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MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

X-10

VOLUME 1 - GENERAL FEATURES

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW

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FOREWORD

This volume of Book IV of the Manhattan District History has been written to provide the reader with the background necessary for a clearer understanding of the succeeding volumes of this book. A brief discussion of the independent research on radioactivity and nuclear physics leading up to the discovery of plutonium is presented, as well as the administrative arrangements under which the Pile Project has operated from January 1942 to 31 December 1946. Features which have been common to more than one phase of the Pile Project are included in this volume to avoid repetition in succeeding volumes.

Book IV of the Manhattan District History has been written as of 31 December 1946. In an effort to present a clear, comprehensive history of the Pile Project to that date, minute details and highly technical discussions have been avoided wherever possible.

The summary contains an abstract of every main subject treated in the text and is keyed to the text in such a manner that paragraph numbers and headings in the summary correspond to the various sections in the text.

No supplementary material or references are included in this volume. A glossary of terms is presented in Appendix A.

Other phases of the history of the Pile Project are described in:

Book IV - Volume 2 - Research

Book IV - Volume 3 - Design

Book IV - Volume 4 - Land Acquisition, H.E.W.

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Book IV - Volume 5 - Construction

Book IV - Volume 6 - Operations

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BOOK IV - PILE PROJECT

VOLUME 1 - GENERAL FEATURES

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SUMMARY

1. Introduction. - The Pile Project was organized to conduct the research and development essential to assure the success of the controlled chain reaction and to design and construct the research and production facilities necessary to supply military requirements for plutonium. This work involved theoretical studies, physical and chemical research, such development work as time would allow, the acquisition of a suitable site, and the design, construction, and operation of large-scale production facilities without the benefit of complete research or pilot plant investigations. The Pile Project was authorized by the President of the United States as a result of recommendations by Dr. J. B. Conant, Chairman of the National Defense Research Committee, and Dr. V. Bush, Director of the Office of Scientific Research and Development.

2. Early Developments. - The natural radioactivity of uranium was discovered in 1896 by H. Becquerel. This work was followed by the isolation of radium and the discovery that thorium, polonium, radium, and actinium give off penetrating radiations. The theory that the disintegration of an atom is accompanied by the emission of a single alpha or beta particle was proposed by E. Rutherford and F. Soddy in 1902. The artificial conversion of one chemical element to another was accomplished by Rutherford in 1919. A new, high energy radiation was noticed in 1932 and J. Chadwick proposed that this was a neutron, a neutral particle possessing approximately the same mass as a proton. The nuclear capture of neutrons was discovered in 1934 and was followed

by many attempts to convert uranium to new elements higher in the atomic scale by bombardment with neutrons. This work established the fact that uranium-235 and uranium-238 fission upon bombardment. In 1940, however, evidence was obtained proving that uranium can undergo transmutation to new elements higher in the atomic scale. This was followed by the discovery and isolation of plutonium.

3. Administration. - Efforts were made to interest the Government in research on uranium fission because of the possible military use of the large amounts of energy released by fission. This resulted in the formation of the Advisory Committee on Uranium. With the organization of the National Defense Research Committee, nuclear physics research on uranium was conducted at several universities under NDRC contracts. In December 1941, the Uranium Section was reorganized under the Office of Scientific Research and Development and an "all out" effort was begun at the University of Chicago under the direction of Dr. A. H. Compton. The Manhattan Engineer District was organized and assumed over-all direction of the Pile Project effective 16 August 1942. The OSRD remained in charge of research until 1 May 1943 when the Manhattan District assumed full jurisdiction over all phases of the Project.

4. Phases of the Pile Project. - The evolution of the Pile Project differed from the usual procedure because the urgent military need for plutonium did not permit the completion of the customary exhaustive research and pilot plant studies prior to design and construction of the large scale production plants. The research program was conducted under the auspices of the Metallurgical Laboratory at the University of Chicago. The separation chemistry of the Pile Project was studied on a

semi-works and pilot plant scale at Clinton Laboratories, Oak Ridge, Tennessee. The design of the production plants at the Hanford Engineer Works was accomplished by close cooperation between the research and design organizations. The University of Chicago was selected as the center of research for the Pile Project because of its location and available laboratory and housing facilities. The Metallurgical Laboratory at the University of Chicago was retained as the research center after the assumption of jurisdiction by the Manhattan District and was selected to operate Clinton Laboratories because of its experience on the Project. Construction of the Piles and laboratories in the Argonne Forest was assigned to the Stone and Webster Engineering Corporation. The Top Policy Committee considered it advisable to select one competent industrial organization to design, construct, and operate the semi-works and production plants. E. I. du Pont de Nemours and Company, Inc. agreed to accept this assignment after the urgency of the program had been explained and, after completing construction in March 1945, operated the Hanford Engineer Works until 31 August 1946. On 1 September 1946, The General Electric Company took over operation of the Hanford phase of the Pile Project, based upon a contract identical to that under which du Pont operated.

5. Costs. - The total cost of the Pile Project to 31 December 1946 was approximately $487,763,103. This includes the costs of the Metallurgical Laboratory, $32,304,258; Clinton Laboratories, $36,291,000, and the Hanford Engineer Works, $419,567,820 but does not include the costs of district overhead; military salaries; feed materials; or other plants or projects, which may be applicable, in whole or in part, to the Pile Project.

