The Ames Project: Administering classified research as a part of the Manhattan Project at Iowa State College, 1942-45

by

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CHRONOLOGY OF IMPORTANT EVENTS

ca 400 B. C.	Democritus, a Greek, theorized that minute particles or atoms, which were unchangeable and indivisible, composed all material things.
1789	M. H. Klaproth from Germany isolated a metallic substance from pitchblende, naming it uranium after the recently-discovered planet Uranus.
1803	John Dalton proposed all elements were composed of like atoms and were distinguishable from each other by mass.
1841	Eugene Peligot, a French chemist, first prepared uranium as a metal after obtaining uranium chloride and reducing it with potassium.
1869	Dmitri Mendeleyev of the University of St. Petersburg found that all elements could be arranged in the order of atomic weights. He created the first periodic table of elements.
1893	Henri Moissan, a French chemist, obtained a metallic uranium ingot from uranium oxide and sodium chloride. This experiment was repeated in 1942 by many of the scientists on the atomic bomb project with better success.
1895	W. C. Roentgen discovered x-rays.
1896	A. H. Becquerel presented to the Paris Academy of Sciences his discovery of radioactive radiation from uranium.
1898	Marie and Pierre Curie announced the discovery of polonium in July and radium in December.
1905	Albert Einstein published his special theory of relativity including the equation for the equivalence of energy and mass ($E=MC^2$).
1910	F. Soddy suggested existence of atoms with different atomic masses but identical properties called isotopes.
1911	Ernest Rutherford proposed an atomic theory where a critical mass and a positive charge were located in nucleus of atom.

1913	Niels Bohr suggested the existence of a central nucleus with electrons moving in orbits around the outside.
1919	Discovery of protons by Ernest Rutherford.
1922	J. W. Marden from the Lamp Division of Westinghouse obtained a patent for reducing uranium halides with aluminum, publishing the first known example of uranium preparation in the United States.
1932	P. P. Alexander, a student at M. I. T., reported his thesis work on reduction of uranium oxide with calcium hydride.
1932	H. C. Urey discovered heavy hydrogen called deuterium, which was used in atom smashing experiments.
1932	Ernest Lawrence reported in the literature about his invention of the cyclotron, an instrument that accelerated and aimed protons and other nuclear particles at a target, using powerful magnets to control the action of those particles involved.
1932	James Chadwick announced the discovery of the neutron, a neutral-charged particle of about the same mass as a proton.
1932	L. S. Taylor developed an air ionization chamber to determine the value of a roentgen.
1934	F. Joilet and I. Joilet-Curie discovered artificial radioactivity by bombarding aluminum with alpha particles, noticing neutrons and positively charged particles were emitted.
December 1938	Nuclear fission discovered by Otto Han and Fritz Strassmann by bombarding uranium and noticing it broke into two fragments. Made public in *Die Naturwissenschaften*, January 1939.
December 1938	Lise Meitner and Otto Frisch confirm the experiment and inform Niels Bohr of their findings.
January 26, 1939	Niels Bohr reports the European discoveries at a meeting on theoretical physics in Washington, D.C.
August 2, 1939	Einstein letter to President Franklin D. Roosevelt detailing need for atomic bomb project.
September 1, 1939	Germany invaded Poland, setting off World War II.
October 11, 1939	President Roosevelt met with Alexander Sachs, a representative from Einstein and other immigrant

	scientists, convincing him to create a uranium study group.
October 21, 1939	First meeting of the Committee on Uranium with Lyman Briggs of the National Standards of Bureau serving as chairman.
1940	John R. Dunning and his research group at Columbia University discovered that fission is more readily produced in U_{235} than in U_{238}.
1940	Two new elements created from uranium bombardment: neptunium (atomic number 93) and plutonium (atomic number 94).
April 1940	American scientists propose voluntary censorship plan for scientific publications.
June 27, 1940	Organization of the National Defense Research Council (NDRC) organized under Vannevar Bush.
May 1941	Glenn Seaborg proved that plutonium was more fissionable than U_{235}.
May 17, 1941	A National Academy of Sciences committee headed by Arthur Compton released its first report encouraging further research in power applications of nuclear energy.
June 22, 1941	Germany invaded the Soviet Union.
June 28, 1941	Institution of the Office of Scientific Research and Development (OSRD).
July 2, 1941	The British MAUD report is released and concluded that an atomic bomb was feasible.
July 11, 1941	A second National Academy of Sciences report confirmed the first one in May.
October 9, 1941	Vannevar Bush convinced President Roosevelt to start an all-out study of uranium, but with strict secrecy controls.
November 9, 1941	The third and last National Academy of Sciences report like the MAUD report confirmed the feasibility of an atomic bomb.
December 7, 1941	Japan attacked Pearl Harbor.
December 8, 1941	U.S. declared war on Japan as result of previous day's bombing of Pearl Harbor.
December 10, 1941	Germany and Italy declared war on the United States.
December 16, 1941	The secret Top Policy Committee became responsible for policy decisions in uranium research.

December 18, 1941	The S-1 Executive Committee replaced the Uranium Committee and gave Ernest Lawrence $400,000 for research on electromagnetic research.
January 19, 1942	Roosevelt responded to Bush's report from the National Academy of Sciences and officially approved atomic bomb research.
January 1942	Metallurgical Laboratory established at the University of Chicago. Columbia and Princeton groups move to Chicago.
January/February 1942	Frank Howard Spedding invited by Arthur Compton to become leader of Chemistry Division in Chicago at the Metallurgical Laboratory.
February 21, 1942	Ames Project established to back up Chicago metallurgical studies, with Harley Wilhelm joining and signing oath on February 24.
February 1942	Iowa State College signed first sub-contract for $30,000 with Metallurgical Laboratory to conduct metallurgical and chemical studies in support of the Chicago group.
May 23, 1942	The S-1 Executive Committee recommended that the project move to the pilot stage and build one or two reactors or piles to produce plutonium and plants for the electromagnetic, centrifuge, and gaseous diffusion separation methods of uranium.
June 1942	Bush recommended that Roosevelt continue four methods of uranium separation. Also suggested that the Army be brought into the project.
June 1942	Designs for the pile developed at the Metallurgical Laboratory.
June 17, 1942	Roosevelt approved the commercial plants suggesting that the Army Corps of Engineers take over this construction stage.
June 18, 1942	Creation of a new district under the control of J. C. Marshall within the Army Corps of Engineers. Called the DSM Project (Development of Substitute Materials).
August 13, 1942	Manhattan District formally established in New York City under Colonel James C. Marshall.
August/September 1942	At Iowa State College, Wayne Keller, with help from Spedding, Wilhelm, and others successfully produced uranium metal from a reduction experiment with calcium and uranium tetrafluoride

	and then cast an 11-pound ingot of uranium, the largest single piece of uranium to that date.
September 15, 1942	Iowa State signed two contracts, one for production and one for research, both directly with OSRD rather than under Metallurgical Laboratory.
September 17, 1942	Brigadier General Leslie R. Groves appointed chief of the Manhattan Engineer District (MED).
September 19, 1942	General Groves resolved the priority rating problems by procuring an unheard of rating of AAA for the Atomic Bomb Project.
September 23, 1942	A Military Top Policy Committee named, consisting of Vannevar Bush, James Conant, General Styer of the Army, and Admiral Purcell of the Navy to direct Groves' activities within the Manhattan Project.
September 24, 1942	Clinton Engineer Works site chosen in the hills of eastern Tennessee near the city of Knoxville.
October 1942	DuPont chosen as commercial contractor for the chemical separation plant at the Clinton plant.
October 1942	The centrifuge method of separation of uranium is dropped.
October-November 1942	Upon recommendation from Arthur Compton and other scientists, Groves decided to separate building of the atomic bomb from the Chicago Metallurgical Laboratory and place it in more isolated site. Los Alamos, New Mexico, selected as site for bomb development, code-named Project Y with J. Robert Oppenheimer in charge.
November 1942	The Military Policy Committee endorsed recommendations from Groves and Conant that the project move from research stage directly to the development of industrial-scale plants using electromagnetic and gaseous diffusion of uranium and pile production of plutonium.
December 2, 1942	First self-sustaining chain reaction under the direction of Enrico Fermi at the West Stands, Stagg Field, University of Chicago. Iowa State provided two tons of uranium metal for the project.
December 1942	Hanford, Washington, selected as site for plutonium production rather than Clinton.
December 28, 1942	President Roosevelt officially approved all plans for the production of atomic bombs.

February 1943	Construction of the electromagnetic plant (Y-12) and the plutonium pilot plant (X-10) begun at Clinton.
April 1943	Bomb design work began at Los Alamos.
May 1943	Manhattan Engineer District took over all research and development contracts from OSRD.
June 1943	Construction for the gaseous diffusion plant (K-25) begun at Clinton.
Summer 1943	The headquarters of the Manhattan Engineer District was moved to Oak Ridge at the Clinton Engineer Works.
September 8, 1943	Surrender of Italy.
November 1943	Pile at Clinton (X-10) in operation. Iowa State supplied almost 90 percent of the uranium for this plant.
February 1944	Y-12 plant at Clinton sent first 200 grams of U235 to Los Alamos.
March 1944	Bomb models tested at Los Alamos.
June 6, 1944	Allied invasion of Normandy (D-day).
July 1944	The plutonium gun bomb (Thin Man) was abandoned, leaving only the Little Boy (uranium gun device) and Fat Man (plutonium implosion device) for possibilities.
September 1944	First pile at Hanford operating.
December 1944	Chemical separation plants at Hanford finished.
December 16-26, 1944	Battle of the Bulge.
February 1945	Los Alamos received first plutonium shipment.
February 4-9, 1945	Yalta Conference.
March 1945	Tokyo was firebombed, resulted in 100,000 deaths.
April 12, 1945	Roosevelt died and Truman became president.
April 25, 1945	Stimson and Groves brief Truman on the Manhattan Project activities.
May 7, 1945	Germany surrendered.
July 16, 1945	First successful test of atomic bomb at Almogordo, New Mexico.
May 1945	Tokyo firebombed again, resulting in 83,000 deaths.
June 1945	Scientists at the Metallurgical Laboratory issue the Franck Report asking for a demonstration drop of the atomic bomb before using it in a war effort.

June 21, 1945	The Franck Report's plan for a demonstration was rejected by the U. S. government.
June 16, 1945	Scientists successfully tested a plutonium implosion device in the desert near Almogordo, New Mexico, code-named Trinity.
July 17-August 2, 1945	Potsdam Conference.
August 6, 1945	Uranium bomb (Little Boy) dropped on Hiroshima.
August 8, 1945	Russia declared war on Japan and invaded Manchuria.
August 9, 1945	Plutonium bomb (Fat Man) dropped on Nagasaki.
August 12, 1945	The Smyth Report, containing the story of the secret Manhattan Project activities, was released
August 14, 1945	Japan offered allies terms of surrender.
September 2, 1945	Japan signed surrender articles on the U.S.S. Missouri.
September 9, 1945	Y-12 shut down at Clinton.
September 15, 1945	Army-Navy E Award with four stars conferred to Iowa State for production efficiency. Presented by Groves to the College in a public ceremony, October 12, 1945.
November 1, 1945	Institute for Atomic Energy established at Iowa State College.
August 1, 1946	U.S. Atomic Energy Act signed by President Truman.
January 1, 1947	In accordance with the Atomic Energy Act of 1946 all atomic energy activities were transferred to civilian control under the U. S. Atomic Energy Commission.
August 15, 1947	The Manhattan Engineer District was abolished.
December 31, 1947	The National Defense Research Committee (NDRC) and the Office of Scientific Research and Development (OSRD) were abolished and their functions that remained were transferred to the Department of Defense.

PARTICIPANTS IN ATOMIC RESEARCH

Bohr, Niels	(1885-1962) Danish physicist, Director of the Institute for Theoretical Physics in Copenhagen. Was one of early pioneers in fission experiments during the thirties. During World War II, he was a consultant for Los Alamos.
Briggs, Lyman J.	(1874-1963) Director of the National Bureau of Standards and the chairman of the first uranium committee.
Bush, Vannevar	(1890-1974) A former engineer, he was Director of the NDRC (1940-1941), OSRD (1941-1946), and member of the Top Military Policy to direct the Atomic Bomb Project.
Chadwick, Sir James	(1891-1974) British physicist and discoverer of the neutron in 1932.
Compton, Arthur H.	(1892-1962) Nobel prize-winning physicist (1927) who directed the Metallurgical Project at the University of Chicago.
Conant, James B	(1893-1978) Chemist, assistant to Vannevar Bush, Chairman of the NDRC, Deputy director of OSRD, president of Harvard.
Doan, Richard L.	(b. 1894) A manager in industrial research, he was appointed Director of the Metallurgical Laboratory in Chicago in January 1942.
Einstein, Albert	(1879-1955) Former German Nobel prize-winning physicist (1921) whose theories were proven with the successful splitting of uranium.
Fermi, Enrico	(1901-1954) Former Italian physicist, Nobel prize-winner (1938) who went to Columbia shortly before the war and then to the Metallurgical Laboratory. He successfully demonstrated the first sustaining nuclear chain reaction.
Franck, James	(1882-1964) Former German Nobel laureate who became head of Chemistry at the Metallurgical Laboratory after Frank Spedding.
Frisch, Otto R.	(1904-1979) Nephew and collaborator with his aunt Lise Meitner, he publicized the early fission work of the German scientists.

Groves, Leslie R.	(1898-1970) Brigadier General in the Army Corps of Engineers who was placed in command of the engineering and production side of the Atomic Bomb Project, called the Manhattan Engineer District.
Hahn. Otto	(1879-1968) Collaborator with Lise Meitner at the Kaiser Wilhelm Institute in Germany. Discovered fission with Fritz Strassmann for which he won the Nobel prize in 1944.
Hilberry, Norman	Originally from New York University, he became the right hand man of Compton at the Metallurgical Laboratory. His official title was Associate Project Director and his task was to see that the various groups worked effectively toward their goals.
Hopkins, Harry L.	(1890-1946) Long-time friend and advisor of President Roosevelt.
Joilet-Curie, Frederic	(1900-1958) French chemist who with his wife, Irene Joilet-Curie (1897-1957), worked on early experiments with transuranium elements, particularly in the area of induced radioactivity.
Lavender, Cpt. Robert	Career Naval officer who was called out of retirement to head up the patent office within OSRD in 1942.
Lawrence, Ernest O.	(1901-1958) Nobel prize-winning physicist (1939) for the invention of the cyclotron. He was director of the University of California at Berkeley Radiation Laboratory and worked on the electromagnetic separation of uranium.
McCoy, Herbert	(1870-1945) The foremost rare earth specialist in the country. He was invited to head up the chemistry division at Chicago's Metallurgical Laboratory, but since he was retired he suggested Frank H. Spedding as his substitute.
Meitner, Lise	(1878-1968) Head of the nuclear physics department at Kaiser Wilhelm Institute where she worked on radioactivity experiments with Otto Hahn. Shortly after she fled Germany, her former colleagues discovered fission.
Oppenheimer, J. Robert	(1904-1967) American physicist and director of Los Alamos.
Sachs, Alexander	(b. 1897) Russian-born economist crucial in convincing Roosevelt to create a committee on

	uranium. Took the famous Einstein Letter to President Roosevelt in 1939.
Seaborg, Glenn	(b. 1912) Chemist from University of California and co-discoverer of plutonium in 1943.
Smyth, Henry D.	(1898-1986) Employed by the Manhattan District to write the documentary history of the Atomic Bomb Project. The book was the first public disclosure of the secret project, although it was primarily aimed at the scientist and technician.
Irvin Stewart	(b. 1899) Business and contracting officer for OSRD, he developed the contract for research during World War II.
Spedding, Frank H.	(1902-1984) Head of the physical chemistry division at Iowa State College, he was the first head of the Chemistry Division for the Metallurgical Laboratory and eventually the Director of the Ames Project.
Stimson, Henry L.	(1867-1950) Secretary of War, 1940-1945.
Strassmann, Fritz	(b. 1902) With Otto Hahn discovered fission in 1939.
Styer, Wilhelm	(1893-1975) Lieutenant general who was Groves' first supervisor in the Construction Division of the Army Corps of Engineers and served as the Army representative on the Top Military Policy Committee.
Szilard, Leo	(1898-1964) Hungarian-born physicist who helped convince Einstein to write to President Roosevelt Eventually in charge of materials procurement at Chicago's Metallurgical Laboratory.
Tolman, Richard	(1881-1948) Physical chemist, chairman of a Groves-appointed committee to investigate declassifying documents after World War II.
Wallace, Henry W.	(1888-1965) Vice President of the United States (1941-1945).
Wilhelm, Harley A.	(b. 1900) Metallurgist and professor of chemistry at Iowa State College who was Associate Director of the Ames Project.

ACKNOWLEDGMENTS

This project could not have been undertaken without the assistance of many individuals, almost too numerous to name. I must first thank my major professor, Charles R. Kniker, for interesting me in the whole field of qualitative research, and particularly in the area of oral histories. Had he not allowed me the latitude in a class to conduct an oral history, it is possible that this dissertation could never occurred. One of the interviews that I conducted introduced me to Little Ankeny and the secret war-time project that no one talked about. I must also thank him for his assistance and guidance in the development of this dissertation, and I look forward to future collaborations.

Thanks must also go to the other members of my committee. To Professors Owen and Kizer, thanks to both of them for introducing me to Plato, Rousseau, and the other philosophers of education. Their classes were most interesting and thought-provoking. To Professor Marcus, I thank for making me persevere in his challenging classes. He taught me that perhaps I could produce a dissertation; he certainly helped me improve my writing skills. I respect his scholarship as a teacher, and, just as importantly, his advice as a friend. To Dr. George Karas, I thank for his patience and guidance in teaching me first-hand about graduate education, because I think no one knows more about the field at Iowa State University than he. Thanks must also go to him for giving me some additional incentive to finish this project by hiring me in the Graduate College.

I must also thank the many librarians, archivists, and historians at the facilities I visited and telephoned to complete this research. I especially thank the staff at the Iowa State University Parks Library Special Collections Room and the Ames Laboratory. To Anne, Becky, and Betty, I thank for patiently and courteously finding me materials in the boxes in the archives and for sharing with me the enthusiasm of small discoveries. To Diane Borgen at the Ames Laboratory, I especially thank for allowing me access to the materials in the Ames Laboratory warehouse, to the photographic collection, and to the tape recordings in the vault. This courtesy was especially appreciated because I know she and her staff had other things on their minds, such as a federal inspection tour, but they patiently worked with me.

Thanks must also go to all those I interviewed. The men who worked on the project—Drs. Carlson, Voigt, Peterson, Daane, Svec, and Wilhelm—I thank for the interviews. Their enthusiasm and assistance in helping me discover the information I needed was most appreciated. And though I was not a scientist by training, they never withheld information, but patiently explained processes, experiments, and other matters in ways I could always understand. Their leads to other people to contact were also most helpful.

Special thanks must also go to Edith Landin and Elizabeth Calciano. Giving me access to these most important and personal documents was much appreciated. They made me feel the presence of the man who, though dead now, still leaves his mark on the Ames Laboratory—Dr. Frank Spedding. The interviews and the manuscript history were entertaining and most useful. I must especially thank Edith for allowing me in her home to do the necessary research on these papers while she was busily engaged in her own family activities. Her hospitality was most gracious.

Finally, I must thank the two important men in my life, my husband, Don and my son, Austin for their patience during this long period of time. I thank them for their encouragement and for never once pressuring me to hurry up and finish. To them go a special thanks for meals not prepared and for clothes not washed by me, so that I could finish this dissertation in a timely fashion.

INTRODUCTION

About 10:00 a.m. on Monday, August 6, 1945—a typical summer day on the Iowa State College campus—a radio bulletin broke into the placid daily activities. President Harry S. Truman announced suddenly:

> Sixteen hours ago an American airplane dropped one bomb on Hiroshima, an important Japanese Army base. That bomb had more power than 20,000 tons of TNT. It had more than two thousand times the blast power of the British "Grand Slam" which is the largest bomb ever yet used in the history of warfare.[1]

According to Harley A. Wilhelm, a young metallurgist and associate director of a secret laboratory at Iowa State College, the word spread quickly that a more detailed announcement would come that afternoon from Secretary of War Henry A. Stimson.[2] By 3:00 p.m. a small group of scientists, primarily chemists from a secret project headed by the soon-to-be-well-known Frank H. Spedding, had gathered in the Chemistry Building to listen to Henry Stimson's remarks. Those gathered in Room 113, drinking coffee and waiting for the announcement included the Fornefeldts, Jim Warf, Adrian Daane, Artie

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[1] Quoted in *The Manhattan Project: Official History and Documents*, Book I, Volume 4, Chapter 8, Part I, No. 1, 1, Record Group 77, National Archives, Washington, DC (microfilm, Robert W. Parks and Ellen Sorge Parks Library). (hereafter cited as *MED History*). This statement and the one by Stimson were made available as press releases by General Leslie Groves and his office, the Manhattan Engineer District, which served as the administrator for production of the Atomic Bomb. They were published in entirety in the official history of the atomic bomb, commissioned by General Grove, referred to as the *Manhattan District History*, compiled by a staff member, Gavin Hadden. *The Manhattan District History*, which is located in the National Archives, was made available in a microfilmed version in 1977 called *The Manhattan Project: Official History and Documents*. That edition is the one cited in this paper throughout as *MED History*. The press releases were published in every major newspaper on August 7 after Truman and Stimson had initially broadcast them on the radio.

[2] Harley A. Wilhelm, interview with author, Ames, Iowa, August 1990.

Tevebaugh, Art Kant, and Charlie Banks, all young men and women who had for several years of their lives worked day and night in rooms behind a barricade in the Chemistry Building.[3] Soon Stimson's voice echoed throughout the room:

> The recent use of the atomic bomb over Japan, which was today made known by the President, is the culmination of years of Herculean effort on the part of science and industry working in cooperation with the military authorities.[4]

As the scientists listened to Stimson's recounting of the history of the Manhattan Project and about the importance of laboratories and facilities at places familiar to them but unknown to the public at large—Clinton Engineer Works,[5] Los Alamos, and Hanford—a somewhat pleasant announcement came over the airwaves:

> Certain other manufacturing plants much smaller in scale are located in the United States and Canada for essential production of needed materials. Laboratories at the Universities of Columbia, Chicago, and California, and Iowa State College and at other schools as well as certain industrial laboratories have contributed

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[3] Harry A. Svec, interview with author, Ames, Iowa, February 1991; Adrian Daane, telephone interview with the author," March 18, 1992.

[4] Quoted from "Statement by the President of the United States," August 6, 1945, in *MED History* Book I, Vol. 4, Chapter 8, Part I, No. 2. press release 1. Also appeared in *New York Times*, August 7, 1945, 7.

[5] The Clinton Engineer Works was actually the laboratory facility and Oak Ridge was the town next to the plant The laboratory was never officially called Oak Ridge until after the war. In this dissertation all references to the laboratory will refer to the Clinton Engineer Works and references to the town will be Oak Ridge. (*New York Times*, August 7, 1945, 7; "Background Information on Development of Atomic Energy Under Manhattan Project," December 31, 1946, in *MED History*, Book I, Vol. 4, Chapter 8, Part I, No. 2, press release no. 99; F. G. Gosling, *The Manhattan Project: Science in the Second World War*, Energy History Series (Washington, D. C.: U.S. Department of Energy, Office of Administration and Human Resources Management, 1990), 20.

> materially in carrying on research and in developing special equipment, materials, and processes for the project.[6]

At the mention of "Iowa State College," a cheer erupted from the small group gathered around the radio.[7] The secret was finally out—Iowa State College had been a major player with institutions like the University of California, Columbia University, and the University of Chicago in a substantial research effort for the war.

As the news spread, reporters came to the College, and for awhile the campus was a whirlwind of activity. Reports in several local newspapers revealed that Iowa State College discovered a method for the production of uranium metal and then at its own pilot plant produced over 1,000 tons of the metal until industry took over the process.[8] On Friday, October 12, 1945, General Leslie R. Groves, the leader of the Manhattan Engineer District, came to Ames to present Iowa State College the Army/Navy Flag for Excellence in Production with Four Stars, demonstrating excellence in industrial production five times for over a period of two-and-one-half years, making the College the only educational institution to ever receive the honor.[9]

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[6] Quoted from "Statement of the Secretary of War," August 6, 1945, in *MED History*, Book I, Vol. 4, Chapter 8, Part I, No. 2, press release no. 2. Also appeared in *New York Times*, August 7, 1945, 7.

[7] Wilhelm, interview with author, 1990.

[8] See "Atomic Bomb Opens New Era in Scientific History: Dr. Spedding Heads ISC Research on Atomic Bomb and Worries about Weeds in Victory Garden in Spare Time," *Ames Daily Tribune* (August 7, 1945): 1; "ISC Research Speeded Development of World's Most Destructive Weapon," *Ames Daily Tribune* (August 8, 1945): 1; "Intricate System of Passes for Bomb Project at College," *Ames Daily Tribune* (August 10, 1945): 8; "I. S. C. Experts Speeded Work on Atom Bomb," *The Des Moines Register* (August 8, 1945): 1; and "College Does Secret Atomic Power Work," *Iowa State Daily Student* (August 8, 1945): 1 for a sampling of area newspaper articles that appeared on the Ames Project.

[9] "The Ames Laboratory: How it Started," n.d., 1; "The United States Army-Navy Production Award for Excellence to Iowa State College Men and Women of Chemistry Annex 1

The Significance of the Ames Project

From 1942-1945, Iowa State College, like several other universities and colleges, conducted classified, war-related research, under the sponsorship of the National Defense Research Council (NDRC), the Office of Scientific Research and Development (OSRD), and the Manhattan Engineer District (MED), three federal government units each supervising research on the atomic bomb. Although some scientists participated in research during World War I, the United States entered that war at such a late date that research activity was minimal compared to that of World War II.[10]

At the beginning of World War II, few administrative structures existed within most academic institutions to carry on extensive weapons research. The federal government likewise had no single central organizational unit dedicated to weapons research. In general, government research funding agencies consisted primarily of specialized bureaus like the Census Bureau, the Bureau of Mines, and for awhile the Works Progress Administration, which supported applied research in narrow fields. The

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and 2," (October 12, 1945), in the Ames Laboratory Papers Record Group 17/1, Robert W. Parks and Ellen Sorge Parks Library, Ames, Iowa (hereafter cited as Ames Laboratory Papers); "Schedule and Script", the Ames Laboratory Papers; Press Release about the Ceremony, the Ames Laboratory Papers. In 1906 the Navy instituted the Navy E Award for excellence, first awarding it in gunnery, later expanding it to include engineering and communications excellence in wartime activities. With the advent of World War I, the award recognized industrial plants that produced war machinery. In World War II, both the Army and Navy supported the award.

[10] Vannevar Bush, *Science the Endless Frontier: A Report to the President* (Washington: The Government Printing Office, 1945), 80. There are no really accurate estimates for government funded research in World War I, but the research budget of the government in 1923 was $15,000,000. By 1940, it had grown to $69,000,000 and by 1944 the total grew to over $720,000,000.

largest research funding unit supporting scientific research, the United States Department of Agriculture, worked primarily with land grant schools through state experiment stations to subsidize research in agriculture and related areas. There was no central organized science policy nor one group in the federal government that could finance research in broad academic disciplines. In addition, most government funding efforts in the early 1930s revolved around recovery from the depression and not support for science at all.[11]

World War II though demonstrated a successful marriage between government and science. But before this marriage could be consummated, both the federal government and universities and colleges had to inaugurate a new administrative system in order to oversee unique war-related research. That same structure, in many ways distinctive to classified research, became the foundation for post-war federal and university relationships to continue.

The new administrative structure also exhibited one of two administrative management styles or a combination of both in some cases: an academic system of committees, group research, and consensus-building indicative of academic institutions, or the hierarchical, control-based, command-laden military structure of management. Even though the military eventually controlled the atomic bomb project through classified research, this dissertation contends that the administrative apparatus

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[11] A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge: The Belknap Press of Harvard University Press, 1957), 361.

which the federal agencies (NDRC, OSRD, and MED) adopted was, by and large, characterized by the academic style of management.

The Ames Project then serves as a case study of a wartime classified laboratory—a laboratory conducting and managing research in the name of national security. But just as importantly, it is typical of federally-funded research units appearing after the war because most of the rules and regulations that controlled research administration in the war laboratory evolved into the rules and regulations that governed university-wide relationships with the federal government after World War II.

An Explanation of the Format of the Dissertation

This dissertation will examine the Ames Project in that light—as a precursor for the post-war research apparatus of Iowa State College. Though the dissertation will discuss some aspects of science and technology, it will concentrate primarily upon the administrative aspects of the Ames Project during World War II, examining the history of the Ames Project in the life of Iowa State at the time and its contributions to the development of the college's research infrastructure after the war. The author uses newly-released archival materials, interviews from many of the actual participants in the war-related research project, and some heretofore private manuscripts and unreleased interviews related to the project and its participants to analyze the Ames Project in detail. Although Part 1 will chronicle the scientific role for the Ames Project, it will also concentrate on the organizational structures that were initiated and adapted to place a security-intensive laboratory on an academic campus. Part 2 will concentrate primarily upon administrative issues, defining the academic and military styles of management and revealing how security, governmental and military relationships, financial methods of operating a contract research facility, and health regulations contributed to the final research funding apparatus.

A Review of the Sources

The story of the Ames Project appeared for some time in bulletins from the College, in newspaper accounts as information was declassified, and in other local College reports. But the story of Frank H. Spedding and his contingent of graduate students and young Ph.D.s did not appear in any detail in the national printed accounts after the war.

The *Smyth Report*,[12] the first officially sanctioned report to surface after the war, traces the administrative and technical history of the Manhattan Project, the official name for the secret project that led to the development of the atomic bomb. This book-length report was published in three editions.[13] The first, called *A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government 1940-1945*, appeared only days after the atomic bombs were dropped on Japan. General Leslie Groves hired Henry DeWolf Smyth, chair of the physics

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[12] Henry D. Smyth, *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government 1940-1945* (Princeton: Princeton University Press, 1948).

[13] There is a full account of the publishing activities of the *Smyth Report* in *MED History*, Book 1, General Volume 4: Auxiliary Activities, Chapter 13, 1-18. Also, the *Princeton University Library Chronicle* published in its Spring 1976 issue (vol. 37, 173-218) several articles on the publishing history of the Smyth Report. Smyth himself reprinted a report he had written on the history of the Smyth Report dated January 1947, a memorandum that had remained buried in his files until its publication in this journal.

department at Princeton, to write the report in April 1944. Smyth was given access to all security protected materials. He submitted the first draft to Conant and Groves in May 1945 at which time Groves appointed several scientists as reviewers and editors. A mimeographed version reached Conant, Groves, and Truman's inner circle of advisors for final review in July 1945. Because the group had to wait for Truman's return from overseas, the edition was not ready at the time of the bomb explosions. One thousand copies were printed though, kept by Groves' staff, and finally released after an announcement appeared in the Sunday newspapers on August 12, 1945. The first one thousand copies quickly sold; another press run of two thousand copies was ordered and printed. Other editions were released in September 1945. The report provided the literate or technical-oriented public an explanation of the activities that took place in the various laboratories, companies, and agencies within the government. Later, the report was published with pictures, an index, and some material added from Britain and Canada. Somewhat later, a government document version was published with the original title displayed. This official history of the project mentioned the Ames laboratory in less than ten lines of text in over 400 pages of material.

The release of the official manuscript history in the late 1970s, simply called *The Manhattan District History*, dispels the notion that the Manhattan Project did not produce a lengthy written record. General Leslie Groves, commander-in-chief of the project, commissioned the work, not so much a single book as it was a collection of reports, charts, pictures, memos, and other materials about the Manhattan Engineer District. The collection of materials, now housed in the National Archives, serves as the complete and definitive work about every aspect of the massive project. Iowa State rated one single chapter of approximately fifty pages in this massive document, a reprint of a post-war report that was published in an Ames Laboratory scientific series by E. I. Fulmer.[14] Compiled with summary accounts from the division heads and project leaders, this short work is the only published account of Iowa State's role in the Manhattan Project. It does provide a short summary of Iowa State's participation and is particularly useful as a scientific guide to the various projects undertaken in Ames' wartime laboratory.

Several other archival collections include documents about the Manhattan Project. Most of the old Argonne Laboratory[15] documents have been moved to the National Archives in Washington, D.C., and though they detail administrative, financial, and scientific information, Iowa State College information is very scant. The collections of archives that are scattered throughout the present U.S. Department of Energy files include scientific reports, fiscal information about the individual academic laboratories, and some general commercial contractor information. The Oak Ridge National Laboratory housed most of the information related to Iowa State since much of the Ames laboratory correspondence was sent to the Manhattan Engineer District, which moved its headquarters to Oak Ridge in 1943. Much of that documentation about the project is still classified and what information is housed there is also located at Iowa State or elsewhere.

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[14] E. I. Fulmer, "History of the Ames Project Under the Manhattan District to December 31, 1946," ISC Report No. 10 (Ames: Iowa State College, 1947), typescript.

[15] Argonne Laboratory was the successor to the Metallurgical Laboratory of the University of Chicago.

Iowa State College fared no better in the secondary historical accounts because so many of them were taken from the "official" documents above. Shortly after the declassification of the countless documents on the atomic bomb project in the seventies, *The Secret History of the Atomic Bomb*[16] appeared The first book to be published that relied heavily on the *Manhattan District History*, this account filled in many of the gaps that to that date had been unavailable to researchers. The book emphasizes the scientific and technological development of the project and serves as a good summary of the more complete history located in the National Archives. This book contains only a few references to contributions by Iowa State College.

The best and probably most thoroughly researched scholarly document on the Manhattan Project is the Atomic Energy Commission's first volume of a series on the history of the commission by Hewlett and Anderson.[17] The authors cover the development of the atomic bomb in their first volume. Given unlimited access to the classified and unclassified documentary and archival materials under the auspices of the Commission, Hewlett and Anderson produced a non-partisan, independent history of the time period, with a particular emphasis on the scientific advancements within the Manhattan Project. The substantial notes section of the book is an especially invaluable scholarly aid. Iowa State's contributions are given several scattered references, and almost one-half page details the Ames process for reducing

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[16] Anthony C. Brown and Charles B. MacDonald, eds., *The Secret History of the Atomic Bomb* (New York: Dial Press, 1977).

[17] Richard G. Hewlett, and Oscar E. Anderson, Jr., *The New World*, 1939-1946. Vol. 1 of *A History of the United States Atomic Energy Commission* (University Park: Pennsylvania State University Press, 1962).

uranium metal. A more recent, popularized Pulitzer Prize book by Richard Rhodes[18] updates the atomic bomb story, providing a novelistic type format for the reader. It is well-documented for the scholar but adds little information on the Iowa State story.

Vincent C. Jones,[19] with help from the Center for Military History, examines the Manhattan Project from the U.S. Army's viewpoint. His well-documented volume depends heavily on the *Manhattan District History* and summarizes in great detail the Army's role in the development of the atomic bomb. It includes topics such as the Army take-over of the project from the civilian Office of Scientific Research and Development (OSRD), the creation of the Manhattan District, the appointment of General Leslie Groves as head of the District, the administration of the production plants, laboratories, and other support facilities, the actual testing and employment of the bomb, and a chapter on the transition from the Army-controlled Manhattan Engineer District to the civilian-administered Atomic Energy Commission after the war. For the researcher, the bibliographical essay is invaluable for its detail, currency, and complete location information, but Iowa State is virtually ignored except in a chapter on laboratories that provided fuel feed materials.

Personal accounts proliferate in the atomic energy story, but none are more famous than the one by Groves.[20] Leslie R. Groves, the General in

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[18] Richard Rhodes. *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986).

[19] Vincent C. Jones, *Manhattan: The Army and the Atomic Bomb,* United States Army in World War II Special Studies (Washington, DC: Center of Military History, 1985).

[20] Leslie R. Groves, *Now It Can Be Told: The Story of the Manhattan Project* (New York: Harper & Row, 1962).

charge of the Manhattan Engineer District, wrote his memoirs in order to tell the story of the Army's role in the Manhattan Project from his own unique perspective. A man called tyrant, czar, and other more derogatory names by the scientists under him, Groves was an imposing figure in the development of the atomic bomb. The book is certainly a reflection of the General's personality. It also displays his support for military action in the development of sensitive, secret projects but gives no insight into Iowa State contributions.

Arthur H. Compton,[21] who headed the Metallurgical Project at University of Chicago, wrote *Atomic Quest*, a personal account of his involvement with the Manhattan Project. The book is important because the Ames Project constituted a part of Compton's laboratory. The value of a study like this is more in its personal accounting of impressions and perceptions, but its major disadvantages are the lack of referenced notes and bibliography to prove the validity of its text Even though Frank Spedding served under Compton as his chief chemistry officer for a time, Compton provides only scattered information about the Ames Project and Spedding.

Today, more than forty years after the events of World War II, no book-length history of the Ames Project exists. Only one public account of the work is available as a manuscript at the National Archives and also as an Ames Laboratory scientific report. Documents, papers, correspondence, research notebooks, and declassified materials remain in the Iowa State University Library, to date unpublished by scholars.

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[21] Arthur H. Compton, *Atomic Quest: A Personal Narrative* (New York: Oxford University Press, 1956).

A large portion of this dissertation will rely on interviews with participants from the Ames Project. Because some of the material in this dissertation cannot be verified by the documentary history, every effort has been made to use several interviews as source materials rather than to rely upon one person's memory of events. However, there still may be errors. In some cases, for example, dates cannot be substantiated for personnel becoming a part of the project, the role of military personnel on the Ames campus during the time under Manhattan District authority cannot be substantiated from existing sources, and sometimes it is unclear about the organizational relationships between Ames and other laboratories. What these interviews do provide though is a complement to the official records, which consist most often of scattered correspondence, scientific and administrative reports, and documentary history for events at the national and regional levels of the Manhattan Project

PART 1. CREATION, ORGANIZATION, AND PURPOSES OF THE AMES PROJECT

THE GENESIS AND ORGANIZATION OF THE AMES PROJECT

Pre-1941 Uranium Research Activities

Niels Bohr, an imminent physicist in Copenhagen, remained late in his laboratory on January 3, 1939, finishing up work before he was to leave for an extended research visit at the Institute for Advanced Study in Princeton, New Jersey. Otto Frisch, another Danish physicist, rushed into the laboratory with incredible news from his aunt, Lise Meitner, a recently exiled Austrian physicist. Meitner had just received news from Germany that Otto Hahn, her former collaborator, and his new colleague Fritz Strassmann had bombarded uranium with neutrons and produced barium. "Had they split the atom?" Hahn asked in a letter to his former colleague, Meitner. After several long discussions with his aunt, Frisch contacted a biologist friend and asked him what term was used when a cell split. "Fission," was the term Frisch heard from his friend, and he was the first to apply it to what happened in the Hahn-Strassmann experiment.[22]

Hahn and Meitner had been collaborating on identifying mystery radioactivity materials, generally thought to be transuranic (beyond uranium) that Enrico Fermi, an Italian physicist, had first discovered in the mid-thirties when he bombarded uranium with neutrons. This problem was also being investigated in France by Irene and Frederic Joilet-Curie. In fact, Hahn and

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[22] Ruth Moore, *Niels Bohr: The Man, His Science, & the World They Changed* (New York: Alfred A. Knopf, 1966), 222-223.

Meitner were replicating an experiment that the French scientists reported when Meitner decided to flee from the country because her homeland Austria had come under Nazi rule. Fritz Strassmann then teamed with Hahn, helping him precipitate the Joilet-Curie radioactive products with barium. Amazingly, the radioactive materials precipitated, leading the men to consider the impossible: they had split the atom. They repeated the experiment certain that the materials must be some form of radium (no. 88 on the periodic chart, not barium which was 56). The same result occurred. The men, believing that this was impossible, tried to separate the "radium" isotopes from the carrier barium. That failed proving again that they had indeed precipitated barium. Hahn immediately wrote to Meitner about their discovery. Shortly after this encounter, Bohr left for America and repeated the news of the experiment to the American scientific community.[23]

The famous paper by Hahn and Strassmann appeared in *Die Naturwissenschaften* January 6, 1939. However, many people did not hear about it until the Fifth Conference on Theoretical Physics held in Washington January 26-28, 1939, when Bohr and Fermi announced the news to the audience even before a single paper had been presented.[24] Papers by Frisch, Fermi, Szilard and Bohr followed rapidly in *Nature* and *The Physical Review*.[25]

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[23] Moore, 222-223; Roger H. Stuewer, "Bringing the News of Fission to America," *Physics Today* (October 1985): 49-56; Otto R. Frisch, "How It All Began," *Physics Today* (November 1967): 272-277. See also Peter Wyden, *Day One: Before Hiroshima and After* (New York: Simon and Schuster, 1984), 22; Rhodes, 233-275; and Anderson and Hewlett, 10-11 for other accounts of bringing the news to America.

[24] Stuewer, 54.

[25] Louis A. Turner, who published an article in the January 1940 *Reviews of Modern Physics* summarizing the research appearing only after the Hahn and Strassmann work, found nearly 100 articles published to that date (p. 1).

The Einstein letter

Though the experiment was exciting for its energy applications, scientists had already predicted that a powerful weapon could be produced from such a release of energy. In the United States, several recently-arrived European immigrants were particularly concerned because the discovery had occurred in Germany and that added to the fear that Germany could first produce an atomic weapon. Enrico Fermi, a recent émigré from Italy, upon hearing the historic news in January 1939 "shaped his hands into a large-sized ball. A little bomb like that, he remarked, and it would all disappear."[26]

Leo Szilard, a brilliant physicist formerly of Hungary, and another former European physicist colleague, Eugene Wigner, met in the summer of 1939 to discuss the uranium research events, particularly the development of a uranium-graphite system to create a chain reaction, something Szilard had been working on as early as 1933.[27] Both men, worried about the world situation, wondered what would happen if Germany shut off uranium exportation by the Belgians, who were mining in the African Congo region.

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[26] Quoted in Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, MA: Harvard University Press, 1971), 324.

[27] Spencer R. Weart and Gertrud Weiss Szilard, eds., *Leo Szilard: His Version of the Facts: Selected Recollections and Correspondence*, Vol. II (Cambridge, MA: MIT Press, 1978), 17-18; 80-82. As early as 1933, Szilard had the idea if an element could be found that emitted two neutrons and absorbed one, and if it could be obtained in large enough quantity, a self-sustaining chain reaction could be created. In 1934, he applied for a patent that described the laws governing a chain reaction. Because he did not want the patent to become public at that time, he assigned it to the British Admiralty and went on to other experiments. The chain reaction idea appeared again after the discovery of fission by Hahn and Strassmann. He teamed up with Fermi at Princeton trying to work out a uranium-water system that might be capable of sustaining a chain reaction. By the summer of 1939, Szilard had decided that because Fermi was lukewarm to his idea and because of the world political situation he would take matters into his own hands and approach the United States government directly to warn it of the dangers of world domination by Germany.

They wanted to warn Belgium of the dangers but had no idea of the state protocols involved. A friend, Albert Einstein, another émigré living in a summer house on Long Island knew the Queen of Belgium, so they decided to solicit his assistance. On July 16, 1939, Wigner and Szilard drove to Long Island to visit Einstein and inform him of recent discoveries. After a lengthy discussion, the group decided not to contact Belgium directly with a letter but to somehow get the U.S. government involved.[28]

Through a friend, Szilard found Alexander Sachs, an economist and investment banker, who had been an informal advisor of several government officials, including President Roosevelt himself. Szilard visited him in New York, and Sachs suggested that Einstein compose a letter to President Roosevelt on the concerns of the immigrants. Sachs volunteered to take the letter to Roosevelt personally and argue the scientists' case for increased research and the German dangers of world domination if, as they all guessed, German atomic research could deliver a bomb first.[29]

The letter was written, signed by Einstein on August 2, 1939, and given to Alexander Sachs for delivery to the President.[30] Sachs did not encounter President Roosevelt immediately because World War II broke out in September 1939.[31] On October 11, he finally got an audience to present the

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[28] Rhodes, 303-305. This visit to Einstein is also recounted in detail in Weart and Szilard, 82-83; Anderson and Hewlett, 16-17; and Wyden, 32-34.

[29] Weart and Szilard, 84.

[30] There is some debate about who wrote the letter (see the letter in Appendix A). It appears to have been a collaborative effort between Szilard and Einstein. See Weart, 83-84 and Rhodes, 305-308 for details of the collaboration.

[31] Wyden, 35. Poland was invaded by Germany on September 1, 1939. On September 3, 1939, Britain and France retaliated by declaring war on Germany and on September 8

scientists' case. Knowing that Roosevelt was a busy man, Sachs prepared a reading file for the President containing the two letters, his own paraphrase of the letters, and a copy of a book of lectures by F. W. Aston of Cambridge, Oxford in honor of Lord Ernest Rutherford, an early British atomic physicist.[32] Interestingly, to open the meeting Sachs read his own paraphrase to Roosevelt rather than the Einstein Letter:

> Briefly, the experimentation that has been going on for half a dozen years on atomic disintegration has culminated this year (a) in the discovery by Dr. Leo Szilard and Professor Fermi that the element uranium could be split by neutrons and (b) in the opening up of the probability of chain reactions—that is that in this nuclear process uranium itself may emit neutrons. This new development in physics holds out the following prospects:
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> 1. The creation of a new course of energy which might be utilized for purposes of power production—
> 2. The liberation from such chain reactions of new radio-active elements, so that tons rather than grams of radium could be made available in the medical field.
> 3. The construction, as an eventual probability, of bombs of hitherto unenvisaged potency and scope. . . .
>
> In connection, then, with the practical importance of this work—for power, healing, and national defense purposes—it needs to be borne in mind that our supplies of uranium are limited and poor in quality compared with the large sources of excellent uranium in the Belgian Congo, and, next in line, Canada and former Czechoslovakia.[33]

Roosevelt had proclaimed a National Emergency and was trying to get Congress to lift the arms embargo.

[32] Alexander Sachs, Testimony before the United States Senate, Special Committee in Atomic Energy on Senate Resolution 179, Tuesday, November 27, 1945, 7-8. Sachs revised his statement a bit and placed it as an appendix to the proceedings. He also deposited a copy for the *MED History* in the National Archives. An account of the meeting is also summarized in Rhodes, 313-315; Wyden, 35-38.

[33] Sachs, 7.

Then, Sachs quoted from a series of lectures prepared by F. W. Aston in honor of Lord Rutherford on the theory of atomic research. The book, *Forty Years of Atomic Theory* reviewed the progress of atomic research in England and other countries. Sachs read the last paragraph of that work to Roosevelt:

> There are those about us who say that such research should be stopped by law, alleging that man's destructive powers are already large enough. So, no doubt, the more elderly and ape-like of our prehistoric ancestors objected to the innovation of cooked food and pointed out the grave dangers attending the use of the newly discovered agency, fire. Personally, I think there is no doubt that subatomic energy is available all around us and that one day man will release and control its almost infinite power. He cannot use it exclusively in blowing up his next door neighbor.[34]

Roosevelt evidently got the point of Sachs' presentation.

> The President remarked, "Alex, what you are after is to see that the Nazis don't blow us up."
> I said, "Precisely," and he then called in General Watson . . . . and he said, "This requires action."[35]

Early government support—The uranium committees

Watson organized an informal committee, first selecting the two military men most concerned with science—Lt. Colonel Keith Anderson for the Army and Commander Gilbert Hoover for the Navy—to serve on the committee. He appointed Dr. Lyman J. Briggs, director of the Bureau of Standards, the nations' government physics laboratory as the chairman of the committee.[36] Sachs sent a letter to Eugene Wigner, a respected physicist to help

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[34] Sachs, 9.

