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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

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1st Review - Date: 9/19/13	Determination [Circle Number(s)]
Authority: ☒ADC ☒ADD	1. Classification Retained
Name: C. Kimbrough	2. Classification Changed To:
2nd Review - Date: 9/23/2013	3. Contains No DOE Classified Information
Authority: ADD	4. Coordinate With:
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FOREWORD

This volume is the third in a series of six which contain a short documented history of the Electromagnetic Project of the Manhattan District. The subject material in this volume is comprised of discussions covering the design, engineering and procurement of equipment for the Electromagnetic Plant. The period covered is the time between June 1942 and 1 January 1947 during which time the major part of the work on the plant was started and carried to a successful conclusion.

The text of this volume is supplemented by appended charts, documents, illustrations and a glossary of technical terms. For information concerning other phases of the Project the reader is referred to the appropriate volumes which are titled as follows:

Volume 1 - General Features

Volume 2 - Research

Volume 4 - Silver Program

Volume 5 - Construction

Volume 6 - Operation

1 June 1947

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

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SUMMARY

1. General. - The purpose of the design of the Electromagnetic Project was to convert the basic theories and research findings of an electromagnetic separation method into an industrial plant to provide U-235 for atomic energy for military use. The electromagnetic separation method was one which at one time was considered infeasible because of seemingly insurmountable difficulties, but from discussions of Dr. E. O. Lawrence of the University of California with Dr. Vannevar Bush of OSRD, in early 1941, work was continued so successfully as to culminate in definite plans for plant scale operation. Consequently, authorizations for the Manhattan project given by the President on 17 June 1942, under authority conferred on him by the War Powers Act, included plans for the design of a 100 grams per day electromagnetic separation plant.

a. Contracts. - The Stone and Webster Engineering Corporation, having been associated with early phases of the uranium project, was selected as Architect-Engineer-Construction-Manager of the DSM project. A letter of intent for Contract No. W-7401-eng-13 was subsequently given to them on 29 June 1942. The Electromagnetic Plant was allotted $35,000,000 of the total $86,000,000 allocated to the DSM Project. Eventually this contract was supplemented five times until by 31 March 1945, the cost of Stone and Webster's work was estimated as $409,731,900 and a fee of $3,020,028 had been set. Later, two other contracts were also awarded to Stone and Webster, affecting only installations within Y-12 or the Electromagnetic Plant. The first of these, Contract No. W-14-108-eng-49, for service and maintenance of a major nature, was given on 2 February 1945. It was estimated that work under this contract would amount to $6,000,000 per year and the contractor's fee was set at $15,000 per month. The second additional contract, Contract No. W-14-108-eng-60, was negotiated 2 April 1945, for the construction of a fourth Beta process building, estimated to cost $18,000,000 exclusive of the contractor's fee of $225,000.

b. Plant Site. - The Electromagnetic Plant is located in the Bear Creek Valley in the southeastern portion of the Clinton Engineer Works. This part of the 59,000 acre reservation was selected because of the protecting hills, readily available power supply, and accessibility to central facilities.

2. Description of the Electromagnetic Plant. - The Electromagnetic Plant consists of nine main process buildings, five Alpha or first stage and four Beta or second stage and over 200 additional permanent buildings providing greater or lesser auxiliary functions. These lie along the floor of the narrow Bear Creek Valley protected on the north and south by hills and extend over an area approximately 2½ miles long by 3/4 miles wide.

a. Alpha Stage. - The chloride salts of uranium were early recognized as the most desirable track feed material. Uranium tetrachloride was selected as the most feasible. The material received at the plant from the ore refineries was uranium trioxide. Consequently, a chemical conversion step had to be designed and installed before any material could be used in the separation process. Two methods,

[redacted]

the vapor phase and the liquid phase, for the conversion were used. Both utilized carbon tetrachloride as the chlorinating agent. A vacuum sublimation refining step was introduced to produce a highly refined uranium tetrachloride charge material for the Alpha stage. A relatively minor fraction of the material fed to the track is actually ionized and effectively utilized in separation. This unused Alpha material must be collected, repurified, reconverted to uranium tetrachloride. The first step to do this is called primary recovery. Here, the equipment after completing a run in the tracks is washed and scraped to collect the unused materials collected on the walls and parts during the run. The wash water collected, called "gunk", is transferred to the Alpha chemistry building where it is chemically processed in the "bulk recovery" department. The processing consists essentially of purification steps, conversion to uranium trioxide and this to uranium tetrachloride for further use as a track feed material. The actual physical separation of uranium isotopes takes place in the units known as bins or tanks. The bins are contained in a magnet which was originally oval and because of this shape became known as "racetracks" or more commonly "tracks". The tracks in turn are housed within process buildings, the main structures within the area. In each bin, the feed material is first vaporized by heating. The hot vapor is ionized by passing through an electric arc. The cloud of charged atoms, or ions, is then accelerated to form a high velocity stream or beam by the action of a high voltage electric field. The beam of ions, in passing through the field of a powerful magnet, is bent into a semi circle; the lighter ions are deflected in their path more than the heavy ones, thus effecting

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a separation which permits the collection of the isotopes in separate receivers. Because of changes in development and an accumulation of better methods discovered through actual operations, the group of five Alpha process buildings represents three different designs, Alpha I, Alpha 1½ and Alpha II. Alpha I design, with two oval tracks of 96 bins each is present in Buildings 9201-1 and 9201-2. Alpha 1½ consists of only one oval track with 96 bins in Building 9201-3. Alpha II consists of 2 buildings, Buildings 9201-4 and 9201-5, with two rectangular tracks per building of 96 bins per track. The original Alpha process buildings, 9201-1 and 9201-2, were virtually duplicates of each other. Each building contains two tracks, each 122 feet long, 77 feet wide, and 15 feet high. The tracks are hollow leaving an interior floor space of 84 feet by 40 feet. The two tracks are located end to end in a large hall nearly 450 feet long on the second floor of each building. Each racetrack is divided into 48 sections, a section containing two bins or tanks, placed back to back so that the sides facing the inside and outside of the track are open. The process bins are spaced in the gaps between the large vertical magnet coils. Power for the coils is fed through bus bars which run along the top of the racetracks and are energized with direct current from motor generator sets located in the ends of the buildings. Leading from the bottom of each bin is a duct which passes through the floor to a vacuum system which occupies practically the entire floor beneath the racetracks. The source unit which ionizes and accelerates the uranium atoms is mounted on one end of the vertical door. The two metal bottles, containing feed material for each

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source are mounted in electric heating coils. Upon heating, the uranium tetrachloride is vaporized and passes through a valve and manifold system to two "ionization chambers", each of which contains an electric arc which forms uranium ions in the vapor cloud. As ions are formed by the electric arc in each chamber they are accelerated by the electrical field to extremely high velocities. Under effect of the magnetic field, the ion beams assume semi-circular paths, each having a radius of about 4 feet. At the opposite end of the door from the source are located the "receivers", so arranged as to separately collect the U-235 and segregate it from the unwanted U-238. The whole door with source, receiver and liner, copper duct for housing the ion beam, is referred to as the "D" unit. Controls for the bins are located away from the track in separate two-story control bays. The control of each bin is accomplished by individual control panels. Behind each panel is a cubicle containing rectifiers which supply the high voltage direct current required in accelerating the ions. The original plans for Y-12 included five racetracks to be housed in three buildings. By the time the third building, to house only one track, was under construction, a number of developments to improve Alpha track operations had been devised. Since Building 9201-3 was partially constructed and procurement had been initiated, it was impossible to install all the improvements desired. As a result, Track 5, Building 9201-3, is a cross between the original Alpha tracks and Alpha II which included the latest improvements. After Y-12 Extension was authorized in September 1943 and it was decided to add four Alpha tracks to Y-12, it became possible to plan for the design of these tracks on the basis of developments realized at the University of California Radiation Laboratory (UCRL).

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From the standpoint of production, the most important of these changes were that the sources would have four ionization chambers instead of two and would operate at a high voltage whereas the original sources operated at ground potential. These changes had also been incorporated in Alpha I½.

b. <u>Beta Stage</u>. - The functions of Beta chemistry include processing of Alpha product material for Beta feed material, recovery and processing of unseparated Beta feed material, and the processing of Beta product material for shipment to Los Alamos. The material collected in Alpha receivers has to be chemically purified and converted to a suitable feed for the Beta separation stage. Much greater caution is required to prevent losses of the Alpha Product than was necessary with the less valuable Alpha feed. The uranium, enriched in U-235, taken from the receivers, is purified in a series of chemical steps and converted to uranium tetrachloride for feed to the Beta tracks. The unseparated material from the Beta separation process which collects in the separation equipment is removed by washing, scrubbing, and rinsing. An initial chemical processing step is made within the respective process buildings to remove the majority of the uranium and to shorten the recycle time. The material removed is then ready for drying and conversion to uranium tetrachloride. The remaining material is further processed to insure maximum extraction of uranium. All the uranium obtained is converted to the tetrachloride for reuse as feed material in the Beta tracks. Beta receivers containing the highly enriched material from the Beta separation step are handled with the utmost care. The material contained

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within them is processed in small batch equipment on a laboratory scale. Purification processes are performed similar to those done previously, but much greater emphasis is placed upon preventing losses. The purified uranium is then converted to uranium tetrafluoride (UF_4) for shipment to Los Alamos. As mentioned previously, the physical separation of U-235 from U-238 is performed in two steps. The second stage, "Beta", process buildings are somewhat similar to Alpha in appearance and function. Four process buildings are provided (9204-1, 9204-2, 9204-3, and 9204-4). Each building houses two racetracks with 36 bins per track. All bins, as in Alpha II, face the outside of the track. The Beta units are distinguished from Alpha by being smaller in size and having additional features that stress against losses or contamination of the feed material. The principle is, of course, the same as that for the Alpha process. As there are only 9 main process buildings, the other (over 200) buildings house many additional auxiliary facilities. Included in these are two boiler houses, cooling towers, chemical processing buildings and laboratories, pump houses, process development facilities, service facilities, shops, warehouses, and office.

3. <u>Design Program.</u> - In June 1942, ~~the District was given~~ a Presidential Directive was issued which authorized the design of a plant to produce 100 grams per day of U-235. While considerable work had been done on an electromagnetic separation method, a tremendous amount of detail remained to be worked out. The District, therefore, when it was organized had to enter immediately into an extensive design program which was coordinated by Stone & Webster, based on the developments and basic information revealed at UCRL. The original conception was of process bins consisting of a single source

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unit and a single receiver unit operating in a vacuum in a magnetic field. To produce 100 grams per day, it was estimated that 2000 single source units would be required. Later, UCRL developed a two source unit so that by December 1942, when the magnet design was released, the Alpha I accepted design provided for 48 bins per track, each bin having two double source units. Procurement and construction proceeded on this basis. A total of 3 Alpha buildings and 5 tracks was decided upon. Buildings 9201-1 and 9201-2 would each have two tracks of 96 bins each, while the 5th track would be in Building 9201-3 and have one track and 96 bins. Early in 1943, it was decided to install a second or Beta stage. Use was made of a fully enclosed recovery liner and a source and receiver subdoor assembly. Trouble was experienced at first from the source unit but a workable design was completed by the end of April 1944. An expansion of the Electromagnetic Plant was authorized on 11 September 1943. The extension covered design and construction of four Alpha tracks and two Beta tracks along with the necessary auxiliaries for an estimated cost of $140,000,000. The new Alpha buildings (9201-4 and 9201-5) were designed to house two straight line 96 gap magnets each. A four "hot" source unit and increased vacuum capacities were also incorporated in the design. A second Beta building (Building 9204-2) was to follow the design of the first Beta building. In May 1944, a third Beta building was authorized and was redesigned from Beta Buildings 1 and 2 and to follow latest developments. In October 1944, a liner service for Alpha II was begun. This was necessary in order to use enriched feed material. Original requirements for Y-12 operations included Alpha and Beta chemical process buildings.

Alpha Chemical Building (Bldg. 9202) was designed to include Vapor Phase and Liquid Phase methods of uranium tetrachloride preparation, vacuum sublimated facilities, dry room and charge bottle loading facilities, and a bulk treatment department for the recovery of recycle material from the Alpha process buildings. The Beta chemical building (Bldg. 9203) included facilities for receiving and recovering material from Alpha product receivers, carbon burning furnaces for recovery of material impregnated in carbon parts, processing equipment for Beta recycle material, chloride conversion equipment to prepare Beta track feed material, and final product preparation equipment. In addition, miscellaneous equipment was installed in Beta recovery wash areas to insure maximum recovery of unused material from the Beta separation equipment. After the decision to expand Y-12 facilities and Y-12 Extension had been authorized, additional Alpha and Beta chemical facilities were authorized. For Alpha expansion a new extension to Bldg. 9202 was designed and provided additional Bulk Treatment capacity, along with equipment to salvage material from effluents and solutions used during the process. A new Beta chemistry building (Bldg. 9206) was authorized which would take over all Beta chemistry functions while the original Beta chemistry building was converted to an analytical and assay laboratory. In May 1944, when it was decided to utilize enriched feeds from the Diffusion Plants, it became necessary to rebuild completely Alpha chemistry facilities. The new facilities were grouped together and became known as the 9207 group. They were designed to perform the same functions with the new feed material as Building 9202 has performed for feeds of normal material. They, however, were necessarily designed to more exacting specifications and to handle large quantities of 1.4 to 5% U-235 enriched material. The latter group, too, had the added function of converting uranium hexafluoride (material received from K-25) to uranium trioxide (which the equipment in Y-12 was prepared to handle). Most of the 9207 group was later made obsolete by the introduction of K-25 feed directly into the Beta stage at Y-12. Many additional changes were made to existing chemical facilities and a few additions were authorized. Beta recovery areas in the process buildings and Alpha bulk treatment departments were converted early in 1945 to a new type of process called the Cold Precipitation Process. Innumerable changes were made to the Beta chemical facilities. Authorizations for additional facilities included a new final product preparation building (Bldg. 9212), an electroplating building (Bldg. 9744), development laboratories (Bldgs. 9733-1, 9733-2, 9733-3, and 9733-4), and the conversion of Building 9211 to a Beta Salvage Building. Stone and Webster design and engineering personnel, exclusive of those on construction, reached a peak of 739 people employed on the ~~DSM~~ Manhattan District project early in 1944. Before and after that time they varied as the demands of the job dictated. Fortunately, the permanent staff of Stone and Webster was large enough and flexible enough to be able to meet these demands at all times. From the three contracts awarded Stone and Webster, a total of $2,888,000 was allotted to the Design and Engineering group for the work performed by them.

4. <u>Procurement of Equipment</u>. - Stone and Webster early established a purchasing office to handle all orders made by the design group in Boston. They also set up an office in the field to procure construction

equipment and supplies. Purchase orders and subcontracts were made in the name of Stone and Webster Engineering Corporation while contracts were Stone and Webster managed but in the name of the U.S. Government. Methods of procurement were standard methods modified to meet War Department regulations. Over half of the personnel employed in procurement were assigned to inspection and expediting throughout the country. The cost of the equipment for the Y-12 plant amounted to $138,930,123.50 including the cost of fabricating silver for magnet coils. This, however, did not include the cost of the silver. There were only 3 large electrical suppliers in the country considered suitable to manufacture the type of equipment needed by the Electromagnetic Project. An effort was made to divide the total requirements among the three and still have the parts that were divided as closely related as possible. For this reason General Electric Company was given a number of contracts for regulators, rectifiers, cubicles, substations, etc., comprising the majority of equipment needed for power supply. Over $40,000,000 was allotted to them for 5 contracts. As General Electric Company was awarded contracts for power supply equipment, Allis-Chalmers Manufacturing Company was awarded the contracts for the manufacture of the magnet excitation coils. A total of 6 contracts was awarded to them for about $8,500,000. The third electrical manufacturer, Westinghouse Electric and Manufacturing Company, was awarded the contracts for manufacturing the process bins and allied equipment. A total of 8 contracts was allotted to them for about $34,000,000. The procurement of vacuum valves soon became a major item in the procurement program of the Electromagnetic

Project. The Chapman Valve Manufacturing Company was awarded four contracts for valves at a total cost of $5,000,000. With a few exceptions, the procurement of chemical equipment was largely a problem of finding, among ~~within~~ a limited number of suppliers, one who was willing to take the comparatively large orders offered and one who would agree to supply the items within the time requested. Particular emphasis was placed by the expediting department upon supplying the manufacturer the materials he needed and every effort was made to help the supplier meet his commitments. The magnitude of the tube supply problem was early emphasized. The country's yearly production of some types was not enough to keep a month's replacements on hand for the Electromagnetic Project. As a result, new plants had to be built and a control of the supply carefully kept. General Electric Company furnished most of the tubes but orders were later placed with Machlett, Amperex, and Federal Radio. The immensity of the vacuum system required by the Y-12 plant resulted in the necessity of design and manufacture of diffusion pumps that were twice the capacity of anything previously manufactured. For this work Westinghouse Electric and Manufacturing Company was selected, to manufacture the pumps from designs submitted by Stone and Webster. Distillation Products, Inc., was later awarded orders for other diffusion pumps of their own design. Many miles of cable and copper wire were used in the construction of Y-12. Of these the process cable for high voltage electrical conductors presented a special problem, since there were no previous installations of cable operating continuously at 35-50 KV d.c. to ground. Specifications were released and bids were invited. Orders were finally placed with Kerite Wire and Cable Company and General Cable Company. Because of unique equipment required for this project, it was necessary to use certain materials not commonly found to such a large extent in plant usage. Included in these were silver, graphite, zircon and liquid nitrogen.

5. Organization and Personnel. - The organization of the Electromagnetic Project for purposes of design was largely dependent upon close cooperation of a number of groups. Under the Y-12 Unit Chief, Stone and Webster was directly responsible for the design of the Electromagnetic Project. They were assisted by or received the basis of design from UCRL, TEC, and various manufacturers. The combined efforts of all were transplanted by Stone and Webster to a workable design from which a production unit was obtained.

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

SECTION 1 - GENERAL

1-1. Purpose. - The theory of isotope separation by the Electromagnetic* process had been tested and proven by the pioneer research workers. The purpose of the design phase of the Electromagnetic Project was to develop the research data into the design for a plant which would perform large scale separation of uranium 235 from the other isotopes* of uranium.

1-2. Scope. - The scope of the work described in this volume consists of the design of an electromagnetic plant (code name Y-12) at the Clinton Engineer Works. This included procuring and developing the laboratory equipment of an unfinished experiment into a vast industrial plant. The amount of commercially available equipment that could be adapted to these specialized tasks was small, necessitating the design of much of the equipment from scratch. In order to meet the military requirement of speed, the development, design, and manufacture of all this new equipment had to be carried on concurrently with laboratory research. Since the full scale plant had to be built without the customary intermediate step of constructing a pilot plant, buildings were designed to house equipment before the design of the equipment itself had been determined, and the arrangement of the equipment was determined before the relationship and size of the various units had been worked out.

Consequently, numerous changes in design were found to be necessary during construction. The quantities of material required for the equipping and continued operation of the plant made it necessary for the suppliers to construct additional manufacturing facilities and these facilities had to be completed in the minimum time so that there would be no delay in the construction or operation of the Electromagnetic Plant itself.

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 the Acts there described.

b. Under the authority vested in him by these Acts, the President 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. (Appendix D1; See also Section 6, Organization and Personnel.)

1-4. Early History of the Project. - As a result of conversations between Dr. E. O. Lawrence of the University of California and Dr. Vannevar Bush of the Office of Scientific Research and Development (OSRD) in the Spring of 1941, experimental work at the University of California, on the separation of the uranium 235 isotope from the uranium 238 isotope by the electromagnetic process, was directed toward the design of a process which would make possible the large scale separation of the isotopes. This early work and the development of the research phases of the project are described in Volume 2. In June of 1942, coordination of the overall problem of developing atomic energy for military purposes was placed under the control of the War Department and was called the DSM Project, for ~~secrecy~~ security reason. The Manhattan District of the Corps of Engineers was organized to administer the work for the Government and a vigorous program was immediately initiated to develop all promising methods. The electromagnetic method was one of the most promising, and, consequently, received early and intensive attention. By midsummer of 1942, work had progressed to the point where it was evident that the electromagnetic process was practicable and the design of the pilot plant was started. Although plans for the pilot plant were approved in the Fall of 1942, it became evident that time would not permit the construction and operation of such an intermediate plant. The Government, concurring with the recommendations of Dr. Lawrence and his associates, made the courageous decision to abandon the pilot plant, which was to have been constructed at the University of California, and to direct all efforts toward the single purpose of designing and constructing a large scale plant and placing it in operation within the shortest possible time (See App. B1).

1-5. <u>Selection of Architect-Engineer.</u> - Stone and Webster Engineering Corporation was selected as Architect-Engineer-Construction-Manager of the DSM Project because of its previous association with the early phases of the uranium project. Prior to the formation of the Manhattan

District, discussions had taken place between executives of the Stone and Webster Engineering Corporation and representatives of the OSRD in connection with the development of the "centrifuge" process (See App. B2), and Stone and Webster had become generally informed on the problems in connection with part of the work as then conceived. In addition to the familiarity with the program, Stone and Webster was considered the best qualified among the large engineering and construction concerns in the country, and also was considered the only contractor, with sufficient facilities and staff, available to meet the requirements of the Project (See App. B3).

1-6. Original Stone and Webster Contract. - In addition to the design of the electromagnetic plant (Y-12), the Stone and Webster contractual responsibility included construction and extended somewhat into the research and plant operation phases of the work, described in the other volumes. This volume contains a reasonably complete discussion of the overall contract provisions.

a. Letter of Intent. - Discussions held in June 1942, covering the exchange of information and formation of plans for the uranium project, culminated on 29 June 1942, when a letter of intent for Contract W-7401-eng-13 was issued to Stone and Webster authorizing them to proceed immediately with the design and construction of plants for the development of atomic energy (See App. B11).

b. Original Estimates. - At later meetings for discussing the terms of a formal contract, it was pointed out that the estimated cost of an electromagnetic plant which would produce 100 grams per day of U-235 would be between 12 and 17 million dollars. This figure, however, did not include power or water supply, administrative buildings, change houses, guard houses, railroads, sewer systems, etc. Consequently, it was agreed to allow $35,000,000 for the 100 gram electromagnetic plant, which amount was to be taken from the $66,000,000 allocated to the DSM Project (See App. B12).

c. Scope of Original Contract. - On 13 October 1942, the Stone and Webster Engineering Corporation's formal Contract No. W-7401-eng-13 was executed, effective as of 29 June 1942. Under the terms of this cost-plus-a-fixed-fee contract, Stone and Webster was to be Architect-Engineer-Construction-Manager and agent for the Government on all matters concerning the so-called DSM Project. The contract covered a broad scope of work which included procurement of raw uranium ore for plant operation, the design and construction of manufacturing plants at various locations, all housing developments, water and sewer systems, and other facilities required in connection therewith. The contract set up the budget of $66,000,000, including $35,000,000 for the electromagnetic process. The contractor's fee under this contract for the above work was $900,000.

d. Supplemental Agreement No. 1. - During the early part of 1943, the scope of the Stone and Webster contract was reduced by deleting responsibility for procurement of uranium, for design and construction of the plutonium manufacturing plant, and for design of housing at Oak Ridge. The reduced scope was effected in order that Stone and Webster might expend full effort toward the rapid completion of the Y-12 plant, which was expanded to almost double the original number of manufacturing units, including facilities for a second stage process*. Supplemental Agreement No.

1 dated 15 June 1943, included the above changes and also increased the estimated cost of the Electromagnetic Project to $150,852,500 and reset the fee at $1,600,000 ~~(See App. B1)~~.

e. Supplemental Agreement No. 2. - During the summer of 1943, an extension to the Y-12 plant was authorized. Supplement No. 2, effective 9 October 1943, provided for an extension to the main plant which would multiply ~~more than~~ quadruple the manufacturing units originally contemplated. In addition, Supplement No. 2 permitted the AEW, under certain conditions, to place unit price or cost-plus-a-fixed fee contracts, as well as lump sum contracts. The revised construction cost was included as $390,000,000 and the fee was set at $2,980,028 (See App. B13, B14, B15, and B16).

f. Supplemental Agreement No. 3. - Supplement No. 3 was made effective as of 27 June 1944, and gave authority for the AEW under certain terms and conditions to dispose of certain Government-owned property.

g. Supplemental Agreement No. 4. - Supplement No. 4 was made effective as of 2 February 1945, and provided for changes in the scope of the work, which included the addition of new facilities and the conversion of existing facilities as a result of new engineering developments. The supplement calls for the installation and revision of processes to provide increased efficiency of operation and the performance of research, studies, development, and design required by the Contracting Officer. The supplement also requires the AEW to convert facilities already in operation, to design and construct additional facilities to provide for improvements, and to convert a chemical pilot plant at CEW to a production plant. Work outlined in this supplement was to be generally completed by 31 March 1945. A new cost estimate was included, which placed the cost of the work at $409,731,100 and set the fee at $3,020,028 (See App. B4).

h. Supplemental Agreement No. 5. - This supplemental agreement dated 7 August 1945, provided that the contracting officer could, after a year of satisfactory performance under the contract, authorize payment of the portion of the fee retained in an amount not to exceed 50% (See App. B5).

1-7. Service Contract No. W-14-108-eng-49.

a. Selection of Contractor. - It was understood and agreed in Supplemental Agreement No. 4 of Stone and Webster Contract No. W-7401-eng-13 that no additional work would be authorized under this contract subsequent to 15 February 1945, and that no work would be performed by the AEM after 31 March 1945, except for supervision and administration of existing subcontracts; protection of government property; and auditing and administrative work necessary to close out the contract and complete the records. Therefore, a new Contract, W-14-108-eng-49, was entered into on 2 February 1945, to provide for further developments in process detail as well as conversion and major repairs of existing facilities. Stone and Webster was familiar with the design, engineering, and construction of the project as already built and logically was selected for this new work (See App. B6).

b. Scope of Contract. - The scope of the work under this cost-plus-a-fixed-fee contract provided that the AEM would, as directed by the Contracting Officer, furnish consultant services; organize and maintain a consultant's staff; furnish labor, materials, equipment, services, etc., to expand, modify, or repair existing facilities; and perform such other construction services necessary to accomplish the adoption of new developments at the Y-12 Project. It was estimated that the cost of such work would be $6,000,000 per year, exclusive of the fee, which was established at $15,000 per month, based on the above estimated annual cost. The term of the contract was from 2 February 1945 to 2 August 1945, and could be continued for an additional six months period. As of 1 July 1945, the cost of work authorized under this contract was $14,387,600 (See App. B7). The grand total as of termination date, 30 September ~~1946~~ 1945, was $18,514,431.94.

1-8. Contract No. W-14-108-eng-60.

a. Selection of Contractor. - Since Contract No. W-14-108-eng-49 specifically eliminated the construction of any single item costing more than $6,000,000 (See App. B7), it was necessary to negotiate a new contract for a new process building to handle the estimated increase in feed material from K-25. Because of Stone and Webster's immediate experience and personnel, organized and timed to fit the job, and by reason of the known efficiency of the contractor's past performance, it appeared logical that Stone and Webster would perform the work to the best interest of the Government. Therefore, Contract No. W-14-108-eng-60 was negotiated with them. Stone and Webster had previously constructed a building substantially the same as the one to be constructed under this contract (See App. B8 and B9).

b. Scope of Contract. - The scope of Contract No. W-14-108-eng-60, dated 2 April 1945, provided that the AEM should render all architect-engineering and other services incidental to design, inspection, supervision, and construction of a second stage (Beta) process building. This work was to duplicate, substantially, Beta Process Building No. 9204-3 (See App. D2) and its accessory equipment, together with the necessary connections to existing utilities. It was estimated that this work would be completed and ready for utilization by the Government by 1 December 1945, at a cost of $18,000,000 exclusive of the AEM fee. A fixed-fee in the amount of $225,000, based on the above estimated cost (See App. B9) compensated the contractor for its work under this contract.

1-9. Selection of Plant Site.

a. Requirements. - The selection of a suitable site upon which the large scale electromagnetic plant would be located was initiated early in 1942. The primary requirements for such a plant site were that it be in a secluded area with an ample water supply and have a dependable source of power capable of delivering at least 100,000 KVA. As a result of previous study based on these requirements, Stone and Webster made a report to the Army recommending an area in Roane and Anderson Counties of Tennessee, adjoining the Clinch River in the vicinity of the town of Elza, and located near the high voltage transmission lines connecting the Tennessee Valley Authority's Norris Dam and Watts Bar Dam power stations. This 59,000 acre site was subsequently approved and called the Clinton Engineer Works (See Book I, Volume 12). Plants for isotope separation by other methods, and an experimental uranium transmutation plant, were also located at this site; and because of the influx of labor necessary for the completion and operation of all these plants, Oak Ridge, now the fifth largest city in Tennessee, was planned and developed.

b. Plant Location. - The Electromagnetic Plant is located in Bear Creek Valley in the southeastern part of this Reservation. This secluded valley, drained by the East Fork of Poplar Creek, is of sufficient width to lend itself well to the straight line layout of the plant, and the high ridges on either side afforded security and an excellent location for water storage (See App. D1 and C1).

