how much uranium and graphite was needed to how long it would take to initiate and sustain the reaction. The event took place under the West Stands of Stagg Field in a room in the squash court. Arthur Compton had chosen the University of Chicago site in November without any prior notification of the university president Robert Hutchins or without prior governmental approvals from Vannevar Bush or James Conant. He had concluded that the site under construction outside Chicago in the Argonne Woods could not be ready in time because of delays caused by construction strikes. After a lengthy discussion session, the governmental leaders finally acceded to his wishes because the project was under so many deadlines to push ahead and everything depended upon the feasibility of a chain reaction.[166]

Construction on the pile began in November 1942. Constructed in a thirty by sixty foot room, the large stack or pile of black graphite bricks and wooden timbers dominated the room.[167] Over the top of the stack was a

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[166] Actually, it was later revealed by Compton himself and Hewlett and Anderson as well as other authors that Compton was so concerned about the continuance of the bomb and plutonium projects at Chicago that he wanted to impress a governmental review team, the Lewis Committee, that just happened to be in Chicago in early December investigating the processes used to obtain a bomb. There was still no decision as to which of the three methods for separation of uranium—electromagnetic, centrifuge, or gaseous diffusion—or the one method for separation of plutonium from irradiated uranium would win out in the four-way race for a weapon. Since Compton counted on plutonium, this chain reaction experiment was crucial. But the experiment did not take place until the team was on its way back across the country. As important as the event was as a technological accomplishment, the Lewis team had already made its recommendations in draft form that gaseous diffusion would have the best possible chance of success. However, they recommended to continue to support Lawrence's work in electromagnetic separation and to support pile production. The experiment was another anticlimax in the policy-making arena, but it did help confirm the committee's recommendations, just like Compton's third review report a little more than one year earlier. Additionally, on December 1, 1942, Groves issued the command to DuPont to build production plants using both plutonium and uranium (Compton, *Atomic Quest*, 139-145; Hewlett and Anderson, 100-115; Groves, 53-54; Conant, *My Several Lives*, 289; Wyden, 51-52; Smyth, 90; Hewlett and Anderson, 112-113; Gosling, 15-16).

[167] Corbin Allardice and Edward R. Trapnell "The First Pile," 1961 reprint of AEC Report TID-292, March 1955, located in Spedding Papers, 2. This booklet was originally

balloon cloth bag constructed by Goodyear. The bag had one side open exposing a circular layer of graphite bricks with machined holes to insert cadmium/wooden strips for absorbing neutrons. Uranium was placed in the middle holes and uranium oxide in the holes on the outside of the pile. The pile contained over 400 tons of graphite (over 40,000 bricks), 6 tons of uranium and 58 tons of uranium oxide (over 22,000 slugs) and cost approximately $1 million to construct. Each layer was braced with a wooden frame. One hand-controlled rod was used to stop the reaction if needed. A set of motor-driven rods was controlled from the balcony and one emergency rod ran through the middle of the pile, a rod attached with a rope and heavy weight for the unthinkable emergency. The pile was completely uncooled, unshielded, and constructed primarily by physics undergraduate students from the University of Chicago[168]

Enrico Fermi concluded from the constant tests he had been conducting throughout the fall that the pile reached its critical size on the afternoon of December 1. On Wednesday morning, December 2, 1942, those invited, on this cold wintry day, gathered on a balcony to watch the experiment (see the

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written in 1946 and reproduced several times as the definitive history of the Chicago experiment. Most of the material in the booklet had been prepared for a press release to be issued from the War Department on the fourth anniversary of the Chicago experiment to be released Sunday December 1, 1946 (Record No. 95 from the *MED History*, Book I, Vol. IV, Chapter 8, Press Releases).

[168] Allardice and Trapnell, 9. Hewlett and Anderson, 112-113. H. L. Anderson, "The First Chain Reaction," in *The Nuclear Chain Reaction—Forty Years Later*, ed. by Robert Sachs, A Symposium at the University of Chicago, Chicago, Illinois, 1984 (Chicago: University of Chicago Press, 1984), 32-33. Rhodes, 430-436. George W. Tressel, CP-1 25th Anniversary Film, Transcript of a film produced by the Argonne National Laboratory, August 10, 1967, Ames Laboratory Papers, 13-14.

photographic interpretation of the day of the experiment in Appendix B). Frank Spedding was on the balcony with men like Arthur Compton, Crawford Greenewalt from DuPont, Eugene Wigner from the theoretical section of the Metallurgical Laboratory, perhaps twenty more men, and one woman. Spedding remembered the day:

> Sitting on a stool . . . watching the galvanometer was Fermi, and he had a slide rule in his hand. . . . What we saw was a beam of light hitting a small mirror and reflecting on a scale on the wall. . . . When they pulled the control rod, this beam went up little ways and then went back as it was dying out.[169]

The room was tense and quiet as the preliminary testing and calculating continued all morning. Then as his custom, Fermi called for a lunch break at about 11:30 a.m. After lunch, Fermi began the experiment itself. He called for a cadmium strip to be pulled a certain distance, usually one foot at a time. Herbert Anderson, of the Metallurgical Laboratory and one of the observers, later recalled:

> The rod was pulled out a specific amount and you could hear the counters clicking away—clickety-clack, clickety-click. They went faster and faster and then at a certain point there was silence. The rate had become too great for the counters to follow. . . . Attention turned to the chart recorder. It was silent but could record much higher levels of intensity. You watched a pen moving across the scale as the chart advanced . . .
>
> The intensity kept rising and soon the pen was off-scale. So the scale was changed. . . . It was understandable that some of the onlookers might become a little nervous. They didn't hear anything, they didn't feel anything, but they knew that a dangerous activity was mounting rapidly. Everyone's eyes were on Fermi. It was up to him to call a halt. But he was very confident and very calm. He wanted the intensity to rise high

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[169] Frank H. Spedding, "Interview with George Tressel," July 12, 1967, Ames, Iowa, transcript in Ames Laboratory Papers, 18-19.

> enough to remove all possible doubt that the pile was critical. He kept it going until it seemed too much to bear. "Zip in," he called, and Zinn released his rope. The control rod he held went in with a bang and the intensity dropped abruptly to comfortable levels. Everyone sighed with relief Then there was a small cheer.[170]

Spedding reinforced some of the above feelings in his memories of the moment. Quiet, intensity, tension, relief were all words in the vocabulary of those who were there. Leona Libby Marshall, another observer of the occasion, and the only woman in attendance, summed up the mood as the famous bottle of Chianti was passed around afterward:

> There was absolute dead silence. Nobody said anything. Then somewhat later, after the control rods were all put to bed and the charts were pulled out and clipped off and so on, Eugene Wigner showed up with the famous flask of Chianti . . . and he poured into a paper cup and everyone drank it very quietly. There was no toast . . . nothing . . . no remarks . . . very dramatic. The most effective kind of drama at that point.[171]

This experiment had just demonstrated the harnessing of an awesome power, though most of the people there were thinking of the immediate days ahead—how to take this power and win a war. However, Leo Szilard, one of the men who had originally pushed the United States into this research effort, later remembered the doubts he had about the day:

> There was a crowd there and then Fermi and I stayed there alone. I shook hands with Fermi and I said I thought this day would go down as a black day in the history of mankind.[172]

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[170] H. L. Anderson, in Allardice and Trapnell, 35-36.

[171] Tressel, "CP-1 25th Anniversary," 18.

[172] Szilard and Weart, 146.

After the success of the experiment, more uranium was needed to create a working pile. The new site for the larger pile would be the Clinton Engineer Works in a small little community nestled in the hills of Eastern Tennessee. The Chicago Metallurgical Laboratory thought it would be in charge of this site, but they had to eventually turn over their expertise to an industrial concern that would run the actual pile—DuPont. The small Ames production group, which was in the process of moving to its new production facility, would produce over ninety per cent of the uranium that went into that first reactor at the Clinton Engineer Works.[173]

The Production Project at the Ames Laboratory 1943-45

During the months of November and December, the Ames metal manufacturing unit began to set up in its new building, the Physical Chemistry Annex.[174] The supporting chemical and metallurgical research continued, but because of the critical need for the production of metallic uranium, Spedding quit as head of the Chemistry Division in early 1943 and devoted his full efforts to work in Ames, especially since there were really two projects on campus to oversee.