[35] Sachs, 9.

[36] Sachs, 9; Hewlett and Anderson, 19-20.

him contact interested scientists. The first Advisory Committee on Uranium met on October 21 with nine in attendance.[37]

Leo Szilard began the session with an overview of the possibilities of a chain reaction using uranium and graphite layered together. Edward Teller then addressed the group, and the issue of money for funding the project was raised. Commander Hoover insisted upon a precise amount, and Teller told him $6,000 would work for the first year so that the scientists could buy graphite. The amount was agreed upon, and a report of the meeting was sent to the President on November 1, 1939, claiming that a chain reaction was a possibility but still unproved. The group suggested that the government support a thorough investigation though and concentrate it in the universities of the country. The President noted the report, according to a memo from Watson on November 17, and decided to keep it on file for future reference.[38]

The government could not be pushed into any other action for several months mainly because there seemed to be so much debate on the feasibility of an atomic weapon. The scientists also tended to avoid military applications and concentrated their studies instead upon a chain reaction to develop nuclear power. The one fear—world domination by Germany—waxed and waned throughout those early months, and with it saw the rise and fall of interest in the uranium research problem. Just when government interest would seemingly die, Germany would cause a renewed interest in the weapon

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[37] Sachs, 9-11; Hewlett and Anderson, 20. Briggs, Fred L. Mohler a physicist of the Bureau of Standards, Richard Roberts a physicist of the Carnegie Institution, Sachs, Szilard, Wigner, Edward Teller, Anderson, and Hoover were the attendees.

[38] Hewlett and Anderson, 20.

by conquering another area of Europe. The money for graphite calculations was not transferred from the Army and Navy until February 1940.[39] Events in March renewed interest when *The Physical Review* began reporting that in order for a chain reaction to occur, U_{235}, the lighter isotope of uranium, must be used.[40] Several experiments helped close the gap on the possibility of a nuclear chain reaction, but no earthshaking discoveries came from the scientific community. Einstein, in the spring of 1940, sent yet another letter relating the experiments at the Kaiser Wilhelm Institute in Germany. At a meeting of the Uranium Committee in April, the émigrés still could not shake the Army, Navy, or the government into decisive action; the bureaucrats decided to wait until calculations of the uranium graphite system at Columbia had been completed before taking decisive action. At a meeting in June 1940, a request of $40,000 was made for continued research on the Szilard-Fermi experiments at Columbia. Before the money could be awarded though, other administrative events affected the future of the Uranium Committee.[41]

The organization of the National Defense Research Committee (NDRC) on June 27, 1940, placed the Uranium Committee within a new organizational structure[42] under Vannevar Bush.[43] The first contract awarded was the $40,000

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[39] Smyth, 47-48.

[40] Hewlett and Anderson, 22.

[41] Smyth, 49.

[42] Irvin Stewart, *Organizing Scientific Research for War* (Boston: Little, Brown and Company, 1948), 8-9. NDRC was to direct and coordinated scientific weapons research by issuing contracts to individuals, educational institutions, and industry. It was not intended to replace the Army or Navy and its laboratories but was supposed to expand the scientific role in national defense.

[43] Rhodes, 356; Kevles, 293-94. Vannevar Bush was a technical genius, an engineer who received a doctorate jointly from MIT and Harvard in 1916. He went on to conduct war

to Columbia University for continuation of the Fermi-Szilard experiments for a chain reaction.[44] The committee continued to operate in the same form until the summer of 1941, when it was enlarged, renamed the Uranium Section or S-1 Committee, and placed under the Office of Scientific Research and Development with subcommittees formed on uranium isotope separation, theory, power production, and heavy water.

After a year, NDRC showed some definite weaknesses since it acted primarily as a research organization, with little power in engineering aspects of the uranium problem. As a solution, Bush founded an umbrella organization to coordinate all scientific research related to national defense. On June 28, 1941, an Executive Order was signed instituting the Office of Scientific Research and Development (OSRD) within the Office for Emergency Management directly under the President of the United States. Bush became director of this new organization and took with him the Committee on Uranium. James Conant replaced Bush as head of NDRC, which became a division of OSRD delegated to make recommendations on research and development. Bush understood well the rearrangement of authority because he stated in an interview later in his life: "'I knew you couldn't get anything done in that damn town unless you organized under the wing of the president.'"[45]

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research creating a successful submarine detector and in the 1920s experimented with analog calculating machines. He rose to the Vice Presidency of MIT and moved to the Carnegie Institution as president in 1939 to become closer to the hub of government work.

[44] Weart and Szilard, 117.

[45] Smyth, 51; Hewlett and Anderson, 41; Kevles, 299-301; Kevles, 301.

Science and National Security

In 1941, several events cemented the link between science and national security. Many American scientists became convinced about the merits of the uranium research program, partly with help from their British colleagues. When the British MAUD Committee[46] sent a report on its scientific progress to the U.S. scientific community, several American physicists became convinced about the possibilities of building a bomb. This committee was much like the U.S. uranium committee, except that it was made up of active working physicists instead of government bureaucrats. MAUD, in the spring of 1940, came to the conclusion that a bomb could be built.[47]

Americans were somewhat more convinced about the feasibility of a bomb after Glenn Seaborg and his research group identified plutonium in E. O. Lawrence's laboratory in California in early 1941.[48] In the spring of 1941, Lyman Briggs persuaded Vannevar Bush to initiate an independent review of the entire uranium project; Bush, in turn, asked F. B. Jewett, president of the National Academy of Sciences, to establish a committee. Jewett appointed a

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[46] Rhodes, 340. The committee was code named MAUD after the mysterious message Lise Meitner had cabled to an English friend: "MET NIELS AND MARGRETHE RECENTLY BOTH WELL BUT UNHAPPY ABOUT EVENTS PLEASE INFORM COCKCROFT AND MAUD RAY KENT. The message was believed to be an anagram for "radium taken." Later in the war, the committee found out that Maud Ray was a governess for the Bohr children who lived in Kent.

[47] Moore, 276-79; Rhodes, 329-330, 340-41. The committee reported that fast neutrons as well as slow neutrons could cause nuclear fission. The report included an estimation that U235 could be reproduced in a sphere small enough to make a bomb. The best method to produce the bomb—gaseous diffusion—would turn uranium into a gas thus allowing for the collection of the U235 isotope. The committee also severely criticized American scientists because they were doing nothing about the German menace.

[48] Rhodes, 352-355. In March 1941, Glenn T. Seaborg, a young chemist in Lawrence's laboratory, discovered a new element called 94, later named "plutonium" in 1942.

committee chaired by Arthur H. Compton of the University of Chicago, charging it to study the military importance of uranium and decide upon the level of expenditure needed for a concentrated government-supported effort in uranium research.[49]

Shortly after a meeting in May 1941, the committee presented its first report recommending an intensification of the research effort for at least six months.[50] Later that summer, an appropriation of $267,000 was made for uranium research, partly because of that first report and partly because of the reports on British research.[51] A second report produced recommendations on the engineering aspects of uranium research in the summer of 1941.[52]

A third report was commissioned and delivered in the fall of 1941, but not before Bush, at a high-level presidential meeting on October 9, 1941, was given a free hand to investigate the possibilities of making an atomic bomb.

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[49] Smyth, 51. Arthur Compton was a physicist already of some renown and the younger brother of Karl Compton, President of MIT, who had already had some interest in this general field.

[50] Rhodes, 365. The committee detailed three military applications of research: production of radioactive materials to spread on enemy territory, a power source for submarines and other ships, and explosive bombs. The committee also developed a timetable: a year was needed to produce and test the radioactive materials, the power source would require three years after a chain reaction was created, and bombs could not be ready before 1945. A priority was placed on obtaining a sustaining chain reaction.

[51] Smyth, 51. Briggs was still in charge of the budget recommendations for the Uranium Committee. He made pleas not just from the first report but based also on work that had been undertaken in England by MAUD. Briggs argued for continuing the first objective of a chain reaction. But he claimed that isotope separation was crucial for any military applications of uranium production and suggested that a chain reaction could occur in an airplane-carried bomb device.

[52] Hewlett and Anderson, 39. Compton traveled to South America that summer so William D. Coolidge, a physical chemist recently retired from General Electric, was given the charge to add some engineers to the committee and review the first report. Their review was sent to Bush on July 11, 1941, and supported the first report's recommendations. The emphasis was still on creating a chain reaction rather than a bomb.

Bush conferred with Roosevelt and Vice President Henry Wallace whom he had already briefed on uranium progress earlier in the summer. He outlined British research achievements, the costs of building a production plant, what little was known of German research, and the time needed to produce a weapon. Bush was told to expedite the work in every way but not to proceed on building a production plant since that would need more discussion and a different organization to carry out Policy considerations on these matters were to be restricted to Roosevelt, Wallace, Bush, Conant, Secretary of War Henry Stimson, and Army Chief of Staff George C. Marshall, transferring responsibilities from the Uranium Committee to a new, more secretive group around the president. The specter of German domination played a major role in the actions on the part of Bush and the president. By the fall of 1941, both men had seen the results of Hitler's campaign and coupled with reports from British research and reports from those escaping from Germany who insisted the country was progressing on atomic research, their inclinations were much stronger to support an ultimate weapon. Bush actually gained permission to finalize the bond between science and national security in that meeting.[53]

Bush received the third report on November 6, 1941, and the President was sent his copy on November 27. Compton had traveled extensively in October of that year to gather the information needed for this third and most important report.[54] In that third report, he issued a clear call to build a bomb,

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[53] Hewlett and Anderson, 45-46.

[54] Smyth, 46-49; Rhodes, 373-376, 386-387; Compton, 53. It was probably the Mark Oliphant visit that helped Compton and several other Americans including Conant, Bush's right-hand man issue a clear call for a bomb. Oliphant from Britain toured the United States in the late summer and early fall of 1941 as an strong advocate for building a bomb. He relayed news of British research at a meeting of the Uranium Committee in August, using the

thus moving scientific research into practical, military applications tied to national security. The objective of the program in scientific research would simply be: "'to consider the possibilities of an explosive fission reaction with U$_{235}$.'"[55] A bomb with enough destructive power could be created by gathering together a mass of U$_{235}$. How much destructive power was still unknown, but something on the order of a few hundred tons of TNT was possible. The report evaluated methods of isotope separation including gaseous diffusion which the British were committed to and the centrifuge system in development at Columbia. It estimated that bombs could be ready in three to four years. Costs were difficult to estimate, but the most expensive part of the process, the separation of the isotopes, could cost $50 to $100 million and the production of bombs could cost as much as $30 million. The report was just what Bush wanted and could have been the impetus to push America headlong into the uranium research project except that Bush had received approval to proceed a full month before this report. It did verify, after the fact, what Bush had convinced Roosevelt of in the October 9 meeting: science could

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word "bomb" very clearly. He solicited assistance from the United States because Britain, according to him, did not have the resources, an estimated $25 million, to build a bomb. Since he was not immediately effective with the Uranium committee, he decided to attempt to convince the most enthusiastic scientist he knew in America, Ernest O. Lawrence. And convince him he did. Lawrence contacted Arthur Compton at Chicago shortly after Oliphant's visit and repeated his conversation with Oliphant. A special meeting was set in Chicago on September 25, 1941, because Lawrence was to be in town to speak on the occasion of an honorary degree to be bestowed upon James Conant, the chairman of the NDRC. The three men met and after a heated discussion agreed to push uranium research in the United States. Conant went back to report the meeting to Bush, and shortly thereafter the third report was commissioned. Compton described that meeting as the start of the wartime atomic research program. Conant, in his secret history of the Manhattan Project, indicated that men like Oliphant helped turned the tide in the American uranium research enterprise.

[55] Rhodes, 386.

be used in a practical, military way to protect the country's security. Roosevelt returned his copy to Bush two months later on January 19, 1942, with a note attached that said:

> V. B. OK—returned—I think you had best keep this in your safe.
> FDR.[56]

Bush took action long before that returned note. Lyman Briggs, at Bush's request, called members of the Uranium Committee to come to Washington on December 6, 1941, to talk about reorganization of the uranium work. Bush sent more detailed letters, dated December 13, 1941, to each of the primary administrative men to be involved in the expanded government-supported project. A planning board with Eger V. Murphree, a young chemical engineer as head, would oversee engineering planning studies and supervise any pilot plant efforts. Bush appointed three program chiefs in charge of physics and chemistry research: Harold Urey to handle separation by diffusion and centrifuge methods as well as heavy water studies; Ernest Lawrence in charge of small-sample preparation, electromagnetic separations, and plutonium (element 94); and Arthur Compton with responsibility for the chain reaction to produce plutonium and oversee weapons theory. Two weeks after Pearl Harbor, the first large contract was awarded to Lawrence for $400,000 to study electromagnetic separation techniques.[57] Arthur Compton went back to the University of Chicago to create the Metallurgical Laboratory. The uranium research project had begun in earnest.

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[56] Rhodes, 388.

[57] Hewlett and Anderson, 49-52.

The Metallurgical Project and Laboratory

The period from December 1941 to February 1942 revealed more effort devoted to the administration of uranium research than to research itself, as evidenced by the creation and organization of the Metallurgical Project under Arthur Compton at the University of Chicago. Compton, author of the three National Academy of Science reports, was already a committed and distinguished physicist in the field of atomic research when called upon to head a program coordinating theoretical studies on plutonium and building a reactor to confirm a sustaining chain reaction.[58] In 1939, he heard about the discovery of uranium fission but thought his research was far afield from nuclear physics. When he became active in the field of cancer research though, his friend at the University of California in Berkeley, Ernest O. Lawrence, convinced him to take another look at atomic research.[59] That involvement began when Jewett called upon him to head a review of recent atomic research and its military applications, a task Compton took enthusiastically.

On the afternoon of December 6, 1941, Arthur Compton first had lunch with his new bosses Bush and Conant and then proceeded to his hotel room to make arrangements for his new assignment. According to his recollections, he spent that whole afternoon and evening on the telephone making contacts to

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[58] Riedman, 188-190. Compton, the son of a Presbyterian minister, was born on September 10, 1892. He received his doctorate from Princeton in 1916 and studied under J. J. Thomson, the famous English physicist, at Cambridge where he also attended lectures by Ernest Rutherford, a Nobel-winning physicist. Upon his return to the United States in 1920, he became a professor at Washington University in St. Louis where he concentrated his research on x-rays. Three years later, the University of Chicago appointed him professor of physics. In 1927, he received the Nobel Prize for work on waves and light.

[59] Riedman, 190.

coordinate his new enterprise. He called Fermi at New York and George G. Pegram, a physicist friend at Princeton, to get advice and talk of plans for the future. On December 7, 1941, he remembered going to New York to talk to Fermi and his colleagues about the direction of research and to get their assurances that the group would work with him. Out of great respect for Compton as scientist, they readily agreed to support the project.[60]

The S-1 Committee met in Washington on December 18, 1941, and Bush announced the official revamped uranium research organization. Compton sent Bush a memorandum on December 20, 1941, detailing his plans and proposing a preliminary budget for the project. For the time being, the project research would be centered in Columbia, Chicago, Princeton, and Berkeley. His budget of several million was approved when it would have been unfathomable only a short time ago.[61]

From December to February, Compton was immersed in organizational plans and problems. In January, he began a series of meetings to discuss centralizing the efforts at one site rather than have research sites at Columbia, Princeton, Berkeley, and Chicago.[62] The various discussions, often heated,

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[60] Compton, 72-73. Laura Fermi, 185. Laura Fermi summed up the respect for Compton in the following way: "Compton was a thoughtful and considerate person, who took no step without weighing its effects upon others. Perhaps because of this, whenever he expressed an opinion, it was interpreted as an order and accepted without much comment."

[61] Rhodes, 398; Hewlett and Anderson, 53-54. At Columbia and Princeton the building of a pile and corresponding physical measurements would require 80 men and $340,000 for six months; Chicago needed 150 people and $278,000; and Berkeley wanted 150 men and $650,000 to prepare U_{235} and plutonium. Compton asked for another $500,000 for pile materials.

[62] Hewlett and Anderson, 53-55. The first meeting occurred at Chicago on January 3, 1942, and the best he could accomplish was a promise to continue existing work at the various sites. The second meeting at Columbia on January 18 at least developed a preliminary program timetable: by July 1, 1942 to determine whether a chain reaction was possible, by January 1943 to achieve the first chain reaction, by January 1944 to extract plutonium (element 94) from uranium, and by January 1945 to have a bomb. In the afternoon of that meeting, the

culminated in the now-famous and often repeated sickroom episode. Compton called his main scientists to Chicago and when they arrived on January 24, 1942, they were ushered into the bedroom where Compton was battling the flu and a fever. He argued to move the site to Chicago to concentrate all the research from the various laboratories. He tried to convince the others at the meeting—Leo Szilard from Columbia, Ernest Lawrence from Berkeley, Luis Alvarez from the M. I. T. Radiation Laboratory, Richard Doan from Phillips Petroleum Research Laboratory, and Norman Hilberry from New York University—the merits of a Chicago location. Compton had already received enthusiastic support from the president and vice president of the University of Chicago; there were more men to draw from in the central part of the country since there were fewer involved in war-related work, and Chicago was centrally located between the east and west coasts. After endless discussion, the physically and mentally exhausted Compton, the noted consensus builder, made an arbitrary decision: the site would be Chicago and those at the meeting should join him in the research effort there.[63] The only objection came from Lawrence, and Compton later recounted that objection:

> "You'll never get the chain reaction going here. The whole tempo of the University of Chicago is too slow."
> "We'll have the chain reaction going here by the end of the year,"

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topic turned again to centralizing the research at one site. Compton and Lawrence dominated the discussion and both agreed that at least the chain reaction research should be in the same place, if not the whole project. They had agreed that the large cyclotrons at Berkeley could not be moved elsewhere, and Lawrence would remain in Berkeley to oversee that part of the research. However, Columbia and Princeton scientists did not want to move their operations either.

[63] Compton, 80-81; Rhodes, 399.

> I predicted.
> "I'll bet you a thousand dollars you won't," he challenged.
> "I'll take you on that," I answered, "and these men are the witnesses."
> "I'll cut the stakes to a five-cent cigar," countered Lawrence.
> "Agreed."
> I won the bet, but I haven't yet received the cigar. Maybe the five-cent variety is no longer made.[64]

After the meeting, Compton called Fermi who somewhat reluctantly agreed to come to Chicago as soon as possible, and sent his assistant, Herbert Anderson, ahead to prepare for Fermi's arrival. Eugene Wigner at Princeton was also called and agreed to come. Leo Szilard, who had immediately left Chicago after the meeting, was telegraphed in New York to join Fermi.[65]

Compton had previously discussed the wartime research project with President Robert M. Hutchins and Vice President E. T. Filbey. They had already talked about the location of a nuclear reactor and what adjustments might need to be made on campus to accommodate the research. On the morning of January 25, Compton went to see Vice President Filbey to get clearance for the moves of the scientists to Chicago and to discuss their locations on campus. Shortly, thereafter, the mathematics department, which shared quarters with the physicists in Eckhart Hall, was contacted and volunteered to move its entire operation to the library in order to make room for the expanded research project and the anticipated new personnel.[66]

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[64] Compton, 81.

[65] Rhodes, 400.

[66] Compton, 80, 82.

By February, the centralized project had taken its code name as the Metallurgical Project, so called, according to Compton, because

> we had been considering for some time setting up at the University an institute of metals, which indeed became a reality after the war was over. Thus our Chicago colleagues saw nothing surprising in a wartime metals research program.[67]

Compton was director of the Metallurgical Project and Norman Hilberry was appointed Associate Director. But now the project needed a centralized research facility or laboratory. Called the Metallurgical Laboratory, it was also organized and staffed during this period. Richard Doan, because of his experience in industrial organizations, was made director and scientists from around the country were brought to Chicago, including one from Iowa State College.[68]

The Ames Project

Frank H. Spedding: Chemistry division leader and Ames Project head

Sometime between December 1941 and February 1942,[69] Frank H. Spedding, a professor in charge of physical chemistry at Iowa State College in

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[67] Compton, 82.

[68] Compton, 83.

[69] In several interviews later in his life, Spedding claimed he was contacted by Compton on December 6, 1941, and asked to take over the Chemistry division. Though that is possible, it is somewhat unlikely if Compton needed to contact others to get Spedding's name. Also, the Metallurgical Laboratory was not organized until sometime in January and this would have been a more logical time to contact Spedding. There is also evidence that Spedding was in Chicago in January for several weeks according to some of his later interviews and interviews with Wilhelm making this a more likely time to be asked to head up chemistry research. In other accounts, particularly from the early Ames Laboratory publications, Spedding claimed he was contacted sometime in February. In any event, Spedding was officially hired on the project on February 21, 1942. Referenced in J. C. Sterns, "Letter to Frank H. Spedding on Hiring," March 19, 1942, the Frank H. Spedding Papers, Record Group 17/1/11, the Robert W. Parks and Ellen Sorge Parks Library, Ames, Iowa (hereafter cited as Spedding Papers). A memorandum was sent to President Charles Friley on

Ames, Iowa, was asked to take over the Chemistry Division of the Metallurgical Laboratory in Chicago. How a young professor of chemistry, who had not been directly involved in uranium research before 1942, could be asked to direct some of the most famous atomic chemists is puzzling at best, unless considerable information is provided about Spedding's background and the situation at Iowa State College in 1942.

Frank Howard Spedding was actually uniquely qualified to take over the Chemistry Division. His academic preparation had been meticulous, and his breadth of chemical knowledge in rare earth chemistry exemplary. Spedding was born October 22, 1902, in Hamilton, Ontario, Canada to American parents. The family moved to Ann Arbor, Michigan shortly after Spedding's birth where his father became a well-known, successful photographer. Spedding graduated from the University of Michigan in 1925 with a B.S. in Chemical Engineering and an M.S. in analytical chemistry the following year. Spedding worked under H. H. Willard and though he liked the man, he did not like the scientific area. Early in his studies, he received a taste of the hard work of experimentation. Given a 50-pound rock of pollucite or cesium ore by Professor Willard, Spedding was told to extract cesium from it and prepare it, preferably as a pure salt or chloride. By 1926, he gave his professor several kilograms of the salt.[70] Spedding almost had his moment of glory when he

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February 24, asking for the half-time release of Spedding to work on the Metallurgical Project (Referenced in Charles E. Friley, "Letter to Arthur H. Compton on Frank Spedding's Appointment," February 28, 1942, Spedding Papers).

[70] Frank H. Spedding, interview 1 with Elizabeth Calciano, Ames, Iowa, April 21, 1971, revised October, 1979 by Frank Spedding, transcript in possession of Edith Landin, Ames, Iowa, 5-6 (hereafter cited as Spedding, interview 1 with Calciano). This series of interviews

thought he had discovered a new element. He was set to call it Michiganium, but discovered that what he thought was a new element were actually impurity traces in the materials with which he was working.[71] As he was about to finish his Master's degree, Spedding met one day with a professor he had in his undergraduate days, Moses Gomberg, who suggested that he go on to Berkeley and work under G. N. Lewis, head of physical chemistry at the best school in that area in the country.[72] Gomberg wrote a recommendation and despite the fact that Spedding applied late, he was offered a teaching assistantship and placed in Lewis' prestigious research group.[73]

The advantages to a young scientist coming to Berkeley were obvious. Almost every nationally known and internationally known figure in chemistry and physics found his/her way to lecture or present seminars at Berkeley Equipment was readily available to conduct theoretical or experimental studies. G. N. Lewis was also the consummate scientist, and Spedding later estimated that clearly one-third of all physical chemistry department heads in the country had studied under this master chemist.

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was conducted in the late seventies and early eighties by the daughter of Frank H. Spedding. The author was given permission to view the transcripts of interviews that were revised by Spedding, those in possession of Edith Landin who served as Spedding's assistant at the Ames Laboratory.

[71] Spedding, interview 1 with Calciano, 7-8.

[72] Harry J. Svec, "Prologue: F. H. Spedding (Oct. 22, 1902-Dec. 15, 1984)" in *Handbook on the Physics and Chemistry of Rare Earths,* edited by K. A. Gschneidner, Jr. and L. Eyring, Vol. 2 (London: Elsevier Science Publishers, 1988), 1-2. Some of the material for this book was taken from a Svec interview with Spedding in 1984, that was reprinted in various forms for several Ames Laboratory publications for Spedding's eightieth birthday and for a narrative to nominate Spedding for the J. B. Priestly medal.

[73] Spedding, interview 1 with Calciano, 1, 14.

Lewis encouraged discovery and experimentation in any field of interest When asked to define physical chemistry once, G. N. Lewis was reported to have said it was anything that interested him.[74]

Frank Spedding was put to work proving and disproving several of Lewis' far out theories [75] In addition to learning about experimentation, Spedding also developed an approach to science that would be used later in the organization of the Ames Project. Lewis did not teach chemical theory. Instead, his students were taught that scientists had to experiment and stand up to scrutiny by their peers through an ongoing examination that took place under the seminar system. Spedding later described that seminar experience vividly. It generally met on Tuesday night from 7:30 to 9:00 or 10:00 p. m. in a special room with one long table in the center where faculty sat and a eight-inch platform surrounding the table where the students sat two rows deep. All senior faculty attended. Professor Lewis with his smoky cigars continuously filling the room often made the main speech, or a student would sometimes have to present a paper and stand for criticism. After about an hour, the moment arrived that the graduate students dreaded. Lewis would call on some unsuspecting student and ask him or her to present to the group a summary of his research in progress. Once Lewis called upon a student and she froze and ran from the room. Because that event somewhat disturbed him, Lewis began to stop students on Tuesday afternoon and tell them to be ready. Later, he called major professors and told them to have their students

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[74] "Frank Harold Spedding Turns 80," *Ames Lab Changing Scene* 8, 10 (October 1982): 2.

[75] Spedding, interview 1 with Calciano, 24.

ready for that night.[76] Spedding, cigar and all, would repeat those very scenes in his own organization during the war and long after the war with his infamous Sunday and later Thursday Speddinars (as they came to be known).

Spedding inherited from Lewis another scientific approach that would be crucial to the development of the Ames Project: good scientists tackled tough problems whether or not they knew anything about them. Once a question could be formulated or what the scientists were looking for could be identified, the problem was practically solved. That philosophy was sorely tested during the war years at Ames.[77]

Frank Spedding spent two years in research for Lewis without finding a problem to publish as a thesis topic. Finally, Simon Freed, another graduate student, just finishing his Ph.D. in the band spectra of rare earths, invited Spedding to work with him evaluating the magnetic properties of the rare earths at low temperatures. Lewis encouraged the experimentation but did not place his name on any of the publications since he was not directly involved in the research work.[78] Spedding finished his Ph.D. in May 1929, after writing his dissertation. There were numerous jobs for young Ph.D.s at that time, but Lewis offered Spedding an instructorship to remain at Berkeley, a common way for obtaining a long-term academic job at this particular institution.[79]

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[76] Spedding, interview 1 with Calciano, 39-41 In that interview Spedding admitted to modeling his own seminars after those of Lewis.

[77] Frank H. Spedding, interview 2 with Elizabeth Calciano, transcript in possession of Edith Landin, Ames, Iowa, n.d., 76.

[78] Spedding, interview 1 with Calciano, 30.

[79] Calciano interview 1, 30-33. Generally, a bright student would be offered an instructorship whereupon he would work one year at a time under the instructorship. If reappointment occurred four times, usually an assistant professorship with a three-year contract was offered. After one or two terms of those assistant professorships, the department

Spedding took the offer and, of course, expected to remain at Berkeley permanently. Unfortunately, the Depression intervened in October 1929, and Spedding had to settle for a series of one and two year temporary appointments, each adding to his knowledge about his specialties—spectroscopy and rare earths—but none adding to his job security or to his financial situation. In 1931, he received the prestigious but not lucrative National Research Fellowship, awarded by the Rockefeller Foundation, for two years of full-time research at Berkeley In 1932, he received his old job back from G. N. Lewis for two more years at the salary of $1,000 per year.[80] By this time, it had become common for the younger men to take associateships for about one-half of an instructors pay.[81]

The year 1933 was an auspicious year for the young chemist, even though he still had no permanent academic appointment. Early that year, Spedding had obtained some samples of rare earths from a professor in Illinois and set about to prove a theory: the fine structures of the rare earth bands depended upon the adjacent atoms in the crystal in which the rare earths were placed. For this work he was awarded the Langmuir Prize for Chemistry in 1933.[82] Spedding was invited to receive the award and make a speech at the

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examined the person's credentials and if it wanted that person as a permanent faculty member, an associate professorship with tenure was offered.

[80] Svec, "Prologue," 1988, 4.

[81] Spedding, interview 1 with Calciano, 35.

[82] "Frank Harold Spedding Turns 80," 3; Svec, 1988, 4-5. Spedding was only the third chemist to win the award, following Oscar K. Rice and Linus Pauling. He was the last under 31 to win it. The next year the award name was changed to the Award in Pure Chemistry of the American Chemical Society and awarded to young chemists under 35.

Chicago World's Fair. When he finished his speech and received his award, he noticed an older man approaching the podium. In his later years, Spedding remembered the old man:

> [He] was short, had a long white beard and was bald. . . . He blurted out "How would you like to have a pound of europium and two or three pounds of samarium?"[83]

Of course, Spedding thought the man was crazy. As far as he knew, those rare earths were available only in milligram quantities. He answered the man politely and told him that would be fine; it would certainly help his work to receive europium and samarium. After he arrived back in California, a box containing fruit jars of europium and samarium oxides arrived from this odd man in Chicago. As it turned out, his patron was Herbert McCoy, a professor of chemistry from the University of Chicago. Spedding started a correspondence with the man that lasted until McCoy's death in 1945. McCoy befriended young chemists like Spedding and provided them with quantities of rare earths for their research, only charging them cost or nothing at all in some cases.[84]

In 1934-35, Spedding won the Guggenheim to work abroad in Germany with two physicists, James Franck, a Nobel Prize winner, and Francis Simon, an expert in low temperature physics. Unfortunately, before Spedding could finalize his trip plans, Hitler came to power and both men fled the country.

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[83] Svec, "Prologue," 1988, 5.

[84] Svec, "Prologue," 1988, 5-6. It was probably Herbert McCoy who later got Spedding the job as Chemistry Division chief and even Compton in *Atomic Quest* confirmed that it was McCoy who recommended Spedding to him (p. 93). See also Norman Hilberry, interview with George Tressel, 1967, Transcript of Reel 2, In possession of author, Ames, IA, 4. Hilberry also indicated that it was McCoy who suggested Spedding to the physicists when they met in early February 1942.

Spedding went instead to England to work at the famous Cavendish Laboratory with Ralph Fowler, a noted theoretical physicist. He also traveled to other laboratories in France and Germany and spoke in Leningrad. The Speddings, Frank and Ethel, also went to Copenhagen for a month where he worked with the eminent Niels Bohr. After this time abroad, Spedding and his wife returned to the United States. Still with no permanent job, Spedding took another temporary two year position, the George Fisher Baker Assistant Professorship at Cornell University for 1935-37.[85]

Spedding, working with Hans Bethe a colleague at Cornell, resumed his previous rare earth research and continued to depend upon Herbert McCoy for a supply of rare earths.[86] When the two year stint was over, Spedding was in the same situation, with no promise of a permanent job. He decided to try his luck again in Berkeley, so he and Ethel packed their old Chevrolet and turned west. Spedding had heard of an opening at Ohio State, but when he arrived, William Lloyd Evans, the chairman of the department, had just hired a chemist the day before. Evans told Spedding that his friend Buck Coover had an opening at Iowa State College for a physical chemist, and Evans even

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[85] Svec, "Prologue," 1988, 5-7; Frank H. Spedding, interview with Harry A. Svec, Ames, Iowa, September 1984, transcript in Spedding Papers, 3-4. For a very detailed account of the trip abroad see one of the chapters in Edith Landin's possession called "Year in Europe—1934-35." This manuscript of several chapters was dictated to Ms. Landin, Spedding's assistant, hired to help him prepare a book he wanted to publish on his life. Unfortunately, Spedding died before he could publish the work. Dr. Spedding's daughter has given this author permission to use material from this book in this dissertation. It was dictated in the late 70s and early 80s and much of the material is duplicated in the Calciano interviews. The "book" is a collection of chapters with some paged, but none arranged in a definite order (hereafter cited as Spedding Manuscript).

[86] Spedding, Letters to Harold McCoy, June 28, 1936 and January 20, 1937; Letter from Harold McCoy February 8, 1937, Spedding Papers. McCoy's only demand for giving Spedding rare earths was that he continue in the field of low temperature research, a research field of none of the other eight to ten receivers of McCoy's largess.

offered to write a letter of reference. Spedding traveled on to Ames, Iowa and talked to Coover who offered him the job on the spot. Spedding tells the rest of the story:

> [Coover] was a horse trade and he said, "Now I can give you an appointment if you take assistant professorship."
> And I had guts enough to say, "No, I've been seven years on temporary appointments and I'm looking for a job with tenure, so I won't take anything less than associate professor."
> So he said, "I'll have to go to the Board of Regents."
> I said, "Fine. I'll go on West and you can wire me."[87]

Spedding traveled to Yellowstone National Park and after a week of not hearing, he decided to move on to Berkeley. They started to leave, but first Ethel stopped at the bathroom. Spedding remembered:

> While she was in there, I was over looking at the bulletin board. There were a lot of telegraph messages on it. There was a note on there to Dr. Spinolza, and I read it. And it said: Regents granted you an appointment. And I thought it sounds just like what I'm looking for, but the wrong name. Anyway, I got on the phone and called Coover, and it was his message; they just got the name all wrong. It was just a minute's difference of whether I'd got it or not. . . . I wouldn't normally have chosen the place. I was desperate; I hadn't been able to get a job except fellowships for seven years, and I thought, "Well I can go there and build up Physical Chemistry and when things really open up, I can go to another school."[88]

So Spedding, the nationally known chemist from Berkeley, found his way to Iowa State College in 1937 to take over the physical chemistry section. In early 1942, Arthur Compton invited Frank Spedding to participate in the

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[87] Spedding, interview with Svec 1984, 6.

[88] Spedding, interview with Svec 1984, 6. At the time, when Spedding corresponded with his friends or colleagues, he presented Iowa State in much better light. In a letter to McCoy on November 10, 1937 (Spedding Papers), he said: "So far, I have liked my new position very much as I am able to run things just to suit myself and the research opportunities are very good."

atomic bomb project. According to Spedding, Arthur Compton decided that he needed expertise in chemistry and metallurgy to complete his project satisfactorily. At this time very little about the chemical qualities of uranium and its byproducts was known. Spedding was chosen as head of the Chemistry Division, but because there was little room for the number of scientists needed, Spedding volunteered to start chemical and metallurgical research on the Ames campus. Spedding later related:

> They had vastly underestimated the amount of chemistry that had to be done. So that when I arrived at Chicago, they were allowing two rooms for the chemists to do all the chemical work and I informed [Compton] that two rooms would be woefully inadequate. . . . So I told Dr. Compton that they had to have a lot of chemical and metallurgical work done immediately, and we couldn't do it at Chicago until we built a building and till we got some staff together. . . . But it takes time for people to pick up and move, and I told him that we had a metallograph and we had a furnace here at Ames and that we could get some of this work going. And so after he deliberated a week or two they decided . . . that I would spend half a week in Ames . . . . testing out various things that might be used in a reactor.[89]

The only other professor in the section was Harley A. Wilhelm, an instructor who had graduated from Iowa State in 1931. Wilhelm had held the area together and was the College's only spectrochemist. When Spedding came in, that was his area too, so he took an old spectrograph that had been ordered in the 1920s by Anson Hayes, a physical chemist of some renown that Iowa State had lost to industry. Spedding gave Wilhelm the area of metallurgy.[90] Spedding soon found his teaching load heavy; he served on a large number of

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[89] Interview with Frank H. Spedding, Harley Wilhelm, and Adrian Daane, May 1967.

[90] Wilhelm, interview with author, 1990.

Ph D. committees; and the equipment to do the type of research he wanted to conduct could not be ordered because of the lack of funds.[91] He even had to temporarily change his emphasis from the rare earths to topics of an agricultural emphasis, an area of research in which he could find College funds.[92]

Iowa State University: The location of the science laboratory

It is surprising that Iowa State College became the center for this uranium research, considering the state of research and science at the institution at the time. Spedding recalled Iowa State as typical of many midwestern schools. The student body numbered around 5,000 and was dominated by agriculture, engineering, home economics, and other applied

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[91] In several letters to McCoy, Spedding tells of the deteriorating situation. On February 27, 1939 he tells McCoy: "I have been extremely busy getting this division organization and getting my teaching under way so that my research has suffered. However, I have finally assembled my equipment and expect to be producing at the same old rate shortly." On January 28, 1941, he again tells McCoy, "It has taken longer than I anticipated to get my research program functioning here at Ames but I expect to have it go full blast from now on." He tells McCoy about building a spectrograph and wood grating, but he does not tell him the frustrations of writing over two hundred companies to get the pieces necessary to build that equipment (Spedding Papers notation on a miscellaneous file).

[92] "Industrial Science Research Institute Progress Reports on Projects," Iowa State College, Division of Industrial Science, Office of the Dean, May 8, 1939, Ames Laboratory Papers, 5; Iowa State College of Agriculture and Mechanic Arts, *Announcement of the Graduate Division*, Ames, Iowa, 1945-46, 126-130. Spedding's first funded project involved his area of absorption spectra at low temperatures, but was for vitamins and organic materials rather than rare earth metals. Spedding's department was part of the Division of Industrial Science, a service division that included most of the non-engineering and agricultural departments on campus. The funds came from the Industrial Science Research Institute, the administering unit that oversaw research for those same departments. Spedding also told McCoy about this new approach in a letter as early as February 27, 1939 (Spedding Papers): "I have become interested in the possibility of quantitatively determining the amount of vitamins, hormones, etc., present in complex organic mixtures by means of adsorption spectra at low temperatures." In 1940 with R. M. Hixon another faculty member in Chemistry, he examined spectra of sugars and starches (F. H. Spedding and R. M. Hixon, "Ramen spectra of sugars, dextrins and starches, *Iowa Corn Research Institute Report of Agricultural Research* 5 (1940): 62-63). Spedding also had five Ph.D. students before the war, all working with adsorption spectra.

subjects.[93] In fact, every Graduate Catalog from 1920-21 until 1946-47 made the following announcement about the purpose of graduate study at Iowa State:

> Iowa State is a technical institution. Its Graduate College offers to qualified students the opportunity to pursue advanced courses and to undertake research in technology and those branches of science that find their application in industry.[94]

In 1937 when Spedding was hired, some basic scientific research was being conducted, although it tended to be primarily in agricultural areas. As far as equipment and research facilities were concerned, Spedding later recounted his version of Iowa State's condition:

> When I arrived in 1937, only a fraction of the building was reasonably and adequately equipped, and many rooms did not have standard laboratory equipment. Instead they had sawhorses with planks on top and a shelf underneath to hold glassware. The glassware was protected by a chintz curtain hanging down from the planks. These rooms were under-wired and the lighting was one cord from the ceiling with a bare electric light bulb. There was [sic] almost no wall plugs. As far as equipment was concerned, there was little of it. As far as I could tell when I arrived in 1937, the building had never been repainted since 1912.[95]

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[93] Frank H. Spedding, interview 3 with Elizabeth Calciano, Ames, Iowa, July 1979, transcript in possession of Edith Landin, 1.

[94] Iowa State College of Agriculture and Mechanic Arts, *Announcement of the Graduate Division*, Ames, Iowa, 1920-21, 11. Each year the bulletin explained that no major advanced degree offerings were made in the liberal arts areas. According to a gentlemen's agreement, the University of Iowa in Iowa City was to handle those areas; Iowa State was supposed to offer only applied courses in its chemical and physical sciences also. The head of the Iowa State chemistry department though resisted that ruling and managed to attract men of the caliber of Henry Gilman, an internationally known organic chemist, as well as Spedding by disregarding that gentlemen's agreement.

[95] Spedding, interview 3 with Calciano, 3; Svec, interview with author, 1991. The chemistry building had burned in 1912, and Coover as chair of the department had built a beautiful new building, but he put all the funding into the building; there was not enough money to furnish it adequately.

Organization of the chemical division of the Metallurgical Laboratory

Spedding's expertise with the rare earths garnered him the division job under Compton. Because there was not enough room at Chicago to conduct the needed chemical and metallurgical research, Spedding volunteered Ames as an additonal laboratory site. Thus, he had two projects to begin—one in Chicago and one in Ames. He spent Monday, Tuesday, and Wednesday at the University of Chicago and Thursday, Friday, Saturday, and Sunday in Ames, making an arrangement with the station master at the Ames depot to reserve a sleeper car every Sunday night into Chicago and one on its return on Wednesday night.[96]

At Chicago, Spedding attempted to gather the best chemists he could find from around the country. He and Arthur Compton visited Glenn Seaborg at Berkeley and convinced him to head up plutonium studies at the University of Chicago. The young, ambitious chemist and some of his research group arrived on April 19, 1942.[97] While in California on the same visit in late

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[96] Frank H. Spedding, interview 5 with Elizabeth Calciano, May 5, 1980, transcript in possession of Edith Landin, Ames, Iowa, 2. Train travel was the preferred mode of travel during the war years. There had been a regular daily train to and from Chicago for several years. Ames was a side station for Des Moines, and the Northwestern Railroad dropped off a sleeper car from Des Moines about 9 p.m. daily ; it sat on the side track in Ames until the *City of San Francisco* came about midnight on it way to Chicago and picked it up. The same train returned with a sleeper car the next morning leaving Chicago about 11 p.m., and arriving in Ames around 5 a.m. It sat until 8 a.m. when it was taken to Des Moines. Spedding always reserved lower berth 5, in car 194 each week.

[97] Spedding, interview 5 with Calciano, 16-17; Glenn Seaborg, "Letter to Frank Spedding," March 2, 1942, Spedding Papers; Frank Spedding, "Letter to Glenn Seaborg," March 11, 1942, Spedding Papers; Glenn Seaborg, "Letter to Frank Spedding," April 9, 1942, Spedding Papers; Hewlett and Anderson, 90. Seaborg, partly due to his youth and lack of experience in administration, had been one of the scientists overlooked when Spedding was chosen as the head of the Chemistry Division, and according to Spedding, he gave him several headaches during his tenure as division head. Spedding had to deal with complaints from those working under Seaborg that he did not give due credit for work. When Spedding stepped down from the job eighteen months later, Seaborg was again overlooked and gave the next director, James Franck, problems too. Eventually, his colleagues, including Spedding,

March, Spedding met an inorganic chemist at the University of California, Los Angeles, Charles Coryell, who specialized in radioactive fission products on cyclotrons and offered him the division of fission products. Milton Burton, from New York University took over the radiation damage section. The fourth group, analytical chemistry, was headed by George Boyd who was already at the University of Chicago. Later, Compton added John Chipman from MIT to head up the metallurgical studies at Chicago.[98]

Summary

From 1939 to February 1942, strides were made in scientific studies of uranium, even though there had been no chain reaction, uranium in only gram quantities was available for experimentation, and knowledge of the chemistry of uranium and its byproducts was virtually nonexistent. But some subtle changes in uranium research and funded research in general had occurred. Scientists arguing from 1939 until early 1941 could not convince the government to fund scientific research. By the end of 1941 though, Vannevar Bush, the engineer/scientist, had convinced President Roosevelt that it was

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came to respect him as a great scientist. They felt that it was his youth and ambition that caused the early problems of not crediting his staff with discoveries or not being the necessary team player (Hewlett and Anderson, 90; "James Franck," Spedding manuscript, 2-3).

[98] Frank H. Spedding, "Charles D. Coryell," Spedding Manuscript, [1]; Charles Coryell, "Letter to Frank H. Spedding on Employment," April 7, 1942, Spedding Papers; Frank H. Spedding, "Letter to Charles Coryell on Employment," April 10, 1942, Spedding Papers; Charles Coryell, "Letter to Frank H. Spedding on Employment," April 24, 1942, Spedding Papers; Spedding, interview 8 with Calciano, 10-11; Spedding, interview 5 with Calciano, 16; Spedding, interview 8 with Calciano, 11; Milton Burton, "Letter from to Frank Spedding," May 13, 1942, Spedding Papers; Spedding, interview 5 with Calciano, pp. 16-17; Milton Burton, "Letter to Frank Spedding on Employment," May 30, 1942, Spedding Papers; Spedding, interview 8 with Calciano, 11.; Spedding, interview 5 with Calciano, 16-17; Compton, 185.

imperative to the survival of the free world to invest in building atomic bombs. The original requests by the immigrants were ignored, partly because they were not U.S. citizens, but partly because the government was not ready to accept the idea that scientific research was necessary to protect national security. The turning point came partly because of the British who convinced many American scientists that science could be used in the development of a weapon, and, in turn, those American scientists convinced the American government bureaucrats that science had a practical goal, in this instance at least. However, in February 1942, many other problems awaited the scientists at Chicago and the newly organized Ames Project, problems challenging both scientific research and the administration of that scientific research.

SCIENCE AND TECHNOLOGY IN THE AMES PROJECT, 1942–45

Organizing Research and Technology Development

When Frank Spedding indicated to Arthur Compton that he had personnel in Ames who could examine chemical and metallurgical problems for Chicago, he must have been thinking of the only other faculty member in physical chemistry—Harley A. Wilhelm. Spedding's job as chemistry division leader was dated February 21,[99] and by February 24, 1942, he had signed up his colleague as the associate director on the Ames Project.[100] Wilhelm was not an internationally known scholar like Spedding, and his academic credentials, though sound, were not as impressive as those of his more famous colleague. Harley A. Wilhelm, whose parents were tenant farmers, was co-valedictorian of his small Iowa high school, but it was athletics that allowed him to financially afford college at Drake University in Des Moines, Iowa. A basketball scholarship paid his tuition, but in order to earn enough money to remain in school, in the summers he worked construction gangs and played semi-pro baseball, another passion. He graduated from Drake in 1923 in mathematics, having taken only two courses in chemistry. He applied for a

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[99] J. C. Sterns, "Letter to F. H. Spedding on Chicago Metallurgical Laboratory Employment," March 19, 1942, Ames Laboratory Papers. On March 19, 1942, Spedding received this letter from the University of Chicago acknowledging that he had been on their payroll since February 21, 1942.

[100] Oath of Secrecy signed by Harley A. Wilhelm, Spedding Papers; Spedding, interview with Svec, 1984, 14.

fellowship at Iowa State University but lacked the number of courses in chemistry to enroll. Turning to his other love, athletics, and to support a new wife, he took consecutive high school positions teaching science and coaching. Later, he held a less than successful college coaching position in Helena, Montana. He returned to Drake in the summer of 1927 and took enough chemistry courses to qualify for an assistantship at Iowa State. The family stayed in Des Moines while he went to Ames alone, since the assistantship could not support a wife and baby daughter. In 1928, he was awarded an instructorship that enabled the entire family to move to Ames.[101]

Wilhelm initially worked for Anson Hayes, the head of physical chemistry and a well-known metallurgist in iron and steel technologies. Hayes left Iowa State College in January 1928, for industry, leaving one of his former graduate students, W. H. Jennings, in charge of physical chemistry. Because Wilhelm showed an interest in spectrochemistry, he inherited the newly ordered spectrograph that was to have gone to Hayes. He earned his Ph.D. degree in December 1931, after writing his thesis on band spectra of magnesium sulfide and lead sulfide.[102] Wilhelm remained at Iowa State as an instructor, turning down a job in Nebraska because it left him no time for research.[103] Wilhelm remained as an instructor for several years because as a graduate of Iowa State, the president of the College refused to promote him or give him

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[101] "Wilhelm Recalls the Early Days," *Ames Laboratory Changing Times* (August, 1980): 4-5.