SECTION 2 - DESCRIPTION OF ELECTROMAGNETIC PLANT

2-1. General. - The Electromagnetic Plant may be visualized as a group of huge laboratory buildings, each containing a labyrinth of fantastic equipment. Much of this equipment was developed in sizes never before constructed and is regulated within a degree of accuracy never before attempted; some of it was manufactured in enormous quantities; much of it was revolutionary in design; and most of it was built under trying manufacturing conditions, among which were material and labor shortages and the ever present necessity of speed. There are numerous auxiliary and service facilities, necessarily provided to aid in the successful functioning of the plant and to facilitate its maintenance. Facilities for the development and testing of new equipment and operating methods are continually pointing the way to improvements. The layout plan (See App. D2) and the photograph (See App. C1) indicate the extent of the facilities.

2-2. Basic Design. - The process for the separation of U-235 from U-238 at the Y-12 Plant was divided into two separate stages. The first stage*, known as the Alpha Stage*, effected only a partial separation of the isotopes, while the second or Beta stage*, effected an almost complete separation, using the partially separated material which was the product of the first stage as the starting material for the second stage. Each of these stages was in turn broken down into two steps, namely, chemical and process. The chemical, or "preparation" step, prepared the feed material* for the process step and also purified the unseparated feed material which was returned from the process step. The process or "separation step" received the feed material prepared by the chemical step and effected the separation of the isotopes by the electromagnetic process. The product of the second stage separation, after purification, is converted into the final product of the electromagnetic plant.

2-3. Alpha Preparation Units.

a. General. - The initial plant was designed to receive uranium in the form of uranium trioxide (UO_3), an orange powder shipped in fiber containers (75 pounds contents) from the Mallinckrodt Chemical Works of St. Louis, Mo. Later uranium hexafluoride (UF_6) (See Par. 3-3) was introduced as the uranium source. As uranium is most conveniently ionized for separation if made into a gas from a chloride, extensive chemical facilities were provided to convert the raw material (UO_3) into uranium tetrachloride (UCl_4). It is in this form that it is sent to the Alpha Process Building where the actual separation of isotopes is made. About 90% of this material, after passing through the separation process, is returned to the Alpha Chemical Building for reprocessing as the separation is only about 10% efficient. This returned feed material, highly contaminated with iron, nickel, copper, and chromium picked up from equipment during the process, is chemically treated to remove contaminants, then reconverted to the feed material (UCl_4) and again sent to the Alpha Process Buildings. (For location and code numbers of buildings see App. D2).

b. Alpha Material Preparation Building No. 1

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(1) Charge Preparation Department. - The initial step in the preparation of the raw material was performed in the Charge Preparation Department of the Alpha Material Preparation Building No. 1 (Building 9202). In this department are several reactors, or large glass-lined tanks, in which the UO_3 is converted to UCl_4 by means of reaction with carbon tetrachloride (CCl_4). The solid UCl_4 which formed in the reactors, is separated from the carbon tetrachloride in centrifuges, which are machines using centrifugal force for separating materials of different densities. The UCl_4 is then dried in an electrically heated drier. The product from the Charge Preparation Department(UCl_4) is not sufficiently pure for use as a feed for the separation units so another step is used to purify it.

(2) Vacuum Sublimation Department. - This final step in which the charge material* is changed from the crystalline form into a vapor without passing through the liquid stage is called vacuum sublimation* and is a very effective method of removing the impurities. The equipment in this department consists of a series of electrically heated stills (See App. C2 and C3), which heats the UCl_4 under high vacuum to a point where it is vaporized. The UCl_4 is then collected on a cold plate in a highly pure form, while the impurities are left behind, never having been vaporized. It is this highly pure UCl_4 that is used as a feed for the Alpha separation units.

(3) Bulk Recovery Department. - As only a small percentage of the feed material is separated, the "unseparated" uranium is recovered from the process bins* and returned to the Alpha Feed Material Preparation Building No. 1 for reconversion to pure UCl_4. It is subjected to a series

of purifications to remove carbon, iron, copper, chromium, and nickel, which have been picked up in the Separation Units. The removal of these contaminants is performed in the Bulk Recovery Department, which contains a series of reactors, filters, centrifuges, and driers. The uranium as it leaves the Bulk Recovery Department, is in the form of UO_3, the same form as the material which was originally furnished by the District. It is therefore fed directly back to the Charge Preparation Department, where it is again made into UCl_4.

e. Alpha Material Preparation Building No. 2.

(1) Intended Use. - The intended use of this chemistry building (See App. C4) was out-moded before it was placed in operation. The original intention of the Alpha Material Preparation Building No. 2 (9207 group) was to prepare the enriched material* from the diffusion plants (K-25 and S-50) for the Alpha separation units (See App. B166). In order that the large feed requirements could be met successfully and safely it was necessary that considerable small size equipment be installed. The new building contains a Bulk Recovery Department and a Charge Preparation Department which was to operate using the same principles and type of equipment as in the Alpha Material Preparation Building No. 1 (9202). The Vacuum Sublimation Department was housed in an adjoining building with units similar in design and performing the same function as the original Vacuum Sublimation Department.

(2) Hexafluoride to Oxide Conversion Building. - Since the K-25 and S-50 products are sent to Y-12 in the form of uranium hexafluoride (UF_6), a corrosive chemical, it was also necessary to have equip-

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ment capable of converting the UF_6 to UO_3. Therefore, a building (No. 9211) (See App. C4) was constructed for the purpose of converting UF_6 to UO_3, and it was planned to convert the UO_3, so produced, into UCl_4 by the normal Charge Preparation Process. The so-called "Hexafluoride to Oxide Conversion Building" contains equipment very similar to the equipment in the Bulk Recovery Department (See App. C5). Uranium Hexafluoride (UF_6) is brought from K-25 and S-50 plants, into the Hexafluoride to Oxide Conversion Building, where it is dissolved. A series of precipitations, filtrations, and dryings follow, whereby the fluorine is removed and the uranium converted to uranium trioxide (UO_3). This oxide is then sent to the Charge Preparation Department for conversion to UCl_4.

2-4. Alpha Separation.

a. General.- As the Alpha separation step of the Process was working with extremely low concentrations of the desired U-235 isotope, it was necessary to process large quantities of material in this stage to insure a fair return of enriched material. New developments in design and additional buildings were required to meet the production requirements. The basic theory, through all of these changes, however, remained the same and in general is as follows:

The feed material is first vaporized by heating. Then the individual atoms are electrically charged by passing the vapor through an electric arc. The cloud of charged atoms, or ions as they are called, is then converted into a high velocity stream or beam by the action of a high voltage electric field. The beam of ions is directed between the poles

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of a powerful magnet, the action of which bends the path of the ions into a semi-circle; the lighter ions being deflected in their path more than the heavy ones, thus affecting a separation which permits the collection of the isotopes in specially constructed receivers.*

b. Alpha 1 Separation.

(1) Racetracks. - Two of the original Alpha Process Buildings were virtually duplicates of each other (9201-1 and 9201-2) and the third (9201-3) was equivalent to half of one of these. Two of these buildings contained, each, two large production units known as "racetracks",* so called because of their elliptical shape, and the third housed a single track. Each racetrack is a massive steel structure, 122 ft. long, 77 ft. wide, and 15 ft. high. When observed from above, it can be seen that each racetrack is hollow inside, leaving an interior floor space about 84 ft. by 40 ft., so that the racetrack has the shape of an elongated annular ring. The two tracks are located end to end in a large hall nearly 450 ft. long, on the second floor of each building (See App. C6).

(2) Process Bins. - Each racetrack is divided into 48 sections, each section containing two "process bins" or tanks. These tanks are large, vertical, rectangular steel boxes, placed back to back so that the sides facing the inside and outside of the track are open. The process bins are spaced in the gaps between the large vertical magnet coils with steel cores (See Par. 4-3b). All of the magnet coils, which are connected together by a bus bar running along the top of the racetracks, are energized with direct current from motor generator sets, located in

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the ends of the building. As a note of interest, the magnet coil conductor and bus bar are of pure silver (See Vol. 4-Silver Program). When the current passes through the coils, an intense magnetic field is created in the gaps between them, where the process bins are located.

The open sides of the process bins are fitted with gasketed joints to which air-tight doors can be clamped (See App. C7). On each door is mounted all the internal apparatus of the separation process, so arranged that when the door is clamped over the open face of the bin, the apparatus is in the correct position in the bin for the electromagnetic separation to take place. Leading from the bottom of each bin is a duct, which passes through the floor to the vacuum system, which occupies practically the entire ground floor beneath the racetracks. When the door and its associated equipment, including a source, a liner* and a receiver/, is sealed into the process bin, operation of the vacuum pumps evacuates the bin to the extremely low pressure required by the process. The entire door and assembly is completely non-magnetic so that it can be installed or removed while the magnetic field is operating. All electrical and water connections enter internal equipment through vacuum seals in the door.

(3) Ionization Chambers. - The source unit, which ionizes and accelerates the uranium atoms, is mounted on one end of the vertical door. Each door is equipped to produce two beams of ionized uranium. Thus, each source contains two metal bottles containing the charge material/, mounted in electric heating coils (See App. C8, C9, C10 and C11). Upon the passage of current through these coils, sufficient heat is generated to vaporize the charge material, which passes through a valve

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and manifold system to two "ionization chambers", each of which maintains an electric arc which forms uranium ions in the vapor cloud.

(4) High-voltage Electrode. - Immediately in front of the ionization chambers are located the "high-voltage electrodes" which set up an electric field. As ions are formed in each ionization chamber, they are accelerated by the electrical field to extremely high velocities, forming, in effect, two beams of ions, one from each ionization chamber.

Under the effect of the magnetic field, the two ion beams assume semi-circular paths, each having a radius of about 4 ft. It is while the uranium ions are traveling this semi-circular path that the lighter U-235 ions travel on a slightly smaller semi- circle than the heavier U-238 ions and hence may be collected separately (See App. C8 and C9).

(5) Receivers. - At the opposite end of the door from the source are located the "receivers." Each receiver is a trap or box with a narrow slit opening, so located as to catch the beam of the lighter isotopes (See App. C8 and C9). The unwanted isotopes are caught on carbon plates placed close beside the slit opening. It should be pointed out that not all of the uranium vapor formed in the source is ionized in the ionization chamber. That part which is not ionized is not affected by either the accelerating electrodes or the magnetic field and hence merely spews from the source and collects on the sides of the source or on the tank liner. As the tank liner is attached to the removable door and is, hence, removed with the source units,* (See App. C7), the excess material is collected at the time when the door and its associated equipment are removed. This removal occurs when the metal bottles containing

charge material become exhausted, which may be after a week of continuous operation, and another door containing a freshly charged source is installed in its place. The old door is removed to the "service" wing of the building where the receiver cans of enriched material are removed, the impoverished material is discarded, and all unprocessed material is recovered by scrubbing, rinsing and washing.

(6) D Unit or Door. - The main door of the tank, more often referred to as the D Unit,* consists of a non-magnetic steel plate, containing the source and receiver units and a copper duct, housing the path of the ionized particles from the source to the receiver. The purpose of this copper duct, or liner, is to catch the excess material coming from the charge material and to aid recovery (See App. C7, C8 and C9).

(7) Controls. - Parallel to the large room, in which the two racetracks are located, and on both sides of it, are located two-story control bays which house all of the electrical control equipment,* associated with the process (See App. C12). For each process bin in the racetrack there is a control panel, with instruments to indicate the condition of operation. Each control panel also contains control switches for conditions which depart from normal. Behind each panel is located a cubicle* containing rectifiers which supply the high voltage direct current required in accelerating the ions. Much of the low voltage equipment used for controlling the ionization arcs and charge heaters is located on the floor below the two-story control bays.

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(8) Vacuum System. - The ionizing of the uranium atoms and the formation of the ion beams both require that the space in which these functions take place shall have most of the air molecules removed. Therefore a vacuum system was arranged so as to maintain each bin at an absolute pressure of the order of one-one hundredth micron of mercury. This pressure is the approximate equivalent of one-one hundred millionth of normal atmospheric pressure. As vacuums of this magnitude were previously obtainable only in laboratory experiments, it was necessary to expand from these experiments and produce pumps in large quantities and of sufficient size to operate the electromagnetic plant successfully. In order to accomplish an almost absolute vacuum, both mechanical and diffusion pumps are used. Mechanical "roughing" pumps* are used to reduce the bin pressure as quickly as possible. Diffusion pumps are essential in reaching reduced pressure below those obtainable by the use of the mechanical roughing pumps. Mechanical finishing pumps are necessary to the proper functioning of the diffusion pumps. The vacuum system is located on the ground floor of the building immediately below the racetracks; the installation begins at the bottom of each bin and the equipment includes a tank header, shut-off valves, diffusion pumps with boosters, motor driven mechanical pumps, inter-connecting piping, special apparatus, gauges and thermometers. The system evacuates each bin by using multiple diffusion pumps connected to a manifold system of roughing and finishing pumps (See App. A3).

c. Alpha II Separation.

(1) Track Arrangement. - While the original two Alpha

process buildings were under construction, improvements were developed at the Radiation Laboratory of the University of California and it was advisable to incorporate these improvements into any future racetracks to be constructed. Therefore, when the two additional Alpha process buildings were built (9201-4 and 9201-5) at the site known as Y-12 Extension, each contained racetracks which incorporated the later design. As in the case of the original two Alpha process plants, the newer buildings contained two tracks, each track having 96 process bins. The most obvious change was the difference in racetrack arrangement (See App. C13). Difficulty had been experienced on the old tracks in handling the bin doors that opened at the inside of the tracks, so the decision was made to eliminate the inside bins on the newer racetracks. Thus, in order to have 96 bins per track it was necessary to have twice as many sections as before. Such an arrangement made each track approximately twice as long as the original, but simplified the electrical connections and permitted a valuable increase in the vacuum system capacity. These longer tracks were assembled in separate runs, which gave a better building arrangement. There were other minor changes in piping and electrical equipment to suit the new layout (See App. A1).

(2) Other Improvements. - One of the main differences of design between the later racetracks and the earlier racetracks was that instead of each bin containing two ion chambers, each bin of the new racetracks contained four ionization chambers (See App. C14), thus doubling the production output of each bin. In addition, the sources of the new racetrack were designed to operate at a high voltage, whereas the

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sources of the units in the original racetracks were designed to operate at ground potential.* This change gave greater capacity per source and used less power in the accelerating system. The introduction of sub-doors on the main door of the process bin allowed changing of a receiver or a source without necessarily changing the complete separation mechanism. The main door (See C15) consisted of a non-magnetic steel plate having an opening near the bottom for the E subdoor(or source unit) and one near the top for the E subdoor(or receiver unit). It also had a rectangular steel frame built on the inside face of the plate so that when the main door was in place, the steel frame held a carbon sheet in position to partially define the beam of ionized particles.

d. Modified Alpha I Separation. - When these improvements were developed, it was too late to incorporate them in the fifth Alpha I track which is housed in a separate building, (9201-3) then under construction. It was possible, however, to include the additions of the high voltage source and the four beams. As a result, this track, known as Alpha I½, is a cross between the original Alpha I and the improved Alpha II. The size of the track, the vacuum system, and the general arrangement correspond with that used in the original Alpha I process racetrack, but the bin equipment and electrical apparatus correspond to that of the Alpha II process, except that the main door contained an enclosed liner similar to that of the Alpha main door (See App. C16).

2-5. Beta Preparation.

a. General. - The enriched material collected by the Alpha separation process is sent to Beta preparation, or chemistry buildings.

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As was previously pointed out, the first stage merely effects a partial separation of the uranium isotopes, and hence it is necessary to subject the partially separated material collected from the first stage process to a second electromagnetic separation, in order to obtain the desired concentration. However, it is first necessary to remove the contaminants picked up by the first stage process. This is a function of the Beta preparation step. After purification, the material is converted to UCl_4 for use as feed material in the Beta Separation Process. The unseparated material, which again represents about 90%(approximately 85% as of 1 January 1947) of the total feed material processed, is recycled through the Beta Chemistry Building, and reused as feed for the Beta Separation Process.

b. Beta Material Preparation Building.

(1) Receiver Washing Department. - The "receivers" which contain the enriched product from the Alpha Separation Process are taken to the Beta Material Preparation Building. Here, in the "Receiver Washing Department," the receivers are sprayed with nitric acid, dissolving the uranium which had been collected (See App. C17). This solution of uranium in nitric acid is then passed through a purification process which removes all contaminants. This purification process comprises an ether extraction step, a precipitation step, and a drying step which converts the uranium to the form of uranium trioxide (UO_3).

(2) Charge Preparation Department. - This material is then sent to the "Beta Charge Preparation Department", where the UO_3 is converted to uranium tetrachloride (UCl_4) by reaction with carbon tetra-

chloride. The equipment in the Beta Charge Preparation Department is considerably smaller than the charge preparation equipment in either of the two Alpha Material Preparation Buildings and the design is somewhat different; however, the basic function is the same. The UCl_4 produced in the Beta Charge Preparation Department is considered sufficiently pure to be used directly in the Beta Separation Process, hence no vacuum sublimation is required (See App. C18).

(3) <u>Recovery Operation</u>. - The unseparated material from the Beta Separation Process which collects on the separation equipment is removed by washing, scrubbing, and rinsing. The solution of uranium which results is sent directly to reactors, located in the respective Beta Process Buildings, where the uranium is precipitated as uranium peroxide (UO_4), and separated from the solution by means of centrifugation (See App. C19 and C20). The uranium peroxide, so obtained, is then taken to the Beta Material Preparation Building, where the UO_4 is converted to UO_3 by heating. The precipitation step, the centrifugation step, and the heating step are collectively known as the "Beta Recovery Operation." The UO_3, formed in this operation, is then sent to the Beta Charge Preparation Department, where it is converted to UCl_4. Also, during the Beta Recovery Operation, small quantities of enriched uranium are left behind in the various solutions. Since uranium is extremely valuable, great care is taken to recover as much as possible of this material. The various solutions are sent to the Beta Material Preparation Building where the uranium is recovered by means of other extraction. Then, as before, the uranium so obtained is converted to UO_3 and finally to UCl_4.

(4) Final Product Preparation Department. - The receivers, containing the highly enriched material from the Beta Separation Process, are also brought to the Beta Material Preparation Building. Here, in a separate section of the building, known as the "Final Product Preparation Department," these receivers, being largely carbon, are burned to thoroughly remove the uranium. Then, after an ether extraction and a precipitation, the uranium is converted to uranium tetrafluoride (UF_4), which is the form of the final product. The equipment in the Final Product Preparation Department is extremely small because of the small quantities of product which are handled at this point of the process. In fact, most of the equipment is laboratory size.

(5) Salvage Department. - The Beta Material Preparation Building also houses the "Salvage Department." This department is equipped with large and small size equipment, such as extractors, reactors, filters, centrifuges, evaporators, driers, etc., for the sole purpose of recovering the last traces of uranium from discarded solutions, solids, rags, sponges, or any pieces of equipment which may have traces of uranium on them.

2-6. Beta Separation. - As pointed out earlier, the product of the first-stage is subject to a second separation step. In order that this step may be carried out, four second stage, or "Beta", process buildings were provided (9204-1, 9204-2, 9204-3, and 9204-4). Each Beta process building contains two tracks in a room 368 ft. long; each track is 104 ft. long. The tracks are assembled, as in the Alpha II process buildings, with the bins facing only on the outside of the tracks (SeeApp.C21);

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the bin equipment is designed on the two beam basis, with each track containing 36 process bins. The total Beta installation contains 288 units. The general arrangement of equipment and principles of design, of the Beta process, which uses the "hot" source*, are quite similar to those of the Alpha II. The distinguishing feature of the Beta process is the extreme precautions taken to prevent loss or pollution of the charge material, as it is the product of extensive manufacturing effort and a small amount of it has considerable value. Everything in the Beta Process is on a smaller scale, to cut down the risk of loss and to prevent the accumulation of material in quantities large enough to reach the critical mass* necessary for atomic fission and its attendant hazards. More attention is also paid to the use of non-corrosive parts, to reduce contamination of the product. The main door of the Beta tank is equipped with a source subdoor and a receiver subdoor, as well as a completely enclosed water cooled liner, to aid recovery and prevent loss of the highly enriched charge material (See App. C22).

2-7. Auxiliary Facilities.

a. Steam Plants. - Two boiler houses, complete with coal-and-ash-handling equipment, and designed to furnish steam at 200 psi working pressure, were provided for cleaning equipment and heating buildings in the Y-12 Areas. The second boiler house was necessary when the extension was authorized (See App. C23). The plant accessories include feedwater heaters, boiler feed pumps, chimneys and flues, zeolite softeners and necessary piping. The distribution system, which

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carries an average pressure of 175 psi with 50° of super heat, consists of overhead steam lines insulated with 85% magnesia covering and is supported on wooden pole structures. The designed normal maximum steam load is about 543,200 pounds per hour. Allowing for boiler auxiliaries, distribution losses, and load diversity, the demand on the boilers is estimated to be about 480,000 pounds of steam per hour. This does not include an allowance required for steam jet refrigeration, since this load occurs during warm weather when the buildings are not heated.

b. Cooling Systems.

(1) Cooling Tower Systems. - A circulation cooling tower system was designed to remove surplus heat generated as a part of operations carried on in the process buildings. Each track has cooling facilities located immediately adjacent to the building (See App. C24). These facilities consist of a mechanical draft cooling tower, a water cooling basin, enclosed tubular coolers, and separate piping systems for the circulation and distribution of oil, distilled water and filtered water. The heat is dissipated by indirect contact of the down-flowing cooling tower water over the enclosed tubular coolers, or heat exchangers, through which the heated oil and water circulate. Pumping facilities for each track were provided to circulate these liquids to and from the cooling towers.

(2) Air Cooling System. - The air cooling is accomplished by means of a primary system in which filtered air is introduced into the building by means of axial flow fans, which force air through concrete tunnels beneath the ground floor. This air is used for

general ventilation of all process areas and also for specific ventilation of transformers and process power supply equipment. Axial flow exhaust fans located near or at the roof levels remove the heated air from the building. Special cooling of the gaps between the magnet coils (9201-1, 9201-2, and 9201-3) and the bins was accomplished by a secondary system in which air chilled to 55 degrees was forced by centrifugal fans into a plenum chamber which feeds air through the gaps. Varying portions of fresh air and recirculated air are used, depending on outside weather conditions.

c. Water Pump Houses. - Water pump houses are provided to house the motor-driven pumps used in the circulation of water in the filtered water cooling systems. Pumping facilities for the distilled water systems are similarly housed (See App. C25).

d. Oil Purification and Pump Houses. - Because the oil used as a coolant in the magnet coils also required purification, facilities for this purpose were designed. The purification step is accomplished, after the oil has left the cooling towers, by adequate filters inserted in the circulatory system. These filters are housed with the pumping facilities in separate buildings adjacent to each process building (See App. C26).

2-8. Process Development Facilities.

a. Laboratories. - Process development buildings were designed to provide laboratories in Chemistry, Engineering, and Physics in order that immediate problems of design could be investigated and to assure the feasibility of future developments. Process development shops are provided for the maintenance and repair of apparatus housed in the development buildings and for the construction of new equipment.

b. Development Plant. - A separate building, complete with necessary equipment, was designed in which to train operators for the major Y-12 units, and also for the purpose of conducting experimental work for the improvement of the process. The major equipment includes two experimental tracks (XAX and XBX), each containing two process bins with excitation and control equipment, material preparation and recovery equipment, two power supply transformer substations and associated equipment, two 60 ton refrigeration units, miscellaneous electrical equipment, machine tools and process piping (See App. C27).

2-9. Service Facilities.

a. General. - In addition to those facilities already mentioned, there are numerous other facilities which provide services essential to the successful functioning of the plant. To meet the needs of the large number of employees there are office buildings, clock alleys, change houses with locker rooms, medical service buildings, cafeterias, canteens and a laundry. To serve the plant, there are numerous shops, warehouses, storage tanks, etc; each facility has served its specific purpose and all were instrumental in achieving the final goal.

b. Shops. - The immensity of the job and its isolated location require an assortment of shops, tools and machinery essential to the immediate repair and development of process equipment. It was the original intention to house most shop facilities in one large building. However, in the final plans, separate buildings were provided for a Foundry, Electrical Maintenance Shop, Garage and Repair Shop, and a Generator Shop. With the expansion of the program and the necessary changes in design to incorporate new developments, the facilities of the main shop became inadequate, and the sheet metal, welding, carpenter and pipe shops, plus a part of the machine shop, were moved to separate buildings, which for the most part were Stone and Webster temporary construction buildings. Several special shops are maintained in order to facilitate the work of the project. In a "Valve Pickling Shop" provisions are made to remove contaminating material from valves and pipes by dipping them in an acid solution. A portion of the main shop building is utilized for the "Carbon Shop" where the receiver pockets and other carbon shapes are ground from blocks of graphite. An Instrument Shop for the repair of ammeters, voltmeters, pH meters, etc. is included in the main shop building. An Electroplating Shop was designed for copper plating parts of the stainless steel receiver units, and for other plating essential to the program.

e. Storage. - General warehouses and storage facilities, some of which include unloading shipment have been provided for process materials and supplies. Cement, electrical supplies, gas cylinders, etc. are stored in separate warehouses. Acetone, ammonia, carbon tetrachloride, etc., used in the preparation of feed material, have been purchased in large quantities and are stored until desired. Liquid nitrogen(See Par. 4.11d) is stored in tanks on top of the process buildings and piped into the buildings for use in cold traps on the vacuum system.

A building is provided for storing Dry Ice (CO_2) which is used in the condensation of moisture in the vacuum system. Separate provisions for storing water and oil used in cooling systems have been provided for each track.

Classified materials and supplies are stored in a restricted area called Midway. This site, located on the CEW railroad halfway between Oak Ridge and Y-12 Area, was chosen because of the flat terrain and contains warehouses and storage yards with handling equipment. Central Facilities' excess warehouse space in the Administration Area of the CEW reservation was also utilized as it became available.

d. Telephone. - The telephone system was installed by the Southern Bell Telephone Company under the supervision of the U. S. Army Signal Corps. During peak load conditions approximately 767 telephones were used. These phones were connected to the main telephone switchboard in the administration area. Originally a manual (PBX) system was provided but was converted to the dial (PAX) system in January 1944 (See Book I, Vol. 12). Separate telephone facilities between each process bin and the cubicle operator have been provided to facilitate immediate correction of any disturbance not conducive to proper operation.

e. Transportation. - For transportation of materials and personnel, a network of railroad spurs, hard surfaced roads and walks were provided. There are 7.2 miles of standard gage tracks to provide easy access to the buildings for heavy equipment and the multitude of supplies. The primary roads were designed for industrial traffic and constructed of crushed stone with bituminous surfacing. Bus terminals and parking lots were provided for the thousands of employees traveling to and from the area (For Access Roads See App. D1). Shuttle bus service within the area is provided over established routes (See App.D2).

f. Plant Protection.

(1) Fire Protection. - Two completely equipped fire stations provide ample protection for the Y-12 Area, and in case of necessity the Oak Ridge facilities are available. In the original design for fire protection, 2000 gpm (2.88mgd) was estimated as the demand on the water supply system. This was increased to 5.0 mgd when the Y-12 extension was built. Fire hydrants are spaced so as to provide four points of attack for the process buildings and two points for other buildings. Sprinkler systems were designed where conditions required their use. The larger buildings are of fireproof construction to further simplify protection.

(2) Guard Facilities. - The restricted Y-12 Area is fenced with a security type of woven wire fencing for which protective lighting is provided. Elevated guard towers, six feet square, of wooden frame construction, have been installed at critical locations so that adequate protection and policing can be accomplished. A Headquarters Building for administration and Barracks for housing men on the Area are among other guard facilities provided. All persons desiring entrance into the area are scrutinized by the Guards and are admitted through the gates only upon presentation of proper credentials (See Security, Book I, Volume 14).

2-10. Utilities.

a. Electricity.