Uranium production

By January 1943, several changes had occurred in the production area. Most of the equipment like cutters and mills that had been ordered were in

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[173] Frank H. Spedding, interview 8 with Elizabeth Calciano, transcript in possession of Edith Landin, Ames, Iowa, n.d., 13.

[174] Frank H. Spedding, "Report for the Month Ending December 15, 1942: Ames Metal Manufacturing Department," Ames Laboratory Papers, 1.

place. Also new experiments using magnesium as a reductant rather than calcium proved successful, lowering the production costs considerably. By early January, uranium tetrafluoride came to Ames from three sources—Mallinckrodt, DuPont, and Harshaw. Production in general was stepped up, rising from an average of 3,600 pounds a week during the early part of January to about 5,600 pounds during the last week of the month. There was a temporary reduction in early February because of the lack of tetrafluoride, but overall production levels using magnesium had risen from about 100 pounds a day in December to an average of 550 pounds in the middle of January with a high of 971 pounds on January 24.[175]

Reduction of uranium tetrafluoride with magnesium became the choice of the project by March since by then this more complicated method had been successfully demonstrated. Magnesium was more attractive because it was readily available, purer than calcium, could be used in smaller quantities than calcium, and was much cheaper to obtain. It did present some more difficult problems than calcium reduction though, which is why it was not used in earlier production runs. Magnesium needed a booster to initiate the reaction with uranium tetrafluoride, unlike calcium which could fuse with uranium tetrafluoride without additional ingredients. Additional heat or preheating also had to be employed, which led to investigating new types of bomb liner materials. Casting presented problems, but most were solved by replacing the

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[175] Wayne Keller, "Production of Crude Uranium, Period Ending February 15, 1943," the Ames Laboratory Papers, 12.

old drip casting method with a crucible and valve apparatus for pouring the metal.[176]

By March 1943, the essential methods that industrial companies could use were in place in the new production facility at the Annex. The steps in the process were essentially the same as those earlier with a few modifications for the magnesium. The uranium tetrafluoride, also called green salt because of its color, came in barrels from either Mallinckrodt, DuPont, or Harshaw and needed to be ground into smaller pieces. A metals preparation crew which worked only in the daytime handled that job. They also took samples for analysis by scientists to make sure the quality was that required by project leaders. They also ground or chopped the magnesium metal as it arrived. The refractory or liner that was used to line the retort or bomb to prevent it from coming into contact with the steel vessel came from various sources. At first, a very hardened lime called "dead burnt" lime was used, but late in 1943 Electromet produced an electrically-fused dolomitic oxide which became the standard refractory material. It was pre-ground and needed no further preparation. The reduction materials then moved to the reduction crew where

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[176] Fulmer, 10-11. Wilhelm, "A History of Uranium Metal Production in America," 43-44. See also C F Gray, "Early Methods for Casting Uranium at Iowa State College," Report CT-2958, Ames Laboratory Papers for a discussion of casting methods. Also see "Report of W. H. Keller on Uranium Metal Production" in Report CC-298, Report of the Metallurgical Project for the Month Ending October 15, 1942, the Ames Laboratory Papers, 2-4 for some preliminary results with magnesium; "Experimental Production of Crude Metal," Report CT-393, Report of the Metallurgical Project for the Month Ending December 15, 1942, the Ames Laboratory Papers, 38-39. In Report CT-686, May 22, 1943, the magnesium method of metal production is described further (Information from "Abstracts of Reports from the Ames Project, April 1942 to November 1944," from the National Archives Great Lakes Regional Center Records on the Metallurgical Laboratory, Chicago, Illinois).

the apparatus for reduction was put together with the charge and refractory materials[177]

Reduction of uranium tetrafluoride required a steel pipe, usually 6 inches by 36 inches long (sometimes the pipes could measure 10-inches by 3.5 feet in order to produce a 125-pound ingot). Production workers then welded a bottom to this pipe to create a bomb or reduction retort. The refractory liner consisted of approximately one-half inches of lime or dolomitic oxide, which was a granulated substance placed between a form, or mandrel, that was one-half inch smaller in diameter than the vessel. The vessel and mandrel were placed on a pneumatic table and jolted to join the refractory to the sides. After the jolting or shaking process, a worker removed the mandrel and carefully placed a measured charge of uranium tetrafluoride and magnesium in the bomb. He placed more refractory liner material on top of the charge, and closed the top of the container by bolting a flange on the outside. A hoist and transfer system raised the pipe bomb and placed it in a heat soaking pit for preheating to the point where ignition would take place. Later, a gas furnace replaced the

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[177] David Peterson, "Interview with the author," July 10, 1990, Transcript in the possession of the author, 4. Peterson was an assistant foreman at the Physical Chemistry Annex from late December 1942 till the end of the production part of the project. The author asked him to describe the entire process from beginning to end and so much of the above and following material is attributed to him. Several other sources give portions of the process including Wilhelm, "A History of Uranium Metal Production in America," Hewlett and Anderson, 293-294, and several of the interviews various people conducted with Frank H. Spedding. For a pictorial view of the Ames Process see the photographs in Appendix B. For more technical information on the process, see Warner, "Early Methods," 152-161; J. C. Warner, "Methods for Production of Uranium Metal," Chapter 7 in *Uranium Technology: General Survey*, by J. E. Verne and J. C. Warner, National Nuclear Energy Series, Division VII, vol. 2A (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 164-174; J. C. Warner, "Large-Scale Melting and Casting of Uranium Metal," Chapter 8 in *Uranium Technology: General Survey*, by J. E. Verne and J. C. Warner, National Nuclear Energy Series, Division VII, vol. 2A (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 175-186 as well as several research reports produced by the Ames Project principals.

heat soaking pit, and the charge and bomb heated at about 650°C for 40-60 minutes. After a period of time, the reaction mixture inside spontaneously reacted and ignited. The internal temperature would reach 1,600°C to 2,000°C and since steel melted at 1,500°C, it was critical that the refractory liner did not allow the heated charge to come into contact with the metal. A rod that was placed in one of the holes of the flange with a microphone attached to a speaker system detected the actual firing or ignition. A rumbling noise resulted when the reaction ignited and alerted the furnace worker. As soon as it fired, he pulled out the vessel and placed it in a spray chamber to cool the retort or bomb. If a successful reaction occurred, the uranium tetrafluoride reduced to uranium metal and a slag of magnesium fluoride, splitting into two layers with the slag on top and the metal on the bottom. As the vessel cooled, both layers hardened. When completely cooled, a worker opened the bomb, turned it upside down, and hammered until the slag and metal separated. He placed the slag and used liner in drums for recovery and the 42-pound (a typical size) cleaned biscuit was stamped and sent to casting.[178]

In the casting process, a vacuum induction furnace heated the biscuit to produce fuel elements. Casting produced a different shape from the biscuit and further removed impurities from the reduced uranium metal. A graphite crucible machined from an electrode held the metal. The crucible had a hole in it that could be closed with a stopper which held the metal until the liquid needed to be poured into a collector bowl. At the point that the stopper was

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[178] Peterson, interview with the author, 1990, 4-5. Wilhelm, "A History of Uranium Metal Production in America," 44; W. H. Keller, "Production of Crude Uranium, Period Ending February 15, 1943," Ames Laboratory Papers, 1-9.

dislodged by a short graphite rod, the molten metal poured into the graphite mold to harden, resulting most often in a 1.5 inch to 5-inch diameter rod, 20-30 inches long. An egg or cropping was cut from one end of the rod for further analysis; the rod was stamped with a number; and it was placed in a small wooden box.[179]

These boxes, made of three-fourth-inch wood, with the ingot most often weighed 100 pounds or more depending on the size of the rod. The boxes were banded, nailed, and small cleats were placed beneath each box so a man's hands could slip under to pick them up. They were usually shipped to Chicago where they were transferred on to Hanford or other sites like Clinton.[180]

By July 1, 1943, Iowa State College was producing 130,000 pounds of uranium per month, a peak in the program. When industrial plants began to take over the process in late summer, Ames gradually cut its output of virgin metal.[181] Electromet began its reduction and casting operations in July 1943, and Mallinckrodt followed suit only a few days later. DuPont was the third company to take over the commercial production of uranium. Westinghouse, which had been producing metal by its electrolytic process, also scaled down and closed its operations in the fall of 1943 when the three other companies took over the Ames Process.[182]

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[179] Peterson, interview with author, 1990, 6.; Wilhelm, "A History of Uranium Metal Production in America," 44. Several reports for early 1943 also review the casting processes for working with metal production. See for example: C F Gray to F. H. Spedding, "Report on Casting Contributions from February 42 to December 1943," Ames Laboratory Papers.