6. Intelligence and Security. - The objectives of the Pile Project directly affected the outcome of the war and it was, therefore, necessary that strict secrecy be maintained. Each employee's personal history was checked and, after employment, each person was given access to only such information as was necessary for the completion of his task. Personnel were allowed to enter only those areas in which they worked and were constantly reminded of their security obligations. Areas were patrolled by Contractors' guards and Military Police.

7. Law Enforcement and Jurisdiction. - The problem of law enforcement and jurisdiction was much greater at the Hanford Engineer Works than at the University of Chicago or at the Clinton Laboratories because of the size of the Project and the number of persons employed. The State of Washington maintained jurisdiction over the Project and its laws were enforced by the Contractor's patrolmen, who were deputized by the Benton County Sheriff. A special set of traffic regulations was enacted by the Commissioners of Benton County. The entire reservation was restricted and no contraband, such as cameras, firearms, and liquor, was permitted on the plant area.

8. Care of Real Estate. - The area of the Hanford Engineer Works included several communities, many farms and orchards, and several utilities. Most of the dwellings and business buildings were used during the construction period but have since been boarded up or converted for other uses. The farms and orchards have been operated by Federal Prison Industries. One irrigation district is being used and the other has been abandoned. The highways and railroad have been improved and one electric power line has been dismantled while the others

are being maintained and some portions are in use.

9. Organization and Personnel. - The Pile Project was formed under the National Defense Research Committee and was later directed by a subcommittee of the Office of Scientific Research and Development. In August 1942 the Manhattan Engineer District was formed and from 1 May 1943 until 31 December 1946 the Project has been under the direction of Major General L. R. Groves. Col. K. D. Nichols, as District Engineer, and Col. F. T. Matthias and Lt. Col. F. J. Clarke, as Area Engineers, have directed the Hanford Engineer Works activities. Dr. A. H. Compton has served as Director of the Metallurgical Project; the TNX Division of the Explosives Department and the Engineering Department of the du Pont Company were in charge of design and construction of the Hanford Engineer Works and Clinton Laboratories and of operation of the Hanford Engineer Works, until 31 August 1946, at which time, the General Electric Company assumed responsibility for operating the Hanford phase of production.

MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

VOLUME 1 - GENERAL FEATURES

SECTION 1 - INTRODUCTION

1-1. Objectives. - The Pile Project, known as the X-10 Project and described in the succeeding volumes, was organized to investigate the problems involved in the establishment of a controlled self-sustaining "chain reaction,"* to develop materials and methods most suited for the process, to design and construct the necessary research and manufacturing facilities, and to produce the quantities of "plutonium"* dictated by military requirements in the shortest possible time.

1-2. Scope. - The fulfillment of these objectives involved:

1. Theoretical nuclear physical studies of the fission and transmutation processes.
2. The physical and chemical research necessary to establish a small-scale chain reaction and to isolate minute quantities of plutonium.
3. Such development and "pilot plant"* investigations as time would allow, to adapt these processes for large-scale operation.
4. The design of large-scale production plants without benefit of complete research or pilot plant investigations.
5. The acquisition of an area of land, sufficiently large

for the production plants and attendant service and housing facilities, yet remote from large centers of population, and near abundant supplies of water and electrical power.

6. The construction of intricate production plants, on which the design was ever-changing, and attendant service and housing facilities, in the shortest possible time, during a period in which the supplies of labor, construction equipment, and building materials were already inadequate.

7. The full-scale operation of unorthodox production plants without the benefit of complete research or pilot plant investigations.

8. The protection of all personnel from the serious health hazards that accompany all stages of the process.

1-3. Authorization.

a. All action in connection with the institution and prosecution of this project was taken under authority granted by Congress in the Acts which are described in another book (Book I); the funds used were likewise appropriated by Acts there described.

b. Under the authority vested in him by these Acts, the President of the United States issued orders and authorizations which are described in the same book (Book I).

c. Major General L. R. Groves directed or authorized the general policies and directives under which the Manhattan District carried out the work. The S-1 Committee of the OSRD and the Military

Policy Committee registered their general approval of the basic decisions involved, as recorded in the minutes of meetings or in other documents in the project files. (Book III, Appendix D1; see also Section 6, Organization and Personnel).

SECTION 2 - EARLY DEVELOPMENTS

2-1. Natural Radioactivity. - "Natural radioactivity"* was discovered in 1896 by H. Becquerel. He had wrapped a bit of a uranium salt in black paper and placed it near a photographic plate with a sheet of silver between the salt and the photographic plate. After a few hours a distinct photographic effect was observed which indicated that the uranium salt gave off some radiation sufficiently penetrating to pass through the silver plate and affect the photographic emulsion. Subsequent experiments with different salts of uranium proved that the emission came from the uranium. This work was followed by the isolation of radium by P. Curie and M. Curie in 1898 and the discovery that thorium, polonium, radium, and actinium also gave off penetrating radiations. A great many substances were later found to be radioactive, but practically all of these appeared to come originally from either uranium or thorium. Subsequent work proved that three series of naturally radioactive elements exist. The starting materials, uranium-238, uranium-235, and thorium, disintegrate naturally, forming radioactive elements lower in the atomic scale. This cycle is repeated until stable isotopes of lead are formed as the final products of all three series. The first general theory of radioactive transformations, that the disintegration of an atom is accompanied by the emission of a single "alpha particle"* or "beta particle,"* was proposed by E. Rutherford and F. Soddy in 1902.