(1) General. - Substations, located on the northwest and southwest corners of the Electromagnetic Plant Area, are a part of the main Clinton Engineer Works power system that connects with the 154 KV Tennessee Valley Authority system (See Book I, Volume 12). A 154 KV line leads from the substations to a transformer adjacent to each of the process buildings, except for the Alpha II process buildings which have two transformers, one for each track. The rating of these transformers is based on the use of forced oil and forced air cooling. Without the pump operating, the transformers have negligible capacity. Switch gear control apparatus and other transformers are required for distribution of power at various voltages within the buildings. As each magnet requires direct current for its excitation, motor generator sets are supplied to change the 60 cycle alternating current to direct current. The regulation of this current must be held constant to within one part in five thousand.

(2) Requirements. - Because power requirements played an important part in the design and engineering of the electromagnetic process, early steps were taken by both Stone and Webster and the Corps of Engineers to insure an adequate electric power supply. In September 1942, the general power requirements were outlined and methods of supplying the power were developed. At this time, the requirements for the Y-12 Plant were estimated to be 100,000 KVA by 1 July 1943 (See App.#17). In September 1943, with the extension of Y-12, the estimated requirements for the electromagnetic plant were increased to 255,000 KW, and in January 1945, were revised to 200,000 KW, at 90 to 95% power factor,

based on considerable experience not available in previous estimates (See App. B18). The power consumption for June 1945 was 142,200,000 KWH (See App. B10).

b. Water Supply.

(1) General. - The water supply system for the Electromagnetic Plant is a part of the same system that supplies the town of Oak Ridge (See Book I, Vol. 12). Large quantities of water are required for process cooling, fire protection, and domestic and general consumption; the majority being required for process cooling. Because of the large cooling demand in the process buildings, it was uneconomical to draw this quantity of water from the filtered water force main. Raw water was therefore circulated through the cooling tower systems to dissipate the surplus heat. Filtered water, raw water, or distilled water were utilized where adaptable in the various phases of cooling and consumption (See Par. 2-7b).

(2) Filtered Water. - The filtered water distribution system originates at the clear wells of the Filtration Plant, located north of the Y-12 Plant at an elevation of 1100 ft. Filtered water was originally supplied through two 16-inch diameter supply mains and auxiliary 8-inch mains, under pressure of approximately 40 pounds per square inch gauge. The design of the pipe sizes was based on a normal process and domestic demand of 7000 gpm and an additional 2000 gpm for fire protection service. Filtered water for normal process consumption was used in the diffusion pump cooling coils, vacuum pump water jackets, and tank and face plate cooling. Increased construction at Y-12 required

additional filtered water facilities; a 24" supply main, additional auxiliary mains, and an expansion of the distribution system were authorized in December 1943 (See App. B19 and B20).

(3) Raw Water. - When Y-12 extension was planned it was found that the filtered water facilities would be inadequate for the additional construction. In order to alleviate this condition a 24" raw water main was planned to supply the cooling towers. It was necessary to treat the raw water chemically for demineralization before using.

(4) Distilled Water. - Distilled water is used for cooling in the cubicles and bins of the Process Buildings where non-scaling properties are necessary and where electrical conductance losses through water must be held to a minimum. Facilities were designed to produce the distilled water from the process steam used in the buildings. Distilled water cooling systems were designed to utilize the cooling towers adjacent to the process buildings.

e. Sewerage and Waste Disposal.

(1) Sanitary Sewer System. - The original sanitary sewer system for the Y-12 Plant consisted of a series of collecting laterals which discharged into a 12" diameter gravity sewer leading to a pump house. The sewage was then pumped through a 6" diameter force main to a gravity flow sewer leading to the townsite system. Here the combined wastes flowed by gravity to the sewage treatment plant, which removed the harmful bacteria constituting a menace to public health (See Book I, Volume 12). In June 1944, when the west Treatment Plant was built, to relieve the overburdened townsite system, the Y-12 sewage was

diverted to this plant through a newly constructed interceptor sewer. The run-off for the area is spread over a 24 hour period with the peak loads at change periods. The system is designed for a peak load of 1.02 mgd.

(2) Process Waste. - Certain process wastes are disposed of through a separate process waste collecting system which discharges into the storm sewer after passing through a small acid neutralization plant.

(3) Storm Water Run-Off. - A drainage system, consisting of open drainage ditches, culverts and storm sewers, was designed for the Y-12 Area with consideration given to the rate of rainfall, size and shape of drainage area, and slope and character of the surface to be drained. It was determined that the average rate of storm water run-off for design purposes should be 640 cubic ft. per second per square mile, or 1 cubic ft. per second per acre. The system was carefully planned to drain by gravity into the East Branch of Poplar Creek.

SECTION 3 - DESIGN PROGRAM

3-1. Major Developments.

a. General. - In June 1942, ~~the District was given~~ a Presidential Directive (See Book 1, Volume 1) was issued which covered the authorization, design and construction of a plant to produce 100 grams per day of U-235. As a basis for proceeding with this Project, the OSRD research work, which had already been performed at the University of California and other locations (mentioned in Par. 1-4), was available, and was to continue under the direction of Dr. E. O. Lawrence. With this as a beginning, it was the responsibility of the District after it was organized to select the organizations and methods to be used in the successful accomplishment of the mission. It may be readily seen, when consideration is given to the many factors upon which the design of a successful plant depended, that time would not permit a systematic study of all combinations of variables.

b. Design Variables. - From the small amount of separated material produced by the experimental work it was evident that many and more powerful units would be needed to obtain production of military significance. It was also necessary to consider the various systems of combining groups of units in economical arrangements. The amount of U-235 collected per day and the purity of the material collected were dependent upon many factors, including: the width, spacing and shape of collectors; the degree of vacuum in the bins; the strength and uniformity of the magnetic field; the shape and spacing of the defining slits and accelerating system; the accelerating voltage, the size and shape of the slit in the arc source from which the ions came; the current in the arc; the position

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of the arc within the arc chamber; the pressure of vapor in the arc chamber; and the chemical nature of the vapor. As there was not time for a complete systematic study, the development had to be largely intuitive. A variety of conditions had to be studied and a number of partial interpretations had to be made. Then the accumulated experience of the group and the feel of the problems were translated into specific plans and recommendations.

c. Technical Decisions Required. - The information and experience that had been acquired on the variables, such as those mentioned above, had to be translated into decisions on the following principal points before design could actually begin; number of stages; the size of a unit as determined by the radius of curvature of the ion path, the length of the source slit, and the arrangement and number of sources and receivers; the maximum intensity of magnetic field required; whether or not to use large divergence of ion beams; the number of ion sources and receivers per unit; whether the source should be at high potential or at ground potential; the number of accelerating electrodes.

d. Operating Policies. - In carrying out the President's Directive, the District immediately entered into an extensive design program. This program, which was coordinated by Stone and Webster (See Par. 1-5) and made use of the large technical staff of numerous equipment manufacturers, was planned to produce the greatest possible amounts of U-235 in the shortest possible time. In order to enable the reader to comprehend fully the major decisions reached during the course of the design program, they are briefly reviewed below, prior to a fuller discussion to explain the detailed design problems and their solution.

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e. <u>Decision to Proceed with Complete Design of a 200 Tank Plant</u>. - In July 1942, investigation and preliminary studies had proceeded to the point where it appeared feasible to begin design of an increment of the electromagnetic process plant. On 5 November 1942, a decision was reached to freeze the design for a portion of the work and General Groves, with the approval of the Military Policy Committee, authorized the design, construction and procurement of equipment for a first stage plant that consisted of 200 tanks.

f. <u>Decision for Complete Y-12 Plant</u>. - Although the design had been "frozen", research and design progressed to a point in March 1943, when it was readily apparent that in order to achieve a plant having the required 100 grams per day capacity it would be necessary to add additional first stage facilities and a complete second stage. Therefore, on 17 March 1943, the so-called Y-12 Plant was crystallized as a plant containing 3 first-stage or "Alpha" buildings containing 5 tracks, one second-stage or "Beta" building containing 2 tracks, chemical facilities to serve the process buildings, and such auxiliary services as were required (See App. B21).

g. <u>Conversion of First Stage Track No. 5</u> (See App. B26). - On the basis of results to be expected from the rapid advancements of research and experimental studies, a decision was reached in July 1943, to convert Alpha Track No. 5 to a hot source unit in anticipation of doubling the capacity of this track. Tracks 1 through 4 were too far advanced in fabrication and construction to be adaptable to such a change.

h. <u>Y-12 Extension</u>. - In September 1943, the electromagnetic process had advanced to the stage where successful plant operation was

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practically assured and since it was the process which promised to produce the earliest returns of usable product, General Groves, after discussion with, and approval of, the Military Policy Committee, issued instructions to increase the capacity of the plant by the addition of four Alpha tracks and two Beta tracks (See App. B38 and B13).

i. The Third Beta Building. - Studies initiated by the District, which had been proceeding for some time, culminated, in March 1944, with the decision to use partially enriched material withdrawn from the K-25 and S-50 plants. In order to take advantage of this decision, and the resultant increased capacity, a new Beta Building containing two tracks was authorized.

j. Fourth Beta Building. - Lengthy studies by the District of the optimum utilization of District facilities resulted in the decision to combine the K-25 plant, producing an eventual 36% enrichment, with the second stage facilities at Y-12. This plan, which was adopted in March 1945, called for the construction of a fourth Beta building, and the eventual abandonment of the Alpha stage.

3-2. Process Design. - For purposes of clarity, the design of the equipment and facilities which performed the actual separation of the uranium isotopes are treated separately from the corresponding chemical facilities which were used to prepare and process the feed material through the plant (See Par. 3-3). However, it is emphasized that the chemical design proceeded concurrently with the design of separation equipment.

a. Original Design.

(1) Alpha I.

(a) General. - The first process bins, being studied at UCRL at the time an electromagnetic plant was conceived, consisted primarily of a vacuum tank containing a single source unit and a receiver unit. From the indicated capacity of such a unit it was estimated that a plant to produce 100 grams per day would require approximately 2000 single source bins. During this period, continuous changes were being made in the design of process equipment which were too valuable to cast aside (See Vol. 2). In order to facilitate the introduction of new designs into the plant, it was felt that a program of construction by fixed steps was justified. This would allow new process equipment to be incorporated into the next phase of construction without interfering with that phase already completed. It was decided to break the total into blocks of approximately 200 sources. Design was instigated with these thoughts in mind and resulted in the first building, housing: two racetracks, each consisting of a magnet and 96 two source bins for process equipment; vacuum producing equipment; control equipment housed in separate control rooms (two for each track); the necessary service facilities, and a control room for incoming power (See App. B21).

(b) Track Design. - On the basis of information obtained from the Radiation Laboratory, it was estimated that a block of about 200 sources would separate about ten grams of U-235 per day. On 8 December 1942, the Process Engineering Committee of UCRL released their specification S-7 on the magnet design, calling for 48 gaps per track, each gap dimensioned to hold two double-source bins, or a total of 192 sources. Both of these decisions were based on drawings prepared by

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Stone and Webster Engineering Corporation. Stone and Webster's drawings were, in turn, based upon the following points: (1) A track of approximately 100 bins was large enough to achieve economy in the systems which are common to one track, such as the excitation system and the oil and water cooling systems. On the other hand it was not so large that trouble in one of these systems could lead to a major plant shutdown. (2) A track of this number of sources was a sufficiently small fraction of the total construction contemplated so that an appreciable portion of the total capacity could be brought into production before the plant was completed. (3) Tracks of this size would permit the introduction of new design features into successive tracks as they were developed. (4) A more balanced and economical distribution of bins among substations and special rectifiers could be made if the total number of bins were divisible by a number of factors, such as, 2, 3, 4, 6, 8, 12, etc. This fact led to the selection of 96 for the number of bins per track instead of 100 (See App. B22). Because of the critical shortage of rolled steel, cast steel was used in the magnet core. By using an oval track instead of rectangular track, a saving of approximately 900 tons of core steel was realized on each track (See App. A1 and C6).

(c) Unit Design. - The design of source, receiver, and liner units was fairly well established by December 1942. At that time, however, the Radiation Laboratory had succeeded in controlling two sources in one bin, and the prospect of increased yield was too great to be overlooked. The difficulties in making the necessary changes were not too great, although negotiations were already underway for control equipment based on a single source. The final design of the source and receiver units for the initial Alpha stage were two source units with a double receiver, a liner, and the necessary auxiliary equipment for their proper functioning (See App. C7, C8, C9). In order to achieve the fastest possible construction schedule, the only changes that were to be considered were those which would not delay the scheduled production date (See App. B23).

(d) Design by Manufacturers. - Contracts for major items of production equipment were entered into with several large manufacturers. These contracts, which included provisions for detailed design of specific equipment, were instituted in order that the best possible engineering talent and experience would be available to Stone and Webster in its effort to develop the completed design as rapidly as possible. In application of this plan negotiated contracts were drawn up with the General Electric Company for the general control equipment and unit substations; with Westinghouse Electric and Manufacturing Company for the process tanks, source, liner, and collector mechanisms; with Allis-Chalmers Manufacturing Company for magnet coils (See App. B24). Arrangements for negotiated contracts were made with The Chapman Valve Manufacturing Company for the fabrication of the vacuum valves; with Westinghouse Electric and Manufacturing Company for the construction of diffusion pumps; and with the Fluor Corporation for erection of the cooling towers with integral oil and water cooling coils (See App. B25). A discussion of these contracts will be found in Section 4.

(e) Final Design of Alpha I. - At a conference in Boston, 17 March 1943, attended by Gen. Groves, the final design of

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the Y-12 process was discussed. The principal design features were fairly well fixed. The Alpha stage would be carried out in five racetracks, all of the same basic design. There would be three Alpha stage buildings, two of which would house two racetracks each and the third would house a single racetrack (See App. B22). The track would consist of a 48 gap oval magnet containing two tanks placed back to back in each gap. The source-receiver mechanism would be two cold source units with the necessary mechanisms for collectors, controls, and the required vacuum equipment. This gave a final Alpha stage of three buildings, housing five tracks, each track having 48 gap magnets, with two double source tanks in each gap, giving a total of 192 sources, ~~per magnet~~, or 960 sources for the Alpha stage. The cost of the three Alpha stage buildings was estimated at $61,000,000. The total cost of the Y-12 Project was estimated at this time at $91,300,000 (See App. B21). Following are some of the difficulties encountered in the design of the initial plant: (1) guiding the experimental work of the research groups into channels showing the best promise industrially; (2) developing type and general design of process equipment; (3) design and construction of the largest magnets ever built; (4) power supply and equipment tolerances regulated within a degree of accuracy never before attempted; (5) a tremendous vacuum system capable of producing and maintaining an almost absolute vacuum; (6) diffusion type vacuum pumps developed in sizes never before attempted; (7) development of new types of handling and servicing equipment. These things were accomplished during the worst period of material shortage during the war.

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(2) Modified Alpha.

(a) General. - In July of 1943, a conference was held in Chicago with the design groups and the principal manufacturers of electromagnetic equipment. A number of designs for the Alpha race-tracks were discussed in an effort to obtain the design which would produce the maximum amount of product as soon as possible and the maximum total product within the following year, taking into consideration the improvements in design developed at the Radiation Laboratory and the critical material and manpower situations. It was decided that Track 5 would be constructed with an improved Alpha design using two "hot" sources instead of the two "cold" source design of Tracks 1 to 4. Use of the "hot" source was expected to double the production from the track. No changes in Tracks 1 to 4 would be made (See App. B26). On 8 July 1943, instructions were issued to rework Track 5 for the two hot source design (See App. B27). A decision to base the high voltage cubicle design on the use of water cooled tubes for rectifiers and emission limiting permitted General Electric Company to proceed on the design of control equipment for Track 5. This decision was the result of a conference at General Electric's Pittsfield Plant on 8 and 9 July, which was attended by the Area Engineer and representatives of all other interested parties (See App. B28).

(b) The Two Hot Source Alpha Unit. - The principal difference in the Alpha 1 process and the Alpha "I-1/2" process (See Par. 2-4) is indicated by their units; by the fact that the source of electrons which form the ionization beam is at ground potential for "cold" source or at a very high potential, such as 35 KV, for the

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"hot" source units. The advantage of the "cold" source unit lies in the simplicity of design of the unit and its auxiliary equipment. The advantage of the "hot" source unit, which quickly offsets that of the "cold" source and makes it the more desirable of the two, is that it will produce approximately twice the amount of enriched material as the "cold" source unit. As a result of Alpha experimental plant operation at the University of California, it was indicated that the production per two "cold" source track would be approximately 300 grams per month. The two "hot" source track was expected to produce 600 grams per month of enriched material (See App. B29).

(c) The Four Hot Source Alpha Unit. - At a conference in California on 5 August 1943, a decision to change Track 5 to a four "hot" source design rather than the two "hot" source design was reached (See App. B30). This decision was based on information and test results obtained at the Radiation Laboratory prior to this date. The four "hot" source unit was the one actually placed in use on the fifth Alpha racetrack (See App. C12).

(d) Liner and Receiver. - The main door of the Alpha I-1/2 design was quite different from the Alpha I design. It consisted of the main face plate for the tank, with two openings or subdoors cut in it, one for the source or M unit and the other for the receiver or E unit (See App. C14 and C26). Because of the increase in the number of sources, it was necessary to introduce the main and subdoor (small sections of the main door which can be removed independently) design. The four source M units also required the development of a quadruple receiver (See Volume 2, Research).

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(3) __Beta.__

(a) __General.__ - The need for a second stage in the Electromagnetic Plant was realized late in 1942. It had first been thought that recycling the charge material in a first stage building would satisfy the problem of reaching the desired enhancement, but it was soon learned that this recycling process would never produce material of the desired enrichment without prohibitive losses. It was found that by operating on a smaller scale than that of the first stage and by using a shorter radius of curvature for the path of the ionized particles, better control of the operations was assured and a more nearly pure product was obtained. The source and receiver mechanisms were made smaller than first stage mechanisms to facilitate handling, and the charge size was set at a value which would prevent the critical mass* from being reached. These points just mentioned brought about a decision ~~in February~~ on 17 March, 1943, to construct a second stage building of a design different from that of the first stage (See App. B31). The design of the Beta Building was based on the experimental results, design assumptions, and expected rates of the Alpha plant (See App. B32). The Beta Building was to contain two tracks, two control rooms (one per track) the necessary vacuum system, service areas and other auxiliary equipment. (See App. B21).

(b) __Track Design.__ - It was decided that the Beta track would be constructed with the bins in straight magnets in two parallel lines, one bin per magnet gap (See App. C19). This design was due in part to Tennessee Eastman's study of plant operations.

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The straight magnet design also eliminated the use of inside bins and made the changing of bin equipment much easier.

It was believed that a smaller number of bins than the 96 required for an Alpha track would be suitable for the following reasons:

(1) The required number of Beta bins was smaller than the total number of Alpha bins and 96 would represent too large a fraction of the total Beta bins. It was estimated that from 30 to 40 bins would be required.

(2) The shorter "runs"* (operating time per charge) in Beta and the increased amount of servicing of each bin required a larger proportion of servicing area to track area and the required ratio would be more easily obtained with a limited number of bins per track.

(3) A suitable balance of these factors was obtained with 36 bins per track, this number being divisible by 2, 3, 4, 6, 9, etc., for a more balanced and economical distribution of bins among unit substations and special rectifiers. This number, 36, was first established in a specification, hand-written by Dr. Lofgen, of UCRL on 5 March 1943 (See App. B22).

(c) Unit Design. - The E unit or source was to be of the two hot source type (See App. C27). It was decided to use main and subdoors for ease in installation and servicing. The main door was designed to hold a water cooled recovery liner (See App. C28 and C33) in position inside the tank. The fact that recovery of all unused feed material at this stage was essential made the use of recovery liners imperative. The double collector type E unit or receiver as shown in Appendix C28 was required. A number of H and E subdoor designs were experimented with before the accepted design was chosen.

(d) Equipment. - The necessary equipment for the Beta stage was to be furnished by the same manufacturers as the corresponding equipment in Alpha (See Par. 3-8). The only exception to this was the fact that Westinghouse was to furnish the 20" vacuum valves instead of Chapman, but this decision was later changed to give the work to Chapman (See App. B33).

(e) Accepted Beta Design. - During March, 1944, the Beta Building was placed on the limited operation (See App. B34). At this time, the second stage building consisted of two tracks, each containing a 36 gap magnet in two parallel sections (See App. C19). Each gap housed a vacuum tank which in turn contained an H subdoor carrying the source, an E subdoor carrying the receiver, and a main door holding a water cooled recovery liner in place. Each bin was equipped with the necessary control (See App. C31) and vacuum systems (See App. C29) to insure proper operation.

(f) Redesign of Beta Source Units. - During the preliminary operation of XBK, the Beta Pilot Plant, it was discovered that the source unit chosen was highly unsatisfactory and it was necessary to begin an extensive remodeling and redesigning program. The experimental work connected with this program was largely conducted at the Y-12 plant in the XBK magnet. By the end of April 1944, a satisfactory model was worked out (See App. B35) and was introduced in the manufacturer's production line which had been producing the obsolete model for training use. At the same time inspection at the plant was tightened to eliminate poor workmanship and misalignment of parts which had been causing difficulty (See App. B36).

(4) Design Status in August 1943. - In August 1943, the design of the various units was approximately 96% complete and practically all drawings were issued to the construction forces. Project authorization at this time totaled $101,532,000. The authorizations covered five first stage tracks consisting of 96 tanks each. Four of these tracks contained two grounded sources per tank while the fifth was designed (at that time) for two insulated sources per tank. In addition there was a Beta Process Building, containing two second stage, or refining, tracks consisting of 36 tanks each. These refining tracks were to be constructed with two insulated sources per tank. The authorizations also covered the Chemical Preparation Buildings and such auxiliary facilities and equipment as were known to be needed at that time. The experimental plant operation of the first stage at the University of California had indicated that the output per track would be approximately 300 grams per month of enriched material for each of the tracks constructed with grounded sources. The fifth track, constructed with two insulated sources per tank, was expected to produce 600 grams of enriched material per month. It was estimated, at that time, that the first of the main first-stage tracks would go into operation in November 1943, and that sufficient refining stage tracks would be available to complete the necessary process steps (See App. B29).

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b. Y-12 Extension.

(1) General. - The next significant change occurred during the month of September 1943, when the expansion of the electromagnetic plant was authorized. This authorization was given by General Groves at a meeting in Knoxville, Tennessee, 11 September 1943, and was confirmed by Major W. E. Kelley's memorandum of the same date (See App. B14 and B39). It was further confirmed by Mr. R. T. Branch of Stone and Webster Engineering Corporation in his letter of 23 September 1943, addressed to the District Engineer (See App. B37). This expansion, known as Y-12 extension covered, the design and construction of four racetracks of an improved Alpha design and two racetracks for the Beta stage, with all necessary auxiliary equipment and buildings, at a total cost of approximately $140,000,000. This cost included approximately $18,000,000 for expansion of town facilities made necessary by the increased number of operators (See App. B38). The necessary process equipment was to be furnished by the same manufacturers of the corresponding equipment for Alpha I.

(2) Alpha II Process Design.

(a) Building Design. - Stone and Webster proceeded immediately with the detailed design of the main buildings and, in accordance with the instructions of General Groves, full consideration was to be given to the use of cheaper materials and more economical construction, particularly in the use of materials which tend to reduce the amount of labor required for the installations at the site. In this respect, the new Alpha Process Buildings were designed, to use steel frames and corrugated asbestos siding, instead of the concrete

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similar to that of the original Beta Building.

(4) Beta Building No. 3. - In May 1944, upon a re-analysis of Alpha production, it was decided to construct additional Beta race-tracks, and Building 9204-3 was authorized. The building was designed to contain two tracks and to have steel framing and a sub-basement. Copper was used in place of silver in the magnet coils and bus bar, and the building was estimated to cost $15,000,000. The anticipated operating dates were 1 October 1944, for Track 5, and 1 November 1944, for Track 6 (See App. B42).

c. Modifications.

(1) Alpha II Modifications. - In October 1944, orders were placed for the structural steel required by the liner service area in Alpha II and for the liners themselves. Certain minor changes were requested by TEC (See App. B43), and the Radiation Laboratory. The Alpha II recovery liner was designed in anticipation of running K-25 enhanced* feed through Alpha II. Its purpose was to aid in recovery of the enhanced K-25 feed material and to prevent losses. The liner was an inclosed duct from source to receiver, around the path of the ionized particles, attached to the inside of the main door (See App. C30).

(2) Beta Building No. 4. - In February 1945, Y-12 began chemical processing of S-50 enhanced feed (See App. B44). As a result of the increased enhanced feed from S-50 and the anticipated enhanced feed from K-25, due to authorization of a new unit, K-27 (See Book II, Vol. 3), authorization for a new Beta building was obtained on 31 March 1945 (See App. B45). The building, 9204-4, was to be built by

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Stone and Webster under the terms of Contract No. W-14-108-eng-60 (See App. B8) and was to duplicate 9204-3 (See App. B46). There were no major changes in the process equipment of this building.

(3) Conversion of Alpha Track 9 to Beta. - The fact that K-25 product was being obtained at a much faster rate and at a much higher enhancement than had originally been anticipated forced the consideration of increasing the Beta stage capacity (See App. A2). A number of ways of accomplishing this were considered, among which were:

(a) Construction of a new Beta building.

(b) Construction and installation of stainless steel liners and two source Beta units in one Alpha II track.

(c) Conversion of one Alpha II track to a four source Beta track.

(d) Conversion of the Beta stage to a four source Beta stage (See App. B47).

In order to increase the total production of Y-12, it was decided to increase Beta capacity by converting Alpha Track 9 to a Beta track. In June 1945, Stone and Webster was authorized to proceed with the conversion and an 84,000 sq. ft. addition was to be made to the building, 9201-5, in order to have adequate washing facilities for liner, M and E units (See App. B48).

(4) Proposed Changes. - In the constant search for ways to increase production of the plant, there were many major changes proposed, some of which actually reached the test stage in a process building. The first such major proposition was made by Dr. E. O.

Lawrence, in October 1943. It was to be a pre-Alpha stage, known as Kappa stage, and its purpose was to give a slight enhancement to a large amount of material, thereby reducing the amount of material handled by the Alpha stage. As improvements were made in other methods, this plan was abandoned (See App. B49).

In June 1944, it was proposed to convert Alpha I to a 4 "cold" source system, using subdoors and other mechanisms similar to Alpha II. In the discussions, Dr. Lawrence proposed the following possibilities for conversion of Alpha I:

(a) Four cold source.

(b) Four hot source.

(c) Eight source units hot or cold and

(d) Refinement of present Alpha I to obtain increased output (See App. B50).

A new stage known as Gamma was proposed in July 1944. The purpose of this stage was to enhance the material further after it left the Beta stage. As in the case of the Kappa stage, the Gamma stage was abandoned because of improvements in other equipment (See App. B51).

A proposed conversion known as Alpha III was considered in July 1944. Its purpose was to increase the production of the plant by a factor of 5 by increasing the number of sources from 4 to anything from 10 to 60. This plan never materialized but has not been completely abandoned.

On 25 July 1944, by directive from General Groves, all work on conversion of Alpha I was abandoned (See App. B52).

3-3. <u>Chemical Design</u>. - The chemical steps in the electromagnetic

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plant have often been treated as auxiliaries to the more spectacular process of separation in the racetracks; however, this is not the case. The chemical "Stepchild" is actually the beginning and the end of the plant and accounts for a large percentage of the production work done in the plant. It is in the chemical steps that the battle for production efficiency could have been won or lost. The story of the design and development of the chemical process facilities reflects a constant fight waged by the chemical designers to keep pace with expanded capacities and new developments, and to have chemical facilities ready to operate in time to meet track operation dates.

a. Original Chemistry Facilities.

(1) Alpha Vapor Phase Preparation. - (See App. C38). The vapor phase method of uranium tetrachloride preparation for track feed material was one conceived and developed by the University of California Radiation Laboratory and was the one suggested by them for use throughout Alpha and Beta chloride preparation. When an Alpha Chemistry Building (Bldg. 9202) was authorized, this process had been developed to the extent that little difficulty was experienced with its installation, and it was the first to be accepted by the operators (4 October 1943), in spite of higher priorities for other construction (See App. B63 and B64). The process installed was designed to include twelve rotating furnaces, at 5 RPM, about 12 inches in diameter and 6 ft. 10 inches long. A four inch glass tube in which the reaction took place was within the furnace. Uranium oxide (UO_3) was fed into one end and carbon tetrachloride vapors into the other end. The product was uranium tetrachloride (UCl_4) in solid form.