[102] Wilhelm, interview with author, 1990; R. M. Hughes, *Graduates with the Doctorate*, Studies of the Graduate College, No. 1 (Ames, IA.: Iowa State College, 1939), 20.

[103] Wilhelm, interview with author, 1990, 5; Harley A. Wilhelm, interview with Laura Kline, 1987, transcript in Robert W. Parks and Ellen Sorge Parks Library, Ames, Iowa, 5.

tenure.[104] Finally, in 1940, Wilhelm was offered a higher salaried job in industry and to keep him, Coover obtained for him an assistant professorship and a salary of $3,200.[105] In 1937, Spedding, replacing Jennings as head of physical chemistry, took the spectrograph for his own research work and left the metallurgical area of the department completely to Wilhelm, a fortunate circumstance in the long run for Wilhelm since he became Spedding's expert in that area for the Ames Project.[106]

After hiring Wilhelm for metallurgical studies, Spedding attempted to find other personnel to staff his Ames operation. He appointed I. B. Johns, a researcher with a physical chemistry background, to oversee plutonium research, even though at the time he was a faculty member in plant chemistry.[107] Graduate students who were working with or had previously worked under Spedding, Wilhelm, and Johns were the next most obvious people to work into the project. Spedding and Wilhelm contributed one student each in February—Adrian Daane for metallography and casting studies

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[104] Wilhelm and Spedding both recounted in various interviews that Hughes as president of Iowa State wanted to bring in outside talent for positions rather than hire inbred faculty members. If Coover raised Wilhelm to an assistant professor, he would receive tenure in three years and remain as a permanent faculty member. So it seemed to be common that people in Wilhelm's position would remain instructors or leave. (Wilhelm, interview with Kline, 1987, 12; Wilhelm, interview with author, 1990, 5; Spedding, interview with Svec, 1984, 7).

[105] Wilhelm, interview with Kline, 1987, 12; Wilhelm, interview with the author, 1990, 14; "Wilhelm Recalls the Early Days," 6. According to Wilhelm, Friley who had replaced Hughes as president kept the same rule on inbreeding, so Wilhelm must have been an important asset in the department for Coover to get the professorship for him. He had graduate students working under him, had taught all the metallurgical courses for engineering students as well as a ceramic engineering course. He was also the only other faculty member in physical chemistry.

[106] Wilhelm, interview with author, 1990, 4-6; Spedding, interview with Svec, 1984, 7-8.

[107] Spedding, interview 5 with Calciano, 1-2; Spedding, interview with Svec, 1984, 15.

because he was already working with oxides and carbines and Ray Hoxeng for uranium coatings studies.[108] In April, C F Gray finished his Ph.D. under Wilhelm and joined the small group to work in castings. In June 1942, Wayne Keller, a former student of Spedding's at Cornell, joined the project to work with uranium metal reduction.[109] Rounding out the early group were Amos Newton from Eastman Kodak, W. H. Sullivan from the New England Zinc Company in Pennsylvania, and Adolph Voigt of Smith College, all men originally from a research group that had been using the cyclotron to produce radioactive materials at the University of Michigan At Ames, they contributed their expertise as group leaders in the various non-metallurgical chemical research areas, particularly in studies of plutonium and radiation.[110]

In early February 1942, Spedding contacted President Charles Friley at Iowa State College for clearance to establish the Ames Project. He had previously received permission from him to spend several weeks in Chicago in January. In late February, Friley released Spedding from half his duties at

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[108] Fulmer, Appendix C: List of Scientific Personnel of the Ames Project under the Manhattan District; Wilhelm, interview with author, 1990, 6-7.

[109] Fulmer, Appendix C; Wilhelm, interview with author, 1990, 6-7; Spedding, interview with Svec, 1984, 15; Wilhelm, interview with Kline, 1987, 15.

[110] These three men, all recent Ph.D.s, were students of Kasmir Fajans, a renown radiation chemist at the University of Michigan, whom Spedding was trying to get into the project, either on a subcontract at Michigan or at Chicago where he could set up a group there. His students came to Ames only temporarily while Fajans was in the process of getting security clearance. Unfortunately, because of his Polish descent, he was never cleared and Spedding kept his students, incorporating them as group leaders at Ames. (Adolph Voigt, interview with author, July 1990, Ames, Iowa, 1; "Adolph Voigt Looks Back," *Ames Laboratory Changing Scene* December 1981, 5; 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; Correspondence with Dr. Amos Newton, May 23, 1942, June 3, 1942, and June 10, 1942, Spedding Papers; Correspondence with Dr. William H. Sullivan, May 23, 1942, May 26, 1942, and June 3, 1942, Spedding Papers). Also see Frank H. Spedding, "Auditing," Spedding Manuscript, [5].

Iowa State in order to work on the secret project at the Chicago Metallurgical Laboratory.[111] The government gave Friley security clearance in late February or early March so that Spedding could release information on the nature of the research work at Chicago and Ames. The other top-level administrator allowed access to classified information was Dean Harold V. Gaskill, dean of the Industrial Sciences Division, under whose jurisdiction rested all war-time research projects at Iowa State College.[112]

The original agreement with Compton guaranteed that any personnel hired in Ames would work there for three months and move to Chicago when space was available. Since it took longer than anticipated to hire men, find space at Chicago, and build the buildings to house the Ames and Chicago chemical staffs and because the Ames group was progressing well at the end of the three months, Compton agreed to allow the supporting laboratory to continue at Ames under contract for six additional months.[113] Spedding also had difficulty convincing scientific staff to work on the project at Chicago because many of the chemical scientists were suspicious of atomic research. The project, locally called "Compton's Folly," did not immediately attract large

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[111] Charles E. Friley, "Letter to Arthur Compton on Releasing Spedding for Duties with the Metallurgical Laboratory," February 28, 1942, Ames Laboratory Papers.

[112] Frank H. Spedding, interview 6 with Elizabeth Calciano, May 7, 1980, transcript in possession of Edith Landin, Ames, Iowa, 3. Gaskill's title was Director of Special Research for Iowa State College. (H. V. Gaskill, Letter to Major A. V. Peterson Listing all Personnel who can Sign Forms," August 7, 1943, MED Files, Record Group 77, National Archives, Washington, DC.)

[113] Spedding, interview 5 with Calciano, 13; A. H. Compton, "Letter to S. K. Allison on Reorganization of the Metallurgical Chemistry Section," June 5, 1942, the Ames Laboratory Papers, 1.

numbers of chemists because they thought research on submarine detection, radar, and gas research were much more important to the war effort.[114]

Metallurgical work conducted at Ames began with three 1920-vintage pieces of metallurgical equipment: a small induction furnace that needed a few parts, a photo-micrograph that had been missing a mirror for several years, and the old Hayes-purchased Helger E-1 quartz spectrograph. Luckily, Ames had good analytical equipment available. Eventually, the Manhattan Engineer District replaced the reliable, but old, equipment with government purchased instrumentation from funding especially allocated for the project.[115]

Organizationally, Spedding thought he needed the scientists in Ames in order to supplement the Chicago laboratory in case that larger group failed in its primary tasks. Therefore, he instituted a parallel organization, assigning the scientists at Ames the same problems as those given to scientists in Chicago, but from different perspectives. For example, Johns and his group worked on plutonium chemistry, and Amos Newton and William Sullivan had small groups backing up the fission products research at Chicago. Harley Wilhelm and Wayne Keller each headed small groups dealing with metallurgical problems. James Warf took charge of the group trying to find analytical methods to detect trace elements in pile materials even though there was also an analytical group in Chicago.[116] According to Spedding, there was little

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[114] Spedding, interview 5 with Calciano, 14.

[115] Spedding, interview 5 with Calciano, 13; Wilhelm, interview with author, 1990, 7-8.; Spedding, Wilhelm, Daane interview, 1967, 1-2.

[116] Spedding, interview 5 with Calciano, 15. This organizational concept was used repeatedly throughout the war. Success was so desperately needed that often there was this parallel effort. For example, four methods of producing a bomb (three separation techniques

duplication since, after all, he was in charge of both groups and kept each informed of the other's work.[117]

In late 1943, Spedding delivered a report on the organizational structure of the Ames Project. He acknowledged that the main chemical research group resided in Chicago. Ames served as the "supplementing pioneer research group to the main chemical program."[118] The men in group leader positions even at this date—Spedding, Johns, Wilhelm, Rundle, Sullivan, Newton, and Keller—were all young men, most barely in their thirties; the younger men and the few women under them were equivalent to graduate students working on their doctorates.[119]

Because of the youth and scientific inexperience of the scientists at Ames, Spedding indicated that most of the research needed to be completed "as a result of group discussions and teamwork between the various groups."[120] Twice a week, his group leaders and section leaders met to discuss the previous week's work and plan for the next week's tasks. In addition, each group met once a week with its own section chief or group leader. Spedding later remembered the organization:

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with uranium and the plutonium process) were maintained throughout the war because no one knew which way was ultimately to be successful.

[117] Spedding, interview 5 with Calciano, 19.

[118] Frank H. Spedding, "Report of the Ames Chemical and Metallurgical Groups from February 20, 1942 to Dec. 22, 1943," the Ames Laboratory Papers, 1.

[119] Frank H. Spedding, "Report of the Ames Chemical and Metallurgical Groups from February 20, 1942 to Dec. 23, 1943," the Ames Laboratory Papers, 1.

[120] Frank H. Spedding, "Report of the Ames Chemical and Metallurgical Groups from February 20, 1942 to Dec. 23, 1943," 1-2.

> At these meetings there is a free-for-all discussion and it is very difficult to state just who has the various ideas as one man stimulates another. The net result is that most of our contributions have been the result of teamwork and should not be attributed to any one group or any one individual.[121]

This team approach seemed to be the key to the Ames organization. Spedding often pointed to its role in pressing the research forward. He believed in this approach so much that even the shop personnel gave advice on how pieces of equipment could be modified or built.[122] In this instance, Spedding was actually following the lead of the other academics at the national level in charge of the entire project (as will be noted in a later chapter on the academic organization) and his own experiences as a member of G. N. Lewis' academic laboratory at Berkeley. Spedding's methods—the seminars, research groups, and project-oriented research—may have been novel at Iowa State, but this academic style was already characteristic of research organization throughout the atomic bomb project.

Many of the administrative problems for Spedding throughout the war revolved around getting staff, both scientific and support personnel. To obtain his personnel, Spedding relied on his academic network of contacts, potential scientists and others who contacted him directly, and even the military to provide him with workers. For example, after Leslie Groves and the Manhattan District took over the project in late 1942 and early 1943, Spedding

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[121] Frank H. Spedding, "Report of the Ames Chemical and Metallurgical Groups from February 20, 1942 to Dec. 23, 1943," 2. Also, several of the people this author interviewed indicated they attended and directed these seminars and meetings. See the author's interviews with Voigt, 1990, 4; Carlson, 1990, 5; and Wilhelm, 1990, 15.

[122] Frank H. Spedding, interview 6 with Elizabeth Calciano, Ames, Iowa, dictated May 7, 1980, transcript in possession of Edith Landin, Ames, Iowa, 30.

was allowed to pick out any military men and women who had bachelor's degrees in chemistry, as long as they did not have orders to leave for the war's European front. At one time, he went through military records with Groves' permission and chose forty chemists from the wartime list—twenty to go to Chicago and twenty for Ames.[123]

Spedding also recruited juniors and seniors, primarily at Iowa State, who were chemistry majors and put them to work on production lines. Sometimes these men were drafted, but Spedding often managed to get them reassigned back at Iowa State or in Chicago.[124] Local area people were often hired on the project at Ames. One of the chief jewelers in Ames at the time made small instrumentation; a retired bank president became a store room clerk and later a security guard at Little Ankeny; a gas station owner was head of security; and a small tool shop along with its owner was moved to the campus.[125]

Spedding's support staff was meager at the start of the war. A business manager and two secretaries kept records, made out purchase orders, and handled whatever non-scientific duties were needed. As the red tape grew throughout the war, so did the staff. At the end of the war, the Ames Project was employing almost one non-scientist support person for every scientist. The laboratory had its own janitorial staff. There was a large contingent of security guards hired from the local Ames community that had replaced the

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[123] Spedding, interview 6 with Calciano, 6; Frank H. Spedding, "Security Foul Up," Spedding Manuscript, 1-2.

[124] Spedding, interview 6 with Calciano, 9-10.

[125] Spedding, interview 6 with Calciano, 13; Svec, interview with author, April 1992.

campus police who had handled security before the war. However, the College still provided some services, particularly in the area of purchasing. Since the guards and the support staff were not unionized at Iowa State during the war period, they also participated actively in Spedding's organizational team concept. Guards often doubled as chauffeurs to pick up visitors who came to examine the Ames Project facilities and sometimes even turned off the scientific equipment at night so the scientists did not have to go back to campus.[126]

The Raw Materials Crisis in 1942

Introduction

Shortly after the organizational structure was in place, the Ames Project became involved in both the metallurgical and chemical problems of initiating a chain reaction. Metallurgically, Ames investigated producing sizable amounts of uranium as well as casting it on a large-scale, particularly for the upcoming Chicago experiment to demonstrate the feasibility of a chain reaction. Chemically, in the early years, the project was concerned with the basic chemistry of the relatively unknown uranium, its melting point, viscosity, and its reaction with other compounds. The laboratory also experimented with protective coatings for uranium, preparation of special compounds, and reactivity of uranium and its by-products. After many of these early problems were solved and a nuclear chain reaction had been successfully demonstrated, Ames often engaged in consultant studies and

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[126] Spedding, interview 6 with Calciano, 27-28.

services for other laboratories, producing thorium, cerium, and other rare elements. Ames discovered uses of and recast metallic uranium turnings from scrap pieces shipped from around the country. And probably the best known contribution of the Ames Project—the establishment of a pilot plant to produce metallic uranium, using two of its own methods to both reduce and cast the metal in an old remodeled one-story house near the current-day journalism building—continued until industry could take over the process by late July 1943.[127]

Uranium metal

In February 1942, several research objectives confronted the Metallurgical Laboratory before it could produce a bomb—first, how to find a way to produce a chain reaction using the U_{238} isotope of uranium; second, how to chemically separate plutonium from the uranium isotope in order to produce an explosive chain reaction; and, finally, how to establish a plant to move the processes to a large-scale production of materials necessary to create a bomb.[128] Spedding's chemical division was officially responsible for the second

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[127] Fulmer, 12-13. See also various monthly and weekly reports produced from the Ames Project from February 1942 to December 1945 for technical details of research activities. A sampling of these include: CC-176, July 2, 1942 for a discussion of casting uranium in graphite; CC-177, July 9, 1942 for a report on reduction of oxides with aluminum and magnesium as well as the production of crucibles of different materials; CC-238, August 15, 1942 when coatings on uranium were studied; CC-298, October 15, 1942 a report that included studies of recovery of metal from casting wastes; CT-542, March 27, 1943 for a study and review of methods in casting of uranium ingots; CC-587, April 19, 1943 when a complete write-up of uranium hydride studies was included; CT-751, June 24, 1943 a study of the moisture in lime liner materials; CC-1524, March 10, 1944 a report on the rare gases; CT-1784, August 10, 1944 a report on the production of cerium; and CC-2398, March 17, 1945 a preliminary report on thorium nitrate extraction from uranyl nitrate, all in the Ames Laboratory Papers. For a complete listing of research projects, see Fulmer, Appendix I: List of Reports for the Ames Project.

[128] Smyth, 89; Compton, *Atomic Quest*, 86-87.

objective, but it soon became apparent that chemical concerns were imbedded in every aspect of the project.

Materials procurement became one of the most critical concerns of the Metallurgical Laboratory. Uranium in its metallic form or in a salt form of great purity as well as graphite, beryllium, deuterium, and calcium were crucial for the chain reaction.[129] Purity of the uranium presented a particularly difficult problem. Virtually no uranium metal in its most pure form, or even a pure enough salt or oxide, was available in early 1942. In late 1941, Leo Szilard, reported to Arthur Compton that three processes existed to make uranium metal, each producing only gram quantities: the photochemical process developed at Westinghouse Lamp Division, the uranium-chloride reduction method discovered by J. J. Rodden who was presently at the National Bureau of Standards, and the calcium hydride method developed by P. P. Alexander of Metal Hydrides at Beverly, Massachusetts.[130] Most of these methods had neither scaled up their processes to make enough uranium at a reasonable cost, nor had they eliminated the impurities that so plagued most early production of uranium.

Harvey C. Rentschler, director of the research laboratory, and John W. Marden, a deputy researcher, of the lamp division of Westinghouse, located in

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[129] Smyth, 91; Hewlett and Anderson, 65.

[130] Leo Szilard, "Memorandum for Professor A. H. Compton Summarizing My Contacts with Firms in Connection with the Supply of Uranium Metal, Graphite, Calcium Metal, Uranium Oxide, Uranium Carbide and Beryllium," Report No. R-7 of the Chicago Metallurgical Reports, [1941], in Ames Laboratory Papers. For a summary of the technical characteristics of these early processes, see also J. C. Warner, "Early Methods for Producing Uranium Metal," Chapter 6 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), 142-150.

Bloomfield, New Jersey, as early as 1919 had experimented with using metallic uranium as a substitute for tungsten in incandescent filaments. In 1927, they took out a patent on the process.[131] Knowing that uranium was close to tungsten on the periodic chart, it seemed natural that it could be used as filament material. Since its melting point was lower than tungsten though, it did not prove satisfactory. Nevertheless, the laboratory continued research on uranium and other rare earths and even produced very small quantities of the metal for college and university research experiments.[132]

In 1929, two other researchers at Westinghouse, Frank Driggs and William Lilliendahl, refined the process to obtain pure uranium metal by an electrolysis of the fused salts. Essentially, the electrolytic process involved producing a "green salt," potassium uranium fluoride, which had been photochemically created on the roof of one of the buildings at Bloomfield, using sunlight to initiate the photochemical reaction. The resulting product, KUF_5, was mixed with calcium chloride and sodium chloride and heated. When the salts melted, the uranium ions that had deposited on a molybdenum electrode were removed and crushed into particles. After being washed in barrels, the uranium was dried in vacuum ovens and pressed into

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[131] "Westinghouse Lamp Division Marks 50 Years of Progress in Bloomfield," Press Release from Westinghouse in Harley A. Wilhelm Papers, Ames Laboratory, Ames, Iowa, 4 (hereafter Wilhelm Papers). For an in depth discussion of these three processes, see Harley A. Wilhelm, "Development of Uranium Metal Production in America," *Journal of Chemical Education* 37 (February 1960): 56-68. Most of the material the author has used in the descriptions above and those to follow comes from the letters and other written material sent to Wilhelm as he was preparing this article. Although the material is also summarized by Wilhelm, the author cites the background documents since they are often in more detail than Wilhelm's account.

[132] John Walsh, "A Manhattan Project Postscript," *Science* 212 (June 19, 1981): 1370.

small pieces called buttons.[133] Up until 1941, the process, according to Lilliendahl, had produced only a few kilograms of pure metal, hardly enough for commercial large-scale users. It was for sale in the open market for about $1,000 a pound.[134] In 1941, both the British and U.S. governments approached the company about the possibility of scaling up the process to produce ton quantities of the metal.

In December 1941, the Office of Scientific Research and Development (OSRD) signed a contract with Westinghouse to produce metallic uranium.[135] By the Spring of 1942, little metal had been produced, primarily because of the lack of sunshine in the New Jersey climate. Westinghouse investigated, with little success, the possibility of using ultraviolet lamps and even considered moving the operation to Arizona where the sun would shine more often. Though producing the required quantities of uranium metal remained a problem for the duration of the contract, the Westinghouse Process never encountered an impurity problem because of the high purity of its raw materials and because of its excellent analytical procedures to detect impurities all along the process. Later, after substituting uranium tetrafluoride, UF_6, instead of KUF_5, Westinghouse found that this process did not need the sun, and by November 1942, just a month before the Stagg Field chain reaction experiment, the company had sent 6,000 pounds of the metal to Chicago at a

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[133] Patent No. 1,961,625 issued June 7, 1932; Walsh, 1370; W. C. Lilliendahl, "Letter to Harley A. Wilhelm on his Article on Uranium," August 5, 1958, Wilhelm Papers; Smyth, 92.

[134] Smyth, 93; Compton, *Atomic Quest*, 91 say the cost of producing uranium by this method was around $1,000 per pound while Lilliendahl in his letter to Wilhelm on August 5, 1958 quoted the amount at $500. This author finds no evidence to refute the figure given by Compton and Smyth whose accounts were much closer to the time period.

[135] Lilliendahl to Wilhelm, 2-3.

cost of approximately $22 a pound.[136] Its operations were mostly discontinued in late 1943, when the Ames Process supplanted all other methods because that process produced enough metal of the required purity at a much cheaper cost than others.[137]

In 1932, Peter P. Alexander, who was later president of Metal Hydrides, wrote a Ph.D. thesis on his process to reduce uranium. Assisted by L. W. Davis and Frederick Archibald, he published information about the process in *Metals and Alloys* in 1937. His method first reduced uranium oxide with calcium hydride. The resulting product was leached with a diluted acid, dried, pressed into cubes and sintered in a vacuum. The National Bureau of Standards first contracted with Metal Hydrides in 1941 for 7,000 pounds of the Alexander metal to be delivered to its headquarters. However, the delivery was stopped mid-stream when analytical analysis showed boron had contaminated the uranium. The culprit was the calcium used by Metal Hydrides, so the Bureau decided to establish a calcium distillation unit at Beverly, Massachusetts, where Metal Hydrides was located, a fortuitous coincidence for Alexander's company since it was essentially ready for large-scale production of uranium when three men from the Metallurgical Laboratory came to visit in early 1942.[138]

On January 14, 1942, Lyman Briggs from the National Bureau of Standards, Arthur Compton from the University of Chicago, and Ernest

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[136] Smyth, 93; Lilliendahl to Wilhelm, 3-4.

[137] Walsh, 1371; Wilhelm, "Development of Uranium Metal," 67.

[138] Peter P. Alexander, "Letter to Harley A. Wilhelm on Uranium Production," January 28, 1959, the Wilhelm Papers; Peter P. Alexander, "The Hydride Process—IV," Reprinted from *Metals and Alloys* (October 1938): [1]-[5]; Szilard, "Memorandum for Professor A. H. Compton," 1-2; C. J. Rodden, "Letter to Harley A. Wilhelm on Uranium Production," January 21, 1959, Wilhelm Papers.

Lawrence from the University of California personally contacted Alexander at his company. Shortly thereafter, they signed a contract and the company reorganized to produce large quantities of metals for the Metallurgical Project. Because the company had little equipment such as furnaces and also because its metal was extremely pyrophoric, no appreciable amount of metallic uranium was available from them until almost November 1942.[139]

C. J. Rodden at the National Bureau of Standards experimented with uranium reduction methods involving calcium. He had been working with the "James Process," a method reported in 1926 in a scientific journal, which had been developed at the University of New Hampshire while he was there. It used calcium to reduce uranium oxide and uranium tetrachloride. Late in August 1942, Rodden independently discovered the same process that the Ames Project scientists had developed earlier that month.[140]

Uranium oxide

Uranium generally came in the form of a oxide, and it was well known that a purer oxide would produce, in turn, an end product of greater purity. Uranium oxide had been difficult to obtain since 1939 when Alexander Sachs warned President Roosevelt that the German occupation of Belgium might ruin chances to procure Belgian uranium oxide from the Congo. By the time Sachs was authorized to approach Belgium by Dr. Brigg's Uranium Committee, Germany had invaded Belgium and taken over 500 tons of uranium into its

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[139] Smyth, 94; Peter P. Alexander to Harley A. Wilhelm, August 2, 1968, Wilhelm Papers.

[140] Wilhelm. "Development of Uranium Metal," 58-63.

possession. The shipment of ore from the Congo by then had ceased because of the war hostilities.[141]

By January 1942, the quantity of uranium oxide needed to produce a chain reaction was no problem. Over 1,200 tons of the oxide were stored in a port in New York; additional tonnage quantities were available at the Eldorado Gold Mine in Toronto and at a chemical plant in Colorado. A total of 2,000 tons was actually available, and predictions estimated that only 150 tons of the oxide would be necessary through 1944. Compton thought he needed only 45 tons for his early experiments in Chicago.[142]

However, the National Bureau of Standards had earlier ordered several tons of uranium oxide from Canada for experimental purposes and found that though quantity was not a problem, purity certainly was. J. J. Hoffman had earlier discovered an ether extraction method to remove all impurities from uranyl nitrate.[143] The Metallurgical Laboratory repeated those experiments successfully, but found that companies in North America had neither the necessary equipment nor the desire to purify the uranium oxide using the ether extraction method; ether was known to be very explosive and erratic.[144] When Herbert McCoy and Herbert Anderson visited the Port Hope Refineries of the Eldorado Mine in Canada in April 1942, they posed the question of ether extraction to them. The company claimed they could extract the metal but only

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[141] Szilard "Memorandum for Professor A. H. Compton," [6].

[142] Hewlett and Anderson, 65.

[143] Smyth, 93.

[144] Compton, *Atomic Quest*, 93.

if the proper equipment could be procured for them to scale up their present laboratory method.[145]

Compton, at this point, decided he would contact his old friend Edward Mallinckrodt who ran a chemical plant in St. Louis that specialized in the production of ether and other chemicals. In May 1942, Compton and Frank Spedding in his capacity as head of chemistry traveled to St. Louis. Compton explained the ether extraction project to Mallinckrodt while Spedding worked out the details with the engineers Henry Farr and John Ruhoff. Within two hours Mallinckrodt agreed to tackle the job. At best, Compton had no real idea how much the process would cost, so he approved a letter of intent from the OSRD to Mallinckrodt with a promise to negotiate a contract later for the actual costs. The first quantities were shipped in July 1942, and continued at the rate of 30 tons per month, accomplishing the remarkable feat of producing on a commercial scale pure uranium oxide that was attainable only on a laboratory scale mere months before. The actual contract was not signed until the day that the last of the 60 tons left the Mallinckrodt plant, an example of the flexibility of the government policies toward contracting management on the one hand and the remarkable faith in the project by the company on the other hand.[146] Making pure uranium oxide became crucial in several processes throughout the war, including adding to the pile at Chicago, making uranium

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[145] Herbert Anderson and Herbert McCoy, "Memorandum to A. H. Compton on visit to Port Hope Refineries of the Eldorado Gold Mines, Ltd.," April 16, 1942. Ames Laboratory Papers, 4.

[146] Smyth, 93; Compton, *Atomic Quest*, 93-95; Spedding, interview with Calciano 5, 18; F. H. Spedding, "Patent Letter to Lt. Colonel H. E. Metcalf Describing the Mallinckrodt Process," May 11, 1945, 1-2.

compounds like uranium tetrafluoride, and using the material for research experiments to produce a purer metal.

The Discovery and Development of the Ames Process

The discovery of the Ames Process to develop metallic uranium gave credence to both the administrative apparatus of the Ames Project and the research and development expertise of the Ames scientists. The laboratory worked as a team on the many problems that Spedding brought from his meetings in Chicago. One of the interesting things about uranium at the time was the incorrect assumption that uranium could be reduced by the same processes as those used for the elements around it on the periodic chart. Early in 1942, the Ames Project as well as other laboratories thought that the oxides of uranium would reduce to form a salt slag and clean metal Unfortunately, uranium did not behave in a predictable way. First, the Ames group experimented with the oxide derivatives of uranium in order to produce metallic uranium through a hydrogen reduction, but without tremendous success.[147] The oxides presented temperature-melting problems, casting difficulties, and tended to corrode the normal crucibles made from beryllium, magnesia, and graphite.[148] By June 1942, attempts to reduce the uranium oxide with carbon in a hydrogen atmosphere also only partially succeeded.[149] Other

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[147] F. H. Spedding, "Report on Chemical Project at Ames, March 6-12, 1942," Spedding Papers; Adrian Daane, "Research Notebook," March 31, 1942, Ames Laboratory Papers.

[148] F. H. Spedding, "Report of the Chemical Work Done at Ames up to April 13, 1942," Spedding Papers.

[149] Daane, "Research Notebook," June 2, 1942.

reduction experiments with aluminum, magnesium, and calcium, resulted in little success.[150] During the early weeks of July 1942, the problem of the crucibles was finally solved when several successful uranium castings were made with graphite crucibles, resulting in no uranium sticking to the graphite.[151] The biggest problem remaining then was the lack of uranium metal to cast in the new crucibles. No process had been developed to supplant the processes in existence, methods that were expensive, unpredictable, and still producing only gram quantities.

The situation was so bad that the idea began to circulate around Chicago that perhaps some pure metal could be used in the core of the experimental pile and compounds—oxides, chlorides or fluorides—could be placed on the perimeter. Coincidentally, in the summer of 1942, someone working on the calutron electromagnetic separation processes at Berkeley brought some uranium tetrafluoride (UF_4) to an administrative meeting at Chicago to discuss the possibilities of using this fluoride or an oxide of uranium on the outside of the pile core at Chicago. Spedding looked at the two-inch cube that probably had been produced at Harshaw Chemical Company in Cleveland and wondered if using a salt that produced no oxygen could produce metallic uranium. In the normal reduction experiments oxygen had been the greatest

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[150] Daane, "Research Notebook, "July 2, 1942, July 6, 1942, July 27 1942; Wayne Keller, "Research Notebook," July 8, 1942, July 10, 1942, July 12-18, 1942, Ames Laboratory Papers, 46-48.

[151] F. H. Spedding, "Report of the Ames Chemical and Metallurgical Group for the Week of July 2, 1942," Ames Laboratory Papers.

barrier in reducing the uranium to large pieces of pure metal. He took the block back to Ames in late July and gave it to the metallurgical group to test.[152]

Wayne Keller, one of the men under Wilhelm, took the block and began the historic experiments to reduce the tetrafluoride with calcium or some other salt to uranium metal. On August 3, 1942, he recounted the first reduction attempt in his research notebook:

> The fluoxide and calcium were ground together in a mortar and placed in an iron pipe as a crucible. The crucible and charge were placed with proper packing in a quartz tube and the whole evacuated. A thermocouple was placed between the quartz tube and the furnace coil. The furnace was heated by 110 volts at 12 ampe.
>
> The temperature increased from 30°C at 4:00 p.m. to 370°C at 4:38 p.m. At that time the pressure rose to about one-half an atmosphere suddenly, then began to drop again in a few moments. . . . The temperature was read and was found to have risen from 370°C to 540°C in four minutes. . . . At 600°C heating was discontinued.
>
> When the furnace was almost at room temperature argon was introduced, the furnace opened, and the crucible removed.
>
> The material in the crucible was found to have fused, and a lump of quite compact, but low density metallic material was found in the bottom of the crucible. . . . The large block on the bottom was sawed in two, and inside was found one large button of very pure looking metallic uranium. . . . This button weighed about 20 grams.[153]

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[152] F. H. Spedding, "Interview with Barton C. Hacker," October 21, 1980, Ames, Iowa, transcript in possession of Edith Landin, Ames, Iowa, 10; Hewlett and Anderson, 87-88; Spedding, interview with Svec, 1984, 15; Spedding to Metcalf, May 11, 1945, 2.

[153] Wayne Keller, "Research Notebook," August 3, 1942, 58-60. On subsequent days more experiments were run aiming at a greater yield and more compact single ingot. By August 7, with several adjustments, an ingot of 82 grams was discovered on the bottom of the crucible, the largest single ingot to date. (Keller, "Research Notebook," August 7, 1942, 69). See also A.H. Compton, "Metallurgical Project Report for the Month ending August 15, 1942," Report No. CC-238, in Ames Laboratory Papers, 5-8. Spedding reviewed the work also in a report called "Metal Production," Metallurgical Laboratory Report No. R-414, November 25, 1942 in Ames Laboratory Papers. For a review of the experiments see Wilhelm, Keller,

From the initial success, it was a simple matter to run a series of experiments to refine the process and produce even larger ingots of pure uranium. Other compounds in combination with uranium tetrafluoride were tried in the reduction method, including sodium and uranium chloride, but the process for reduction with calcium improved so much that by the end of August, most of the attention turned to producing a large cast of uranium metal.[154] In September 1942, large quantities of the uranium-calcium charge were prepared in crucibles that were made of 4-inch black steel pipes 15-18 inches long, capped on one end and welded with a solid sheet on the other end. A spark plug for ignition was also welded on the bottom or placed internally. Lime was generally used as a liner to prevent the charge coming in contact with the steel sides.[155]

Several experiments with these new crucibles, or *bombs* as they became known, continued using up to 2,000 grams of the uranium tetrafluoride. After several modifications, a few large ingots weighing over 1,500 grams (3-4 pounds) were produced. On September 21, 1942, several more reduction experiments were tried, with close to 3,000 grams of uranium tetrafluoride and

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Butler, "Production of Uranium Metal by the Reduction of Uranium Tetrafluoride by Metallic Calcium," Report for August 5, 1942, in Report CC-238, "Report of the Metallurgical Project for the Month Ending August 15, 1942," in the Ames Laboratory Papers, 1-8. According to Harry A. Svec (interview, April 1992), Richard Thompson, a former undergraduate, actually conducted the first experiment under Keller's direction.

[154] Keller, "Research Notebook," entries for the rest of August, 91-103.

[155] Keller, "Research Notebook," September 2, 1942, 106. See also "Comparison of Refractories as Bomb Lining Materials in Production," and F. H. Spedding, "Summary of Work at Ames," March 10-April 10, 1944, the Ames Laboratory Papers, 8-9 for a description of the different materials used for liners.

calcium in each experiment. From these experiments, several ingots were cast and recast by C F Gray, producing a final billet of pure metallic uranium weighing approximately 4,980 grams (eleven pounds).[156]

On September 24, 1942, Harley Wilhelm took the 5-inch by 2-inch 11-pound ingot from the casting furnace, placed it carefully in a traveling bag some students had given him from his coaching stint in Helena, Montana, and caught the night train that traveled to Chicago from the Ames Depot.[157] Getting off the train in Chicago, Wilhelm had to catch the "L" to the University of Chicago campus. In transit, the handle of his case broke, so by the time he reached Spedding's office in Eckhart Hall, he was carrying the precious cargo in its case under his arm. Spedding and Wilhelm took the billet to Compton who had never seen one piece of uranium this big before. His immediate reaction was, "I bet there's a pipe [hole] inside." Wilhelm took the ingot to the basement of the biology building and instructed a shop man to cut it open. After a small fire in the cutting process, a cropping from the ingot finally appeared; there was no pipe.[158] Spedding evidently took a cropping to an administrative meeting soon thereafter. R. L. Doan the laboratory director later recalled that momentous day:

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[156] Keller, "Research Notebook," various September entries, including 9/21/42, 107-137. A. H. Compton, "Metallurgical Project Report for Month Ending October 15, 1942," Report No. CC-298, Ames Laboratory Papers. This latter report gives a summary of the metallurgical work for August and September 1942.

[157] Harley Wilhelm, "Interview with Laura Kline, Iowa State Archivist" November 14, 1988, Incomplete transcript in Parks Library, Ames, Iowa, 1. Harley Wilhelm, "Telephone Conversation with author," July 1989, Ames, Iowa; Wilhelm, interview with author, 1990, 12.

[158] Wilhelm, telephone conversation with author, 1989; Wilhelm, interview with Kline, 1988, 2. Wilhelm, interview with author 1990, 12.

> 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.[159]

The Building of a Pilot Plant

But futile it was not. Within a week, R. L. Doan, the Metallurgical Laboratory director, had arrived on the Iowa State campus to write an OSRD contract for the Ames Project to produce 100 pounds of uranium per day, using its simple and cheap process.[160] The intention was that Iowa State would demonstrate the process to companies like DuPont, Electromet, and Mallinckrodt but continue to make uranium until the companies could integrate the processes into their own plants.[161] The Ames Project at this point became two complementary projects—one aimed at conducting chemistry studies on uranium and plutonium and the other incorporating the Ames Process to produce uranium in a pilot plant

Most of the research and chemical studies to date had occurred in the Chemistry Building, but with the need to add a full-scale pilot plant more space was needed for furnaces and other machinery as well as for the increased staff to scale up the uranium-producing process. Wilhelm and Spedding started a

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[159] R. L. Doan, "Letter to Harley A. Wilhelm about Recollections for Paper on Uranium Production," August 21, 1958, in Wilhelm Papers, 2.

[160] Doan, 2.

[161] Spedding, interview with Barton C. Hacker, 11.

search for an adequate site or building. On the east side of Ames, there was an old gas generation plant made of brick. Though sturdy, that building would take too much work to renovate, so it was discarded as a practical possibility for the plant. After a lengthy search, Wilhelm and Spedding discovered an appropriate building on campus, a small World War I temporary wooden house behind the Dairy Industries building, near the power plant on the southeastern edge of campus. It had been used years before as a women's gymnasium. In 1942, it was used primarily for storage; there was evidently a popcorn laboratory in one part of the building, and in a kind of garage the psychology department had stored some trucks with educational, demonstration equipment.[162] The College gave the building to the project, and immediately the chemists had the dirt floor in the garage area replaced with concrete so that casting could take place in this area. The chemists set up the reduction laboratory in the original part of the building where the popcorn lab had been located. The building shortly began to expand in a most curious pattern. The porch was used for the especially dirty work, the least secret of the process. However, when it became too cold to work on the porch, a canvas would be added followed by a crude set of walls and finally a new roof. A new porch appeared and the process repeated itself. The odd expansion of the house took place as soon as more space became necessary to expand operations

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[162] Originally called the Home Economics Annex, the building was built west of the Home Economics Building in 1920. In 1926, when the new Home Economics Building was constructed, it was physically moved to a new site south of the Press Building where it served as the girls' gymnasium, called the Field House. In 1941, it was no longer needed because the new Women's Gymnasium was constructed. It was being used as a storage facility when Spedding and Wilhelm discovered it. H. Summerfield Day, *The Iowa State University Campus and Its Buildings 1859-1979* (Ames, IA: Iowa State University, 1980), 254.

and continued much to the chagrin of the local university architect who had been trying to get this old building torn down for several years prior to its occupancy by the Ames Project people.[163]

After the building became available, a machine shop at the production site became the second necessity. Wilhelm heard of a small machine shop, owned and managed by Bill Maitland, for sale in Ames west of Grand Avenue near the railroad. Maitland made garden tools normally, but he could no longer obtain the metal he needed because of war-time restrictions on material priorities. Wilhelm examined the shop contents and discovered that Maitland would sell all his tools and equipment for $8,000. After consulting with Spedding, both men contacted Maitland and bought the entire shop, moving the equipment along with Bill Maitland to the campus production building, officially called the Physical Chemistry Annex, later nicknamed by the local workmen as "Little Ankeny," after a war munitions plant in Ankeny, Iowa.[164]

Production equipment, unlike lathes, motors, and small tools from Maitland, was much harder to procure. For example, reduction furnaces were especially hard to obtain. The small reduction furnace in the Chemistry Department used to produce most of the metal earlier was not big enough for a

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[163] Wilhelm, interview with Kline 1988, 4.; Spedding, Wilhelm, and Daane, interview, May 1967, 10; Spedding, interview with Barton C. Hacker, 1980, 12. For photographs of the building and a floor plan of the operation see Appendix B, Figures 1-2.

[164] Wilhelm, interview with Kline, 1988, 5. It is not known how the building received its name, but it was quite apt as a name for the project (Esther Polito to Bert Merrill, Letter on the Name Little Ankeny, September 21, 1945 in the Ames Laboratory Papers). Adrian Daane, one of the scientists in the project thought that it was named by some of the local townspeople who worked on the project and the name just stuck. These people knew of the munitions factory in Ankeny and just named it after that factory since the work on the Ames Project was somewhat dangerous, particularly with the number of explosions occurring on a routine basis (Daane, telephone interview with author, March 18, 1992).

large-scale production plant. Luckily for the Ames operation, the Metallurgical Laboratory had ordered two 40,000 watt reduction furnaces for what they called "Site B," but when the Ames pilot plant needed to be established as a production facility, those furnaces were diverted to Ames. Mixers and grinders for processing metals like calcium and later magnesium and vacuum casting apparatus were also purchased from various producers using contract money from the Manhattan Engineer District, an Army Corps of Engineers operation, which took over this part of the Ames Project in late 1942.[165]

The Chicago Pile-1 (CP-1)—December 2, 1942

While these arrangements were still being worked out in the fall of 1942, the Ames group continued to reduce metal in the Chemistry Building, beginning a uranium shipping program to Chicago. The University of Chicago received two tons of the metal from Ames for the Stagg Field experiment that occurred on December 2, 1942. Westinghouse and Metal Hydrides also each shipped two tons to Chicago.

Most of the research and production work that Iowa State undertook to this point supported the critical chain reaction or pile experiment at the University of Chicago. Spedding, in his capacity as head of the chemistry section, was present as one of the few invited guests to witness the historic event. Enrico Fermi, a physicist at Chicago, designed the experiment originally, making all the necessary calculations including everything from

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[165] Wilhelm, interview with Kline, 1988, 7; Wilhelm, telephone conversation with author, 1989.

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 . . .
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> 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 Weatt, 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.

for use on the telephone. Spedding recalled several farm terms developed by the Ames group. "Eggs" were 2" diameters of uranium and often the caller would indicate "2-dozen eggs shipped." Later, when Clinton wanted a 1" x 4" length of uranium shipped, these were called frankfurters or hot dogs; billets 4" in diameter and 2-3-feet long weighing 250 pounds were called "cheeses." Iowa State shipped uranium scrap turnings as "hay." Boron, a dangerous poison and contaminant, was called Vitamin B. Reports referring to a percent of Vitamin B content contained in the metal or tube alloy meant that the uranium contained a certain percent of boron[241]

Code names were also used for the heads of laboratories and other prominent scientists. Dr. Enrico Fermi, for example, was called Mr. Farmer, Dr. Eugene Wigner was known as Mr. Warner, and Dr. Arthur Compton answered to Mr. Comas.[242] Sometimes, though the code name system backfired. In his manuscript history, Spedding explained well what could happen to even a Manhattan District person who made a mistake in realizing the importance of security as far as codes were concerned. As noted earlier, documents of specified classifications were delivered in certain ways. By 1943 and 1944, secret documents were usually sent by registered mail, and top secret

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[241] R. S. Apple, "Letter to C. M. Cooper on Proposed Codes at the Metallurgical Laboratory," October 30, 1942 Spedding Papers; Spedding, interview 5 with Calciano, 10-11; Frank H. Spedding, "A Security Scare—Boy Saying Uranium," 1-2. Humorous names also appeared. At some point later in the project, when Iowa State began shipping thorium billets, some people in the Chicago Metallurgical lab called thorium "mernalloy" after the actress, Myrna Loy. (Spedding, "A Security Scare," 2.) See also Frank H. Spedding, "Interview with George Tressel for film on anniversary of CP-1," July 12, 1967, Transcript in Ames Laboratory Papers, 10-11.

[242] Frank H. Spedding, "Top Secret Incident," Spedding Manuscript, 1; Compton, *Atomic Quest*, 141

ones were sent to Ames by a courier. For delivery of top secret documents, usually the courier was a lieutenant who would come to Ames by train or plane. He would contact the director, Spedding, personally and get his signature on the document before he left. To protect the identity of the directors, each courier used code names to hide their true identity One time, a man carrying a British top secret document on turning rhodium into platinum arrived in Ames looking for Spedding. Spedding related the rest of the tale in his history:

> [He] went to the telephone booth at the Sheldon Munn Hotel and got out his little black book which informed what my true name was instead of my code name, and what my telephone number was. He called me and I made arrangements to meet him at my office. When he arrived, he suddenly became very concerned, because he had left his little black book with the code names for all prominent scientists in the phone booth. We immediately sent him down with a car, but the little black book was gone. He was a very concerned young lieutenant, with some justification, because he had to report the loss! I never saw the young lieutenant again, but I did hear from Washington gossip that he had been transferred to a company which was stationed on the outermost Aleutian Islands.[243]

Whether or not all of the story is true is probably not so important, but it does point to the fact that the Manhattan Engineer District considered adherence to its security policies a serious matter indeed

Sometimes secrecy and protection of documents led to unusual applications. At Iowa State, all books on atomic energy and related topics were removed from the College library and placed in a room behind a barricade that was built across the east and north halls of the first and ground floors in the

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[243] Frank H. Spedding, "Top Secret Incident," Spedding Manuscript, 2.

Chemistry Building. According to one scientist on the project, since Spedding had been given almost carte blanche from President Friley to obtain whatever he needed, when several scientists needed access to books on radio-chemistry, the library was instructed to let him have any books he wished on indefinite loan. To explain the loan to the Ames Project, the entry in the check-out records in the library told users the books were at the bindery. Scientists thus had their own private library behind the wall of secrecy, probably a great convenience as well as a security measure to let no one know what was being used, but any student who wanted information on a field of atomic energy found books that had once appeared in the library suddenly and inexplicably missing.[244]

Evidently, newspapers in Ames and the surrounding towns obeyed the censorship orders prohibiting any news about the secret project. From January 1942 until August 5, 1945, there were only passing references to the project in the *Iowa State Daily Student,* the College newspaper. It was not because the project was so secret that no one knew about it. In fact, there was no attempt to hide the fact that war research was being conducted on campus; no one though questioned just what kind of research was undertaken In the student

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[244] Svec, interview with author, 1991, 3. See also Daane, telephone interview with the author. The books were still behind the barricade in 1946, when an auditor from the Project noted that: "Library books are numbered with yellow paint and charged out by a librarian on a loan basis." (E. Stimpson, Auditor's Report, November 12, 1946, OSRD Files, Finance, National Archives, Washington, DC). These same books after the war became the nucleus of the Physical Sciences Reading Room which Spedding had built from funds left from overhead recovery. (Margaret Mae Gross, "Interview with the Author," January, 1992, Ames, Iowa; Charles H. Brown to Charles Friley, "Memorandum on the Future Organization of the College Library," November 10, 1944, Library Dean's Office Subject File, Record Group 25/1/1, William Robert Parks and Ellen Sorge Parks Library, Iowa State University, Ames Iowa, 1-2 (hereafter called Library Papers); "Physical Sciences Reading Room," *The Library at Iowa State* 2, no. 3 (November 19, 1947): 33.

newspaper, censorship rules were first referred to even before the Manhattan Project took over. In an editorial on May 22, 1942, the newspaper editor hinted that tough measures would come to those who were caught either intentionally or unintentionally revealing secret information.[245]

Direct references to the project during the time period totaled four articles and one editorial. A blaze that damaged the chemistry roof was reported in July 1942. The Ames Fire Department was called, but about thirty members of the chemistry staff had almost extinguished the fire before the fire trucks arrived. The explanation for the fire, given by W. F. Coover, was: "an experiment using highly inflammable materials and a continuously running motor was being conducted for defense work."[246] This article was the only time the project, even in an indirect way, made the front page of a paper before the official announcement in August 1945 about the role of the College in war work. Later that year, Coover reported in the paper that "26 members of the Chemistry Department are engaged in vital war projects of a confidential nature."[247] His reference was never explained in any follow-up article. Earlier that same month, B. H. Platt, the head of the building and grounds department at the College, indicated "considerable remodeling on the inside of the [Chemistry Building] where storerooms and classrooms were rearranged."[248]

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[245] Lyle Abbott, "Be Patriotically Quiet," *The Iowa State Daily Student*, May 22, 1942, 3.

[246] "Chemistry Roof Blaze Brings Out Firemen," *The Iowa State Daily Student*, July 7, 1942, 1.

[247] "Chemists Needed for War Work," *The Iowa State Daily Student*, September 23, 1942, 4.