[180] Peterson, interview with author, 1990, 7.

[181] Wilhelm, "A History of Uranium Metal Production in America," 46; Fulmer, 11-12.

[182] Wilhelm, "A History of Uranium Metal Production in America," 46.

After the virgin metal program diminished in 1943, Ames started uranium recovery from scrap metal turnings from Ames and other places. Ames constructed a brick one-story building in 1944, called the Physical Chemistry Annex 2, for running this simple recovery process.[183] Turnings, first dumped into barrels, were pulled apart and examined by hand for uranium. Passing over a magnetic separator to remove iron and other metallic impurities, the turnings proceeded to a cutter where they were in turn cut, washed, rinsed, dried, sorted and passed again over a magnetic separator. They were pressed into briquettes about 1-inch by 4.25 inches in diameter and sent to the casting room to be melted into regular sized ingots. Ames recovered and shipped over 600,000 pounds of scrap uranium using this process. In December 1945, the method was taken over by Metal Hydrides in Massachusetts and by a recovery plant that had been recently constructed at the Hanford Reactor in Washington.[184]

Iowa State College discontinued most uranium operations on August 5, 1945, coinciding with the end of the war. In the later phases of the war though, the Iowa State group was already more actively involved in metal recovery and research investigations with castings and rod development than with the actual production of virgin metal. Iowa State produced over one thousand

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[183] This building was constructed by contract from the federal government in 1943 and completed in 1944. It was a U-shaped building constructed near the power plant and generally referred to as Chemistry Annex #2. In 1953, the College purchased the building from the Atomic Energy Commission. It became known as the Plumbing Shop and housed Iowa State's Credit Union until that organization erected a new building. The Plumbing Shop was torn down in 1972. Day, 1980, 384; *Minutes of the Board of Education*, March 23, 1944, 298.

[184] Fulmer, 13-14. For treatment of this topic in more detail, see Warner, "Large-Scale Casting," 183-186.

tons of uranium from 1942 to 1945, keeping the pilot plant in operation twenty-four hours a day, seven days a week during the peak months. The Electromet and DuPont metal production facilities were terminated at the end of the war also, leaving only Mallinckrodt producing virgin metal and Metal Hydrides overseeing the turnings recovery program.[185]

Thorium production

The largest quantity of metal produced at Ames after uranium production declined was thorium. Thorium had been considered an alternate to plutonium in an earlier experiment in 1942, when Glenn Seaborg successfully bombarded its nucleus. Thorium decayed to U_{233}, a highly fissionable isotope of uranium. But it was not pursued in earnest at that time because the scientists would have to modify the reactors at Hanford to handle the separation. By 1944 though, the Chicago people believed that starting a pile with uranium and adding only more thorium as a blanket would keep a chain reaction sustained. That made thorium a most important metal for the rest of the war years.[186]

Iowa State had started to work on thorium production as early as 1943, trying to reduce it using the uranium process. However, those early attempts at reduction were unsuccessful, primarily because of the high melting point of thorium.[187] Finally in 1944, the scientists found that if they used zinc chloride

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[185] Wilhelm, "A History of Uranium Metal Production in America," 48.

[186] Hewlett and Anderson, 296-287.

[187] See, for example, the weekly reports of Norman Carlson for July 5-12, July 19, July 24, July 31, August 7, and August 14 for results of his work on trying to produce pure thorium from thorium tetrafluoride and thorium oxide without much success. The high melting point created a problem with each of his experiments. See also Spedding, Wilhelm, Daane

as a booster they could get a zinc thorium alloy When the alloy was heated, zinc was driven off and thorium remained. The success of this reduction process depended in part upon the vastly-improved high-vacuum process recently instituted by scientists on the project.[188] The metal was cast into up to 150 pound ingots with beryllia crucibles. By December 1946, Ames had produced and shipped over 4,500 pounds of thorium metal to various sites. Before the war, the price had been about $3 per gram. By 1946, Ames had made a purer metal and reduced the cost to about 5¢ a pound.[189]

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interview, 1967, 22-23. Other reports explaining the extraction process include research reports by Ward Lyon (Report No. CT-891, Technological Research—Metallography Part II of Report For the Month Ending August 23, 1943) who worked with Carlson and a review of thorium successes and failures in "Thorium Studies," Report No. CT-1985, Technological Research—Metallography Report For the Period October 10-November 10, 1944, 3-15.

[188] Fulmer, 17; Svec, "Interview with the author," 7. Svec was hired and placed in the Physical Chemistry Annex because of his undergraduate experience with high vacuum and gas flow technologies. He improved the vacuum systems so that thorium could be produced more easily. For more technical studies on thorium reduction and production see H. A. Wilhelm, A. S. Newton, A. H. Daane, and C. Neher, "Thorium Metallurgy," Chapter 8 in *Production and Separation of* U^{233}*: Survey*, edited by Glen T. Seaborg and Leonard Katz, National Nuclear Energy Series, Division IV, vol. 17A (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 186-218; F. H. Spedding, et al., "Production of Thorium Metal by Metallothermic Reduction of Thorium Fluoride," Paper 8.4 in *Production and Separation of* U^{233}*: Collected Papers*, edited by Glen T. Seaborg and Leonard Katz, Nuclear Energy Series, Division IV, vol. 17B (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 428-445; W. H. Keller, Ward L. Lyon, Harry J. Svec, and Richard Thompson, "Casting of Thorium Metal and Some Properties of the Cast Metal," Paper 8.5 in *Production and Separation of* U^{233}*: Collected Papers*, edited by Glen T. Seaborg and Leonard Katz, Nuclear Energy Series, Division IV, vol. 17B (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 428-445; A. S. Newton et al., "A Pilot Plant for Purification of Thorium Nitrate by Countercurrent Extraction," Papers 8.6 in *Production and Separation of* U^{233}*: Collected Papers*, edited by Glen T. Seaborg and Leonard Katz, Nuclear Energy Series, Division IV, vol. 17B (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 486-507.

[189] Fulmer, 19. Several research reports were turned in to Chicago on thorium metal reduction and are today located in the Oak Ridge Laboratory under the Department of Energy, Oak Ridge, Tennessee. For a listing of the complete list of reports on thorium, see Fulmer, Appendix I. One report is located in the Ames Laboratory Papers: A. Newton, et al., "The

Other materials supplied by the Ames Project

The Ames scientists experimented with more than uranium, especially as the demand for its production began to wane in late 1943. In 1944, several sites working with plutonium, needed crucibles made from a cerous sulfide. Ames discovered a way to reduce anhydrous cerous chloride with calcium to get a ninety-nine per cent pure metal. After problems with the casting procedures were solved, the first pure metal was shipped from Ames in August 1944. Over 425 pounds of this product was produced at Ames until August 1945, at which time that operation was also discontinued.[190]

Ames also received requests from several sites during the war to produce small quantities of pure rare earth metals discovered in the reduction processes. Ames started a small program during the war, continuing to produce pure quantities of these rare metals well after the war. In fact, this

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Preparation of Anhydrous Thorium Fluoride for Metal Production," Report CC-2713, Physical and Inorganic Section Report for April 25, 1945.

