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

[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

[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, Manhattan 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

[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,

[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.

[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

[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

[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

[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

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 studios, 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

[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

[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

[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

[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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