2-2. "Artificial Disintegration."* - The conversion of one element into another, the dream of scientists since the earliest days of chemistry, was finally achieved by E. Rutherford in 1919. Rutherford had been studying the effects of the collisions of alpha particles with the nuclei of hydrogen, nitrogen, and oxygen. Later work by Rutherford proved that the alpha particle was absorbed in the nucleus and a "proton"* ejected, and that a nitrogen atom was thus converted to one of the relatively rare isotopes of oxygen ($_8O^{17}$), having an "atomic number"* of eight and an atomic weight of 17.

2-3. Discovery and Effects of Neutrons. - W. Bothe and H. Becker noticed in 1932 that if alpha rays from the naturally radioactive polonium were allowed to fall upon beryllium, boron, or lithium, a very penetrating radiation was emitted from these elements. This new radiation was initially believed to be a "gamma radiation."* The work of I. Curie and F. Joliot in 1932 showed that this new radiation would produce greater ionization if it fell upon a hydrogenous substance such as paraffin than if it collided with another nucleus directly. The true nature of this new radiation was postulated by J. Chadwick in 1932 when he showed that a neutral particle possessing essentially the same mass as a proton best satisfied the experimental results. This neutral particle is known as a neutron. It was then determined that the collision of an alpha particle with a beryllium nucleus produces an atom of carbon and a neutron. The discovery of this high energy, neutral particle opened the way for extensive research on radioactive "disintegrations"* since the absence of an appreciable electrical field surrounding the particle readily permits it to penetrate the nuclei of even the heavy atoms.

2-4. Fission. - The generality of neutron capture by nuclei was discovered in 1934 by E. Fermi and his collaborators. Fermi found that, if the neutron source were surrounded by a hydrogenous substance, it frequently was far more efficient in producing radioactivity. He realized that this was the result of the "slowing down" of the neutron by an impact with a hydrogen nucleus and that, if this were repeated several times, the energy of the neutron would be so reduced that the likelihood of its capture would be much greater. Thus a "slow neutron"* would be particularly effective in causing transmutations with the attendant release of great quantities of energy, and bombardment of uranium by such neutrons might lead to the formation of elements of atomic number higher than 92. It was observed by Fermi and his associates that neutron bombardment of uranium produces one or more radioactive products which emit beta particles. Four different half periods were observed for these products, which led to the conclusion that elements 93, 94, 95, and 96 had been produced. In 1939 O. Hahn and F. Strassmann found that certain of the products resulting from the bombardment of uranium with neutrons were really isotopes of barium and lanthanum. Work by N. Bohr and J. A. Wheeler in 1939 and J. R. Dunning and his associates in 1940 showed that slow neutrons caused fission of uranium-235 whereas fast neutrons caused fission of uranium-238. Recognition of the fission process removed the evidence for the existence of elements 93, 94, 95, and 96 which Fermi believed he had obtained. However, in 1940, E. McMillan and P. H. Abelson obtained evidence that neutron bombardment of uranium gives uranium-239 which decays with a "half life"** of 23 minutes to "neptunium-239."*** In 1940 G. T. Seaborg, E. McMillan, A. C. Wahl, and J. W. Kennedy discovered the element 94 (plutonium) which was later found to be plutonium-238. Plutonium-239 was discovered by G. T. Seaborg, E. Segre, J. W. Kennedy, and E. O. Lawrence early in 1941. The first pure plutonium-239 was isolated in the form of its compounds in August and September 1942 by B. B. Cunningham and his co-workers.

SECTION 3 - ADMINISTRATION

3-1. General. - In view of the possible military use of the large amounts of energy released by fission, a group of scientists of many nationalities working in the United States attempted, early in 1939, to restrict publication of further data and to obtain governmental support for further research. In the spring of 1940 the Reference Committee of the National Research Council was organized to control publication policy in all fields of possible military interest. This arrangement of preventing publication was a voluntary one and enjoyed the complete cooperation of the nation's scientists and publishers of technical literature. Efforts to arouse government interest and support of research in nuclear physics began with a conference between representatives of the Navy Department and E. Fermi in March 1939 at which the Navy expressed some interest in the work. On 11 October 1939, through a letter from Dr. A. Einstein, delivered by Dr. Alexander Sachs, the aid of President Roosevelt was enlisted, resulting in the formation of the Advisory Committee on Uranium. This committee made recommendations to the government and attempted to secure raw materials. In February 1940, $6000 was allotted by the Army and Navy for this research.

3-2. National Defense Research Committee (NDRC). - The organization of the National Defense Research Committee, with Dr. V. Bush as Chairman, was announced in June 1940 and the Advisory Committee on Uranium was reconstituted as a subcommittee of the NDRC. Although contracts for research in nuclear physics were made between the NDRC and various research institutions, the funds were first supplied by the Army and Navy. By November 1941, a total of 16 different research organizations were participating in the uranium program. As a result of a complete review of the program and interchange of information with the British during the summer and fall of 1941, it was agreed that the uranium program should be pushed more vigorously and that discussions of general policy should be confined to the Top Policy Group, composed of the President, Vice President, Secretary of War, Chief of Staff, Dr. V. Bush, and Dr. J. B. Conant, Assistant to Dr. V. Bush.

3-3. Office of Scientific Research and Development (OSRD). - In December 1941, the Top Policy Group decided to pursue an "all out" effort in the development of atomic bombs and that the NDRC Uranium Section was not properly organized for such an effort. Accordingly this section was reorganized as the S-1 Section of the Office of Scientific Research and Development. Dr. A. H. Compton was to have charge of fundamental physical studies of the chain reaction and was authorized to explore the possibility of producing plutonium in useful amounts by the controlled chain-reaction method. In the middle of January 1942, Dr. Compton decided to concentrate the work, for which he was responsible, at the University of Chicago. On 9 March 1942, Dr. Bush suggested in his report to the President that, in the summer of 1942, the Army be given the responsibility for the construction of full scale plants.

