedding understood that if Fermi's pile was to succeed, better methods of purifying uranium would have to be found quickly and with the resources at hand. He was counting on the only other Iowa State faculty member in physical chemistry at that time, Harley A. Wilhelm.

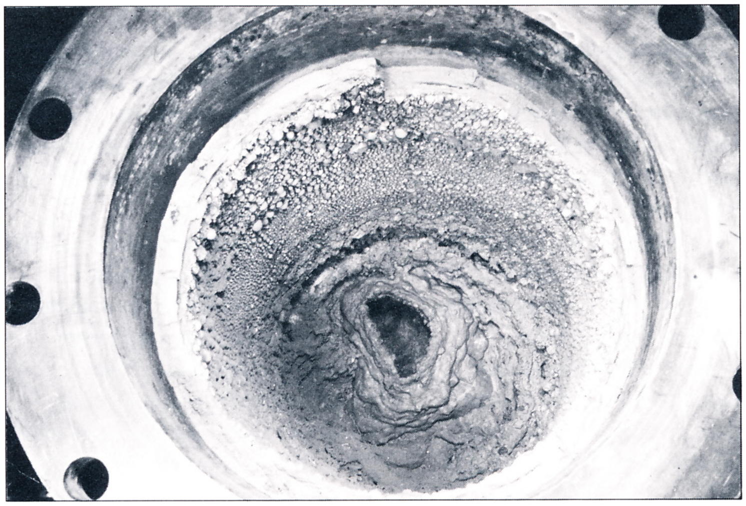
Harley A. Wilhelm

Wilhelm became associate director of the Ames Project on

February 24, 1942.

Returning to college after a brief teaching and coaching career, Wilhelm earned his Ph.D. at Iowa State and was hired to teach metallurgy in the chemistry department. It turned out he had a knack for it.

When Spedding became head of physical chemistry in 1937, he left the metallurgical area of the department to Wilhelm, a fortunate turn of events for both men since Wilhelm became the expert in that area for the Ames Project.



The interior of the reduction vessel.

Metallurgical Work at Ames

The metallurgical work conducted at Ames began with three 1920-vintage pieces of equipment: a small induction furnace that needed a few parts, a metallurgical microscope (metallograph) that had been missing a mirror for several years, and an old Hilger E-1 quartz spectrograph. The equipment was old, but reliable. Ames began investigating how to produce sizable amounts of uranium and cast it on a large scale, particularly for the upcoming Chicago experiment to determine the feasibility of a chain reaction.

In August of 1942, Spedding returned from one of his many Chicago trips with a small pressed block of kelly green uranium tetrafluoride, one of the materials considered for use in the pile. Wilhelm crushed part of the material to a fine green powder, added calcium as a reducing agent and induction heated the mixture in an iron pipe capped at one end and welded shut on the other end. When the apparatus had cooled to room temperature and was dismantled, Wilhelm recovered a 35-gram ingot of pure uranium metal. It was code-named a "biscuit."

From that time on, large quantities of uranium tetrafluoride started coming to Ames. On September 21, 1942, Wilhelm and his team tried several more reduction experiments, using close to 3,000 grams of uranium tetrafluoride and calcium in each. From these experiments, several ingots were cast and recast, producing a final, and now famous, 11-pound ingot of pure metallic uranium.

Eleven-Pound Ingot

Wilhelm carefully packed the 11-pound ingot in a traveling bag, and caught the night train to Chicago. While in transit to the University of Chicago campus, the handle of his bag broke and he had to carry his precious cargo in its case under his arm.

Spedding and Wilhelm took the ingot to Compton, who had never seen a piece of uranium that big. Compton's immediate reaction was, "I bet there's a pipe (hole) inside." Wilhelm took the ingot to one of Compton's shops and had it cut in half. It was found to be a solid piece.

Spedding later took a cropping from the ingot to an administrative meeting. R. L. Doan, Metallurgical Laboratory director at the University of Chicago, later recalled that momentous day.