[190] Fulmer, 15-16. See also C. Banks, et al., "Notes on Miscellaneous Reactions and Properties of Cerium, Thorium, and Uranium Compounds," Report CC-2942, Analytical Section Report, July 15, 1945. For more technical studies see W. H. Keller, Robert P. Ericson, and Clifford Hach, "The Production of Cerium in the Massive Metallic State," Paper 4 in *The Chemistry and Metallurgy of Miscellaneous Materials: Papers*, edited by Lawrence L. Quill, National Nuclear Energy Series, Division IV, vol. 19C, (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 32-36; David Peterson, Ward Lyon, and W. H. Keller, "The Casting of Cerium and Some Properties of the Cast Metal," Paper 5 in *The Chemistry and Metallurgy of Miscellaneous Materials: Papers*, edited by Lawrence L. Quill, National Nuclear Energy Series, Division IV, vol. 19C, (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 37-40; J. E. Powell, Clifford Hach, and R. W. Nottorf, "Recovery of Iodine from Cerium Slag," Paper 6 in *The Chemistry and Metallurgy of Miscellaneous Materials: Papers*, edited by Lawrence L. Quill, National Nuclear Energy Series, Division IV, vol. 19C, (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 41-42.

program, though small during the war, became the mainstay of the Ames Laboratory after the war.[191]

Chemical and Metallurgical Research at Ames Project 1943-45

Chemical and metallurgical research, though completed in the Chemistry Building, was tied very directly to the production process in the Physical Chemistry Annexes 1 and 2 When discoveries were made in the laboratory, they were, in a sense, tested with the production line. Improvements that were made in production were based upon research accomplishments, and failures with runs, in turn, gave the research teams additional problems to study. As noted earlier, there were several research groups established in Ames to complement the research studies at the Metallurgical Laboratory in Chicago.

The Ames scientists examined hundreds of problems, adding significantly to the existing knowledge about the chemistry of materials used in the atomic bomb project. These scientists at Ames discovered new melting points of various compounds and rewrote the existing textbooks on other physical properties like viscosities, reduction characteristics, and isotope separation techniques. Diffusion studies of fission products became a new field of science during the war, and studies undertaken at Ames greatly added to the knowledge of what happened when uranium split into its various forms. The

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[191] Fulmer, 16-17. For the beginnings of rare earth chemistry using the adsorption column, see Spedding et al., "Preliminary Report on a Rapid Method for Separating Rare Earths," Report CC-2720, May 9, 1945. For a later more comprehensive report see Spedding, et al., "Progress Report on the Adsorption Process for Separating the Rare Earths," Report CC-3248, February 26, 1946.

basic studies of uranium included in depth studies of its hydrides, chlorides and other salts. Plutonium chemistry, a small research effort at Ames, became an important part of the project when research on the element as well as the personnel involved were removed to Los Alamos. Elements like thorium, cerium, and beryllium were examined as their reduction methods were worked out at Ames. Rare earth chemistry was studied in great detail, and the beginnings of the separation of very pure materials began during the war.[192]

Summary

The development of the atomic bomb depended upon the kind of research and development work at the Ames Project. Even though production became an important activity, the Ames Project functioned primarily as a research and scientific laboratory. Spedding created the organization as a supplement to the Chicago research efforts with teams of scientists working on and solving problems related to the chemical and metallurgical aspects of producing an atomic weapon.

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[192] See the various chemical and metallographical reports produced from the Ames Project 1942-1945. Some of them have already been discussed in a previous footnote. See also, "Review of Metallography of Uranium and Some of its Binary Alloys," Report CT-1062, November 15, 1943 for a review of uranium, including its melting point. other physical properties, and alloy systems with magnesium, aluminum, copper, etc. See also, for example, Wayne Keller, "Research Studies on Uranium-Magnesium," CT-609, Technological Research-Metallurgy, Part II of Report for the Month Ending April 24, 1943, 15-22 for research studies on conditions affecting the union of the two elements, such as liner materials, the effects of temperature, and purity of materials. For the entire list of research-related reports, see Fulmer, Appendix I. Also see F. H. Spedding et al., "The Production of Beryllium by the Metallothermic Reduction of Beryllium Fluoride," Paper 7 in *The Chemistry and Metallurgy of Miscellaneous Materials: Papers*, edited by Lawrence L. Quill, National Nuclear Energy Series, Division IV, vol. 19C, (Washington, DC: Atomic Energy Commission; Elmsford, NY: Microforms, International, 1977, microfilm), 43-48.

The Ames Project was additionally a pilot plant, developing the bench work on the assembly line. Though there were some factory and clerical workers with non-scientific backgrounds, the vast majority of those involved at Ames were academics—professors, graduate students in chemistry, and undergraduate students with backgrounds in the sciences. The assembly line activity was a complement to the research just as the research problems often occurred because of failures in the assembly line.

PART 2. ISSUES OF ADMINISTRATION

INTRODUCTION: THE ACADEMIC VS. THE MILITARY STYLE OF MANAGING RESEARCH

Background

Since scientific research and development were major parts of the laboratory at Ames, the administration reflected that of a typical university research laboratory in most respects. However, there were some new issues of administration that greatly affected this essentially academic laboratory, and in subtle ways changed it from a typical research laboratory located on a college campus. This war introduced the scientist to the military and other government agencies. In turn, the government, and, particularly the military, found it necessary to deal with the academic scientist in order for the atomic bomb to be built.

The Academic Management Style

The Ames Project was first and foremost an academic laboratory, developed partly out of the experiences and expertise of its founder and director Frank H Spedding. Spedding studied at Berkeley in the late 1920s where many of the ideas about organizational structures that were eventually incorporated into the Manhattan Project already existed. A typical graduate student at Berkeley worked with a research director and a group of students examining critical chemical problems as determined by that group leader. Spedding's experience with the particular type of academic activity at Berkeley—seminars, group meetings and work with sophisticated equipment—probably inspired him to institute that mode in his Ames laboratory. Daniel J. Kevles, in his study of physicists, labeled the Berkeley style of academic management *group research*. Developed in part because of the ratio of students and faculty, and, in part, because of the sophisticated nature of scientific apparatus like the cyclotron at Berkeley, physics, and to a great extent some fields of chemistry, gradually grew into big project disciplines with a complicated array of technicians, students, theorists, and experimentalists.[193] By the time of the Manhattan Project, run scientifically in most part by the physicists, group research was a well-established part of the academic research structure at most larger institutions.

While it is true that Iowa State before World War II had no sophisticated equipment, and though Spedding and his small group of graduate students could hardly be characterized as group research in the Berkeley tradition, he, nevertheless, was familiar with the concepts of large academic research and adopted that model for his laboratory, following closely the one already in existence at the Metallurgical Laboratory of the University of Chicago. Spedding stated in 1943 that he organized his group at Ames with this team approach because of the youth of his scientists, but it is just as likely that he saw an opportunity to establish a research structure with which he had become familiar at Berkeley.

In fact, the structural organization of the atomic bomb project from top to bottom included the management apparatus of a typical large academic organization, complete with committee meetings, ad-hoc review studies, and countless group leaders who had wide latitude in choosing research problems

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[193] Kevles, 283-284.

to study. Vannevar Bush, who created the National Defense Research Committee (NDRC), which was discussed in a previous chapter, used these tools to set up the governmental unit that originally oversaw atomic research. He chose good research directors and allowed them the flexibility to develop their own laboratories with little interference from his office. He also used the review committee approach to continually study the progress of research on the atomic bomb.[194]

NDRC, as an organization, oversaw weapons research that eventually could be turned over to the military to develop into war devices. NDRC took as its organizational model the Council of National Defense, a World War I advisory unit under the Executive Branch that was constituted from the cabinet members of War, Navy, Interior, Agriculture, Commerce and Labor. The Council of National Defense coordinated industries and other resources for national security.[195] Since the law constituting that body had never been repealed, Bush hoped that his new agency could work directly under the Executive Branch receiveing its funds. Roosevelt indeed approved that plan. NDRC, a loosely-based 10-person committee outside the normal channels of government, included only four predetermined members (the President of the National Academy of Sciences, the Commissioner of Patents, a representative of the Navy, and an officer from the Army).[196]

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[194] For a more complete discussion of the academic styles of Bush and Conant who ran the project at the national level, see Montgomery Cunningham Meigs, "Managing Uncertainty: Vannevar, James B. Conant and the Development of the Atomic Bomb: 1940-1945" (Ph.D. diss., University of Wisconsin, 1982).

[195] Vannevar Bush, *Pieces of the Action* (New York: William Morrow, 1970), 36; Dupree, 305.

[196] Bush, *Pieces of the Action*, 36-37; Dupree, 370

Even though Bush later called this organization pyramidal (a military-type according to his own definition of organizations),[197] he certainly described a characteristically academic management style:

> [an] organization, with broad delegation downward, and full facility for programs to move up. Each [member] then built under him a system of sections to deal with explicit problems, and each recruited his personnel for the purpose.[198]

The NDRC had not been as broad-based in its coverage as Bush wanted, so the Office of Scientific Research and Development took its place in 1941. The NDRC became one of its branches as did the uranium committee. Abandoning the committee management structure at the top, OSRD placed Bush directly responsible to the President, but sub-committees and research directors still held independent control over their own laboratories.