3-4. Manhattan Engineer District. - As a result of a report submitted by Dr. V. Bush to the President on 17 June 1942, Brigadier and various research institutions, the funds were first supplied by the Army and Navy. By November 1941, a total of 16 different research organizations were participating in the uranium program. As a result of a complete review of the program and interchange of information with the British during the summer and fall of 1941, it was agreed that the uranium program should be pushed more vigorously and that discussions of general policy should be confined to the Top Policy Group, composed of the President, Vice President, Secretary of War, Chief of Staff, Dr. V. Bush, and Dr. J. B. Conant, Assistant to Dr. V. Bush.

3-3. <u>Office of Scientific Research and Development (OSRD)</u>. - In December 1941, the Top Policy Group decided to pursue an "all out" effort in the development of atomic bombs and that the NDRC Uranium Section was not properly organized for such an effort. Accordingly this section was reorganized as the S-1 Section of the Office of Scientific Research and Development. Dr. A. H. Compton was to have charge of fundamental physical studies of the chain reaction and was authorized to explore the possibility of producing plutonium in useful amounts by the controlled chain-reaction method. In the middle of January 1942, Dr. Compton decided to concentrate the work, for which he was responsible, at the University of Chicago. On 9 March 1942, Dr. Bush suggested in his report to the President that, in the summer of 1942, the Army be given the responsibility for the construction of full scale plants.

3-4. <u>Manhattan Engineer District</u>. - As a result of a report submitted by Dr. V. Bush to the President on 17 June 1942, Brigadier

General, then Colonel, J. C. Marshall, Corps of Engineers, was instructed by the Chief of Engineers to form a new district in the Corps of Engineers of the Army Service Forces under Major General B. Somervell to carry on special work assigned to it. This district was designated the Manhattan Engineer District and was officially established effective 16 August 1942. On 17 September 1942, the Secretary of War placed Brigadier General, now Major General, L. R. Groves of the Corps of Engineers in complete charge of all Army activities relating to the Manhattan District Project. The Manhattan District gradually assumed jurisdiction over the various phases of the Project until, on 1 May 1943, the transfer from the OSRD was complete.

3.4. <u>Administrative Jurisdiction</u>. - Since the Pile Project was the joint responsibility of the Office of Scientific Research and Development and the Army from September 1942 to April 1943, the preliminary negotiations regarding the design, construction, and operation of the Clinton Laboratories and the Hanford Engineer Works were handled jointly by the OSRD and the Army. Subsequently the Army, through the Manhattan District, assumed full jurisdiction over all phases of the Project.

SECTION 4 - PHASES OF THE PILE PROJECT

4-1. General. - The procedures followed from the inception of the Metallurgical Project to the delivery of the first batch of plutonium from the Hanford Engineer Works (See Vols. 2, 4, 5, and 6) differed greatly from those usually followed in producing a new product. The usual procedure in the industrial development of a new product or a new process involves:

1. A research program in which exhaustive studies are made on a laboratory scale to determine the best and most economical methods.
2. A complete testing of the proposed methods on a slightly larger scale to determine if the process can be scaled upward.
3. Pilot plant runs in which the process is tested and altered to meet the requirements for full-scale production.
4. The design of a production plant, based upon all collected data, only after it has been proved conclusively that the process is feasible for full-scale operation.

The urgent military need for plutonium did not permit following this procedure. Instead of a comparatively slow and exhaustive research program pursued by a small group in one organization, an all-out effort was made by scientists and technical personnel from all parts of the country. Most of the work was done at the Metallurgical

Laboratory of the University of Chicago but the facilities of other universities as well as research foundations and industrial organizations were utilized whenever possible. The design of the production plants was made directly from the results of laboratory-scale research or, in some cases, concurrently with it. Development work was confined to studying alternate processes which could be used in the large-scale separation plants as designed. Time did not permit pilot plant studies of the water-cooled transmutation unit ("Pile"*). Economy could be considered only when it would not delay delivery of the final product or tend to reduce the certainty of success.

4-6. Research. - The research program for the Pile Project was conducted under the auspices of the Metallurgical Laboratory of the University of Chicago (See Vol. 2). This group was organized in January 1942 under the NDRC and has functioned as the research organization of the Pile Project under the OSRD and the Manhattan District. This program was designed to furnish the essential information necessary for the design and operation of full-scale production plants within the shortest possible time. This necessitated assembling an unusually large group of technical personnel and constructing new laboratory facilities. The work involved theoretical nuclear physical calculations, physical measurements, metallurgical and chemical experiments, and extensive health studies. In addition, the research group furnished consulting services for the design, construction, and operating forces for the production plants. The quality of the work done by this group is shown by the successful operation of the production plants (See Vol. 6) and the fact that these plants were delivering plutonium approximately three years after the centralization of research under the Metallurgical Project.

4-3. Development. - The Clinton Laboratories was designed and constructed at Oak Ridge, Tennessee, as a "semi-works" and pilot plant for the development of the "separation chemistry" of the Pile Project. This was not a true pilot plant since the research was not sufficiently advanced at the time operations began at Clinton Laboratories and, because of military necessity, it was imperative that design and construction of the production plants at the Hanford Engineer Works proceed before pilot plant results could be obtained. In fact, design work on the Hanford plants and the Clinton Laboratories was progressing at the same time. Results were obtained, however, at Clinton Laboratories in time to aid considerably in the solution of operating problems at the Hanford Engineer Works.