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Glass tubes available at the time were a maximum of 4 inches in diameter and this in turn determined the size of the reactor. Because of this, the capacity of vapor phase reactors was limited to about 2 lbs. per hour. Since this process used UO_2, causing a separate step in preparation (raw material was supplied as UO_3), and since capacities were limited, the vapor phase, after a few runs, was abandoned temporarily in favor of the liquid phase (See App. B85 and B86).

(2) Alpha Liquid Phase Preparation. - (See App. C38) - When, in February 1943, it was thought necessary to produce 2,000 lbs. of initial feed material, for immediate use, due to the limited capacity of the vapor phase, a second method for chloride preparation was proposed and accepted for installation in Building 9202 (See App. B87). This method, known as the liquid phase, was developed by Brown University (See Vol. 2) and was believed by TEC to show greater promise for preparation of larger quantities (as opposed to vapor phase), and greater possibilities for producing uranium hexachloride (UCl_6), at one time being considered for a charge material (See App. B88). Since the liquid phase process had not been fully developed at that time, considerable delay was experienced in its design and installation (See App. B89). It, however, showed such promise that by June it was given priority over the installation of vapor phase, but it was not completed until November 1943, about a month later than that process (See App. B90 and B91). The process as installed utilized a 1000 gal. glass lined reactor, charged in batches with carbon tetrachloride and uranium oxide (UO_3) (See App. C39). The reaction was carried out at about 130°C and at a pressure of 125 lbs. per square inch, maintained for 6 to 7

hours. The product was uranium pentachloride (UCl_5) with liquid excess carbon tetrachloride (CCl_4). Sufficient liquid phase equipment was designed to provide a capacity of about 30 lbs. per hour.

(3) Phosgene Disposal Systems. - A by-product of the two reactions described in the preceding paragraph was phosgene ($COCl_2$), a highly toxic gas. Two separate systems were designed and installed to care for its disposal: caustic scrubbing towers (See App. C40) and an ammonia neutralizing system. Both chemicals, caustic (NaOH) and ammonia (NH_3), reacted readily with phosgene to render it harmless. In the caustic system all vent gases from the reaction mixture (See App. C41) were passed through a tower into which a caustic spray was introduced, thereby washing out all phosgene from the vapors released to the atmosphere. The ammonia neutralization system performed two functions. It provided a continuous flow of from 0-40 lbs. per hour of ammonia (a gas), into the liquid phase and vapor phase vent systems. It further was designed to introduce into the liquid phase vent system from 300 to 500 lbs. of ammonia vapor within a few minutes, as an emergency measure. The emergency system was actuated by a push-button control and, later, provisions were made for an automatic release actuated by an automatic detector (See App. B93).

(4) Vacuum Distillation (Sublimation) - (See App. C38) - The original plan for Alpha Chemistry included seven vacuum distillation stills (See App. C2 and C3). Since both the vapor phase and liquid phase methods produced varying composition and purity of the desired feed material (UCl_4), a method for refinement had to be designed to insure

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dependable results. In vacuum distillation the raw uranium tetrachloride salt from vapor phase or liquid phase was subjected to sublimation (to pass from solid to gaseous state without being liquid) at approximately 600° C and at very low pressure (10 to 5 mm of mercury). This eliminated impurities and produced a crystalline product suitable for process charge material (See App. B94). To do this a charge was placed within a "boat" (special corrosion resistant alloy cylinder), which in turn was placed within an electric furnace. Under the above conditions of heat and pressure the charge passed immediately to the gaseous state, to be deposited on a water cooled receiver in line with the vacuum outlet flow. A liquid nitrogen trap in the vacuum line prevented leaks of material to the vacuum pumps, by freezing the materials in the cold trap. The severe vacuum and heat conditions imposed on the equipment made considerable experimentation necessary before a suitable design was reached. Revised estimates of material to be handled necessitated frequent additions to the units. By May 1943, the number had been increased from seven to ten. In August, pilot plant operations at Rochester, New York (See Vol. 2, Sec. 4-2, Research), indicated necessary changes of design (See App. B95). Materials of construction were modified and heavier materials were used, so that proper machining could be made and closer tolerances reached (See App. B96). However, by February 1944, the units were still unsatisfactory, due to difficulty with temperature regulation and mechanical breakdown, and methods were being devised to improve new units for the extension which had by then been authorized (See App. B97 and B98). The new units decided upon were of TEC design and included new methods of fabrication with no substantial changes in the operational features.

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(5) Dry Room Facilities. - The sublimed product (UCl_4) was highly hygroscopic (absorbed moisture) and when contaminated with moisture formed an unsuitable charge material. The significance of this could not be fully realized until charges were made and used. By August 1943, a dry room was being designed to allow the filling of track charge bottles without the material coming in contact with moist air (See App. C42). The installation in Building 9202 proceeded though there was some doubt that people could work safely in the very dry atmosphere required (See App. B99). By September 1943, a decision was reached to stop installation of the dry room and to store all purchased equipment (See App. B100), since it was believed that dry boxes previously built for laboratory study would be sufficient for production. Later, in May 1944, when production capacity of the plant had substantially increased, a dry room was again authorized and designed. Different ranges of relative humidity were tried with relation to harmful physiological effects. A range of 6 to 10% relative humidity at 70° F was tested and found as a safe working range.

(6) Alpha Primary Recovery (Machine Wash). - The system whereby unused and contaminated uranium tetrachloride (called "gunk"s) was recovered from the track units, when removed for servicing, was a simple water and steam wash method, performed in the process buildings. Such mechanical washing, with water, water and acid, scraping, brushing, vacuum cleaning was used as seemed necessary, but later methods resorted almost entirely to steam spray (See App. B101). Copper plating of a part of the equipment was resorted to, to facilitate cleaning of certain equipment.

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Very little equipment was required. Solutions were stored in "gunk" tanks for transfer to Alpha bulk treatment recovery (Building 9202).

(7) Alpha Recycle Recovery (Bulk Treatment-Building 9202) (See App. C38). - By March 1943, a bulk treatment recovery process, to reclaim material from the tracks for Alpha material, had been designed for the following operations:

(a) Precipitation of iron with ammonium carbonate and ammonium hydroxide (in presence of hydrogen peroxide).

(b) Centrifugation to remove the precipitated ferric hydroxide (Sharples centrifuges were used because of small amounts of iron. The Sharples are small-solid-volume 15,000 RPM Centrifuges).

(c) Precipitation of the effluent (liquid) leaving centrifuge with ammonium hydroxide.

(d) Filtration and washing of solids.

(e) Redissolving of solid with nitric acid and reprecipitation with hydrogen peroxide to UO_4.

(f) Filtration of UO_4.

(g) Drying, grinding, screening and calcining to UO_3 (See App. B102).

Mostly, glass-lined equipment with porcelain and stainless steel piping were used. "Gunk" storage (See App. C43) and reagent storage facilities were also provided. Various modifications were added throughout the year of 1943, from pilot plant experience, but until it was decided to decant in step (d), instead of running through filters, no major changes were made. Here experience had shown that the solids settled very rapidly and an advantage could be taken of this to decrease time of filtering.

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Slurry pumps (See App. C43, Item 4) were also added to replace the centrifugal pumps which could not handle the high percentage of solids from the decanters (See App. B103 and B104).

(8) Beta Chemical Areas in Process Buildings. - Actual operations in Beta Areas followed quite a time behind Alpha Operations, but plans were laid and processes developed long before they were in actual use. First design layouts were offered by May 1943. These included (1) three wash lines for spray and handwashing of parts, (2) three liner washing tanks, (3) receiver washing tanks, (4) storage tanks (where hydrogen peroxide was to be added to prevent depositing ferric oxide), (5) three evaporator systems of 250, 500, and 1,000 gals. per day, and (6) any separate evaporators needed if nitric acid were used for wash. Enough space was included to allow installation of three more lines, if that were found to be necessary (See App. B105). Subsequently, orders for total evaporation capacity of 4,000 gals. per day were placed. In September 1943, nitric acid was substituted for hydrochloric acid, because of high hydrochloric acid concentrations from evaporators attacking stainless steel equipment (See App. B106). By January 1944, a different method of handling the wash solutions was being proposed by the operator, whereby essentially the same equipment would be used but where a large part of the uranium would be taken out before evaporation (See App. B107). However, by the time the Beta tracks and chemical areas were in operation the original method was in use (See App. B108).

(9) Beta Chemistry Building (Building 9203)

(a) General. - The functions assigned to the Beta Chemistry Building were as follows:

1 Receive product from Alpha Process

2 Purify and convert 1 for use in Beta separator process

3 Purify and convert unseparated material from Beta tracks for recycling

4 Process Beta product material for shipment. Design of the Beta Chemistry equipment was not started until about May 1943, from which time it was carried on until August, when Stone and Webster was asked to suspend all work until pilot plant operations could be completed and more information compiled (See App. B109). During September and October, it was decided that Beta chemistry facilities should be designed to have sufficient capacity to handle 1.0 kilogram of UCl_4 per day by 1 December 1943, to be increased to 9.2 kilograms per day by 1 April 1944, (See App. B110).

(b) Laboratory Process. - During September, it was decided that one of two methods (the "hydrogen peroxide" precipitation instead of the "oxalate" precipitation method) being developed by the operator for preparation of UO_3 from separated UCl_4 would be installed as a temporary expedient, until plans for a permanent installation could be provided. Therefore Equipment was designed for the hydrogen peroxide method, ~~minimum~~, which was a small scale, or laboratory, process, consisting essentially of neutralization and cold filtration to remove iron, followed by the precipitation of uranium peroxide. The peroxide precipitate would remove 99% of the uranium and on the scale contemplated (7500 cc of hydrochloric acid (HCl) solution containing about 250 g. of UCl_4) would take about two hours.

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The uranium peroxide filtrate was dried and decomposed to UO_3 and transferred to chloride preparation apparatus as a dry powder or carbon tetrachloride slurry. Two lines of glass equipment for this process were decided upon as sufficient for initial operations, and Stone and Webster proceeded with their procurement. Conversion to the chloride was not far enough advanced in development for a final design to be worked out.

(c) Carbon Burning Facilities. - At the same time as the feed preparation was decided, the extent of needed carbon burning facilities (to recover uranium imbedded in carbon parts) was indicated and these facilities were designed to include electrostatic separation of the gaseous combustion products (recovery of valuable material from flue gas by Cottrell precipitators). The equipment was to be divided into four lines - first line, with capacity of 56 lbs. per day needed by 31 January 1944; second line, 25 lbs. per day, 1 December 1943; third line, 25 lbs. per day, 1 December 1943; fourth line, 125 lbs. per day, 31 January 1944. Initial procurement of this equipment was started immediately (See App. E111).

(d) Oxide and Chloride Preparation Processes. - At Berkeley, California, during October 1943, further decisions were reached which included two methods of oxide and chloride preparation for permanent installation. The University of California group had developed a process known as the "oxalate" process. Essentially, a hydrochloric acid solution of uranium is reduced in a cathode electrolytic cell and then uranium oxalate is precipitated away from impurities. Subsequently, the oxalate is calcined to UO_3 or U_3O_8 and converted to UCl_4 in a vapor phase reactor.

The rated capacity of the cell was 1 lb. of uranium reduced per hour, with losses of less than 0.1%, including vapor phase chloride preparations. The vapor phase reactor was designed to run continuously for 200 hours or more. Another method, developed by the operators, showed good results. It consisted of first precipitating iron from the oxidized gunk solution in the presence of sulfate of iron. The resulting solution contained 99% of the uranium and very little iron. The solution was then treated with hydrogen peroxide and $UO_4 \cdot 2H_2O$ was precipitated. The $UO_4 \cdot 2H_2O$ was ignited to UO_3 and converted to UCl_4 by use of the liquid phase method. An electrolytic salvage method for the 1% of uranium remaining in the sulfate precipitate was also proposed. From the results shown it was decided to install two trains of each process, with a capacity of 10 kilograms for each train, giving a total of 40 kilograms capacity. Comparative analysis of their final products would be determined from actual operation in the tracks. Equipment was to be furnished by UCRL and TEC for their respective methods, thus allowing minor revisions due to advance information to be made (See App. B112).

(e) <u>Operation Period 14 May 1944, to 1 July 1944.</u> - By the time Beta facilities were actually needed, the method used for Beta recycle was essentially that developed by TEC and included the UO_3 conversion to chloride in the liquid phase reactors or autoclaves (See App. B113 and C16).

(f) <u>Final Product Recovery.</u> - The methods used for preparation of UO_3 were essentially the same as Beta recycle methods. Precautions taken, however, were greatly expanded over those taken elsewhere. Materials of equipment were as corrosion resistant as were available and included the use of the noble metals (gold, silver, platinum). Stainless steel was used on floors and benches and wherever any chance of a spill existed. The UO_3 was transferred to Building 9733 (Process Improvement Laboratory) where it was converted to uranium tetrafluoride (UF_4), the final product.

(g) Ether Extraction. - The method of oxide preparation employed during early 1944, proved increasingly unsatisfactory. Iron content increases in the wash solutions seriously affected its operation. From early operations the iron content increased from 10% based on uranium content of the solution, to over 200%. These, plus recovery problems from Alpha receivers (See App. B114), stimulated the design of different methods of recovery and oxide preparation. Included in these was an ether extraction method.* By June 1944, this method had been installed in the Beta Chemistry Building (9203) and was being used successfully. The ether extraction process utilized numerous glass towers (See App. C44), circulating pumps and preparation tanks. The concentrated solution of uranium was fed at top of tower counter current to the ether which entered at bottom. The ether with its load of uranium nitrate was then washed with water. The solution of uranium nitrate obtained from the ether extraction water back wash was then precipitated as UO_4 and the chloride was prepared as before (See App. B115). Ether extraction methods were also extended to Alpha product recovery methods and Beta product recovery methods, and were even proposed for Alpha bulk treatment recovery.

b. Extension to Y-12.

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(1) Alpha Primary Recovery (Machine Wash). - When, in September 1943, it was decided to double the capacity of Y-12, and authorization was given for two new Alpha Process Buildings, preliminary plans for the wash areas were based upon similar areas in Alpha I and Alpha ~~1/3~~ I-1/2 Buildings (9201-1, 2 and 3.). Before installation was complete, however, it became necessary to redesign Alpha chemical wash areas to provide facilities for handling enhanced (K-25) materials. Further reference to these areas will therefore be made under discussion of Modifications and Additions to Alpha Primary Recovery.

(2) Alpha Chemical Building Extension. - It was recognized when additional production capacity was authorized that Alpha Chemistry would have to handle twice as much material as originally proposed for its Chemistry Building (9202). In November 1943, plans were roughly laid for increased bulk treatment capacity and included some changes believed necessary for improved operation (See App. B116). By February 1944, it was agreed that an extension to the building would be necessary. Equipment was designed to include enough "gunk" storage for a week, enough chemical reagent storage for a month, a sulfuric acid precipitation step for iron, suggested changes for drying and calcining (See App. C46), use of filters instead of centrifuges, Oliver filters (See App C45; rotating, continuous filter using vacuum) to supplement the decanting step previously installed and overall increase of capacities of existing equipment (See App. B117). The presence of iron in solution necessitated further requests for changes in design during March. By April, the numerous additions of equipment caused the authorization of an additional bay to the building extension. This further caused

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revisions of layouts and machine location plans (See App. B118). An increase of liquid phase facilities to double production was also requested. Only a few modifications to the liquid phase process were made and the installation of two new reactors was possible in the old building (See App. B119). A salvage area for bulk treatment had been authorized in April. This was for residue salvage in iron precipitates containing varying amounts of uranium. By November 1944, before installation in the old building was started, plans were changed to include the salvage areas in the extension, along with equipment for purifying high boiling ethers, which had been authorized that month (See App. B120 and B121). In July 1944, an addition of equipment including 3 reactors and 2 filter presses was authorized, for salvaging peroxide precipitate effluents (See App. B122). In November, initial operations were started, both in bulk treatment and liquid phase (See App. B123 and B124).

(3) <u>Beta Chemistry in Process Areas</u>. - The authorization of the second Beta Building with the Y-12 Extension carried increased chemical requirements. The chemistry area within this building was essentially the same as in the first Beta process building (Building 9204-1). A third Beta building was later authorized and this was to follow along the same lines. No essential change was made to either until the cold precipitation process was installed, which will be referred to later.

(4) <u>Beta Chemistry Building</u> - β (Building 9206). - Although the handling of second stage material had not utilized the originally conceived Beta Chemistry Building (Building 9203), the amount of assay work that would be required and increased requirements for chemistry made

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it necessary to authorize a new Beta Chemistry Building (Building 9206) and to plan for Building 9203 as an assay and analytical building (See App. B125). Building 9206 was designed so that the Alpha and Beta receiver washing departments, together with oxide conversion and chloride manufacturing lines for each, were allocated most of the space. The Alpha receiver washing area (See App. C15) and the Beta "gunk" recovery department were divided into 3 separate lines, so that 3 different degrees of enriched material could be handled if necessary. The Beta receiver washing was similarly divided into 2 lines for two separate degrees of enrichment. In addition, facilities for chemical recovery of "Q" material (depleted uranium 238 recovered from receiver carbons), storage, shops, and salvage were provided as well as laboratories, rest rooms and offices (See App. B126).

For these operations, a large number of rooms were provided in order to break down the operation into small increments, to prevent the assembly of sufficient material to exceed the critical mass (See App. D3 for a floor plan of the building). There were 13 laboratory rooms, including space for spectrographic analysis and final product control. Alpha receiver washing and processing were provided with 13 rooms. Beta receiver washing and final preparation had 10 rooms. Beta recycle oxide preparation and chloride conversion occupied 7 rooms (See App. B127). The general features and modified processes of Building 9203 were followed, but with many refinements. Particular emphasis was placed upon factors that could contribute to losses. Stainless steel floors, carefully controlled air flows, air conditioned ventilation, non-corrosive materials of construction, enclosed process flows,

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transparent shields or hoods for ordinarily open places of work, and many other methods of protection were devised and provided. By September, Beta operations in other areas were operating at such a peak of capacity that the top priority placed on Building 9206 had to be further broken down and individual areas or rooms were given further high priorities (See App. B128). Frequent alterations, additions and omissions were made to areas within Building 9206, the function of the processes, however, remaining essentially the same. Initial operations in some areas started during October 1944, but construction continued throughout other areas for a considerably longer time.

e. Modifications and Additions.

(1) Alpha Primary Recovery. - The original plans for Alpha II Process Buildings had been designed on the basis of normal feed material and on only 75 to 80% recovery. No provisions had been made for recovery liner washings as no liners had been used. When, in March 1944, it was proposed to process K-25 material in Alpha Buildings (9201-3, 9201-4, 9201-5), it became necessary to revise Alpha II designs and include plans for 100% recovery in the Alpha recovery areas. At the time, Alpha II wash areas were contained within about 6,000 sq. ft. in each building. For the redesigned washing units to include liner wash, an additional space of 14,000 sq. ft. was proposed. Some consideration was given to the inclusion of various processing steps, but these ideas were abandoned in favor of more complete washing procedures (See App. B129). Included in factors governing the scheme for redesigned wash units were careful reviews and studies involving "critical masses", or the possible accumulation of too much material in one area. To prevent such an accumu-

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lation, complicated interlock systems were designed and these were supplemented by the shielding of tanks with cadmium sheets (Cadmium has the property of absorbing neutrons which could set off a chain reaction). The interlocks were so arranged that one central operator could know how many lines were in operation, or how many tanks were filled, and could exercise control of these within the limits established as safe. Previous plans for materials of construction had been made on the basis of corrosive solutions containing 2 to 5% hydrochloric acid, 1% sulfuric acid, plus varying amounts of nitric acid. To handle these solutions it had been decided to use rubber-lined steel tanks, Saran pipe (a plastic) and Hastelloy C (a corrosion resistant alloy) wash stands, which conformed to the original recovery area design (See App. B130). Since it had not been definitely decided that full recovery liners would be used, only rearrangement of storage tanks seemed necessary by 1 June 1944 (See App. B131). When in September it had been decided to use full liners, extensions to Buildings 9201-4 and 9201-5 were also decided as necessary. (Building 9201-3 was designed and built to use liners). The extensions would include six liner wash stands plus areas for mechanical servicing (See App. B132). Further refinements, such as high pressure sprays, cleaning machines for bins, and vinylite (plastic) sleeves to cover bin equipment during handling, were later added, further to decrease losses.

(2) Alpha Chemistry Building 2 - (9207 Group). (See App.C4).

(a) General. - While feeds from K-25 and S-50 to the Alpha track units were being considered, it became obvious that the

Alpha Chemistry Building would not be suitable for the type of enriched feeds that would result from this procedure. The reactors of Building 9202 were all between the sizes of 500 and 1,000 gal. and consequently far greater amounts than the critical mass of U-235 could be contained in one vessel. It therefore became expedient to design a building that would handle "gunks" containing the expected 1.4 to 5% material from K-25 and S-50. By 11 May 1944, authorization was given for the 9207 building group. It was intended for the new building to have a number of small-scale lines of flow, handling at one time not more than 58 lbs. of UCl_4, or 36 lbs. of UO_3, of the K-25 enriched material. It was further estimated that chemical equipment would have to be separated by at least four times the diameter of the equipment in order to insure safe handling (See App. B166).

(b) Bulk Treatment Recovery. - As originally conceived, the bulk treatment department of the new building would be required to produce 15,000 lbs. of UO_3 per week, using 12 separate lines. This, at first, was estimated as sufficient for the nine Alpha tracks, taking into consideration certain basic assumptions, that is, by allotting 200 gal. of wash water per unit from the tracks, 12 terminations per track per day, a 2-1/2 hour time cycle and various volumes of "gunk" from other sources (salvage). The 12 lines for bulk treatment were later reduced to 8 lines to make room for salvage equipment. Rather than construct a larger building, it was decided to use 4 bulk treatment lines and build more process lines, if the need arose. The 8 lines were considered sufficient for 4 Alpha II tracks, and, with possible reductions in wash water volumes and time cycles, would be enough for all nine tracks (See App. B133).

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In order to simplify the flow as much as possible, gravity flow was utilized to a large extent, eliminating otherwise necessary circulating pumps and piping (See App. C5). This necessitated a building of considerable height, but a more simplified operation was assured, with resultant lack of hold-up of material and decreased losses (See App. B134). Ether extractions and ethyl cellosolve* methods of bulk recovery were considered. Ether extraction was eliminated, but the possibilities of ethyl cellosolve delayed somewhat the original design of bulk treatment. By June 1944, however, because of unsolved difficulties with this method, it was decided to proceed with the original, or Building 9202, process (See App. B135).

(c) Liquid Phase. - The liquid phase department was expected to produce 20,000 lbs. of UCl_4 per week and required 24 separate lines, based on 50.5 possible safe runs per day, 8 hours time cycle, and an assumed "down-factor"* of 40%. The process was designed as essentially the same process as liquid phase in Building 9202. It was only later that new specifications required particularly radical changes in the calciner (See App. B133).

Dry room boxes, or rooms, were necessary to handle the calcined material for feed to sublimation. Twenty-four of these rooms were installed, to have a relative humidity of 6% at 73°F.

(d) "Gunk" Storage. - (See App. C47). - Storage facilities for "gunk" solution were planned on a 4 day basis, the original conception of which was to transfer "gunk" solutions from the process buildings in 200 gal. rubber-lined portable tanks. The tanks were to be cadmium shielded and space would be provided for them in the 9207 group,

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each tank being stored until its contents could be processed. It was later considered safe to install interconnected permanent tanks, safeguarded by an interlock system. As a result, 96 tanks of 200 gal. capacity each were installed in a separate building (Building 9208).

(e) Salvage. - Salvage and recovery requirements were covered by evaporation and ether extraction methods. In this connection, the ether extraction system was proposed for the entire bulk treatment recovery system, thereby eliminating salvage operations. As it turned out, the fear of explosions, which would result in the shutdown of Alpha recovery, as well as the possibility of scattering valuable enriched material beyond recovery, eliminated this proposal. For salvage operations the fear of explosion was present and provided for, but did not constitute the overall shutdown possibility that a bulk treatment explosion did (See App. B134).

(f) Incineration. - The amount of incineration that would be required necessitated a separate building. Accordingly, Building 9769 was added to the group. The incinerated material per day was estimated as follows:

"M" (Source) end material

400 lbs. of carbon

400 lbs. of rags

25 lbs. of rubber

100 lbs. of wood and miscellaneous material

"E" end material

200 lbs. of carbon

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100 lbs. of rags and miscellaneous material

"Q" Material (containing impoverished U-238)

50 lbs. of carbon

25 lbs. of miscellaneous materials

(See App. B136).

(g) Status 1 August 1944. - By the first part of August, the following list of main facilities, considered as the 9207 Group, were under design and included all major items except a uranium hexafluoride conversion building and a sublimation building added later.

Building 9207	Bulk Treatment Department; Liquid Phase; Maintenance Shop, Laboratories, Offices.
Building 9208	"Gunk" storage.
Building 9743-2	Ammonia Storage House.
Building 9723-22	Change House and Cafeteria.
Building 9769	Incinerator Building.
Building 9409-19	Water Cooling Towers.
Building 9616-2	Chemical Unloading Station.
Building 9621	Alkali Tower Installation.
Building 9510-3	Waste Chemical Neutralization Station.

(See App. B137).

(h) Sublimation. - By the end of September, a new building (Building 9210) for sublimation was authorized and included in this group. A total of 80 stills was planned, with the installation of 64 to be made. This was based on charges of 35 lbs. of UCl_4, 18 hours time cycle, and a "down-factor" of 40%. The stills to be used in

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Building 9210 were of necessity smaller than those in Building 9202, but their function was essentially the same (See App. B133 and B138). The heating of the boat, or retort, was to be done by a split type oven (later changed to one which could be raised and lowered) that could be opened away from the retort and rolled aside allowing the retort to be cooled by means of water from spray chambers which in turn could be rolled up and away similar to the oven (See App. B139). A number of dry rooms were to be provided to maintain 6% relative humidity at 70°F (See App. B140).

(i) Hexafluoride Conversion Building. - When the fact was first known that Y-12 would receive K-25 feed material it was thought that the feed would be in the form of UO_3, having been converted from the K-25 end product at that plant (See App. B141). It was not until October that plans were revised to include conversion of the feed at Y-12. A building in the 9207 Group was authorized which was designated as Building 9211 (See App. B142). It was to handle a maximum of 400 kilograms of UF_6, which would contain 270 Kg or 594 lbs. of uranium, per day, as well as to be capable of keeping completely separate at least three different grades of material. For calculations, a "down factor" of 30% was assumed and the usual 35 lbs. of uranium limit was imposed (See App. B133).

Later estimates showed the necessity of including, aside from office and storage areas already provided, control laboratories, solutions make-up area, and equipment for salvaging peroxide effluents. Special equipment, too, was needed, since free fluorine and the fluoride ion were

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particularly corrosive and dangerous as a health hazard (See App. B143). Since the equipment necessary for conversion was somewhat similar to that for bulk treatment recovery, it was originally thought expedient to design the lines as close to bulk treatment design (250 gal. reactors, etc.) as possible and add whatever special equipment (silver and lead lined dissolvers, etc.) as was needed. This would then supplement bulk treatment capacity, which had been cut to 8 lines, should the conversion facilities not be needed. Later it was thought expedient to design specifically for conversion, using smaller equipment (150 gal. reactors, etc.) and substitute whatever was necessary as the requirements varied.

(j) Calciners, Bulk Treatment. - Perhaps the most significant change from Building 9202, as far as equipment design was concerned, was in the calciner. From the first reviews made for 9207 equipment design, it appeared that the calciners in use in Chemistry Building 9202 (See App. C46) were adequate and successful. By August 1944, from experimental runs made by the operators, specifications were revised to the extent that the required calciners represented machinery not previously available from any known source. The following table is indicative of many such changes for the bulk treatment calciners and shows how final design differed from the original in order to meet the revised specifications.

BULK TREATMENT CALCINERS

Design Features	Original Design	Modified Design
Pieces of Equipment	1-Dryer	1 - Combination

Design Features	Original Design	Modified Design
	1 - Combination Calciner and Cooler	Dryer, calciner and cooler
Method of Operation	Continuous	Batch
Temperature, maximum	400°C	600°C
Method of heating	Electric furnace	Megatherm (high frequency induction heater)
Operating Pressure	Atmospheric	29 in. Mercury vacuum
Handling material to Equipment	Gravity feed from filter to dryer and from dryer to calciner	Special stainless steel cans which are transported from one floor to another requiring heating furnace to be removable
Interlocks	None	Required- necessitating cadmium sheathed cans, can dollies, scales, etc.
Dust Collection equipment	Water spray(Later electrostatic precipitators)	Electrically heated Glasscloth filter
Method of handling equipment	open drums	Vapor proof stainless steel, cadmium sheathed cans.

