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~~BOOK V – ELECTROMAGNETIC PROJECT~~

VOLUME 1 – GENERAL FEATURES

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

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FOREWORD

This volume of Book V of the Manhattan District History, ("Electromagnetic Project"), entitled "General Features", includes the information applicable to the Electromagnetic Project as a whole, and, in addition, contains a brief summation of information in the other five volumes. Direct references to documents substantiating the summarized information have been omitted from this volume, since the references appear in the other volumes, which bear the following titles:

Volume 2 - Research
Volume 3 - Design
Volume 4 - Silver Program
Volume 5 - Construction
Volume 6 - Operation

Each of the words and phrases which are defined in the Glossary, Appendix C, is designated, at its first appearance in the main text, by an asterisk (*).

In conformity with the other volumes, General Features covers the period from the inception of the project in June 1942 to 31 December 1946.

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

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SUMMARY

1. Introduction. - The Electromagnetic Project was one of the components of the Manhattan District, charged with separating the Uranium Isotope 235 from normal uranium in sufficient quantity and of concentration satisfactory for use in atomic weapons. To perform this function, it was necessary, to carry on a vast program of chemical and physical research, to design a large and complex plant and equipment without the benefit of pilot plant or intermediate development. Speed in beginning production was paramount and complete secrecy was essential to the success of the undertaking. An operating force had to be recruited and trained in an entirely new operation.

2. Development of the Project. - Although the separation work done in 1940 seemed discouraging for this process as a method for accumulating large amounts of relatively pure isotopes, Dr. E. O. Lawrence, of the University of California Radiation Laboratory (UCRL) had faith in the electromagnetic method, and conducted the research that led to the acceptance of the process and the ultimate building of the Electromagnetic Plant at Oak Ridge, Tennessee. This plant was authorized in June 1942 by the President of the United States under the War Powers Acts. Major General L. R. Groves was placed in charge of the Manhattan District, and directed the activities of the Electromagnetic Project as one of the components of the District. General Groves delegated authority to the District Engineer, who in turn, put Construction and Operations Officers in charge of these phases of work at the Electromagnetic Plant. Design, construction and operating organizations were carefully selected to carry out the work,

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and various research organizations were chosen to ~~advise on~~ work out the several phases of the project. A program was started at the University of California Radiation Laboratory (UCRL) to devise huge electromagnets and mass spectrographs that would transform the laboratory methods into large-scale production. This program was actually a continuation, under the direction of the Manhattan District, of work which had been conducted there by Dr. E. O. Lawrence and his associates. Extensive research work in both physics and chemistry was necessary before production of U-235 by this method could be accomplished. The research in physics was primarily concerned with the mass spectrograph. In addition to this, much work had to be done on the huge electromagnets which were to be an integral part of the process. A chemical compound of uranium suitable for use in the mass spectrograph was known but only laboratory methods were available for its manufacture. It was shown at UCRL that most of the material charged into the mass spectrograph would scatter itself about the equipment. Therefore, suitable production methods had to be devised for the recovery of this material. These and many other chemical problems such as recovery of material alloyed in metal and embedded in carbon, and the preparation of final product had to be solved before large-scale operations could be successfully carried out.

3. <u>Description of Plant.</u> - To provide a suitable process, it was necessary to have two ~~sets~~ types of mass spectrographs, called Alpha and Beta. The Alpha mass spectrographs, utilizing normal uranium, produced a product far richer in U-235, but still short of requirements. This product was then used as a feed material for the Beta mass spectrographs. In this way, a final product was obtained from the Beta mass spectrograph, which was suitable for military use.

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Even though better methods were under development, the first workable designs were adopted, ~~instead,~~ [in order] to get into production. It is certain that if this had not been done, a much better plan would have been obtained on paper, but the plan would not have been able to produce the desired product on time. ~~However so,~~ [Nevertheless,] during construction and even when operation had already started, many changes were made for the improvement of the process.

In February 1943, the excavation was begun for the first building to house Alpha mass spectrographs. It was planned that the Y-12 Plant would be comprised of 3 Alpha buildings and one building containing Beta mass spectrographs. The original plan called for uniformity among the 3 buildings containing Alpha mass spectrographs, but developments by July 1943 permitted a change in the mass spectrographs used in the 3rd building. In September 1943, authorization was given to construct Y-12 Extension, a program which promised to ~~more than double~~ [increase] the output of the plant. The plans called for 2 new buildings containing improved Alpha racetracks, and one new building containing Beta racetracks. The construction which had started on the first set of Alpha mass spectrographs in February 1943 was completed by the end of November 1943, a period of 10 months. The final set of Alpha mass spectrographs in the Y-12 Extension was ready for operations in July 1944. Since the Alpha portion of the plant was to supply feed material for the Beta portion, emphasis was placed first on completion of the Alpha mass spectrographs. It was for this reason that the construction of the first building housing Beta mass spectrographs was not started until May 1943. Construction of this building was not completed until March 1944.

First training operations were ~~given~~ [carried out] in the Alpha XAX development

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units. This was a small group of mass spectrographs which served as a pilot plant and research plant for the Alpha system. The trained personnel was transferred to the first Alpha building as soon as the construction had advanced enough to allow it. Attempts to operate the first set of mass spectrographs were, to say the least, not auspicious. Short circuits within the huge electromagnets occurred continually and finally resulted in most of the installation being dismantled for repair. It was discovered that moisture and sediments of metal scale in the oil cooling system were causing the failures. The magnets were re-worked and oil filters were installed to prevent recurrences of this difficulty. Material rich in 235 was badly needed at the laboratory in Los Alamos for experimentation. Therefore, early shipments of Alpha product to Los Alamos prevented the use of this material in the Beta system. In May 1944, shipments of Alpha product to Los Alamos ceased, and the material began to be used in the Beta process. In early June, 1944, the first shipment of Beta material was made to Los Alamos. Though the progress was very slow and operations were hampered by many difficulties, the concentration of the product inched upward and the production rate increased. By the end of 1944, all of the Alpha mass spectrographs were in operation and some of the Beta spectrographs were using Alpha product as feed. S-50, the Liquid Thermal Diffusion Plant, and K-25, the Gaseous Diffusion Plant, were able to supply a material slightly enriched in uranium 235. In March 1945, the Alpha mass spectrographs began operating on the product from these plants. The effect of this was to increase the production rate of the Alpha process as well as the concentration of U-235 in the Alpha product. Beta process meanwhile continued to produce more and more, as operators became more skilled, improvements were made in the machines and more feed became available from the Alpha process. In June 1945, the material produced at K-25 was sufficiently rich in Uranium 235 that it began to be used ~~as going~~ directly ~~to~~ the Beta process with the result that the production of Beta product almost doubled. At the beginning of September, after Japan had been defeated, ~~and it had become apparent that no difficulties would be experienced in the occupation of the Japanese Islands,~~ the plan to close down the Alpha Plant was carried out. By this time, K-25 was supplying enough material to support the entire Beta portion of the plant and, furthermore, the concentration of uranium 235 in the K-25 product was higher than Alpha had been able to produce.

The cost of Y-12 can, for convenience, be divided into five categories: research, engineering and design, construction, operation and fixed fees. In round figures, through 31 December 1946, these expenditures were as follows: research--20 million, engineering and design--6 million, construction--304 million, operation--237 million and fixed fees--6 million dollars.

4. Organization and Personnel. - The first Unit Chief and Operations Officer for Y-12 was Major W. E. Kelley, who was succeeded by Lt. Colonel J. R. Ruhoff in September 1944. Lt. Colonel J. R. Ruhoff was succeeded on 9 November 1945 by Colonel G. J. Forney, who continued as Unit Chief and Operations Officer until this date, 31 December 1946. The research organizations associated with the Y-12 project from the University of California, Brown, John Hopkins, and Purdue Universities had as their heads, Drs. E. O. Lawrence, C. A. Kraus, H. T. McBee and W. E. Burford, respectively. Mr. A. C. Klein headed the Stone and Webster Engineering Corporation operating organization.

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

SECTION 1 - INTRODUCTION

1-1. Purpose. - The purpose of the Electromagnetic Project was to separate sufficient quantities of uranium 235 from "normal uranium",* to permit the secret development and use of atomic weapons, in time to be of military value during World War II.

1-2. Relationship with the Goal of the Manhattan District. - The Electromagnetic Project (Y-12) was one of several projects directly concerned with obtaining material of the right ~~properties~~, concentration ~~and purity~~ of U-235 for use in atomic weapons. There were other projects based upon different methods of separation of uranium 235 or the manufacture of "plutonium."* The District obtained and supplied feed material to all of these several interdependent projects.

1-3. Scope.- The Electromagnetic Project, one of the largest and costliest of the several interrelated components of the Manhattan District, was a huge complex undertaking that cost more than 400 million dollars and employed many thousands of workers throughout the United States. The scope, in general, included the development, design, construction, operations and plant research necessary to attain the purpose indicated above and set forth in contracts. The plant as first planned was to have a daily capacity of 100 grams of the isotope U-235, in a degree of concentration to meet the requirements for military use. Additional construction and improvements in process ~~more than doubled~~ materially increased the capacity (See Vol. 3 Design). Later enriched feed (material carrying a much higher concentration of U-235 than the 0.7 percent found in normal uranium) from the Gas Diffusion Plant, increased the effective production many times (See Vol. 6 - Operations.)

The greater part of the research which justified and supported the project was performed under the direction of Dr. E. O. Lawrence at University of California Radiation Laborator~~ies~~y (UCRL), although several other universities and agencies made important contributions. The main plant, made up of over two hundred permanent buildings and structures, is located at the Clinton Engineer Works (CEW), Oak Ridge, Tennessee, and represents the combined efforts of several of the largest equipment manufacturers and constructors in the nation.

1-4. Authorization. - 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. Under the authority vested in him by these Acts, the President issued orders and authorizations which are described in the same book (Book I). 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.

1-5. Administration. - The practicality of the electromagnetic method having been established and the authorization for the project having been obtained, it was necessary to select the various organizations that would participate in the work. The role of the War Department, represented by the Manhattan District, was to determine policy and to coordinate activities of all groups engaged in the Y-12 project. Originally the Stone & Webster Engineering Corporation was selected to design, build, and operate the plant (See Vol. 3 - Design). It was soon evident that this would be too great a load for the single organization and that another company would have to be chosen to carry out the operations of the plant. Volume 3 and Volume 5 give the details concerning the problems of design and construction and their solution by Stone & Webster working with equipment manufacturers and other subcontractors. The Tennessee Eastman Corporation was awarded a contracted to carry out the operation of the plants (See Vol. 6 - Operation). Since the process had been developed in the Radiation Laboratory of the University of California (See Appendix B18 & 19), this group was retained under contract to continue research on the project. Also, experimental work was carried out by groups at Purdue, Brown, and John Hopkins Universities (See Volume 2 - Research). Each of these organizations ~~reported to the~~ was under the general supervision of District Engineer; however, cooperation was the theme, and ideas were freely exchanged and assistance was rendered by each group whenever possible to carry the purpose of the project to completion with maximum speed.

SECTION 2 - DEVELOPMENT OF THE PROJECT

2-1. Initial Manhattan District Work. - Simultaneously with the formation of the Manhattan District in August 1942, work was begun on the Electromagnetic Project in accordance with the requirements of the President's Directive. The District Engineer established contact with the University of California, and, through the Office of Scientific Research and Development, arranged for the continuation of experimental work directed by Dr. E. O. Lawrence. The Stone and Webster Engineering Corporation, engaged as Architect-Engineer-Manager for the project, set up a design office at the University of California, a design and procurement office in Boston, and sent parties to CEW to select a suitable plant site. With this beginning, the District entered into a full-scale program of research, design and construction which culminated in a huge plant of nine main process buildings and over 200 additional buildings for auxiliary functions.

2-2. Research. - Although most of the fundamentals of isotopic separation were known, incredible amounts of research work had to be done on every phase of the project.

This research had to be done on materials of construction, auxiliary equipment and devices, chemicals used for and in the process, and physical research on the process itself. The physical research alone resolved itself into three major problems: source research which concerns itself with vaporizing, ionizing and accelerating the ions into a magnetic field; magnetic field research to bring about the proper focusing of the accelerated ions through the use of shims and other devices for reception in the receiver; and the receiver research which included such problems as material for receiver to withstand heat and corrosion from the high speed impounding ions and a design for receiving the separated beams of ions of maximum purity and minimum loss through bouncing out of receiver. For a more complete understanding of these research problems and programs, see Volume 3 - Research.

2-3. <u>Design</u>. - For the purpose of this volume, it is only necessary to indicate groupings or classifications of design that contribute to a logical sequence and purpose along two principal lines. One phase of design deals primarily with the buildings, the equipment and the devices necessary to carry on the chemical processes of preparation, utilization and recovery of uranium in the process. This would include changes in design, construction and ~~placements~~ installation to meet the requirements for modifications and improvements in chemical methods. ~~to take care of improvements in process in growth, in concentrations and criticality requirements.~~ The other line deals with the process of isotopic separation. These process designs may logically be grouped around (1) original design, (2) extension, (3) 3rd Beta building, (4) 4th Beta building, and (5) modifications of existing design.

The original design of the electromagnetic plant was made to conform to specifications to produce 100 grams per day of U-235. The design called for two stages, termed Alpha and Beta, and required three Alpha buildings, with two "racetracks"* in each of two buildings, and one racetrack in the third building. Each racetrack would have 96 process bins*. The second stage Beta would require one building with two racetracks of 36 bins each. A major change in design was introduced in Track 5 in the third Alpha building to provide a four beam "hot source"* unit.

The design for the extension dates from the decision made in September 1943 to ~~triple, approximately,~~ increase the design capacity of Y-12 facilities. This required the building of four more race tracks, 96 bins each provided with a four beam "hot source" unit, designated Alpha II. In May 1944, upon a re-analysis of Alpha production increase, due to enriched (enhanced) feed from the Liquid Thermal Diffusion Plant, it was decided to duplicate the 2nd Beta building, with minor changes.

Beta Process Building No. 4, in anticipation of feed from the Gas Diffusion Plant that could go directly to Beta, was authorized on 31 March 1945. The design of this building was "frozen" as of 1 April 1945 so that it was a duplicate of Beta Building No. 3.

Modifications and changes in design of the Alpha buildings were proposed that would convert an Alpha II track in the extension area to Beta facilities. This change was authorized ~~(but later cancelled on finding that K-25 production material could be used as Beta feed)~~ in late Spring of 1945 to take care of feed from the Gas Diffusion Plant (K-25), but was cancelled later. An Alpha III conversion to increase the number of beams in Alpha process equipment from four per bin to ten to sixty per bin was proposed but never carried out (See Vol. 3 - Design).

The history of design for Alpha and Beta chemistry ~~lends itself to~~ followed the same general lines as outlined above for separation processes. To meet changes in quality and quantity of feed material to be processed, and the concentration and incident critical~~ity~~ness of U-235 in both Alpha and Beta processes, it became necessary to alter old designs and make new ones. This increase in enriched material to be chemically processed made it necessary to authorize and erect a new group of chemical buildings at an estimated cost of $20,000,000.

2-4. Construction. - The construction of the Electromagnetic Plant (Y-12) at Clinton Engineer Works in Tennessee was one of the most complex and difficult problems ever undertaken by a construction contractor. The magnitude of the undertaking and the conditions under which the construction contractor had to work to maintain utmost secrecy as to design, purpose and scope make it impossible to treat the subject properly in less than an entire volume. Volume 5, Book V has been written to cover the subject in justifiable detail.

The Stone and Webster Engineer Corporation was first given the contract to design, build and operate the plant, but the contract was soon modified so that this corporation was to design and build the plant only, and a contract was made with the Tennessee Eastman Corporation to operate the plant. To meet plans and specifications as to time, capacity, and design, Stone and Webster found it necessary to use 88 construction subcontractors and a peak of about 12,000 employees. The first authorized Y-12 plant in March 1943 consisted of three Alpha process buildings, one Beta building, one Alpha and one Beta chemical building, a development building, and the necessary plant auxiliaries. Concurrently with this Y-12 building it was necessary to build the city of Oak Ridge with all necessary facilities, to house not only the employees of Y-12 but also those of the other installations, to a total of 50,000 to 75,000 employees and their families. (See Book I, Vol. 12, Central Facilities).