4-4. Design. - The design of the production plants at the Hanford Engineer Works required complete cooperation between the research and design organizations, since these plants were the first of their type to be designed and the design had to be sufficiently flexible to permit changes dictated by subsequent research and operation. This was particularly true in the design of the Separation Plants which were finally designed for the use of either of two processes. The quality of the design work was shown by the ability of the Piles to operate under unforeseen conditions and the ability of the entire plant to produce at or above the proposed capacity (See Vol. 6).

4-5. Selection of Contractors.

a. University of Chicago. - The contract for the research work on the Pile Project was awarded to the University of Chicago as contracting agent for the Metallurgical Laboratory which was established there. Dr. A. H. Compton, a University of Chicago physicist, was named program chief for the Pile Project in December 1941 and he immediately began to organize a research program. Since the University of Chicago was centrally located and had more facilities available for this type of research than other universities, and since housing facilities were more easily available there, Dr. Compton began to centralize the research work at the University of Chicago in January 1942. When the Manhattan District assumed jurisdiction over the research work on the Pile Project in May 1943, the program at the University of Chicago was well organized. A new contract was awarded, therefore, to the University of Chicago for conducting research and development work leading to the design, construction, and operation of chain-reacting production plants and chemical separation plants. This work was undertaken by the university on a non-profit basis. As the Metallurgical Laboratory expanded, the University of Chicago Maintenance Department remodeled many university buildings for use by the various research groups. The Metallurgical Laboratory was chosen for the operation of the Clinton Laboratories because of its experience on the project.

b. <u>Stone and Webster Engineering Corporation.</u> - In the summer of 1942, a section of the Argonne Forest, about 20 miles southwest of Chicago, Illinois, was leased to provide a more isolated site for the erection of Piles and attendant laboratories. The Stone and Webster Engineering Corporation had been awarded a contract to perform architect-engineer-management services for construction work at the

Clinton Engineer Works. Since it was already doing work for the Manhattan District, the Stone and Webster Engineering Corporation was awarded the contract for the construction work at the Argonne site. Upon completion of the Argonne National Laboratory buildings, the phase of work carried on by the Metallurgical Laboratory was transferred to that location, operated by the University of Chicago with a new contract replacing the original arrangments.

c. <u>E. I. du Pont de Nemours and Company, Inc.</u> - The Top Policy Committee decided that it was advisable, for efficiency and security, to assign the work of designing, constructing, and operating the semi-works and production plants (Hanford Engineer Works) to an established industrial organization (See Vols. 3, 5 and 6). The scope of the work would require an extensive technical staff and a construction organization capable of undertaking a task of this magnitude. In view of its industrial experience, its well-developed scientific and technical organizations, its past performance on Corps of Engineers contracts, and the fact that it could divert competent personnel to this work without endangering its other commitments, E. I. du Pont de Nemours and Company, Inc., was approached. After the scope of the work had been explained to W. S. Carpenter, Jr., President of du Pont, and after conferences between General L. R. Groves, Colonel K. D. Nichols, Dr. A. H. Compton, and N. Hilberry and the du Pont Executive Committee, at which the urgency of the Project was emphasized, the du Pont Company agreed to proceed with the work on a cost-plus-fixed-fee basis. To carry out its assignment on the Pile Project Program, the Company made available the major portion of its design and construction organization. At the peak of activity, June 1944, approximately 90% of its design and construction forces were employed on the Pile Project Program. Personnel were transferred from other du Pont plants and trained for Hanford Engineer Works operation at the Metallurgical Laboratory and at Clinton Laboratories. The Prime Contractor awarded many subcontracts for specialized work, in order to facilitate construction by utilizing as much privately owned equipment as possible and to reduce the burden of labor recruitment.

d. General Electric Company. - On 1 September 1946, assumption of responsibility relative to operation of the Hanford Engineer Works and allied research was undertaken by the General Electric Company. The new contract for operation was identical to that under which du Pont had operated from the completion of construction in March 1945 until 1 September 1946, the change being the result of du Pont's voluntary retirement from the atomic field.

4-6. Coordination. - The success of the Pile Project is the achievement of the combined efforts and resources of our scientific institutions, industrial organizations, and Government. The coordination and direction of this Project, with its profuse scientific and engineering problems, have been a great feat of administration. The exceptional degree of success is attributable to the high calibre, close cooperation, and foresight of those persons representing the several responsible organizations in management, scientific and technical advancements, and engineering.

SECTION 5 - COSTS

5-1. General. - The total cost of the Pile Project to 31 December 1946 was approximately $487,753,108, according to the latest available data. This sum includes the costs of the Metallurgical Laboratory, Clinton Laboratories, and the Hanford Engineer Works. Not included in the above sum are the costs of: district overhead; military salaries; feed materials; and other plants or projects under the Manhattan District, which may be applicable, in whole or in part, to the Pile Project.

5-2. Metallurgical Laboratory. - The total cost of the Metallurgical Laboratory to 31 December 1946 was approximately $32,894,288. A breakdown of this cost shows that $2,964,272 was spent for remodeling existing facilities and for new construction, and that operating expenses were approximately $29,880,506, while settlement of restoration claims amounted to $49,510 by the end of 1946.

5-3. Clinton Laboratories. - The total cost of Clinton Laboratories to 31 December 1946 was approximately $35,291,000. A breakdown of this sum shows that the cost of construction was $13,041,000 and the cost of operations was approximately $22,250,000.