[248] "Building and Grounds Men Kept Busy," *The Iowa State Daily Student*, 6.

No mention was made that this extensive remodeling included erecting barricades across the halls of the building. A more direct reference to secret research was made in January 1943 when a report appeared about the building of a gas main for the new research laboratory east of the Dairy Industry Building. "What the gas will be used for was not revealed since the activities within the laboratory are defense secrets."[249] This article was the last to appear and only a small letter to the editor in 1943 complaining about the lack of fire exits in the Chemistry Building followed. In that letter, a reference was made by the student to new construction that " closed off the hallway."[250] The voluntary censorship plan must have worked because no more mention was made of the project at all. This search of the papers probably proved that Groves' method to allow casual references in every day matters did work at least at Iowa State College. The secret was never that there was secret work going on; it was just that the details of the involvement with atomic research and any mention of the Manhattan Project was prohibited.[251]

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[249] "New Research Laboratory Connected to Gas Main," *The Iowa State Daily Student*, 7.

[250] Louise Jaggars, "Believes Chemistry Building Need More Fire Exits," *The Iowa State Daily Student*, March 30, 1943, 3.

[251] There is some evidence that even town's people knew that secret work was on campus. For example, Margaret Mae Gross, a young secretary in the library at the time remembered taking her father's farm milk to the Dairy Industries Building for testing and knowing that secret work was going on next door (Gross, interview with author, January 1992). Also Bess Ferguson, a longtime Ames resident remembered walking by on the cinder path that ran near the present day Physical Plant and knowing that secret work was progressing in what later became known as Little Ankeny (Mrs. Fred Ferguson, "Interview with author," April 21, 1986, Ames, IA, 10). The attitude in both cases seemed to be that even if you knew, you just did not talk about it; after all a war was in progress.

Materials Shipping Security Regulations

Federal rules and regulations for shipping materials

The OSRD and NDRC developed no specific requirements for shipping hazardous materials, so the general regulations of the War Department regarding all military information served as the guide.[252] However, by the time the Manhattan District took over, shipments were becoming more numerous, so the District instituted a survey in November 1943, followed by specific regulations on handling shipments. Guard pools were created at specified sites around the country, including over twenty guards who were stationed at Chicago to guard rail and truck shipments of critical materials to Hanford from sites in the East and shipments of recovery materials from Hanford to sites in the Midwest and East (including Iowa State College). The courier system was also enlarged with pools established at various sites, including Chicago, especially after the institution of the Top Secret classification scheme, to carry small items, often radioactive, in personal luggage from site to site. Finally, a scheme of eight forms of transportation methods ranging from Railway Express to Courier in descending order was standardized to prescribe shipment of the critical materials by the most appropriate and secure means.[253]

Materials shipping security at Iowa State College

Harley A. Wilhelm received the honor of taking the first "shipment" of uranium to Chicago when he made the historic trip with an 11-pound ingot

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[252] *MED History*, Book I General, Volume 14 Intelligence and Security, 5.1.

[253] *MED History*, Book I General, Volume 14 Intelligence and Security, 5.1-5.9.

carried in the old suitcase some students had earlier given him.[254] Frank Spedding continued that tradition for a short while when he transported metal on his weekly trips into Chicago. Soon the quantity and weight of shipments grew too great to hand carry, so the project began to use railway express and then freight. Shortly before moving to the Physical Chemistry Annex, the small 4" x 4" x 3' boxes would be trucked down to the depot to catch a Railway Express car, but when the production plant was set up at the Annex, a train box car would be called to come to the railroad sidetrack that ran by the power plant close to the Annex. Men from the plant would load the train, lock it, and give instructions for shipping the materials. On the other end, quite often Chicago, someone from the laboratory would meet the train and unload it. The railroad personnel had no reason to suspect what was in the little wooden boxes. The trains appeared to come into Ames empty and leave empty because usually one layer of 4" by 4" boxes was all that was necessary to come close to exceeding the weight limits. Most freight cars at that time held approximately 40,000 pounds, so quite often less than 400 boxes would meet the weight limits. Most trains left Ames with what looked like a higher floor, but if anyone had examined the train closely, they would have seen axles straining or even bending under the extreme weight.[255]

Early under the jurisdiction of the Manhattan District, there were no special guard details. After the Manhattan District required shipments of this type to carry guards from the Chicago pool, two men in civilian clothes,

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[254] Wilhelm, interview with author, 11-12.

[255] Peterson, interview with author, 7.

usually overalls and sweaters, came and left with the shipments. Spedding recalled that people in town soon spread stories that empty train cars were coming into the College with two hobos in the car and were leaving empty with those same two hobos aboard. Those who saw the trains probably thought that the scientists or the College had so much power that they could order and send out empty trains when farmers throughout the state could not get a train to ship out their corn.[256] But security remained intact and no one reported in the newspapers the incidents of the empty trains.[257]

Plant Security

Governmental plant security regulations

In the case of academic institutions, the NDRC and OSRD required no special integrity checks or loyalty signatures for the institution as it did for individuals within the organization. Unlike the educational institutions, companies and other private contractors were checked for violations of laws, fraud, and any poor performance with government contracts. OSRD and NDRC made no physical inspections of the majority of plant operations, since it did not have a separate staff from the committee or organization to perform

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[256] Spedding, interview 5 with Calciano, 10; Peterson, interview with author, 1990, 6-7; Wilhelm, interview with author, 1990, 16-17; Spedding, Wilhelm, Daane, Interview, 1967, 12; Frank H. Spedding, "Freight Car Boondoggle," Spedding Manuscript, 1.

[257] There was only one small breach, or what was initially believed to be a breach, in security during the shipping days. A young boy of about twelve, watching some of the men loading the Railway Express car, noticed that they were having trouble lifting the boxes. He shouted, "What are you loading there, uranium? When military security got wind of the incident, they were sure a breach of security had occurred. Upon investigation though, it seemed that the boy had been studying chemistry and the elements on the periodic table. He had made the assumption that the highest numbered element (uranium) was also the heaviest. He just used that as a reference to the heaviness of the boxes. No one from the Project had talked. (Frank H. Spedding, "A Security Scare—Boy Saying Uranium," Spedding Manuscript, 1-2.)

them. All of that activity was left to individual contractors. There were twenty-five plants, however, plants that were contributing a major portion of research expertise, whose operations were checked for any violations of government security measures. The violations though were reported only to OSRD and it was left to the committee to bring about compliance with the recommendations. The national headquarters adopted minimal security measures: staff wore photographic badges like those used by the Army and Navy, the Federal Works Agency provided guards for duty around the building, and OSRD installed electrical burglar alarms in sensitive areas to be turned on after the offices closed.[258]

The Manhattan District instituted a much more thorough program of plant security when it launched its Plant Protection Program in August 1943. The program required a survey of all installations engaged in important work to discover if conditions existed to delay and hamper production or to violate security, particularly checking to see if a loss or comprise of sensitive information occurred. Reports and recommendations were forwarded to the Area Engineer or an officer assigned to that facility as security officer. The District compiled a list of important facilities and revised it bi-monthly starting in June 1944. Each facility was rated *A* (where interruptions would seriously delay the project work), *B* (infractions would cause minor delay), and *C* (where violations would cause no delay). Each report contained a composite rating of *Excellent*, *Good*, *Fair*, or *Poor*. All A and B facilities had to maintain at least

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[258] Stewart, 253-254.

Good and Fair ratings respectively, and it was up to the area engineers to bring them into compliance.[259]

Protection against sabotage was another concern of plants, so erecting barriers like fences and screens as well as locking entrances and providing guard details was common practice. Usually workers wore an identification badge to gain entrance to restricted areas that were normally set aside or protected in some way. The Manhattan District also instituted a rigorous program of visitor access in order to protect the plant from the unwanted, the undesirable, or the curious. For a visitor to gain access, written permission had to be obtained from the District Engineer Office. Since most visits were personnel employed elsewhere on the project, background checks had already been completed. Those completely outside the jurisdiction of the Manhattan Project facilities at first had to undergo a background check before gaining admittance to a site facility. Later, the Area Engineer's Office initiated a standard pass and completed checks, which speeded up the process of visitor access. When visits were considered urgent by the contractor, as was quite often the case later in the war, teletype and telephone clearances substituted for written requests.[260]

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[259] *MED History*, Book I General, Volume 14 Intelligence and Security, S4-S5., 4.1-4.9.

[260] *MED History*, Book I General, Volume 14 Intelligence and Security, 4.9-4.11. See also The War Department, "Plant Protection for Manufacturers," Pamphlet No. 32-1, May 1, 1943, revised from the February 1942 pamphlet of the same name for more information on every aspect of plant security from sabotage to fire protection.

Plant security at Iowa State College

At the start of the project, Iowa State developed its own security system. After clearances were received, all employees were informed that the Ames Project's purpose was to obtain pure materials used in the construction of an atomic bomb and that the work was highly classified. No one was to discuss the work with another person except others on the project. Papers and notebooks were always to be locked up and no non-project person who was in the area at the time should see handwriting on paper or on the blackboard By summer, the Chemistry Building had two wooden partitions or barricades erected, one at each end of the area in which the project people were working, and a guard was posted at each barricade at all times to check identification badges of workers and passes from visitors. That guard kept a log of visitors with names, time of arrival, and time of departure. There were no special barriers erected at the production plant, but it was guarded at all times and spotlights were placed outside and fluorescent lighting inside for extra protection. Since three shifts ran 24-hours per day, it was probably thought that guards and the spotlights were sufficient. The Manhattan District added some guards to the local force and also required extensive logs to be kept. Work was compartmentalized and only the top men in each project were briefed on work elsewhere.[261]

John W. Moore, personnel director of the Ames Project, in an interview with a local Ames paper in 1945, explained a bit more about the local personnel

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[261] Frank H. Spedding, "Problems Encountered with Setting and Maintaining a Security System," Spedding Manuscript, 1-2; Frank H. Spedding, "Security," Spedding Manuscript, 1-2; "Building and Grounds Men Kept Busy," 6; "'Little Ankeny' Plays Part in Victory," *Iowa State Student*, August 15, 1945, 6.

situation at Ames, especially the hiring and maintaining of guards. Moore conducted the personnel checks for many of the Ames workers hired on the project. He was also responsible for hiring guards. These men, usually local residents, were equipped with revolvers and controlled passage in and out of buildings. Moore went on to explain the tight security:

> A system of pass identification (if you didn't have one, you didn't get in period, and if you had left it home you went home after it period) was worked out for employees. The guards were tough, too. On one occasion, even Moore was refused admittance because he had left his pass at home, although he remedied that situation by writing one out.[262]

Several scientists found out that the guards were just as strict about notebooks or research materials left about. If someone left a notebook unlocked, he or she was telephoned at home and told to come back immediately to put it in the safe. Needless to say, coming back late at night to put away secret materials soon cured the forgetful scientists about carelessness.[263]

Few documents remain recording the results of plant inspections,[264] but in one recorded instance, the security inspection team proposed some unusual measures to correct a perceived security problem. Iowa State disposed of the slag material from the reduction experiments at the College dump. The material included calcium fluoride, lime, and probably a little uranium that might be left in the slag. The calcium chloride, according to Spedding, served

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[262] Bernie Kooser, "Intricate System of Passes for Bomb Project at College," *Ames Daily Tribune*, August 10, 1945, 8.

[263] Peterson, interview with author, 2.

[264] See, for example, John L. Ferry, "Letter to F. H. Spedding about Visit to Project to take Radioactivity Tests," August 18, 1943, Ames Laboratory Papers.

as a good rat poison, but the security officials for the Manhattan District were concerned about the uranium pieces as a security risk. The project employees were instructed to dig up material that had been deposited in the dump and ship it to New Jersey for storage as well as any future waste. Security inspectors also noticed that small amounts of the uranium tetrafluoride were sometimes deposited in the soil at the Chemistry Annex building. The Ames Project personnel dug up six inches of soil in a strip twenty inches wide all around the Annex to ship to New Jersey also. Filters were installed on the exhaust fans to eliminate the deposition of uranium outside the annex.

The project administration searched in vain for containers to ship this material in until Wayne Keller suggested that in his Kentucky hometown, whiskey barrels were quite often left over from the distillation process and could make suitable containers. Spedding approved the suggestion and asked him to order 1,000 whiskey barrels. By mistake, Keller's secretary typed on the purchase order, "one thousand barrels Hiram Walker Whiskey." The purchasing agent of the college, Mr. Potts, had been told early in the project that for security reasons he was to approve anything Dr. Spedding ordered, and the government would pay for it. Despite the security requirements, Potts called Spedding at 6 o'clock one morning and questioned why he was ordering whiskey through the College in Iowa, a dry state. Needless to say, Spedding straightened out the agent and assured him that it was just a typographical error; he only needed the barrels.[265]

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[265] Spedding, interview with Hacker, 37-38; Frank H. Spedding, "Security Involving Scrap," Spedding Manuscript, 1-3. This story also appeared in varying forms in several publications including many Ames Laboratory publications after the war.

That was not the only trouble the project had with those whiskey barrels. When the barrels arrived, a group of men who did the heavy lifting around the project called the "Bull Gang," were instructed to dig up the dump material. Suddenly, Dr. Wilhelm had too many men volunteering for this dirty and strenuous duty. He suspected something was amiss, and when he went to the dump, he found 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 dump material. Despite the happy workers, the slag was eventually crated and shipped to New Jersey as the instructions provided. What New Jersey finally did with the fine Iowa black dirt and slag is not mentioned in any records, and evidently no one to this day knows.[266]

Occasionally, more than plant security was threatened by secrecy. Because the chemicals were volatile, frequent fires errupted. Since the Ames fire department could not come into the buildings that housed the production plant or the research activities because of secrecy requirements, the College allowed the firemen and equipment to come, but remain outside in the event a fire went out of control. Luckily, the workman were always able to use the lime and powdered graphite around the production building to squelch any flames. Some days that was quite a chore; there were at least six explosions in one day because some wet raw lime being mixed in the bomb retort containers adversely affected the reduction experiment.[267]

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[266] Frank H. Spedding, "Security Involving Scrap," Spedding Manuscript, 1; Frank H. Spedding "Interview with Dorothy Kehlenbeck," July 5, 1961, Transcript in Spedding Papers, 5-6; Tressel, 10-11; Daane, Spedding, Wilhelm Interview, 1967, 13-14.

[267] Kooser, 8; Frank H. Spedding, "Explosions," Spedding Manuscript, 4-5; Daane, Spedding, Wilhelm Interview, 1967, 25.

Incidentally, that was the day that several secretaries threatened to resign and one Army officer received a rather suspicious wound. Secretaries, who were at an office attached to the production plant, had to pass through the firing pit area in order to get outside the building. After that series of explosions, they were wary of staying any longer in a potentially dangerous work environment. Spedding, however, 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. That same day Major H. A. Savigny, an Army officer who also happened to be the Area Engineer, came to investigate the problem after the third explosion. While he was there, another explosion occurred, and, of course, he immediately ran for the door. As he was talking to someone a few moments later, he suddenly grabbed his leg, and a small piece of metal fell from a burned hole in the seat of his pants. Since he sustained a minor burn, he was kidded that he was probably entitled to a purple heart that could be used as a patch to cover that hole in his pants. Others, however, thought it might be somewhat hard to justify his "bravery" since it was apparent what he was doing when he was injured.[268]

When there were breaches of plant security, Spedding could often depend upon his own personnel to let him know about potential problems. Only one letter existed in the documentary files about a potential lack of security, and that was from a night shift manager at the Physical Chemistry

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[268] Frank H. Spedding, "Explosions," Spedding Manuscript, 5-6; Daane, Spedding Wilhelm Interview, 1967, 11-12, 25-26.

Annex I. During a blackout one night that foreman, testing the project security, found that he could move freely around the building without being challenged since only one roving guard was posted. He noticed that there was no guard in the back room where locked files were located, so he suggested that guards be posted in each room. The three regular guards then could be placed at the front door, the back door, and roving.[269]

Compartmentalization of Information

Federal rules for compartmentalization

Compartmentalization of information as conceptualized by the NDRC and OSRD meant that no person contracting a project from the government needed more information than what was necessary to complete a contract. As a result, no one except the members of the committee or some central staff members knew the entire operation of NDRC or OSRD. The purpose of this restrictive policy was to minimize the amount of damage if any individual, either intentionally or inadvertently, divulged secrets.[270] The policy was highly criticized by the scientists throughout the war as a detriment to efficiency. The principle, as it operated under NDRC and OSRD, was probably as much a concession to the armed forces to allow them to entrust the agency with classified information as it was to protect indiscretion since there were no known cases of the latter.

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[269] Jack Boyt, "Letter to Frank H. Spedding, on Security," July 30, 1943, Spedding Paper.

[270] Stewart, 28-29.

The guiding principle for the Manhattan Engineer District was also compartmentalization, interpreted in the most stringent of terms. Groves took his rules from an intelligence bulletin that stated:

> Two cardinal rules govern the right to possess classified information:
>
> (1) The person must be authorized to have the information (i.e., known to require the information in connection with official duties and in performance of his work.)
>
> (2) If the person is authorized to have the information, then he is entitled to only so much as is necessary for him to execute his function.[271]

Groves applied this policy much more literally than the guidelines used under the NDRC or OSRD. For example, blueprints for plant construction project had to be broken into parts to conceal total project designs; orders for raw materials were supposed to come from a number of suppliers because a large quantity coming from one supplier could betray the project's purpose; and functions like assembly of certain equipment and its manufacture were to take place in separate locations. The Army took a much stricter view of information and personnel exchange between laboratories and even within each laboratory. As a result, written agreements such as one developed between Los Alamos and Chicago Metallurgical Laboratory were spelled out in such minute detail that the only practical channel open for exchange of information was for Oppenheimer or his representative from Los Alamos to visit the Chicago laboratory in person when information was needed.[272] The

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[271] *MED History*. "Safeguarding Military Information," 4.

[272] *MED History*, Book I General, Volume 14 Intelligence and Security, 6.3-6.4; Jones, 268-270; Hewlett and Anderson, 238-239.

case of holding a colloquium at Los Alamos, for example, created such a stir within the project that the Military Policy Committee sent Bush to Roosevelt for a letter that could be sent to Oppenheimer and project directors emphasizing the need for strict compartmentalization. Finally, a compromise was reached with Los Alamos where they were allowed to continue weekly colloquiums for exchange of information; these meetings were restricted as to who was given access, a concession to Groves' extreme interpretation of compartmentalization.[273]

Compartmentalization at Iowa State College

There was some compartmentalization at Iowa State, especially after the Manhattan District took over. Only the top research directors had access to what transpired at other sites and travel between sites became more restrictive. But the seminars started under Spedding in 1942 continued throughout the war. The Manhattan District seemed to be much more interested in the products that came out of the Ames Project itself, and since production was not interrupted, the Manhattan District did little to interfere with the internal workings of the scientific side of the laboratory.

Just like at other institutions, the Manhattan District did provide its own separate staff to Iowa State College An area manager, security agents, safety engineers, and auditors were placed on campus to run the project administratively. These agents could not interfere with the scientific progress,

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[273] Franklin Roosevelt, "Letter to Leslie R. Groves, on Security in Manhattan Project," June 29, 1943 in *MED History*, Book I General, Volume 14 Intelligence and Security, Appendix A-1; Hewlett and Anderson. 238-239; Wyden, 99-100.

but they reported production progress, checked security measures, and audited travel and other expense accounts. Spedding revealed in his manuscript history that these people were rarely scientists, or were they even security agents by training. They were often businessmen or lawyers, so they had little experience with either how science worked or how to make a plant secure. They used compartmentalization techniques that were handed down from headquarters, but often they did not understand what they were implementing.[274] So often this level of organization seemed to the scientists more of a nuisance than actually facilitating the project's goals.

The District Area Manager himself was Spedding's counterpart on the Army side. Usually, he was a major in training for a higher management position in the Army and because Ames was such a small installation, the area managers changed as often as every six months. It became almost a joke that Ames was breaking in so many new managers constantly. Spedding said the Army told him (in jest he assumed) that they would send someone to Ames, and, if he could get along with Spedding, he was ready for a larger assignment, such as a project that employed 5,000-30,000.[275]

Compartmentalization affected many sites much more than Iowa State. Because Iowa State, by the time the Manhattan District arrived, had already completed much of its original research under freer conditions, it was not as hampered. From 1943 onward, Iowa State was primarily serving as a

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[274] Frank H. Spedding. "Security of Scientific Information, 1941-1954," Spedding Manuscript, 3.

[275] Frank H. Spedding. "My Personal Contacts with General Groves," Spedding Manuscript, 2-3.

production facility and also doing specific research at the request of other contractors. Its purification program may have benefited from access to others' files, but most of that was done on demand from another contractor with whom conversation was allowed. The Manhattan District's strict rules and regulations were more a nuisance than probably anything else.

Effect of Security on the Academic Laboratory, 1942-1945

Despite the requirements and regulations imposed by added security when the Manhattan District acquired the atomic bomb project, the Ames Project remained an academically-managed unit. The security requirements were added along side the academic structure, and even the military employed academic management techniques when time and expediency required it. For example, compartmentalization often broke down when a laboratory wanted information to continue its project. Los Alamos was a perfect example when Groves allowed the weekly seminars to continue. Groves never set foot on the Iowa State College campus during the war, and Spedding recounted several instances when security was compromised to accommodate other concerns. For example, once a security officer asked that bars be placed on the windows in the Chemistry Building to prohibit entry by some saboteur. There were no bars placed on the windows because the design of the building required that ventilation go through those windows when experiments were in process. Another time, a Manhattan District officer told Spedding to darken some windows in the Chemistry Building. They were never darkened because Spedding thought that would make the working area for the scientists too dark. It was also a well-known fact that the Manhattan District officers were required to go through channels, but if a research director had an urgent problem, he could even directly approach Groves if he wished[276]

Security did prevent publication of the results of research, and on the surface that was a military victory. But that requirement was imposed long before the military took over, and the scientists found a substitute for publication that served the project just as well in secrecy—the report. In the beginning of the project, weekly reports were required, then bi-weekly, and eventually monthly reports of progress in each laboratory. Each project leader was responsible for his own group's report and those were summarized by Spedding and submitted to the Metallurgical Laboratory.[277] An elaborate process of coding, numbering, and distributing these reports was instituted, and the only way added security from the military affected this system was to require that only laboratory or project directors request reports from another facility. Written agreements had to be formulated with each facility as to what it could provide to others. But by the time this took effect in 1943 and 1944, most scientists already knew, in a general way, who was working on the project and what each laboratory might discover. It was a matter of getting around the paperwork to obtain information.

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[276] Spedding, interview with Hacker, 1980, 25-26.

[277] Numerous memos and letters abound in the files relating to the receipt of reports, weekly, bi-monthly, and then monthly. For a sampling, see A. H. Compton, "Letter to S. K. Allison, Encouraging Widespread Use of the Reports for Dissemination of Information," June 5, 1942; J. A. Wheeler, "Memo to Research Associates on the Change in Plans for Weekly Reports to a Monthly System," August 13, 1942; Warren C. Jones, "Memo to Boyd, Burton, Coryell, Seaborg, Spedding, Eastman, and Latimer Discussing the Receipt of Reports to Provide Summaries for Dr. Compton," August 4, 1943; "Request for Assistance in Indexing Your Reports," n.d.; A. H. Compton, "Letter to F. H. Spedding Requesting a Report for the Transfer of OSRD Contracts to Manhattan District," April 19, 1943; and Canfield Hadlock, "Letter to F. H. Spedding on the Consolidation of Monthly Reports and Letters into Semi-monthly Reports," September 6, 1943, all located in the Ames Laboratory Papers.

Visits to other facilities were still allowed under the Manhattan Engineer District though more paperwork accompanied each visit. There is some discrepancy in how much time the military security requirements actually delayed the project. In a Senate Hearing after the war, Leo Szilard complained that he thought compartmentalization delayed the atomic bomb deployment by up to eighteen months.[278] When one considers that in the National Academy Report in 1941, Compton predicted a device by January 1945, compartmentalization and other security measures delayed the achievement of the final goal only until August. Other problems were just as important in the delay as the nuisance of security measures: innovative procedures had to be developed; shortage of raw materials delayed the development of processes; and the experimentation and calculation and recalculation in a new field certainly caused as much delay as security. Groves even hinted in his book that perhaps the Manhattan Project speeded up the process because scientists were not allowed to discuss every alternative and spend a great amount of detail in the discussion process. When a method worked, it was immediately used and usually became the preferred method; action on all others was stopped.[279] Perhaps, in some strange way, that was the case. The military did not change the existing academic structure set in place by Bush; it merely added procedures and requirements along side the other

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[278] "Hearings Before the Senate Committee on Atomic Energy, U.S. Senate Resolution 179: A Resolution Creating a Special Committee to Investigate Problems Relating to the Development, Use, and Control of Atomic Energy," November 27, 1945-February 15, 1946, 294.

[279] Groves, 140; Hewlett and Anderson, 239. See also Richard G. Hewlett, "Beginnings of Development in Nuclear Technology." *Technology and Culture* 17, no. 3 (July 1976): 469.

structure. In most cases when security was lifted, what was left was an academically-styled unit or laboratory.

However, there was one area in which security continued to exert a detrimental influence and that was in the declassifying process of documents used in the creation of the atomic bomb and the many processes developed for atomic energy applications. As early as 1944, there was a movement under way to discuss ways to notify the public about atomic energy. Henry Smyth was hired to begin the history of the project and release certain kinds of information at the end of the war. The process of declassification of information though became ensnared in procedure after procedure. The Tolman Committee (Spedding served on the committee) was commissioned in early 1946 to implement a declassification scheme, designating which information could be released to the public and when it could be released. Information to be released immediately included that of "a broad scientific or general technical nature."[280] Information to be held secret included the "design and availability of atomic weapons. On these we believe that release of information must be made a matter of general policy to be determined by the Congress and the President."[281]

The major complication after World War II was the developing Cold War, with the Soviet Union as the target of continued secrecy. The Tolman Committee recommendations were not implemented quickly by the new civilian agency overseeing atomic research. By 1948, three of four research

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[280] "Statement of Recommendations on Release of Atom Bomb Project Information," Spedding Papers, 2.

[281] "Statement of Recommendations on Release of Atom Bomb Project," 3.

papers from the laboratories of that civilian body, the Atomic Energy Commission, were still classified "Secret." Also after the war, academic theses on atomic energy remained classified until information could be later released, and academic journals could publish nothing about atomic processes. It was not until 1955 after the Geneva Conference on the Peaceful Uses of Atomic Energy that many of the previously held secrets were released. This conference was also coupled with a directive from President Eisenhower that all atomic energy information be released so that industry could use the information to build nuclear reactors.[282]

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[282] Kevles, 378; Greenburg, 216. Also see Richard G. Hewlett and Francis Duncan, *Atomic Shield, 1947/1952* (A History of the United States Atomic Energy Commission, Vol. II; College Park, Pennsylvania State University Press, 1969). At Iowa State theses also remained classified. By 1951, Robert Orr, the Director of the Library, reported that at that point a total of 26 theses were still classified and 5 were restricted. Of the 31 total, 11 were from Physical Chemistry (Robert Orr, "Record of Classified Theses Written at ISC," Library Papers).

CONTRACTING—FINANCIAL CONTROL OF THE AMES PROJECT

Introduction

Just as security challenged the administration of research, financial control also became an important issue in research administration. Financial controls were placed on the Ames Project by the NDRC, the OSRD, and the Manhattan Engineer District. Each of those wartime national organizations adopted a financial management device known as a *contract*, a mechanism that essentially redefined the relationship between government and the academic world. Unlike security, which was by and large a temporary measure that affected primarily the administration of a wartime laboratory, contract administration actually changed the nature of research administration forever.

Early University/Governmental Research Relationships

Contractual arrangements actually developed out of a long-time and somewhat ambivalent relationship between scientists and the federal government.[283] The academic scientist, particularly in the non-agricultural disciplines, generally taught courses while completing research and

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[283] For detailed reports on early governmental and academic relationships, see A. Hunter Dupree, *Science in the Federal Government*, who traces what he calls a split between the government that values primarily applied research and the universities that conduct what he calls basic research. Though this argument doesn't take into consideration all of the complexities governing the developing relations, it does portray the fact that the two entities did in many ways feel suspicious of each other. Also see Daniel S. Greenburg, *The Politics of Pure Science* (New York: New American Library, 1967), 51-67 for a discussion of pre-World War attitudes in academia and government towards scientific research.

scholarship at his/her own expense as a part of the teaching appointment. Little governmental support of academic science developed before World War II, except some attempts at supporting application-oriented research that would have short-term benefits to a particular segment of society (i.e., that provided by agricultural support or public health research). A report commissioned by Franklin Roosevelt in 1938, for example, reported that universities spent $50 million on research in 1935-36; of that $6 million came from the federal government, mostly supporting agricultural research.[284]

By the 1930s, some of the barriers to government funding changed by a complicated set of circumstances. The financial situation, caused in large part by the Depression, eroded many university endowments as well as those of private foundations that had supported scientific research through the 1920s. By the beginning of World War II, coupled with the advent of more sophisticated and expensive research equipment, the transition to large group research, and the need for large infusions of money to make new scientific discoveries in fields like nuclear physics, scientists had begun to make overtures to interest the government in funding scientific research.[285]

However, the eroding world situation was probably as much a contributor to the changing attitude as anything. Most documentary sources do not give enough credit to this dangerous condition, but physicists and other scientists were most often, as the majority of professionals and non-professionals alike, patriotic people. This situation more than anything else

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[284] *Research—A National Resource: I. Relation of the Federal Government to Research*, National Resources Committee, December 1938, 189.

[285] Greenburg, 65-66; Dupree, 367.

probably made the difference in the relationship between government and science—they needed each other to win a war which was to be fought with advancing technology as well as human resources.[286] The split between academic scientists, if indeed there was an actual split, and the government establishment dissolved when scientists and federal money were both needed to win the war against Germany.

Cementing the Relationship—Bush's NDRC and OSRD

When the National Defense Research Council (NDRC) and the Office of Scientific Research and Development (OSRD) were established, they did not create their own laboratories to support scientific efforts, but they decided to support research through existing laboratories, mostly in educational institutions. The idea was certainly novel, since during the last war scientists had most often worked in uniform at makeshift laboratories away from their home institutions. This new approach though necessitated some way to register the government/academic relationship, thus the NDRC looked at the contract as a device to cement that relationship with academic laboratories.

Interpreted in its broadest sense as an agreement between two or more parties to conduct work for the benefit of those involved, the contract had long existed as a device to control relations between the government and others. For example, the government had been known to contract for surveys of coastal or geographic areas of importance, to fund expeditions across the

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[286] Arnold Frutkin, *International Cooperation in Space* (New York: Prentice Hall, 1965), 10-17, argues that scientists in war time have generally reacted to the national needs of the country.

country, or to support some project of national importance throughout its history, but these were not by and large scientific ventures.[287] By the early twentieth century, the primary support for science funding was still located within the university structure. Government support of scientific research efforts in World War I became temporarily necessary for national defense. Scientists were recruited into the military forces and given problems, especially those of a chemical nature, to solve. The National Research Council was set up as an agency to oversee this cooperative research, but after the war when the emergency was lifted, most scientists returned to their individual institutional efforts.[288]

The agricultural research movement

That is not to say there were no cooperative ventures between the government and the academics. Federal money provided through semi-independent research institutes called experiment stations had supported agricultural research at land grant colleges since the passage of the Hatch Act in 1887. The Adams Act in 1906, the Purnell Act of 1925, and the Bankhead-Jones Act in 1935 further codified and structured the rules for agricultural research. The experiment station was organized as essentially a separate, but cooperating organized research unit (ORU) or research institute, or center within a

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[287] For the most definitive work on government and science relations see Dupree, *Science in the Federal Government.* See also books like Alice M. Rivlin, *The Role of the Federal Government in Financing Higher Education* (Washington, DC: Brookings Institution, 1961), Chapters 2 and 3; and Homer D. Babbidge and Robert M. Rosenzweig, *The Federal Interest in Higher Education* (New York: McGraw-Hill, 1962), Chapter 1 for general historical surveys on governmental and academic relations.

[288] John C. Burnham, ed., *Science in America: Historical Selections* (New York: Holt, Rinehart and Winston, 1971), 257.

university or college. The Hatch Act was not explicit about the particular structure to be employed in the organization of experiment stations, except that the stations act somewhat like departments in colleges or universities:

> in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges or agricultural departments of colleges in each State or Territory . . . a department to be known and designated as an "agricultural experiment station" . . .[289]

Since the research crossed several departments, for all practical purposes, most stations were separately administered by their own staff, quite often run by governing boards from various disciplines in universities or colleges. Early on, some university presidents even served as station directors, but by 1905 only four states remained in this situation. A more common practice saw the dean of agriculture serving as the station director.[290] This administrative structure, akin to a quasi-departmental structure, surfaced again in the twentieth century as a standard model for interdisciplinary research in physics and chemistry during and after World War II.[291] The passage of the Hatch Act

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[289] "Act of 1887 Establishing Agricultural Experiment Stations," in H. C. Knoblauch et al., *State Agricultural Experiment Stations: A History of Research Policy and Procedure*, U. S. Department of Agriculture Miscellaneous Publication No. 904 (Washington, D. C.: U. S. Government Printing Office, 1962), 219.

[290] Alfred Charles True, *A History of Agricultural Experimentation and Research in the United States 1607-1925*, U.S. Department of Agriculture Miscellaneous Publication, No. 251 (Washington, DC: U.S. Government Printing Office, 1937), 134-136

[291] Several works have been written detailing the passage and effects of the Hatch Act and subsequent legislation. See H. C. Knoblauch et al., 1962 for a summary discussion of the Hatch Act and its subsequent implementation; Alfred Charles True, 1937 for one of the first surveys of agricultural research and its relationship with the government; and Alan I Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and*

and its subsequent legislation affecting agricultural research, certainly set the stage for certain notions of contract research to be implemented later in the twentieth century.

The National Advisory Committee for Aeronautics

However, the National Advisory Committee for Aeronautics (NACA) came closest to the actual model for contract research as interpreted and put into place by Bush. NACA employed a contract type arrangement to fund research in both its own laboratory and in those instances it went outside to the university. Created in 1915, NACA consisted of a committee of twelve unpaid people, including two from the War Department, two from the Navy Department, one each from the Smithsonian, the Weather Bureau, the Bureau of Standards, and five more at-large members commissioned to solve problems in the aeronautics field.[292] After splitting into thirty-two subcommittees during World War I, the Committee reorganized after the war

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Experiment Stations, 1870-1890 (Ames, IA.: Iowa State University Press, 1985) for an examination of the complicated relationships between the various peoples and associations involved in establishing and maintaining the experiment stations in the late nineteenth century. Robert S. Friedman and Renee C. Friedman, *The Role of University Organized Research Units in Academic Science*, National Science Foundation Report, NTIS PB 82-253394 (Washington, DC: National Science Foundation, 1982), 35-36 point to these agricultural units being separate from academic departments and foreshadowing a trend for research institutes in the twentieth centuries as separate, sponsored-driven and funded, task-oriented, and problem-focused entities. Agricultural research received the lion's share of federal funding from the federal government up until World War II. For example, from the time of the enactment of the Hatch Act through 1933-34, experiment stations had received almost $74 million. (Malcolm M. Willey, *Depression, Recovery and Higher Education: A Report by Committee Y of the American Association of University Professors* (New York: McGraw-Hill, 1937), 360.

[292] Roger Bilstein, *Orders of Magnitude: A History of the NACA and NASA, 1915-1990* (Washington, D. C.: National Aeronautics and Space Administration, 1989), 4.

into six technical committees and a research director who handled most administrative matters.

By the late 1920s, the committee was enlarged to fifteen members with its own national laboratory conducting most of the research work. The committee received suggestions for research from three sources: the government (most often the military), the NACA staff, and outside sources like aircraft manufacturers. The projects from outside sources were assigned to a subcommittee in the area for evaluation on technical merit and then sent to the executive committee for final approval. The suggestions from the military services and other government bureaus were sent directly to the executive committee and approved unless they duplicated work already in process. Once a project was approved, it generally ended up at the Langley Laboratory where a research authorization was written with a scientist who was allowed great latitude in the conduct of the research Review of the research was guaranteed at the beginning of the project and at intervals along the way, but researchers were essentially left to conduct the research by their own devices.[293] Prior to building the laboratory at Langley, NACA had also contracted research on aeronautics to individuals within universities. The earliest contracts were for studies on propellers with William F. Durand at Stanford, who coincidentally was a member of the main committee.[294] Even after establishing the laboratory, NACA continued to contract with universities for scientific

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[293] Alex, Roland, *Model Research: The National Advisory Committee for Aeronautics, 1915-1958* (Washington, D. C.: National Aeronautics and Space Administration, 1985): 103-106.

[294] Roland, 33.

research work. By 1939, NACA had contracts for twelve investigations at ten universities.[295] This flexible contract style of research management attracted Vannevar Bush when he became the committee's chairman in 1938.

The Contract As Developed By NDRC and OSRD

When Bush looked around for a structure to administer NDRC research, contracts were fairly common. However, those developed outside the USDA and NACA were most often military procurement devices so fraught with requirements and special safeguards that they would not work with universities that already suspected government control. When Bush originally developed the plan for the NDRC organizational structure, he made a decision to split the actual research areas from the business side of the agency under the assumption that once work started, the scientist need not worry about financial regulations with the Bureau of the Budget or the Patent Office or the other bureaucratic agencies that were concerned with the administration of research. He chose Irvin Stewart, a lawyer who had been a member of the Federal Communications Commission, to oversee the business side, or the administration of contracts.[296]

In Stewart's mind as well as Bush's, the development of a special contract with universities must "combine a maximum of freedom for the exercise of scientific imagination on NDRC problems with those safeguards

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[295] Dupree, 366.

[296] Stewart, 191; Bush, *Pieces of the Action*, 37-38. Conant, *My Several Lives*, 241.

necessary for the expenditure of public funds."[297] Upon first hearing of this new way of mobilizing science, James Conant, Bush's colleague, remembered:

> I recall saying something to the effect that, of course, we would have to build laboratories and staff them with government employees. "Not at all," Bush replied. "We will write contracts with universities, research institutes and industrial laboratories." He pointed out that such a procedure had already been used by the National Advisory Committee on Aeronautics of which he was then chairman. . . . Scientists were to be mobilized for the defense effort in their own laboratories. A man who we of the committee thought could do a job was going to be asked to be the chief investigator; he would assemble a staff in his own laboratory if possible; he would make progress reports to our committee through a small organization of part-time advisors and full-time staff.[298]

The actual contract form adopted on August 29, 1940, contained two characteristics: work at the home laboratory and complete flexibility in the research plan of attack. The performance clause, the key to the new contract, was an exercise in simplicity: the contractor would conduct studies on a given topic and make a final report on a specified date; no details were provided as to how the work must be performed.[299]

Another departure from past contracting procedures required contract negotiation with the investigator's institution, not the individual. This legal precedent freed the researcher to do the work but did not leave the institution holding the bag if additional costs were incurred. To provide further safeguards, the contract was written on a no-cost basis to the institution, plus an overhead recovery, or administrative charge, of fifty percent of the wages

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[297] Stewart, 191.

[298] Conant, *My Several Lives*, 236.

[299] Stewart, 191.

and salaries to cover the institution's cost in providing research facilities.[300] As Bush later reported:

> We proposed to contract with the university itself, thus placing on it the responsibility for all such matters, and also giving it the authority necessary for proper performance. In return we proposed to pay its overhead costs, the portion of its general expenses properly attributable to the added operation.[301]

OSRD also adopted the contract device as developed by NDRC, and by January 1943, it created what became known as Standard Form 1001 to use for all contracts (See Appendix E for a copy of this form). When procurement became a necessary part of the project as it scaled into its engineering stage, another contract form, the Standard Form 1002, was created allowing for work on a fixed price, plus a reasonable profit for the contractor. Educational institutions, however, never benefited from this form since by charter they could not make a profit.[302]

Establishing research administration at the institutional level also involved splitting the functions of business and research. NDRC and then OSRD assigned each institution receiving a contract both a research officer and a business or contracting officer. Likewise, the institution receiving a contract was expected to assign someone to handle business affairs for the institution, in addition to the principal investigator already chosen by OSRD to handle research. This important division into two functions became a characteristic of

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[300] Stewart, 191; Irvin Stewart, "Memo on Explanation of Overhead and Survey Report on Possible Changes," August 5, 1942, in OSRD Papers, Record Group No 227, National Archives, Washington, D. C.

[301] Bush, *Pieces of the Action*, 38.

[302] Stewart, 19192-198.

the wartime research, but it also continued as government relations with universities continued to grow after the war. It is still a common characteristic of academic research administration.[303]

This type of research organization succeeded then, partly because of the novel form of the contract, and partly because scientists were more than willing to support the defense efforts. By 1942, work on between 400 and 500 contracts with about seventy-five educational institutions had commenced.[304]

The Manhattan District followed the policies of OSRD and NDRC in the contracting area. It used the cost plus overhead basis for all its academic research program contracts. Payment for work completed continued by a reimbursement system just as it had under OSRD However, the Manhattan Engineer District required each contractor to submit a voucher to its assigned area office first where a preliminary audit would be conducted before the request for reimbursement would be forwarded to the District headquarters.[305]

Contracting at Iowa State College

The University of Chicago's Metallurgical Laboratory negotiated the first contract with Iowa State College, actually a subcontract from its own OSRD Contract No. OEMsr-410 in February 1942 for $30,000, to last until July 1942 to conduct experimental studies on the chemical and metallurgical aspects of

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[303] Milton Lomask, *A Minor Miracle: An Informal History of the National Science Foundation* (Washington, D. C.: National Science Foundation, 1975), 38-39.

[304] Karl Compton, "Scientists Face the World of 1942," in *Scientists Face the World of 1942: Essays by Karl T. Compton, Robert W. Trullinger, and Vannevar Bush* (New Brunswick, N. J.: Rutgers University Press, 1942), 20-21.

[305] *MED History*, Book IV Pile Project, Volume 2 Research, Part 1 Metallurgical Laboratory, Appendix D-1.

uranium and related materials.[306] Most early contracts were actually letters-of-intent with specific details to be worked out later in a formal written document. In the summer of 1942, the OSRD negotiated directly a separate contract (No. OEMsr-433) with Iowa State College for experimental studies of tube alloy and for experimental chemical and metallurgical studies in building a power plant.[307] (For examples of versions of these two contracts, see Appendix E.) In late November 1942, the Manhattan Engineer District took over OEMsr-410, changing its status to a production or supply contract and continuing it as Contract No. W-7405-eng-7 until termination on December 31, 1945.[308] OEMsr-433 transferred to the Manhattan District as Contract No. W-7405-eng-82 on May 1, 1943, when most other OSRD contracts were placed under district control. That contract with some modifications is the present contract with which the Ames Laboratory continues its work through the U. S. Department of Energy.[309] (See Appendix E for extracts of those under the Manhattan District, and the full contract with the U. S. Atomic Energy Commission is included for 1948.)

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[306] *MED History*, Book IV Pile Project, Volume 2 Research, Part 1 Metallurgical Laboratory, 2.1. E. I. Fulmer, "History of the Ames Project under the Manhattan District to December 31, 1946, 7 also published as *MED History*, Book I General, Chapter 11 Ames Project (Iowa State College).

[307] Vannevar Bush, "Letter to F. H. Spedding Appointing Him as Official Investigator for Contract OEMsr-433," July 20, 1942. "Contract OEMsr-433, Supplement No, 2," December 26, 1942, 1, both located in Ames Laboratory Papers, Parks Library.

[308] Manhattan Engineer District, "History of Account," attached to an Audit by E. J. Stimpson, May 6, 1947, in Manhattan Engineer District Files, Record Group No. 77, National Archives, Washington, DC. Also see *MED History*, Book IV Pile Project, Volume 2 Research, Part 1 Metallurgical Laboratory, 2.9

[309] Manhattan Engineer District, "Listing of Accounts," attached to an Audit by E. J. Stimpson, May 6, 1947, in Manhattan Engineer District Files, Record Group No. 77, National Archives, Washington, DC.

As seen in the appendix, the early contracts with the University of Chicago and OSRD were quite flexible. When the Manhattan District took charge, the production contract underwent several modifications. Because all contracts were on a cost plus overhead basis, there could be no profit to an educational institution like Iowa State. Particular problems arose when the Manhattan Engineering District wanted to negotiate the contracts on a price-per-pound delivery of uranium and also on certain purity and quantities produced. However, there was no adequate way to predict the costs of these requirements. Price per pound started at about $22 when the district took control, but Spedding thought that he could make uranium for around $8.50 per pound. It was actually produced at a cost less than that, so with each contract supplement, the price was negotiated downward as quantity and purity scaled upward. Renegotiating supplements demanded by the no profit clause created a constant problem, and during the war it was never solved because Iowa State, an educational institution, was the only full-fledged industrial plant operating under no-profit requirements. Eventually, the Manhattan Project had to reimburse Iowa State for actual costs because the project could not get extra money from the College or anywhere else if the costs of materials suddenly changed or delays were encountered in the processing.[310]

By December 31, 1946, the face value of the Ames contracts amounted to approximately $7 million. However, the work, including research, production, and service had been carried out for $4 million with the laboratory producing

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[310] Frank H. Spedding, "Contracts," Spedding Manuscript, 1-2; Manhattan Engineer District, "Listing of Accounts." See the appendix for the history of costs reductions.

over two million tons of uranium billets with smaller amounts of thorium and other rare earths. Uranium production costs fell from around $22 per pound to $1 per pound before the end of the war, in most part, because of the Ames process of uranium production. All in all, the government received quite a bargain working on a no profit basis with the College.[311]

The issue of overhead cost recovery was a particular thorny issue for Iowa State because of the difference in the face value of the contracts and the actual costs incurred. After the war, that charge was negotiated and renegotiated until Iowa State finally received approximately $1.2 million in administrative charges for research and development work for the war work.[312] Some of the federal overhead money paid for a new building that linked the chemistry and physics departments physically as well as symbolically. President Friley, as controller of the overhead money, spent $10,000 for journals and books to start a Physical Sciences Reading Room on the second floor of the new administration building; some of the funds even went to assist the new commercial television station on the campus.[313] These

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[311] Fulmer, 7.

[312] Iowa State Board of Education, *Minutes of the Iowa State Board of Education,* December 9, 1947, 97. To understand the enormous value of that figure one needs only note that the entire operating budget of the College for 1944-45 was $4.5 million (*Biennial Report of the State Board of Education Ending June 30, 1946, 476*). The total value of business transacted by Iowa State during the 1944-45 fiscal year was $8 million, a 50 percent increase over the last peace time year 1941-42. Most of that increase was due to increased activity in military training and war-related research (*Biennial Report of the State Board of Education Ending June 30, 1946,* 394).