The Establishment of the Manhattan Engineer District

In early 1942 under OSRD, the scientific program proceeded sporadically. By summer, many of the problems in procuring raw materials were solved, but no single uranium separation process seemed to be the winner in what became known as the four-horse atomic bomb race.[199] The Top Policy Group, which consisted of Vice President Wallace, Secretary of War Stimson, Army Chief of Staff George C. Marshall, James Conant, and Vannevar Bush, began to consider

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[197] In *Pieces of the Action* (27-31), Bush discusses the traits of a military style and one of them is pyramidal or hierarchical control.

[198] Bush, *Pieces of the Action*, 37.

[199] For a complete description of the four separation processes (the gaseous diffusion, electromagnetic, and centrifuge methods for uranium and the plutonium separation from irradiated uranium method), see Smyth, 154-205.

when to bring in the Army to build the full-scale construction plants, and by June 13, 1942, Bush and Conant recommended that the separation and power plant construction be turned over to the Army, specifically to an officer designated by the Army Chief of Engineers, by the end of the summer of 1942.[200] The Top Policy Group sent the recommendation to the President who signed it on June 17, 1942. On June 18, 1942, the Army chose Colonel James C. Marshall to organize a new district within the Corps of Engineers to oversee construction of the atomic bomb's full-scale separation and power plants. That district, called the Manhattan District, because of its headquarters in New York came into existence on August 13, 1942. Though it was officially designated the DSM Project (Development of Substitute Materials), the Manhattan Project became its popularly known name.[201]

Marshall, as the new district engineer, began to form his staff and open his offices. His organization was by and large pyramidal, more rigid than the OSRD structure, and certainly by Bush's definition a *military* organization.[202] Most district engineers were responsible to a geographically-placed division engineer, but because of the special nature of the atomic bomb district, Marshall was directly responsible to the Chief of Engineers, Major General Eugene Reybold. More often though, Marshall's contacts were with Brigadier General Thomas M. Robins, who was in charge of construction, and his

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[200] Jones 38-39; Smyth, 82.

[201] Jones 43-44; Smyth, 83.

[202] Bush, *Pieces of the Action*, 27. Bush defined a military organization as "pyramidal, with lines of authority explicitly clear and positively enforced. The object is to ensure that every need for a decision promptly finds an individual who can and must decide, but no commander shall thus become burdened with more than he can handle."

assistant, Colonel Leslie R. Groves. Marshall opened a liaison office in Washington, D.C., depending there on Colonel Kenneth Nichols, an officer who had previously served under him. At the headquarters in New York, he received assistance from the North Atlantic Division and also the New York office of Stone and Webster, a large engineering firm that Marshall designated as the main contractor for the new district.[203]

In the late summer of 1942, this split administration of the atomic energy program caused a great deal of confusion. The Army men, for example, had little experience with atomic energy; they had few good personnel since most military personnel were in demand for more critical assignments; and the new organization had little respect or power within the Army, despite the promises of support from the War Department. Additionally, Marshall was ineffective as a leader, displaying his lack of leadership in two areas that caused particular concern—the selection of the site for a production plant in Tennessee and the problem of obtaining a high priority for the raw materials needed for the atomic bomb project.[204]

The selection of the Tennessee site dragged throughout the summer, and in August, Marshall finally delayed the selection of a site altogether. The OSRD and the Army came to a standstill with no organization to coordinate the two groups or solve the site problems. Obtaining priority ratings also affected the relationships between OSRD and Army negatively. It became an impossible situation when both the OSRD and the Army fought for high

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[203] Hewlett and Anderson, 74-76.

[204] Hewlett and Anderson, 75-76.

priority ratings. The rating system covered AA-1 to AA-4 in descending order for major programs with a special emergency priority rating of AAA assigned to projects that had short-term delivery demands in critical situations. Unfortunately, Roosevelt had not been specific in determining what priority levels he wanted for the new program; he implied it should be given a relatively high rating, though balancing its needs against other projects.[205] In July, the atomic research project received a AA-3 rating from the Army and Navy Munitions Board, the governing agencies. The rating came as a great disappointment to OSRD and the Army, but the AA-1 and AA-2 ratings were reserved for very critical projects that needed materials, those like weapons, airplanes, and tanks. This unproved project with its estimate of producing a weapon as late as 1945 probably fared much better than could be expected.[206]

By the end of August, Bush realized he needed to rethink his June reorganization scheme; he began to doubt that the project could become a reality under the present circumstances. The Army was also aware of the ineffectiveness of the new organization and in September, Lieutenant General Brehon Sumervell, the chief of the Services of Supply (the construction wing of the Army Corps), decided to meet with Colonel Leslie Groves and offer him command of the entire atomic bomb operation, though evidently without Bush's knowledge. Bush and Sumervell had discussed the idea of a Military Policy Committee to put some clear-cut authority into the Army's part of the

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[205] Jones, 57.

[206] Jones, 58; Hewlett and Anderson, 79; K. D. Nichols, "Memo on Preference Rating for D.S.M. Project in *MED History Book* I, Vol. 9, A-3.

project, but Bush had assumed that this committee would select the person to be in charge only after it had been organized.[207]

On September 17, 1942, Colonel Leslie Groves thought he was going overseas to direct a wartime unit, but his supervisor, Sumervell, told him that he had been assigned to a new position, one that might, in fact, win the war. Since he had been involved in the early organization with Marshall, Groves knew a bit about the work. He accepted the new post and even received a new commission of Brigadier General just before the official announcement was made.[208]

Groves met with Bush, and even though an initial first meeting did not go well at all, Groves was later given the blessing of the OSRD head. Groves proved to be a man of immediate action. On September 19, he called upon Donald Nelson, head of the War Production Board, about the priority rating situation. At first Nelson told him he would not raise the rating, but after Groves threatened to go to the President and abandon the entire project because the War Production Board would not cooperate, he quickly reversed himself. Groves left with the following letter in his pocket:

> I am in full accord with the prompt delegation of power by the Army and Navy Munitions Board, through you, to the District Engineer, Manhattan District, to assign an AAA rating, or whatever lesser rating will be sufficient . . .[209]

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[207] Hewlett and Anderson, 81.

[208] Groves, 3-5; Smyth, 83.

[209] Quoted in Groves, 22. The letter was also quoted in a September 26, 1942 memo from Theron D. Weaver to Groves located in the *MED History*, Book I General, Volume 9 Priorities Program, Appendix A-6.

Groves also contacted Nichols on September 17, and commanded him to procure the supply of uranium ore so desperately needed by the scientists. Nichols luckily found a Belgian company ready to sell some 1,250 tons of the ore valued at more than $2 million stored in a Staten Island warehouse. The fast-acting General had won another victory.[210]

The governing group, the Top Military Policy Committee, finalized on September 23, 1942, consisted of Vannevar Bush as Chairman, James Conant as an alternate chair, Lt. Gen. William D. Styer from the Army, and Rear Admiral William R. Purnell of the Navy. Another example of the academic controlling management style, the committee served as a governing board of directors for Groves. It met frequently, but had no staff or support personnel; it kept no formal records, but followed and discussed every important event in the atomic bomb development.[211]

On September 23, after hurriedly leaving that initial meeting of the Military Policy Committee, Groves caught a train to Knoxville, Tennessee, hoping to procure land for the Tennessee site. The next morning after an inspection of the site, he telephoned the Corps of Engineer's real estate branch requesting them to start the land acquisition. It was an auspicious beginning for the new commander, who had been in charge for only seven days.[212]

However, Groves met his first real bottleneck when he left Washington, his personal choice of headquarters, for a tour of the research facilities in

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[210] Wyden, 57-58.

[211] Bush, *Pieces of the Action*, 61-62.

[212] Jones, 78.