5-4. Hanford Engineer Works. - The latest available data shows that the total cost of the Hanford Engineer Works to 31 December 1946 was $419,567,820. The cost of construction, $348,101,240, including $2,881,868 for design, is for all construction completed prior to 30 June 1945 but includes liquidation of Project obligations and cost adjustments through 31 December 1946. The operation cost, based upon the cost-plus-fixed-fee prime contract and Government hired labor through 31 December 1948, was $71,446,580. Area overhead for construction and operation was $8,088,064. Deposits, including insurance deposits of $13,512,008 (G.E.) and $10,500,000 (du Pont), welfare deposit of $5,000,000, deposit for unclaimed checks of $7,590, and a power deposit of $1,012,651 with the Bonneville Power Administration, total $30,032,250. These deposits represent expenditure of Project funds but are not carried as part of construction or operation costs since such monies will revert to the Government at a later date.

SECTION 6 - INTELLIGENCE AND SECURITY

6-1. General. - The intelligence and security program established for the Manhattan District (See Book I, Vol. 14) was closely followed in all phases of the Pile Project. Since the nature of this work directly affected the outcome of the war it was necessary that the strictest secrecy be maintained.

6-2. Employment. - Each applicant for employment on the Project was required to execute personal history questionnaires and to furnish proof of citizenship. Wherever possible the applicant's personal history was checked before he was employed to ensure that he met the requirements established for his particular assignment. In most cases this pre-employment check was not possible and the employee was put to work immediately, although not accorded access to classified information or areas until he had been cleared.

6-3. Distribution of Information. - Each person on the Project, regardless of position or rank, was allowed to obtain only such information as was essential for the performance of his particular job. Employees were permitted to enter only those areas or buildings in which they worked. Through the medium of an educational program consisting of security training films, editorials, talks, signboards, and posters, personnel were constantly reminded of their individual obligations both under Project regulations and the Federal Espionage Laws.

6-4. On-Project Investigations. - All cases of possible espionage, sedition, sabotage, or treason were promptly investigated by the

Security and Intelligence Offices. All rumors regarding the purpose of the Project, health hazards, or other rumors which might create unrest among the personnel were promptly traced to their source and disciplinary action was taken in the form of termination or reprimand.

6-5. Physical Security. - All work areas were fenced and patrolled by the Contractor's guards. Key buildings were further restricted and only those persons wearing badges with special designation were permitted to enter them. Perimeter patrol of the Hanford Engineer Works has been conducted by a Military Police Detachment and was supplemented by aerial patrol of the entire reservation.

6-6. Security of Information. - All Project personnel were cautioned to refrain from writing or speaking about the Project. News publications and radio stations were contacted and requested to delete and not seek any information regarding the Project. This was a particularly difficult problem in respect to the newspapers in towns near the Hanford Engineer Works, where the great influx of population with its attendant problems, the Government acquisition of such a large area, and the obvious size of the Project aroused considerable speculation. In general, the newspapers and other news agencies cooperated fully, and local outlets were given releases of news items on Richland community activities which could not affect the security of the Project, thus tending to treatment of the town as a normal community rather than focusing special attention to it.

SECTION 7 - LAW ENFORCEMENT AND JURISDICTION

7-1. General. - Because of the comparative magnitude of the Hanford Engineer Works and the number of persons employed during the construction period, the problem of law enforcement and jurisdiction was much greater than that encountered at the University of Chicago or at Clinton Laboratories.

7-2. Jurisdiction. - At the inception of the Hanford Engineer Works Project, the problem arose as to whether or not the United States should obtain exclusive jurisdiction over lands acquired for the Project. Under existing laws of the State of Washington concurrent jurisdiction only is ceded to the United States over lands acquired by it. Federal Law requires that the Secretary of War accept the jurisdiction ceded by the State before it becomes effective. In connection with this Project, the Secretary of War, by letter written early in 1943, requested the Governor of the State to have legislation enacted granting the United States exclusive jurisdiction. This, the Governor did not deem advisable, and it became necessary to determine whether concurrent jurisdiction should be accepted. After conferences between State and Federal officials it was decided that concurrent jurisdiction would lead to confusion so it was decided to leave the administration and enforcement of State laws to the State and/or its subdivisions so long as such laws did not unduly interfere with the prosecution of the Project. Most of the Project lies within Benton County and as the county was not prepared to assume the entire burden the Benton County Sheriff deputized the Prime Contractor's patrolmen. These patrolmen were then empowered to enforce the laws of the State of Washington and to apprehend violators as well as perform their regular duties of protecting the Project. The highways on the Project could not be classed as public highways so the Commissioners of Benton County enacted a set of traffic regulations to be enforced by the special deputies on the Project. Other State laws pertaining to public health, sanitation, hunting, and fishing are administered and enforced throughout the area. Schools on the area are part of the State school system.