Such progress was made that, on 19 August 1943, the development plant was turned over to Tennessee Eastman Corporation for operation. The first race track in Alpha building 9201-4 was ready and put into operation on 13 November 1943.

An authorization was given in September 1943 for an extension which ~~trebled~~ materially increased Y-12's size and capacity. This was for two new Alpha process buildings, a second Beta process building, a new Beta chemistry building, and an addition to the Alpha chemistry building. A third Beta process building was authorized in May 1944. A fourth Beta process building was authorized and begun in April 1945 to take care of feed material from the Gas Diffusion plant.

2-5. Operations. - The problems of research, design and construction, already indicated, were not greater than those that were faced by the people whose job it was to make the Electromagnetic Plant work. Not the least of these problems was to recruit thousands of workers including operators, supervisors, electricians, engineers, chemists, and physicists to operate, maintain and improve the process. This was made doubly difficult by lack of experimental background (just ~~two~~ separation machines at Berkeley had heretofore furnished the only analogous experimental experiance) and lack of ~~and~~ facilities such as housing, transportation, and training equipment. The project as a whole seemed stranger than the most fantastic scene from fiction.

In the midst of the din and fury of construction, the first chemical process and racetrack production was started. By April 1944 all four of the Alpha I tracks were operating. About 11,000 persons were employed at Y-12 and were either ~~in~~ training or were already assigned to their jobs in operation (See App. B-11). Beta track 1 (See App. B-12) was started in March 1944 on normal feed (not enriched) to provide training for process operators, to aid in working out chemical recovery problems before introducing the more expensive enriched feed from Alpha, and as far as possible, to correct construction faults in recovery equipment.

In September 1944, Beta track 2 began operation on Alpha product feed; track 3 started on this material in December; and track 4 in January 1945. Alpha tracks 6 and 7 started on feed supplied by the Liquid Thermal Diffusion plant (S-50) in March 1945. The first Beta material was sent to Los Alamos 7 June 1944. The fifth Alpha track, the first four-beam unit, was started in June 1944. This track served as a personnel training unit for the later Alpha II, four-beam units. As fast as the personnel was trained it was divided and a part was sent to each of the these two Alpha II buildings. By the end of 1944 all the Alpha tracks were operating successfully. At this time the Y-12 plant was costing 9 million dollars per month, the total operating expenditures had reached 65 million dollars, and the plant roll had reached 20,000 workers. (See Vol. 6 - Operations.) By July 1945, the Alpha production was 60% higher than at the end of 1944. This higher production rate continued until Alpha shut down in September 1945. The closing down of Alpha was made possible by the ending of ~~the war~~ hostilities and the reaching of high U-235 concentration feed material from K-25 in sufficient quantity to maintain Beta operational demands and production schedules. In June 1945, K-25 began delivering 7% material directly to the Beta cycle, by July the concentration was assaying 10-12%, in August the concentration was 23% and all material of lower U-235 content was being returned to K-25. In August 1945, the personnel in Y-12 Operations had increased to an all time high of over 21,000 and the cumulative operating costs were over 165 million dollars. (See App. A-3).

SECTION 3 - DESCRIPTION OF PLANT

3-1. <u>Description of the Site.</u>

a. <u>Location.</u> - The Electromagnetic Plant is located, along with several other plants under the jurisdiction of the Manhattan District, at the Clinton Engineer Works, approximately 18 miles west of Knoxville, Tennessee. Some 5 miles southwest of the commercial district of Oak Ridge, in a secluded valley, lies the vast group of operating buildings that make up the Electromagnetic plant. ~~So cleverly placed are these buildings that even Oak Ridge residents traveling along the highway toward Knoxville cannot discover the magnitude of the plant~~ (See App. A-6, B-1, 2, 3, 4, 5, 6).

b. <u>Main Features.</u>

(1) <u>Portals.</u> - On approaching the plant from Scarboro Road (See App. A-6), one finds three main gates for entry; namely the East, North, and West portals. These portals include bus loading docks for both local and out-of-town busses, and are surrounded by large parking lots for private vehicles. On passing through the portals, badges are checked by guards.

(2) <u>Process Buildings.</u> - In order to distinguish between buildings in the Y-12 Area, each building was assigned a number. Reference to buildings in this account will be made by number to avoid confusion, and a plot plan (App. A-5) is included showing both the building number and the type of building. On entering North portal there lies immediately ahead the first process building which was constructed. This was Building 9201-1 housing two Alpha I type tracks. (See Vol. 3 Design.) Building 9201-2 housing two more Alpha I tracks was built adjacent to

Building 9201-1 on the east side. East of Building 9201-2 was located the final building of this Alpha section, Building 9201-3, which housed a single track intermediate between the Alpha I type and the Alpha II type and was called Alpha I½. (For comparison of Alpha I and Alpha II tracks see paragraph 2-3 and Appendix A-1. Also see Vol. 3, Design.) The first Beta Building, 9204-1, was built in line with and west of Alpha Building 9201-1. Building 9204-3 was west of 9204-1, Building 9204-2 was north in front of 9204-3, Building 9204-4 was in Y-12 extension just west of Alpha Building 9201-5 (See Vol. 3, Design).

(3) Chemical Buildings. - Near the Alpha I section of buildings, Building 9202 was erected to prepare the feed for the Alpha tracks. Initial Beta chemical operations took place in Building 9203, adjacent to 9202, but these were moved to the new Beta Chemistry Building, 9206, near the Beta track buildings, as soon as it was completed. Although it was never used for the purpose, Building 9207 was built, near 9202, to handle an expected feed with slightly greater concentration of Uranium 235 than natural feed (See Vol. 5, Construction). ~~At present,~~ Building 9212 was erected to handle the final product material as obtained in the Beta track buildings.

(4) Other Buildings. - In order to provide the necessary facilities for operation of the units, other buildings were erected where necessary. These included the hospital, laundry, change houses, warehouses, laboratory buildings, shops, cafeterias, and administration buildings (See App. A-5).

3-2. Security Program.

a. General. - In keeping with the overall security regulations of the Manhattan District, (See Book I, Vol. 14), a Security and Intelligence organization was established at the Electromagnetic Plant to direct all activities pertaining to security. The measures adopted fall into three categories: Military security, guarding government property, and fire protection.

b. <u>Military Security</u>. - Before an employee could be told anything about the project, or admitted to the plant, routine character investigations were made, lectures were given to him stressing the importance of silence about the project, and these were followed up by constant reminders in the form of further lectures, posters, etc. All incidents which might have stemmed from attempts at sabotage, rumor mongering or speculation were thoroughly investigated by the Military Intelligence office and as a result this department produced an excellent record in that there were no losses of time or material attributable to subversive activities at Y-12.

c. <u>Guard System</u>. - The first guards assigned to protect Y-12 were Civil Service and Stone and Webster Engineering Corporation employees. In October 1943, when Tennessee Eastman Corporation was considered to have a sufficient number of well-trained guards, the responsibility for guarding in Y-12 was turned over to them. The duties they performed included safeguarding the entire Y-12 area, checking all persons in and out of the general area by inspecting passes and badges, and guarding certain interior posts which were more restricted than the rest of the installation. Until July 1945, picture passes included letters indicating areas which the bearer could enter, Roman numerals to indicate what information he had access to, and Arabic numerals to show what type of work he did, whether production, research, clerical, chemical, etc.

Subsequent to July 1945, badges with a color band at the top were issued for the several areas, and the numerals and letters were eliminated.

d. <u>Fire Protection</u>. - The Clinton Engineer Works Fire Department was given the responsibility for protecting Y-12 until November 1943, at which time a trained Tennessee Eastman Corporation force took over the duties of fire protection and prevention. The extremely small loss by fire ($35,000 from November 1943 to June 1945; and a total of $38,000 to 1 January 1947) is a measure of the remarkable job done by this department.

3-5. <u>Summary of Costs</u>. - The total costs of the Y-12 project are divided among fixed fee costs, the cost of engineering and design, cost of plant erection, cost of plant operation, and cost of research. The fixed fees for design and construction paid to the Stone and Webster Engineering Corporation under three different contracts totaled approximately $3,400,000 (See Vol. 3, Design). The fixed fees paid to the Tennessee Eastman Corporation for operation, on a monthly basis, to 1 January 1947 totaled approximately $3,000,000. Design costs (excluding fixed fees) amounted to $5,600,000. Cost of plant erection to 1 January 1947, including procurement of materials and the silver program, was $303,394,000 (See Vol. 5, Construction). The cost of operation of the plant to 1 January 1947 was $237,200,000 (See Vol. 6, Operations). The Cost for research for the project to 1 January 1947 was $19,600,000 (See Vol. 2, Research). This makes a total cost of approximately

$672,700,000 for the project as of 1 January 1947. A breakdown of these figures is shown in Appendix A-7.

3-4. "Manhattan District Project Cost Summary". - As explained in Book I, Volume 1 (in Section 4, "Total Costs"), a "Manhattan District Project Cost Summary for the period ending June 30, 1947" was prepared after the termination of the control of the Manhattan District on 31 December 1946. This summary enumerated the expenditures made from Manhattan District funds only, - the so-called "Military" expenditures - some of which were made as late as February 1947.

The total costs of the Y-12 project, which are given in the various other volumes of this book and are summarized in paragraph 3-3 above, may be listed as follows (including fees):

Research	$ 19,642,325
Design	6,628,920
Construction	303,787,178
Silver Program	2,482,620
Operation	240,200,000
Total	$672,741,023

These total costs are also given in the "Manhattan District Project Cost Summary" but are not completely identifiable for comparative purposes, for the reasons described in Book I, Volume 1, with relation to the overall total costs of the Manhattan District.

The following table of Y-12 costs (simplified by combinations of items) is quoted from the "Project Cost Summary":

Research Program		
Capital Costs	$ 17,601,714	
Operation Costs	3,424,555	$ 21,026,269
Main Plant Program		
Capital Costs	$302,047,243	
Operation Costs	229,873,236	531,920,479
Special Operating Materials		349,832
TOTAL		$553,296,580

This total appears in the tabulation of total Manhattan District costs, in Book I, Volume 1, under the item designation "Y-12 and Special Accounts".

SECTION 4 - ORGANIZATION AND PERSONNEL

4-1. <u>General Organization</u>. - The Army, as the governmental agency in charge of developing the Atomic Bomb, formed a separate unit, the Manhattan District, ~~within the Corps of Engineers~~ to take charge of all phases of development. To the District Engineer, acting for General Groves, fell the task of directing the various phases of the work, including overseeing the research, design, construction and successful operation of Y-12. The line of authority is shown in the organization chart reproduced as Appendix A-4.

4-2. <u>Key Personnel</u>. -

a. <u>Military</u>. - From the start of construction operations in 1943 until the fall of 1944, the Unit Chief for Y-12 was Major W. E. Kelley. Major Kelley also occupied the post of Operations Officer. ~~who~~ He was replaced in September 1944 by Lt. Col. John R. Ruhoff, and assigned to other important duties within the District. Lt. Col. Ruhoff, who previous to this assignment had been Area Engineer of the Madison Square Area in New York City, was responsible for all phases of work done at Y-12, *until he was succeded by Col. G. J. Forney, 9 November 1945.*

b. <u>Civilian</u>. - The following is a list of the heads of University Departments and companies who held contracts with the District for research, engineering, construction and operations.

Dr. Ernest O. Lawrence was head of the Radiation Laboratory at the University of California, where most of the physical research for the Electromagnetic Project was carried out, and he has been associated with the Project since its inception.

Dr. Charles A. Kraus headed the research group at Brown University where work was done on liquid phase conversion of uranium oxide to uranium tetrachloride, solvent extraction* and preparation of the green salt (UF_4) for ~~shipment of Y-12 product.~~ charged material for the Y-12 plant. He has been officially associated with the Project since April 1943.

Dr. William B. Burford was in charge of the group at Purdue University which worked, among other problems, on that dealing with the removal of uranium from graphite. This group has also been under Y-12 contract since December 1944.

Dr. Earl T. McBee was in charge of the research group which conducted studies on physical characteristics of uranium tetrachloride made by different methods, cold precipitation of uranium in dilute solutions by means of lime, etc., at Johns Hopkins University. This group has been under contract with Y-12 since December 1944.

Mr. A. C. Klein, Project Engineer, in charge of Y-12 for the Stone and Webster Engineering Corporation, headed that organization through the design and construction of Y-12, beginning in June 1942.

Dr. Frederick R. Conklin was Works Manager in charge of the Tennessee Eastman Corporation organization at Y-12 from April 1943; it was this organization which operated the Electromagnetic Plant.

~~SECRET~~

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

APPENDIX "A"

CHARTS

No.	Description
1	Plan View of Racetracks.
2	Employees on Payroll, Stone & Webster.
3	Number of Operation Employees.
4	General Organization, Electromagnetic Project.
5	Plot Plan Y-12 and Y-12 Extension.
6	Clinton Engineer Works Showing Electromagnetic Project.
7	Expenditures for Y-12 Project to 1 ~~July 1945~~ January 1947