Chicago and California on October 5. At the Metallurgical Laboratory, he had the first look at the insurmountable task before him when he, in engineering fashion, asked the physicists for an estimate on the amount of material needed for a bomb. The scientists replied that their estimates were accurate to at least a factor of ten. Later, Groves recalled his reaction:

> While I had known that we were proceeding in the dark, this conversation brought it home to me with the impact of a pile driver. There was simply no ready solution to the problem that we faced, except to hope that the factor of error would prove to be not quite so fantastic.[213]

Iowa State College and the Manhattan District

Although the Manhattan Engineer District was originally formed to oversee engineering plant construction, by August 1943, the entire project fell under Groves' jurisdiction. Iowa State's production unit had initially come under District control in late 1942, but by July 1943, its research contract was under District control also. Iowa State was a part of the Madison Square District (see two organization charts in Appendix C) under the Feed Materials Program.[214] Essentially, the program was divided into seven areas as seen in the chart to supply critical materials like uranium, uranium oxide, uranium tetrafluoride, and thorium products to the rest of the atomic bomb project, all under the direction of Captain John R. Ruhoff, the chemical engineer who had earlier helped work out the ether separation of uranium at Mallinckrodt

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[213] Groves, 40.

[214] The entire organization is described in *MED History*, Book 7, Vol. 1 Feed Materials and Special Procurement. I have used Jones' summary (307-318) because that portion of the *MED History* in the microfilm edition was still classified when the microfilm was released.

(visited by Compton and Spedding in early 1942) Two of the areas, Murray Hill and Colorado, controlled the procurement of materials while the other five, including Iowa State, processed the ores into fuel elements. Three steps in the processing stage included the conversion of black oxides into brown or orange oxides, the conversion of brown or orange oxides into green salts, and the conversion of green salts into uranium compounds or metallic uranium. Mallinckrodt, DuPont, and Linde composed the brown and orange oxide parts of the network while four chemical firms, Harshaw, Mallinckrodt, Linde, and DuPont formed the green salt link. Four commercial firms, Mallinckrodt, DuPont, Electro Metallurgical, Metal Hydrides, and Iowa State College constituted the uranium metal portion of the network. By late 1943, the delivery of nearly 3,500 tons of metal had come from the contractors, 900 tons from Iowa State alone, second to the 1,000 tons from Electro Metallurgical.[215]

Organizationally, the Iowa Area controlled the Manhattan District side of the Ames Project. Though little contact existed between the Ames scientists and the District employees, there was a group of men and women stationed at Iowa State College to oversee security, financial concerns, and shipments of uranium in and out of the College. These Manhattan District personnel were housed in the Collegiate Press Building across the street from the Physical Chemistry Annex I. Most of the personnel were lawyers, business persons, and other non-scientists with little experience in academic management.[216]

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[215] Jones, 309-316.

[216] There is little direct documentation on what this organization actually accomplished at Iowa State College. Most of the scientists interviewed remembered that these people were on campus, but they thought they were responsible for activities like obtaining hard-to-acquire equipment, controlling the train movement in and out of campus, and conducting periodic security inspections. (Carlson, interview with author, 1990; Peterson

At Iowa State, as at other installations, the Manhattan District set in place a parallel military structure. The scientists still ran the site's scientific research for the atomic bomb, but the Manhattan District added staff in the three areas it considered under military control—security, finances, and worker health and safety. Although the laboratory remained an academic laboratory by and large, basic differences in the administration of the atomic bomb project and the administration of a typical academic research project did arise. Those differences are detailed in the next sections of the dissertation, including the effect of compartmentalization on academic research, how contracting changed the financial management of research, and, finally, how the attitude toward the special hazard, radiation, contributed to the standardization of health and safety regulations.

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interview with author, 1990; Wilhelm, interview with author, 1990; Frank Spedding, "Safety Inspections," Spedding Manuscript, 102; Frank Spedding, "My Personal Contacts with General Groves," Spedding Manuscript, 1-2.) Evidently, the Iowa Area at one time encompassed St. Louis as well as Iowa and even some of the Manhattan District personnel themselves were not so sure of its status. Frank Huke, one of the earliest of the Manhattan District employees located at Iowa State wrote in 1943, "I would like a little clarification of the set up out here. We hear variously that Ames is an Area, is not an Area; I'm being transferred to St. Louis and then I'm not, etc." (Frank Huke, "Memo to Major G. W. Russell at Madison Square Area," September 15, 1943, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN, Miscellaneous Papers on Iowa State College, hereafter known as the Oak Ridge Papers.) The District Office assured him, "Although formal notification to the effect that Iowa has been designated as a an area has not yet been received from the District Office, for all intents and purposes Iowa is considered by this office to be an Area. You are accordingly considered assigned to the Iowa Area." G. W. Russell, "Letter to Frank Huke from the Madison Square Office," September 22, 1943, in the Oak Ridge Papers. Some of the financial duties, at least, were detailed in J. King, "Letter to Frank Huke from Madison Square Area on Purchase Orders and Vouchers," February 29, 1944, in the Oak Ridge Papers.

SECURITY REGULATIONS AND REQUIREMENTS

Introduction

Security measures among scientists developed before either Vannevar Bush's OSRD or the Manhattan Engineer District, even though these agencies contributed important security regulations that helped solidify governmental control of research during the war. As early as 1939, Leo Szilard, Enrico Fermi, and several other émigré scientists debated publishing the results of their atomic research. Szilard, the most vociferous of the group, urged his fellow scientists to withhold publication of any mention of a chain reaction or the development of atomic weapons. He was particularly upset that Henri Joilet in France, who was working with radioactive fissionable elements, periodically published his research findings. Spurred by his fear of a world war that might conclude with domination by the Nazi regime, Szilard had been a proponent of restrictions on publication since he assigned his own chain reaction patent to a secret British governmental agency in the early 1930s. Szilard also admitted to influence from authors like H. G. Wells, a popular science fiction writer, who had predicted destruction of the world by atomic bomb as early as 1913.[217] By 1939, Szilard was a vocal proponent for security and non-disclosure of atomic research results.

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[217] The book was H. G. Wells, *The World Set Free* (New York: Dutton, 1913), 40-149. Szilard supposedly read the book in 1932, before he was involved in nuclear physics. He claims it was one of the things that influenced his beliefs about security of this type for atomic energy. Wells tells the tale, according to Szilard, that the war was fought by an

Szilard's initial efforts brought him no success, but at a meeting of the National Research Council in 1940, Gregory Breit proposed controls on the publication of articles on atomic energy in American scientific journals through a censorship committee The Reference Committee, established later that year, controlled publications in all fields of military interest. Gregory Breit chaired a subcommittee on uranium fission publications, which reviewed journal articles submitted to it from editors of scientific journals. This censorship process was voluntary and completely in control of the scientists and journal editors. However, by the time the war was well underway, virtually no articles received review, since the Manhattan Project oversaw all uranium work and security rules permitted no publications of any kind in commercial journals.[218]

The OSRD and NDRC Security Policies: A Summary

It was Vannevar Bush, however, who had more influence on the policies of security for atomic research than Szilard or the Reference Committee. Vannevar Bush, in setting up the NDRC and OSRD, added security and the concept of *compartmentalization* to the agency, a policy that even Szilard later argued against.

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alliance of England, France, and America against Germany and Austria. In this war set in 1956 the major cities of the world are destroyed by atomic bombs. (Paraphrase by Szilard in Weart and Szilard, 16.)

[218] Smyth, 45-46; Spencer R. Weart, "Scientists with a Secret," *Physics Today* (February 1976): 30.

In June 1940, when Bush established the National Defense Research Committee, he placed the Committee on Uranium as one of its subcommittees. By becoming a part of that federal agency, NDRC became subject to federal security regulations. The Committee, knowing that its projects would be involved in areas of interest to the Navy and Army, adopted regulations that conformed with military ideas about security.[219]

After Bush began to reorganize research on the atomic bomb under the aegis of his new agency, the OSRD, secrecy became one of the chief tenants of management policy. In October 1941, the meeting at which Bush briefed the President and the Vice President on the developments of atomic research, Bush had asked for reorganization; the President, in turn, insisted upon the utmost secrecy for continuation of the project. Roosevelt and Bush established a Top Policy Group headed by Vice President Henry A. Wallace, with Secretary of War Henry L. Stimson, Army Chief of Staff George C. Marshall, James Conant and Vannevar Bush who would develop policies for the reorganized research efforts in secret.[220] That meeting actually secured the atomic bomb project as a practical reality and officially brought the Army into the project. The policy group also incorporated Bush's ideas for secrecy and compartmentalization. Since OSRD left so much of the security arrangements to the individual sites, it actually instituted a modest security system that

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[219] Jones, 254; Irvin Stewart, *Organizing Scientific Research for War: The Administrative History of the Office of Scientific Research and Development* (Boston: Little, Brown, 1948): 27-31; James Conant, *My Several Lives* (New York: Harper and Row, 1970): 245.