7-3. Law Enforcement. - The Hanford Engineer Works Patrol was organized to protect the security of the Project and to prevent sabotage or other acts against Government property on the Project. In addition, patrolmen were designated deputy sheriffs of Benton County to enforce State and local laws and to apprehend violators. The Patrol was directed from Hanford during the early part of the construction period and in August 1944 headquarters was moved to Richland. The Hanford Engineer Works was designated as Total Exclusion Area No. 3 by Lieutenant General J. L. De Witt, Commanding General, Western Defense Command on 14 July 1943. This proclamation and subsequent rulings by Colonel K. D. Nichols, District Engineer, Manhattan Engineer District, and Colonel F. T. Matthias, Area Engineer, Hanford Engineer Works, prescribed the conditions that would be met by any person entering, remaining on, or leaving the area. All articles of contraband, such as cameras, firearms, and liquor, found on persons entering the plant area are confiscated by the Patrol or Military Police and held for the owner until he leaves the area. During the construction period a clerk of the Kennewick, Washington, Justice of the Peace Court was stationed at Hanford and a jail was established as a branch of the Benton County Jail. From May 1943 to August 1944 a total of $72,[illegible] was collected by Benton County as bail forfeitures and fines on the Project.

SECTION 8 - CARE OF REAL ESTATE

8-1. General. - The size of the land area, approximately 670 square miles, of the Hanford Engineer Works indicates a problem in the care of real estate which was practically nonexistent at the University of Chicago or at Clinton Laboratories. Included in the Hanford Engineer Works site were several communities, many farms and orchards, two irrigation districts, one State highway and many county highways and village streets, three electric power systems, and a branch line of the Chicago, Milwaukee, St. Paul and Pacific Railroad (See Vols. 4 and 5).

8-2. Village Residences and Business Buildings. - In the actual plant areas all dwellings and business buildings were boarded up as the original occupants moved out. In the Richland Area all of the usable buildings were used during the construction period and then converted for other use, dismantled, or boarded up, except for a few of the better dwellings which are still occupied. All buildings that have been boarded up are inspected frequently to check on their condition.

8-3. Farms and Orchards. - Many of the farm buildings were used during the period of peak population but have since been vacated and the better ones boarded up and checked frequently as the farms will be worth more for future sale if the buildings are maintained. Most of the farms and orchards have been operated since the acquisition of the land. In the plant areas, however, it was believed that the farms and orchards should not be operated after the plants went into operation as the hazard to scattered groups that could not be evacuated quickly would be too great. The Federal Prison Industries entered into a contract in the summer of 1943 to take care of the farms and orchards. Prisoners do the work and the crops become the property of the Federal Prison Industries and the food is processed at McNeil Island Prison, on Puget Sound. In the spring of 1944, plant operation made it necessary to cease operation of approximately [illegible] acres of orchards in the Hanford-White Bluffs area. In addition to caring for the orchards and crops the prison labor maintains pipe lines, fences, and other farm property to protect the Government's investment in the land.

8-4. Irrigation Districts. - Two irrigation districts, Priest Rapids and Richland, served the area acquired by the Government and the complete irrigation districts were also acquired. The Priest Rapids Irrigation District, consisting of a pumping station at Allard and a power generating plant at Priest Rapids served the plant areas. The pumping station has been closed and is in a stand-by condition while the power plant has been leased to the Pacific Power and Light Company and is operated by that company. The Richland Irrigation System has been improved and is used both in the village and for the farms and orchards operated by Federal Prison Industries.

8-5. Streets and Highways. - Most of the streets and highways on the area were improved and have been used either as temporary or permanent area roads. Many of the existing streets in Richland could not be incorporated into the new village, so they were abandoned.

8-6. Electric Power Lines. - Three electric power systems served the area prior to its acquisition for the Project. The Rural Electrification Administration distribution line serving Richland was taken over and largely dismantled. A Bonneville Power Administration line crossed the Project and its custody remained with the Bonneville Power Administration under an agreement with the Army. The entire Pacific Power and Light Company system within the area, a transmission line from Cold Creek to Hanford and thence south through Richland and distribution systems in the Hanford-White Bluffs area and in the Richland area, was purchased by the Government. The transmission lines are maintained, the one from Hanford to Richland being used for area transmission, and will revert to the original owner or be relocated later.

8-7. Railroads. - The Chicago, Milwaukee, St. Paul and Pacific spur line to Hanford, about 25 miles, was purchased by the Government and has been improved and maintained by a subcontractor.

SECTION 9 - ORGANIZATION AND PERSONNEL

9-1. General. - The Pile Project was originally formed under the National Defense Research Committee of the Office of Scientific Research and Development and later was reorganized directly under the Office of Scientific Research and Development. The Manhattan District of the Corps of Engineers gradually assumed control from August 1942 until assuming complete jurisdiction on 1 May 1943. The work continued under the existing contracts and new contracts were awarded as the Project expanded. Only organizations and personnel that were concerned with several phases of the Pile Project will be mentioned here. Contributions of organizations and personnel to any particular phase of the Project are discussed in the respective succeeding volumes.

9-2. Government.

a. National Officials. - The Pile Project was authorized by the President of the United States, Franklin D. Roosevelt, and periodic reports on its progress were made to him until his death and subsequently to President Harry S. Truman. Serving on the Top Policy Committee were the Vice President of the United States, Henry A. Wallace; the Secretary of War, Henry L. Stimson; and the Chief of Staff, General George C. Marshall.

b. Research Agencies. - Prior to the formation of the Manhattan Engineer District, the Pile Project was under the direction of Dr. V. Bush, Chairman of the National Defense Research Committee and later Director of the Office of Scientific Research and

Development, and Dr. J. B. Conant, his assistant. The program chief for the Pile Project was D. A. H. Compton.

c. Manhattan Engineer District. - The Manhattan Engineer District of the Corps of Engineers was formed during August 1942 by Colonel J. C. Marshall. On 17 September 1942 Brigadier General, now Major General, L. R. Groves of the Corps of Engineers was placed in complete charge of all Army activities relating to the Manhattan District Project. Brigadier General T. F. Farrell has acted as General Groves' deputy. Colonel, K. D. Nichols served as District Engineer of the Manhattan Engineer District with headquarters at the Clinton Engineer Works, Oak Ridge, Tennessee. Colonel F. T. Matthias has served as Deputy District Engineer in charge of the Pile Project and area offices have been maintained at Wilmington, Delaware; Chicago, Illinois; Clinton Laboratories, Oak Ridge, Tennessee; and Hanford and Richland, Washington.