(See App. B14).

Modifications necessary for liquid phase calciners were somewhat in line with the above, though operating conditions (temperature and pressure) were different in detail.

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(k) <u>Other Facilities and Features.</u> - A partial list of additional facilities provided will tend to indicate the complexity to which design had to be carried. These include balance rooms, instrument rooms, glass blowing laboratories, ignition room, mercury still room, non-volatile material laboratory, laboratory glass-ware wash rooms, machine shops, pilot plant laboratories (major items of equipment on miniature scale), demineralized water systems, distilled water systems and air conditioning in some areas (See App. E145). A ventilating system had to be devised to provide 80 changes of air per hour to operating areas. The outlets for such ventilation were to be at sources of possible leaks of noxious gases (phosgene, ammonia or nitrous oxide). Since this included reactors, removable or retractable ventilator ducts had to be devised over a large amount of equipment. It was thought necessary that filtration, in some parts of the process, be conducted under an atmosphere free of carbon dioxide. For this a system had to be designed whereby air could be scrubbed free of carbon dioxide and fed to enclosed filtration units.

(l) <u>Cancellation of the 9207 Group.</u> - During the Spring of 1945, it became increasingly evident that the enhanced material from K-25 would exceed all expectations and that the plant could perform so satisfactorily that the relatively low enhancement of 1.4 to 5% for which the 9207 Group was designed would be entirely passed over. When full realization of this actually occurred in late spring, the 9207 Group was cancelled for the operations originally intended. All construction was stopped and with a few exceptions (Building 9769 and several bulk treatment recovery lines) the 9207 Group was left as of the day cancelled (See App. B166).

(3) Beta Salvage (Building 9209 and 9211).

(a) General. - During August 1944, plans were being discussed for a Beta Salvage Building. This was in line with the extremely high hold-up of material being realized in Beta Chemistry. At that time there was considerable lack of knowledge concerning Salvage Operations and while Beta Chemistry Building 9206 was being built to include some of these operations, they were considered inadequate to the total needs.

(b) Preliminary Study and Authorization. - Design for the following operations was involved: (1) carbon burning, (2) ignition (filter pads, rags, etc.), (3) other residue recovery, (4) ammonia effluents treatment, (5) electrostripping (See App. B146). A complete study for operations and design was initiated and decisions on the general features were reached. All process lines were to be in triplicate, with some having spare equipment. The building provided for 25,000 sq. ft. of area and included 5,200 sq. ft. for future expansion. An addition of a small building was provided to handle nitrate residues, some of which had explosive properties. The use of Building 9206, its general facilities and tank farm was intended for salvage work (See App. B147). On 18 September 1944, construction of the building was authorized (See App. B148).

(c) Added Facilities. - By November several areas had been added to include further salvage operations. The electro-

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stripping operations were to include grinding, shredding, leaching and fusing sections and added were special metals recovery (tantalum, tungsten, etc.), miscellaneous wash recoveries, small scale laboratory recoveries. Provisions were made for a receiving and dispatching area, office, control laboratories, storage utilities and change houses (See App. B148).

(d) Cancellation. - During the latter part of November, it became evident that the salvage building would not be completed before the summer of 1945. Before that time increased facilities within the Salvage Areas of Building 9206 would be necessary. Further developments in recovery had also improved operations to the extent that revised values were put on salvage operations. For these reasons, a study was made to determine the further necessity for Salvage Building 9209. As a result, it was decided on 26 November to cancel all design and procurement for this building (See App. B149 and B150).

(e) Use of Building 9211. - As construction developed in Beta operations, with a fourth Beta process building authorized and with contemplated conversion of Alpha Tracks to Beta tracks, it became evident, in May 1945, that increased salvage facilities would again become necessary. This time the reason was purely a matter of insufficient present capacity. When construction of Building 9211 was cancelled for Alpha hexafluoride conversion operations, this building became the subject of much speculation concerning its suitability for Beta salvage. On 21 July 1945, the use of Building 9211 was authorized for this purpose (See App. B151 and B152).

(4) <u>Hexafluoride Conversion Facilities.</u> - When it was determined that conversion facilities for K-25 were to be provided at Y-12 rather than K-25, the unfamiliarity of Y-12 personnel with the new chemical necessitated the installation of a pilot plant, so that intelligent plans and designs could be made for a permanent installation. Authorization was given in October 1944, for the erection of such an installation in Chemistry Building 9202. It was thought then that about 550 lbs. per day would have to be handled and designs were made accordingly. The material was to be received as crystalized UF_6 in 50 lb. cylinders. The cylinders were to be heated in steam cabinets to 70°C to insure vaporization of the material and the vaporous UF_6 was to be dissolved in water contained in either a silver or a lead-lined 25-gal. dissolver. The dissolved material was dropped into a glass-lined reactor, containing ammonium hydroxide, which precipitated the uranium. This was washed and put into solution, to be reprecipitated with hydrogen peroxide, which was then filtered, dried and calcined to the oxide(UO_3). The material was then sent to liquid phase for chloride preparation(See App. B153). The pilot plant was soon turned into a production plant and was supplemented in production with two Building 9207 bulk treatment lines converted for this purpose. The latter was authorized in February 1945, when it became obvious that Building 9211 would not be completed in time to receive the ever-increasing amounts of incoming K-25 material. As has been described, the bulk treatment lines were easily converted to conversion lines by the addition of dissolvers and rearrangement of piping (See App. B154, B155, & B156).

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(5) <u>Cold Purification Process</u>. - During the summer of 1944, much work was done to shorten the Beta wash and recycle time cycles. Two methods were under investigation, both working from the standpoint of precipitating most of the product from Beta machine washes before evaporation. The first method was similar to the method prepared for operation in January 1944, that is, to precipitate the uranium with ammonium hydroxide, filter the precipitate and transfer it to Beta recycle for further treatment. The low-bearing uranium solution after filtration was then evaporated and the residue was sent to Beta Chemistry Building for further processing. An installation of this type was authorized in Building 9204-1 and some work was done on it. Also, during this time another method was being worked out, following a known laboratory technique. This was known as the cold precipitation process and had been developed to a point, where, in December, an authorization was given for its installation in Beta Buildings 9204-1 and 2, (See App. B157). Along with the process improvements noted was the recognition of a need for greater capacity in wash lines. The addition of 3 lines was therefore authorized to bring the total of wash line and process lines to 6 for each of the three Beta Buildings (See App. B158). Equipment was designed to provide for this process, which was essentially to treat wash solutions from wash areas, filter, cool to 0°C, precipitate the uranium as UO_4 with hydrogen peroxide, and separate the UO_4 with a Sharples centrifuge. The centrifuge bowl, containing the separated UO_4, was then shipped to the Beta Chemistry Building where the UO_4 could be immediately dried, calcined

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and converted to the chloride. The solutions passing through the centrifuge were evaporated and the residues treated as previously (See App. E159). The installation required many new items of equipment, including stainless steel reactors, pumps, head tanks, centrifuges, stainless steel and pyrex glass piping, weir tanks, filters, reagent measuring tanks, reagent storage tanks, interlock controls, instruments (See App. C17), and a refrigeration unit. The construction status of the three Beta buildings ~~were~~ was in various stages of completeness and ~~each~~ building was a separate problem in installation. Because of their adaptability for conversion, the lines in Building 9204-2 were given top priority. As a result the first two lines in Building 9204-2 were ready for operation by the middle of March, 3-1/2 months after authorization (See App. B160). From the favorable results shown with the conversion of the Beta recycle to the cold precipitation method, authorization was given, in February 1945, for the conversion of Chemistry Building 9202 bulk treatment recovery, including both the old bulk treatment and bulk treatment extension. This again was a large task, consisting of altering, adding and substituting many items for the type of process described above (See App. E161 and E162).

(6) Modification in Chemistry Building 9206. - As has been mentioned, frequent changes were made throughout chemical areas, dictated by improved methods and by designed conditions not meeting actual operating procedures. As a case of the former condition, much time was spent in an endeavor to find an extraction medium other than diethyl ether.* One of the mediums found which produced favorable results

was dibutyl carbitol*. As a result, authorization was given in February to use carbitol as an extractor in a batch process instead of the column type of extraction used with ether. Rooms 39 and 42 were converted for this use (See App. B163). Other changes included extensive modifications to the equipment in ether extraction and oxide preparation to facilitate handling operations. When the hexafluoride from K-25 was of sufficiently high enrichment to be used in Beta tracks directly, a conversion unit was installed in oxide preparation. This, however, was of a minor nature.

(7) Final Product Building. - (See App. C48). - With the introduction of K-25 material to Beta, the amount of final product increased to such an extent that the area assigned to it in Building 9206 was no longer considered adequate from a capacity or safety standpoint. In April 1945, a new building was authorized, to handle only final product recovery. This building was designated as Chemistry Building 9212 and was scheduled for completion 1 September 1945. (See App. B164).

d. Auxiliary Facilities. - The nucleus of main process buildings was supplemented by operations in buildings performing minor or complementary functions. The more important operations and the buildings they occupied are:

(1) Laboratories. - Normal laboratory functions were generally performed in areas within the chemistry buildings. Other work was recognized as needed, such as assay and analytical operations. For this, Building 9205 was originally authorized. Later, when Beta Chemistry Building 9203 was converted for assay and analytical work, Building 9205 was devoted to functions of assay. Along with the two above buildings, four chemical process development buildings were authorized at various stages. The first one of these was Building 9733 and original conversion of final product

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to uranium tetrachloride was performed here along with the other functions. Later Buildings 9733-2, 3 and 4 were added for development work.

(2) Electroplating. - When trouble was encountered with stainless steel Alpha Product receiver units, it had been the intention to plate these receivers with copper in Buildings 9203 and 9206. The plating required, however, was so extensive that a separate building (Building 9744) was authorized. Facilities for copper, nickel, chromium, silver and gold plating, metal cleaning, and miscellaneous equipment were provided.

(3) Utilities. - Outside of general utilities, many separate chemical utilities had to be furnished, including tank farm areas, chemical unloading areas, compressor buildings, sump tank buildings, pump houses, cooling towers, absorption units, and refrigeration unit areas.

(4) Miscellaneous. - The limits to which valuable material could be separated from solutions were often indefinable and questionable. As a result, an area (called S-2) was provided where the more questionable material could be stored. Two 25,000-gallon stainless steel tanks were provided, in addition to 3 tanks formerly used for pickling operations. Later an earthen pit was provided that would furnish 500,000 gallons of storage but would allow normal seepage away from it.

3-4. Labor. - One of the primary considerations in the selection of Stone and Webster Engineering Corporation was the size and known ability of their Engineering and Design Staff. It was known that additions to their permanent staff would have to be made but only for assistance and not key positions. There were several main sources of talent

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available to Stone and Webster. The first of these was the group of supervisory engineers who had been associated with that company on the many construction projects they had supervised. Another source was the Design group of their organization. From the latter group, a number of design men were shifted to supervisory engineers. These sources provided enough talent so that at no time was it felt necessary to advertise for such engineers. The design group, however, was felt to be insufficient and various means were found to augment this group in numbers as well as to authorize as much overtime as could be physically endured by the individuals. The following tabulation indicates the number of engineering and design personnel employed in six month increments throughout the project. From the beginning of the project until 30 June 1944, their work included design and engineering on Oak Ridge, Plutonium Project (until January 1943 only), the Heavy Water Project, and other phases of the District program, but from that time on work was devoted primarily to Y-12, the Electromagnetic Project.

STONE AND WEBSTER ENGINEERING AND DESIGN PERSONNEL

Date	At Boston	At Berkeley	In Field	Total
1 Jan. 1943	239	29	9	277
1 July 1943	738	19	13	770
1 Jan. 1944	743	13	33	789
1 July 1944	685	8	79	772
1 Jan. 1945	463	8	49	520
1 July 1945	338	3	40	381
1 Jan. 1946	65	0	1769	1834
1 July 1946	38	0	41	70 79

(See App. B165)

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3-5. Safety.

a. Safety in Design. - On this project, which was in effect a dangerous experiment, with its new and unknown quantities, many of which could prove so devastatingly disastrous, it behooved the designers to place a strong emphasis on safety. Every effort was made to design equipment and facilities which could be built and operated with safety and assurance. Safety devices were incorporated in the design of the electrical system by the installation of interlocking switches, protective barriers, special insulation, etc. Convenient exits, mechanical alarm systems, and gas detectors were designed to provide protection against accidental leakage of toxic gases. Cadmium plating, as protection against neutron emission, was provided in certain equipment. Special attention was given to the size of process and chemical preparation equipment, in order to avoid attaining a "critical mass", and thus preventing the opportunity for chain reaction to start.

b. Safety of Personnel. - The safety of design personnel was administered by the Manhattan District Safety Section (See Safety, Book I, Volume 11). Design personnel, for the most part, were not located at the Plant Site, and, consequently, were not subjected to industrial or special hazards. However, at Berkeley, California, where design was carried on in conjunction with the hazardous procedures and materials of the research program, measures were taken to assure the safety of all personnel.

3-6. Security. - The general policies of the Manhattan District were observed in designing the electromagnetic plant (See Security, Book I, Vol. 14). Design offices were confined in restricted areas, into which

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only authorized personnel were admitted. Documents, drawings and correspondence were classified and meticulously guarded. Equipment drawings were broken down into component parts so that the manufacturer's employees could not become familiar with the over-all picture of the program.

3-7. Cost of the Design Work. - The design and construction of the Electromagnetic Plant were accomplished by the Stone and Webster Engineering Corp., under three contracts. The design cost of the first contract (W-7401-eng-13) covering the original work in the plant area was $5,936,684.00, of which $837,991.00 was the contractor's fee. The design cost of the second contract (14-108-eng-49)covering design and construction of the extension to the plant was $419,511.00, of which $81,667.00 was the contractor's fee. The design cost of the third contract (14-108-eng-60), covering the design and construction of the fourth Beta Process building was $272,731.00, of which $89,445.00 was paid as design fee. The total design cost for the Electromagnetic Plant was therefore $6,628,926.00, of which $1,008,103.00 was the contractor's design fee.

3-8. General Plant Cost. - The total cost of designing, constructing and equipping the Electromagnetic Plant under the three Stone and Webster contracts was $307,279,000.00, of which $3,385,000.00 was paid to the contractor as fee.

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SECTION 4 - PROCUREMENT OF EQUIPMENT

4-1. <u>General.</u> - A project purchasing office was established in conjunction with the Stone & Webster Boston Office and handled procurement of major items of technical equipment and material designed by the Boston engineering group. A local Purchasing Department was established at the site to procure construction equipment, materials, supplies and items needed by field design changes. Material and equipment lists were prepared at the outset of an authorization for construction, and responsibility for purchasing was assigned from this. Purchase orders and subcontracts were made in the name of Stone and Webster Engineering Corporation and approved by the Government's authorized representatives. Contracts were negotiated in the name of the U.S. Government and signed by the authorized representative of the contracting officer. Methods of procurement were Stone & Webster standard procedures (as described in Appendix A4) modified to conform to War Department Regulations. There were about 70 persons employed in the Boston Purchasing Office and 80 in the local office. In addition, there were approximately 250 personnel devoted to inspection and expediting throughout the country. A Manhattan District Liaison Office was established in Washington which cleared procurement problems with the War Production Board and arranged upratings and directives (See Bk. I, Vol. 9).

Careful study was given to determine the best method of obtaining the major items of special process equipment. This special equipment fell into three general classifications; namely, process power supply equipment,

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magnet coils, and bin equipment. All three of these required special skill for design, special shop facilities for manufacture, and the greatest degree of accuracy. Consideration was given to dividing the equipment among the only three major electrical manufacturers in various ways. As a result of this study, it was agreed that the most progress and the greatest speed could be made by requesting one manufacturer to concentrate on a particular item. Consideration was given to the available manufacturing facilities, engineering talents, and performance of the major manufacturers; and, as result of this study, the General Electric Company was requested to develop and produce the power supply equipment, the Westinghouse Electric Corporation was requested to develop and produce bin equipment, and the Allis-Chalmers Manufacturing Company to produce the magnet coils. A manufacturer, awarded a contract for secret equipment, was required to isolate the part of his plant devoted to this work, and to allow only specially authorized personnel within that area. Many of these items were sealed before shipment to the site and were accompanied by a guard. Over 4000 freight carloads of equipment were sent to the site, besides innumerable motor truck and express shipments. Many pieces of equipment, including 500 gallon tanks, were needed so urgently that they were shipped in by air. Freight cars had to be rebuilt in order to ship some of the heavier apparatus. The Purchasing Department furnished about 60,000 tons of steel to contractors for the manufacture of process equipment. One order was for 5000 tons of an item that required the Government purchase of a special roll for the mill to use in producing this item. Another steel casting

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order for 7,680 pieces (of about 5000 tons) involved from 240 to 3300 units, each of 6 different patterns. A total of 38,960 contracts and purchase orders, with 13,795 modifications, were handled, ranging from $17,500,000 to $0.83. A detailed summary of these would be impossible within these pages, but a number of major items, with the problems they involved, are discussed in the following paragraphs.

4-2. Process Power Supply Equipment.

a. Power Supply Equipment Required. - The process power supply equipment received early attention by the Radiation Laboratory, and Stone & Webster groups at the University of California Laboratory, and various ratings and arrangements of this equipment were studied. The purpose of the equipment is to deliver and control power for the various operations of the process. The general design of the equipment was laid down in a conference in Boston on 30 December 1942 (See App. B53). The essential parts of equipment for the original five Alpha tracks included 10 magnet current regulators, 480 cubicle and operator's panels, 1000 filament rectifiers, 240 heater control panels, 50 indoor unit substations, and 10 phase-shifting transformers. The Beta equipment included 5 regulators, 75 cubicles, 74 filament rectifiers, 36 heater control panels, 9 unit substations, and other auxiliary equipment. The conversion of Track 5 to a hot source necessitated new equipment which included 96 cubicles, 192 arc rectifiers, and 8 unit substations. This change required the original items for this track to be canceled. The equipment required for Alpha II included 16 current regulators, 384 cubicles, 768 arc rectifiers, 72 unit substations, and numerous smaller items. The equipment for the

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three other Beta Buildings duplicated that of the first Beta building with only minor changes.

b. Contracts for Power Supply Equipment. - On 8 January 1943, General Electric Company was given a letter contract for supplying the process power supply equipment for the first stage. In view of the facts, that General Electric was one of the larger manufacturers of this type of equipment, and that other manufacturers were overloaded, the contract was awarded to them. In awarding subsequent contracts for this type of equipment, the experience gained by General Electric in manufacturing the original equipment outweighed any other possible factors, and they were awarded the contracts (See App. A8).

Contract No.	Scope of Work	Cost
W-7401-eng-39	Power supply and control	$13,161,746.34
W-7401-eng-51	" " " "	2,332,867.98
W-7401-eng-73	" " " "	17,443,557.97
W-7401-eng-74	" " " "	4,418,383.77
W-22-075-eng-48	" " " "	2,974,852.00
	Total	$40,331,408.06

4-3. Magnet Coils.

a. Magnet Coils for Original Plant. - The design of the magnet excitation coils, known during construction as "reactors", received attention at the very beginning of the project. The initial design was completed in September 1942, but subsequent modifications, in size and in general arrangements for construction, were made. The methods of insulating and cooling were reviewed in conferences held during the latter part of 1942.

Conferences were also held regarding the silver (See Book V, Volume 4) and regarding steel plate to be procured under the War Production Board's approval. Based on the decision to divide the main items of equipment among the princip~~le~~al electric supply manufacturers of the first "Alpha" coils, the design of which was tentatively frozen in the latter part of December. The initial plans were that Alpha I track 1 and 2 would have coils approximately 12 feet high, and that subsequent tracks would be 3 feet higher. However, in order to speed production, it gradually developed that all of the Alpha coils for tracks 1 to 5, a total of 364, including spares, were made from the same design with slight changes. In March 1943, 76 coils for two Beta tracks and six experimental units (XAX & XBX) were added to the original contract. The Beta coils were smaller in size but were of the same fundamental design.

b. Description of Magnet Coils. - A "reactor" consists essentially of a steel bobbin on which the conductor is wound. The conductor is insulated from the steel by use of wood and fibre board, and turn-to-turn insulation is provided by kraft paper (See also Fabrication of Magnet Coils, Silver Program Book V, Vol. 4). This construction followed generally that used in building magnets for the various laboratory cyclotrons in use at that time, including the 184-inch unit at Berkeley. The bobbin is of completely welded construction and is oil tight. The oil, which circulates through the magnet coils, provides coil insulation and cooling (See App. B54 and B55). Steel castings (installed at the site and not included in this contract) were used for the core of Alpha I "reactors", in order to save rolling mill capacity. For the Beta

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coils, steel plate cores were installed by the manufacturer.

c. Magnet Coils for Y-12 Extension. - In September 1943, two additional Beta tracks (79 coils, including spares), four improved Alpha II tracks (403 coils including spares), and 12 Alpha I "spares" were added. The coils for the additional Beta tracks were identical to previous Beta coils. The Alpha II coils were of entirely different dimensions and special design steel bulb beams were used for the core. The core was installed and welded in place by the manufacturer (See App. B56, B57, B58). In May 1944, two more tracks of Beta design were ordered. The coils were duplicates of previous Beta design except that copper was used for conductor instead of silver (See App. B59 and B60). In April 1945, these coils were again duplicated by Allis-Chalmers for use in Beta Building No. 4.

d. Repaired Magnet Coils. - The coils of Alpha Track No. 1 failed shortly after being placed in operation because of the presence of dirt and moisture in the coils. These coils were removed from the track and returned to the manufacturer for complete rebuilding. This failure prompted the manufacturer to vacuum dry the reactors in the shop and fill them with oil before shipping to the site. This development was also incorporated in Alpha II coils and all Beta coils, except the first two tracks (See App. B61). The cost of this reconditioning work was $473,200.

e. Contracts for Magnet Coils. - The magnet coils were procured through War Department prime contracts with Allis-Chalmers Manufacturing Company on a lump sum basis. All coils for this work were procured from one contractor to insure uniformity of design and construction,

[redacted]

to reduce the required number of operating spares, and to secure earlier manufacture and delivery because of the contractor's previous experience with the apparatus. The following list indicates the amount and quantity of equipment procured (this total cost or $8,376,000 does not include cost of silver, copper or steel plates, which materials were furnished by the Government) (See App. A5).

Contract No.	Scope of Work	Cost of Work
W-7412-eng-27	5 tracks oil filled magnet coils	$2,573,500
W-7412-eng-36	2 "	598,500
W-7405-eng-106	4 "	2,821,000
W-7405-eng-107	4 "	1,431,000
W-7405-eng-278	Reconditioning Reactors	473,200
W-22-075-eng-63	2 tracks oil filled Reactors	478,800
	Total	$8,376,000

4-4. Process Bins.

a. Alpha I Process Bins. - Early in the program, various arrangements and sizes of process bins were studied by the Radiation Laboratory and Stone and Webster. The basic design was crystallized in December 1942. Westinghouse Electric and Mfg. Co. was given a letter contract on 5 January 1943, to supply the bins and bin equipment for the Alpha tracks. It was specified that the design and construction, in general, be in accordance with the requirements outlined in a conference in Boston on 31 December 1942 (See App. B62). The manufacturer was directed immediately to send engineers and designers to the Laboratory to develop details of design in cooperation with engineers of the Radiation Laboratory and Stone & Webster Engineering Corporation.

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App. B63). The initial procurement was for 500 vacuum tanks (12' x 7' 6" x 2' with 2" side wall plates) and 590 face plates (doors) with associated mechanisms, complete in accordance with plans and specifications, as modified for suitability to quantity production. This contract was augmented by the addition of 510 liquid nitrogen traps, 500 sets of connection boxes and other miscellaneous equipment, such as auxiliary shims (which were later cancelled), blank faceplates, electrical jumpers, etc. A conference in October 1943 reviewed about 30 design changes that were required in some or all of the doors (See App. B64).

b. Beta Process Bins. - In March 1943, a contract for the bins and bin equipment of the first Beta building was placed with Westinghouse. This equipment consisted of 76 vacuum bins (approximately 51" x 68" x 23" with 4" side wall plates), 102 main doors with liners, 152 source subdoors, 102 receiver subdoors, extra collector boxes, liquid nitrogen traps, connection boxes and connectors. This equipment was also subject to many changes during the process of manufacture. The equipment required for two Beta tracks was set at 100 main doors and liners, 170 E units, and 116 E units. This equipment is standard for all Beta Process Buildings.

c. Modified Alpha Process Bins. - In July 1943, the decision was made to convert the fifth Alpha track to high voltage (hot) source operation instead of grounded (cold) source operation. This involved the changing of 100 bins, cancellation of 118 cold source doors, and the design and manufacture of 110 main doors, 125 source doors, and 125 receiver doors in their place. The details of this design were supplied directly to Westinghouse Electric & Mfg. Co. by Stone & Webster and Radiation Laboratory personnel at Berkeley (See App. B65).

d. Process Bins for Y-12 Extension. - In September 1943, when it was decided to proceed with the Y-12 Extension program, Westinghouse was engaged to supply for the Alpha tracks: 400 vacuum bins of a new design; 400 main doors, also of a new design, 500 source subdoors and 500 receiver subdoors, both of which were to be similar to the subdoors of track 5. Along with this equipment, orders were placed for liquid nitrogen traps, terminal boxes, water and electrical jumpers, etc. At this time an order was also placed for Beta equipment, which was essentially a duplicate of that in the first Beta track. In January 1944, based on experimental work at the site, it was decided that both the Alpha II and new Beta receivers were unsatisfactory, and a new design had to be worked up and the units produced according to the new design (See App. B66 and B67). In April 1944, decision was made to proceed with a third Beta building, and the bins, doors and associated equipment were ordered from Westinghouse, as was the equipment for the fourth Beta building on 2 April 1945.

e. Contracts. - Most contracts, relevant to the procurement of this equipment, were War Department prime contracts, negotiated on a unit price basis with Westinghouse Electric Company. When the facilities at Westinghouse became overloaded, two other contracts were negotiated to assist in the manufacture of the parts for this equipment. The following is a list of prime contracts pertinent to this work (See App. A5).

Contract No.	Scope of Work	Cost of Work
Westinghouse		
W-7407-eng-11	Bins, Doors & Collector Boxes	$11,286,038.09
W-7407-eng-20	"	2,639,677.80
W-7407-eng-27	"	13,817,276.71
W-7407-eng-28	"	5,366,383.38
W-22-075-eng-66	Bins, Doors, & Cold traps	1,984,642.00
[illegible] and [illegible]		
W-17-028-eng-50	Main Door Liners	468,419.26
Process Engineering, Inc.		
W-17-028-eng-49	Main Door Liners	37,896.79
	Total	$34,590,407.73

4-5. Vacuum Valves.

a. Vacuum Valves for Original Plant.- In January 1943, the Chapman Valve Mfg. Co. was given the preliminary design for vacuum valves and manifolds for the initial Alpha and Beta tracks (See App. C29), as prepared by Stone and Webster in collaboration with the Radiation Laboratory. This manufacturer prepared the arrangement drawings, which were modified to suit their manufacturing methods and embodied their extensive experience in valve design. In the case of the 6-inch valve, the changes offered by Chapman were of a minor nature but their redesign of the 20-inch valve was a considerable improvement over the previous design, in that the valve was a self-contained unit and did not depend on the manifold casing for its guidance and support.

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Following the approval of these designs, Chapman prepared shop detailed drawings[95] and arranged for the manufacture of the various parts. For the most part, the machine work was sub-contracted to outside shops, with only the assembly and testing of units performed at the Chapman Plant (See App. B69). After a number of 20-inch valves had been built and shipped to the job, tests indicated that the chain pull and the number of turns to open and close the valve were excessive, and Chapman suggested that they change the operating spindles from single to triple thread and change plain bearings to needle bearings. This resulted in considerable improvement, and all 20-inch valves not shipped were equipped with the fast operating mechanism.

b. Contracts for Vacuum Valves. - The following equipment was procured through War Department prime contracts, negotiated on a unit-price basis with Chapman Valve Mfg. Co.

	1st Stage Process Nos. 1,2,3	1st Stage Process Nos. 4 & 5	2nd Stage Process Nos. 1,2,3,4
Single 20" Valves	9	60	13
Double 20" Valve	538		292
Single 30" Valves		1,200	
Single 6" Valves	2,054	1,051	1,457

As this equipment was not available elsewhere (so far as it was known) and to insure uniformity of design, the Government made use of the facilities, special testing equipment, and the experience of this manufacturer by awarding them the following contracts (See App. A5).