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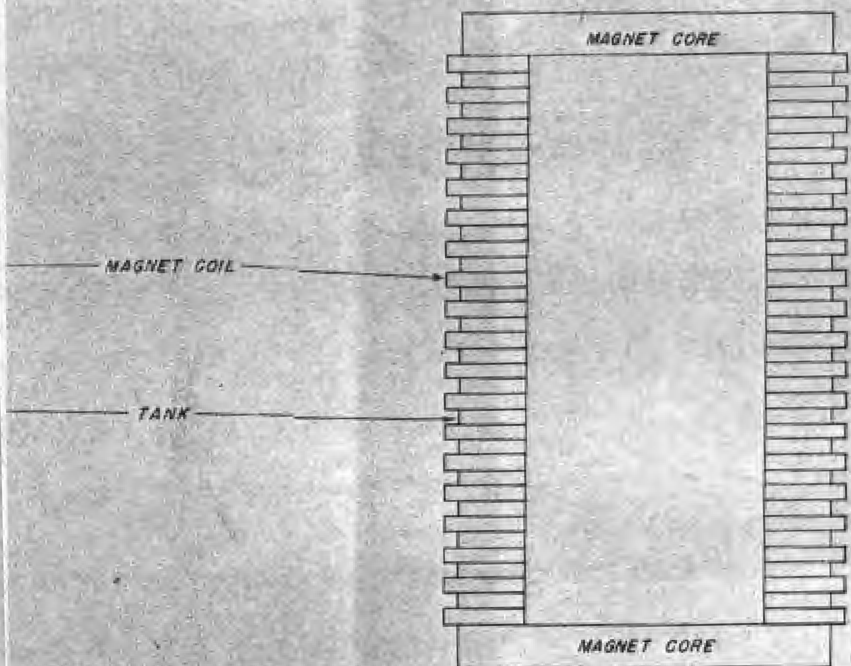
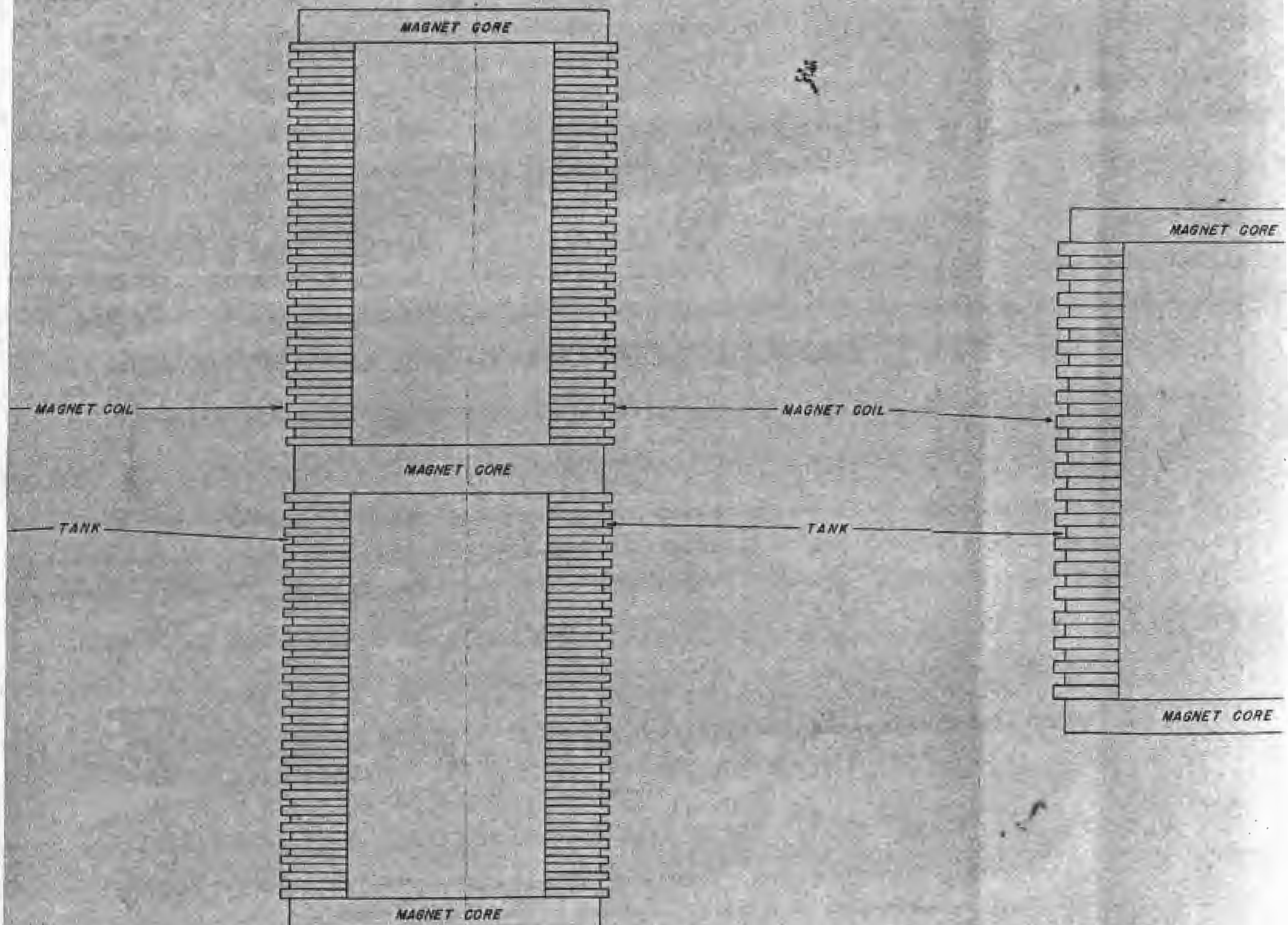
BETA



38 MAGNET COILS
36 TANKS
2 MASS SPECTROGRAPHS PER TANK

ALPHA II

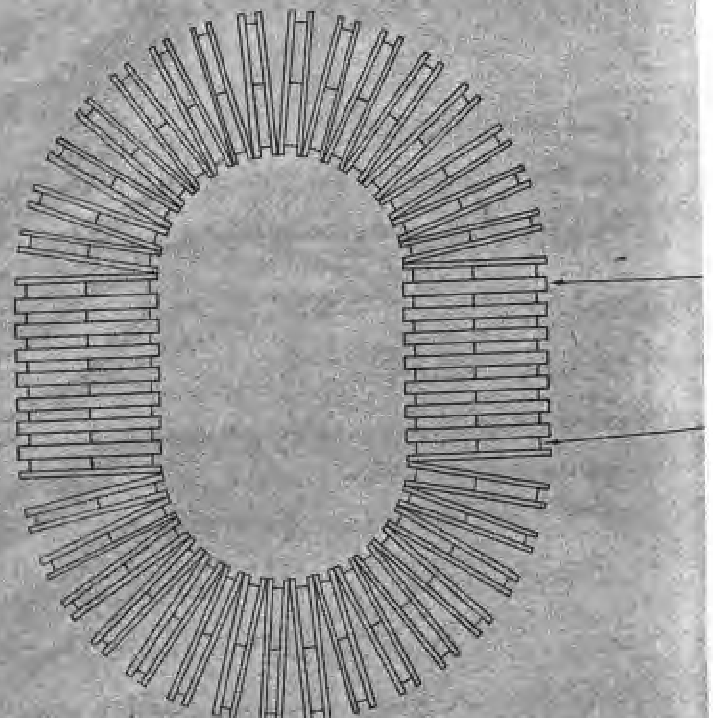
BET



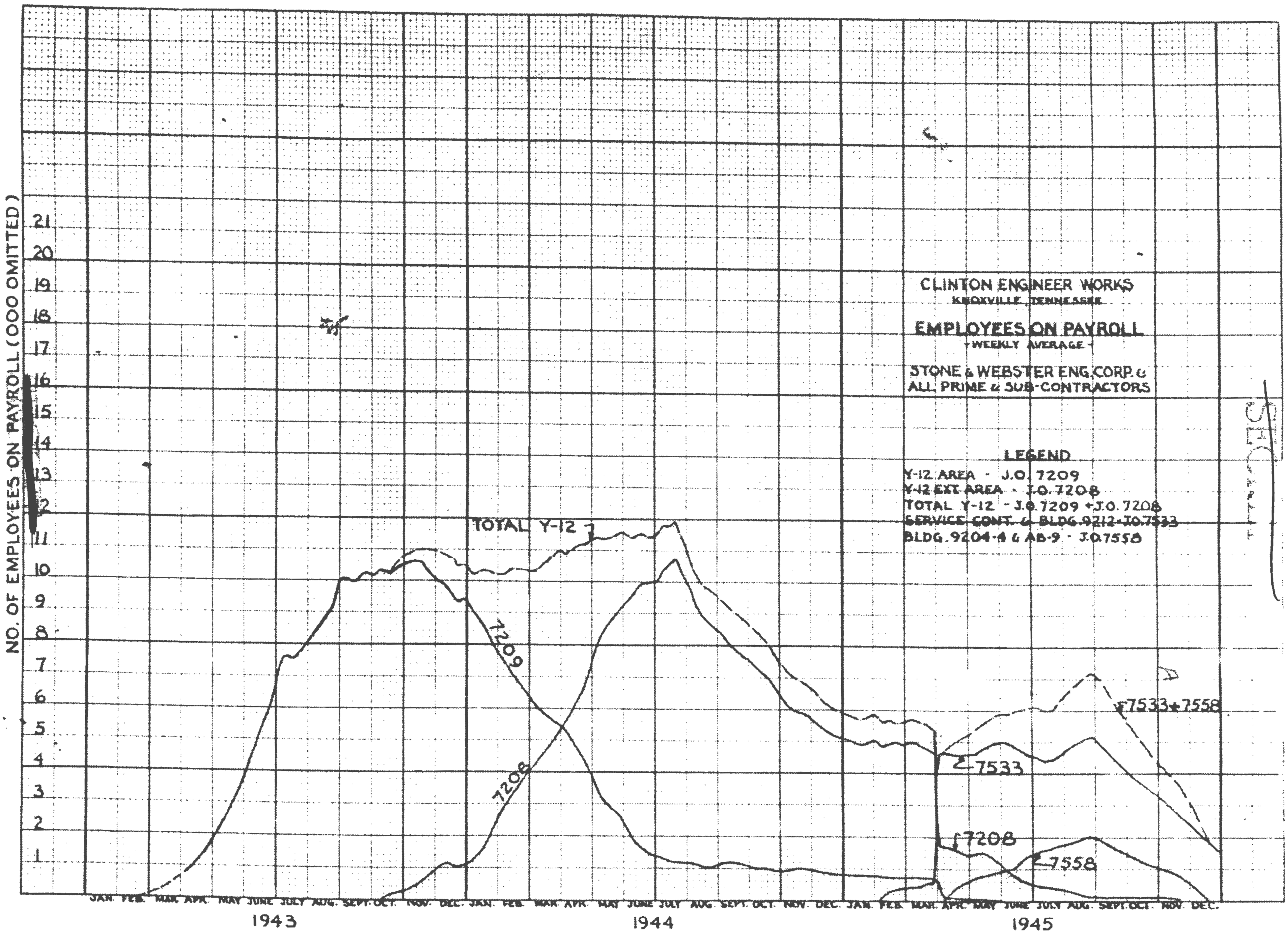
98 MAGNET COILS
96 TANKS
4 MASS SPECTROGRAPHS PER TANK

38 MAGNET COIL
36 TANKS
2 MASS SPECTROGRAPHS

ALPHA I



48 MAGNET COILS
96 TANKS
2 MASS SPECTROGRAPHS PER TANK


CLINTON ENGINEER WORKS
KNOXVILLE, TENNESSEE
EMPLOYEES ON PAYROLL
- WEEKLY AVERAGE -
STONE & WEBSTER ENG. CORP. &
ALL PRIME & SUB-CONTRACTORS
LEGEND
Y-12 AREA - J.O. 7209
Y-12 EXT. AREA - J.O. 7208
TOTAL Y-12 - J.O. 7209 + J.O. 7208
SERVICE CONT. & BLDG. 9212 - J.O. 7533
BLDG. 9204-4 & AB-9 - J.O. 7558
NO. OF EMPLOYEES ON PAYROLL (000 OMITTED)
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
TOTAL Y-12
7209
7208
7533
7208
7558
7533 + 7558
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1943
1944
1945

A2

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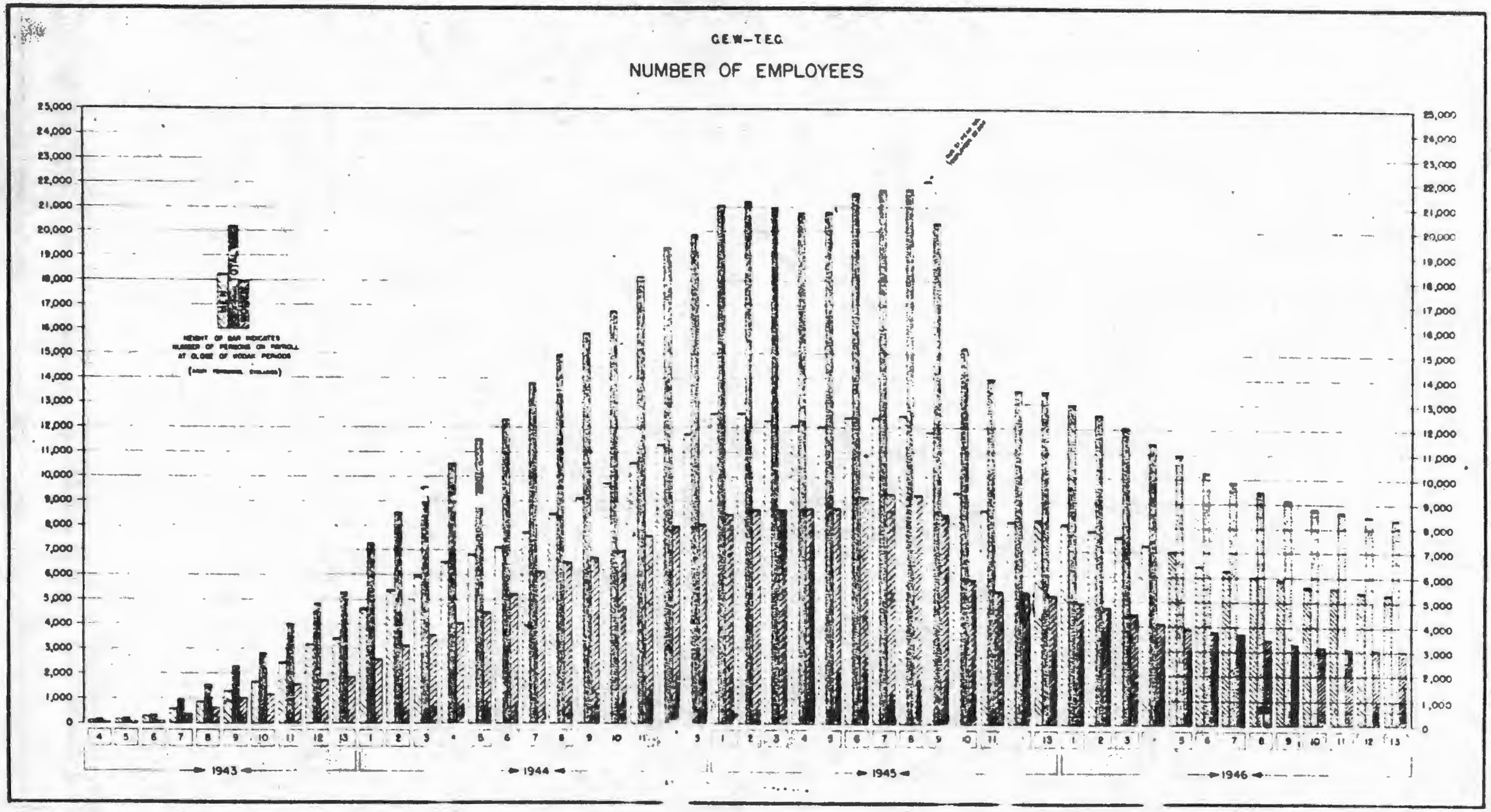
A3