"I don't believe anyone took the work there [at Ames] very seriously until Spedding came to a technical council meeting one fine autumn day and smugly laid an 'egg,'—an almost perfect cylinder of uranium metal— on the table for inspection. Even then, while admiring the accomplishment, everyone, I am sure, felt that it would be futile to look to a couple of college professors for the production of any significant quantity of metal."

They couldn't have been more wrong. Within a week, Doan came to the Iowa State campus to write a contract for the Ames Project to produce 100 pounds of uranium per day. Uranium casting and production continued in Ames until industry was able to integrate the processes into their own plants.

The Chain Reaction

By December 1942, the Ames Project had furnished two tons of pure uranium metal to support the critical chain reaction or "pile experiment" at the University of Chicago. Because the uranium made in Ames was the purest he had, Fermi had it placed in the pile's central core. Fermi had planned a spherical reactor, but the Ames uranium proved so effective as a neutron absorber that the top 20 layers of the planned pile were eliminated, making the world's first nuclear reactor an ellipsoid.

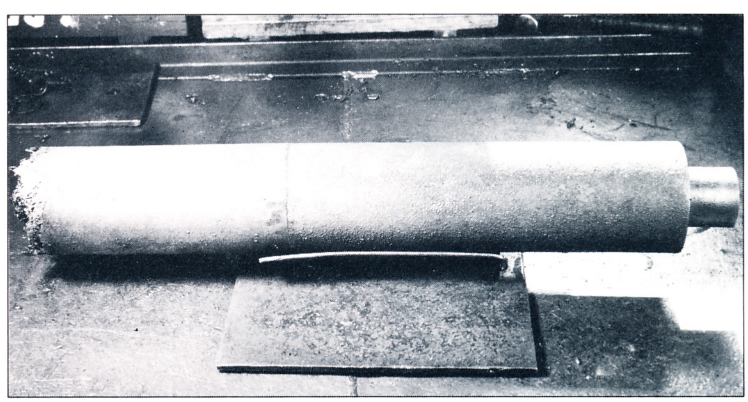
The Chicago pile contained 385 tons of graphite, 40 tons of uranium oxide and six tons of uranium metal. It operated for 28 minutes and produced half a watt of power.

The Manhattan Project

The Manhattan Engineering District took charge of the Metallurgical Project after the successful chain reaction experiment. In January 1943, the secret operation that was to build the world's first atomic bomb became known as the Manhattan Project.

Large induction furnaces were installed in Ames in late December 1942, and the Ames operation grew into one of the largest college/university projects of the Manhattan District.

At its peak, the Manhattan Project employed 500 people in Ames.



An ingot of pure uranium: this one was 4 1/4 inches in diameter, over 2 feet long and weighed 250 pounds.

Little Ankeny

In the beginning, most of the Ames Project's work was done in the chemistry building. When full-scale production began, more space was needed for furnaces and other machinery. Spedding and Wilhelm found a small WWI temporary wooden house behind the Dairy Industry building that had been used years before as a women's gymnasium and was used at that time primarily for storage. Iowa State gave the building to the Project, and the chemists immediately replaced the dirt floor with concrete so the uranium casting could take place in that area.

The building began to expand in a curious manner. The porch was used for the especially dirty work, the least secret part of the process. However, when it became too cold to work on the porch, a canvas was added followed by a crude set of walls and finally a new roof. As needed, a new porch would appear and the process would repeat itself.

A machine shop at this site soon became necessary. Wilhelm bought a small machine shop, including the tools, and moved it next to the production building. This building was officially called the Physical Chemistry Annex but workers nicknamed it Little Ankeny, after a war munitions plant in Ankeny, Iowa.

After Little Ankeny was demolished in 1953, a stone marker was erected to commemorate the site. Part of the plaque reads, "On this site between 1942 and 1946 over 2,000,000 pounds of uranium metal were produced for the Manhattan District Project by Dr. F. H. Spedding and Associates." The marker is there today between Hamilton Hall and the Dairy Industry building.