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Contract No.	Scope of Work	Cost of Work
W-7401-eng-38	Vacuum Valves and Manifolds	$1,905,664.57
W-7401-eng-136	" " " "	2,587,390.26
W-7401-eng-137	" " " "	427,828.32
W-22-075-eng-64	" " " "	157,966.56
	Total	$5,078,849.71

4-6. Door Handling Equipment.

a. Alpha I Face Plate Removers. - During the latter part of 1942, and early in 1943, various schemes were drawn by Stone and Webster for equipment to remove the big main doors of the Alpha Bins (See App. C7) and transport them to the service area where the enriched material was removed and the units were cleaned and serviced. The three main items of handling equipment are the face plate remover, the holding and rotating equipment and the face plate carrier. This combination is capable of exchanging door assemblies between any two units in any sequence. The basic design was forwarded to Boston early in 1943 and Link-Belt Company was selected to design, develop, and manufacture this equipment as stated in negotiated contract No. W-7407-eng-12 (See App. A5 and B70). Various design changes were made at the request of Stone and Webster and Tennessee Eastman. Some of these changes were brought about by operating experience and others by revisions to the main door details, which were in course of design and manufacture by Westinghouse.

b. Modified Alpha Face Plate Remover. - It was agreed, in conference held during September and October 1943, that the main doors for the converted track 5 would be handled by removers similar to those

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already developed, and that the sub-doors would be handled by means of a truck, similar in principles to a warehouse stacking truck. This arrangement facilitates the removal of the subdoors without removing the main door. This equipment was procured under Supplemental Agreement No. 4 of Contract No. W-7407-eng-12 with Link-Belt Company (See App. B71).

c. Alpha II Face Plate Removers. - Since the main doors and subdoor units for Alpha II were similar to those in the Beta Buildings the same general design for door handling equipment was adopted and its size was increased. From these drawings, Link-Belt Company made the shop detail drawings and manufactured this equipment in accordance with Contract W-7407-eng-37 (See App. A5 & B72). In the later part of 1944, when liners were introduced in Alpha II, it became necessary to handle the liner and the main door, simultaneously. This required the design and manufacture of new rails and other parts to enable the removers to handle the heavier loads. Link-Belt was selected for this work as they had manufactured similar equipment on previous contracts, and possessed the special knowledge and design information required.

d. Beta Face Plate Removers. - The handling equipment for the Beta main doors was similar to that of Alpha II except that it was necessarily smaller in order to handle the smaller doors, (See App. C33 and C34). This equipment was procured through Westinghouse Contracts for bins, doors, and collector mechanisms (See App. A5).

e. Contracts for Door Handling Mechanisms. The following contracts were let with Link-Belt Company for door handling equipment for the electromagnetic plant (See App. A5).

Contract No.	Scope	Cost
W-7407-eng-12	Door Handling Mechanisms	$642,874.34
W-7407-eng-37	" " "	611,322.00
	Total	$1,254,196.34

4-7. Chemical Process Equipment. - The procurement of chemical equipment was largely a problem of expediting production of the large volume of standard items from comparatively few manufacturers. Emphasis was placed, when designing a new building, upon standardization of equipment. This facilitated procurement and allowed interchangeability but made deliveries dependent upon the production facilities of the manufacturer. Every effort was made to expedite materials of construction to the manufacturer. This often meant the securing of high priorities for stainless steel, special alloys, etc., with which the manufacturer had to work. In some cases the securing of priorities conflicted with other vital projects, as was the case when 16,000 lbs. of Hastelloy C (chloride resistant special alloy) was diverted from the Navy program for use in Building 9207 (See App. B73). In a few instances special equipment was required which necessitated completely new design and experimentation. The most prominent case of this, as has been mentioned, (See Pg. 3.40), was with the design of calciners for Building 9207 bulk treatment and liquid phase departments. Here a manufacturer had to be contacted who was willing to undertake such a task and had a sufficiently large engineering staff to perform the work within the time limits imposed. After several refusals the Federal Telephone and Radio Corporation was contracted and expressed a willingness to undertake the design

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and fabrication of such a unit. This they accomplished successfully. There are also cases of manufacturers being requested to make their standard items from materials with which they had no experience. Instances of this kind occurred when Crane Company was asked to make (within a very limited time) silver valves for hexafluoride conversion, and when the Sharples Corporation were asked to fabricate their super-centrifuge bowls and liquid contract parts of 316 stainless steel. Both companies expressed willingness to cooperate and produced the items satisfactorily. Rigorous demands were also placed upon Corning Glass Works, The Duriron Company, Leeds & Northrup Company, Bristol Company, Oliver United Filters, Inc., The Bimco Corp., S. Blickman, Inc., The Pfaudler Co., Glascote Products, Inc., Fansteel Metallurgical Corp., The Sharples Corp., Hills-McCanna Company, and many others for their standard items of equipment. Reference to Stone and Webster Contracts Report (See App. A5) will indicate the manufacturers and dollar values of orders placed, but this report does not reflect the seemingly impossible time limits often demanded.

4-8. Vacuum Tubes.

a. General. The procurement of vacuum tubes in sufficient quantity received early attention, as these tubes were to be used throughout the Alpha and Beta plants as rectifiers, limiters, regulators and controls (See App. B74). The magnitude of the tube supply problem is indicated by the fact that 85,000 tubes were required for the initial equipping of the plant. As these tubes have a life of from 1000 to 8000 hours, many replacements were necessary, and the manufacturers were required to expand their facilities and even to establish new plants. The extent of this work is further indicated by the costliness of equipment; the larger tubes range from $100 for a type KU-4, to $550 for a type GL-893 (See App. C35).

b. Contracts. - On 5 January and 11 March 1943, respectively, General Electric Company was awarded contracts W-7401-eng-39 and W-7401-eng-51 for electrical control equipment, which included electronic vacuum tubes. General Electric had proposed to manufacture these tubes, using their own facilities. However, when contracts for the Y-12 Extension equipment, in addition to replacement orders, were also given to General Electric, thus overloading their already expanded facilities, it became necessary for the War Production Board to instruct other agencies to help fulfill these commitments. General Electric continued to manufacture most of the tubes required for their control equipment, but orders were placed by Tennessee Eastman Corporation, with Machlett, Amperex and Federal Radio for such replacements as they could supply.

4-9. Diffusion Pumps.

a. General. - When work on the project started, no vacuum system had been built, at least in the United States, which approached in size those contemplated, and no diffusion pumps, of even half the desired capacity, had been developed (For a description of diffusion pumps see App. A3 and C36). The Berkeley group of the Stone and Webster Engineering Corporation reviewed the designs of the smaller pumps already built by the University of California laboratory, and with the advice of members of the laboratory, designed a 20-inch and an 8-inch pump, which in combination, were expected to have a pumping capacity of 3,000 liters per second. General drawings, establishing the design, were received in Boston early in 1943. The numerous mechanical pumps, used in conjunction with diffusion pumps to obtain the extremely low vacuums required, were of standard design, and created no special problem. They were procured by Stone and Webster through Kinney Mfg. Co.

b. Diffusion Pumps for Original Plant. - In view of the quantity of diffusion pumps required, and the limited time available to meet construction schedules, Westinghouse Electric & Mfg. Co., was considered to have the most suitable engineering and shop facilities, and, accordingly, was selected to manufacture the diffusion pumps for the Alpha buildings. Westinghouse agreed to undertake the work as a manufacturing proposition, using the designs given them by Stone & Webster. Westinghouse, however, contributed some design changes in the 8-inch pump to raise the fore pressure. Subsequently, when additional diffusion pumps were required for the Beta Process Bldg. No. 1, Distillation Products, Inc., was awarded a contract for a quantity of their 20-inch and 6-inch pumps, sufficient for two Beta tracks. These pumps were later shifted to Beta Process Bldg. No. 2 and Westinghouse pumps were installed in Beta Process Bldg. No. 1. The 6-inch diffusion pumps used in connection with the test equipment in the various buildings were specified by Tennessee Eastman Corporation to be of Distillation Products, Inc., make, and were so ordered. They were made entirely in accordance with the manufacturer's designs.

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c. Diffusion Pumps for Y-12 Extension. - When the Y-12 Extension was authorized in the Fall of 1943, 32-inch and 8-inch diffusion pumps were specified for Alpha II by the California group, and again, in view of the quantity required and the necessity to meet urgent completion dates, Westinghouse was selected to design and manufacture them. The design work done by Westinghouse was, to a considerable extent, an enlargement of the 20-inch and 8-inch design to meet the requirements of a 32-inch and 8-inch combination, except that the 32-inch pump was built with three stages, whereas the 20-inch pump is a two-stage unit (See App. B75). Additional pumps of the original Beta design were procured from Westinghouse for Beta Bldgs. Nos. 3 and 4.

d. Development Program. - In August 1944, a diffusion pump improvement program was begun by the California group, and accordingly, at the suggestion of the Laboratory, engineering and development contracts were awarded by the War Department to National Research Corp., Westinghouse Electric & Mfg. Company and Distillation Products, Inc. These contracts called for the design and manufacture of experimental jets to fit the casing of a Westinghouse 32-inch diffusion pump. Later, these contracts were supplemented to include experimental jets for the 8-inch pumps. Tests on these experimental units were completed at the Berkeley Laboratory, and by the Vacuum Test Section of Y-12 Process Improvement group. It appears that DPI has produced a design which improved materially the performance of the 32-inch pumps; also that Westinghouse has developed jets for their 8-inch pump which has given considerably better results (See App. B76, B77, B78, and B79).

e. Contracts for Diffusion Pumps. - Stone and Webster negotiated contracts for the following diffusion pumps with Westinghouse and Distillation Products, Inc.: (See App. A5).

WESTINGHOUSE ELECTRIC & MFG. CO.

Pumps:	1st Stage Material Prep. No.1	Pilot Plant	1st Stage Process Nos. 1,2,3	1st Stage Process Nos. 4 & 5	2nd Stage Process Nos. 1,2,3,4
20" & 8"		11	1004	24	560 (144 barrels only)
32" & 8"				1200	

DISTILLATION PRODUCTS, INC.

20" & 6"					304 (144 internals only)
6"	24				116

4-10. Process Cable.

a. General. - Many miles of cable and copper wire were used in the construction of the Electromagnetic Plant. The procurement of copper wire offered no particular problem, other than WPB's approval; however, process cable, used for high voltage electrical conductors, required special study, as there were no previous installations of cable operating continuously at 35 to 50 KV dc to ground. The nearest approach to this application was probably X-ray cable, in which the service is, in general, quite intermittent. Radar service, apparently, has somewhat similar requirements. The initial requirements specified that the cable would be subject to frequent double voltage transients. Contracts for cable and copper wire are listed in Stone and Webster's contract report (See App. A5).

b. Process Cable for Original Plant. - The cable problem was reviewed by engineers of the largest cable manufacturers, who were then requested to submit bids. Kerite Wire and Cable Company offered complete delivery on an AAA priority by September 1943 (See App. B80). As they were also the lowest bidder, the original cable was purchased from them, as was subsequent cable of this same general type. The Okonite Company, Simplex Wire and Cable Co. and General Cable Co., also bid on and received some contracts for this work.

c. Process Cable for Y-12 Extension. - For Alpha II use, 800,000 circular mil, 2 conductor, concentric "K" cable was required. It was felt that this cable was too heavy to be satisfactory in the oil base compound insulation, and studies were made of the use of paper and varnished cambric insulation. The paper insulation was eliminated because of the size of "potheads"* required for its termination at the bin. General Cable Company offered a varnished cambric cable, and, as lowest bidder meeting the requirement, was awarded the contract. They also offered earlier delivery than did the unsuccessful bidders, The Okonite Company and the Simplex Company. Considerable trouble developed, primarily with the "J"* motor cable in Alpha II. It was confined, however, to a relatively small number of cubicles. Considerable work has been done on this problem and although no definite conclusions have been reached, it appears that the power surges are of much greater magnitude, and more frequent, than originally anticipated.

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4-11. Special Material. Because of the unique equipment required for the Electromagnetic Project, it was necessary to use certain special materials, not commonly found in normal plant usage. Listed below are four materials, used on a large scale, which required special procurement, design or manufacture.

a. Silver. - During the period of design for the electromagnetic plant, it was anticipated that considerable quantities of copper would be required for use in the magnet coils and for busbars of the racetracks. This and other war projects needed such large quantities of copper for wire, cables, electrical conductors, bronze and other alloys that it became wise and economical to supplement the copper with other metals whose properties would make them satisfactory. Hence, the decision was made to substitute silver for copper in the coils and busbar. Arrangements were made with the Treasury of the United States to obtain silver on a loan basis. Stipulation was made to guard the silver at all times during its fabrication and installation in the racetracks. The value of the 29,363,168.26 pounds of silver withdrawn from the Treasury was approximately $304,000,000 (See Silver Program, Book V, Volume 4).

b. Graphite. - Because of the intense heat generated in certain parts of the electromagnetic separation apparatus, it was found necessary to use graphite wherever possible. The "J" or ionization chamber, and many parts of the "R", or receiver (See App. G37), were machined to close tolerances from solid blocks of graphite. With the experience gained in operating the plant, and because of the fact that

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graphite was comparatively cheap and highly resistant to deterioration under operating conditions, new and varied ideas were found for its use, and soon the supply of graphite parts became a major problem. Block graphite was procured chiefly from National Carbon Company and International Graphite & Electrode Corp., and was fabricated into specific sizes and shapes, by Westinghouse, for the initial installation. However, the majority of standard shapes were procured from numerous manufacturers all over the country. For the month of June 1945, the graphite consumption at the Y-12 Plant was approximately 1,200,000 pounds (See App. B21).

c. Zircon. - The high voltage necessary to operate the electromagnetic process successfully made it difficult to obtain insulators which would not break down under the high potentials, mechanical strains, and pressure and temperature changes. At first, it was thought that porcelain would serve the purpose satisfactorily, but it was found that under constant plant usage porcelain insulators had very short lives. After considerable experimentation with various insulator materials, it was found that zircon insulators gave satisfactory performance. Large orders were necessary but, because of the inadequacy of production capacities, insulators were received in small quantities. Even with the use of zircon insulators, considerable replacement was necessary. These zircon insulators cost $65.00 each and were procured from Coors Porcelain Company and from Westinghouse (See App. B21). There were other less expensive insulators whose rate of failure was much greater than that of the Alpha II E bushing.

d. Liquid Nitrogen. - In order to obtain satisfactory vacuums in the electromagnetic process, it was considered necessary to remove all moisture from the system by condensation on an extremely cold surface. Liquid nitrogen was found to be most suitable for this purpose. A storage tank was provided on the roof of each process building and was filled by a pump and filling pipe installed at the railroad siding adjacent to the building. A delivery piping system was installed from the tank on the roof to the end of each racetrack. Nitrogen "buggies" were used for distribution to the cold traps. The piping system was 2½-inch copper tubing with "streamline" type fittings, all of which, in turn, were protected by 8" or 14" O.D. spiral welded, steel pipe, vacuum type casings. The space between the copper tubing and the casing was stuffed with Johns Manville Rock Wool or Santocite. On the inside delivery line to the tracks, a vacuum was maintained in the space between the tubing and the 14-inch O.D. casing. The filling line to the roof tank was not in continual use, and therefore the space between the tubing and its 8-inch casing did not require a vacuum. The quantities of liquid nitrogen required for the electromagnetic plant were extremely large, in fact so large that it was necessary to construct additional facilities at the plants of Linde Air Products Company to assure an adequate supply.

4-12. Cost of Equipment. - The cost of equipment for the Y-12 Plant represents a very substantial proportion of the total plant cost. As shown by the tabulation in Appendix A5, the equipment costs amounted to $136,447,497.50 as of 1 July 1945. This figure may be subdivided into 45 Government contracts totaling $97,631,793.66, two Stone and Webster subcontracts totaling $200,597.77, and the Stone and Webster purchase orders totaling $38,615,106.07. To the cost of equipment purchased by Stone and Webster must be added the cost of fabricating silver for the magnet coils and bus bar, $2,482,626 (See Vol. 4)., making the total equipment cost $138,930,123.50. The total equipment cost at the termination (30 September 1946) of the Stone and Webster contracts exceeded $150,000,000.

SECTION 5 - ORGANIZATION AND PERSONNEL

5-1. General. - The organization for the Electromagnetic Project for purposes of design depended to a large extent on cooperation, between the groups involved, at the design level. As shown by the organization chart (See App. D4) the Y-12 Unit Chief was responsible to the District Engineer for coordination of the contractors. Stone and Webster, as Architect-Engineer-Manager, was responsible for producing the plant design, with assistance on specific features from the manufacturers of special equipment. The Tennessee Eastman Corporation reviewed all designs from the standpoint of operability and efficiency of plant operation. The University of California furnished data and recommendations upon which to base the design. Consequently, the design of the plant and its equipment was the result of the combined efforts of all groups.

5-2. Manhattan District Organization and Personnel. - An Area Office, or its equivalent, at each of the important locations, such as the University of California, Boston and the Y-12 Plant, was established. The Officers in charge at these locations reported to the Unit Chief on matters pertaining to design, and directly to the District Office for administration. The following personnel occupied key positions in the District Organization during the period that the design of the plant was being evolved:

Lt. Col. W.E. Kelley, as Unit Chief for the electromagnetic plant from March 1943, through September 1944, was responsible for the supervision of the design of the plant through the architect-engineer's Boston office and his liaison personnel at the site.

Lt. Col. J.R. Ruhoff, was assigned as Unit Chief in September 1944, and served until 9 November 1945. He assumed the responsibility for design during that period. Colonel O.J. Ferney as Unit Chief from 9 November 1945 to the present, 1 January 1947, was responsible for design.

Maj. Benjamin Hough, Jr., as Area Engineer at Boston from August 1942 to February 1943, was responsible to the Unit Chief for the design of the plant and the process equipment.

Maj. M.O. Swanson assumed the duties and the responsibilities for design, as Boston Area Engineer, from February 1943 to June 1943.

Maj. F.H. Belcher relieved Maj. Swanson as Boston Area Engineer in June 1943, and was responsible for design at Boston until August 1944.

Capt. W.W. Lord was assigned as Boston Area Engineer 17 August 1944, and retained this responsibility until 8 February 1946.

Mr. Francis D. McKeon assumed and retained these responsibilities from 8 February 1946 until the Boston Area Engineer Office was closed 30 April 1946.

5-3. <u>Stone and Webster Engineering Corporation Organization and Personnel.</u> - From the start of S&W's participation on the Manhattan District Project, Mr. A.C. Klein, Project Engineer, was directly responsible for the S&W Engineering and Design Group. An Area Office of the District was set up in Boston, to facilitate District approvals to S&W and to form liaison between S&W's engineering and design offices and the District Engineer and Y-12 Unit Chief on the site, who were in charge of the Y-12 project. In order to establish close relationship with the Radiation Laboratory development section, S&W early recognized a need for a group at that place. Consequently, Mr. R.E. Argersinger was put in charge of a unit at Berkeley, to coordinate developments of that group with the Boston Office. Early in 1943, S&W was asked by the District to move their entire engineering and design section to Oak Ridge. This was decided as impractical but at the same time a need for Boston engineers at the site was recognized. In June 1943, Mr. E.W. Seckendorff was assigned to the site to act as liaison between the operating contractors (TEC), construction forces, and the Boston Group. He was assigned a number of engineers to follow various phases of development and necessary field changes, which were reported to the Boston office. Because of the increasing number of changes that developed and that required immediate attention, a segment of the Boston engineering and design group was assigned to Oak Ridge under Mr. R.R. Wisner, Asst. Project Engineer, who reported directly to Mr. Klein. They were entirely separate from the Liaison Group and from the construction forces. With Mr. Wisner were additional mechanical, electrical, structural, and chemical engineers along with design personnel. Their responsibility was to handle field changes in design as they became apparent and necessary. A Power Division was also assigned to the site under Mr. Fred Taylor, and later, in February 1944, under Mr. Fred Argue, which had the responsibility of insuring initial operations and proper functioning of installations before they were considered adequate to turn over to the operating contractor. They worked in close harmony with the engineering and design group, to change, or perfect, improperly designed equipment. In May 1944, Mr. B. W. Whitehurst, was assigned to the site, to report directly to Mr. Klein on the research and development activities carried on at Oak Ridge by TEC and the Radiation Laboratory. He further collected experimental and operational data, as required by the design groups at Berkeley and Boston, and prepared reports covering S&W activities at the site. The latest work done by Mr. Whitehurst included the collection of material and editing the several volumes contributed by Stone & Webster Engineering Corporation to the Manhattan Project Technical Series (MPTS). Their final contract with the Manhattan District was concluded in late 1946. An organization chart may be seen in Appendix D5, which illustrates the relationship of the Engineering and Design Group with the rest of Stone and Webster Organization.

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

APPENDIX "A"

DOCUMENTS

No.	Description
1	Letter from Mr. A. C. Klein to General Groves, 3 September 1943, Subject; Recommended Design of Racetracks 6 to 9 and attached Sketch S&S 141.
2	~~Letter~~ Memorandum from Col. K. D. Nichols to General Groves, 22 June 1945, Subject: Additional Beta Capacity; Also General Groves approval of above subject.
3	Explanation of Diffusion Pump Performance, 29 May 1945 and attached sketch.
4	Outline of Stone and Webster Engineering Corporation's Procedure for Placing Purchase Orders.
5	Equipment contracts, subcontracts, and orders for Y-12.

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STONE & WEBSTER ENGINEERING CORPORATION

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Room 106, Durant Hall
September 3, 1943

Brigadier-General L. R. Groves
P. O. Box 2610
Washington, D. C.

RECOMMENDED DESIGN RACETRACKS 6 TO 9

Dear Sir:

We have reviewed the present design of racetrack No. 5 and wish to recommend the following design improvements for racetracks 6 to 9:

(1) The arrangement of tanks in two parallel single straight lines in place of the present back to back double oval arrangement.

(2) The use of three 20 inch diffusion pumps in place of the present two pumps.

(3) A building arrangement comprising a central plate service bay, two magnet bays and four control bays arranged as shown diagramatically on the attached Engineering Sketch 141.

These design changes will permit the use of control equipment to be furnished by the General Electric Company duplicating that now in production for No. 5 racetrack.

On the part of the Westinghouse Company, there will be no change in door equipment but it will require slight changes in the tank making it 8' 9" instead of 7' 9" deep and adding a flanged opening at the back to which a diffusion pump can be attached. We also believe the tank should be made 6 inches higher to eliminate the complication of stainless steel plate welded into top and bottom of the tank. This is not due to the track arrangement but we believe is justified by probable improvement in tank operation and simplification of manufacture.

The propose arrangement will have the following advantages:

(1) The straight side track obviates the use of cranes in handling doors from the inside of the oval track. This should reduce outage time and amount of labor.

(2) It permits placing a diffusion pump on the back of the tank where its use becomes more efficient than if added to the header below the tank.

(3) It permits half the track to be shut down leaving the other half in operation. This will greatly reduce outage time for maintenance work on process and coil tanks.

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(4) All sources will be on the lower sub-door so that the high voltage connections are shortened and can be kept below the middle of the door, and enclosed with comparatively low safety doors. This removes such connections above the upper operating platform and reduces the operating hazard.

(5) The magnet coils will be much smaller permitting easier fabrication and the use of standard flat cars for shipment.

(6) It is expected that the magnet coil cores, being much smaller, can be built and installed as units with the coils rather than being built up on the job with small castings, thus saving construction time and securing a more uniform magnetic structure.

(7) Being accessible both front and rear, the process tanks can be more accurately and quickly installed thus reducing construction time and cost.

(8) The operating process should be speeded up and made more of a straight line function.

(9) Core construction will be such that access can be had at floor level to the inside of the track.

Disadvantages

(1) There are 100 Magnet coils per track requiring approximately 1630 tons of silver instead of 72 coils with approximately 1015 tons of silver.

(2) There will be about 3,200 tons instead of 2,300 tons of core steel.

(3) Magnet room floor space for one race track is about 12% greater with the straight side layout.

(4) Power required for magnet excitation per track will be about 8,000KW instead of 5,000 KW.

Tennessee-Eastman, Stone & Webster and the Laboratory have signed this memorandum to indicate their concurrence in the recommendation of the proposed general arrangement and in the statements concerning it. Westinghouse and General Electric by signing it indicate that the proposed changes will not delay the schedules of deliveries which they reported in the conference of September 2nd at Berkeley.

Yours very truly,

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/s/ A. C. Klein
A. C. Klein, for
STONE & WEBSTER ENGINEERING CORPORATION

ACK-ml
REA

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For approvals see attached page three.

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APPROVAL SHEET
attached to letter A. C. Klein to Brigadier-General Groves dated September 3, 1943; Subject: Recommended Design Racetracks 6 to 9.

TENNESSEE-EASTMAN CORPORATION, by

/s/ F. R. Conklin
F. R. Conklin

STONE & WEBSTER ENGINEERING CORPORATION, by

/s/ R. E. Argersinger
R. E. Argersinger

RADIATION LABORATORY, by

/s/ Everett O. Lawrence
E. O. Lawrence

WESTINGHOUSE ELEC. & MFG. CO., by

/s/ L. R. Ludwig
L. R. Ludwig

GENERAL ELECTRIC COMPANY, by

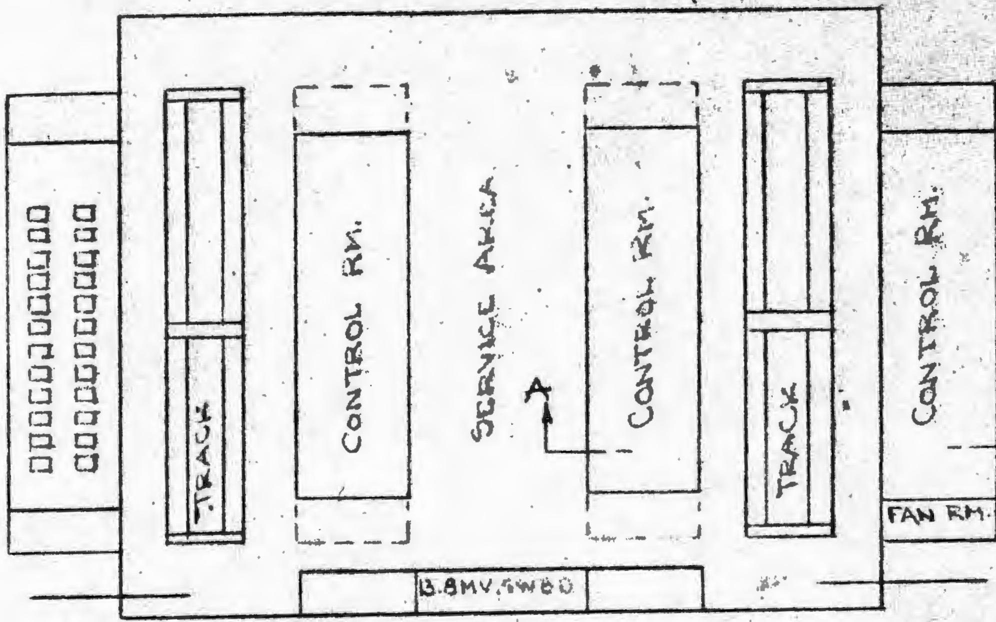
/s/ J. C. Roser
J. C. Roser

COPY

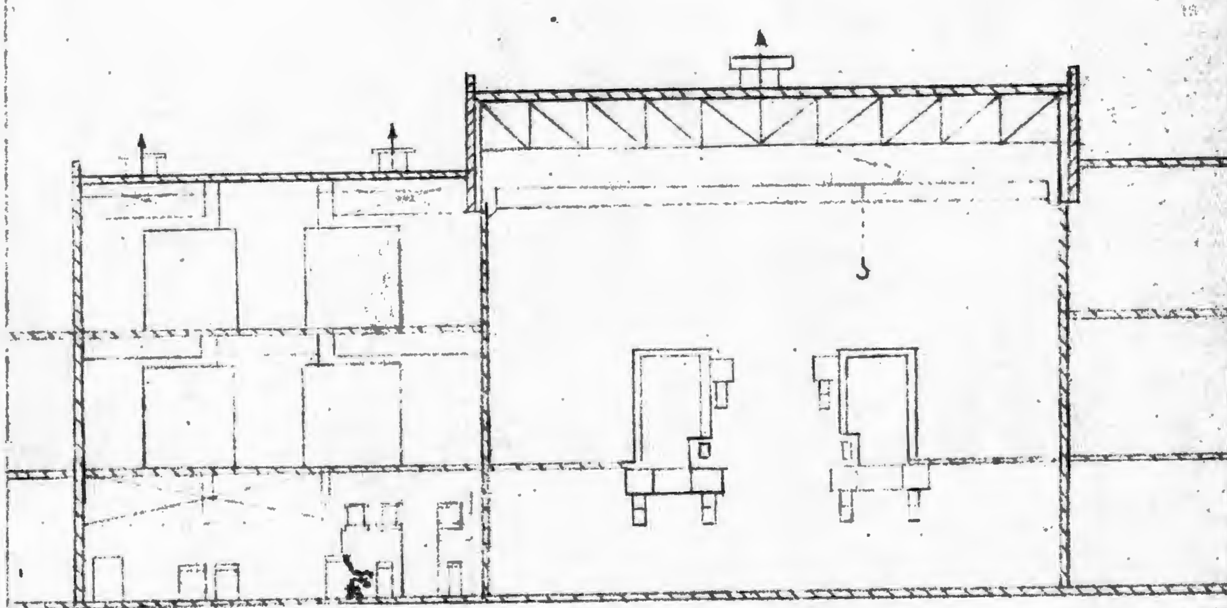
~~CONFIDENTIAL~~

~~SECRET~~

Section incorrectly drawn. X [See scales]



KEY PLAN
SCALE 1" = 100'-0"



SECTION AA
SCALE 1/30 1'-0"

KEY PLAN & CROSS SECTION
PROPOSED ALPHA 2 BLDG.