[313] Frank H. Spedding, "1946-55," Spedding Manuscript, 3; Spedding, Wilhelm, Daane Interview, 1967, 35-36. Actually Gaskill and Friley could sign for Iowa State according to a resolution adopted at the February 8, 1944 Board of Education meeting: "WHEREAS, President Friley has reported the negotiation of contracts with governmental agencies for war research, BE IT THEREFORE RESOLVED that the President of Iowa State College, the Business Manager of Iowa State College, and Harold V. Gaskill, Dean of the Division of Science be authorized to sign, either separately or jointly, contracts with U.S. Governmental

funds were spent essentially at the discretion of the President, and it was not until 1950 that a policy was created to handle this administrative money differently (see Appendix F). That policy again established the two tier system: both a science officer and a business officer for the College needed to negotiate contracts The policy for handling administrative costs was also established: that all overhead funds should go into the General Fund instead of the President's Office to compensate the College for the costs of doing research.[314]

Shortly after the war's end, Spedding approached the state of Iowa to take some of the overhead money and invest in the initiation of an Institute for Atomic Research at Iowa State College to run atomic research projects of interest to the state. The Ames Laboratory was also established in 1947 funded from the federal government, and continued under the newly formed U.S. Atomic Energy Commission the same research and development contract held by the old Manhattan Engineer District. The contract declared that Iowa State as a national laboratory should continue atomic research, particularly specializing in materials preparation research. The newly-formed Institute for

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Agencies for War Research, and to accept grants for such research programs, subject to the approval of the Building and Business Committee" (*Minutes of the Board of Education*, February 8, 1944, 273). A separate account was created to receive the funds from the government for war research, but Friley reported each of the payments to the Board of Education during the war. (See *Minutes of the Board of Education*, June 22, 1943, 181 for a report of the receipt of $300,000; *Minutes of the Board of Education*, March 28, 1944, 298 for a report of a $500,000 amount on a research supplement as well as the report of the inspection of an addition to the Physical Chemistry Annex on February 14 paid for by government funding; *Minutes of the Board of Education*, September 19, 1944 for receipt of $1,314,000 for continued research. Subsequent reports follow in June 1945.)

[314] Iowa State Board of Education, "Statement of Principles Relating to the Negotiation and Acceptance of Research Contracts," *Minutes of the Iowa State Board of Education, 1949/50*, March 15-16, 1950, 269-272.

Atomic Research would contractually administer the federal laboratory for the College.[315]

Patents and the Contracting Process

The use of the contracting mechanism by universities had one requirement that greatly affected research administration during the war as well as set a precedent after the war: all patents belonged to the United States government when research work was completed on federal contracts. This policy developed out of lengthy discussions during the time both NDRC and OSRD controlled atomic research. As can be seen in the Standard Contract 1001 there are two forms for patents. The first patent arrangements, worked out with companies, essentially stated that the government received a royalty-free license from any invention developed from war research. This policy helped break the bottleneck that developed when companies refused to sign contracts that did not give them title to patents. However, all atomic research eventually came under jurisdiction of the short form which stated that the government had the sole right to determine who had title to the patents. In the beginning, the long form patent policy was used, but as the project grew, in the summer of 1942, President Roosevelt instructed Bush to make sure that the government obtain assignment of the patent titles for all research done under

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[315] Note the similarities between this unit and the agricultural research units described above. Spedding went to the state legislature also hoping to receive state funding for his research unit, much like an experiment station. It was separately administered by a research institute outside any one department; it was focused upon research in both chemistry and physics as they related to atomic research; and it was sponsored by the federal government through a contract-like appropriation.

the government-sponsored programs.[316] Bush succeeded in convincing all OSRD contractors to move toward that goal.

> It was agreed that no monetary consideration would be given by the Government for the patent rights that already had been vested in the contractors through operation of the original provision, but instead that the necessary legal consideration would be supplied by the signing of supplemental agreements to continue the work, as each of the contracts involved required renewal.[317]

Bush wanted someone familiar with Army and Navy patent practices to administer patents for OSRD, so the Navy assigned Captain Robert A. Lavender (retired) the task of handling the patenting process for the OSRD.[318] When the Manhattan District took over the project, it continued the practices set up by the OSRD and even allowed Lavender to handle all patents for them as well, since he was already familiar with the rules and regulations that governed military and defense interests.[319] Bush as director of the OSRD continued to receive "on behalf of the Government, assignments of rights to inventions made under the Manhattan District contracts."[320] Bush, in turn, assigned the patents to the public, thus keeping individuals after the war from profiting from research completed by the contractors during the war.

The practice of issuing patents followed very specific instructions, and all projects upon termination had to clear up and file patents according to

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[316] Stewart, 229-230, Bush, *Pieces of the Action*, 83-84; *MED History* Book I General, Volume 13 Patents, S2, 2.1-2.4 See also Office for Emergency Management of the Office of Scientific Research and Development, "Inventions and Discoveries," Administrative Circular 10.06, *MED History*, General, Volume 13 Patents, Appendix A3.

[317] Stewart, 230.

[318] Stewart, 226; Bush, *Pieces of the Action*, 83.

[319] Stewart, 226-227; *MED History*, Book I General, Volume 13 Patents, 6.1.

[320] Stewart, 231.

those specifications. For example, research notebooks could be used as proof and evidence for both assigning the patent to the government and crediting a patent to the named contractor. This evidence was followed with statements and certifications from the prime contractor head.[321] As of December 31, 1946, over 5,600 inventions had been docketed by the Patent Advisor Lavender's office from over 2,400 prime and subcontracts.[322]

After the project was discontinued, this kind of paperwork created additional headaches for men like Spedding who not only had to worry about the disposal of property for the projects under them, but they also had to clarify what was patentable and then go through the lengthy processes of determining who should be credited for the inventions. Spedding, for example, spent countless hours and several letters clarifying the varying potential patentable processes under his control at Chicago and Ames during the war.[323]

The Impact of the Contract on Research Management Styles

The contract encouraged universities to participate in defense work because of the benefits incurred doing government research without many of the administrative problems that had previously plagued agency-supported

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[321] Amy Services Forces, Manhattan District, "District Circular Letter," Legal 44-5, June 12, 1944, *MED History* Book I General, Volume 13 Patents, Appendix A10.

[322] *MED History* Book I General, Volume 13 Patents, 5.1.

[323] For just a sampling of the various cases that required Spedding's attention, see the following letters all in the Ames Laboratory Papers: Frank H. Spedding, "Letter to Col. H. E. Metcalf Regarding Case S-520, Patent for a Uranium Hydride Method Under Newton and Johnson," February 27, 1945; Frank H. Spedding, "Letter to Col. H. E. Metcalf Regarding Case S-324, Reduction of Uranium Tetrafluoride with Magnesium," May 4, 1945, Frank H. Spedding, "Letter to Col. H. E. Metcalf Regarding Cases S-4035 and S-4036, Purifying Uranium Materials," May 11, 1945.

research. At first, the contract was flexible, open-ended, and did not prescribe the work needed. Those principles laid down by NDRC and OSRD were in line with basic goals and principles of academic management techniques. The contract also allowed administration of research to be split from the actual work of research and that appeased the scientists involved. It satisfied the educational institutions because they were to be reimbursed at cost, plus an administrative fee for providing facilities and other necessities to enable the scientists to undertake the necessary work without jeopardizing the financial situation of the institution. The patent clause became an additional control device over the project because no one person could benefit financially from the work undertaken though due credit for effort and innovation was promised. The Manhattan District did not do away with the contract or patent principles laid down by OSRD, even though it made the contract somewhat more prescriptive, particularly under those regulations that controlled production.

But the contract did more than enhance the academic style of management; it allowed the relations between government and universities to continue in much the same fashion after the war was over. Unlike World War I, the scientists did not retreat from seeking research funding from the government, because Bush had brought that research support along with its administration to the researcher in his own laboratory, and in order to continue work with necessary support, the scientist had a stake in seeing that the relationship with government continue to grow after the war. The contract helped cement that relationship between the academic world and government in ways that heretofore had been unknown. The contract remained the primary way of doing business with the government until the National Science Foundation was created in 1950. At that time, the non-military agencies like the National Science Foundation began to develop what they called a new mechanism to control scientific research. However, if one looks closely at the *grant*, it was first and foremost a flexible contract. It had all the characteristics of Bush's earlier device: non-limiting in its geographical applications, supporting project research with no prescribed formula except the demand of a report at project's end, the award of the funds to the institution rather than the individual, and fiscal as well as research responsibility demanded from the institution. The contract then—first a wartime fiscal device—grew to be the controlling device for most research administration after the war. It was the foundation upon which the academic world and the government built a long-term relationship, a relationship that appeared to mutually benefit both parties.

WORKER HEALTH AND SAFETY

Introduction

> Mr. Premo Chiotti was working with Dr. Wilhelm and me on the reduction of thorium fluoride to thorium metal. Mr. Chiotti was adding a booster to the reaction in a room a few doors down the hall from my office. Suddenly there was a terrific explosion which blew out several of the windows in the front of the chemistry building. When I came out of my office to see what had happened, the corridor was filled with dust about six feet above the floor to the ceiling. I was relieved to see that Mr. Chiotti had not been injured, but he looked very dazed and was pacing up and down the corridor. As I passed him, I heard him muttering, "I must have misplaced that decimal point, I must have misplaced that decimal point."[324]

The story above was probably embellished in the retelling, because health and safety of workers were serious matters on the Ames Project. As long as the atomic bomb project remained a research project, worker health protection schemes concentrated on protecting scientists, who by training were careful experimenting with potentially hazardous materials, from the dangers of known radioactive and toxic materials that would be used in the wartime laboratories. Little was known though about the risks with new materials like plutonium, thorium, and other potentially harmful daughter products created as a result of splitting uranium. Since the scientific literature contained information about the harmful effects of radioactivity, it was natural to start a protection program upon that established knowledge base. However, when

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[324] Frank Spedding, "Humorous Story Concerning Explosions and Education," Spedding Manuscript, 2.

the project turned to production, engineering, and construction, different considerations were brought into play. For example, scientists were not usually placed in the role of industrial production workers nor were they typically supervisors of industrial personnel, so common industrial safety procedures were often unfamiliar. Additionally, nonscientific personnel were brought into the project, people who were not trained in taking proper safety precautions in dealing with potentially volatile materials.

Early protection measures to protect the health of scientists, were suggested as a part of OSRD contracts, but the implementation generally fell to the individual laboratories to develop procedures for their own unique situations. When the Manhattan Engineer District took over the bomb production processes though, it established and maintained two administrative units, one to protect the health of workers from potentially hazardous materials and another to protect the workers' occupational safety in a production, construction type environment.

Early Health Protection Under OSRD Jurisdiction

The early wartime knowledge of health issues concerning bomb building centered primarily around laboratory procedures for proper handling of the radioactive materials that might be produced in chemical and physical reactions. Radioactivity protection actually began shortly after the scientific discovery of radioactivity and the elements that produced it. In 1895, Wilhelm Conrad Roentgen, a professor of physics at the University of Würzburg, published his famous paper on the discovery of x-rays. In 1896, inspired by Roentgen's work, Henri Becquerel discovered that uranium emitted rays.

Within two years, Marie and Pierre Curie had added thorium, polonium, and radium to the list of elements that emitted rays; the Curies even called the process *radioactivity*.[325] In 1903, Ernest Rutherford and his colleague Frederick Soddy examined and broke the rays into three kinds—alpha, gamma, and beta. Rutherford and Soddy also discovered that radioactive elements *decayed*, or passed through stages where they emitted rays or particles until reaching the last stage, lead.[326] By the end of the nineteenth century, of these new elements, radium had become the most useful, but like x-rays, it was also the most dangerous. Only a few radium burns were reported publicly before the 1920s, but during that decade a more insidious discovery was made—radium poisoning. In 1924, Theodore Blum, a dentist, treated a woman whose jaw failed to heal after dental surgery. Blum labeled the syndrome *radium jaw* and attributed the problem to her occupation, painting luminous dials on clock faces.[327]

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[325] Barton C. Hacker, *The Dragon's Tail: Radiation Safety in the Manhattan Project, 1942-1946* (Berkeley: University of California Press, 1987), 19. This book published under the aegis of the Department of Energy's Nevada Operations Office was the first complete examination of the U.S. record in radiation safety practices. Based on both oral interviews and classified documents, it is the first volume of a seminal work on radiological safety in nuclear weapons testing. This volume covers the war years and stops with the end of the management of the atomic bomb project by the Manhattan Engineer District in 1946. Also see Alfred Romer, *The Restless Atom* (New York: Doubleday, 1960) and Lawrence Badash, *Radioactivity in America: Growth and Decay of a Science* (Baltimore: Johns Hopkins University Press, 1979) for detailed discussions of the history of radioactivity. See Otto Glasser et al., *Physical Foundations of Radiology* 3d ed. (New York: Harper and Row, 1967) for a more technical discussion of radiology in its historical setting.

[326] Glasser et al., 318.

[327] The story of the radium dial painters has been told in several sources, so see reports in the following sources for the full story: William B. Castle, et al., "Necrosis of the Jaw in Workers Employed in Applying A Luminous Paint Containing Radium," *Journal of Industrial Hygiene* 7 (1925): 371-382; Roger J. Cloutier, "Florence Kelley and the Radium Dial Painters, *Health Physics* 39 (1980): 711-716; Robley D. Evans, "Radium Poisoning: A Review of Present Knowledge," *American Journal of Public Health* 23 (1933): 1017-1018; Frederick L. Hoffman,

Workers in a factory belonging to the United States Radium Company in Orange, New Jersey, were the most affected by these famous radium poisoning episodes. Fluorescent items were in vogue in the twenties, but none more coveted than the luminous radium dials on watches. Since radium was extremely expensive, the company found that substituting cheaper, but unknown to them, more rapidly decaying radium isotopes and substituting water-based paints for oil paints, they could fill the mass market demand for luminous watches, however at a deadly health cost. Oil paints had been applied with rods, but water paints required a very fine brush that workers invariably pointed by wetting with their lips. This process called *tipping* caused the workers to ingest the paint, which contained the radium isotope, into their mouths and finally into their bodies. Only about 7.5 micrograms per week of radium would be taken in the body, so no one thought that those small amounts could endanger anyone. By the end of 1924 though, nine women had died of the radium jaw syndrome. There were probably more cases that went unreported, or other deaths attributed to anemia, rheumatism or other misdiagnosed diseases that were actually caused by radium poisoning. By 1925, partly due to publicity by health advocates and others, some controls against

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"Radium Necrosis," *Journal of the American Medical Association* 85 (1925): 961-965; Daniel Lang, "A Most Valuable Accident," *New Yorker* (May 2, 1959): 49-94; Harrison S. Martland, "Occupational Poisoning in Manufacture of Luminous Watch Dials: General Review of Hazard Caused by Ingestion of Luminous Paint, with Especial Reference to the New Jersey Cases," *Journal of the American Medical Association* 92 (February 9, 1929): 446-473;. A short summary also appears in Hacker, *The Dragon's Tail*, 20-23. For summaries of the radium dial painters as well as other instances of public stories about the effects of radium in the twenties and thirties, see Spencer R. Weart, "Radium: Elixir or Poison?" in *Nuclear Fear: A History of Images* (Cambridge: Harvard University Press, 1988), 36-54.

tipping had been instituted in the company, but many of the women who did not die in the twenties died later of cancer or other debilitating diseases.

Throughout the period, the company refused to acknowledge that radium was the culprit, although they did finally settle several out-of-court suits with individuals. In 1933, Robley D. Evans published a report that concluded that as little as two micrograms fixed in the bones of a human could cause death, but only two percent of the total amount of radium ingested probably remained for any time in a person's body. No one knew how much radium the bodies of these particular employees retained, but even conservative estimates placed the amount at far more than two micrograms.[328] Although tragic, the cases actually added much to the medical knowledge about radioactive elements. The literature was replete with reports that could be used as a base for the treatment of radioactively exposed patients in World War II. These cases also helped set the stage for the later radioactivity tolerance standards.

Scientists and personnel working with ores and compounds of the radioactive elements were also victims during this period. Often the problems resulted from poor ventilation or careless chemical techniques that allowed these people to ingest chemicals into the mouth. Many of the careless practices were discontinued in the 1930s after public outcry and treats of legal action. Medical patients injected with radium were also victims of overexposure, and often many of them were unsuspecting recipients of radium in popular over-the-counter medicines. After the death of several famous people who took

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[328] Evans, "Radium Poisoning," 1019.

these false cures, research began to be published on just how much radioactive material a person could safely ingest.[329]

This idea of *tolerance* was debated widely throughout the late twenties and thirties.[330] Developing out of the debate came the first quantified measure of exposure tolerance, the *roentgen*. Adopted at the 1928 International Congress of Radiology, it was based upon the ionization per unit volume of air by the radioactive rays in question.[331] By 1934, the agreed upon exposure for a human being was no more than .1 roentgen (r)/day for most of the body and perhaps 5 r/day for the fingers. This tolerance standard remained in force throughout the next decade and became the starting point for the Manhattan Engineer District to use for its atomic bomb project.[332] By 1941, the National Bureau of Standards had also published the first handbook detailing safe standards of handling radioactive substances. Fortunately, this handbook proved to be just in time for the war projects; subsequent health and safety protections substantially built upon these published standards.[333]

The Health Division at the Metallurgical Project

When the Chicago Metallurgical Project was created in 1942, health issues began to be discussed in earnest. The materials to be used in the project

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[329] Hacker, *Dragon's Tail*, 23-24; Lang, "A Most Valuable Accident," 49, 51.

[330] For a discussion of tolerance and a general history of radiation standards see Lauriston S. Taylor, *Radiation Protection Standards* (Cleveland: CRC Press, 1971), 13-21.

[331] Glasser et al., 228-230.

[332] Taylor, *Radiation Protection Standards*, 18-19.

[333] Hacker, *Dragon's Tail*, 25.

obviously posed considerable dangers Interestingly, the half-life of uranium^{238}, the most common isotope and the one that was to be used in ton quantities on the project, was measured in billions of years and uranium^{235} in hundred of millions, numbers not presenting significant radiological hazards.[334] Plutonium though was another matter. So much was unknown, but it was certain that the separation processes would involve far more radioactive materials than those produced in the radium industry to date. Even the effects of plutonium on the body were virtually unknown.[335]

As a result of the known and unknown health concerns, the Metallurgical Project established the Chicago Health Division under Robert Stone, originally from the University of California, to protect all the scientists and workers under the jurisdiction of the Metallurgical Laboratory. The unit was formed August 6, 1942, with divisions in medicine, health, and a new division called health physics to cover radiation protection or the *special hazard* as it became commonly known. Health physics was an unusual name for the new division. Perhaps "radiation protection" was not secure enough, but that new division gave the name to a profession that later came to denote the

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[334] Hacker, *Dragon's Tail*, 21, 35; Smyth, 90. For one of earliest letters detailing the potential problems with uranium toxicity see C. R. Wallace, "Letter to Lyman Briggs on the Toxic Properties of Uranium Metal, Uranium Oxide and Uranium Hexafluoride," July 24, 1941, the Ames Laboratory Papers. Wallace reports that though little is in the literature about uranium salts, it is a toxin exhibiting itself through symptoms of high sugar levels in the urine of the exposed. He also reviews the general symptoms of uranium poisoning, concluding that though it is not a grave danger, great care should be given to prevent its ingestion since that is where its potential danger lies (1-2).

[335] Robert Spencer Stone, *Industrial Medicine on the Plutonium Project: Survey and Collected Papers*, National Nuclear Energy Series, Manhatten Project Technical Section Division IV [Plutonium Project], vol. 20 (Elmsford, NY: Microforms International, 1977, microfilm), 2, hereafter called Stone, *Industrial Medicine*.

entire field of radiation protection.[336] Three plans of action were developed early in the Metallurgical Project by these divisions: the development of sensitive instrumentation and clinical tests to detect radiation and other harmful exposures; research on the effects of radiation exposure on people, animals, and instruments; and the incorporation of shields and safety measures into actual plant design and construction. These Metallurgical Project sections soon set the standard for health and medical care for entire Manhattan Project, serving as the model for providing information on and protection from radiological exposures.[337]

The medical section

The medical section at Chicago performed the normal functions related to personnel on the project: conducting pre-employment health examinations, taking routine tests of blood and urine, and conducting x-rays of the chest. But the section was also charged with developing clinical tests to detect exposure as

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[336] Hacker, *Dragon's Tail*, 29-30. Stone, *Industrial Medicine*, 3; Robert S. Stone, "Health Protection Activities of the Plutonium Project," A paper read at the Symposium on Atomic Energy and its Implications, Joint Meeting of the American Philosophical Society and the National Academy of Sciences, November 16-17, 1945, *Proceedings of the American Philosophical Society* 90 (1946): 13. Also see S. T. Cantril. "Letter to all Group Leaders Detailing the Dangers of Radiation Exposure and Eliciting the Support of Group Leaders to Educate Workers to the Dangers," September 15, 1942, the Ames Laboratory Papers.

[337] Smyth, 123. In addition to the medical, health, and health physics sections, there was also a military section established in the beginning. It was short lived because it was soon taken over by the Army since it was concerned with German atomic weaponry design and the use of German weapons in the field and what effect they might have on troops in the area. At this time, it was thought that Germans were developing an atomic weapon. Additionally, there was some deliberation on using a pile to produce radioactive materials other than plutonium as offensive weapons against the Germans. That idea was quickly dropped, and the defense against German weapons was completely taken from the Metallurgical Laboratory and placed under the Army's control. Stone, *Industrial Medicine*, 4.

well as conducting research on the many medical aspects of potential health hazards.[338]

Blood and urine tests were both used to detect exposure in personnel. At the beginning of the project, blood counts were considered an accurate measure of abnormalities, but the medical section research revealed that normal changes in blood count varied so much that a small amount of exposure to radiation or hazardous products could never be determined with a great deal of accuracy. Since no better tests were developed during the period to detect low level exposure, these blood tests continued to be used to monitor personnel once a month for potentially high levels of exposure.[339]

Urine tests were successfully instituted to detect small amounts of uranium and plutonium. Since uranium would be handled in ton quantities, and it was already published in research literature that uranium was a highly toxic substance once inside the body, there was concern for providing adequate protection to these workers. Conversely to the scientific literature though, personnel from the Port Hope factory in Canada had been extracting radium from tons of uranium for years with no adverse effects. Also some early research with mice exposed to thick levels of uranium oxide dust showed no ill effects on the animals. After several toxicology studies, the Metallurgical Project proved that while uranium was toxic once in the blood, its various compounds were difficult to get through the lungs or intestines to the blood. However, plutonium was another matter. In the beginning, plutonium only

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[338] Stone, "Health Protection Activities," 12; Stone, *Industrial Medicine*, 2-3; J. E. Wirth, Medical Services of the Plutonium Project," in Stone, *Industrial Medicine*, 22-31.

[339] Stone, "Health Protection Activities," 12.

existed in micrograms so there was little danger of exposure, but after 1943, cyclotron production raised that amount to gram quantities and subsequent research proved that plutonium was just as dangerous as radium. Since it had no gaseous daughters like radium with its radon, the problem was controlling the dust and vapors of the element. Because it was excreted in a person's urine, laboratory procedures were developed to detect it in very minute quantities.[340]

Research in the medical section tied very closely to clinical services. All research with human beings was placed under the jurisdiction of the medical section, and many of the early tests studied blood cells for evidence of minimal radiation damage. Urine was also examined and studied for any radiological damage to kidneys. Because it was well known that the liver was the detoxifying center of the body, studies were undertaken on the liver, but changes found here were so small that they could not definitely be linked to overexposure.[341] A summary of the contributions of the section up until 1945 included: the rapid and simple method of detecting uranium in the urine, sensitive to one-hundred-billionth of a gram; urine uranium studies of Ames personnel showing good correlation with their history of uranium exposure; and significant correlation of personnel exposure to uranium, beryllium, and other metals to their urinary excretion of certain products.[342]

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[340] Stone, "Health Protection Activities," 13; Wirth, "Medical Services," 35.

[341] Stone, *Industrial Medicine*, 3; Stone, "Health Protection Activities," 12.

[342] Stone, *Industrial Medicine*, 14.

The health-physics section

The health-physics section provided physical methods to provide health protection from hazards, but its goal was more than just designing instruments or measurement development. Its ultimate goal was to test and monitor these methods and instruments and to provide whatever protection personnel needed from any dangers that the new and unknown materials might deliver. Its first task was to determine the amount of shielding needed when piles became commonplace. All of the early protection schemes initiated from the principle of placing enough material (gas or solid shielding) between the source of radiation and the person nearby in order to reduce the radiation to less than the maximum dose (or the tolerance level as discussed above).[343]

Piles presented a particular problem because concrete alone was not always adequate shielding. For example, holes had to be placed in the walls for unloading and loading the uranium into the pile. Since shielding alone could not provide adequate protection, monitoring systems were developed to keep tract of dangerous exposures. Photographic film had long been used to detect radiation levels but had been problematic in detecting the rays of different energies to which the workers would now be exposed. New badges were developed with a thin shield of metal to cover all but a small area, so that these rays of varying intensities could be detected.[344]

Public safety was also under the domain of the health-physics section. Every attempt at safety by the health-physics section involved prevention,

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[343] J. J. Nickson, "Protective Measures for Personnel," in Stone, *Industrial Medicine*, 75.

[344] Stone, "Health Protection Activities," 14-15.

particularly prevention from harmful substances entering the body. Air-control devices such as hoods, respirators, face masks, and even oxygen supply units were made available to protect the workers against radioactive substances. Dust-laden air was also taken away from workers by the use of ventilated hoods that filtered air out through ducts. This principle of air flow away from the body had been used for years because scientists often worked with noxious fumes. This principle worked equally well for radioactive materials. There were some problems introduced because of the necessity to completely change the air every four minutes, particularly in work with plutonium. Fans capable of handling over 50,000 cubic feet of air per minute were purchased for the job, but then heating the buildings became a problem. Accurate measuring devices to monitor contamination had to be developed since there was not often enough time to design completely effective hoods.[345]

Prevention of ingesting hazardous materials through the mouth or skin was another matter of concern to the health physicists. Eating food with contaminated hands, smoking and inhaling hazardous materials along with the smoke, or using contaminated eating vessels were all ways to ingest dangerous materials. Smoking was prohibited in places where toxic materials were handled, and at Chicago it was prohibited in all areas and offices of the plutonium laboratory. Rubber gloves were encouraged when working with any radioactive material to partially prevent contact with the skin by radioactive materials, but also to prevent transfer of the materials to the mouth through the hands. Geiger counter systems of monitoring the alpha,

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[345] Nickson, "Protection Measures for Personnel," 81-86.

beta, and gamma particles and rays on the hands were established at Chicago and other sites. Additionally, special clothing was worn to protect other parts of the body and laundry facilities were employed to decontaminate these working clothes. Instruments were developed to monitor the particles from the clothing before and after laundering. Personnel were also required to shower before leaving the sites to prevent taking contamination outside to the home. Any skin wound was a particular hazard since radioactivity could enter an open wound and react with the body just as if the material had been injected. Any wound, occupational or not, had to be reported; no one was permitted to work with radioactive materials until a cut healed.[346]

S. T. Cantril, reporting his observations about the working conditions of the chain reaction experiment in late 1942, suggested several measures to protect workers at the Stagg Field, controls that were later put into force throughout the project. He detailed items like the importance of cleanliness of workers through showering He recommended adding several showers as well as always providing the proper kind of soap. He suggested paper cups and sodium-bicarbonate for brushing teeth after working in the affected areas. Protective clothing like gloves and overalls as well as masks in the dusty areas were recommended. He also suggested altering ventilation systems in the pile area, the materials storage room, and other preparation centers to better protect workers. He finally recommended the hiring of a full-time janitor to collect clothing and masks and supply clean clothing at the beginning of the day as

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[346] Nickson, "Protection Measures for Personnel," 87-92; Stone. "Health Protection Activities," 15-16.

well as routinely clean shelves, floors and benches to kept the affected areas as free of dust as possible.[347]

Waste disposal was also under the jurisdiction of the health physicists. All sites had to develop burial grounds for radioactive waste materials. However, the problem with most of the burial sites was that long-lived materials like plutonium were buried along with those of short-lived status. This problem continued long after the war when containers broke or seals came undone contaminating ground water and soils around particularly hazardous sites. No final solution to this problem was devised during the war, but suggestions for disposal ranged from burying the more contaminated materials at sea in concrete to firing rockets of contaminated material out of the earth's atmosphere into deep space.[348]

It fell to the health-physics section not only to build instruments that monitored hazardous materials, but it also became their charge to keep meticulous records of the levels of the exposure to personnel and also those levels of radiation found in plants, soils, water, and other living things for information to future generations. These personnel became especially valuable to the project during the war, and those trained in this area during the war found that their tasks continued well after the war years.

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[347] S. T. Cantril, "Memo to R. L. Doan Regarding Safety Precautions for the Experiment at the West Stands, Stagg Field," August 31, 1942, Ames Laboratory Papers, 1-3.

[348] Nickson, "Protection Measures for Personnel," 87-92; Stone, "Health Protection Activities," 15-16.

Biological research section

Most of the biological research dealt with the maximum permissible exposures to radiation. The roentgen had already been established as the unit measure in monitoring radiation activity, but further studies were conducted throughout the war on large exposure in chain reacting piles or other conditions where large amounts of alpha and beta particles and gamma rays might be present. Studies of the decay of various fission products like iodine, strontium, barium, and yttrium were conducted in relation to the metabolism of these elements by animals and humans. The effects of plutonium on the human body was also examined, and researchers found that it was indeed just as dangerous as radium when deposited in the bone. Studies examined the elimination of these elements from the body, while others examined overexposure in animals and humans.[349]

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[349] Summaries of the research appear in Stone, "Health Protection Activities," 16-19 and S. T. Cantril, "Biological Bases for Maximum Permissible Exposures," in Stone, *Industrial Medicine*, 36-74. For more details see the individual reports that were also presented at a symposium at the 32nd annual meeting of the Radiological Society of North America, Chicago, December 1-6, 1946. The reports were published in an issue of *Radiology* in 1947 and include the following: Raymond Zirkle, "Components of the Acute Lethal Action of Slow Neutrons," *Radiology* 49 (September 1947): 271-273; Egon Lorenz et al., "Biological Studies in the Tolerance Range," *Radiology* 49 (September 1947): 274-285; Leon O. Jacobson and E. K. Marks, "The Hematological Effects of Ionizing Radiation's in the Tolerance Range," *Radiology* 49 (September 1947): 286-298; C. Ladd Prosser et al., "The Clinical Sequence of Physiological Effects of Ionizing Radiation in Animals," *Radiology* 49 (September 1947): 299-313; John R. Raper, "Effects of Total Surface Beta Irradiation," *Radiology* 49 (September 1947): 314-324; Joseph G. Hamilton, "The Metabolism of the Fission Products and the Heaviest Elements," *Radiology* 49 (September 1947): 325-343; William Bloom, "Histological Changes Following Radiation Exposures," *Radiology* 49 (September 1947): 344-34; P. S. Henshaw, E. F. Riley, and G. E. Stapleton, "The Biologic Effects of Pile Radiations," *Radiology* 49 (September 1947): 349-360; and Hermann Lisco, Miriam P. Finkel, and Austin M. Brues, "Carcinogenic Properties of Radioactive Fission Products and Plutonium," *Radiology* 49 (September 1947): 361-363.

Summary

The Metallurgical Laboratory established the first and probably most comprehensive medical and health protection unit during the war period. In 1942, there was a limited body of knowledge upon which to build, but by 1945, Stone could list several division accomplishments:

> We calculated the anticipated hazards from known facts and extrapolated to the probable permissible levels of exposure. It was agreed at the time that we would be given the opportunity to check our calculations by experiments and so establish the tolerable limits of exposure on solid ground. Our program to date has been based on accomplishing these aims for uranium, fission products, plutonium, neutrons, beta rays, pile gamma rays, and other chemically toxic and radioactive substances that might come into the processes on the Metallurgical Project. In addition we have attempted to understand the mechanism by which these agents acted so as to be able to treat anyone who might be overexposed to any of them. . . . The results which we have obtained and will obtain are of value not alone to the Metallurgical Project, but also to any Project making use of the materials developed with the Manhattan District.[350]

The Development of Health and Safety Measures under the Manhattan Engineer District

The Manhattan Engineer District developed essentially two areas of expertise under its jurisdiction: the health or medical program and the safety program. Each of these programs built upon previous OSRD installations like the University of Chicago's Metallurgical Laboratory.

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[350] Stone, *Industrial Medicine*, 9-10.

The medical program

The medical program developed slowly at first since the District was involved with just engineering and construction in the early days. After the OSRD projects became a part of the District in 1943, it was apparent that some coordination of the diverse medical operations needed attention. At first, Groves considered pulling Stone from the Metallurgical Laboratory to oversee the entire operation, but as he visited with installations one name continued to surface as the best choice for coordination of the entire program: Stafford L. Warren, professor of radiology at the University of Rochester. Warren was brought into the project, initially in June 1943, as chief of a provisional medical section at the District headquarters. The need to procure and retain medical men and women necessitated militarizing the medical operation, so negotiations soon began with the Office of the Surgeon General. After negotiations concluded successfully for the Manhattan District, Warren moved to Clinton where he was commissioned as a colonel on November 2, 1943.[351]

Warren quickly set about reorganizing the Medical Section's three branches: medical research, industrial medicine, and clinical medicine.[352] The basic objective of the medical research branch was to collect data on toxic material to protect workers who were being hired for the plant projects and to

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[351] Stafford L. Warren, "The Role of Radiology in the Development of the Atomic Bomb," in Office of the Surgeon General, Department of the Army, *Radiology in World War II* (Washington, DC: U.S. Superintendent of Documents, 1966), 841-842, hereafter known as Warren, "The Role of Radiology." Also see K. D. Nichols, "Letter to Stafford L. Warren on the Responsibilities of the Medical Section," *MED History* Book I General Volume 7 Medical Program, Appendix A1 for a detailed elaboration of the responsibilities of the Medical Section.

[352] Jones, 410-413; *MED History* Book I General, Volume 7 Medical Program, 6.1-6-3.

treat those who might be overexposed to these same materials. The Metallurgical Laboratory conducted much of the early research on toxic materials and continued that research when the Manhattan District took supervision of its contracts in 1943. Other laboratories involved in this research included the University of Rochester, initially under Warren, which investigated the exposure of animals to high-level x-rays in its radiology group, the radioactivity of certain toxic chemical substances in its pharmacology unit, and the design of monitoring devices that were to be tested in Clinton, Hanford, and elsewhere in its instrumentation group. Columbia University also tested instruments as well as Hanford, which had its own instrument testing group. The University of California carried out medical research in the area of fission products at its Crocker Radiation Laboratory. The Clinton Laboratories had a complementary research program directly under S. T. Cantril who originally worked with Stone at Chicago.[353]

The industrial medicine program tried to control the particular industrial hazards associated with the atomic bomb production processes. Captain John L. Ferry, the head of this branch, established groups to monitor industrial hygiene activities at the University of Rochester, to oversee hazards in materials procurement at the Madison Square Area Engineers Office, and to serve as consultants in first aid or whatever needed throughout the District. The industrial medicine program did not oversee Clinton, which was under the University of Chicago, or Los Alamos, which had its own industrial

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[353] Jones, 414–416; Warren, "The Role of Radiology," 850-853; *MED History* Book I General, Volume 7 Medical Program, 5.1-5-23.

hygiene group. The program also had a large field effort that encouraged doctors to conduct research studies on special industrial activities and hazards through the District. They also drafted minimum procedures and standards that were sent to the various facilities detailing approved methods of working with materials like fluorine, uranium hexafluorine, or plutonium, including the proper first aid measures in working with those hazardous materials. Inspections were also under the control of this group and those were carried out according to the type of contract involved. Cost-plus-fixed-fee contract sites and others where the government had financial responsibility for the costs were likely to receive very close scrutiny; where a company had primary liability for costs were inspected less often and less rigorously.[354]

The clinical services branch provided the isolated installations of Clinton, Hanford, and Los Alamos with on-site medical facilities. These facilities operated primarily without supervision or interference from the Manhattan Engineer District. Facilities at Oak Ridge in Clinton included a fifty-bed hospital, an animal hospital, a psychiatric and social welfare consultation service as well as the full range of medical services for its community. The Hanford clinical medicine program, primarily civilian in nature since it was under the control DuPont, provided regular medical services as well as emergency dental care and public health services. Los Alamos residents also received full medical care, an important program for

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[354] Jones, 416-418; *MED History* Book I General, Volume 7 Medical Program, 3.1-3-6; Warren, "The Role of Radiology," 858-859.

such a remote site. In 1944, Warren even sent a psychiatrist to help with the tensions in this strain-producing plant.[355]

The safety program

The start of the large-scale building activities under the Manhattan District required the implementation of safety standards in the plants for the workers. In June 1943, James R. Maddy was hired to assume command of the safety program and immediately began the accident prevention program for the District. By the end of 1943, Maddy had reorganized his program into two units: an occupational safety section that operated as any large industrial staff requiring contractors to provide workers with safe drinking water, goggles, hard hats, safety shoes and other items that would prevent accidents, and a public safety section that worked with the community in Hanford and Oak Ridge to implement programs in traffic control and other areas of community safety. The District employed a district safety engineer and several resident safety engineers to serve as consultants to the various area engineers.[356]

The Manhattan Engineer District, just like the earlier agencies, acknowledged the importance of health and safety issues in its operations. It took the policies that had been developed in laboratories like the Metallurgical Laboratory and applied them to the entire district. In short, what had been started under individual laboratories was continued and coordinated by the Manhattan Engineer District.

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[355] Jones, 422-426; *MED History* Book I General, Volume 7 Medical Program, 4.1-4.40; Warren, "The Role of Radiology," 872-875.

[356] Jones, 426-427; *MED History* Book I General, Volume 2 Safety Program, 1.1-1.6, 2.1-2.12, 3.1-3.8, and 6.1-6.4.

Health and Safety at Iowa State College

Because the Ames Project at first fell under the jurisdiction of the Chicago Metallurgical Laboratory, there was always a concern for the health of the workers on the project. Ames worked with uranium in ton amounts and most of the health considerations evolved from that work in the pilot plant situation. As long as the chemists were involved in research with the various elements, typical laboratory precautions were taken. Ventilating hoods to take the dust away from workers were already being used before the war and obviously continued throughout. Respirators were used on occasion, and some scientists remembered that lead aprons were around when needed to work with particularly hazardous chemical materials. Chemists were generally careful people, trained in working with danger. So if explosions were a problem, they built walls to hide behind when processes could be potentially dangerous. Even when working with the unknown, they took precautions based upon what was in the research literature about the chemicals with which they were working. Uranium was thought to be toxic when ingested, so proper methods of handling already discussed were implemented at Ames when scientists were working with the materials. Rarely did any scientist receive more than cuts or abrasions from the work they were doing. Spedding indicated that when experiments were discussed in the Sunday seminars, instructions were also included on safety precautions. It was most often when someone was careless that problems occurred, such as falling off a chair, or doing something careless to get metal in the eyes Those were typical accidents recorded by the scientists throughout the war period. This same attitude continued under the Manhattan Engineer District.[357]

Radiation was never a large problem at Ames, but unfamiliar elements, like beryllium, probably caused the greatest risks at Iowa State. Little was known about dangerous levels of exposure to this chemical, but it was a concern because Iowa State experimented with this element in quantity, particularly in crucible making. Beryllium was an insidious killer in many installations, but Iowa State scientists had a particular built in safety feature all around them—large amounts of calcium. Unknown at the time, beryllium was a bone seeker, but if the body could get enough calcium, it would reject beryllium. Fortunately, there were great quantities of calcium around the Ames laboratory.[358]

There were a few instances at Iowa State of overexposure to beryllium by the scientists, and nationally there were over fifty known deaths from handling of this material. Norman Carlson, for example, one of the researchers, received too much beryllium and was put into the university hospital with a high fever for a short time. He did recover though and had no further exposure problems.[359] Premo Chiotti, another scientist on the project, remembered that he too visited Dr. Grant at the hospital for an overexposure problem. Ironically, his developed not from the reduction experiment that

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[357] Spedding, interview with Barton Hacker, 1980, 14, 24, 29,38-39; Premo Chiotti, interview with Barton Hacker, 1980 in Ames Laboratory Papers, 3, 11-15; David Peterson, interview with Barton Hacker, 1980 in Ames Laboratory Papers, 4, 9, 12, 15; Spedding, Wilhelm, Daane interview 1967, 23-24; Frank Spedding, interview with George Tressel 1967, 16.

[358] Spedding, interview with Hacker, 1980, 18.

[359] Carlson, interview with the author, 1990, 7.

used open pots to reduce beryllium fluoride with magnesium but from making his work area clean. A gummy sort of fluffy dust collected on the side of the pots and Chiotti decided that he would clean them out one Saturday morning He got a pail of water and sponge, rolled up his sleeves, and washed the areas thoroughly. By Sunday morning, he had chills and by Monday a rash on his arms. It was subsequently cured. and he also never had a recurrence, but it pointed to the dangers of handling a material that evidently affected people differently.[360]

Beryllosis was the most dangerous reaction to beryllium When beryllium traveled to the lungs, it acted much like the flu initially, but then it migrated to the bones and behaved like radium, displacing calcium. Some of it would also travel back to the lungs, giving the symptoms of tuberculosis, inevitably causing death. Wayne Jones, a nonscientist glassblower on the project, did die of beryllosis later in his life, and though he was never in the main area where beryllium was handled, he may have ingested it from the glass he was blowing or from even the beryllium in fluorescent lighting in his glassblowing area. Twenty years after the project he died, and the Atomic Energy Commission settled the case out of court with his family.[361]

There were few examples of safety breaches or carelessness by the scientists at the Ames Project. The production area though presented quite a different problem. Scientists generally had security clearance, so they knew with what they were working. Because of their past training, they also

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[360] Chiotti, interview with Hacker, 5-6.

[361] Frank Spedding, "Spedding 's Role as Guinea Pig," Spedding Manuscript, 2-3; Spedding, interview with Hacker 1980, 18-19.

generally knew to handle certain substance carefully. When Iowa State instituted a pilot plant, a rarity for an educational institution, two problems arose: scientists were unfamiliar with some industrial safety practices in some cases, and workers, often from the community, had to be hired who were often unfamiliar with even routine industrial practices. They rarely had enough security clearance to know the dangers of the materials with which they were working. Most of the foremen though, who were in charge of shifts and the production areas, were, in most cases, at least undergraduates in chemistry, so they did know about chemical reactions, but most had little training in industrial practices. At first these foremen, with the help of other scientific leaders, instituted safety and health procedures much like any college research laboratory. Ventilation and hoods were provided, but it soon became apparent that stricter adherence to safety would be needed. There was also a basic conflict trying to balance safety with accomplishing the work in time to win the war. Iowa State's production facility was set up in a small house-like building that had to be equipped with even the basics in safety features. Due to the emergency, much of the early work was not done under the best of conditions, and there was certainly a make-do attitude combined with great difficulty in obtaining safety equipment, or any equipment for that matter. For example, most of the tools that had been obtained from Bill Maitland's shop garden in downtown Ames were hand-driven, so power apparatus had to adapted and added to them. Also many of the grinders, cutting mills, and machining tools were originally manufactured for other industrial purposes and naturally did not have all the necessary safety features for working with uranium. It took months to obtain fans that were needed for proper ventilation in the building.

and since much of the work took place in hot months without the luxury of air conditioning, respirators and masks, though required for particularly dusty work, were sometimes discarded for worker comfort. Rules and regulations were clearly spelled out by project leaders, but it was up to the individual work chiefs to enforce them while also completing the production work on time.[362] David Peterson, one of the foremen on the project, remembered:

> There was a higher level of concern, probably at the higher levels of management, and we were given some instructions on what to do. I was acting as either assistant foreman or foreman for a crew of from six to fifteen or sixteen people. We had the direct responsibility for seeing that things were done as they should have been done. In a situation of that type it often falls on the immediate supervisor to make some decisions with his own judgment. I would say that we were perhaps occasionally guilty of erring on the side of, "Well, let's get the job done and not worry too much about this or that safety rule." . . . There were other factors at that time which were probably weighed in. This was a period of wartime. There were other hazards besides radioactivity to be concerned with. There was a great deal of emphasis and interest in trying to push things along quickly, one reason being that at that time it was not at all known for certain that the Germans weren't working along parallel line.[363]

Dust was a particular industrial problem on the Ames Project, as it was evidently throughout the District, probably even more of a problem than radiation exposure itself. Uranium salts had to be ground, which produced dust; boosters and other materials placed in reaction with uranium had to be ground from salt or compound chunks; cleaning uranium caused dust; and

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[362] Spedding, Wilhelm, Daane interview 1967, 19-20; Chiotti, interview with Hacker 1980, 19-20; Peterson, interview with Hacker, 7-8, 10, 15-15. For the example of obtaining fans for metal work in the chemistry building see W. F. Coover, "Letter to F. H. Spedding Regarding Order of Fans and Rating Problems Slowing Deliveries," July 31, 1942, Ames Laboratory Papers.

[363] Peterson, interview with Hacker, 4-5.

finally uranium machining operations also caused dust build-up. Uranium in dust form could be more easily ingested, so there were several research studies conducted by the medical research section at Chicago and at other installations in the Manhattan Engineer District on uranium ingestion in this form. In fact, it was one of the early experiments with mice and uranium dust that proved work with uranium was not as dangerous as first thought.[364]

Probably the second most difficult problem in Ames was controlling the hazardous chemicals to prevent explosions. Impure materials caused explosions as well as wet materials. Improper handling or lack of attention to properly lining the bomb retorts could cause blowout problems when the uranium reaction came into contact with the steel or iron in the bomb containers. Magnesium was a particularly volatile material, and protection from explosions on many occasions became making sure that at every step of the process workers had a wall between the bomb vessel and themselves. As noted earlier, in one day alone there were six explosions. Once an explosions blew out the south wall of Little Ankeny in the early hours of the morning; by then explosions were so commonplace that the workmen went outside and pushed the wall back in as far as they could. Fires were also a danger at several steps in the process. Magnesium could shoot a flame several feet in length sometimes setting anything in its path on fire. Until the proper insulation techniques were learned, uranium cutting or machining caused fires when the cutting blade struck such a hard metal. Controlling these special chemical fires

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[364] Peterson, interview with Hacker, 18; Jones, 419; Warren, "Role of Radiology," 855.

with lime or graphite became a common practice that every worker had to learn.[365]

There were several industrial safety measures employed in the production facility at Ames. When grinders or cutting mills were used, workers had to wear respirators; that requirement was apparently rigorous enforced. Every man and woman was given time off to shower and change clothes at the end of the shift in order to prevent taking uranium and thorium particles home or outside the work area. Special work uniforms were issued to every worker and required to remain on the premises at the end of a shift. Washing thoroughly before eating was also rigorously enforced. To prevent ingesting radioactive dust in the process of smoking, no one was allowed to smoke in work areas; smoking was allowed in the locker rooms, however. Sometimes, a fire would occur at the bottom of a bomb, and molten uranium would pour out on the floor. The building personnel would immediately evacuate and wait until the fumes died down before cleaning up the accident. Ventilation was at least adequate in the old house, due partly to the fact that it was a drafty old building. After fans were installed, the air was changed and filtered enough to prevent the kind of dusty haze often encountered in the average foundry operation.[366]

Sometimes, these extreme safety precautions caused trouble with the uranium production purity standards. One summer, boron began to show up

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[365] Frank Spedding, interview with Hacker 1980, 18-19; Frank Spedding, "The Day the Wall Blew out of Little Ankeny," Spedding Manuscript; Frank Spedding, "Explosions," Spedding Manuscript.