[220] Meigs, 41; Jones, 31.

worked well enough until the expansion of the uranium production program began to tax OSRD's very existence as a secret organization.

The Manhattan Engineer District immediately remedied the somewhat complacent attitude towards security under OSRD. Colonel James Marshall in June 1942, installed the Protective Security Section for a personnel security program, a plant security system, and a program for protecting information of military importance.[221] When the District headquarters moved from New York to the Clinton Engineer Works in August 1943, the Protective Security Section combined with the Intelligence Section, and security became centralized into one unit called the Intelligence and Security Division. At that point, many of the security measures once administered by laboratories and companies were standardized, and the Manhattan District eventually assigned security officers to every installation.[222]

Specific Security Procedures: An Overview

The Ames Project came into existence in February 1942, so OSRD originally directed its security. With the establishment of its production plant though, that unit received a contract directly from the Manhattan Engineer District while scientific research continued under OSRD until mid-1943, when those contracts as well were transferred to Groves' operation. Under the Manhattan District, Iowa State's security was the responsibility of the Chicago Branch Office of the Intelligence and Security Division with Captain J. Murray

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[221] *MED History*, Book I General, Volume 14 Intelligence and Security, 7-1.

[222] Jones, 256-259.

in charge.[223] The Manhattan Engineer District did not dismantle the OSRD scientific organization, although an extra layer of administration paralleled the scientific structure. Security regulations covered personnel clearance, document protection, materials shipping security, plant security, and compartmentalization of information. Although scientific research reporting remained under the command of the Chicago Metallurgical Laboratory, these security procedures changed the nature of the academic administration, if not the research itself.

Personnel and Security Clearances

Procedures at the federal level

Under the NDRC rules, each member of the Committee as well as any division or section worker, including clerical staff appointed to work for the committee, was required to take an oath of allegiance and secrecy not to release any information about the special work undertaken. To impress upon academic laboratories the importance of secrecy, official investigators in charge of projects with contracts from the committee were sworn to secrecy, never to discuss the results of research with any persons but those in the contracting research groups or with the NDRC Committee.[224]

Personnel clearance background checks of official investigators began to present the Committee with problems almost immediately, since there was no internal NDRC staff to conduct the background checks. Originally, a

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[223] *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix A-7 Organization Chart, Intelligence and Security Division.

[224] Stewart, 27-28.

biographical sketch of an individual seeking clearance had to be sent to the Army or Navy. The receiving agency sent back a clearance report, but as more and more people were added to the project, the branches of the services became overloaded. By late 1940, there were calls for special investigators to be assigned to the work, and in early 1941, the Secret Service and some other agencies were beginning to be brought into the security clearance process. Delays in the process sometimes kept people from attending important meetings or conducting research for several months.[225]

Under OSRD, the above rules and regulation continued. Each contracting unit signed a standard contract which set forward the exact personnel security provisions: no disclosure of information obtained as a result of a contract with OSRD unless prior approval given; reporting to OSRD any acts of espionage; prior permission from OSRD for hiring aliens; reporting citizenship of all employees on contract to OSRD; and hiring no one on the list of undesirables retained by the agency.[226]

OSRD investigated the lead researcher but left the clearance of other employees up to the individual contractor. OSRD did admit that all classified workers should be checked, but since it never developed consistent procedures for implementation, clearance procedures varied widely from contractor to contractor. Originally, OSRD used both the Army and Navy for its investigations, but after June 1942, when the Army came into the project, they alone were in charge. By the next year, OSRD turned all atomic research

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[225] Stewart 30-31.

[226] Stewart, 247.

contracts, including security regulations, over to the Army's Manhattan Engineer District.[227]

The Manhattan Project security system for personnel differed in several respects from the old OSRD system. Under OSRD there were no agencies outside the military involved in the clearance of personnel. Groves instituted a program of clearance for all personnel, with the FBI and Office of Naval Intelligence assisting in personnel backgrounds clearances.[228] Starting in the fall of 1942, all personnel were either *classified* or *unclassified* workers. The classified employee, underwent different procedures according to modifications over time, but all had to undergo an identification process by filling out a personnel security questionnaire or personal history statement; each person was finger printed and had to provide proof of citizenship; each employee had to read and sign a copy of the Espionage Act or a secret agreement oath; and no one had access to any information until clearance was received. Over 400,000 employees participated in this process from July 1942 until August 1945.[229]

Personnel clearance at Iowa State College

Iowa State College followed these same procedures in the clearance of its personnel. Workers on the project remember clearly that they signed oaths of allegiance and later filled out personnel questionnaires. No man or woman was allowed to work on the actual project until clearance was received.

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[227] Stewart, 248-249.

[228] *MED History*, Book I General, Volume 14 Intelligence and Security, S2.

[229] *MED History*, Book I General, Volume 14 Intelligence and Security, S3-S4.

sometimes taking as long as three to six months. In this limbo position, an uncleared employee typically sat in the library reading literature on the chemistry of certain alloys or elements that might become useful later; or, sometimes he or she conducted simple measurements, cleaned apparatus, or ran miscellaneous errands. When clearance was received, the scientist was brought before Spedding and told about the secret war-related project. It did not take much knowledge of chemistry, according to some of the young scientists, to understand very early on that uranium was being worked with. Each man or woman was told as much as needed to conduct experiments or work on the production line. Though there was not much interaction between the production plant and the chemistry research areas, personnel had some knowledge of each installation.[230]

There were only a few instances in the written documentation when potential employees for the Ames Project were rejected based on the clearance procedures. Early in the project, the most notable example was Kasmir Fajans from the University of Michigan, who was supposed to come to either Chicago or Ames and head a research group along with three of his former graduate students—Amos Newton, Adolf Voigt, and William Sullivan. Unfortunately, because he had relatives in Poland under Nazi domination, he was never cleared to become a part of the project.[231] His former graduate students did

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[230] Peterson, interview with author, 1990, 1-2; Frank H. Spedding, "Security," Spedding Manuscript, 1-2; Frank H. Spedding, "Problems Encountered with Setting and Maintaining a Security System," Spedding Manuscript, 1-2.

[231] Correspondence between Kasmir Fajans and Frank Spedding, May 11, 1942, May 12, 1942, May 14, 1942, May 23, 1942, May 29, 1942, June 24, 1942, and August 10, 1942, Spedding Papers.

come to Ames and each headed a scientific research group. Although the investigators asked questions about any liberal leanings or Russian connections of the individuals to be hired on projects, they were most concerned with those who had German connections. Occasionally, Spedding had to go to bat for one or more of the people he wanted to hire, but generally they were cleared with few complications.[232]

Few security breaches occurred in the personnel area, but one incident certainly proved embarrassing to the Army. Since chemists were desperately needed on the Ames Project, it was sometimes faster to obtain military men who had already received clearances and have them transferred to work on the project, but in civilian clothes. In 1943, Spedding traveled to Washington to select twenty scientists from the Army pool, who were also military men, to transfer to the Ames Project. The Army told the men to report to a Chicago hotel where they would receive their civilian clothes before secretly coming to Ames to work on a classified, sensitive project.