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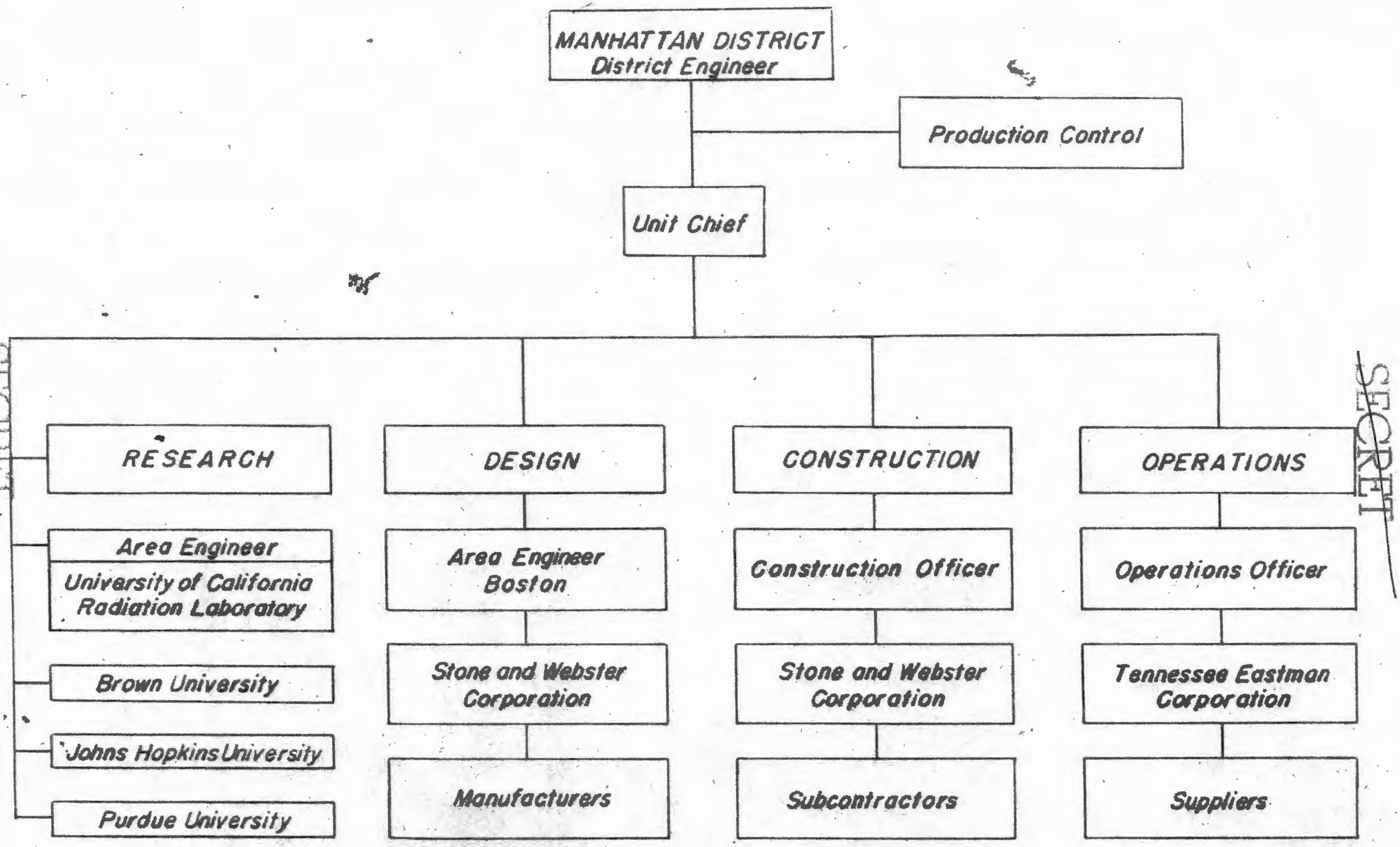
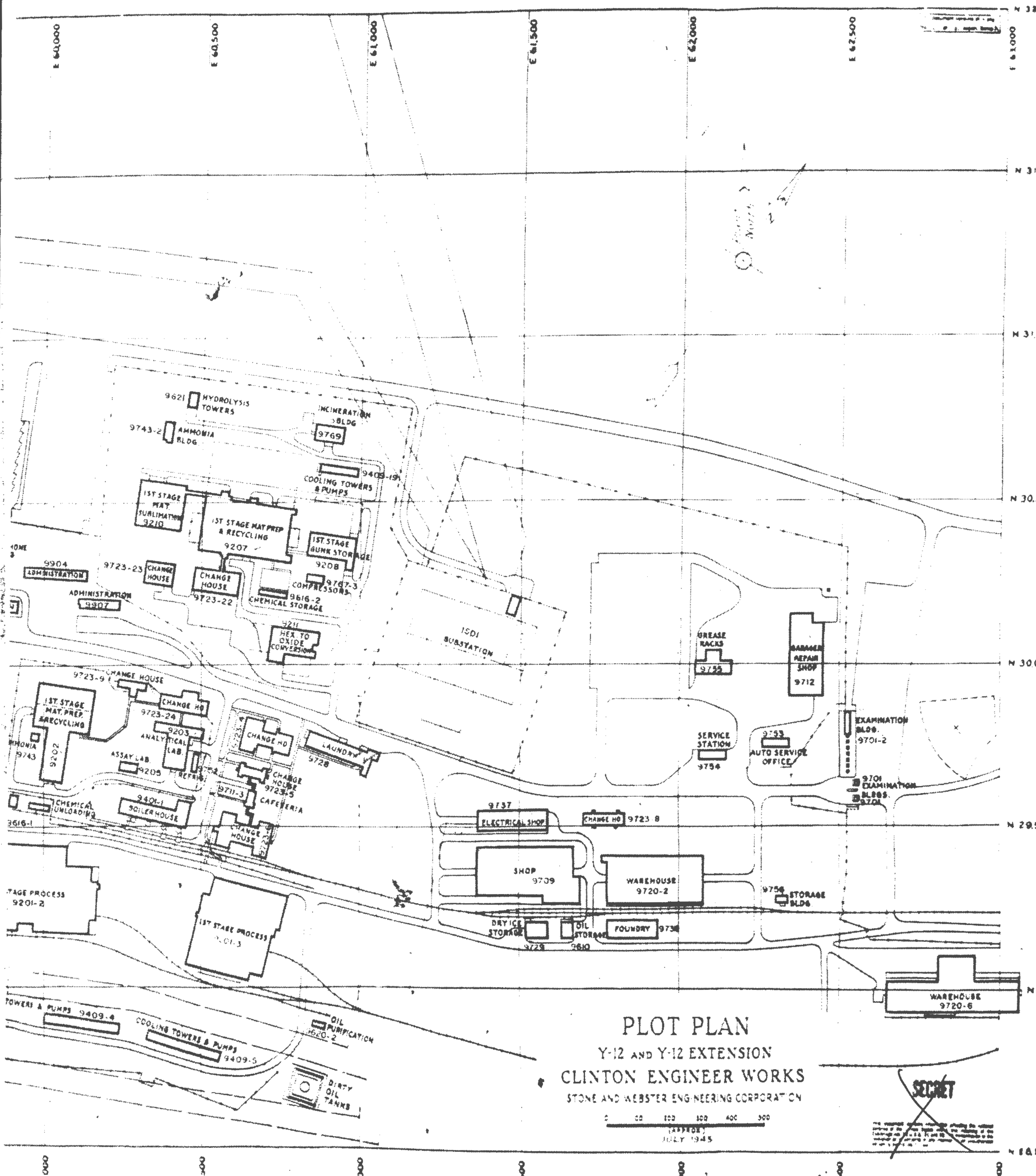


A4

GENERAL ORGANIZATION
ELECTROMAGNETIC PROJECT

SECRET



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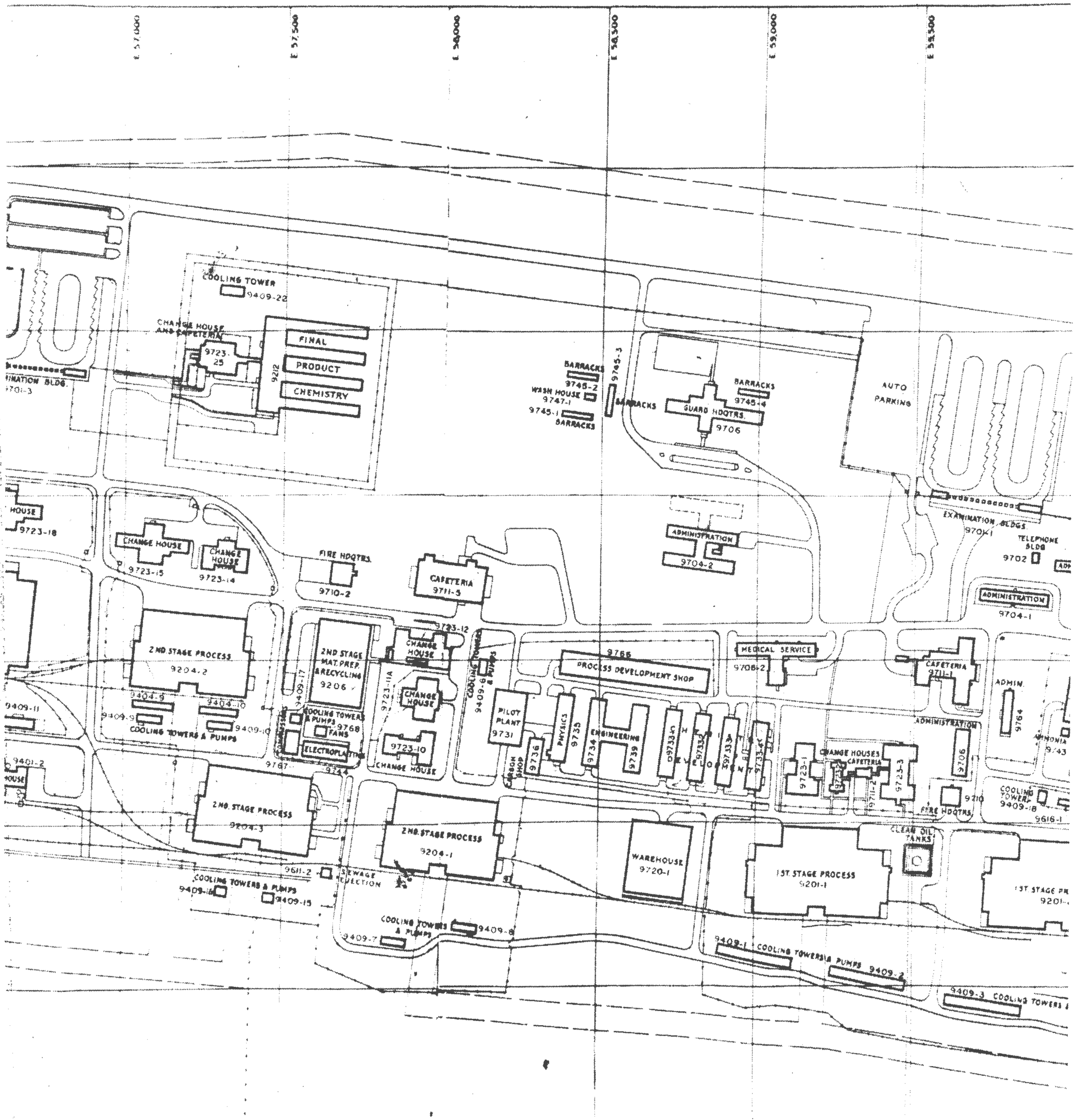
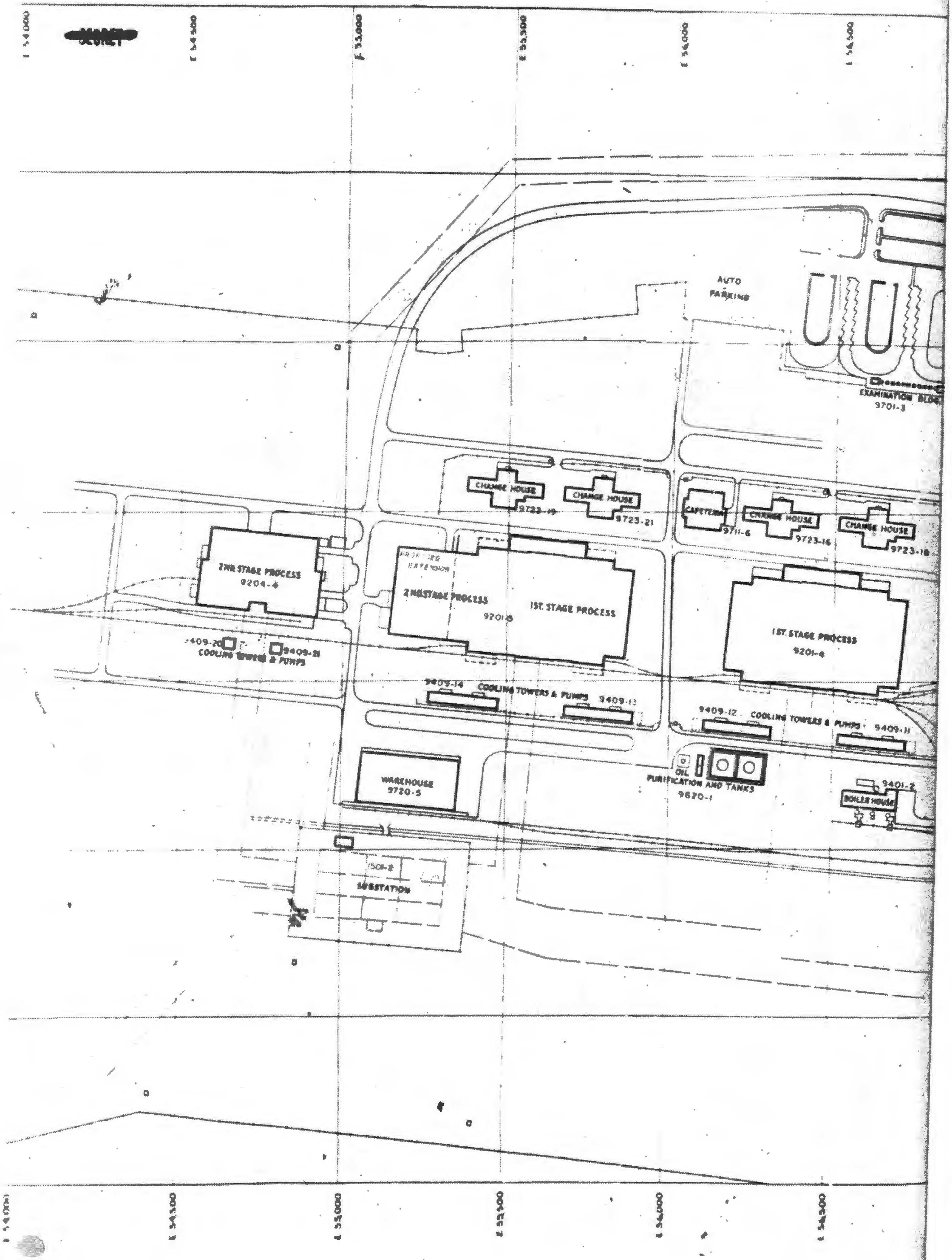
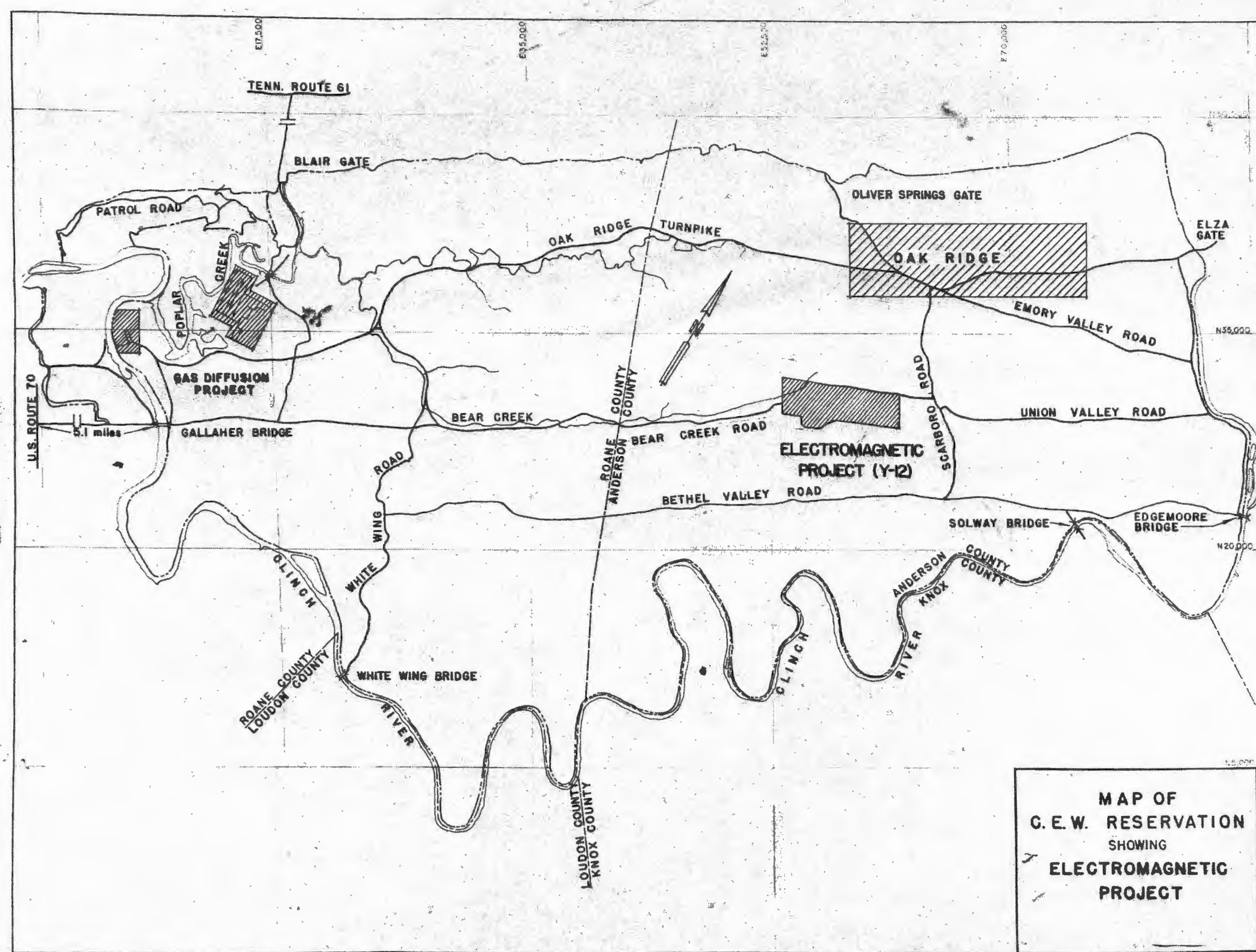
A5