Little Ankeny, where 2,000,000 pounds of pure uranium metal was produced for the Manhattan Project.

A stone marker commemorates the former site of Little Ankeny.

Shipments to Chicago

As part of the agreement with Compton, Spedding was to spend half of his time in Chicago and the other half in Ames. Wilhelm ran the Ames Project while Spedding was gone.

Spedding started carrying the uranium metal with him on his weekly trips to Chicago. When the quantity and weight grew too heavy, freight cars were used for the shipments.

An empty train car would arrive in Ames and be loaded with small 4" x 4" x 2' wooden boxes. After the train was loaded, the cars still appeared empty. However, if anyone had examined the train closely, they would have seen not only a higher floor but the axles straining or even bending under the extreme weight.

No special guards accompanied the shipments, but two men in civilian clothes, usually overalls and sweaters, came and went with the shipments. Townspeople soon began spreading stories that empty train cars with two hobos were coming into the College and leaving empty with the same two hobos aboard.

Whiskey Barrels

Early in the Project, a search was made for appropriate containers to ship the slag left over from the uranium production. Wayne Keller, a colleague of Wilhelm's, said that in his Kentucky hometown, white oak barrels were discarded after being used to age bourbon whiskey and suggested they might make suitable containers.

Spedding approved the idea and asked Keller to order 1000 whiskey barrels. By mistake, Keller's secretary typed on the purchase order, "one thousand barrels Hiram Walker Whiskey." The purchasing agent had been told by ISC President Friley early in the Project that for security reasons he was to approve anything Spedding ordered and not ask any questions. Despite the security requirements, the agent called Spedding at 6:30 one morning and questioned why he was ordering whiskey through the College, since Iowa was a dry state. Spedding straightened the agent out and assured him it was just a typographical error and that he only needed the barrels.

When the barrels arrived, a group of men who did the heavy lifting were instructed to fill them. Suddenly, Wilhelm had too many men volunteering for this dirty, strenuous duty and suspected something was amiss. Upon investigating, he discovered that the men were propping the whiskey barrels on the edge of a hill and draining about a cup of whiskey from each barrel before filling them with the slag. This bonanza helped them get spirits that were rationed and very hard to get during the war.

Frequent Fires

Magnesium and uranium react vigorously with air and fires frequently erupted in Little Ankeny. Because of the secrecy of the Project, Ames fire department personnel were not allowed into the buildings that housed the production plant or the research activities. The firemen would bring their equipment to the site and remain outside in case the fire got out of control. Luckily, the workers were always able to use lime and powdered graphite to squelch the flames.

One day, after more than six explosions, several secretaries threatened to resign. Spedding convinced all but two of them to stay after he promised to strengthen the wall between the office and the operations area and to cut a door to the outside directly from their office.

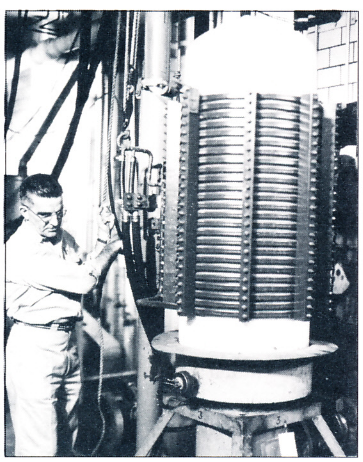
One unexplained explosion was so powerful that the workers had to push the walls back in place as far as they could. When Little Ankeny was torn down, it was said that even then one of the walls was not in its original position.