Unfortunately, the Army personnel in Chicago forgot to purchase suitcases for the men, so the military men showed up in Ames in civilian clothes, but carrying large blue bags with U S. ARMY in 4-inch white letters

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[232] Spedding tells the story in his manuscript history about one young man, who while intelligent and very necessary to the Project, was almost kicked off the project because of his considered liberal leanings. He and his wife, for example, had belonged to several left-winged organizations, and he had written letters to newspaper editors about his own political opinions that were someone left of center. He had never professed that he was a communist, but he often made light of the serious questions of his investigators and tended to take the process of clearance lightly. He also got into trouble when he purposely evaded the FBI on a visit to a Chicago meeting before he was completely cleared. The FBI did not look with kindness at the fact that they spent an entire afternoon trying to find him and later found out he had been at a classified meeting. Spedding did get to keep the scientist, but warned him at the end of the war not to get into work that might require FBI clearance. (Frank H. Spedding, "Example of Wrong Way to Get Clearance: 1943," Spedding Manuscript, 1-2).

stamped on the side. Several Ames residents saw them and within two hours of their arrival, a general in charge of soldiers in Iowa was on the phone with Spedding wanting to know why he had not been informed of soldiers in Ames. Because Spedding had been instructed by Groves not to even admit there was a Manhattan District project in Ames, he had to tell the general that he knew nothing about soldiers; furthermore, the general could call Washington if he really wanted to know why they were in Ames.[233] Evidently, the general never followed through

Document Protection Regulations

Federal regulations for document protection

Classification of documents within NDRC followed the standard military classification scheme: *secret*, *confidential*, and *restricted*. Secret documents were those where disclosure would endanger national security; confidential documents contained no information that would damage national security but could cause embarrassment or be prejudicial to the interests or prestige of the government if released; restricted documents had no secrets but were not for the general public to read.[234] The resolution containing these classifications went into effect on August 29, 1940.[235]

Marking and distributing these documents also demanded strict regulation. *Restricted* was clearly marked on documents, and these had to be

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[233] Frank H. Spedding, "Security Foul Up," Spedding Manuscript, 1-2.

[234] Stewart 29, 250-251. The War Department issued several regulations under No. 380-5 with the latest issued March 15, 1944. That document was included in *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix C-8.

[235] Stewart, 29.

kept under lock and key at night. Confidential and secret documents were more protected and could only be transmitted to other destinations by courier or registered mail, two processes that actually created delays in getting the critical information in areas that had no courier service.

Under OSRD, the above principles continued, and in 1944, the War Department added *Top Secret* and *Secret Security* to the document classification scheme in order to protect those secrets of the most profound nature as America geared up its war machine. These documents could be transmitted only by officer courier.[236]

The Manhattan District continued the same scheme of document classification, and in 1943, in an Intelligence Bulletin, the District published just what constituted each classification. For example, materials and documents that related to technical designs; letters and other material that contained names, formulae, and technical data; documents relating to personnel and organizational matters of concern to the Manhattan District; maps, photographs displaying features of the Project; material and supplies distinctly related to the project; and documents showing meanings of codes all deserved a Secret rating. Confidential matter included documents relating to design where only code names were used; documents of a financial nature that did not divulge secrets; drawings, and photographs that showed parts of the project; material less critical than those under the secret category; and

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[236] Stewart, 251-52. The information was also given to all the Manhattan Engineering District Offices through K. D. Nichols, "District Circular Letter (MI44-113)," May 6, 1944 included in *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix A-6. The letter detailed the classification, transmission and handling, processing, reproduction, storage, and destruction requirements of these documents.

meanings of code names of less critical nature Restricted was reserved for documents relating to the design of non-technical building associated with the project; documents of relatively unimportant administrative matters; drawings of sites prior to construction and with no labels divulging what is to be located there; documents that use code names in such a way that no one can interpret the scope of the project from them; documents referring to shipment of coded materials; personnel clearance investigation matters where no adverse information was disclosed.[237]

This bulletin also spelled out in great detail the rules for marking, receiving, transmitting, storing, and destroying documents. Markings on all documents, for example, had to be in red color with letters not less than one-quarter inch in all capitals. Notations on the classified documents appeared along with a statement about the Espionage Act. Dissemination, transmission, and receipt of secret documents had to be handled with great care by authorized agents. Inventories of contents were to be clearly displayed and copies kept in transmitting offices Numbering of separate parts and notations of copies of each document were displayed in prominence. Secret material had to be locked in a safe or lock files and was never to be left unattended on desks. Top secret documents had to be filed in a three-combination safe whose combination was known by certain designated people, including at least confidentially-rated secretaries. Combinations had to be changed at least twice

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[237] Manhattan Engineer District, "Safeguarding Military Information Regulations," Manhattan Engineer District Intelligence Bulletin No. 5, November 27, 1943, Revised September 1, 1944, 2-4. Provided in *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix B-7. Also see *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix C-8 for the March 15, 1944 Army Regulation No. 380-5, called "Safeguarding Military Information."

a year. Destruction of material was also handled by level of classification. Secret documents could be only burned and in the presence of a disinterested person who served as a signatory to the Certificate of Destruction. Restricted documents could be shredded or burned by an authorized person, but not a custodian. Waste (drafts, worksheets, carbon paper, etc.) could be shredded and burned under the supervision of an employee cleared to handle classified information. Classified material destroyed in any form required a report to be sent to the District Intelligence Officer explaining the type of material destroyed, its value, and the name of the person supervising the destruction.[238] This is probably why very little material was destroyed on the project and why so many copies of what was written down survive today.

Press restrictions and censorship were also a part of the control of military information during the Manhattan Project days under the Censorship Review Program. Shortly after the District came into being, the Army surveyed several daily newspapers and periodicals for release of information. Starting with only the major serials, a list of approximately 370 newspapers and 70 magazines began to receive scrutiny, primarily from members of the Women's Army Corps hired in the District Engineer's Office. By 1944, Branch Intelligence Officers reviewed periodicals in their own area offices. Bush had suggested voluntary compliance for the nation's newspapers, and at first the Army and Groves resisted, but with the insistence of men like Nathaniel Howard formerly of the *Cleveland News* and then an assistant director in the Office of Censorship, Groves finally agreed to voluntary censorship. On June

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[238] *MED History*. "Safeguarding Military Information," 6-16.

28, 1943, Byron Price the Director of Censorship sent a confidential note to the nation's editors and broadcasters asking them to voluntarily refrain from mentioning anything about new and secret military weapons in general, but especially to exclude mention of terms and concepts involving atom smashing, atomic energy, atomic splitting, radium, radioactive materials, and any references to elements like uranium, thorium, and others Although Groves wanted any references to Los Alamos excluded completely, he allowed local newspapers around Clinton and Hanford to publish limited articles in order to avoid drawing attention to their work by trying to suppress all information. The program, by and large, worked, and, though there were some small breaches of security, they caused no known detrimental effects. The process continued even after the war, with most newspapers using District-prepared press releases after the bombing of Japan rather than reporting their own information.[239]

Information protection at Iowa State College

All materials were handled in the ways described above by the government throughout the period (see Appendix D for a typical document with markings). All classified documents were also placed under lock and key at Iowa State College. These included letters, reports from Ames and from other projects, and research notebooks that every scientist kept. There were some incidents of slack handling of security, especially early in the project, but problems were generally worked out quickly. In 1942, for example, one of the

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[239] *MED History*, Book I General, Volume 14 Intelligence and Security, 6.14-6.16; Jones, 277-278; Groves, 146-148.

scientists reported to Spedding that on at least one-half dozen instances, he had seen notebooks lying open in full view of the custodial staff. Spedding immediately addressed a note from his Chicago Office to Wilhelm:

> I am still very much worried about the matter of secrecy. I have had one complaint about Ames from an indirect source so I think we should take double precautions to see that notebooks are not left around, that secret letters are not opened in front of other people, and that reports are not lying around where people coming into the office can see them, either in the typewriter or on the table. Please pass this information on to the stenographers and the other boys.[240]

The conditions improved considerably after the warning, and there were no other instances or reports in the files indicating problems with documents.

Code names also protected documents from the public at Iowa State and other sites. The Manhattan District particularly encouraged this practice. Lists would periodically appear from the District Office with new code names added. Uranium was generally called "tube alloy" throughout the project, for example, although at first it was designated "copper" until studies of copper and uranium alloys system began to appear. Until the code name for uranium changed to tube alloy, the metal copper was sometimes called "Honest to God Copper." Tube alloy was an official code name for the British uranium project throughout the war. The Metallurgical Laboratory developed several of its own codes too. They preferred "the metal" for uranium, "sensitivity" for radioactivity, "green salt" for uranium tetrafluoride, and "black powder" or "brown powder" for the types of uranium oxides. Codes were also developed

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[240] C F Gray, "Letter to F. H. Spedding on Security Breach, "August 6, 1942; Frank H. Spedding, "Letter to H. Wilhelm on Security," August 8, 1942; C F Gray, "Letter to F. Spedding on Security Follow-up," August 11, 1942, Spedding Papers.