[366] Peterson, interview with Hacker, 6-11.

in uranium samples at the rate of 1-2 parts-per-million, enough to contaminate the runs. After a thorough investigation, the culprit was found to be the shower. After the men showered, they used a preparation to treat athlete's foot that contained boron. They tracked the boron into the plant from the shower, thus contaminating the uranium runs. A sign finally had to be placed in the shower area warning against certain powder preparations.[367]

Occasionally, there were people on the Ames Project who did not follow safety rules. The most notorious person at Ames was a man known locally as the "Green Hornet" because he did not properly shower or clean up after working on the shift. According to the prevailing stories, he did not wear a respirator and refused to take other precautions in his dusty work. Since uranium tetrafluoride was a green salt, the dust stuck to his clothes, giving him his nickname. Unfortunately though, no one knows exactly what happened to this man as a result of his dangerous overexposure to dust. Spedding told the story in his manuscript history that this man was chosen as one of the most likely subjects to be tested for heavy exposure to uranium. He was approached by one of the medical researchers asking for a sample of bone tissue from his sternum. Apparently, he agreed but when time came for the test, he vanished, from the room, and from the project. The Ames Project owed him several days of pay, but he never came back to claim it. No one evidently ever heard from him again.[368]

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[367] Frank H. Spedding, interview 1 with Calciano, 5-6

[368] Frank Spedding, "The Green Hornet," Spedding Manuscript, 3-4. The story was also repeated in varying detail in the following sources: Adolf Voigt, interview with the author 1990, 6; Spedding, Wilhelm, Daane interview 1967, 15-16.

On several occasions, the tight security of the Manhattan Engineer District also interfered with health and safety standards. One security expert from the District tried, for example, to get Spedding to put bars on windows in the long narrow rooms of the Chemistry Building, but since that could have prevented escape in the event of an emergency, Spedding had that plan overruled. Another time a security officer insisted upon painting the windows black in the same building to prevent sabotage. That would have led to a very dark room in which to do the dangerous chemical work; again he was overruled.[369] At yet another time, Elroy Gladrow, one of the scientists on three separate compartmentalized projects, gave three different blood samples each week from his ear lobes. Once, after appearing before Spedding with swollen ear lobes and asking why he needed three separate samples, Spedding convinced the officials to take only one sample and divide it into three parts for the health reports.[370]

A thorough safety and health program was instituted at Ames over a period of time. The program at the pilot plant was aimed at eliminating the typical kinds of accidents common in any industrial situation. In August 1943, a survey conducted at the pilot plant concluded that since August 16, 1942 there were 16.2 injuries per million men hours, somewhat high for a chemical plant, but probably low considering the plant was experimenting with new, heretofore untested processes. The production plant was also run by scientists

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[369] Frank Spedding, "Frustration of the Manhattan District Safety Officials," Spedding Manuscript.

[370] Frank Spedding, "Gladrow's Ears," Spedding Manuscript; Spedding, interview with Hacker, 1980, 30-31.

who were not familiar with all industrial practices, and many of the employees were local men and women who had little experience with labor practices.[371] In June 1943, Elroy Gladrow took over the health and safety program, working closely with group leaders in the scientific project and initially with Mr. Rafdel, one of the guards, on the production pilot plant project.[372]

Finally though it was radiation, the "special hazard," that received the most attention at every installation. Research studies monitored and kept a record of the dangers of the levels of exposures of employees. Clinical testing was also employed at Ames as well as other installations. Blood tests were administered routinely, though most employees do not remember what was done with them. Urinalysis tests administered at least once a month evidently, were turned in to higher authorities at the Metallurgical Laboratory and the Manhattan District. No medical doctor was on staff for the Ames Project though Dr. John G. Grant of the University Hospital was called upon to provide some support in treatment and research. Thelma Bruce, a nurse evidently at the hospital, was the other medical technician who administered routine blood and urine tests throughout the war. On occasion, certain staff of the Ames Laboratory participated in research studies to determine the effectiveness of clinical tests or to serve as subjects for medical research carried on by the district. Those research studies were particularly important because they became the foundation upon which standard exposure levels were tested. These studies also became the building blocks for protection of workers in the

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[371] "Safety Report for Period Ending 8/1/43," the Ames Laboratory Papers, 2.

[372] Frank Spedding, "Letter to Group Leaders," June 16, 1943, Ames Laboratory Papers; "Health and Safety Report for the Week Ending June 28, 1943," Ames Laboratory Papers.

nuclear plants after the war. Workers at Ames were carefully monitored by research teams. Certain men and women were also studied after they left the project to determine long-term effects of the work they were doing. Probably because of this system, very few workers and almost no scientists appeared to die due to some problem that arose in the Ames Project. It was incredible that the major problems on the Ames Project were those that any industrial laboratory or factory might contend with—accidents, carelessness in handling heavy materials, and typical first aid cuts and abrasions.[373]

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[373] For research studies, for example, see Samuel Schwartz, "Letter to Dr. Grant on Report of Studies of Personnel at Ames, Iowa," June 1, 1944, in Ames Laboratory Papers, 1-2 for blood, urine, kidney, and liver studies on a group of 19 employees with heavy, moderate and relatively slight exposure to uranium activities. The results indicated "less abnormality than I would have expected from the amount of exposure these men are getting" (2). Other research studies were reported in S. T. Cantril, "Letter to F. H. Spedding on Testing of Two Men for a very Sensitive Urine Test Developed by the Metallurgical Laboratory," January 29. 1943; Samuel Schwartz, "Letter to J. G. Grant for Results of Kidney Studies on a Select Group of Workers," June 7, 1944; Samuel Schwartz, "Letter to J. G. Grant on Tests for Certain Named Employees for Urine Samples," June 14, 1945; in the Ames Laboratory Papers. For the kind of follow-up studies that were conducted, see numerous letters in the files to those who were leaving the project requesting that they submit to tests after leaving. For example, see Elaine Katz, "Letter to Mr. Elmer J. Peterson on Weekly Urine Tests for One Month," January 19, 1945 in the Ames Laboratory Papers. Also see Appendix F for a sample letter of this type.

SUMMARY: THE IMPACT OF THE MILITARY MANAGEMENT STYLE UPON THE ACADEMIC MANAGEMENT STYLE, 1942-1945

The Manhattan Engineer District represented the typical military management style, controlling three areas of administration during World War II: security, contracting, and health. However, as seen in the preceding chapters, each of the areas had already been addressed before the Manhattan District took control of the project, and, in most cases, the organization and administration of these areas remained essentially academic in management style. The Ames laboratory, even under the Manhattan District, ran by committee, as exhibited by group leaders' meetings every Saturday to both discuss results and plan for the next week's activity. These sessions employed an academic style where everyone participated and added ideas to the group. Often the plan of research changed or modified itself based upon suggestions at these meetings.[374] Even that these seminars continued was a victory for the academic management style, because Groves had tried at one point to discontinue these at Los Alamos, without success.

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[374] For the organization and topics of these meetings, see "Meeting of Metallurgical Group October 15, 1943," "Meeting Saturday 2:30 p.m., Chemical Group," "Meeting October 24, 1943, 12:30 p.m.," "Chemical Meeting October 30, 7:30 p.m.," and "Metallurgical Meeting October 30, 1943, 2 p.m." Norman Hilberry, somewhat in jest, indicated that at Chicago there was not always consensus in these typically academic meetings: "There was never consensus. Each one consensed with himself and went out and did—go thou and do as thou pleaseth. The real consensus was that this gave a mechanism for two or three different brilliant people to disagree effectively because the instant they made up their minds that the path that they were on was wrong, that was the last you ever heard of it. . . . It was an extremely effective management system and a complete anarchy in a sense" (Hilberry, interview with Tressel, 1967, Reel 2, 19).

Security did affect the academic management style to an extent though. The Ames Project remained isolated from the other installations, and this isolation probably meant that, to an extent, no one knew when duplication was going on between this laboratory and others. Personnel were also not as free to travel to other installations, so later in the war, the group at Ames knew less of what was transpiring at Los Alamos or Hanford than at Chicago. Early in the project, there was a great deal of interaction between the laboratory and other facilities, partly because Spedding was more involved at a central facility early in the war. He became somewhat isolated from Chicago when Ames demanded his full attention. By that time, Groves moved the bulk of the activity to the secret, well-guarded sites at Los Alamos, Hanford, and Clinton. Even Chicago was out of the loop for what was going on at the secret facilities. That decision had been a military victory of sorts because those new facilities were under much stricter secrecy requirements.[375]

The strict requirements for secrecy though did not really affect the style of management at Ames because the laboratory's organizational structure had been established long before the Manhattan Engineer District took over the

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[375] There were several other reasons for the move to three secret facilities than just isolation. Compton had been in trouble for disclosing secret information to some uncleared workers in early 1942. Bush had interceded on his behalf, but when it came to building the bomb, the site was moved from Chicago partly because of this security problem at the Metallurgical Laboratory. (For a more complete discussion, see Montgomery Cunningham Meigs, 69-70.) Groves also had particular problems with other scientists at Chicago, such as Szilard and other immigrant scientists, when he had to inform them about DuPont taking over the Oak Ridge project instead of them. The resulting isolation of the Metallurgical Laboratory probably extended in some ways to Iowa State since Ames was a contracting agency under Chicago. Groves never visited Iowa State, for example, and though it was used as an industrial plant to supply uranium and other metals, after December 1942, Ames was not a part of any policy making group. It served as a supplier to other facilities like Oak Ridge, Hanford, and Los Alamos, laboratories that were making decisions. (For these various concerns see Groves, 1962, 42-46.)

contracts. The Manhattan District did send security personnel as well as financial and safety advisors to Ames where the Iowa Area of the Manhattan District was located, but these personnel were essentially placed there to see that work was completed on time. They did conduct safety and security inspections and reported those back to District headquarters, but they must have had little effect on the day-to-day operation because the research scientists barely knew these men and women were around. No reports remain of their activities in the files at Ames and most of the scientists were never sure what they were there to do.[376]

Contracting certainly influenced the direction of research in the Ames Project. However, it was not the Manhattan District that placed the basic tenants of contracting—flexibility, institutional responsibility and control, fiscal accountability, no cost/no profit terms—in place. Those characteristics were developed from the OSRD and NDRC, both civilian, academic-type organizations. The Manhattan District continued contracting under much the same system, although it often added more requirements or stricter controls.

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[376] None of the scientists that I or others interviewed spoke of the group of Manhattan Project personnel who were in Ames. Scientists made passing references to them, but few names were remembered except when humorous stories about their inefficiency or insufficient training were noted. Spedding's manuscript refers to them in passing and is the only local account of their existence. However, the miscellaneous records from Oak Ridge show correspondence from several majors in charge of the area, plus at least a couple of minor officers who often signed correspondence for the area engineer. There was also a project manager, a financial officer who checked vouchers and reported discrepancies to both the Madison Square Area Office and brought the same concerns to Spedding's attention. The best estimate on the number of these military staff members located at Ames must have been under ten. There were certainly not enough of them to create much of a sensation on the campus. (See bills of lading and miscellaneous correspondence between Oak Ridge and these officers in the Oak Ridge Papers). The property manager or fiscal officer was located in the Collegiate Press Building ("History of Account," attached to 1946 Audit, [1]). Whether other personnel were there or not is unknown, but it was a logical place for offices since the building was across the street from Little Ankeny. (It is also somewhat ironic that such a secret group of personnel were located in a press building.)

Patent administration was not controlled by the District either; those policies were already set in place by OSRD. In fact, the Manhattan District chose to use the existing OSRD structure to manage the patent process for its facilities too.

Health was certainly a concern of the atomic bomb project, but it was not the Manhattan District that initiated most of the health and safety organizations. Those carried over from the individual laboratories like the Metallurgical Laboratory. In fact, the Manhattan Engineer District used the Metallurgical Laboratory for its model to establish an organization to coordinate all the facilities under its jurisdiction. The District continued to supply many of the same services as those created originally by the Metallurgical Laboratory.

It is true that these areas of administration—security, contracting, and health and safety—changed research administration during and after the war. However, those changes did not originate out of military style management techniques employed by the Manhattan District. It might be said that the Manhattan District, while employing some military management techniques, such as hierarchical control and strict adherence to command structure, for example, was also controlled from the top by an academic management structure, a committee. The Military Policy Committee actually made final decisions on every activity that the District undertook. So, in a sense, the academic management style won the last victory, finally determining and controlling the policies for the Manhattan District operations.

CONCLUSIONS: THE IMPACT OF THE AMES PROJECT UPON IOWA STATE COLLEGE

From 1942-1945, Iowa State College, like many other colleges and universities conducted classified, war-related research. At the beginning of World War II, no administrative structures existed for academic institutions to conduct classified research. By the end of the war, however, three units—the NDRC, OSRD, and the Manhattan Engineer District—had coordinated and funded war-related research. Each of these units contributed to winning the war, but each was a temporary agency. It was apparent at the end of this war that scientists wanted to continue the research started and sustained by these agencies. For one thing, the agencies had allowed research to be conducted on campuses across the nation, not at some remote military site. Structures to handle the administration of research had been developed at institutions, and they did not want to see the benefits disappear after the war. There was talk of converting the war-time weapon to peace-time uses under civilian control, and already there were pockets of research around the country that could continue the efforts if an infusion of funds flowed from the federal government. Even Iowa State, a small college by many national standards, had been greatly affected by the war-time research efforts.

In many ways, Iowa State could not return to the normalcy of the pre-war years. The College, like others in the nation, 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 at Iowa State to incorporate the physical chemistry and physics research into a permanent laboratory at Iowa State College. Spedding formalized his plans in a letter to President Charles Friley in September 1945, calling for a state-funded institute to cut across several disciplines, continuing the work started during the war:

> I believe that a permanent institute should be set up, similar to the Agricultural Experiment Station . . . which would cut across all divisions and departments, and that this institute should have its own state budget independent of any federal money which might and almost certainly would be forthcoming. In this way we could build a sound research organization which would have security over a long range, and which would not be subject to the whims of federal patronage. . . Further, . . . we should be in a much better position to maintain our freedom of thought, action and research when accepting any federal aid.[377]

However, Spedding saw more than just an independent research laboratory providing services to the government in return for federal funding. He wanted the institute to be fully incorporated into the academic structure of the institution. Perhaps because of the concern left from his own lean years of searching for an academic appointment, he insisted that the institute be fully functioning within the academic structure:

> I feel that the institute should be closely integrated with the Science departments on the campus, since the everyday contacts of scientists with their exchange 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 a definite part-time for the institute and a definite part-time for the departments in their major fields. This arrangement would of course have to be voluntary with the heads of the departments concerned, but I

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[377] Frank Spedding, "Letter to President Charles E. Friley Regarding Creation of the Institute for Atomic Research." September 6, 1945, Ames Laboratory Papers, 3.

> think it would be mutually beneficial to both parties. It would permit the institute to obtain men who would feel a greater security in being members of a regular department, and it would give us pleasant relationships with the other departments involved. It would permit the department to have more exerts on their teaching staffs, so that a wider variety of courses could be given.[378]

Asking for an initial budget of $50,000, Spedding got his institute after some negotiations with the University of Iowa, which wanted to establish its own nuclear institute.[379] After several meetings and discussions, both schools were satisfied. On November 1, 1945, the Institute for Atomic Energy at Iowa State College and the University of Iowa's Institute of Nuclear Research were approved by the Board of Education.[380] In 1947, the Ames Laboratory was

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[378] Spedding, "Letter to President Friley," 6.

[379] These negotiations revolved around the role of fundamental research in chemistry and physics at Iowa State College. President Virgil Hancher from the University of Iowa precipitated the discussion when he wrote to President Friley after a *Des Moines Register* article implied that Iowa State was about to enter fundamental physics research rather than continue with the type of applied research undertaken for the Manhattan District. He questioned why Iowa State should suddenly enter a type of study that previously was Iowa's responsibility. In an eloquent reply to Hancher, Friley argued that Iowa State must conduct fundamental research in those areas of chemistry and physics that relate to its ongoing war research in atomic energy. "These two aspects of any research cannot be separated. Since applied science always springs from pure science the two have to go together or the applied science dries up and becomes sterile." He went on to indicate that duplication was really the problem, and, of course, Iowa State would not duplicate those known strengths of the University of Iowa. (Virgil M. Hancher, "Letter to Charles E. Friley Referring to Article in Paper on Establishing an Atomic Institute," September 13, 1945, Papers from the Office of the President, Charles E. Friley, located in the Robert Parks and Ellen Sorge Library, Iowa State University, Ames, Iowa (hereafter called the Friley Papers); Charles E. Friley, "Letter to Virgil M. Hancher Regarding Creation of an Atomic Institute," September 25, 1945, Ames Laboratory Papers, 2. See also R. M. Hixon, "Letter to Charles E. Friley on Fundamental and Applied Science Issues," September 15, 1945, Ames Laboratory Papers; Harold V. Gaskill, "Letter to Charles Friley on Recommending the Institute," October 12, 1945, The Ames Laboratory Papers; G. W. Stewart, "Minutes of a Meeting of a Group from Iowa State College and the University of Iowa," November 1, 1945, Friley Papers; Harold V. Gaskill, "Letter to Charles Friley on Establishing the Institute," November 9, 1945, Friley Papers; R. E. Buchanan, "Letter to Dean H. V. Gaskill Regarding the Role of the Graduate College in the Institute," November 13, 1945, Friley Papers.)

[380] *Minutes of the State Board of Education*, November 2-3, 1945, 317.

established by the Atomic Energy Commission to be administered by the state-established Institute for Atomic Research.[381] Spedding's plan had worked; he had created both a state-operated and federally-funded facility on the Iowa State campus linked academically to the institution. Spedding hired departmental faculty members part-time at the Group and Section Leader levels for the new laboratory. There were some members of the Ames Laboratory hired without faculty rank, but not that many until much later when the Department of Energy needed very specialized scientists who were not represented by a departmental area of expertise. He also managed to get some of the men on the project who already had Ph.D.s to stay in his employ and receive academic appointments in departments part-time and continue their research work at the laboratory.

Several other men remained behind after the war to complete studies or finish up advanced degrees. Many of the men working on the project had the equivalent of a Ph.D. but had not finished their theses. In the next few years, several of these men finished degrees, including: Donald Ahman who finished a Ph.D in 1949; John Ayers, Ph.D. 1946; Norman Baenziger, Ph.D. 1948; Charles Banks, Ph.D. 1946; Adrian Daane, Ph.D. 1950; Elroy Gladrow, Ph.D. 1946; Harry Svec, Ph.D. 1950, and James Warf, Ph.D. 1946. Dave Peterson, a foreman at the pilot plant even finished his bachelor's degree in 1947, his Ph.D. in 1950.[382] There was one problem with these men getting degrees

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[381] Chemistry Department Newsletter, January 1, 1947, 3; Frank Spedding, "The Operation and Scope of the Ames Laboratory of the Atomic Energy Commission," n.d., The Ames Laboratory Papers, 1-2.

[382] Robert Orr, "Thesis Card Files" the Library Papers.

shortly after the war. Their theses were classified; however, by 1955, all of these plus others had been released, and the men and women could finally publish their classified results.

War research work certainly added new men and women to the scientific ranks of colleges and universities across the nation. Iowa State benefited greatly from the infusion of these scientists who were already willing to form partnerships with the federal government. They had worked under strict conditions during the war, gaining expertise, if not in publishing research results, certainly in reporting research. It was only a small matter for them to become active in publishing their research results in the national journals of the day.

However, the Ames Project and its successors served as more than educational laboratories for the increasing numbers of graduate students making their way through Iowa State College. This laboratory and its successor served as models for developing research relationships with the federal government after the war. As noted above, the OSRD, the NDRC, and the Manhattan District were merely temporary structures in the federal bureaucracy. Shortly after the war though, the type of research and contracting agreement with universities remained while the civilian versus military status could be debated in Congress. The relationships forged during this interim helped Iowa State set up its administrative apparatus to handle research funding that would come as a result of the federal government's role in agencies like the National Institutes of Health and in the establishment of new agencies like the National Science Foundation in 1950. The Manhattan District continued its contracting with the Ames Project under much the same circumstances as during the war. When the civilian Atomic Energy Commission took over from the Manhattan District in 1946, it too continued to use the contracting principles established during the war.

This was also a time when Iowa State and other institutions solved many of the overhead problems created by the war. Iowa State finally instituted and clarified its regulations and in 1950 with Board of Education approval published both a policy for conducting research and a policy for accepting and maintaining an overhead fund. Those two policies were developed out of the experiences of the Ames Project contracts just in time for the creation of the National Science Foundation in the same year.[383]

After the war, a familiar theme about research funding recurred, one prevalent during World War II—that research was somehow connected to national security and thus a federal responsibility—developed partly because of the new conditions of Cold War confronting the nation. When the federal agencies like the Manhattan District, OSRD, and NDRC dismantled, research funding distributed itself in three different directions, all borrowing from the administrative structures of the war organizations. When the atomic bomb exploded in Japan, the Manhattan Engineer District as a unit no longer had a mission. It disappeared only after numerous hearings in the Congress discussed its future, but finally a civilian board took over the jurisdiction of atomic energy on January 1, 1947, keeping many of the same administrative structures.[384] Iowa State's contract under the Manhattan

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[383] *Minutes of the Board of Education*, March 16, 1950, 269-272. See the two policies in Appendix G.

[384] Hewlett and Anderson, 654-655.

Engineer District was transferred to this civilian board, and later that year, the Ames Laboratory appeared to administer atomic energy research at Iowa State College.

When the OSRD disappeared, weapons research was in limbo. The military picked up the slack by contracting directly with institutions. The Navy established its Office of Naval Research (ONR) and adopted the research contract as its mechanism of administering research. Weaponry though was not its only interest. As the military agencies came to realize, the future of military research was dependent upon advances in the fundamental sciences. Boyd Keenan in *Science and the University* examined the role of military research after the war and concluded that "realizing that the future of naval weaponry depended on progress in the entire range of sciences, ONR provided support and let contracts in fields ranging all the way from biology to physical sciences, mathematics, nuclear science, and engineering."[385] Military research funders used many of the structures that characterized war research and certainly exhibited the attitude that research was related to national security.

Vannevar Bush had set the stage for the third path as early as 1944 in his *Science: The Endless Frontier* when he stated, "it is my judgment that the national interest in scientific research and scientific education can best be promoted by the creation of a National Research Foundation."[386] This foundation should

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[385] Boyd R. Keenan, *Science and the University* (New York: Columbia University Press, 1966), p. 47.

[386] Bush, 1945, 27.

> develop and promote a national policy for scientific research and scientific education, should support basic research in nonprofit organizations, should develop scientific talent in American youth by means of scholarships and fellowships, and should by contract and otherwise support long-range research on military affairs.[387]

Bush thought that his foundation would incorporate medical research, natural science research, and military research. That did not happen, but eventually the National Science Foundation, created in 1950, contained many of Bush's ideas about research that he had developed in his capacities as head of several war-related organizations. Interestingly though, it did not allow support of secret research. After much debate in Congress, the "representatives decided that fundamental, scientific research was of such great national importance as to warrant the expenditure of Federal funds in its support."[388] Again, the inference to national security determined the direction and structure of this new organization. It had embodied many of the principles of war-related research, including its primary administrative structures—the flexible contract, no geographic requirements for the research work, the cost, plus no-profit principles, and institutional rather than individual contracting responsibilities.

In conclusion, in the post-war period, science again became linked with national security, which was by law a federal responsibility. Research funding also came under jurisdiction of the federal government because there the most money could be expended to secure America's future in a real war or in a cold war. This attitude was an important carry-over from war

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[387] Bush, 1945, 27.

[388] *Annual Report of the National Science Foundation*, 1 (1950-51): vii.

research support days. Also, administrative and financial structures had been created in both the federal government and universities and colleges to regulate research funding. Although classified research required special considerations and the Ames Project encompassed these stringent rules and regulations, many of the administrative structures survived or evolved into the post-war period to affect a new generation of research organizations, but ones with similar attitudes to those developed during the war.

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APPENDIX A. THE GENESIS AND ORGANIZATION OF THE AMES PROJECT

The Einstein Letter to Roosevelt

Albert Einstein
Old Grove Road.
Nassau Point
Peconic, Long Island

August 2nd. 1939

F. D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations;

In the course of the last four months it has been made probable - through the work of Joliet in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium,by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

-2-

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an inofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,

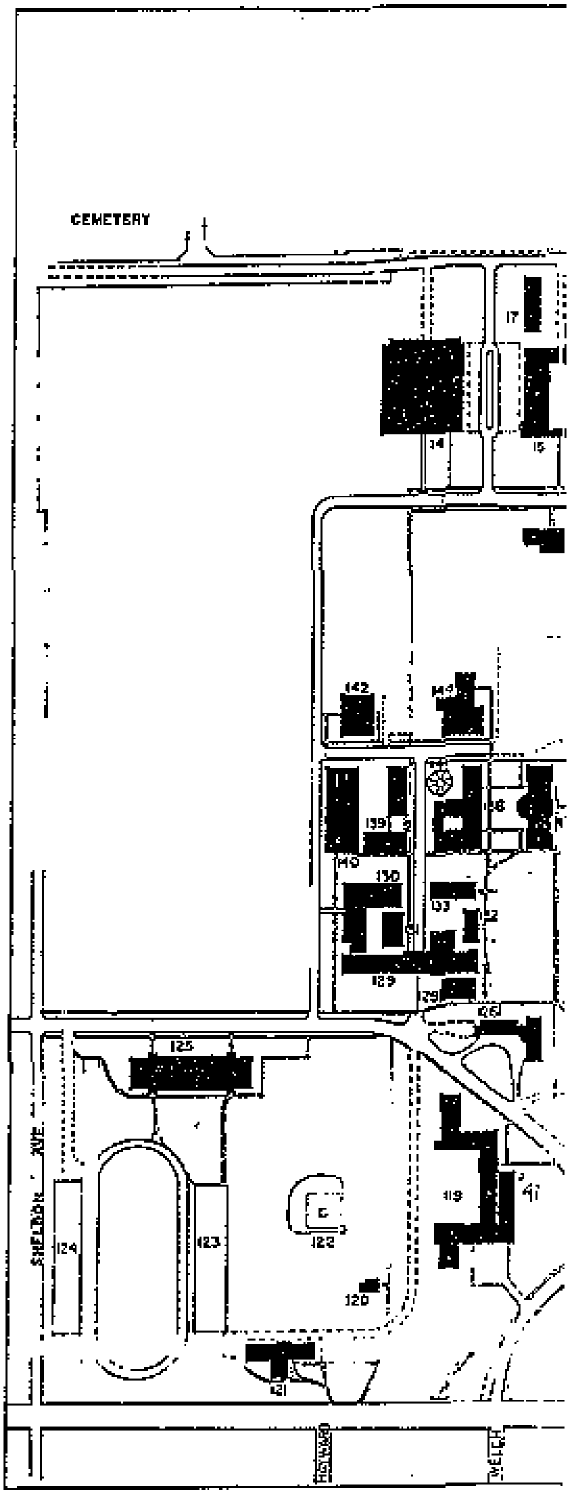
(Albert Einstein)[388]

---

[388] Michael B. Stoff, Jonathan F. Fanton, and R. Hal Williams, *The Manhattan Project: A Documentary Introduction to the Atomic Age* (Philadelphia, PA: Temple University Press, 1991), 18-19. (Original in Franklin D. Roosevelt Library at Hyde Park, New York.)

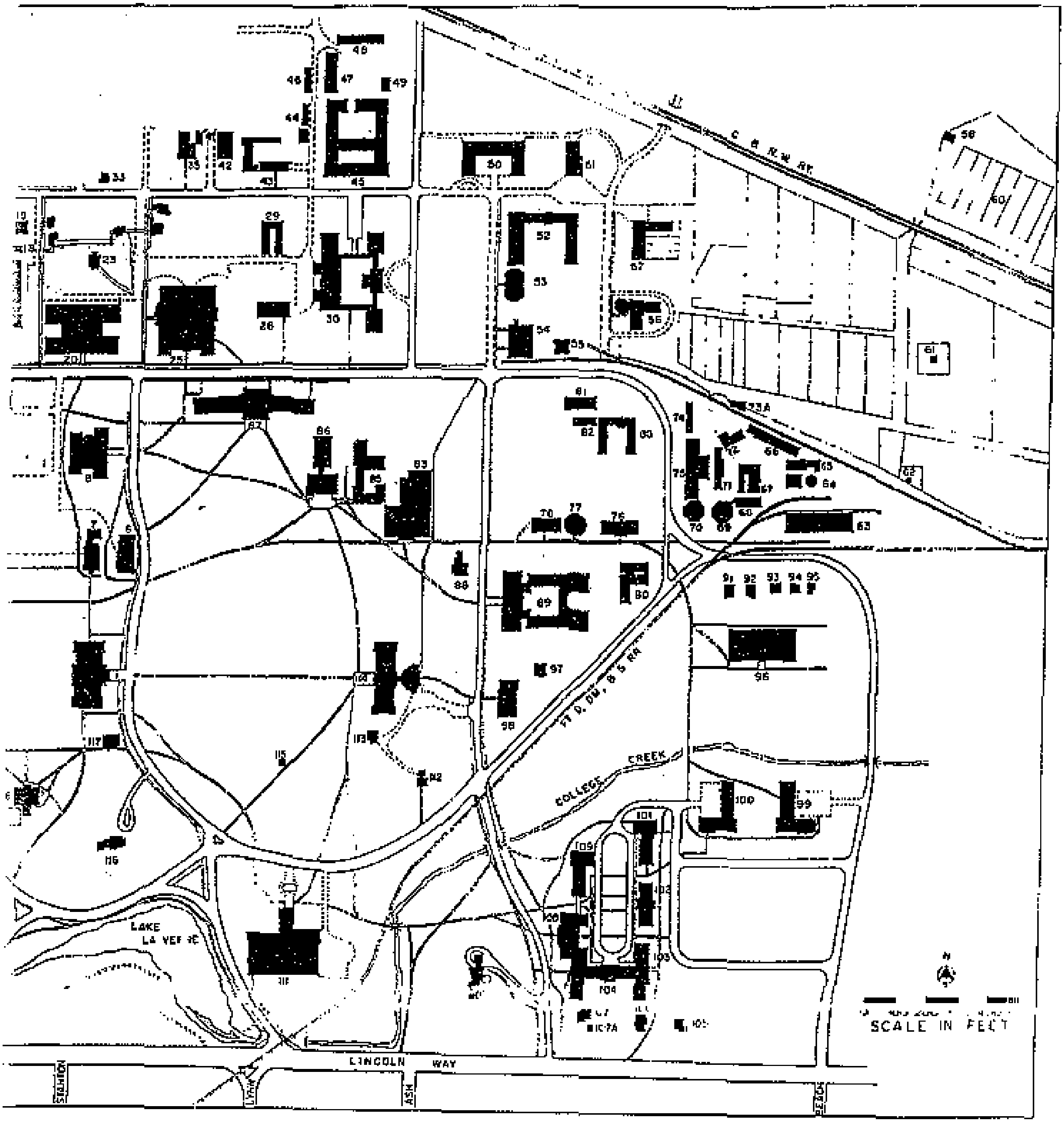
APPENDIX B. SCIENCE AND TECHNOLOGY IN THE AMES PROJECT, 1942-45

Campus Map, 1945



Important Buildings on the Campus

Agricultural Engineering	15
Agriculture Hall	114
Armory	14
Beardshear Hall	1
Botany Hall	86
Chemistry Building	20
Collegiate Press Building	76
Dairy Industry	89
Engineering Hall	137
Hospital	126
Landscape Architecture	78
Home Economics	87
Library	8
Physical Chemistry Annex I (Little Ankeny)	90
Physical Chemistry Annex II	67
Physical Plant	63
Physics Building	28
Veterinary Quadrangle	30
Women's Gym	96



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FT D, DM, & S RR
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113
112
COLLEGE
CREEK
100
99
116
101
105
102
LAKE
LA VERNE
103
104
SCALE IN FEET
LINCOLN
WAY
SHELDON
LYNN
ASH
BEACH

A Pictorial History of the Ames Project[389]

Figure B1. Physical Chemistry Annex (Little Ankeny) north view.

Figure B2. South view of Little Ankeny.

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[389] The Ames Laboratory in Ames, Iowa, provided the photographs on this and the following pages from its historical photographic archives.

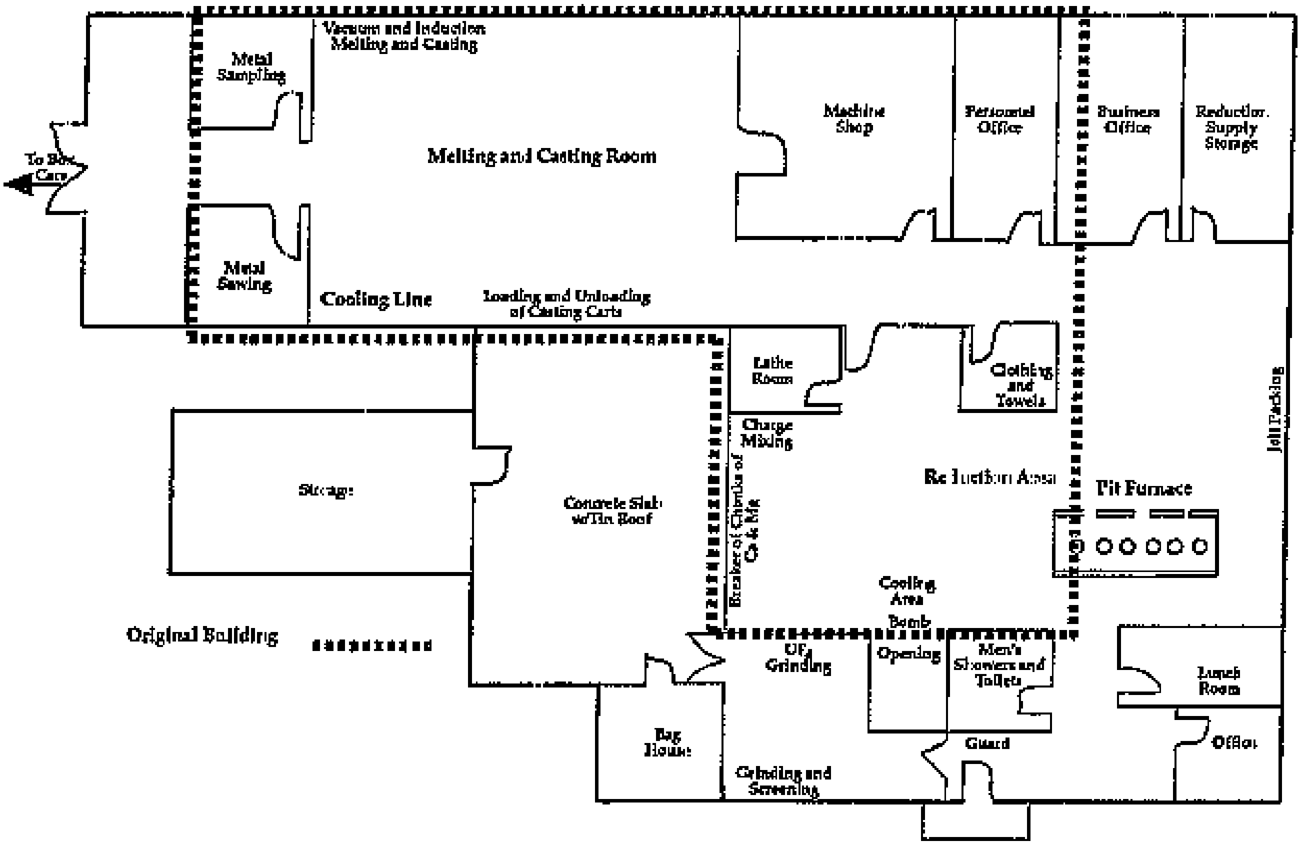


Figure B3. Floor plan of Little Ankeny production facility for uranium and thorium.

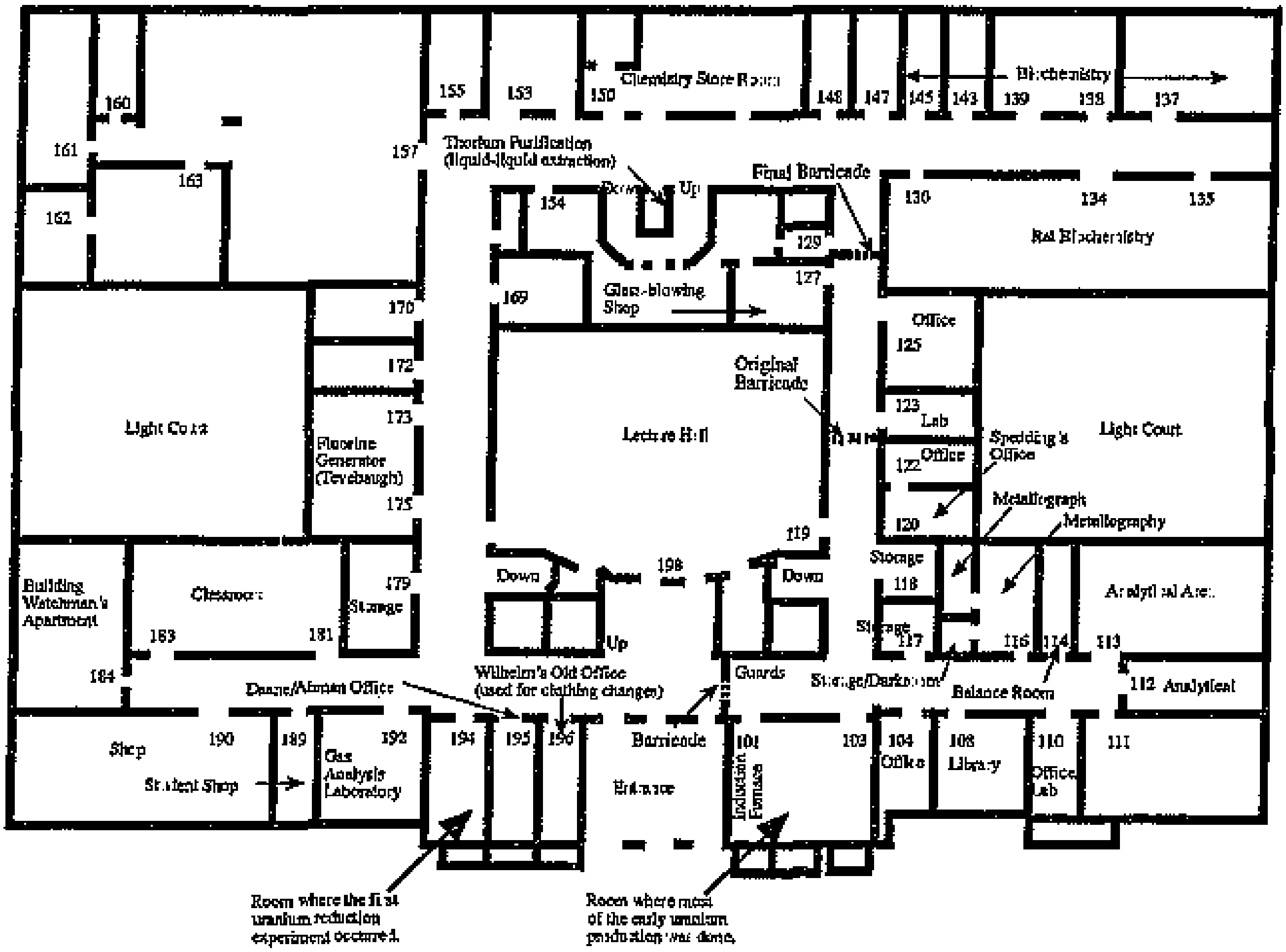


Figure B4. First floor plan of the Chemistry Building where the research and development work were carried out. Included are: the barricade on the east hallway and Room 101/103 where the early reduction experiments for the University of Chicago were completed. (The labeling for these rooms was provided by Norman Carlson, David Peterson, and Harry Svec, former participants on the project.)

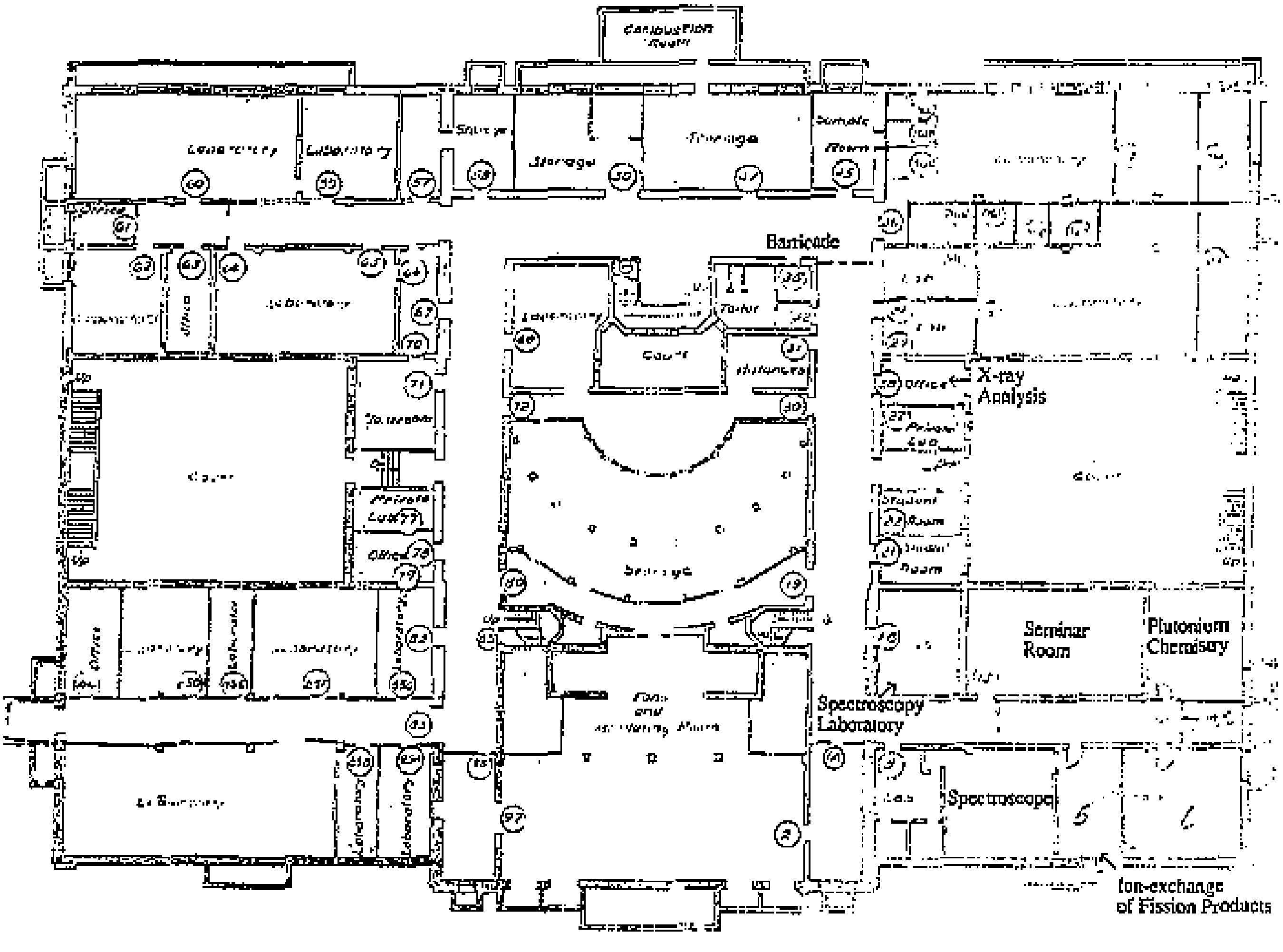


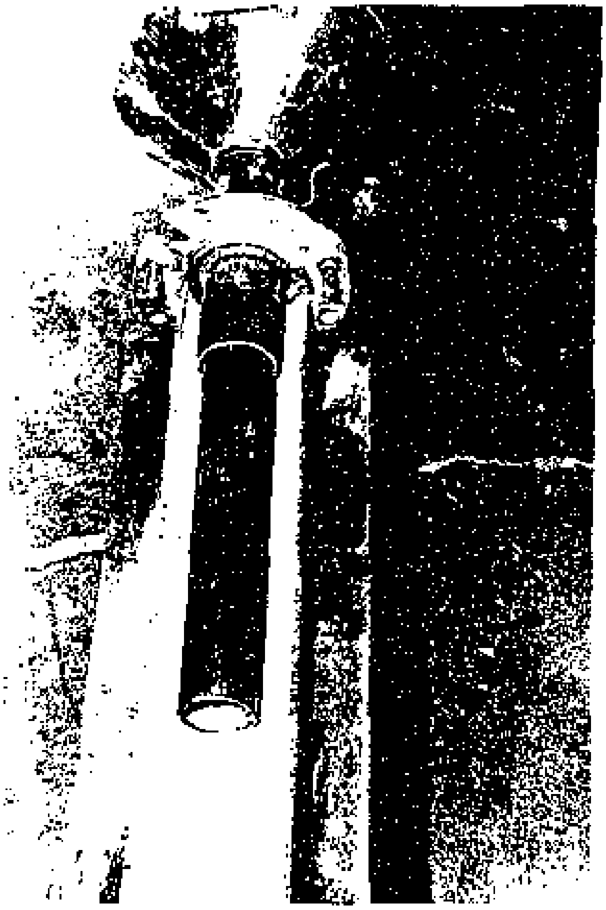
Figure B5. Basement plan of the Chemistry Building where some of the research and development work were carried out. Included in the basement was the famous seminar room where the Speddinars occurred.

a.

Figure B6. The uranium metallic reduction process.

- a. Several bombs of various sizes.
- b. Cutaway view of a bomb retort after packing, but before putting in charge.
- c. Using the Sprout Waldon Mill to grind calcium for the charge.
- d. Lining the bomb retort with electrically-fused dolomitic oxide.
- e. Bolting the flange on top of the prepared charge and liner.
- f. Lowering the bomb into the reduction furnace.

d.



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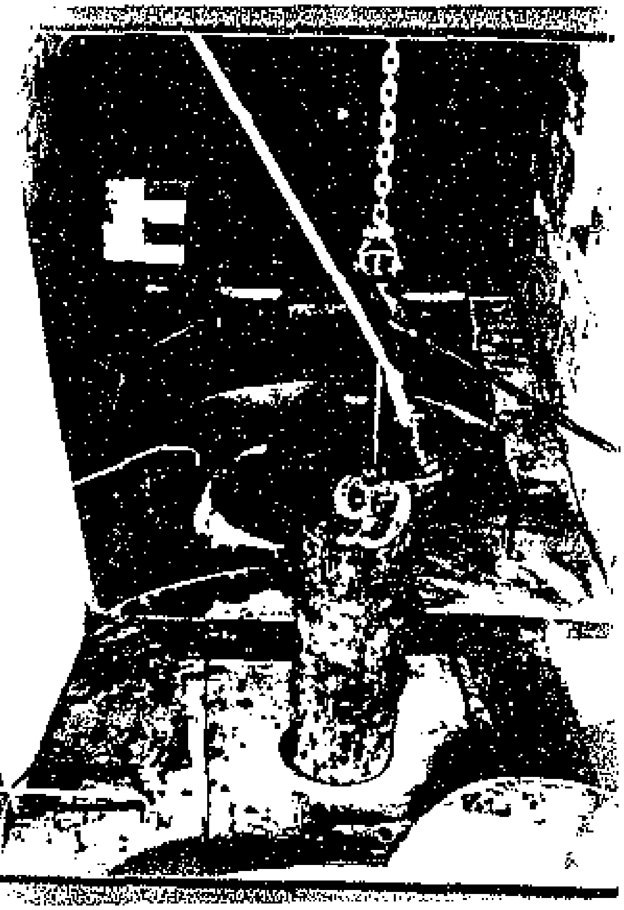


f.

Figure B7. The uranium casting process.

a. A marked uranium biscuit before casting.

b. An induction furnace used to melt uranium biscuits into ingots.