E 57,000
E 57,500
E 58,000
E 58,500
E 59,000
E 59,500
COOLING TOWER
9409-22
CHANGE HOUSE AND CAFETERIA
9723-25
9212
FINAL
PRODUCT
CHEMISTRY
BARRACKS
9745-2
9745-3
WASH HOUSE
9747-1
9745-1
BARRACKS
BARRACKS
9745-4
GUARD HDQTRS.
9706
AUTO PARKING
EXAMINATION BLDGS.
9701-1
TELEPHONE BLDG
9702
ADMINISTRATION
9704-2
ADMINISTRATION
9704-1
HOUSE
9723-18
CHANGE HOUSE
CHANGE HOUSE
9723-15
9723-14
FIRE HDQTRS.
9710-2
CAFETERIA
9711-5
2ND STAGE PROCESS
9204-2
2ND STAGE MAT. PREP. & RECYCLING
9206
9723-12
CHANGE HOUSE
9723-11A
CHANGE HOUSE
9723-10
CHANGE HOUSE
9409-17
COOLING TOWERS & PUMPS
9768
FANS
ELECTROPLATING
9767
9744
9404-9
9404-10
9409-9
9409-10
COOLING TOWERS & PUMPS
9409-11
9401-2
HOUSE
COOLING TOWERS & PUMPS
9409-6
PILOT PLANT
9731
9736
PHYSICS
9735
ENGINEERING
9734
9739
9766
PROCESS DEVELOPMENT SHOP
MEDICAL SERVICE
9708-2
CAFETERIA
9711-1
ADMIN.
9764
ADMINISTRATION
CHANGE HOUSES
CAFETERIA
9723-1
9711-2
9723-3
9706
9710
FIRE HDQTRS.
COOLING TOWERS
9409-18
9616-1
9743
2ND STAGE PROCESS
9204-3
2ND STAGE PROCESS
9204-1
WAREHOUSE
9720-1
CLEAN OIL TANKS
1ST STAGE PROCESS
9201-1
1ST STAGE PROCESS
9201-
9611-2
SEWAGE EJECTION
COOLING TOWERS & PUMPS
9409-16
9409-15
COOLING TOWERS & PUMPS
9409-7
9409-8
9409-1
COOLING TOWERS & PUMPS
9409-2
9409-3
COOLING TOWERS


[redacted]
E 54,000
E 54,500
E 55,000
E 55,500
E 56,000
E 56,500
AUTO PARKING
EXAMINATION BLDG.
9701-3
CHANGE HOUSE
9723-19
CHANGE HOUSE
9723-21
CAFETERIA
9711-6
CHANGE HOUSE
9723-16
CHANGE HOUSE
9723-18
2ND. STAGE PROCESS
9204-4
PROPOSED EXTENSION
2ND. STAGE PROCESS
9201-5
1ST. STAGE PROCESS
1ST. STAGE PROCESS
9201-4
9409-20
9409-21
COOLING TOWERS & PUMPS
9409-14
COOLING TOWERS & PUMPS
9409-13
9409-12
COOLING TOWERS & PUMPS
9409-11
OIL
PURIFICATION AND TANKS
9620-1
9401-2
BOILER HOUSE
WAREHOUSE
9720-5
1501-2
SUBSTATION

SECRET



MAP OF
C. E. W. RESERVATION
SHOWING
ELECTROMAGNETIC
PROJECT

SECRET

A6

SECRET

COSTS FOR Y-12 PROJECT TO 1 JANUARY 1947

Fixed Fees		
For Design and Construction (Stone and Webster Engineering Corporation)	$3,384,679	
For Operation (Tennessee Eastman Corporation)	2,998,500	
	6,383,179	$ 6,383,200
Design Costs		5,619,800
(Stone and Webster Engineering Corporation)		
Cost of Plant Erection		
Silver Program	2,482,626	
Construction & Procurement of Equipment	301,411,600	
(Stone and Webster Engineering Corporation)		
	303,894,226	303,894,200
Cost of Plant Operation		237,211,700
(Tennessee Eastman Corporation)		
Cost of Research		
University of California	18,000,000	
TEC Research	1,300,000	
Brown University	189,325	
Purdue University	92,000	
Johns Hopkins University	61,000	
	19,642,325	19,642,300
Total Cost of Y-12 Project to 1 January 1947 (Figures in totals approximated to nearest 100)		$ 572,751,200

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

APPENDIX "B"

PHOTOGRAPHS

No.	Description
1	Aerial View of Y-12
2	Aerial View of Y-12.
3	Panoramic View of Y-12, April 1944.
4	Y-12 Extension, June 1944.
5	Panoramic View of Y-12, June 1945.
6	View of Alpha I Buildings.
7	An Alpha I, Two Beam Unit.
8	A Beta Source Unit (S unit).
9	Beta Receiver (R unit).
10	Hospital.
11	Alpha I Racetrack.
12	Beta Racetrack.
13	XAX Development Unit.
14	Vacuum Piping, Beta Racetrack.
15	Beta Cubicles.
16	Beta Chemistry, Hexafluoride Conversion.
17	Beta Chemistry, Calcining.
18	184" and XA Magnets.
19	University of California Radiation Laboratory 184" Magnet Area.

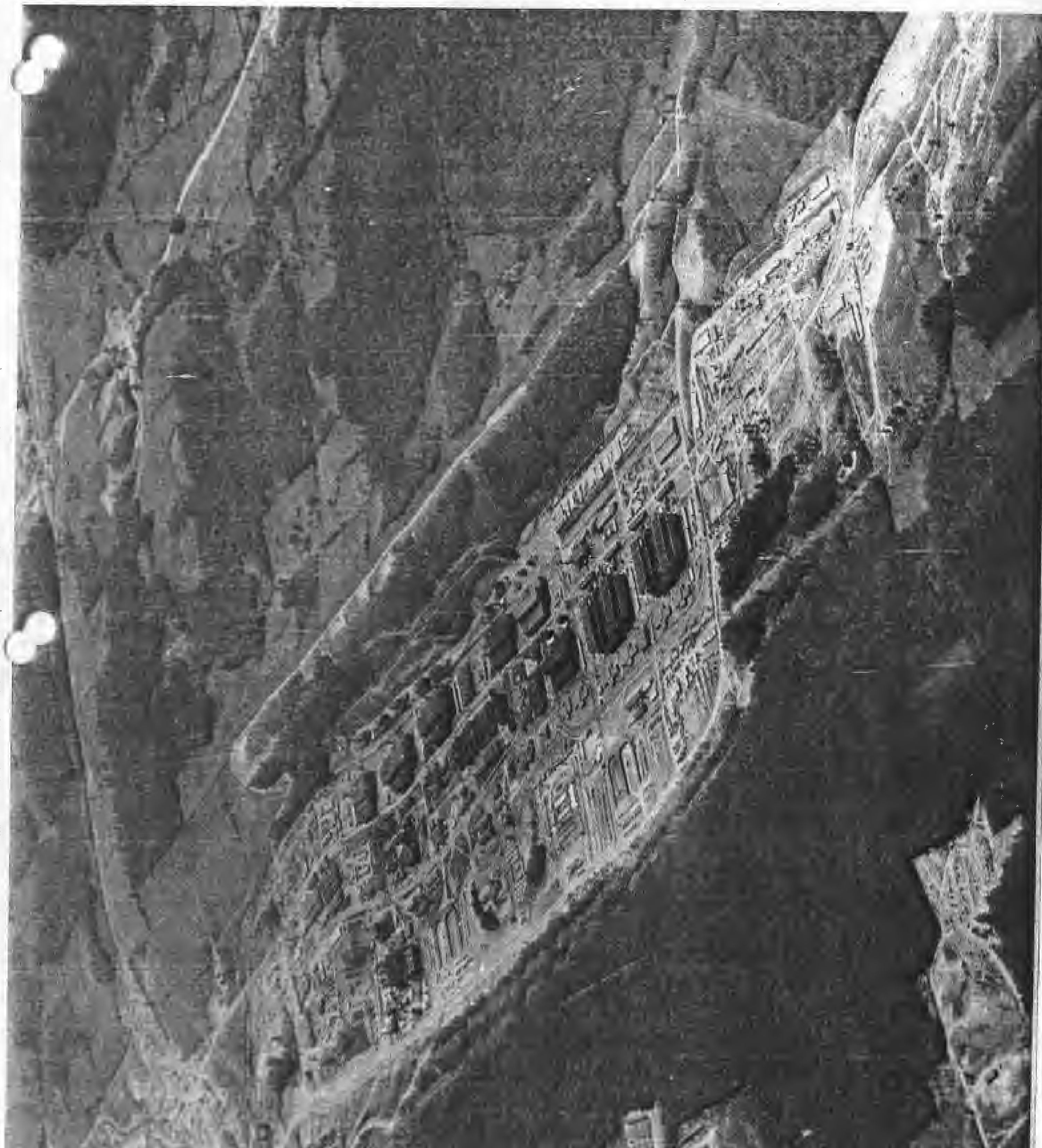
SECRET

B1 **Aerial View of Y-12**

Looking North, the Y-12 installations are in the foreground, while part of the residential district can be seen in the background.

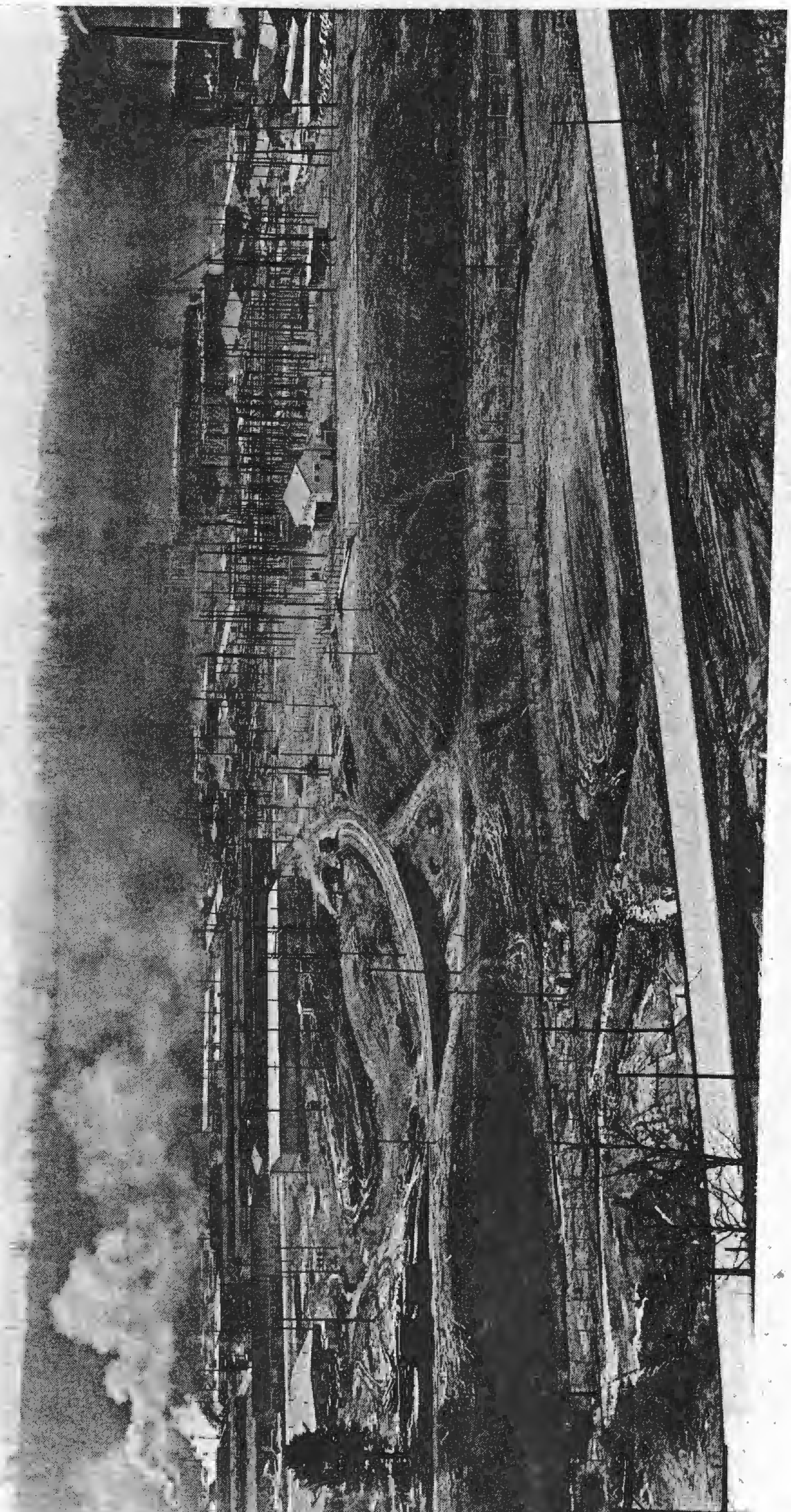
B2 Aerial View of Y-12.

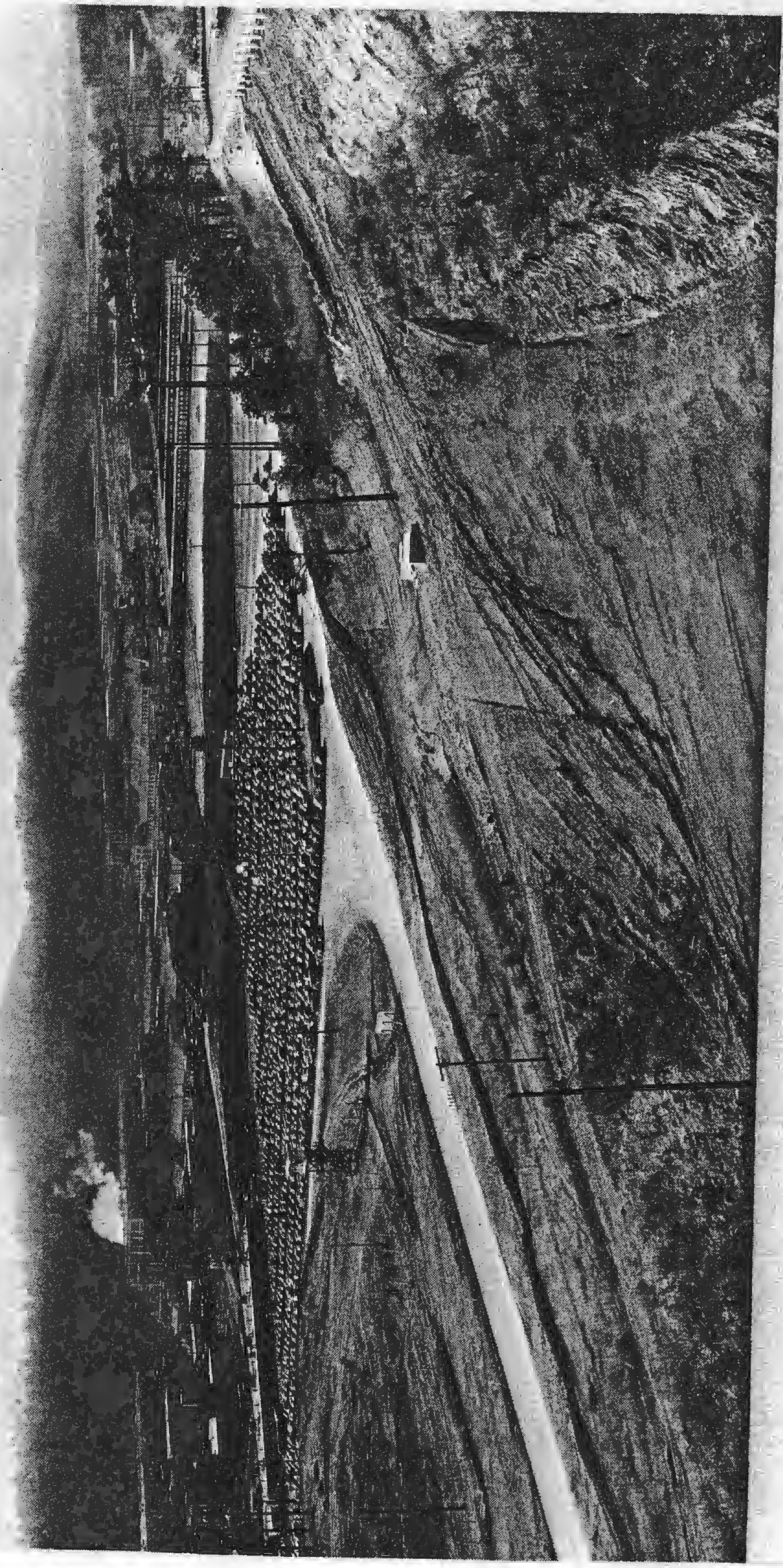
Viewed from the West, Y-12 Extension is in the lower center, and the original Y-12 installation in the upper center of the picture.