9-3. Contractors.

a. University of Chicago. - Dr. A. H. Compton has been Project Director of the Metallurgical Project with headquarters at the University of Chicago.

b. E. I. du Pont de Nemours and Company, Inc. - The E. I. du Pont de Nemours and Company, Inc. designed and constructed Clinton Laboratories and the Hanford Engineer Works and have operated the Hanford Engineer Works. W. S. Carpenter, Jr., as president of the company, entered into preliminary contract negotiations with the OSRD and the Army, represented by the Manhattan District. Decisions affecting policy or new projects are referred to the Executive Committee and major decisions must be approved by the board of directors. The work on the Pile Project was assigned to the Explosives Department of which W. H. Ward is General Manager. The TNX Division of the Explosives Department was organized under R. Williams, Assistant General Manager of the Explosives Department, to assume responsibility for the operation of the Hanford Engineer Works and to furnish technical assistance for design and construction, which were under the supervision of E. G. Ackart, Chief Engineer of the Engineering Department.

e. General Electric Company. - The General Electric Company took over operation of the Hanford Engineer Works on 1 September 1946 under a contract identical to that under which du Pont operation was conducted. The General Electric share of the atomic program is directed by C. E. Wilson, President of the Company, while D. H. Lauder, as Works Manager and assisted by G. G. Lail and C. C. Tallman, has assumed local supervision of the production, research and related activities of the atomic mission.

MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

VOLUME 1 - GENERAL FEATURES

APPENDIX A

GLOSSARY

__Alpha Particle.__ - An alpha particle is the nucleus of the helium atom. It is composed of two protons and two neutrons and has an atomic number of two and an atomic mass of four.

__Artificial Disintegration.__ - The breaking up of an element which has been exposed to bombardment with particles such as neutrons or protons.

__Atomic Mass.__ - Atomic mass is the relative weight of any atom compared to 16 for oxygen. It is equal to the total number of protons and neutrons in the nucleus.

__Atomic Number.__ - The atomic number of any atom, or element, is equal to the number of protons in the nucleus of the atom. Since the proton possesses a unit positive electrical charge, the atomic number is also equal to the net positive charge on the nucleus.

__Beta Particle.__ - A beta particle is an electron which, for convenience, may be assumed to have been associated with a proton in the nucleus of an atom in the form of a neutron. Thus, when a beta particle is emitted, the nucleus contains one more proton than before resulting in transmutation to an element one number higher in the atomic scale.

__Chain Reaction.__ - The term chain reaction refers to the method of conducting the fission process so that it is self-contained and self-perpetuating.

Disintegration. - Disintegration is a term used to describe the breaking up of an atom under certain conditions. If an atom disintegrates naturally, it is radioactive. Artificial disintegration is that resulting from the bombardment of an atom with sub-atomic particles.

Gamma Radiation. - Gamma radiation is the radiation of energy resulting from the complete conversion of mass to energy. The gamma ray has zero electrical charge and zero mass and possesses a frequency which is dependent upon its energy. Gamma rays may be likened to light rays or X-rays, differing from them only in frequency and energy. Gamma rays are emitted from many radioactive substances.

Half Life. - Half life is the term applied to the period in which the activity of a radioactive substance decreases to half of its initial value. It varies from 3×10^{10} years for thorium to 0.002 seconds for one isotope of actinium.

Neptunium. - Neptunium is the chemical element of atomic number 93. It is manufactured in the Hanford process and decays to the Hanford product, plutonium.

Pile. - A term used to describe the unit consisting of a lattice arrangement of cylindrical pieces of uranium metal and a light weight material, usually graphite, such that the proper conditions for the continued fission of the uranium are obtained with the subsequent production of plutonium.

Pilot Plant. - A pilot plant is a small-scale production plant, used experimentally for research and to determine the best design for large-scale production units.

Plutonium. - Plutonium is the chemical element of atomic number 94. It is the product of the Hanford process and constitutes the end toward which all manufacturing operations are directed.

Proton. - The proton is a sub-atomic particle and is one of the constituents of every known substance. Protons are associated with neutrons to form the nucleus of each atom of every chemical element except hydrogen, the nucleus of which contains only one proton. The number of protons in the nucleus identifies the element.

Radioactivity. - Radioactivity is the phenomenon of spontaneous disintegration of elements accompanied by the emission of rays. Natural radioactivity is shown usually by elements of atomic weight higher than lead and is not affected by chemical or physical influences. Artificial radioactivity is a temporary radioactivity caused by bombardment of an atom with sub-atomic particles.

Semi-works. - A semi-works is a development laboratory in which the equipment and batches handled are larger than those used in regular laboratory research. The semi-works stage is the intermediate stage between laboratory research and pilot plant development.

Separation Chemistry. - The term separation chemistry refers to the study of the chemistry of the various processes for the separation of plutonium from uranium and fission by-products.

Slow Neutrons. - Slow neutrons, also called thermal neutrons, are those of lowest velocity and energy. They are captured more readily by nuclei of uranium and plutonium than are neutrons of any other velocity and energy.

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