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SAVE

This document consists of 1 page.
Copy No. / of 3, Series A.

SAVE

ARMY SERVICE FORCES
UNITED STATES ENGINEER OFFICE
MANHATTAN DISTRICT
OAK RIDGE, TENNESSEE

IN REPLY REFER TO

EIDME-a

MD.400.5

22 June 1945

Subject: Additional Beta Capacity.

MEMORANDUM to: Major General L. R. Groves.

1. Reference is made to our conversations with Mr. White on 19 June and to letter of 31 May 1945, subject as above. Since Stone & Webster, Tennessee Eastman Corporation, and Professor E. O. Lawrence concur that the conversion of Alpha track 9 to Beta 2J 24" radius unit is the best method of several studied for increasing Beta capacity, it is strongly recommended that plans for the conversion be put into immediate operation. Stone & Webster's present estimate of the cost of conversion is $8,670,000.

2. The conversion of Alpha track 9 will (1) provide additional capacity equivalent to 2-2/3 normal Beta tracks; (2) result in a 4% increase in production rate when all of the projected 25 producing plants are operating in proper combination, at an increase in total over-all plant construction costs of less than 1%, or will permit a considerable decrease in operating personnel with little change in production by shutdown of part or all of the running Alpha tracks; (3) insure more nearly adequate Beta production facilities should K-25 and K-27 fail to produce 25 of required higher concentration, or if K-25 and K-27 produce 25 at a rate greater than the design rate, which from data obtained during the last month of operations appears likely; and (4) allow greater flexibility and certainty in combined operations of Y-12 and K-25. This scheme for conversion is preferred to the cheaper 2J 48" radius conversion because of the undesirable loss in enhancement and decreased recovery that is expected in the 48" unit.

3. Stone & Webster's estimate for completion of the first half track is 1 January 1946, and 1 February 1946 for the second half. It is believed that by proper expediting these dates can be advanced. The outage time for each half track is estimated to be one month, and will take place directly prior to completion.

4. Stone & Webster has already placed several orders on items of a critical nature. In order to insure completion of the unit in time to take advantage of increased production resulting from completion of K-27, they must be given authority to proceed at full speed at once. Approval is requested at the earliest possible date.

K D Nichols
K. D. NICHOLS,
Colonel, Corps of Engineers,
District Engineer.

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53200

THIS DOCUMENT CONSISTS OF 2 PAGES
COPY NO. 1 OF 3 SERIES A

~~SECRET~~

1st Ind.

Subject: Additional Beta Capacity.

P. O. Box 2610, Washington, D. C., 25 June 1945.

TO: The District Engineer, U. S. Engineer Office, P. O. Box E, Oak Ridge, Tenn.

Approved.

L R Groves

L. R. GROVES,
Major General, C. E.

MANHATTAN DISTRICT
ENGINEER OFFICE
CLASSIFIED FILE
RECEIVED

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~~RESTRICTED~~

May 29, 1945

EXPLANATION OF DIFFUSION PUMP PERFORMANCE

Diffusion type vacuum pumps are used to obtain vacuum lower than can be created by mechanical pumps and they can only be used where reasonably good vacuum has already been established.

A diffussion pump makes use of a feature of an oil vapor stream whereby it will pick up gas molecules, and by condensation will collect and compress the gas particles into groups of a smaller volume and greater mass, then deliver the gas to another diffusion pump or a device that can receive it, and transport and compress it still further.

Please refer to the attached drawing.

The diffusion pump consists fundamentally of a boiler containing oil; an inner cylinder or chimney; and a series of nozzles to collect oil vapor rising through the chimney and divert it sideways and downward to a cooled outer cylinder or condensing surface. Oil heated in the boiler is vaporized and the vapor rises in the chimney at the top of which it is directed by the nozzle toward the condensing surface where the vapor is cooled and condensed to its original liquid form then collected at the bottom where it flows through small openings at the bottom of the chimney back into the boiler. In the boiler the oil is heated and vaporized again and the cycle is repeated.

Air or other gaseous particles moving into the space between the chimney and the condensing surface are caught in the oil vapor current then condensed and would continue travelling through the recycling operation, if separation were not provided; the separation is obtained by providing small openings in the bottom of the chimney which offer an obstruction while another and easier path of flow for the compressed gas molecules is provided by the connection to the second diffusion pump or to a mechanical vacuum pump. Since the gas leaving the first diffusion pump is more dense than when it first entered, the second diffusion pump may be physically smaller than the first pump. The second smaller diffusion pump may discharge into an even smaller diffusion pump or to a more positive means of gas removal such as an ejector or a rotary pump or a reciprocation pump.

The gas removed by diffusion pumps using an operating cycle as described above must of course be noncondensible otherwise it could not be removed from the oil used to entrain it.

Diffusion pumps are not efficient but they are effective as carriers and compressors of extremely light and finely divided gases, reducing them in volume and increasing them in density to a point where such gases can be handled by more positive or more efficient devices.

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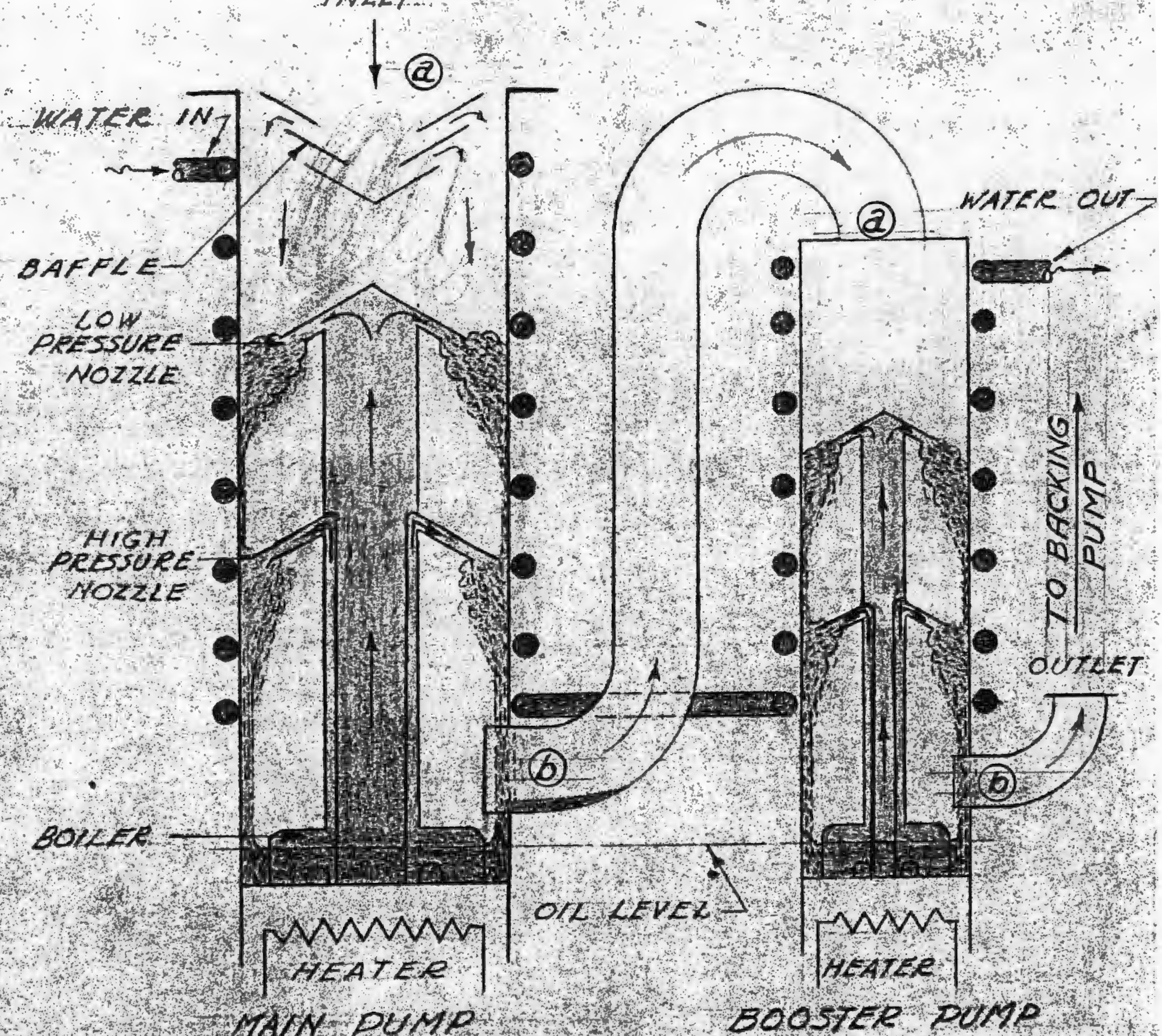

No Scale

OIL
AIR
WATER

NOTE:
SPEED OF PUMP MEASURED AT POINT a
FORE PRESSURE MEASURED AT POINT b

OUTLINE OF STONE & WEBSTER ENGINEERING CORPORATION'S PROCEDURE FOR PLACING PURCHASE ORDERS CLINTON ENGINEER WORKS PROJECT

1 - Requirement is determined by the Engineering Division.

2 - Requisition is prepared by Engineering Division and sent to the Purchasing Department.

3 - Requests for Bids are prepared by the Purchasing Department and sent out to prospective bidders.

4 - Bids are received, and tabulated by the Purchasing Department.

5 - Bids are analyzed and recommended award sent to Engineering Division for their concurrence.

6 - Comparison of bids is typed in multiple copies and approval is obtained by the Purchasing Department from the USED.

7 - Necessary Priority, CMP and WPB Limitation Order clearances are arranged where required.

8 - Order is typed and formally approved by the USED.

9 - Order is mailed to the Vendor.

10 - The multiple copies of purchase orders are distributed to all concerned.

11 - The formal purchase order is mailed to the Vendor in triplicate (original and two copies). The original is retained by the Vendor and the two copies which are acceptance copies, are signed and returned to the Purchasing Department.

12 - The two acceptance copies thus received, are formally approved and accepted by the Government after which they are sent to the Job Office; one for the permanent file of Stone & Webster and the other for the Corps of Engineers.

Supplementing the "General" footnotes on Page 15 of Stone & Webster's Contract Report, the following explanation is furnished covering the exceptions there noted:

The purchase transactions indicated as having been under unusual circumstances fall in the following classes:

1) <u>WPB Direction:</u> Sixteen orders cover carbon steel plates, stainless steel plates, stainless steel pipe and copper bars. All these items were under WPB Control and no order could be accepted by a mill without WPB approval.

therefore, time spent in taking bids was wasted as WPB had the final authority over which month a mill could produce and order. As delivery was the prime factor, WPB reviewed mill schedules and decided which was in the best position to fill an order. Base prices from all mills were the same and therefore there was no point in taking bids.

2) OCE Teletype: of 1/27/43 — Six orders are indicated under this authority. It is based on Office or Chief Engineer's instructions to place all orders for materials and equipment that came under WPB Control Orders before 2/6/43 for requirements for 2nd Quarter of 1943 and before 3/1/43 for requirements for 3rd and 4th Quarters of 1943. As this involved many orders, time did not permit taking bids.

3) Uniformity of Design: — Two orders were thus placed on basis of duplicating previous orders for the purpose of saving engineering and manufacturing time and expense. The orders being duplicated were awarded in the first instance on the basis of lowest bid and the subsequent awards were for speed and ultimate simplicity of operation and minimizing of spare parts required for maintenance.

4) Choice Between Equal Bidders: — Two orders fell in this class. Normally lots would have been drawn between tie bidders but instead, in these cases, one was selected because of the equipment being offered requiring the utilization of less critical material than the other tie bidder.

5) Miscellaneous: Other Reasons — (a) Kinney Pump Order No. 267 - Only two bidders offered pumps meeting design conditions. Kinney and Beach-Russ. Kinney Pumps had known performance value under service conditions required and time did not permit delaying award until tests could be made on Beach-Russ pumps. Sample pump was obtained for testing, and some Beach - Russ pumps were purchased later in program.

(b) American Bridge Company Order No. 915 - Roof Steel for building. Change of design of roof from concrete to steel made to speed up construction. Time did not permit taking bids. Award was made as soon as bills of material and drawings were prepared.

(c) Bristol Steel & Iron Works Order No. 50203 - Covered structural steel for Building 9201-5 and was a duplication of Order No. 50008 (Building 9201-4) which was awarded on basis of lowest bidder.

(d) Merco Nordstrom Company Order No. 55938 for stainless steel plug valves was placed by WPB Direction after it was determined that all other plug valve manufacturers were so heavily scheduled with high priority orders that they could not produce these valves until two to four months after our required delivery date.

In all cases the approval of the Area Engineer was secured.

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CLINTON ENGINEER WORKS
EQUIPMENT CONTRACTS FOR Y-12
AS OF 1 ~~JULY 1945~~ Jan. 1947

Contract Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Contract Amount
Prime Contract Number W-7401-eng-13						
W-7401-eng-134	W.D. No. 1	10-22-43	Gisholt Machine Co.	Madison, Wisc.	Lathes	$ 57,715.79
W-7412-eng-27	W.D. No. 1	1- 5-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	5-Sets Oil Filled Reactors	2,573,500.00
W-7412-eng-36	W.D. No. 1	3- 6-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	2-Sets Oil Filled Reactors	598,500.00
W-7405-eng-106	W.D. No. 1	9-13-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	4-Sets Oil Filled Reactors	2,821,000.00
W-7405-eng-107	W.D. No. 1	9-13-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	4-Sets Oil Filled Reactors	1,431.000.00
W-7405-eng-116	W.D. No. 1	11- 9-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Metalclad Switch-gear	189,565.00
W-7405-eng-117	W.D. No. 1	10- 6-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	5-5000 K.W.M.G. sets	973,392.00
W-7405-eng-278	W.D. No. 1	1- 3-44	Allis-Chalmers Mfg. Co.	Boston, Mass.	Reconditioning Reactors	473,200.00
W-17-028-eng-50	W.D. No. 1	10-19-44	Bonner & Hauman	Oakland, Cal.	150 - Main Door Liners	468,419.29
W-7401-eng-38	W.D. No. 1	1-18-43	Chapman Valve Mfg. Co.	Indian Orchard, Mass.	Vacuum Valves & Manifolds	1,905,664.57
W-7401-eng-136	W.D. No. 1	10-29-43	Chapman Valve Mfg. Co.	Indian Orchard, Mass.	Vacuum Valves & Manifolds	2,587,390.26
W-7401-eng-137	W.D. No. 1	10-29-43	Chapman Valve Mfg. Co.	Indian Orchard, Mass.	Vacuum Valves & Manifolds	427,828.32
W-7407-eng-155	Service	8-21-44	Distillation Products Inc.	Rochester, N. Y.	Development Vacuum Pumps	8,300.00
W-7407-eng-158	W.D. No. 1	8-29-44	Federal Tel. & Radio	Newark, N. J.	Steel Calciners	1,123,205.42

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CLINTON ENGINEER WORKS
EQUIPMENT CONTRACTS FOR Y-12
AS OF 1 JULY 1945 Jan. 1947

Contract Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Contract Amount
			Prime Contract Number W-7401-eng-13 (Contd.)			
W-7412-eng-28	W.D. No. 1	1-29-43	Fluor Corp., Ltd.	Boston, Mass.	Cooling Towers	718,884.73
W-7412-eng-153	W.D. No. 1	10-21-43	Fluor Corp., Ltd.	Boston, Mass.	Cooling Towers	181,890.25
W-7401-eng-39	W.D. No. 1	1- 5-43	General Electric Co.	Boston, Mass	Transformers & Rectifiers	13,161,746.34
W-7401-eng-51	W.D. No. 1	3-11-43	General Electric Co.	Boston, Mass.	Transformers & Rectifiers	2,332,867.98
W-7401-eng-73	W.D. No. 1	9-24-43	General Electric Co.	Boston, Mass.	Transformers & Rectifiers	17,443,557.97
W-7401-eng-74	W.D. No. 1	9-24-43	General Electric Co.	Boston, Mass.	Transformers & Rectifiers	4,418,383.77
W-7405-eng-365	Services	7- 5-44	General Electric Co.	Boston, Mass	Services of Scientists	70,967.74
W-7407-eng-12	W.D. No. 1	8- 9-43	Link-Belt Co.	Chicago, Ill.	Door Handling Mechanisms	642,874.34
W-7407-eng-37	W.D. No. 1	10-21-43	Link-Belt Co.	Chicago, Ill.	Door Handling Mechanisms	611,322.00
W-7412-eng-152	W.D. No. 1	11-26-43	Marley Company, Inc.	New York, N. Y.	Cooling Towers	191,223.00
W-7407-eng-156	Services	8-21-44	National Research Corp.	Boston, Mass.	Development Vacuum Pumps	27,000.00
W-17-028-eng-49	W.D. No. 1	10-19-44	Process Engineering, Inc.	Somerville, Mass.	125-Main Door Liners	27,898.79
W-7407-eng-7	W.D. No. 1	2-11-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Vacuum Boosters & Heaters	1,123,009.69

CLINTON ENGINEER WORKS
EQUIPMENT CONTRACTS FOR Y-12
AS OF 1 ~~JULY 1945~~ Jan. 1947

Contract Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Contract Amount
Prime Contract Number W-7401-eng-13 (Contd.)						
W-7407-eng-11	W.D. No. 1	1-5-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Bins, Doors & Collector Boxes	$11,286,038.09
W-7407-eng-20	W.D. No. 1	3-17-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Bins, Doors & Collector Boxes	2,639,677.50
W-7407-eng-27	W.D. No. 1	9-15-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Bins, Doors & Collector Boxes	12,817,378.71
W-7407-eng-28	W.D. No. 1	9-15-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Bins, Doors & Collector Boxes	5,366,353.35
W-7407-eng-36	W.D. No. 1	9-15-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Vacuum Boosters & Heaters	2,186,080.00
W-7407-eng-66	Services	1-5-44	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Service of Scientists	275,000.00
W-7407-eng-543	Services	8-22-44	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Development of Vacuum Pumps	15,000.00
Prime Contract Number W-14-108-eng-49						
W-22-075-eng-87	W.D. No. 1	4-25-45	Fluor Corp., Ltd.	Los Angeles, Calif.	Cooling Towers	26,990.00
W-22-075-eng-78	W.D. No. 1	4-19-45	S. Blickman, Inc.	Weehawken, N. Y.	Laboratory Equipment	456,518.20
W-7405-eng-365	Services	7-5-44	General Electric Co.	Boston, Mass.	Services of Scientists	66,000.00
W-7407-eng-66	Services	1-5-44	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Services of Scientists	125,000.00

CLINTON ENGINEER WORKS
EQUIPMENT CONTRACTS FOR Y-12
AS OF 1 ~~JULY 1945~~ Jan. 1947

Contract Number	Type of Contract	Date Contract	Contractor's Name	Contractor's Address	Scope of Work	Contract Amount
Prime Contract Number W-14-108-eng-60						
W-22-075-eng-64	W.D. No. 1	4- 2-45	Chapman Valve Co.	Indian Orchard, Mass.	Process Equipment	$ 157,966.56
W-22-075-eng-68	W.D. No. 1	4- 2-45	Fluor Corp., Ltd.	Los Angeles, Calif.	Cooling Towers	27,258.00
W-22-075-eng-67	W.D. No. 1	4- 2-45	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Process Equipment	124,416.00
W-22-075-eng-63	W.D. No. 1	4- 2-45	Allis-Chalmers Mfg. Co.	Boston, Mass.	Process Equipment	478,800.00
W-22-075-eng-79	W.D. No. 1	4-19-45	Distillation Products Co.	Rochester, N. Y.	Process Equipment	33,516.00
W-22-075-eng-66	W.D. No. 1	4- 2-45	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Process Equipment	1,984,642.00
W-22-075-eng-65	W.D. No. 1	4- 2-45	General Electric Co.	Boston, Mass.	Process Equipment	2,974,852.00

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CLINTON ENGINEER WORKS
EQUIPMENT SUBCONTRACTS FOR Y-12
AS OF ~~1 JULY 1945~~ Jan. 1947

Subcontract Number	Date of Subcontract	Subcontractor's Name	Scope of Work	Amount of Subcontract
		Prime Contract Number W-7401-eng-13		
97-C-50777	5-18-44	Eastman Kodak Company	"F" Doors - Figure Type	$ 116,047.77
106-C-50921	5-24-44	Eastman Kodak Company	Sump Receiver Units	84,550.00

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 JULY ~~1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13			
51197	Order	6-13-44	Abel, Robert, Inc.	Boston, Mass.	Monorail Tracks & Trolley Systems & Mounted Elevators	$ 99,229.59
512	Order	4-12-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Motor Generator Sets	329,702.70
750	Order	5-12-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Motor Generator Sets	107,626.90
1425	Order	6-14-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Transformer Oil	189,250.00
50001	Order	10- 6-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Motor Generator Sets	118,749.00
51009	Order	5-11-44	Allis-Chalmers Mfg. Co.	Boston, Mass.	Motor Generator Sets	115,407.90
51400	Order	7-18-44	American Air Filter Co.	Boston, Mass.	Electoclone Precipitators	64,881.00
7930	Order	7- 1-43	American Air Filter Co.	Louisville, Ky.	Air Filter Units	80,247.30
53306	Order	4-29-44	American Air Filter Co.	Louisville, Ky.	Air Filter Units	162,247.10
50511	Order	2-28-44	American Car & Foundry Co.	New York, N. Y.	Lubricated Plug Valves	71,690.00
514	Order	3-10-43	American Steel Foundaries	New York, N. Y.	Normalized Steel Castings	2,471,791.65

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 JULY ~~1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13			
50088	Order	11-18-43	Anaconda Wire & Cable	Boston, Mass.	Copper Wire & Cable	$ 59,516.25
51494	Order	8- 7-44	Artisan Metal Products, Inc.	Boston, Mass.	Steam Chests, etc.	124,070.00
50366	Order	1-20-44	Automatic Transportation Co.	Chicago, Ill.	Automatic Transporters, Rectifiers	104,994.00
15777	Order	3-17-44	Bartlett, C.O. & Snow Co.	Cleveland, Ohio	Rotary Calciners	50,560.70
50117	Order	10-12-43	Bethlehem Steel Co.	Boston, Mass.	Steel Plate	59,175.04
51375	Order	7-13-44	Blaw-Knox Div. of Blaw-Knox Co.	New York, N. Y.	Small Reactors	192,420.00
50514	Order	3-14-44	Blickman, S., Inc.	Weehawken, N. J.	SS Benches & Basins	154,153.65
51159	Order	6-22-44	Blickman, S., Inc.	Weehawken, N. J.	SS Tanks and Trays	82,888.77
51326	Order	7- 1-44	Brettler Steel Tank Works, Inc.	New York, N. Y.	Carbon Steel Tanks	87,155.25
50403	Order	1-29-44	Brown Instrument Co. Div. of Minneapolis-Honeywell	Boston, Mass.	Water Flow Switches	50,856.00
737	Order	5- 8-43	Carlson, G. O., Inc.	Thorndale, Pa.	Stainless Steel	56,587.07

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 JULY ~~1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13			
319	Order	1-25-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	$ 61,790.98
939	Order	6-21-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	71,810.57
50110	Order	10-12-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	61,701.54
50111	Order	10-13-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	93,378.95
50123	Order	10-6-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	71,419.94
50144	Order	12- 4-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	53,486.40
50145	Order	12-14-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	215,479.27
50150	Order	12-14-43	Carnegie-Illinois Steel Corp.	Boston, Mass.	Steel Plate	88,222.02
15619	Order	1-17-44	Commercial Filters Corp.	Boston, Mass.	Filter for Distilled Water	56,447.04
51703	Order	8-30-44	Corning Glass Works	Corning, N. Y.	Pyrex Pip & Fittings	59,054.01
51628	Order	8-19-44	Cox, C. J. Engineering Co.	Cambridge, Mass.	Filter Boxes	89,621.00
51629	Order	8-19-44	Cox, C. J. Engineering Co.	Cambridge, Mass.	Filter Boxes	76,125.00

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 JULY ~~1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13			
376	Order	2- 3-43	Crane Co.	Boston, Mass.	Forged Steel Fittings	$ 81,375.60
460	Order	4- 5-43	Crane Co.	Boston, Mass.	Valves	92,889.91
601	Order	2-24-43	Crane Co.	Boston, Mass.	Valves	71,338.72
51984	Order	10-11-44	Crane Co.	Boston, Mass.	Valves	59,339.75
50214	Order	12-26-43	Delta-Star Electric Co.	Boston, Mass.	Switches	56,374.16
1128	Order	5- 7-43	Distillation Products, Inc.	Rochester, N. Y.	Vacuum Boosters	250,860.00
50573	Order	3-28-44	Dollinger Corp.	Boston, Mass.	Water Filters	71,310.00
51900	Order	9- 8-44	Du Pont, E. I. deNemours & Co., Inc.	Arlington, N. J.	Gaskets	58,930.63
51650	Order	9- 7-44	Duriron Co., The	Dayton, Ohio	Plug Valves	55,816.85
51811	Order	9- 9-44	Duriron Co., The	Dayton, Ohio	Pipe Fittings & Valves	93,685.60
1627	Order	7- 9-43	Economy Engineering Co.	Chicago, Ill.	Service Trucks	181,481.77
51525	Order	8-14-44	Eimco Corp., The	Chicago, Ill.	Vacuum Filters	113,844.88
671	Order	2-27-43	Elliott Co.	Boston, Mass.	Steam Jet Refrigerator Units	55,641.23

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF ~~1 JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Contd.			
50837	Order	5-5-44	Fansteel Metallurgical Corp.	Chicago, Ill.	Tantalum Evaporator Units	$65,700.00
50668	Order	4-6-44	Fansteel Metallurgical Corp.	Chicago, Ill.	Tantalum Evaporator Units	54,634.50
51239	Order	6-19-44	Fansteel Metallurgical Corp.	Chicago, Ill.	Tantalum Evaporator Units	51,000.00
50011	Order	10-16-43	General Cable Corp.	Boston, Mass.	Cable	226,300.00
443	Order	2-3-43	General Electric Co.	Boston, Mass.	Transformers	63,886.60
454	Order	2-5-43	General Electric Co.	Boston, Mass.	Metalclad Switchgear	52,433.94
489	Order	2-5-43	General Electric Co.	Boston, Mass.	Unit-Sub-Stations	55,690.23
646	Order	3-13-43	General Electric Co.	Boston, Mass.	Mass Spectrographs	66,678.58
872	Order	4-8-43	General Electric Co.	Boston, Mass.	Transformers	145,685.95
51263	Order	6-22-44	Glascote Products, Inc.	Cleveland, O.	Glass Lined Tanks	53,360.82
50904	Order	5-15-44	Grinnell Co., Inc.	Providence, R.I.	Oil Filters	52,052.30
51023	Order	5-15-44	Griscom-Russell Co., The	Boston, Mass.	Heat Exchangers	55,048.00

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 JULY ~~1945~~ Jan. 1947.