B3 <u>Panoramic View of Y-12, April 1944</u>

This view, looking South shows the Y-12 plant in the final stages of construction in the center, with the Y-12 Extension just getting under way at the far right.





H. <u>Aerial View of Y-12 Extension, June 1944.</u>

The four important buildings in the center of the picture are, from left to right, 9206, Beta Chemistry, 9204-2, Beta Process, 9201-4 and 9201-5, Alpha II Process.

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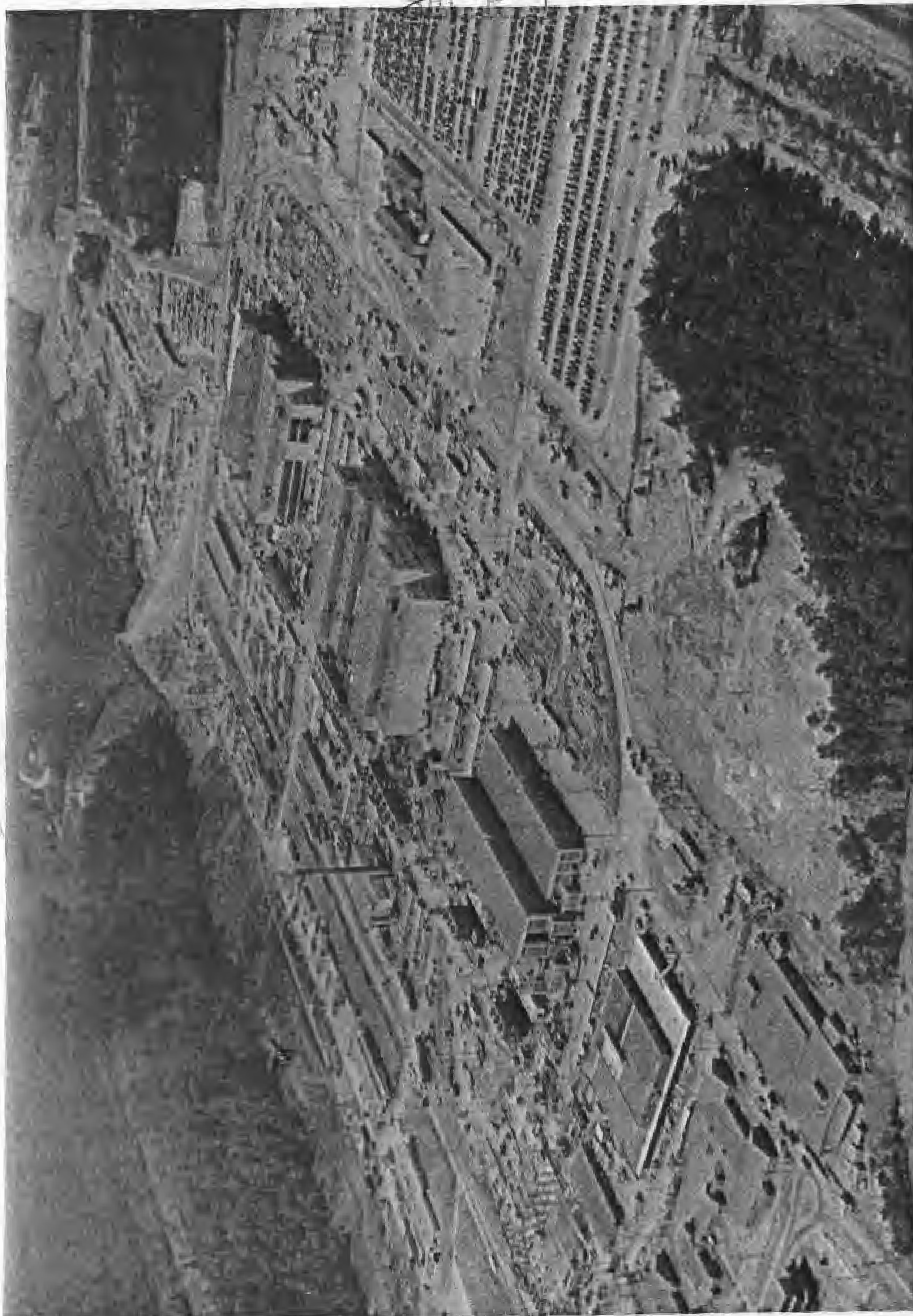

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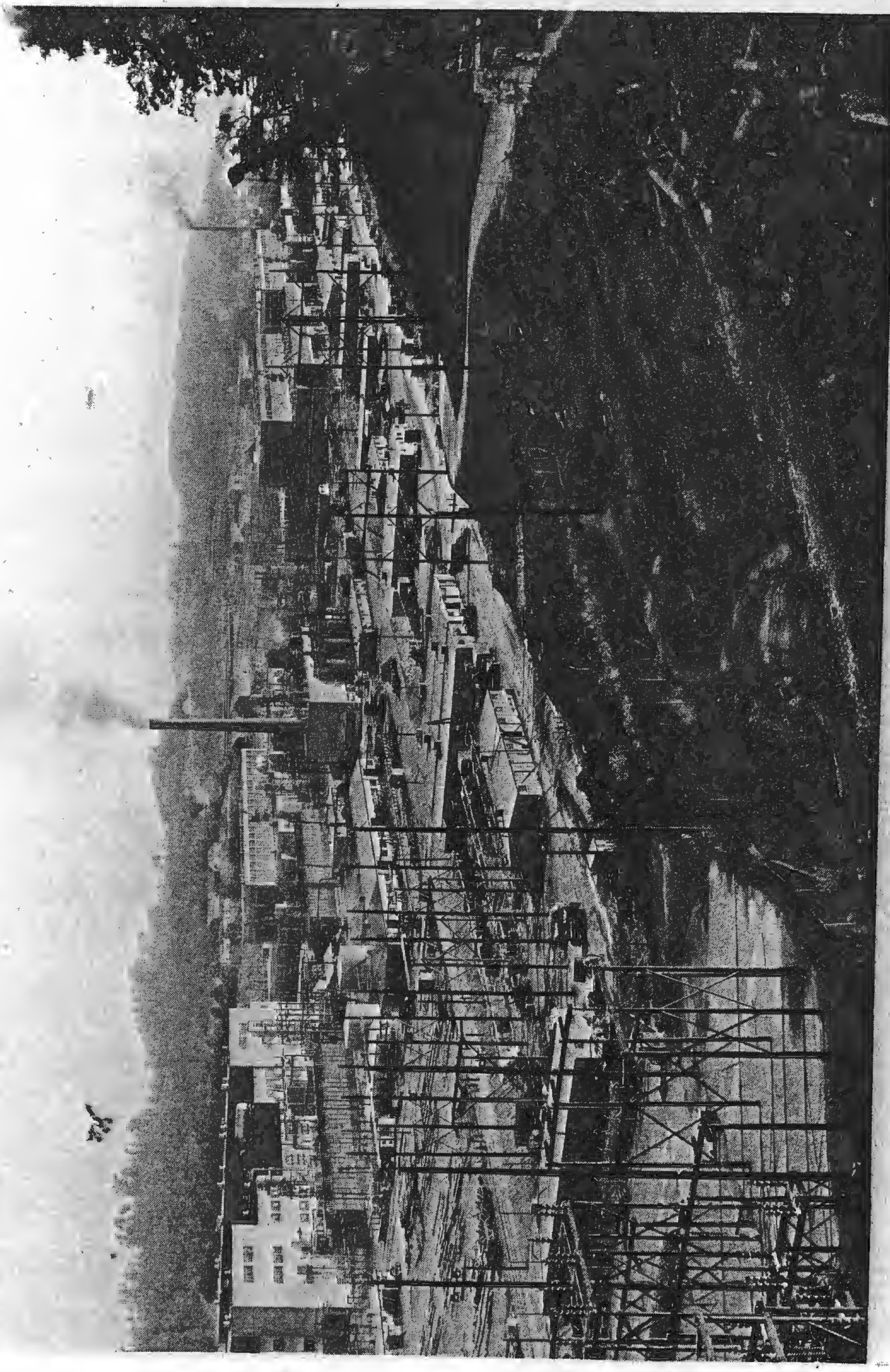
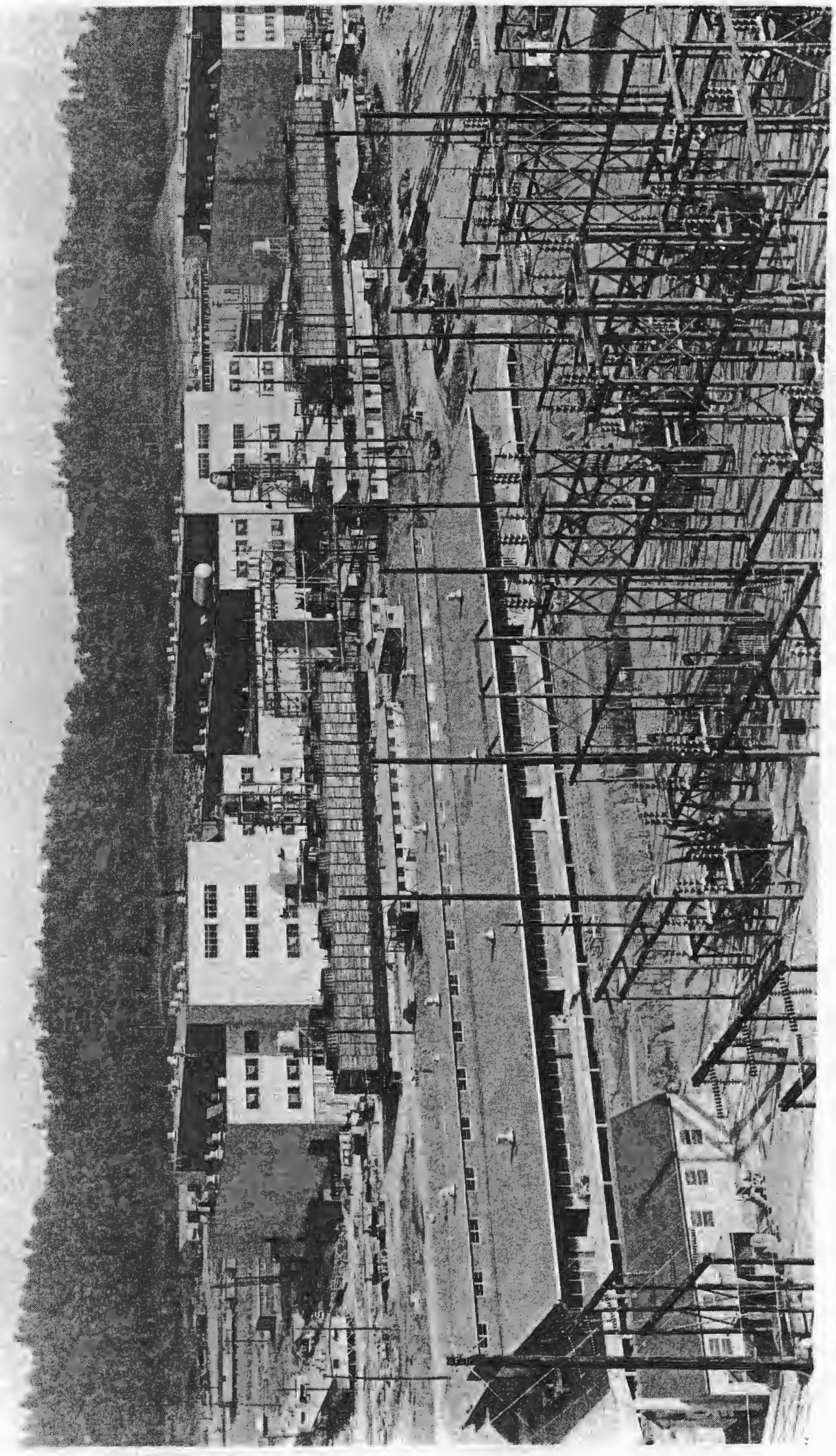
15 **Panoramic View of Y-12, June 1945**

By June 1945 the process buildings in the Extension at the left were practically complete and in operation. The original Y-12 plant to the right had been in operation for a year.





B6 View of Alpha I Building.

Alpha Chemistry Building 9202 is at the left near the Smokestack. Alpha I buildings 9201-3 and 9201-2 are in the center, with 9201-1 just showing at the far right.

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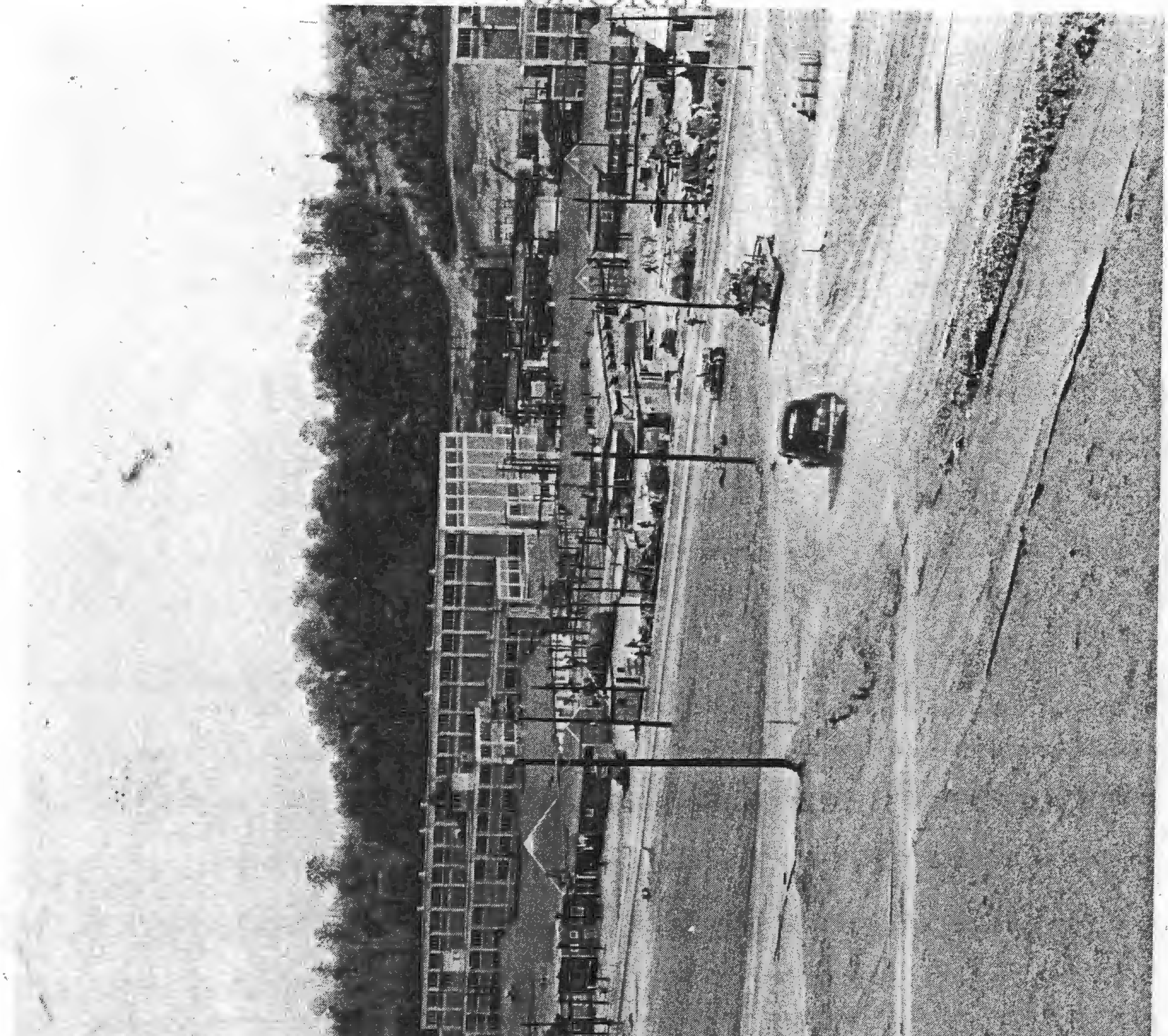

SECRET

B7 <u>An Alpha I Two Beam Unit</u>

This Alpha I "D", of separation unit, is resting on its back on a storage dolly. The covers have been removed to show the double source unit at the right and the two receivers at the left.