Code Names

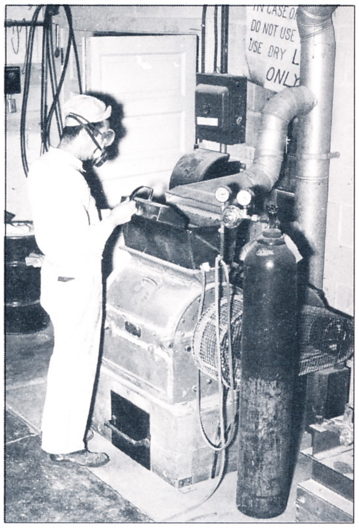
Workers on the Ames Project used farm terms when they needed to talk in code. "Eggs" were 2" cylinders of uranium, and one would often hear "two dozen eggs were shipped"; 1" x 4" lengths of uranium were called "frankfurters" or "hotdogs"; uranium scrap turnings were called "hay"; boron was called "Vitamin B"; uranium, "the metal"; radioactivity, "sensitivity"; uranium tetrafluoride, "green salt"; uranium oxides, "black or brown powder"; uranium, "tubealloy"; and thorium, "Myrna Loy."

Safety and Health Considerations

There was always concern for the health and safety of the workers on the Project, and typical laboratory precautions of that time were taken. Ventilating hoods, already being used before the war, took the dust away from grinding uranium compounds. Respirators were used in dusty operations, and some scientists used lead aprons when working around particularly hazardous chemical materials. If explosions were a problem or processes potentially dangerous, walls were built to shield workers. When working with the unknown, precautions were used based upon the research literature about the chemicals.



The thorium casting system that formed thorium into billets.



The garbage hog used to cut up calcium and magnesium for the reduction process.

Every worker was given time to shower and change clothes at the end of a shift in order to prevent taking uranium and thorium particles home or outside the work area. Washing thoroughly before eating was rigorously enforced. To prevent ingesting radioactive dust, no one was allowed to smoke in work areas.

Blood tests were administered routinely and urinalysis tests were given at least once a month. Some staff members participated in research studies and served as subjects for medical research. These studies became the foundation upon which standard exposure levels were based. They also became the building blocks for protection of workers in the nuclear plants after the war. Workers at Ames were carefully monitored while they worked and also after they left the Project to determine long-term effects of the work they were doing.

Costs

Because work on the Manhattan Project was being done at Iowa State College, an educational institution, there could be no profit involved. All contracts were on a cost plus overhead basis, but there was no adequate way to predict the price-per-pound of uranium. Contracts demanding the no-profit clause created a constant problem. During the war it was never resolved because Iowa State was the only full-fledged industrial plant operating under no-profit requirements.

After the war, Iowa State negotiated and received approximately $1.2 million in administrative charges for research and development work. Some of the federal overhead money was used to start WOI, a commercial television station on campus; to construct the Office and Laboratory building linking chemistry and physics; and to start a Physical Sciences Reading Room.

Ames Laboratory

Iowa State College saw its enrollment burgeoning after the war years in both undergraduate and graduate areas. Spedding understood the future possibilities and immediately after the war started pushing for the creation of an atomic institute to incorporate physical chemistry and physics research into a permanent laboratory at Iowa State. In a letter to ISC's President Friley, Spedding wrote, "I believe that a permanent institute should be set up, similar to the Agricultural Experiment Station ... which would cut across all divisions and departments ... in this way, we could build a sound research organization which would have security over a long range.

"I feel that the institute should be closely integrated with the science departments on the campus, since the everyday contacts of scientists, with their exchanges and clashes of ideas, are very fruitful in producing new discoveries. I believe this close relationship could be maintained by having the permanent members of the institute working part-time for the institute and part-time for the departments in their major fields."

Spedding's plan worked. In 1947, the Ames Laboratory was established by the Atomic Energy Commission to be administered by the state-established Institute for Atomic Research (today known as the Institute for Physical Research and Technology). Spedding had created a facility on the Iowa State campus that was both state-operated and federally-funded, and after the war Ames Laboratory served as a model for developing research relationships with the federal government.

Note: Due to the historical nature of this article and for clarity, the standard measurement system was used.

(Portions of this text were taken from several historical documents and from Carolyn Stilts Payne's Ph.D. dissertation, "The Ames Project: Administering classified research as a part of the Manhattan Project at Iowa State College, 1942-45," completed earlier this year at ISU.) ■