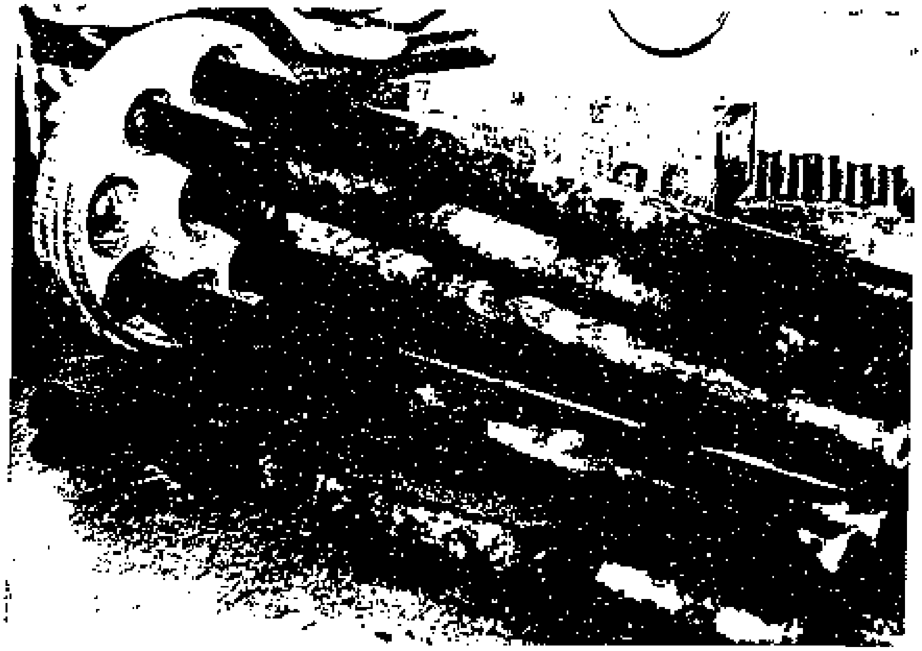
c. A uranium ingot on the scale after casting.

d. Uranium ingots in the shape of rods or "hot dogs."

e. Cartoon about the fires in the reduction and casting processes.

f. Cartoon about keeping staff on the Ames Project.

a.



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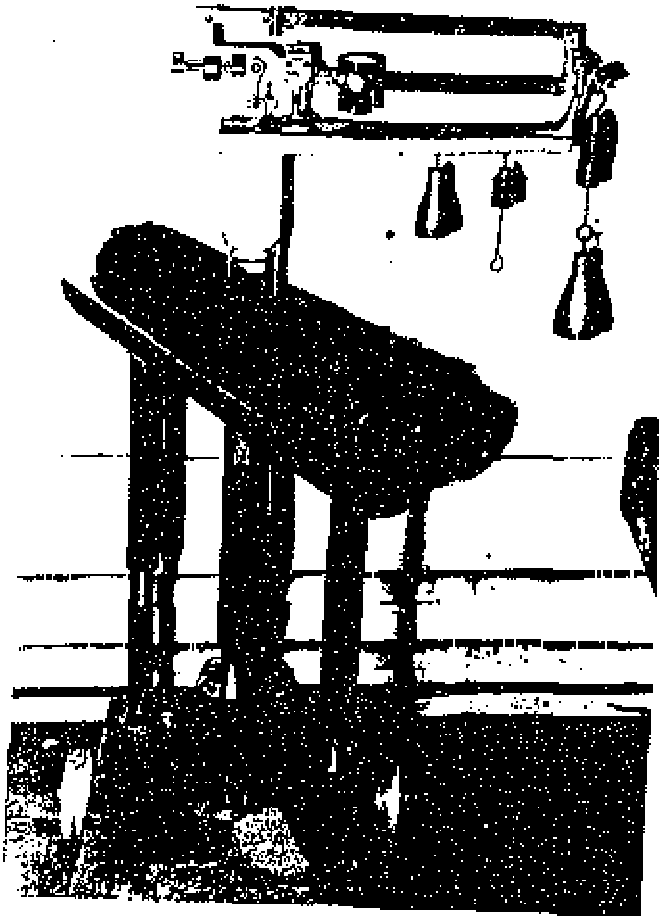

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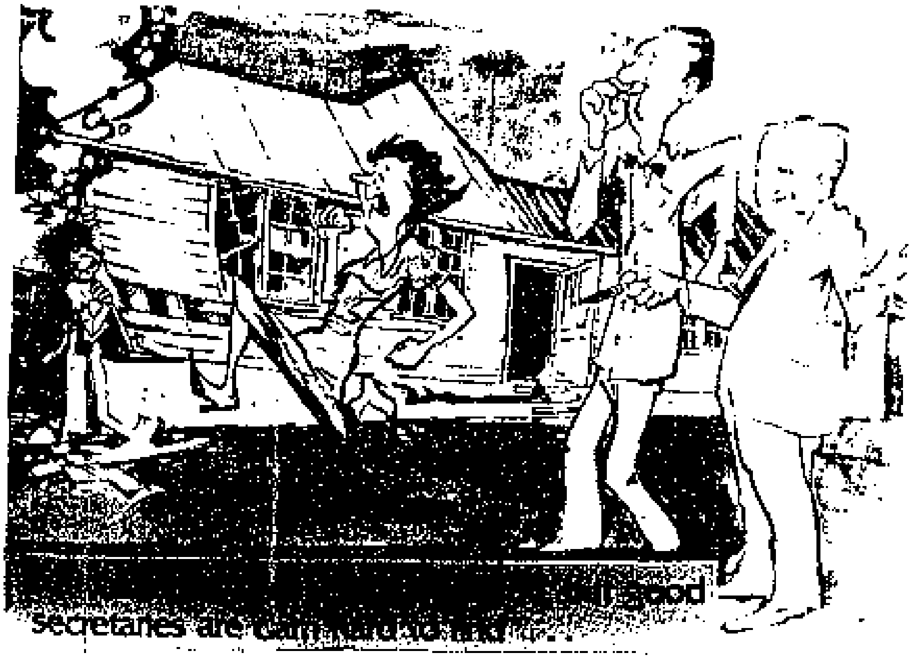

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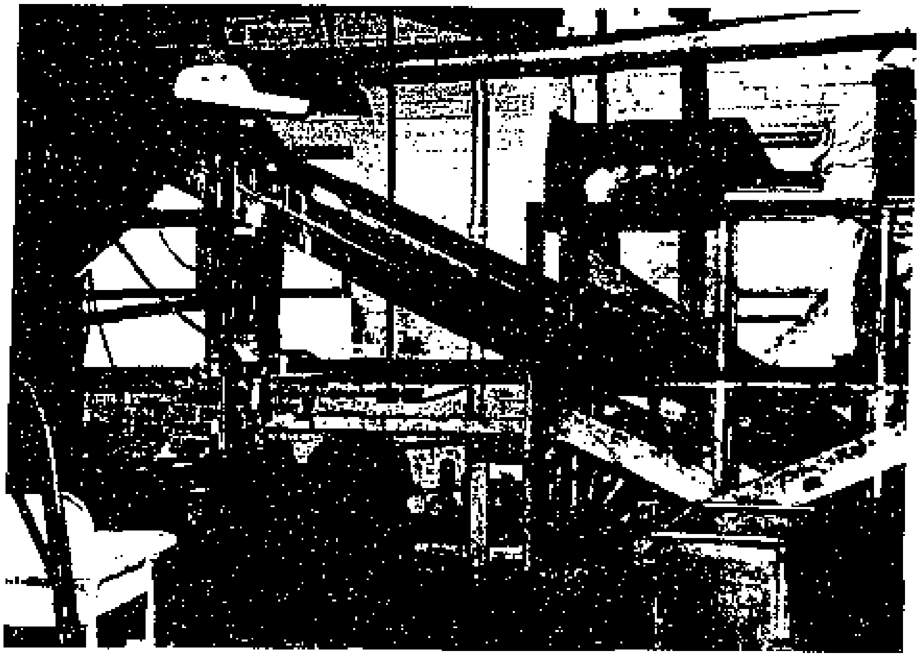


Figure B8. The uranium turnings recovery process in Physical Chemistry Annex II.

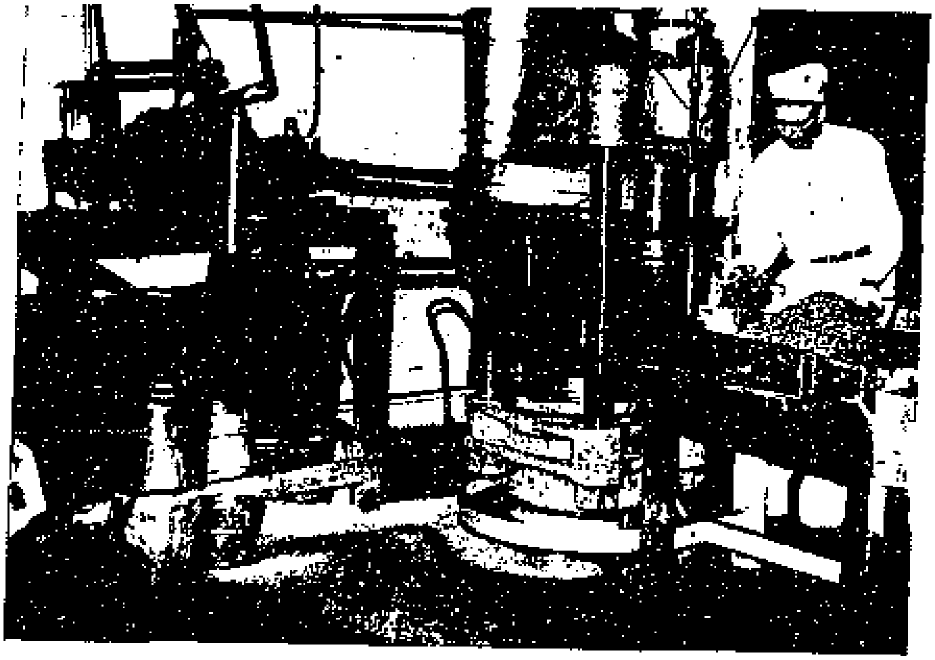


Figure B9. Pressing the uranium turnings into briquets.

Figure B10. Compressed uranium briquets from turnings process.

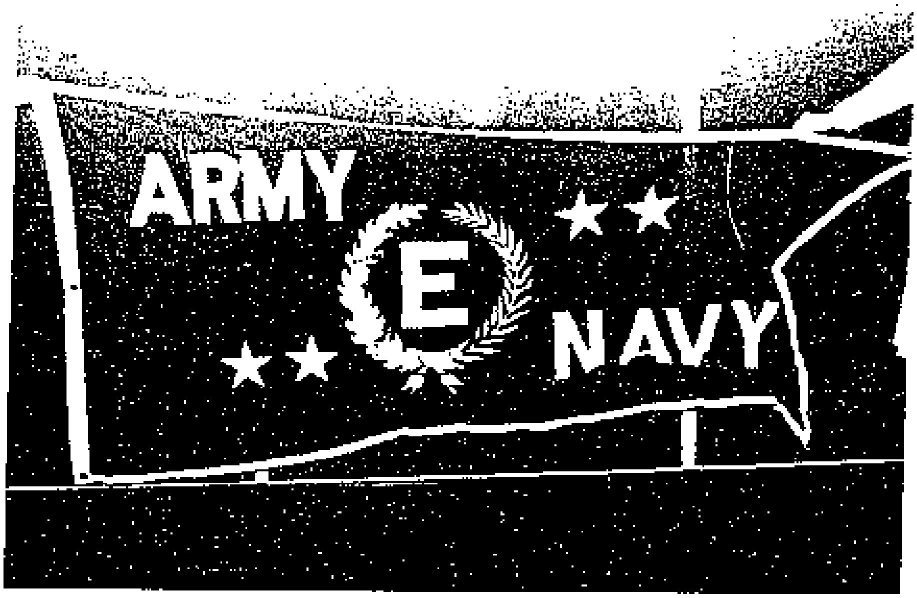


Figure B11. The Army/Navy E Flag represented to Iowa State College for excellence in the critical wartime materials production from 1942-1945.

Figure B12. Group Leaders in charge of the Ames Project. From left to right are: Harley A. Wilhelm, Adrian Daane, Amos Newton, Adolf Voigt, Wayne Keller, C F Gray, Frank Spedding, Robert Rundle, and James Warf.

Figure B13. Tearing down Little Ankeny in 1953, south view. The building was used shortly after World War II for the production of thorium and for other particularly dirty processes. By 1953, it had outlived its usefulness and as Harley A. Wilhelm succinctly put it, "it had become more reactive than active."

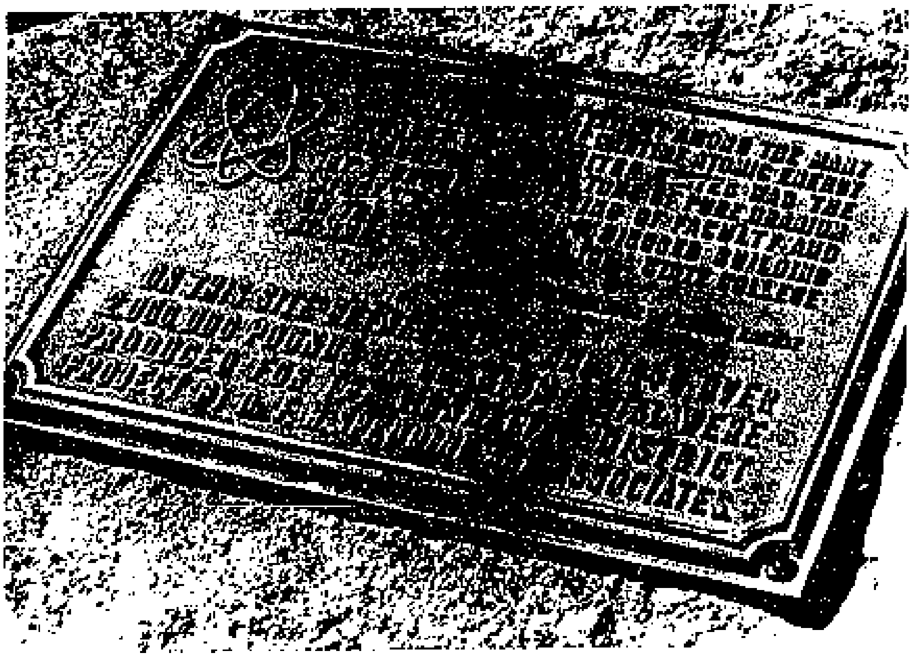
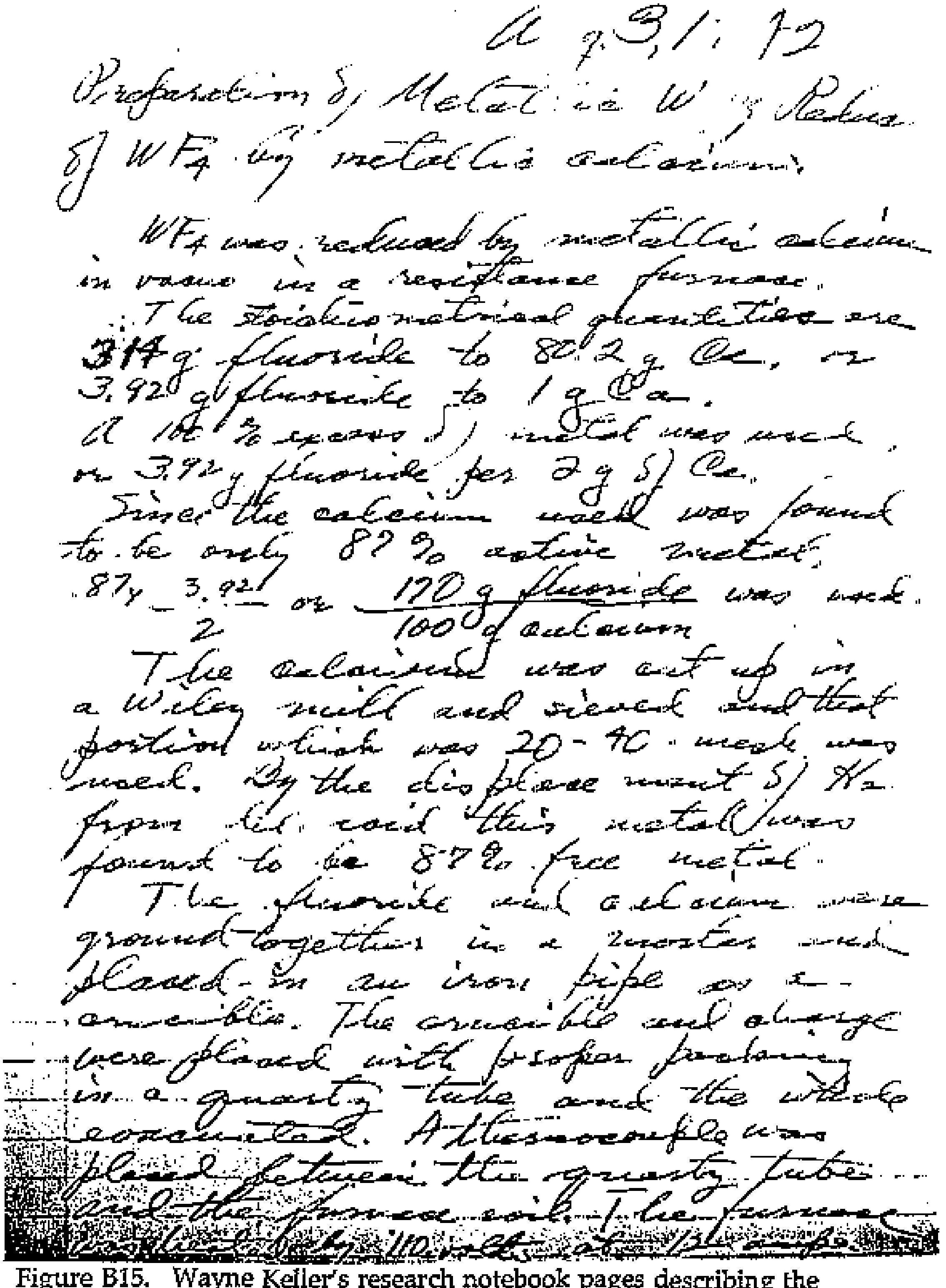


Figure B14. Stone and plaque that were placed on the Little Ankeny site.



Aug. 3, 1942

Preparation of Metal i.e. U by Reduc. of UF$_4$ by metallic calcium.

UF$_4$ was reduced by metallic calcium in vacuo in a resistance furnace.

The stoichiometrical quantities are 314 g. fluoride to 80.2 g Ca, or 3.920 g fluoride to 1 g Ca.

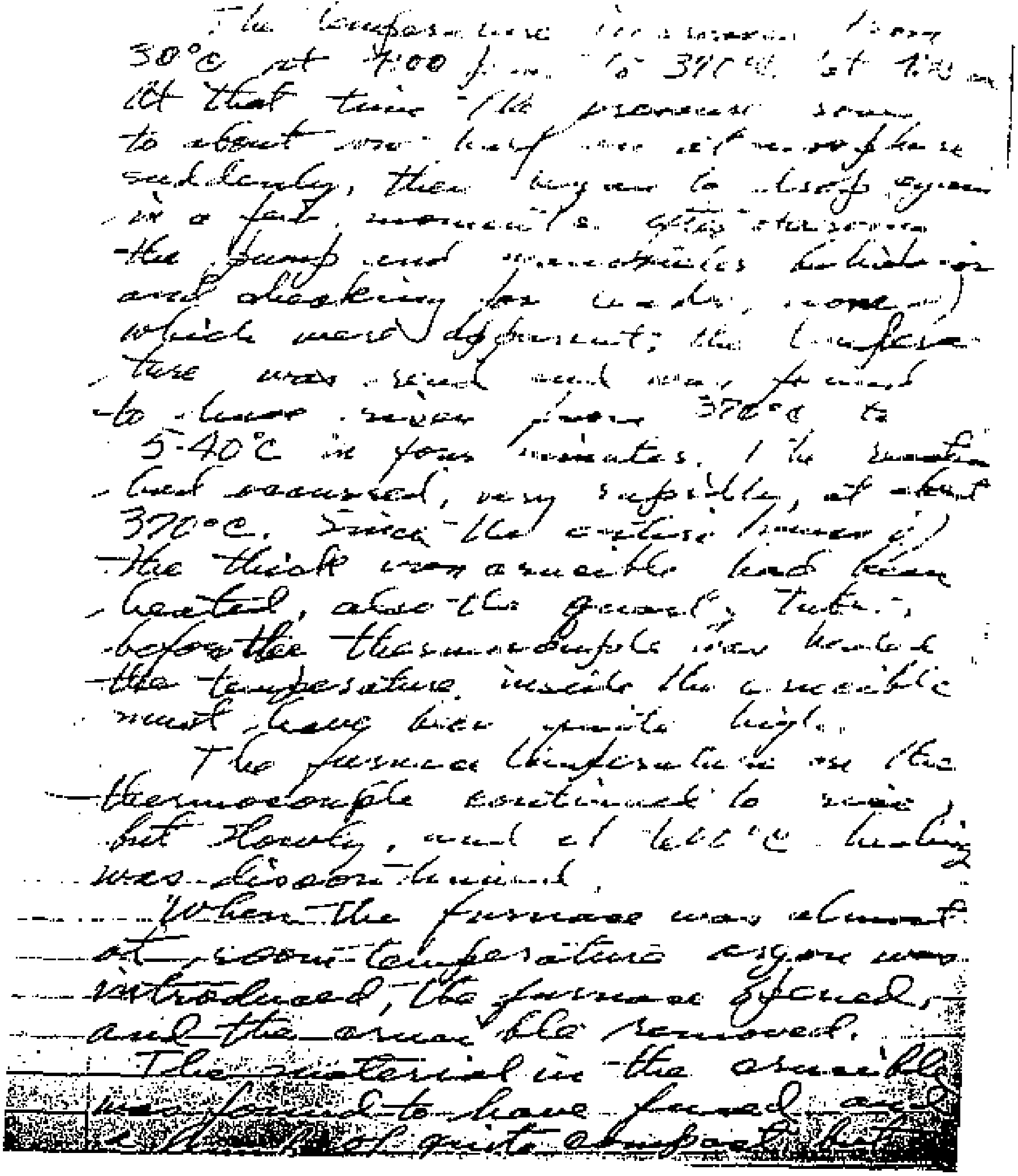
A 100% excess of metal was used, or 3.92 g fluoride per 2 g of Ca.

Since the calcium used was found to be only 87% active metal, $.87 \times \frac{3.921}{2}$ or $\frac{170\text{ g fluoride}}{100\text{ g of calcium}}$ was used.

The calcium was cut up in a Wiley mill and sieved and that portion which was 20-40 mesh was used. By the displacement of H_2 from acid this metal was found to be 87% free metal.

The fluoride and calcium were ground together in a mortar and placed in an iron pipe as a crucible. The crucible and charge were placed with proper packing in a quartz tube and the whole evacuated. A thermocouple was placed between the quartz tube and the furnace coil. The furnace was heated by 110 volts at 15 amps.

Figure B15. Wayne Keller's research notebook pages describing the successful uranium reduction experiment with calcium and uranium tetrafluoride, August 3, 1942.



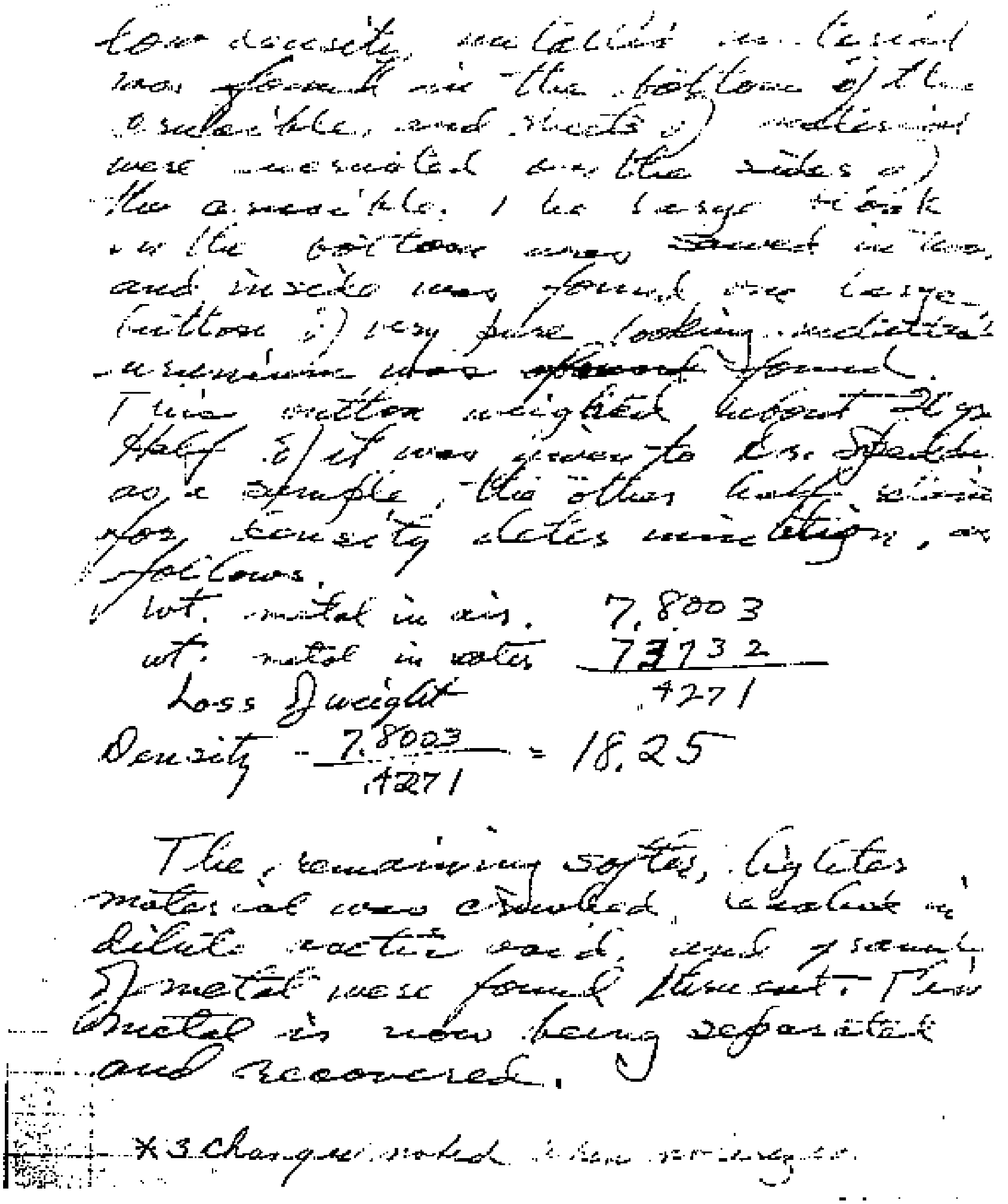
The temperature increased from 30°C at 4:00 p.m. to 370°C at 4:[illegible] p.m. At that time the pressure rose to about one half an atmosphere suddenly, then began to drop again in a few moments. [illegible] the pump and immediately [illegible] and checking for [illegible], none of which were different; the temperature was raised and was found to have risen from 370°C to 540°C in four minutes. The reaction had occurred, very rapidly, at about 370°C. Since the entire [illegible] of the thick iron crucible had been heated, also the quartz tube, before the thermocouple was heated the temperature inside the crucible must have been quite high.

The furnace temperature on the thermocouple continued to rise, but slowly, and at 600°C heating was discontinued.

When the furnace was almost at room temperature argon was introduced, the furnace opened, and the crucible removed.

The material in the crucible was found to have fused and [illegible] quite [illegible]

Figure B15. (Continued).



low density metallic material was found in the bottom of the crucible, and sheets of metallic were deposited on the sides of the crucible. The large chunk in the bottom was sawed in two, and inside was found one large button of very pure looking metallic uranium was ~~formed~~ found. This button weighed about 21 g. Half of it was given to Dr. Spedding as a sample, the other half used for density determination, as follows.

Wt. metal in air. 7.8003
wt. metal in water 7.3732
Loss of weight .4271

$$\text{Density} = \frac{7.8003}{.4271} = 18.25$$

The remaining softer, lighter material was crushed, leached in dilute acetic acid, and grains of metal were found therein. This metal is now being separated and recovered.

*3 Changes noted when rewriting.

Figure B15. (Continued).

The Chicago Pile Experiment, December 2, 1942

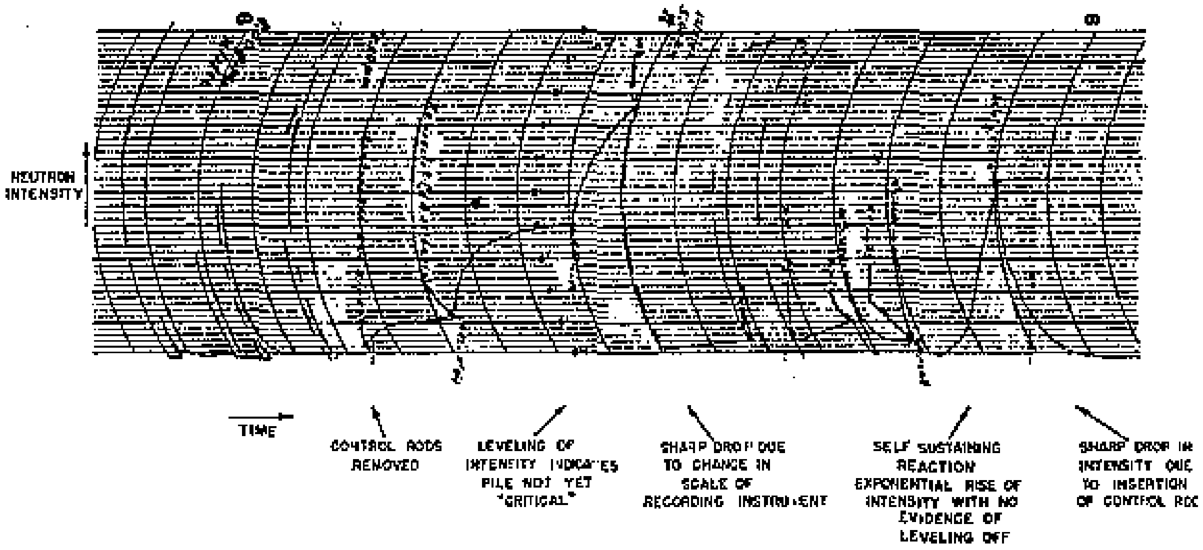


Figure B17. The galvanometer showing the start-up of the first self-sustaining nuclear chain reaction, December 2, 1942.

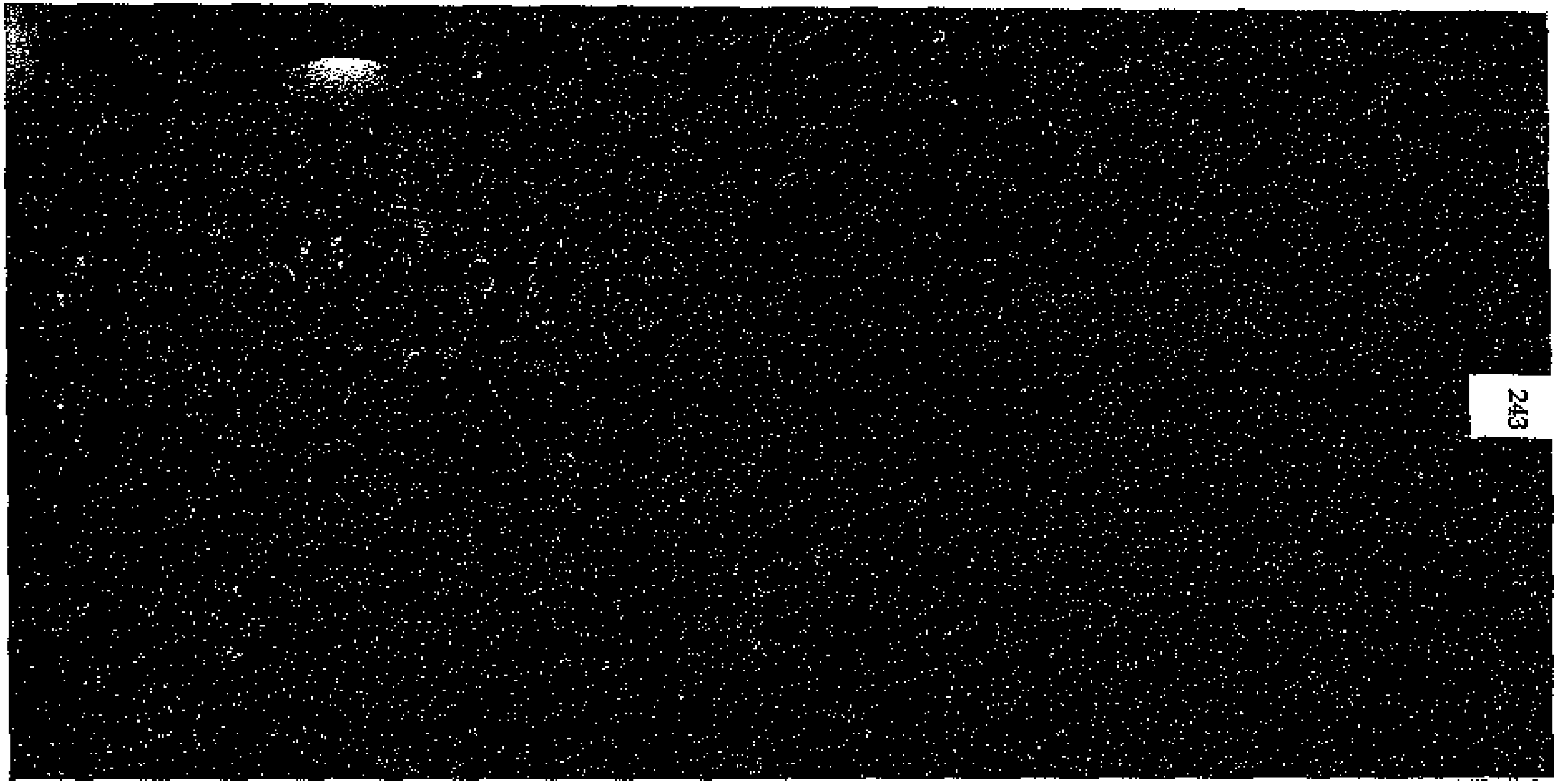
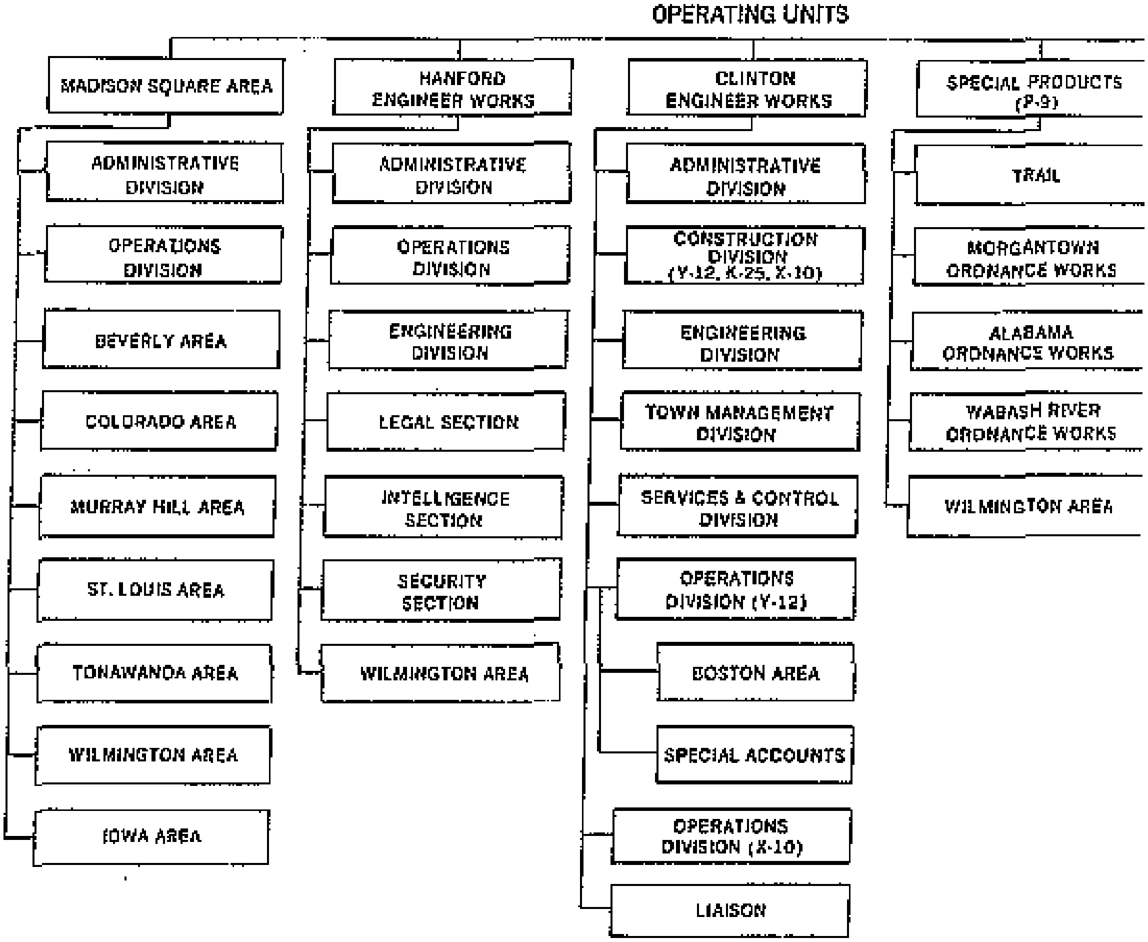


Figure B16. An artist's rendition of the chain reaction experiment on December 2, 1942. Frank Spedding is the man leaning forward in the middle of the row of standing people (fifth from the left).

APPENDIX C. THE ACADEMIC VS. THE MILITARY STYLE OF MANAGING RESEARCH

Manhattan District Organization Chart, 1943[390]



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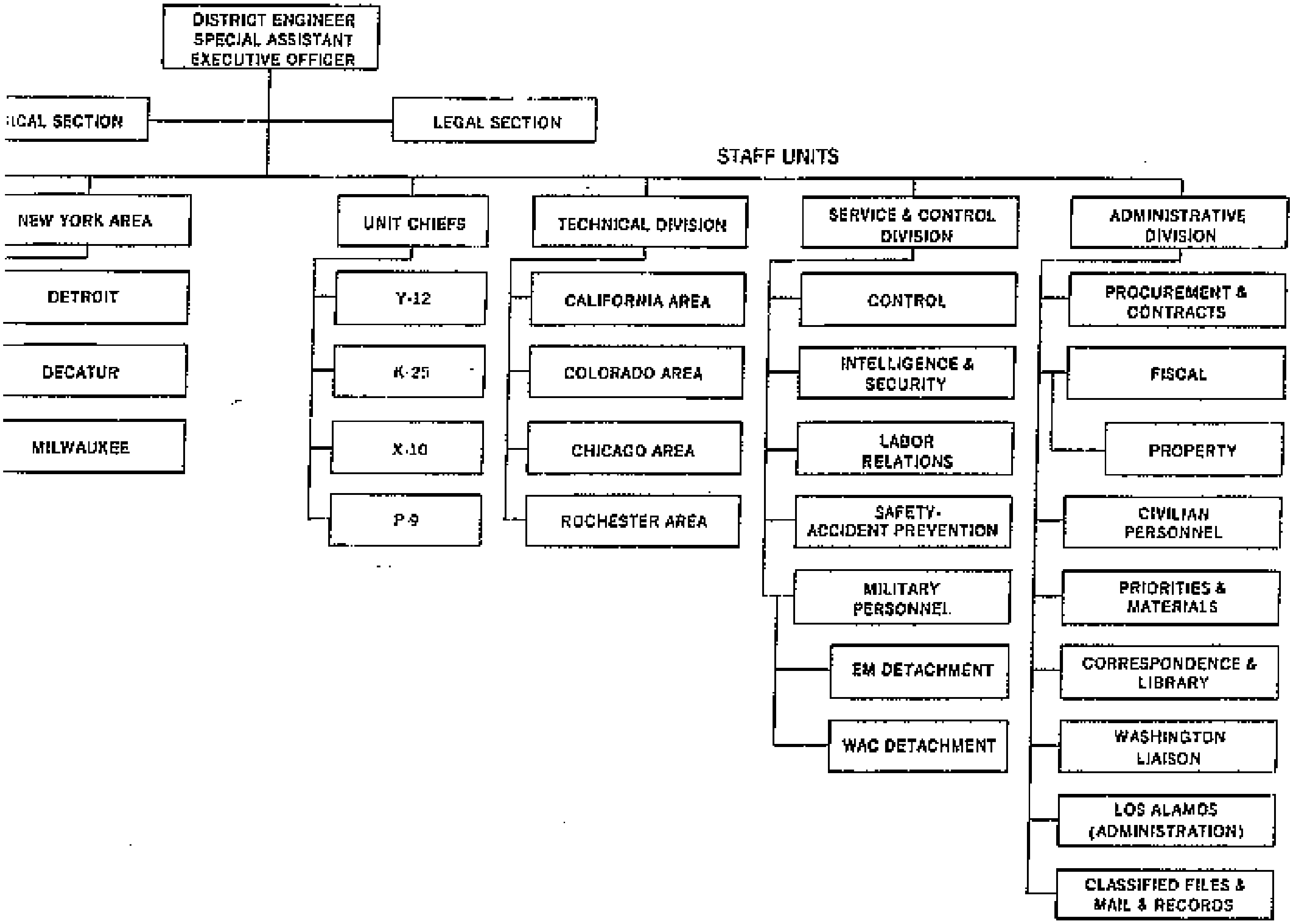
[390] Iowa State College was in the Iowa Area, one of the operating units of the Madison Square Area. (Jones, 90a.)


DISTRICT ENGINEER
SPECIAL ASSISTANT
EXECUTIVE OFFICER
ICAL SECTION
LEGAL SECTION
STAFF UNITS
NEW YORK AREA
DETROIT
DECATUR
MILWAUKEE
UNIT CHIEFS
Y-12
K-25
X-10
P-9
TECHNICAL DIVISION
CALIFORNIA AREA
COLORADO AREA
CHICAGO AREA
ROCHESTER AREA
SERVICE & CONTROL DIVISION
CONTROL
INTELLIGENCE & SECURITY
LABOR RELATIONS
SAFETY-ACCIDENT PREVENTION
MILITARY PERSONNEL
EM DETACHMENT
WAC DETACHMENT
ADMINISTRATIVE DIVISION
PROCUREMENT & CONTRACTS
FISCAL
PROPERTY
CIVILIAN PERSONNEL
PRIORITIES & MATERIALS
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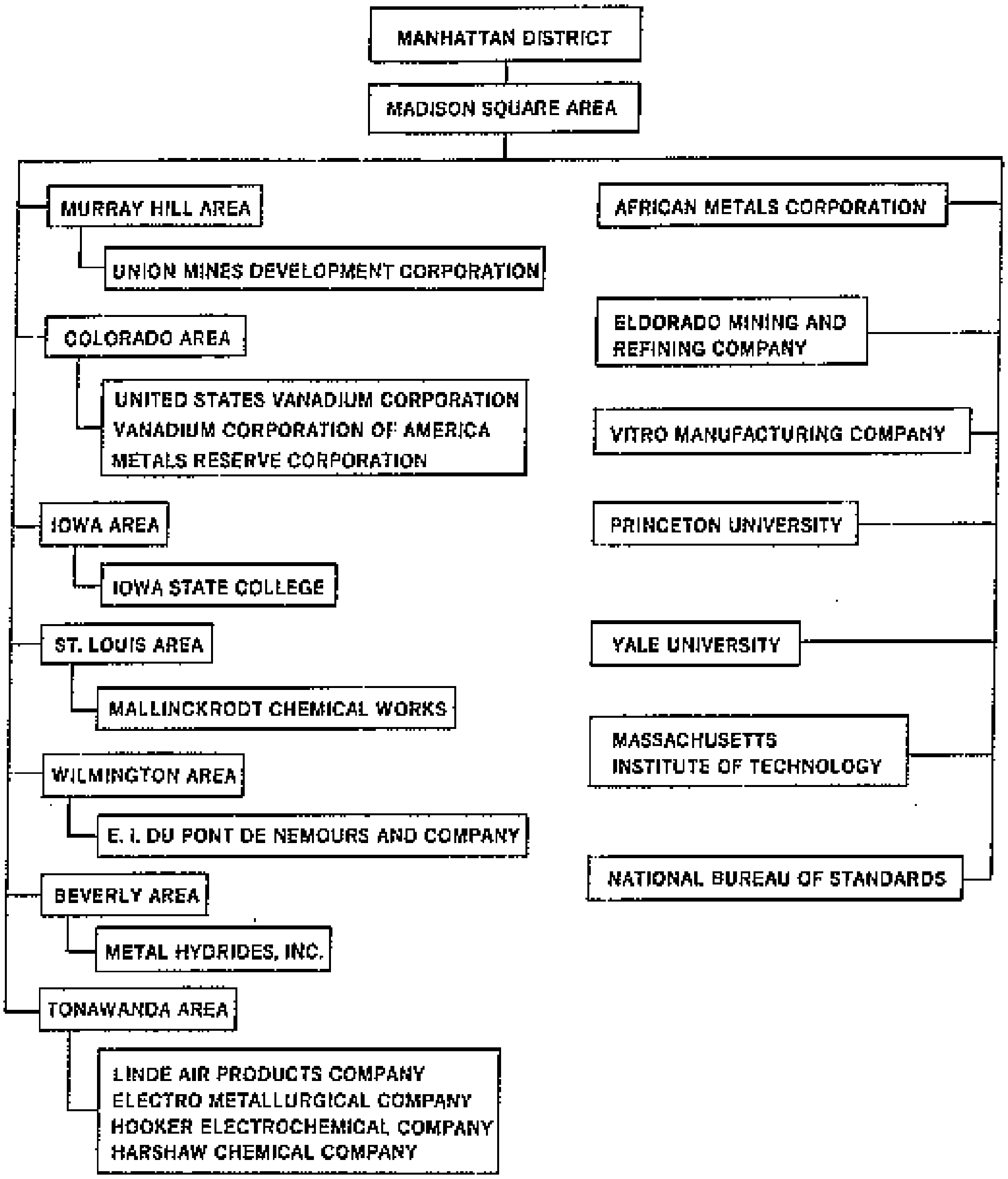
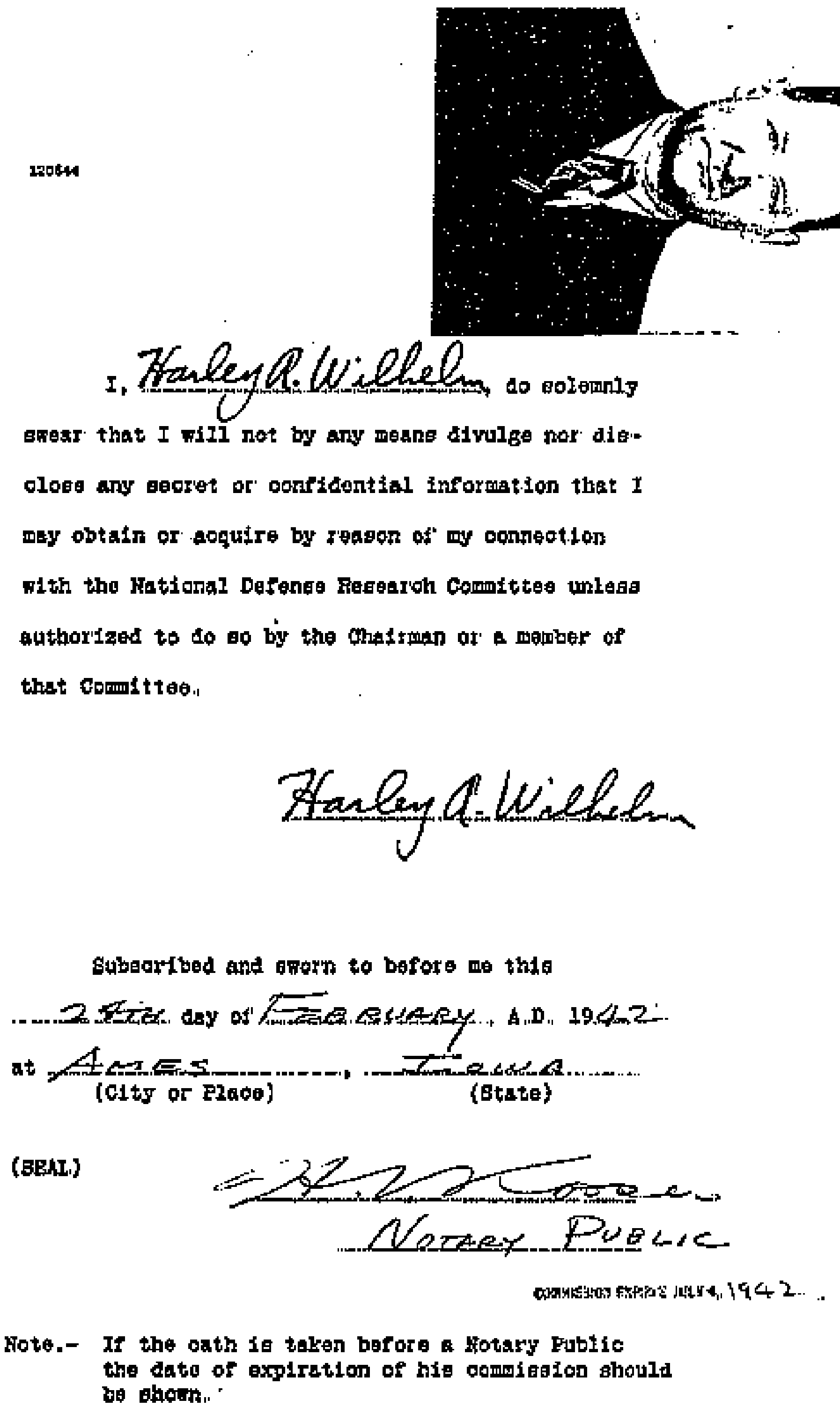
CLASSIFIED FILES & MAIL & RECORDS

Madison Square Area Feed Materials Network, 1945



APPENDIX D. SECURITY REGULATIONS AND REQUIREMENTS



120644

I, Harley A. Wilhelm, do solemnly swear that I will not by any means divulge nor disclose any secret or confidential information that I may obtain or acquire by reason of my connection with the National Defense Research Committee unless authorized to do so by the Chairman or a member of that Committee.