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[redacted]

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~~EXPORT CONTROLLED INFORMATION~~

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~~EXPORT CONTROLLED INFORMATION~~

~~UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION~~

~~OFFICIAL USE ONLY~~

B8 **A Beta Source Unit (M Unit)**

If this unit were in operation the two beams of ions would be projected from the vertical slots, toward the reader. This "M" has just been removed and all the scale which shows must be washed off and recovered. Recovery and processing of this and similar material is the cause of the Chemical recycle operation.

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E9 **Beta Receiver (E Unit)**

This mechanism collects the separated isotopes.

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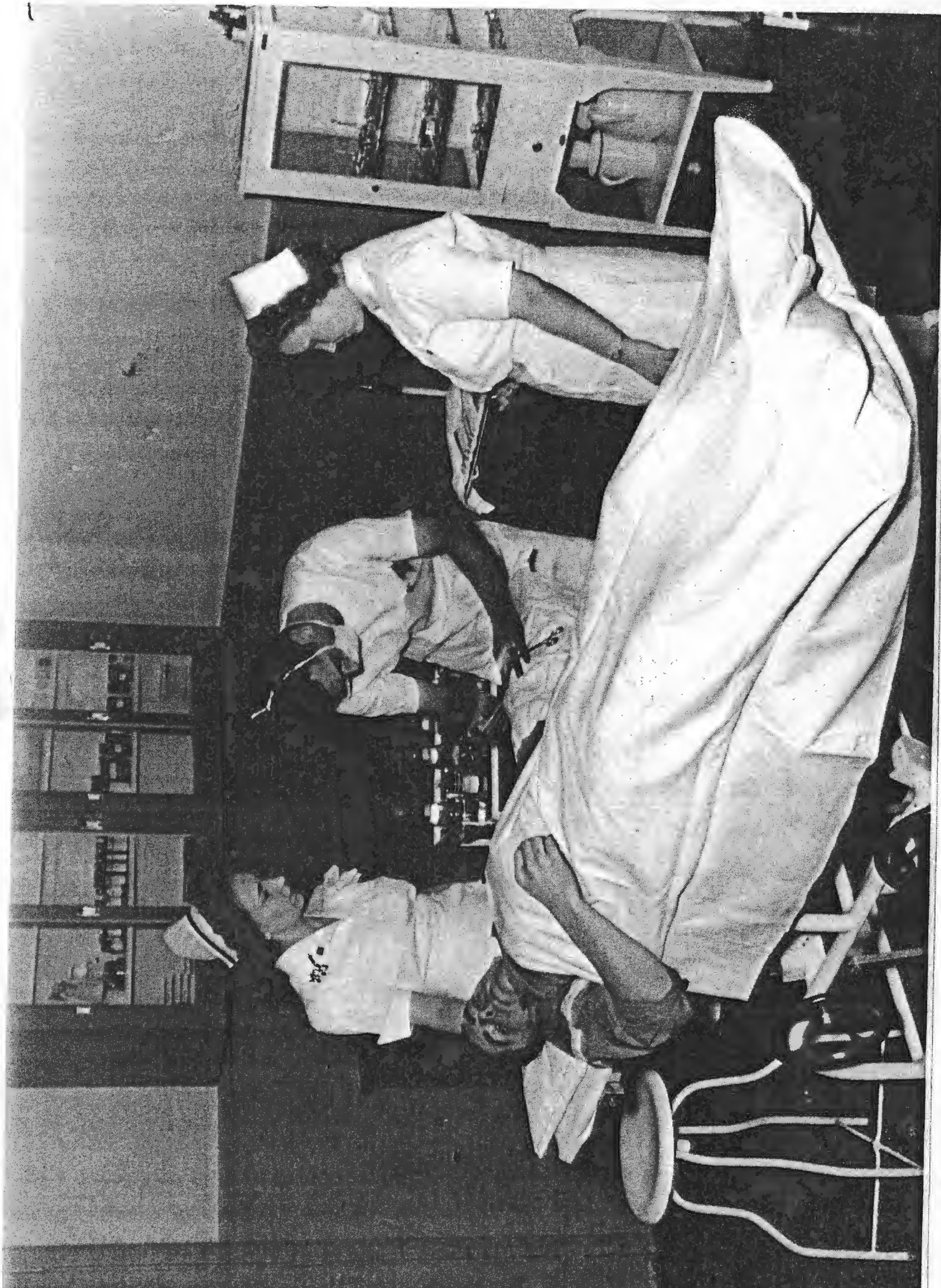
E10 Hospital

This photograph shows a part of the interior of the well-equipped hospital. Here a workman is being treated by one of the doctors in attendance, assisted by two nurses.



Ill. Alpha I Racetrack

The oval shape of the huge magnet caused them to be termed racetracks. The protruding ribs are the magnet coils (wound with silver). The box-like cover around the top contains the electric busbar which is also of silver.

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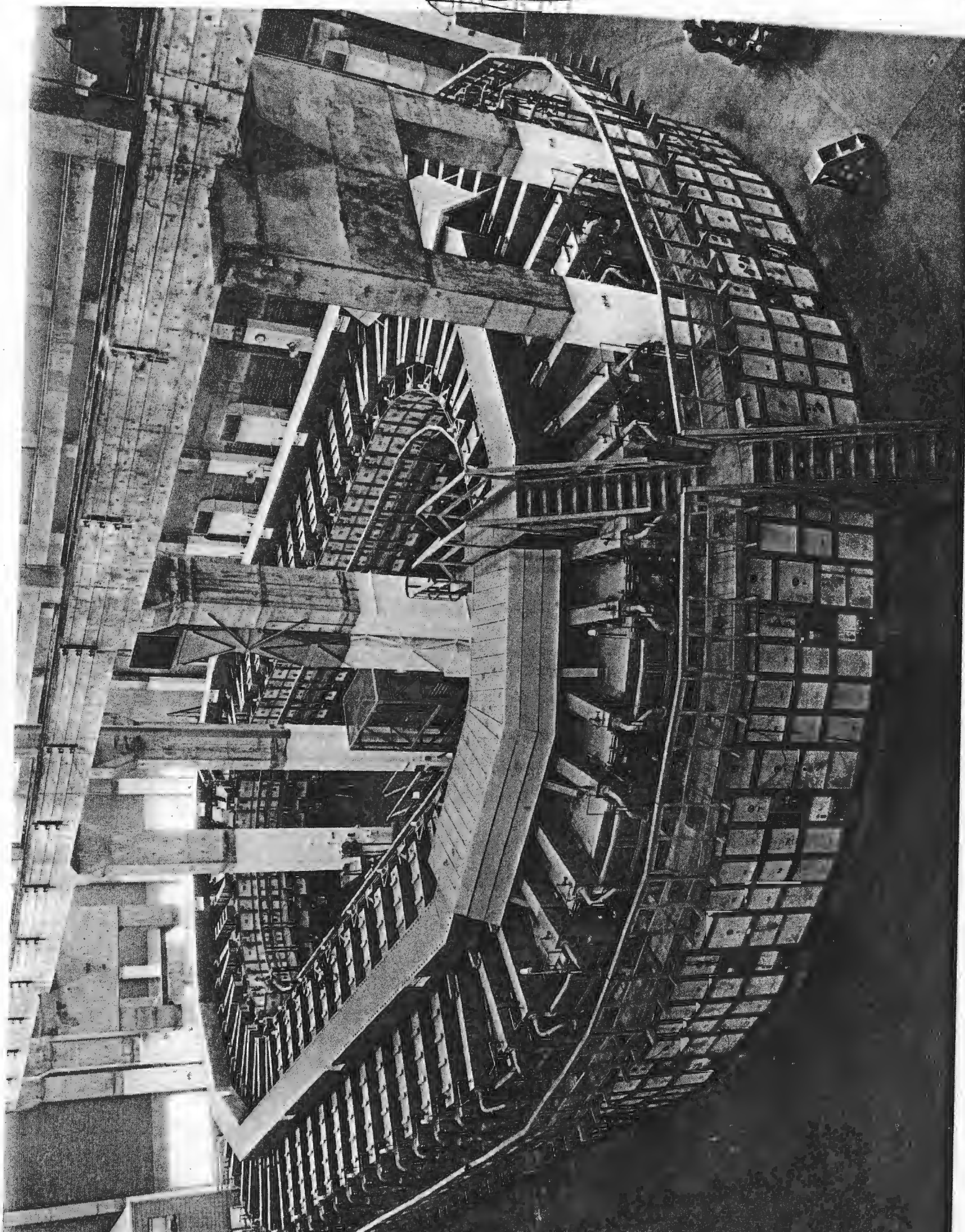

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B12 <u>Beta Racetrack</u>

These second stage racetracks are much smaller than the Alpha tracks and contain fewer process bins. Note that the oval shape of the Alpha I tracks has been abandoned for ease of servicing.

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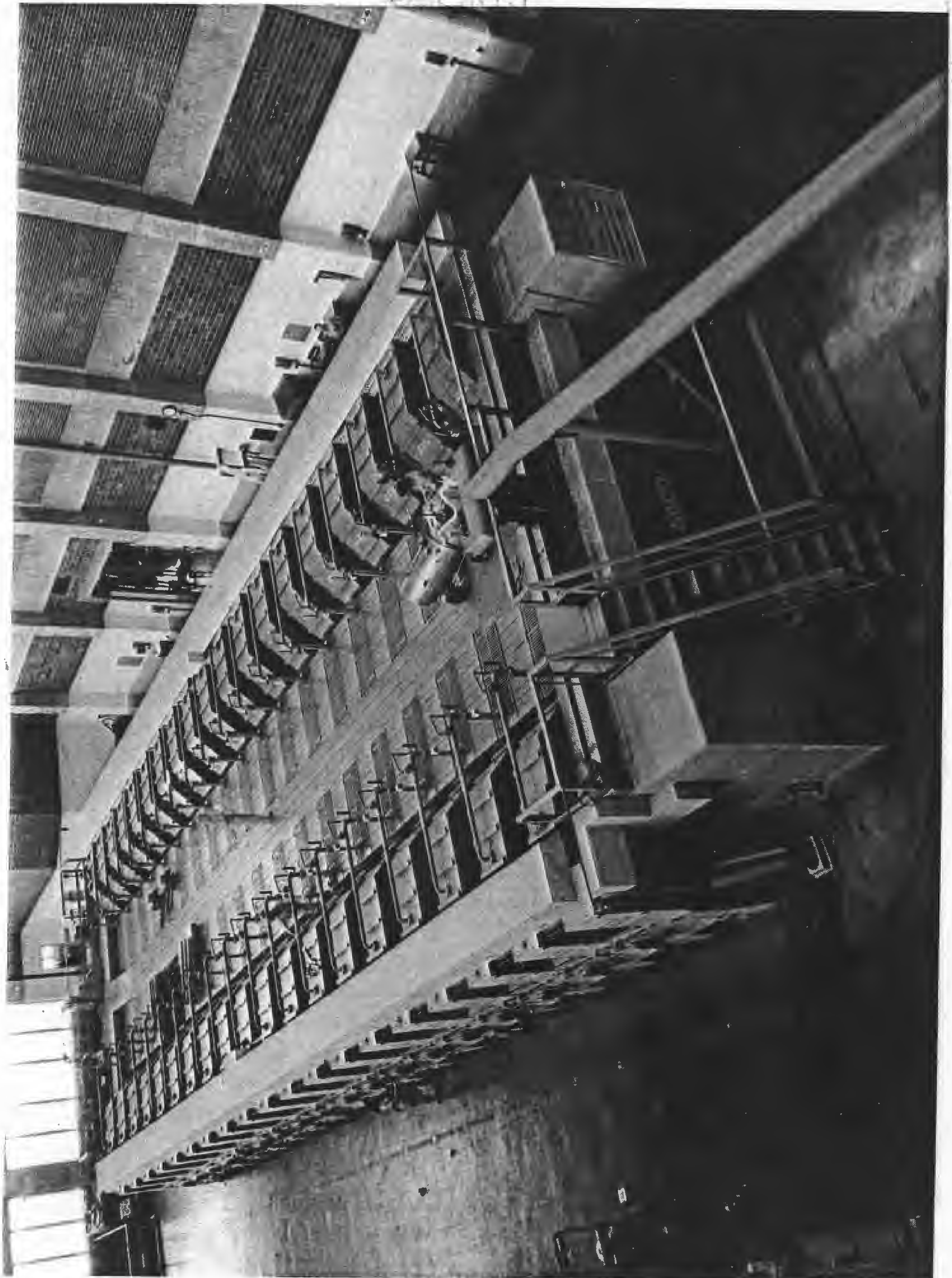
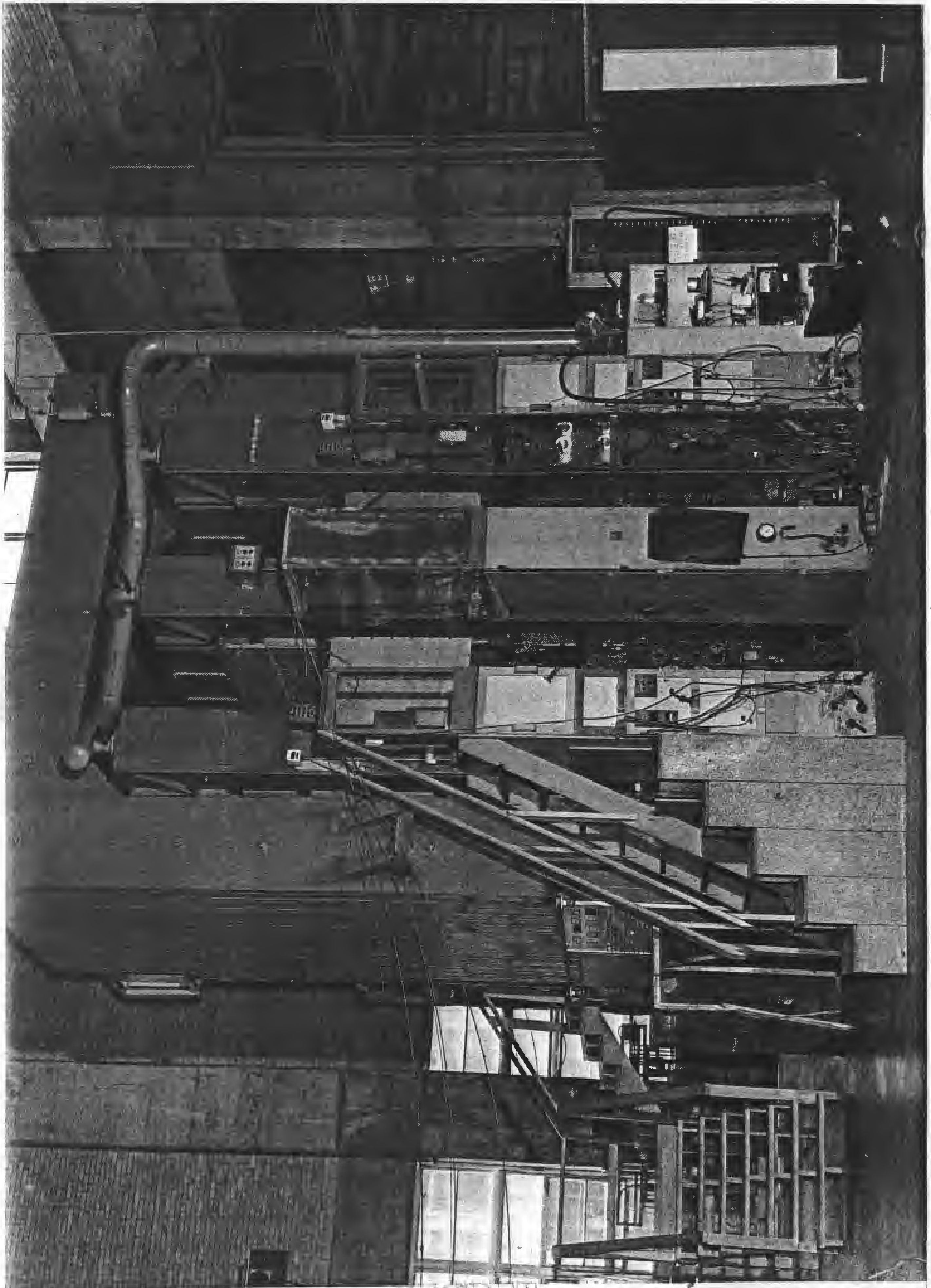


SECRET

E13 <u>XAX Development Unit.</u>

This magnet with a capacity of two process bins is located in Development Building 9731 along with a two bin Beta Unit, XBX. The development units were used for experimentation, training and process improvements.



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B14 Vacuum Piping, Beta Racetrack.

This view shows part of the complicated piping and conduit arrangement which is in the basement under a racetrack.

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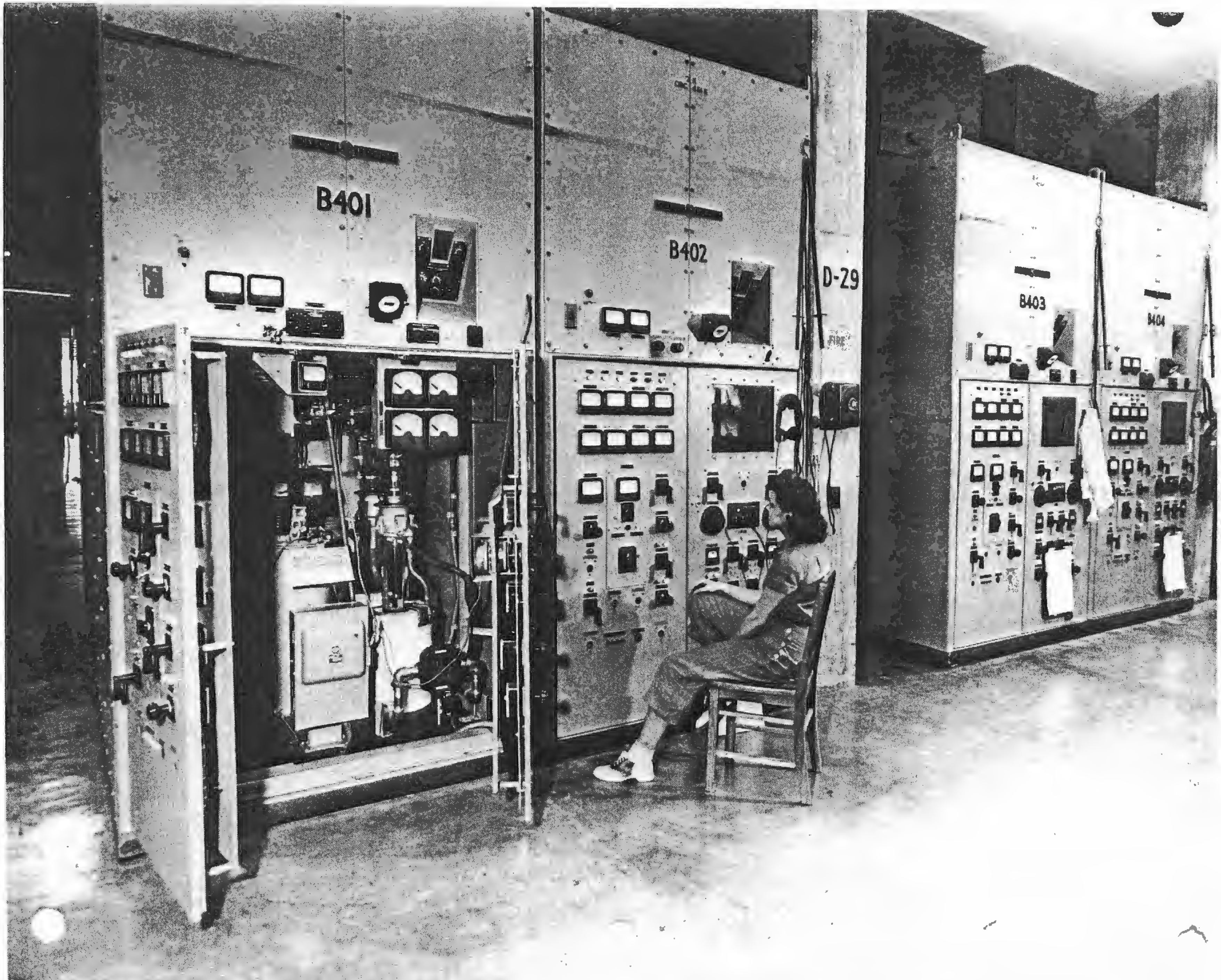
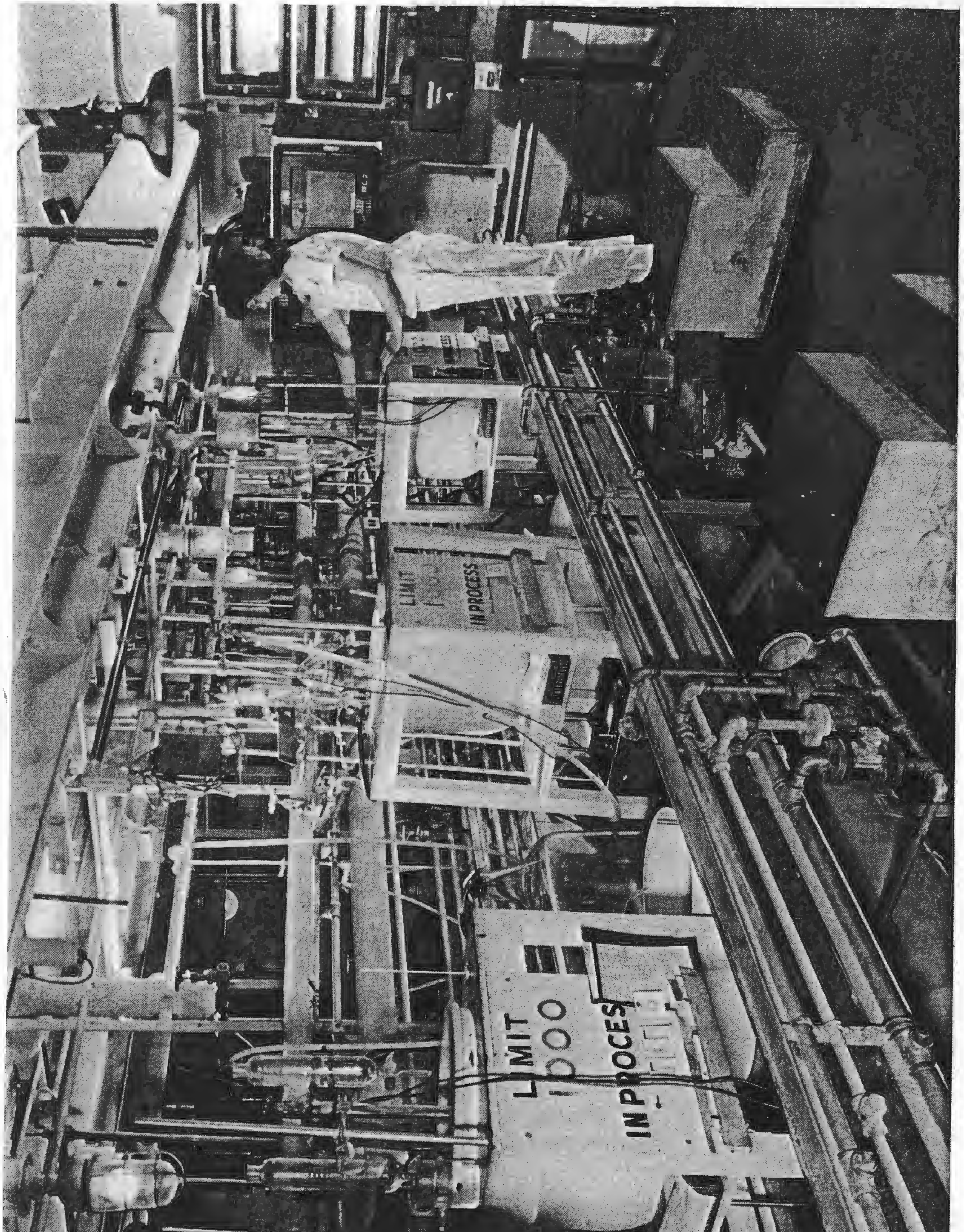
B15 <u>Beta Cubicles</u>

Each process bin of a racetrack is controlled by one of these cubicles.


B401
B402
D-29
FIRE
B403
B404

316 <u>Beta Chemistry, Hexafluoride Conversion</u>

This equipment performs the first chemical operation on enhanced feed obtained from the Diffusion Plant.

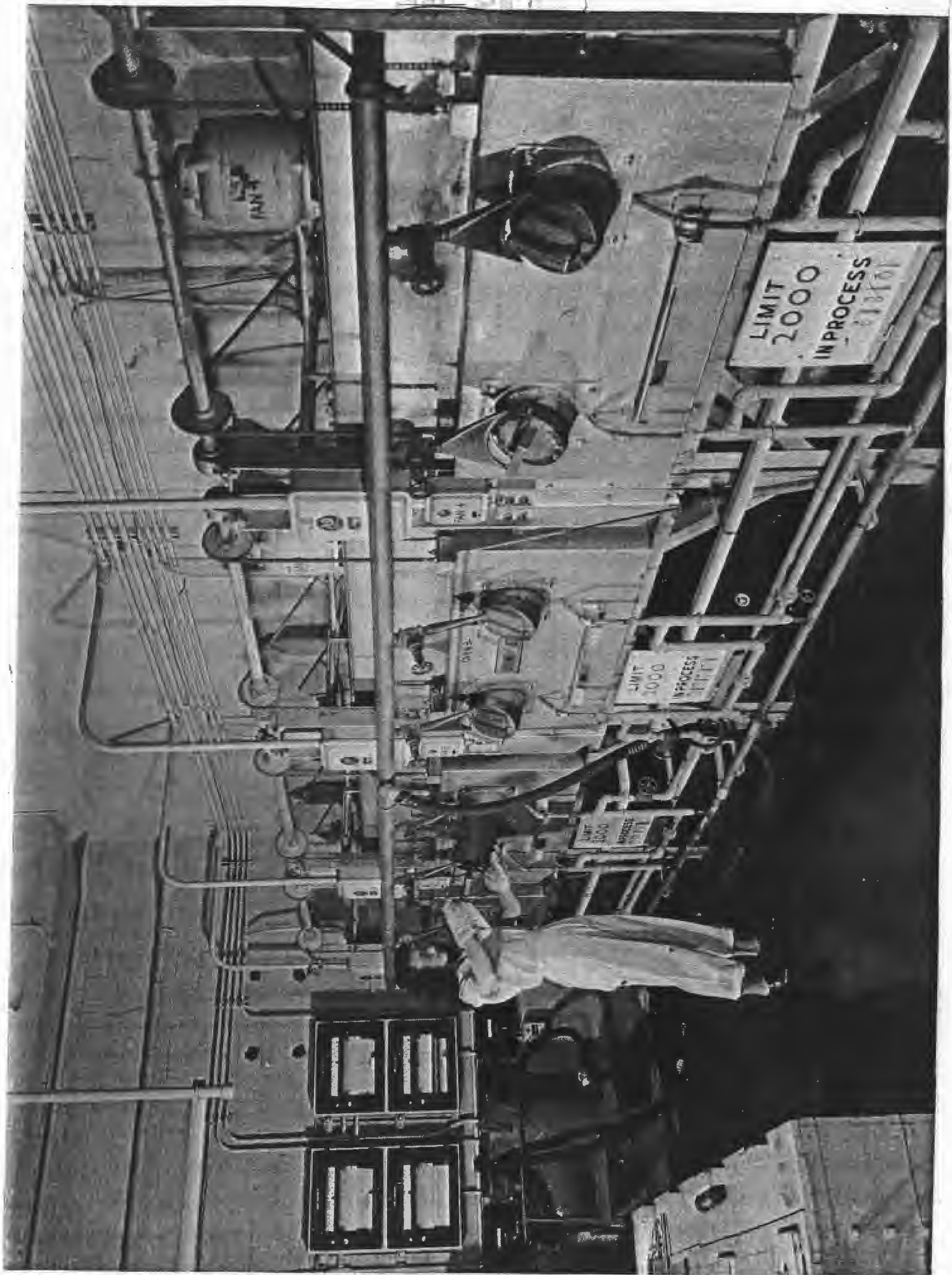


SECRET

B17 <u>Beta Chemistry, Calcining</u>

A step in the production of feed for the racetracks.

SECRET



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[illegible] **<u>184" and XA Magnets</u>**

These magnets, located at the University of California, played an important part in the Y-12 research program.

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519 University of California Radiation Laboratories, 184" Magnet Area.

PLATE IV
THE 184" AREA
View Looking South-West

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

APPENDIX "C"

GLOSSARY

GLOSSARY OF TECHNICAL AND CODE TERMS

AS USED IN THIS VOLUME

Beam - Represents the path of the charged particles in the spectrograph, which is a semicircle from the emitter to the collector.

Bushing - Electrical insulator which passes through the face plate of the unit and must therefore be vacuum tight.

"Hot" Source - A source unit operating at high positive potential.

Normal Uranium - Uranium as it occurs in nature containing approximately 99.3% of uranium 238, 0.7% of uranium 235 and 0.006% of uranium 234.

Process Bins - Also called bins or tanks. Steel tanks fitted into gaps in the electromagnet which serve as a vacuum tight housing, with connections to the vacuum pumps, into which the parts of the mass spectrograph are installed for operation.

Racetracks - Also called tracks. The oval or rectangular structures containing the magnet coils and the process bins.

Receiver - The unit which collects the separated materials in the mass spectrograph and removes the charge from the ions.

Solvent Extraction - The use of selective solubility of materials in immiscible solvents for the purpose of separation.

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 1 - GENERAL FEATURES

INDEX

RESTRICTED DATA
Atomic Energy Act 1946
Specific Restricted Data
Clearance Required