Harley A. Wilhelm

Subscribed and sworn to before me this

25th day of February, A.D. 1942

at Ames, Iowa
(City or Place) (State)

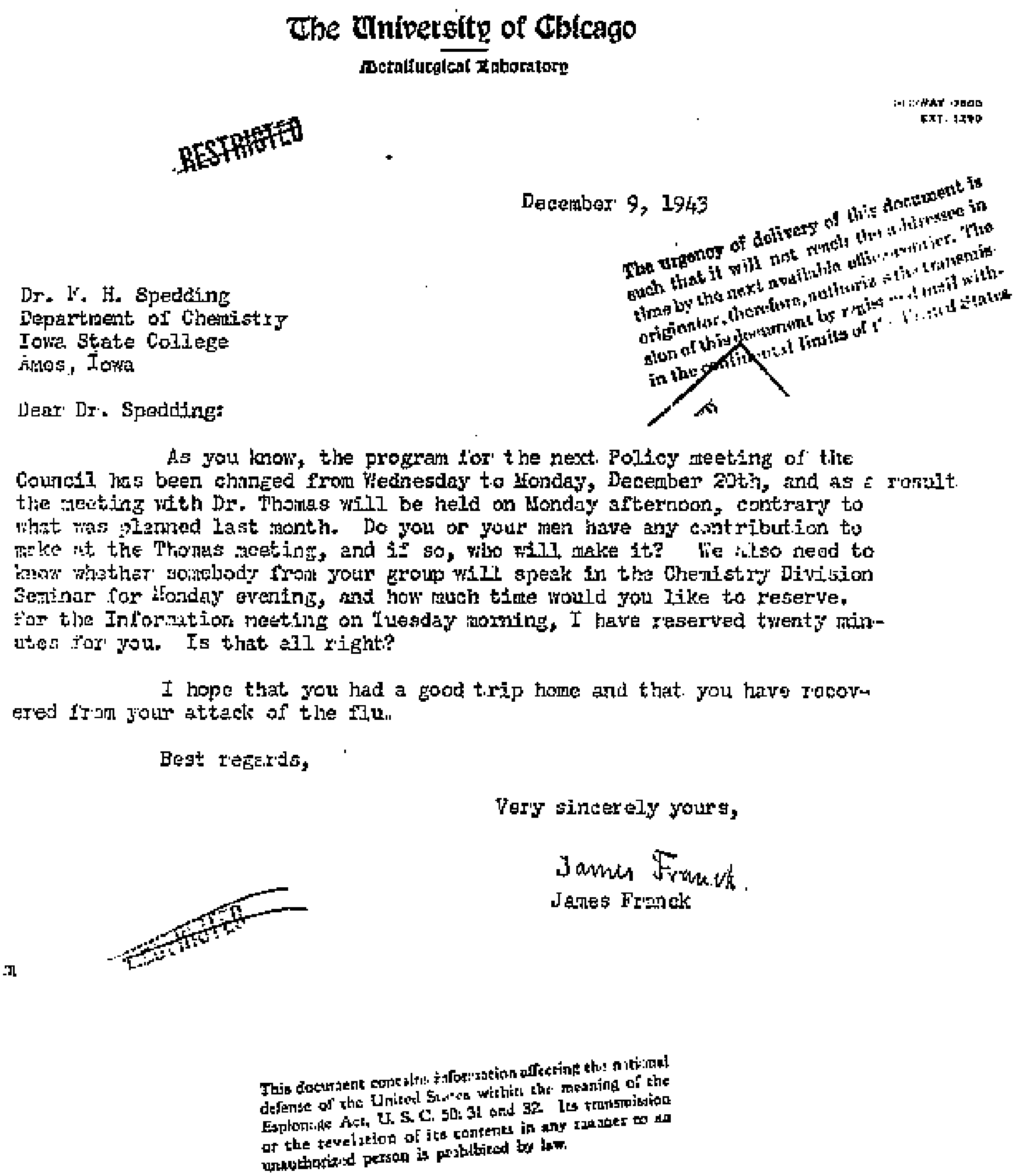
(SEAL)

Notary Public

COMMISSION EXPIRES JULY 4, 1942

Note.- If the oath is taken before a Notary Public the date of expiration of his commission should be shown.

Figure D1. Oath of allegiance for Harley A, Wilhelm.



The University of Chicago
Metallurgical Laboratory

MIDWAY 0800
EXT. 1290

RESTRICTED

December 9, 1943

The urgency of delivery of this document is such that it will not reach the addressee in time by the next available officer courier. The originator, therefore, authorizes the transmission of this document by registered mail within the continental limits of the United States.

Dr. F. H. Spedding
Department of Chemistry
Iowa State College
Ames, Iowa

Dear Dr. Spedding:

As you know, the program for the next Policy meeting of the Council has been changed from Wednesday to Monday, December 20th, and as a result the meeting with Dr. Thomas will be held on Monday afternoon, contrary to what was planned last month. Do you or your men have any contribution to make at the Thomas meeting, and if so, who will make it? We also need to know whether somebody from your group will speak in the Chemistry Division Seminar for Monday evening, and how much time would you like to reserve. For the Information meeting on Tuesday morning, I have reserved twenty minutes for you. Is that all right?

I hope that you had a good trip home and that you have recovered from your attack of the flu.

Best regards,

Very sincerely yours,

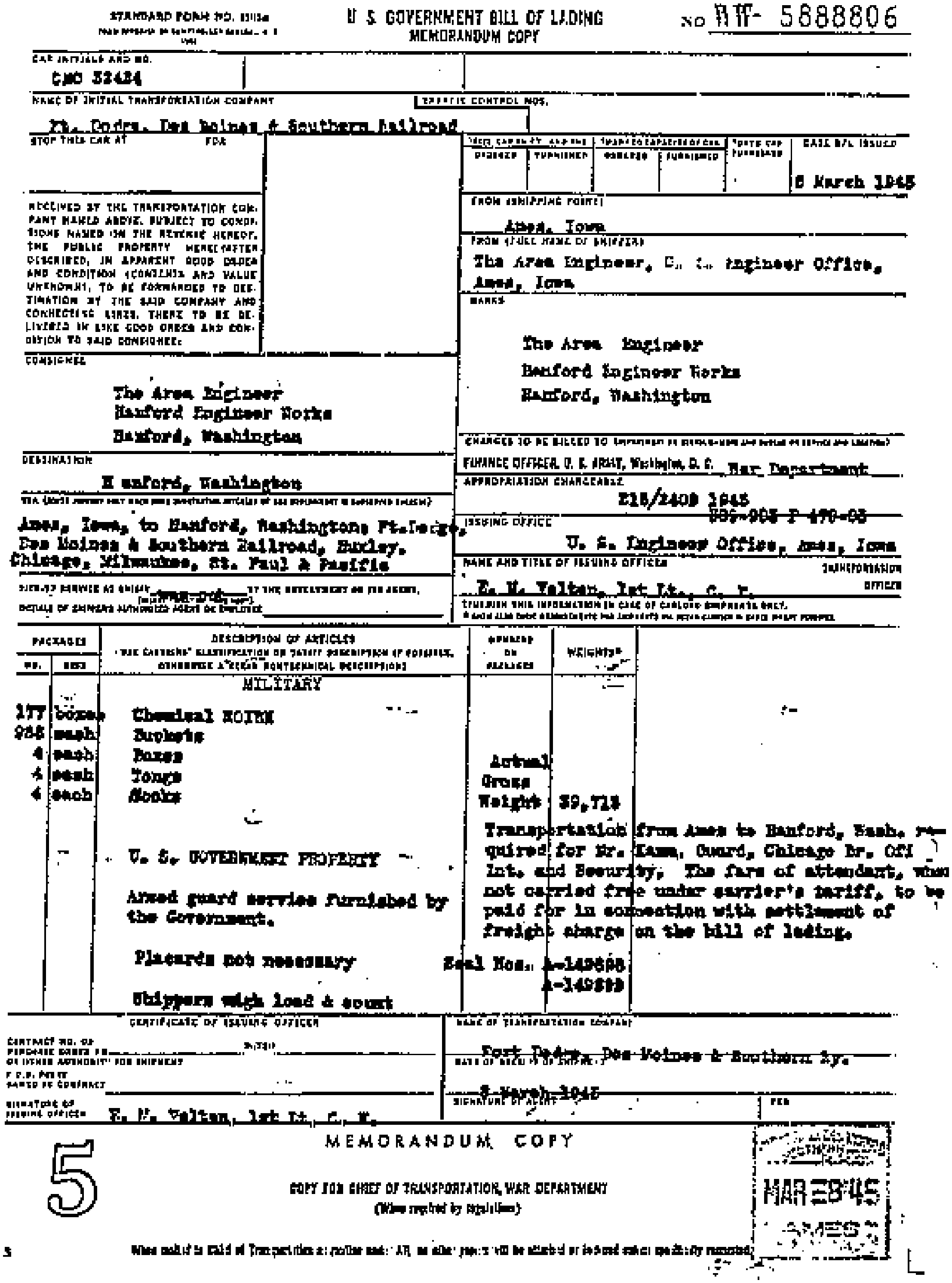
James Franck
James Franck

RESTRICTED

m

This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, U. S. C. 50: 31 and 32. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

Figure D2. Sample classified document with appropriate markings.



STANDARD FORM NO. 1058

U. S. GOVERNMENT BILL OF LADING
MEMORANDUM COPY

NO. WW- 5888806

CAR INITIALS AND NO.: CMO 32424

NAME OF INITIAL TRANSPORTATION COMPANY: Ft. Dodge, Des Moines & Southern Railroad

TRAFFIC CONTROL NOS.:

STOP THIS CAR AT ____ FOR ____

DATE B/L ISSUED: 8 March 1945

RECEIVED BY THE TRANSPORTATION COMPANY NAMED ABOVE, SUBJECT TO CONDITIONS NAMED ON THE REVERSE HEREOF, THE PUBLIC PROPERTY HEREINAFTER DESCRIBED, IN APPARENT GOOD ORDER AND CONDITION (CONTENTS AND VALUE UNKNOWN), TO BE FORWARDED TO DESTINATION BY THE SAID COMPANY AND CONNECTING LINES, THERE TO BE DELIVERED IN LIKE GOOD ORDER AND CONDITION TO SAID CONSIGNEE.

FROM (SHIPPING POINT): Ames, Iowa

FROM (FULL NAME OF SHIPPER):
The Area Engineer, U. S. Engineer Office,
Ames, Iowa

MARKS:
The Area Engineer
Hanford Engineer Works
Hanford, Washington

CONSIGNEE:
The Area Engineer
Hanford Engineer Works
Hanford, Washington

DESTINATION: Hanford, Washington

VIA:
Ames, Iowa, to Hanford, Washington; Ft. Dodge, Des Moines & Southern Railroad, Huxley, Chicago, Milwaukee, St. Paul & Pacific

CHARGES TO BE BILLED TO: FINANCE OFFICER, U. S. ARMY, Washington, D. C. War Department

APPROPRIATION CHARGEABLE: 215/2400 1945

ISSUING OFFICE: U. S. Engineer Office, Ames, Iowa

NAME AND TITLE OF ISSUING OFFICER: E. M. Valton, 1st Lt., C. E. TRANSPORTATION OFFICER

PACKAGES NO.	KIND	DESCRIPTION OF ARTICLES		WEIGHTS
		MILITARY		
177	boxes	Chemical NOITN		
958	each	Buckets		
4	each	Boxes		
4	each	Tongs	Actual Gross	
4	each	Hooks	Weight	39,718
		U. S. GOVERNMENT PROPERTY		
		Armed guard service furnished by the Government.		
		Placards not necessary	Seal Nos.	A-149698 A-149699
		Shippers weigh load & count		

Transportation from Ames to Hanford, Wash. required for Mr. Kamm, Guard, Chicago Br. Off Int. and Security. The fare of attendant, when not carried free under carrier's tariff, to be paid for in connection with settlement of freight charge on the bill of lading.

CERTIFICATE OF ISSUING OFFICER

CONTRACT NO. OR PURCHASE ORDER NO. OR OTHER AUTHORITY FOR SHIPMENT ____ DATED ____

F.O.B. POINT NAMED IN CONTRACT ____

SIGNATURE OF ISSUING OFFICER: E. M. Valton, 1st Lt., C. E.

NAME OF TRANSPORTATION COMPANY: Fort Dodge, Des Moines & Southern Ry.

DATE OF RECEIPT OF SHIPMENT: 8 March 1945

SIGNATURE OF AGENT ____ PER ____

5

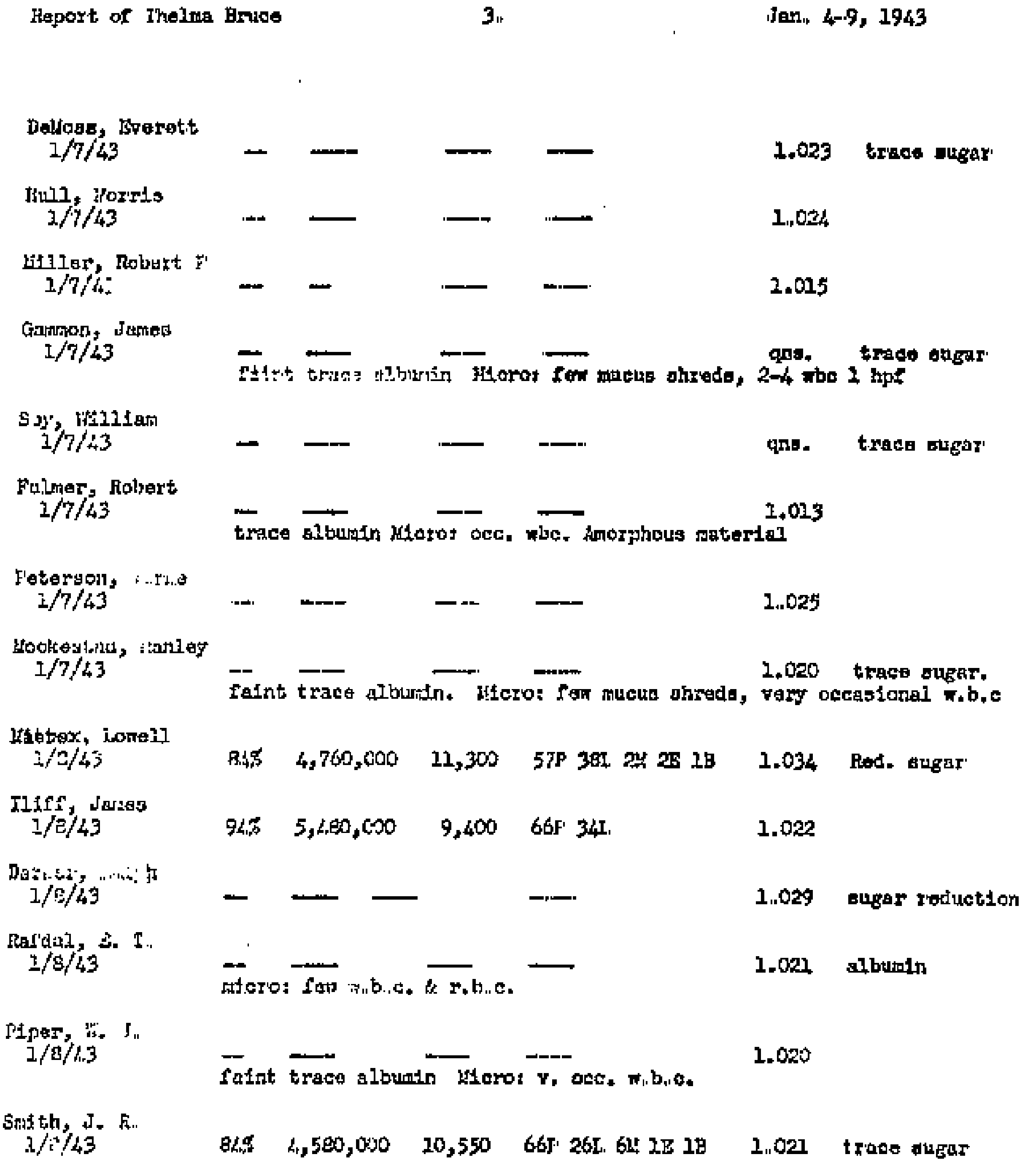
MEMORANDUM COPY

COPY FOR CHIEF OF TRANSPORTATION, WAR DEPARTMENT
(When required by regulations)

MAR 28 '45
AMES

Figure D3. Sample bill of lading for a shipment between Iowa State and Hanford.

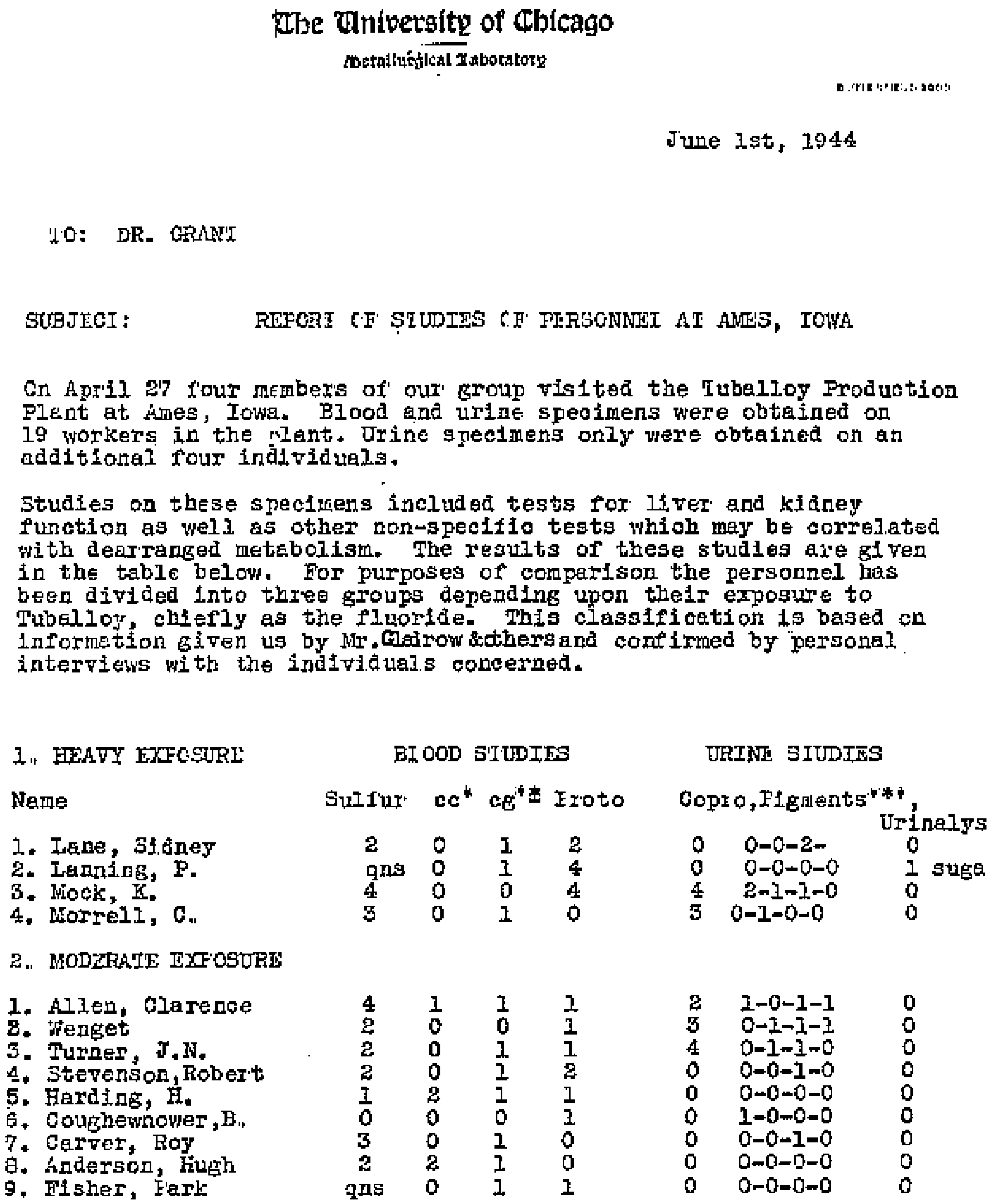
APPENDIX F. WORKER HEALTH AND SAFETY



Report of Thelma Bruce 3. Jan. 4-9, 1943

DeMoss, Everett 1/7/43	—	—	—	—	1.023	trace sugar
Hull, Morris 1/7/43	—	—	—	—	1.024	
Miller, Robert F 1/7/43	—	—	—	—	1.015	
Gammon, James 1/7/43	—	—	—	—	qns.	trace sugar
	faint trace albumin Micro: few mucus shreds, 2-4 wbc 1 hpf					
Say, William 1/7/43	—	—	—	—	qns.	trace sugar
Fulmer, Robert 1/7/43	—	—	—	—	1.013	
	trace albumin Micro: occ. wbc. Amorphous material					
Peterson, [illegible] 1/7/43	—	—	—	—	1.025	
Mookestad, Stanley 1/7/43	—	—	—	—	1.020	trace sugar.
	faint trace albumin. Micro: few mucus shreds, very occasional w.b.c					
Mistex, Lowell 1/8/43	84%	4,760,000	11,300	57P 38L 2M 2E 1B	1.034	Red. sugar
Iliff, James 1/8/43	94%	5,480,000	9,400	66P 34L	1.022	
[illegible] 1/8/43	—	—	—	—	1.029	sugar reduction
Rafdal, E. T. 1/8/43	—	—	—	—	1.021	albumin
	micro: few w.b.c. & r.b.c.					
Piper, W. J. 1/8/43	—	—	—	—	1.020	
	faint trace albumin Micro: v. occ. w.b.c.					
Smith, J. R. 1/8/43	84%	4,580,000	10,550	66P 26L 6M 1E 1B	1.021	trace sugar

Figure F1. Excerpt from a typical Iowa State College health report, January 1943.



The University of Chicago

Metallurgical Laboratory

June 1st, 1944

TO: DR. GRANT

SUBJECT: REPORT OF STUDIES OF PERSONNEL AT AMES, IOWA

On April 27 four members of our group visited the Tuballoy Production Plant at Ames, Iowa. Blood and urine specimens were obtained on 19 workers in the plant. Urine specimens only were obtained on an additional four individuals.

Studies on these specimens included tests for liver and kidney function as well as other non-specific tests which may be correlated with dearranged metabolism. The results of these studies are given in the table below. For purposes of comparison the personnel has been divided into three groups depending upon their exposure to Tuballoy, chiefly as the fluoride. This classification is based on information given us by Mr. Glairow & others and confirmed by personal interviews with the individuals concerned.

1. HEAVY EXPOSURE	BLOOD STUDIES				URINE STUDIES		
Name	Sulfur	cc*	cg**	Proto	Copro,	Pigments***,	Urinalys
1. Lane, Sidney	2	0	1	2	0	0-0-2-	0
2. Lanning, P.	qns	0	1	4	0	0-0-0-0	1 suga
3. Mock, K.	4	0	0	4	4	2-1-1-0	0
4. Morrell, C.	3	0	1	0	3	0-1-0-0	0
2. MODERATE EXPOSURE							
1. Allen, Clarence	4	1	1	1	2	1-0-1-1	0
2. Wenget	2	0	0	1	3	0-1-1-1	0
3. Turner, J.N.	2	0	1	1	4	0-1-1-0	0
4. Stevenson, Robert	2	0	1	2	0	0-0-1-0	0
5. Harding, H.	1	2	1	1	0	0-0-0-0	0
6. Coughewnower, B.	0	0	0	1	0	1-0-0-0	0
7. Carver, Roy	3	0	1	0	0	0-0-1-0	0
8. Anderson, Hugh	2	2	1	0	0	0-0-0-0	0
9. Fisher, Park	qns	0	1	1	0	0-0-0-0	0

Figure F2. Figure F2. Report on research studies of Ames personnel, June 1, 1944

3. RELATIVELY SLIGHT EXPOSURE

	BLOOD STUDIES				URINE STUDIES		
	Sulfur	cc*	cg**	Proto	Copro,	Pigments,***	Urinalysis
1. Storkey, B.	2	0	1	0	1	0-1-2-1	0
2. Orr, John	0	0	0	0	0	0-0-0-0	0
3. Smith, Lowell	0	0	1	0	0	0-0-0-0	0
4. Anderson, Edward	1	0	1	0	1	0-0-0-0	0
Kent, Arthur *****	0	2	1	0	0	0-1-0-0	0

* Cephalin cholesterol ** Colloidal gold *** Absorption at 400 mu and 520 mu Urorosein band and 510 mu band

**** Heavy exposure until about 4 months ago, practically none since.

***** Works away from plant. Radiation chief exposure.

The above scoring system may be interpreted as follows:
0 = normal range
1 plus = border line range
2 plus to 4 plus = increasingly positive reaction

CONCLUSIONS:

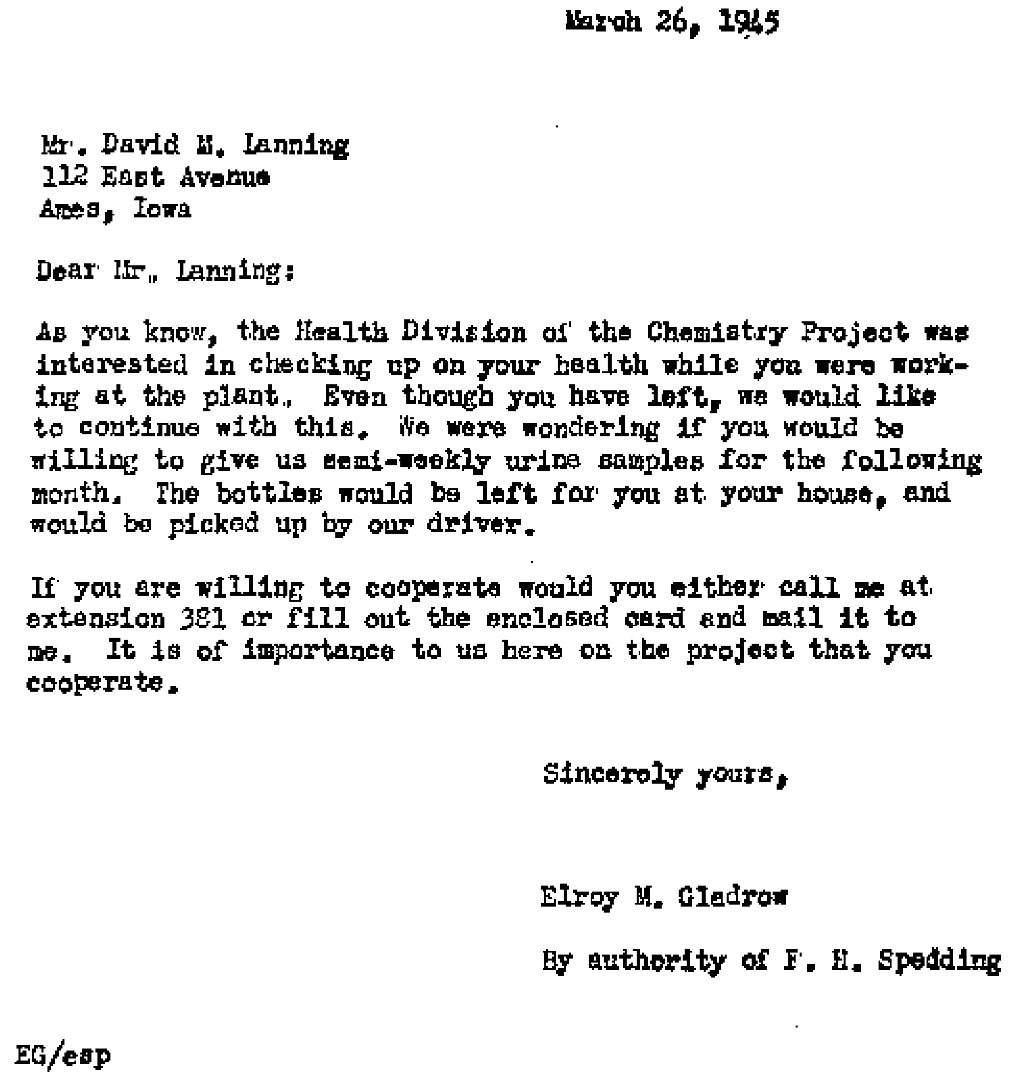
In general, fortunately, the tests indicate less abnormality than I would have expected from the amount of exposure these men are getting. The one exception to this statement is the almost consistent elevatio of serum sulfur which is indicative of probably slight kidney disfunction. Liver function tents are almost uniformally normal. In only the heaviest exposure group is there significant change in porphyrin metabolism.

Sincerely yours,

SAMUEL SCHWARTZ, M.D.

SS:SS

Figure F2. (Continued).



March 26, 1945

Mr. David M. Lanning
112 East Avenue
Ames, Iowa

Dear Mr. Lanning:

As you know, the Health Division of the Chemistry Project was interested in checking up on your health while you were working at the plant. Even though you have left, we would like to continue with this. We were wondering if you would be willing to give us semi-weekly urine samples for the following month. The bottles would be left for you at your house, and would be picked up by our driver.

If you are willing to cooperate would you either call me at extension 381 or fill out the enclosed card and mail it to me. It is of importance to us here on the project that you cooperate.

Sincerely yours,

Elroy M. Gladrow

By authority of F. H. Spedding

EG/esp

Figure F3. Typical letter to a person who has left the project, asking for continued testing.

APPENDIX G. THE IMPACT OF THE AMES PROJECT UPON IOWA STATE COLLEGE

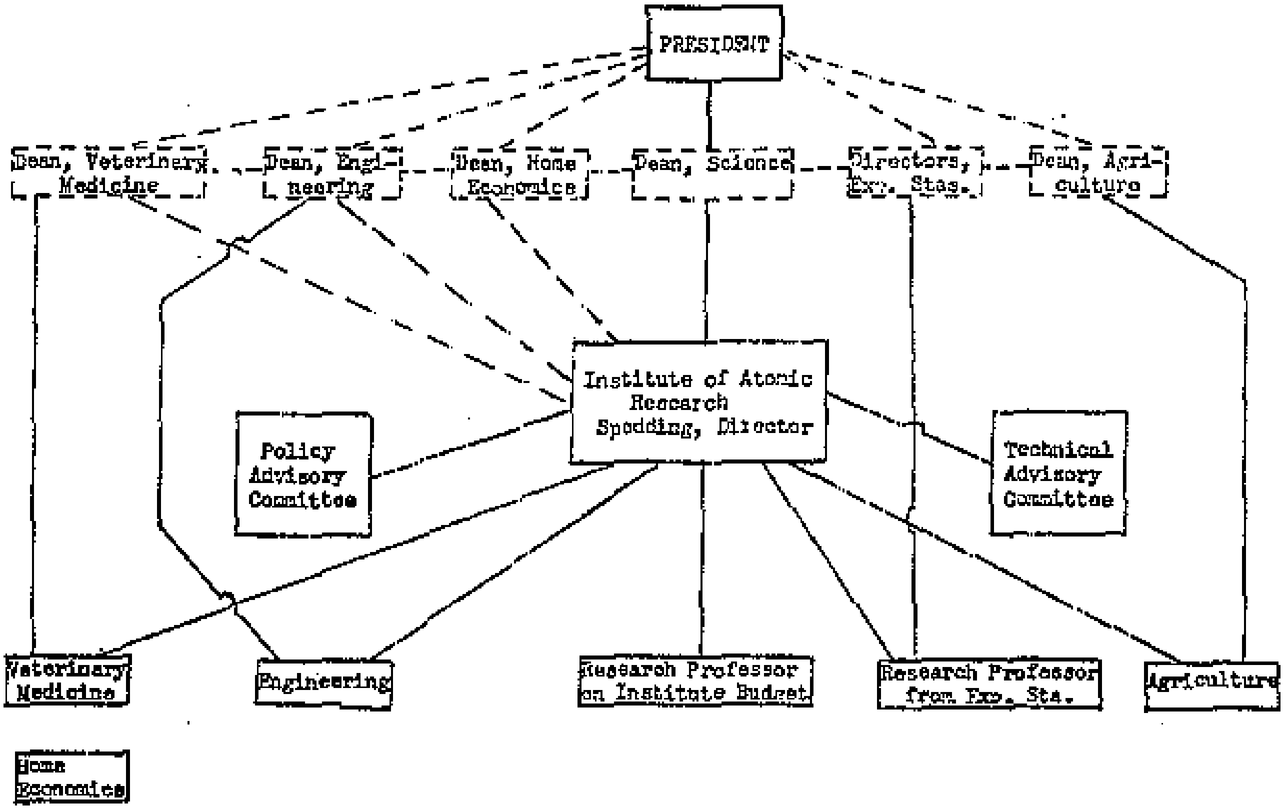
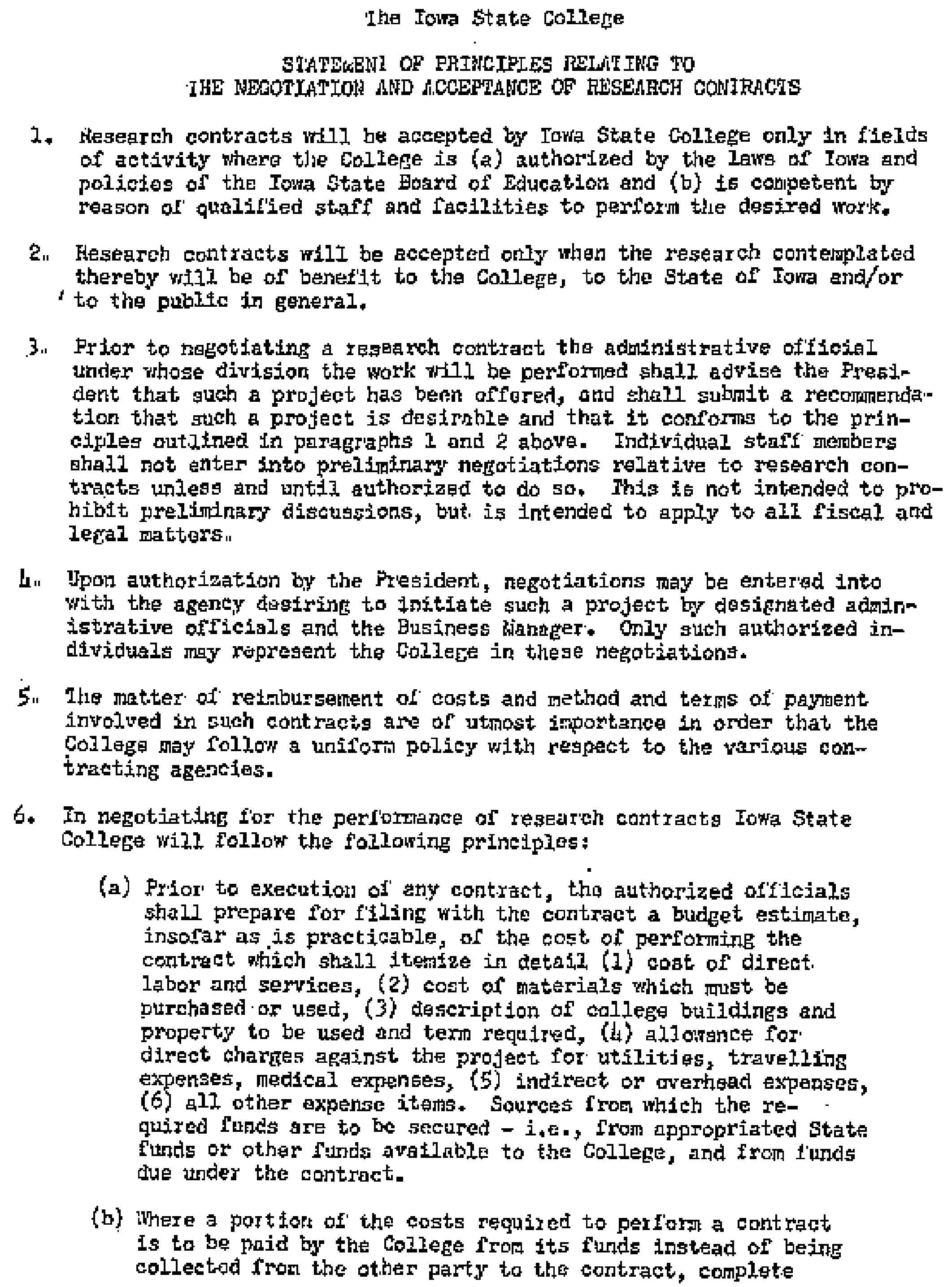


Figure G1. Organization chart proposed for the Institute of Atomic Research at Iowa State College, October 1945.



The Iowa State College

STATEMENT OF PRINCIPLES RELATING TO
THE NEGOTIATION AND ACCEPTANCE OF RESEARCH CONTRACTS

1. Research contracts will be accepted by Iowa State College only in fields of activity where the College is (a) authorized by the laws of Iowa and policies of the Iowa State Board of Education and (b) is competent by reason of qualified staff and facilities to perform the desired work.

2. Research contracts will be accepted only when the research contemplated thereby will be of benefit to the College, to the State of Iowa and/or to the public in general.

3. Prior to negotiating a research contract the administrative official under whose division the work will be performed shall advise the President that such a project has been offered, and shall submit a recommendation that such a project is desirable and that it conforms to the principles outlined in paragraphs 1 and 2 above. Individual staff members shall not enter into preliminary negotiations relative to research contracts unless and until authorized to do so. This is not intended to prohibit preliminary discussions, but is intended to apply to all fiscal and legal matters.

4. Upon authorization by the President, negotiations may be entered into with the agency desiring to initiate such a project by designated administrative officials and the Business Manager. Only such authorized individuals may represent the College in these negotiations.

5. The matter of reimbursement of costs and method and terms of payment involved in such contracts are of utmost importance in order that the College may follow a uniform policy with respect to the various contracting agencies.

6. In negotiating for the performance of research contracts Iowa State College will follow the following principles:

   (a) Prior to execution of any contract, the authorized officials shall prepare for filing with the contract a budget estimate, insofar as is practicable, of the cost of performing the contract which shall itemize in detail (1) cost of direct labor and services, (2) cost of materials which must be purchased or used, (3) description of college buildings and property to be used and term required, (4) allowance for direct charges against the project for utilities, travelling expenses, medical expenses, (5) indirect or overhead expenses, (6) all other expense items. Sources from which the required funds are to be secured - i.e., from appropriated State funds or other funds available to the College, and from funds due under the contract.

   (b) Where a portion of the costs required to perform a contract is to be paid by the College from its funds instead of being collected from the other party to the contract, complete

Figure G2. Policy on negotiation and acceptance of research contracts, approved by the Iowa State Board of Education, March 16, 1950 justification shall be submitted to the President of the College for approval, and such approved justification shall be filed with the contract in the College records. Where the College subsidizes a contract project, the relation of the contract to the work of the College shall be defined clearly.

(c) Indirect and overhead costs shall be computed in accordance with uniform policies and cost studies prepared from time to time by the Business Manager of the College.

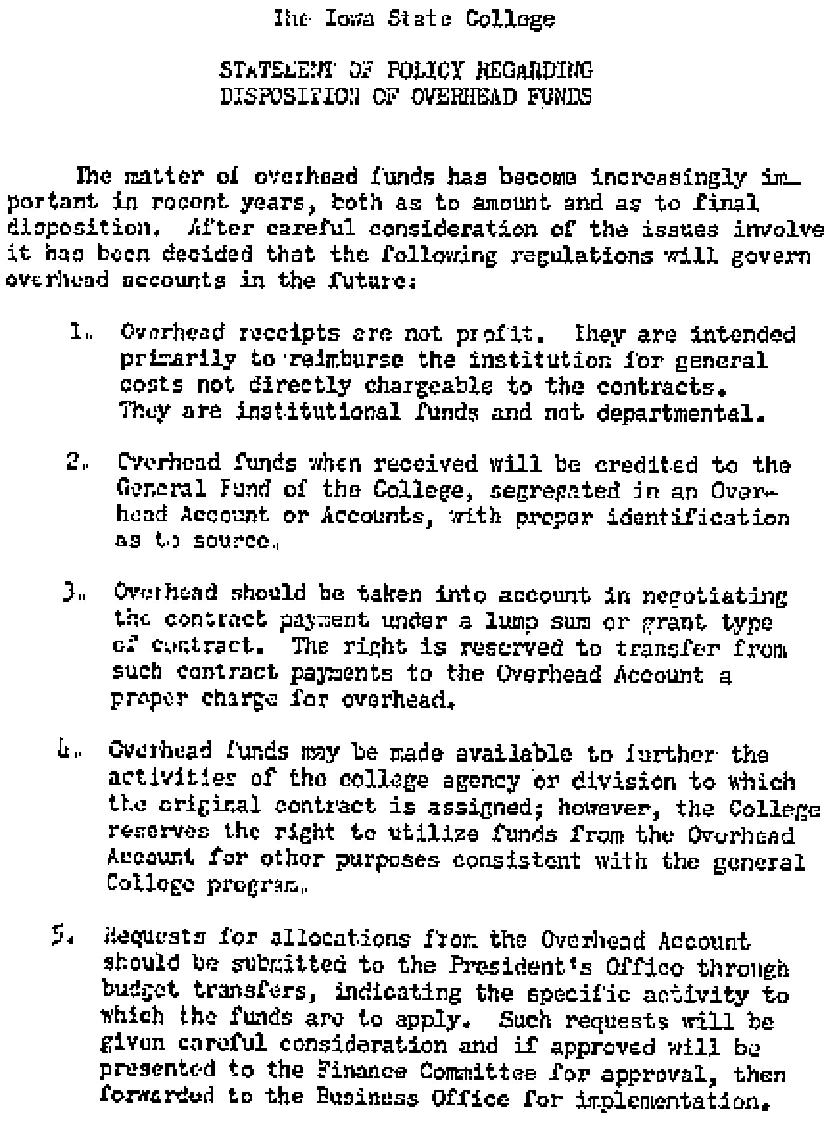
7. The College should retain patent rights on all patentable materials or processes. In cases of contracts with agencies of the United States Government, however, waiver of patent rights will be permitted. If patent rights are relinquished a loss may accrue to the College, the value of which is difficult to determine. Such loss should be taken into account in all contracts in which patent rights are relinquished.

8. Authority to enter into contracts is granted solely by the Board of Education, through its Finance Committee and the President of the College. All contracts must be cleared with the Business Office for a check of the details of payment, conformity with fiscal policies of the College, and for inclusion on Board of Education or Finance Committee dockets for official approval. Contracts shall provide for the signature of the director of the appropriate Research Institute or Experiment Station and the President of the College.

9. The President of the College shall be authorized to consult legal counsel designated by the Finance Committee of the Board of Education in consultation with the Assistant Attorney General assigned to the Board in connection with research contracts as to provisions required in said contracts and rights and obligations of the College thereunder.

10. All contracts between the College and the United States Atomic Energy Commission or other agency of the United States operating under transfer of funds from the Atomic Energy Commission shall be administered within the College by the Advisory Committee of the Institute for Atomic Research. The Advisory Committee shall assign the performance of the research provided for in such contracts to the appropriate College division or Experiment Station. The College divisions and Experiment Stations shall cooperate where necessary in the execution of such projects. Other contracts with the United States shall be administered by the President through the Division or Experiment Station designated by the President, and other agencies of the College shall cooperate where necessary in the execution of such projects. In all contracts where radioactive elements are involved, the Institute for Atomic Research shall be consulted and is charged with responsibility for recommendations as to safety of personnel and the public. Costs incurred in such consultations and in providing monitoring service are chargeable by the Institute for Atomic Research to the contracts in which radioactive elements are used.

Figure G2. (Continued).



The Iowa State College

STATEMENT OF POLICY REGARDING
DISPOSITION OF OVERHEAD FUNDS

The matter of overhead funds has become increasingly important in recent years, both as to amount and as to final disposition. After careful consideration of the issues involved, it has been decided that the following regulations will govern overhead accounts in the future:

1. Overhead receipts are not profit. They are intended primarily to reimburse the institution for general costs not directly chargeable to the contracts. They are institutional funds and not departmental.
2. Overhead funds when received will be credited to the General Fund of the College, segregated in an Overhead Account or Accounts, with proper identification as to source.
3. Overhead should be taken into account in negotiating the contract payment under a lump sum or grant type of contract. The right is reserved to transfer from such contract payments to the Overhead Account a proper charge for overhead.
4. Overhead funds may be made available to further the activities of the college agency or division to which the original contract is assigned; however, the College reserves the right to utilize funds from the Overhead Account for other purposes consistent with the general College program.
5. Requests for allocations from the Overhead Account should be submitted to the President's Office through budget transfers, indicating the specific activity to which the funds are to apply. Such requests will be given careful consideration and if approved will be presented to the Finance Committee for approval, then forwarded to the Business Office for implementation.

Figure G3. Policy on disposition of overhead funds at Iowa State College, approved by the State Board of Education, March 16, 1950.