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Contd.			
50540	Order	3-10-44	Greisser & Schlager Iron Works	Somerville, Mass.	Repair Stands	$81,869.60
51406	Order	9-4-44	Haynes Stellite Co.	Kokomo, Ind.	Tubing	75,809.15
678	Order	2-27-43	Hilliard Corp.	Boston, Mass.	Oil Re-claimers	139,786.00
50284	Order	12-21-43	Hilliard Corp.	Boston, Mass.	Oil Re-claimers	77,449.00
787	Order	3-24-43	Inland Steel Co.	Chicago, Ill.	Steel Sheets	81,574.93
50113	Order	10-8-43	Jessop Steel Co.	Hartford, Conn.	Non-magnetic Hot Rolled Steel	452,909.31
50124	Order	11-2-43	Jessop Steel Co.	Hartford, Conn.	Non-magnetic Steel Plates & Flats	62,459.66
707	Order	3-15-43	Kerite Insulated Wire & Cable Co.	New York, N.Y.	Special High Voltage Cable	106,123.61
50029	Order	10-28-43	Kerite Insulated Wire & Cable Co.	New York, N.Y.	Copper Cables	586,890.28
50048	Order	11-5-43	Kerite Insulated Wire & Cable Co.	New York, N.Y.	Special High Voltage Cable	60,079.69

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF ~~1 JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Contd.			
267	Order	1-7-43	Kinney Mfg. Co.	Boston, Mass.	High Vacuum Pumps	$182,102.06
553	Order	2-18-43	Kinney Mfg. Co.	Boston, Mass.	High Vacuum Pumps	146,103.32
50007	Order	9-3-43	Kinney Mfg. Co.	Boston, Mass.	Vacuum Pumps	314,958.78
50489	Order	2-23-44	Kinney Mfg. Co.	Boston, Mass.	Vacuum Pumps	86,995.02
51004	Order	5-11-44	Kinney Mfg. Co.	Boston, Mass.	High Vacuum Pumps	109,116.31
51648	Order	8-23-44	Ladish Drop Forge Co.	New York, N.Y.	Flanges	87,300.29
50449	Order	2-12-44	Limbert, Geo. B. Co.	Chicago, Ill.	Fabricated Piping	107,088.35
548	Order	2-17-43	Litton Engineering Lab.	Redwood City, Cal.	Molecular Lubricant	51,000.00
50558	Order	3-16-44	Louden Machinery Co., The	Fairfield, Iowa	Monorail Equipment	124,859.26
55439	Order	10-20-44	Louden Machinery Co., The	Boston, Mass.	Cranes & Assemblies	54,665.24
50115	Order	10-15-43	Lukens Steel Co.	Boston, Mass.	Steel Plate	53,054.25
50030	Order	11-5-43	Lunsden & Van Stone Co.	Boston, Mass.	Welding Fittings	152,405.67

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 ~~JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Contd.			
55938	Order	3-21-45	Merco Nordstrom Valve Co.	Pittsburg, Pa.	SS Valves	$204,399.64
50563	Order	3-15-44	Midwest Piping & Supply Co.	Boston, Mass.	Fabricated Piping	121,520.13
50130	Order	11-19-43	National Tube Co.	Boston, Mass.	Stainless Steel Pipe	68,780.89
15881	Order	4-22-44	Oliver United Filters, Inc.	New York, N.Y.	Continuous Panel Type Filters	60,838.00
1688	Order	7-20-43	Pacific Electric Mfg. Co.	San Francisco, Cal.	Testing Equipment	87,383.40
15742	Order	3-2-44	Pacific Electric Mfg. Co.	San Francisco, Cal.	Testing Equipment	118,748.07
366	Order	2-1-43	Allis-Chalmers Mfg. Co.	Boston, Mass.	Centrifugal Pumps	57,055.90
51696	Order	8-29-44	Patterson Foundry & Machine Co.	New York, N.Y.	Portable Mixers	92,242.05
51397	Order	7-18-44	Pfaudler Co., The	Boston, Mass.	Miscellaneous Glass Lined Equipment	145,700.40
50197	Order	6-2-44	Phelps Dodge Copper Products Corp.	New York, N.Y.	Electrolytic Copper Bar	142,240.00
56006	Order	3-15-45	Pittsburg Piping & Equipment Co.	Pittsburg, Pa.	SS Welding Fittings	62,884.60
51495	Order	8-7-44	Process Engineering, Inc.	Boston, Mass.	Wash Tanks	100,224.93

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 ~~JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Contd.			
51961	Order	9-28-44	Process Engineering, Inc.	Boston, Mass.	Sublimation Units	$ 64,366.00
51725	Order	8-30-44	Powell, Wm. Co.	Boston, Mass.	Valves	56,409.00
50196	Order	5-18-44	Revere Copper & Brass Co.	Boston, Mass.	Copper Bar	138,500.47
50965	Order	5-29-44	Schnitzer Alloy	Elizabeth, N.J.	SS Pipe	54,528.98
51249	Order	6-21-44	Sharples Corp., The	Boston, Mass.	Super Centrifuges	64,476.00
51806	Order	8-28-44	Sharples Corp., The	Boston, Mass.	Super Centrifuges	117,067.20
51673	Order	8-24-44	Stanley, A.B. Co.	Boston, Mass.	Laboratory Furniture	192,036.53
55901	Order	1-29-45	Stanley, A.B. Co.	Boston, Mass.	Laboratory Furniture	118,906.19
342	Order	2-2-43	Stedfast & Roulston, Inc.	Boston, Mass.	Machine Tools	82,575.90
51668	Order	10-5-44	Steel & Alloy Tank Co.	Newark, N.J.	SS Tanks	67,508.00
55550	Order	12-2-44	Struthers Wells Corp.	Boston, Mass.	SS Tanks & Reactors	92,660.00
58310	Order	2-13-45	Struthers Wells Corp.	Warren, Pa.	Heat Exchangers	62,880.00

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 ~~JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-7401-eng-13 Cont'd			
51733	Order	8-31-44	U.S. Stoneware Corp., The	New York, N.Y.	Steel Plate Ductwork	$ 76,126.58
50606	Order	3-23-44	Underwood Machine Co.	Boston, Mass.	Service Carriages	146,584.45
55651	Order	11-29-44	Underwood Machine Co.	Boston, Mass.	Service Carriages	112,346.29
50213	Order	11-27-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Motor Control Equipment	83,808.01
50019	Order	10-22-43	Westinghouse Electric & Mfg. Co.	Boston, Mass.	Transformers	385,697.00
50210	Order	11-24-43	Whitlock Mfg. Co., The	Boston, Mass.	Oil Cooling Units	160,318.85
337	Order	2-1-43	Wigglesworth Machinery Co.	Cambridge, Mass.	Machine Tools	71,992.00
771	Order	3-20-43	York Corp.	Boston, Mass.	Refrigerator Plants	66,538.03
			Prime Contract Number W-14-108-eng-49			
48073	Order	5-5-45	J. Bishop & Co.		Gold Boats	61,468.00
48248	Order	5-29-45	Westinghouse Electric & Mfg. Co.		Filter Units	175,451.00

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CLINTON ENGINEER WORKS
EQUIPMENT PURCHASE ORDERS FOR Y-12
IN EXCESS OF $50,000
AS OF 1 ~~JULY 1945~~ Jan. 1947

Number	Type of Contract	Date of Contract	Contractor's Name	Contractor's Address	Scope of Work	Cost of Work
			Prime Contract Number W-14-108-eng-49 Cont'd			
48238	Order	6-1-45	Dalbrook Vent. Co.		Exhaust Vents	$ 81,327.00
48178	Order	6-13-45	General Electric Supply Co.		Electrical Fixtures	50,319.76
			Prime Contract Number W-14-108-eng-60			
45001	Order	4-10-45	Allis-Chalmers		M.G. Sets	$115,407.90
45008	Order	4-10-45	Griscom-Russell Co.		Oil Cooling and Distilled Water Equipment	55,048.00
45010	Order	4-11-45	Fansteel Metallurgical Co.		Evaporators	51,000.00
45014	Order	4-13-45	Kinney Mfg. Co.		Vacuum Pumps	79,663.70
45078	Order	4-21-45	Sharples Corp.		Centrifuges	58,533.60
45099	Order	4-24-45	Economy Engr. Co.		Trucks	55,532.00
49115	Order	5-2-45	Phelps Dodge		Electrolytic Copper Bars	270,406.00
45255	Order	5-11-45	Barbour Stockwell		Elevators	64,042.90
45830	Order	6-28-45	Eastman Kodak Co.		Liner Assemblies	185,875.00

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

APPENDIX "B"

REFERENCES

No.	Description	Location
✓ B-1	Letter from Col. J. C. Marshall to Mr. J. R. Lotz of Stone & Webster, 26 December 1942.	Manhattan District Classified Files
✓ B-2	Letter of Intent from Irvin Stewart, Executive Secretary to C. O. Muhlfield, President Stone & Webster, 13 March 1942.	Manhattan District Classified Files
✓ B-3	Record of Negotiations for Contract W-7401-eng-13.	Manhattan District Contract Files
✓ B-4	Memo from Major W. E. Kelley to B. Diamond, U.S.E.D. on Computation of Proposed Fee for Stone & Webster as modified to 28 February 1944.	Manhattan District Contract Files
✓ B-5	Stone & Webster Original Contract W-7401-eng-13.	Manhattan District Contract Files
✓ B-6	Record of Negotiations for Service Contract W-14-108-eng-49.	Manhattan District Contract Files
✓ B-7	Stone & Webster Service Contract W-14-108-eng-49.	Manhattan District Contract Files
✓ B-8	Record of Negotiations for New Construction Contract W-14-108-eng-60.	Manhattan District Contract Files
✓ B-9	Stone & Webster New Construction Contract W-14-108-eng-60.	Manhattan District Contract Files
B-10	Monthly Power Summary for June 1945.	Manhattan District Contract Files

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No.	Description	Location
B-11	Letter of Intent for Contract W-7401-eng-13, Col. J. C. Marshall to Stone & Webster, 29 June 1942.	Manhattan District Contract Files
B-12	Letter from Mr. T. R. Branch, Vice President Stone & Webster to Col. J. C. Marshall, 24 September 1942.	Manhattan District Classified Files
B-13	Letter Contract Supplement to Contract No. W-7401-eng-13, from Col. K. D. Nichols to Stone & Webster, 9 October 1943.	Manhattan District Contract Files
B-14	Memo from Major W. E. Kelley to files, Magnet Redesign, 11 September 1943.	Manhattan District Classified Files
B-15	Memo from Major W. E. Kelley to Files, Meeting to Discuss Proposed Increase in Beta Racetracks, 6 April 1944.	Manhattan District Classified Files
B-16	Memo from Major W. E. Kelley to Files, Notes on Conference in Great Lakes Div. Office, Chicago, Ill. 7 & 8 July 1943, 12 July 1943.	Manhattan District Classified Files
B-17	Letter from A. C. Klein, Project Engineer, Stone & Webster, to Area Engineer, Boston, Mass., Estimate of Power Demands, 20 March 1943.	Manhattan District Classified Files
B-18	Letter from R. R. Wisner, Asst. Project Engineer, to A. C. Klein, Project Engineer, Power Factor study and Estimate of Ultimate Plant Load, 23 January 1943.	Manhattan District Classified Files
B-19	Letter from Major P. F. Ressell to Stone and Webster, Subproject No. 57, Request for Authorized Water Supply System for Townsite Extension and for Y-12 Area, 6 December 1943.	Manhattan District Classified Files

No.	Description	Location
B-20	Letter from A. C. Klein, Project Engineer, to Area Engineer, Boston, Mass., Water Supply, 25 February 1944.	Manhattan District Classified Files
B-21	Y-12 Unit Chief's Report, 22 March 1943.	Manhattan District Classified Files
B-22	Letter from A. C. Klein, Project Engineer, to Lt. Col. M. C. Fox, Basic Design Clinton Engineer Works, 21 November 1943.	Manhattan District Classified Files
B-23	Memo from Major W. E. Kelley to File, Notes on Meeting in Boston on 16 March 1943, 18 March 1943.	Manhattan District Classified Files
B-24	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report - D.S.M. Project, 14 January 1943.	Manhattan District Classified Files
B-25	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report - D.S.M. Project, 30 January 1943.	Manhattan District Classified Files
B-26	Y-12 Unit Chief's Report 17 July 1943.	Manhattan District Classified Files
B-27	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report - D.S.M. Project 14 July 1943.	Manhattan District Classified Files
B-28	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report - D.S.M. Project 30 July 1943	Manhattan District Classified Files
B-29	Y-12 Unit Chief's Report, 9 August 1943.	Manhattan District Classified Files

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No.	Description	Location
B-30	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report - D.S.M. Project, 14 August 1943.	Manhattan District Classified Files
B-31	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report, D.S.M. Project, 27 February 1943.	Manhattan District Classified Files
B-32	Letter from Gen. L. R. Groves to Dr. E. O. Lawrence, Expectations of Alpha Production, 18 March 1943.	Manhattan District Classified Files
B-33	Letter from A. C. Klein, Project Engineer, to District Engineer Engineer Report - D.S.M. Project 14 April 1943.	Manhattan District Classified Files
B-34	Letter from Major W. E. Kelly to Dr. F. R. Conklin, Beta Operations Date, 29 March 1944.	Manhattan District Classified Files
B-35	Y-12 Unit Chief's Report 31 March 1944.	Manhattan District Classified Files
B-36	Y-12 Unit Chief's Report 30 April 1944.	Manhattan District Classified Files
B-37	Letter from R. T. Branch, Vice President, Stone & Webster, to District Engineer, 23 September 1943.	Manhattan District Classified Files
B-38	Y-12 Unit Chief's Report 6 October 1943.	Manhattan District Classified Files
B-39	Letter from A. C. Klein, Project Engineer, to District Engineer, Engineer Report D.S.M. Project 14 September 1943.	Manhattan District Classified Files
B-40	Stone & Webster Subproject No. 55.	Manhattan District Classified Files
B-41	Letter from A. C. Klein, Project Engineer, to District Engineer, Project Report - D.S.M. Project, 27 November 1943.	Manhattan District Classified Files

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B-42	Y-12 Unit Chief's Report 31 May 1944.	Manhattan District Classified Files
B-43	Letter from A. C. Klein, Project Engineer, to District Engineer, Project Report - D.S.M. Project 31 October 1944.	Manhattan District Classified Files
B-44	Y-12 Unit Chief's Report February 1945.	Manhattan District Classified Files
B-45	Y-12 Unit Chief's Report March 1945.	Manhattan District Classified Files
B-46	Letter from A. C. Klein, Project Engineer, to District Engineer, Project Report - D.S.M. Project, 15 April 1945.	Manhattan District Classified Files
B-47	Y-12 Unit Chief's Report May 1945.	Manhattan District Classified Files
B-48	Y-12 Unit Chief's Report June 1945.	Manhattan District Classified Files
B-49	Y-12 Unit Chief's Report 5 November 1945.	Manhattan District Classified Files
B-50	Report of Activities, Process Modernization Department from 22 May to 30 June 1944, by Ralph Rogers, Superintendent, P.M.D.	Manhattan District Classified Files
B-51	Letter from J. H. Webb to F. R. Conklin, TEC, Gamma Stage, 7 July 1944.	Manhattan District Classified Files
B-52	TT from Col. K. D. Nichols to Area Engineer, Berkeley, California, Alpha I Conversion, 25 July 1944.	Manhattan District Classified Files
B-53	Conference Notes, Stone and Webster Boston Office, Verbal Award of Negotiated Contract with General Electric Co., 30 December 1942.	Manhattan District Classified Files

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No.	Description	Location
B-54	Conference Notes, Stone & Webster's Boston Office, Verbal Award of Negotiated Contract with Allis Chalmers Co., 4 January 1943.	Manhattan District Classified Files
B-55	Conference by Stone and Webster 1 January 1943.	Manhattan District Classified Files
B-56	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Requirements for Alpha II, 14 Oct. 1943.	Manhattan District Classified Files
B-57	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Requirements for Beta Building No. 2, 16 October 1943.	Manhattan District Classified Files
B-58	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Alpha II Reactors, 14 October 1943.	Manhattan District Classified Files
B-59	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Supplemental Agreement No. 3, 11 May 1944.	Manhattan District Classified Files
B-60	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Supplemental Agreement No. 4, 26 September 1944.	Manhattan District Classified Files
B-61	Notes on Conference in Milwaukee, Wisconsin, to Discuss Redesign of Magnet Coils, 28 December 1943.	Manhattan District Classified Files
B-62	Notes on Conference in Boston, Mass., to Establish Requirements for Alpha I, 1 January 1943.	Manhattan District Classified Files
B-63	Notes on Conference in Boston, Mass., 31 December 1942.	Manhattan District Classified Files
B-64	Letter from C. A. N. Weber, Westinghouse, to T. J. Fordo, Stone & Webster, Preliminary Engineering Study, 25 October 1943.	Manhattan District Classified Files

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No.	Description	Location
B-65	Minutes of Coordination Meeting, University of California Radiation Laboratory, 2 September 1943.	Manhattan District Classified Files
B-66	Letter from A. C. Klein, Project Engineer, to T. R. Thornburg, General Superintendent, Alpha I "D" Assembly Modernization, 6 October 1943.	Manhattan District Classified Files
B-67	Letter from R. A. Gordon, Westinghouse Resident Inspector, to C. P. Darlington, Stone & Webster Chief Expediter, Materials for Modernizing Doors, 26 October 1943.	Manhattan District Classified Files
B-68	Record of Negotiations for Pertinent Contracts.	Manhattan District Classified Files
B-69	Letter of Intent for Negotiated Contract from A. C. Klein, Project Engineer, to Chapman Valve Mfg. Co., 18 January 1943.	Manhattan District Classified Files
B-70	Record of Negotiations for Link-Belt Contract.	Manhattan District Classified Files
B-71	Link-Belt Contract W-7407-eng-12, Supplement No. 4.	Manhattan District Classified Files
B-72	Link-Belt Contract W-7407-eng-37.	Manhattan District Classified Files
B-73	TT from F. R. Creedon, Resident Manager, to A. C. Klein, Project Engineer, 14 August 1944.	Manhattan District Classified Files
B-74	Letter from A. C. Klein, Project Engineer, to Major F. H. Belcher, Vacuum Tubes, C.E.W., 12 February 1944.	Manhattan District Classified Files
B-75	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Alpha II Process, 5 October 1943.	Manhattan District Classified Files

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No.	Description	Location
B-76	Letter from A. C. Klein, Project Engineer, to R. H. Argersinger, Stone & Webster, Diffusion Pump Development, 5 August 1944.	Manhattan District Classified Files
B-77	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Development Contract with Distillation Products, Inc., 31 August 1944.	Manhattan District Contract Files
B-78	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Development Contract with National Research Corp., 31 August 1944.	Manhattan District Contract Files
B-79	Letter from A. C. Klein, Project Engineer, to Boston Area Engineer, Contract W-7407-eng-543, 16 September 1943.	Manhattan District Contract Files
B-80	Comparison of Bids on High Voltage Cable, Prepared by Stone & Webster 10 March 1943.	Manhattan District Classified Files
B-81	Tennessee Eastman Corporation Procurement Division.	Tennessee Eastman Corporation Files
B-82	Letter of Requirements from A. C. Klein, Project Engineer, to Boston Area Engineer, Alpha II Process, 30 October 1943.	Manhattan District Classified Files
B-83	Stone & Webster Engineering Progress Reports D.S.M. Project, 15 October 1943.	Manhattan District Classified Files
B-84	Letter 26 June 1943, W. R. Chambers to Major Kelly (No subject - On Liquid Phase Facilities).	Manhattan District Classified Files
B-85	Letter 2 June 1943, Major Belcher to Files, Alpha Chemical Process.	Manhattan District Classified Files
B-86	Unit Chief Report - December 1943.	Manhattan District Classified Files

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No.	Description	Location
B-87	Conference notes 4 and 18 February 1943.	Manhattan District Classified Files
B-88	Conference notes 10 and 11 February 1943.	Manhattan District Classified Files
B-89	Stone & Webster Engineering Progress Report, D.S.M. Project, 13 March 1943.	Manhattan District Classified Files
B-90	Stone & Webster Engineering Progress Report, D.S.M. Project, 26 June 1943.	Manhattan District Classified Files
B-91	P.E. 418, 15 October 1943, Completion of Exceptions, Liquid Phase, Bldg. 9202.	Manhattan District Classified Files
B-92	Letter 2 June 1943 - Major Belcher to Files, Alpha Chemical Process.	Manhattan District Classified Files
B-93	P.E. 500, 23 October 1943, Ammonia Neutralizing System, Liquid Phase Bldg. 9202.	Manhattan District Classified Files
B-94	Letter 22 December 1943 - Dr. J. G. McNally to Major W. E. Kelley (No. subject - On Alpha Chemical Operations).	Manhattan District Classified Files
B-95	Letter 18 May 1943 - W. R. Burton to A. C. Klein, Changes in Design of Vacuum Distillation Units.	Manhattan District Classified Files
B-96	P.E. 478, 22 October 1943, Notes on Conference, vacuum sublimation, Bldg. 9202.	Manhattan District Classified Files
B-97	Letter 24 February 1944 - W. R. Chambers to E. W. Seckendorff, Sublimation Department, Bldg. 9202.	Manhattan District Classified Files
B-98	Eng. P.E. 63, 13 March 1944, Sublimation Unit Ext. Bldg. 9202.	Manhattan District Classified Files
B-99	Letter 21 August 1943 - A.C. Klein to W. R. Burton, Dry Room for 9202.	Manhattan District Classified Files

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No.	Description	Location
B-100	Letter 10 September 1943 - W. R. Burton to A. C. Klein, Dry Room for Bldg. 9202.	Manhattan District Classified Files
B-101	Letter 20 November 1944 - C. E. Winters to File, Alpha Chemistry.	Manhattan District Classified Files
B-102	Letter 25 March 1943 - W. R. Burton to Major J. R. Ruhoff (No subject - Alpha Chemistry).	Manhattan District Classified Files
B-103	Letter 18 December 1943, A. C. Klein to W. R. Chambers, Bulk Treatment Unit Ext. Building 9202.	Manhattan District Classified Files
B-104	Conference Notes - 23 November 1943.	Manhattan District Classified Files
B-105	Letter 15 May 1943 - D. W. Stewart to Dr. F. R. Conklin (No subject - Beta Wash Area).	Manhattan District Classified Files
B-106	Letter 11 September 1943 - W. R. Burton to A. C. Klein, Hydrochloric Acid and Hydrogen Peroxide Handling, XBX Plate Washing Area, Bldg. 9731.	Manhattan District Classified Files
B-107	Letter 21 January 1944 - Lt. L. R. Zumwalt to Major W. E. Kelley, Equipment for Recycle Beta Material.	Manhattan District Classified Files
B-108	Letter 27 June 1944 - Lt. L. R. Zumwalt to Major W. E. Kelley, Time Required for Beta Recycle.	Manhattan District Classified Files
B-109	Stone & Webster Engineering Progress Report - D.S.M. Project - 31 July 1943.	Manhattan District Classified Files
B-110	Letter 20 October 1943 - A. C. Klein to Maj. W. E. Kelley, Beta Chemical Process, Bldg. 9203.	Manhattan District Classified Files
B-111	Conference Notes - Beta Chemistry 15-16 September 1943.	Manhattan District Classified Files
B-112	Conference Notes - October 1943 Berkeley, California.	Manhattan District Classified Files

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No.	Description	Location
B-113	Letter 10 March 1945 - Dr. J. G. McNally to Lt. Col. J. R. Ruhoff, Information Requested by Dr. Benedict.	Manhattan District Classified Files
B-114	Committee Report 24 February 1944 to General Groves.	Manhattan District Classified Files
B-115	Letter 10 March 1945 - Dr. J. G. McNally to Lt. Col. J. R. Ruhoff, See B-113.	Manhattan District Classified Files
B-116	Conference Notes - 23 November 1943.	Manhattan District Classified Files
B-117	Letter 25 February 1944 - W. R. Chambers to E. W. Seckendorff - Bulk Treatment Unit Ext. Bldg. 9202.	Manhattan District Classified Files
B-118	Letter 12 April 1944 - Dr. R. L. Geddes to R. R. Wisner, Bulk Treatment Unit Ext., Bldg. 9202.	Manhattan District Classified Files
B-119	Letter 25 February 1944 - W. R. Chambers to E. W. Seckendorff - See B-117.	Manhattan District Classified Files
B-120	PE 2366, 13 November 1944, Residue Salvage, Bulk Treatment Ext., Bldg. 9202.	Manhattan District Classified Files
B-121	PE 2346, 4 November 1944, Residue Salvage, Bldg. 9202, B. T. Ext.	Manhattan District Classified Files
B-122	PE 2150 21 July 1944, Salvage Operation, B. T. Ext., Bldg. 9202.	Manhattan District Classified Files
B-123	Letter 10 November 1944 - W. R. Chambers to E. W. Seckendorff, Residue Salvage, Bulk Treatment Ext., Bldg. 9202.	Manhattan District Classified Files
B-124	PE 2366, See B-120.	Manhattan District Classified Files
B-125	Letter 4 February 1944 - Major W. E. Kelley to R. R. Wisner, Authorization for Bldg. 9206.	Manhattan District Classified Files

 [redacted]

[redacted]

No.	Description	Location
B-126	Letter 31 January 1944 - Dr. F. R. Conklin to Major W. E. Kelley, Proposed Facilities for Analytical & Assay Works.	Manhattan District Classified Files
B-127	Letter 27 May 1944 - G. O. Neimeyer to R. R. Wisner, Estimated Completion of Building 9206.	Manhattan District Classified Files
B-128	Letter 19 September 1944 - Lt. S. B. Roboff to Major W. E. Kelley, Completion Track Schedule, Bldg. 9206.	Manhattan District Classified Files
B-129	Letter 24 May 1944 - Lt. S. B. Roboff to Major W. E. Kelley, Primary Recovery Departments in Alpha II Buildings.	Manhattan District Classified Files
B-130	Conference Notes 7-10 December 1943.	Manhattan District Classified Files
B-131	Letter 1 June 1944 - Lt. S. B. Roboff to Major W. E. Kelley, Present Design Status, Bldg. 9207.	Manhattan District Classified Files
B-132	Letter 22 September 1944 - Lt. A. B. Babcock to Major W. E. Kelley Ext. to Buildings 9201-5 and 9201-4.	Manhattan District Classified Files
B-133	Conference Notes 13 January 1945.	Manhattan District Classified Files
B-134	Conference Notes 11-12 May 1944 Lt. S. B. Roboff to Major W. E. Kelley.	Manhattan District Classified Files
B-135	Conference Notes 9 June 1944, Brown University.	Manhattan District Classified Files
B-136	Letter 29 June 1944 - R. M. Batch to A. C. Klein, Requirements for Incineration Building.	Manhattan District Classified Files
B-137	Letter 31 July 1944 - Lt. S. B. Roboff to Major W. E. Kelley, 9207 and Allied Facilities.	Manhattan District Classified Files

[redacted]

No.	Description	Location
B-138	Letter 25 September 1944, A. C. Klein to F. R. Creedon, 9207 Group.	Manhattan District Classified Files
B-139	Notes on Requirements of Dr. Schrader 11 September 1944.	Manhattan District Classified Files
B-140	Letter 26 October 1944 - W. R. Chambers to H. W. Seckendorff, Stone & Webster Sketches, Bldg. 9210.	Manhattan District Classified Files
B-141	1st Indorsement to Letter, 6 July 1944 Dr. J. R. Coe to Major W. E. Kelley, K-25 Product.	Manhattan District Classified Files
B-142	Ext. PE 1375, 10 October 1944, Plant for Chemical 735 - 9207 Area.	Manhattan District Classified Files
B-143	Ext. PE 1525, 25 October 1944, Special Chemical Manufacture, Bldg. 9211.	Manhattan District Classified Files
B-144	Notes on Bulk Treatment Calciner, 6 January 1945.	Manhattan District Classified Files
B-145	Letter 19 July 1944 - W. R. Chambers to A. C. Klein, Bldg. 9207.	Manhattan District Classified Files
B-146	Letter 5 September 1944 - Lt. S. B. Roboff to File, Proposed Salvage Bldg.	Manhattan District Classified Files
B-147	Letter 8 September 1944, Lt. S. B. Roboff to Major W. E. Kelley, Salvage Building.	Manhattan District Classified Files
B-148	Ext. PE 1212, 21 September 1944, Beta Salvage Building.	Manhattan District Classified Files
B-149	Letter 29 November 1944 - Dr. J. G. McNally to Lt. Col. J. R. Ruhoff, Beta Salvage.	Manhattan District Classified Files
B-150	Ext. PE 1986, 25 November 1944, Cancellation of Building 9209.	Manhattan District Classified Files
B-151	WA 351, 5 June 1945, Additional Requirements, Beta Chemistry.	Manhattan District Classified Files

G33. <u>Beta Handling Equipment, Loaded.</u>

This view shows three dollies; one holding an "X" unit, one an "E" unit, and one a main door and liner. Note safety goggles worn by operator.

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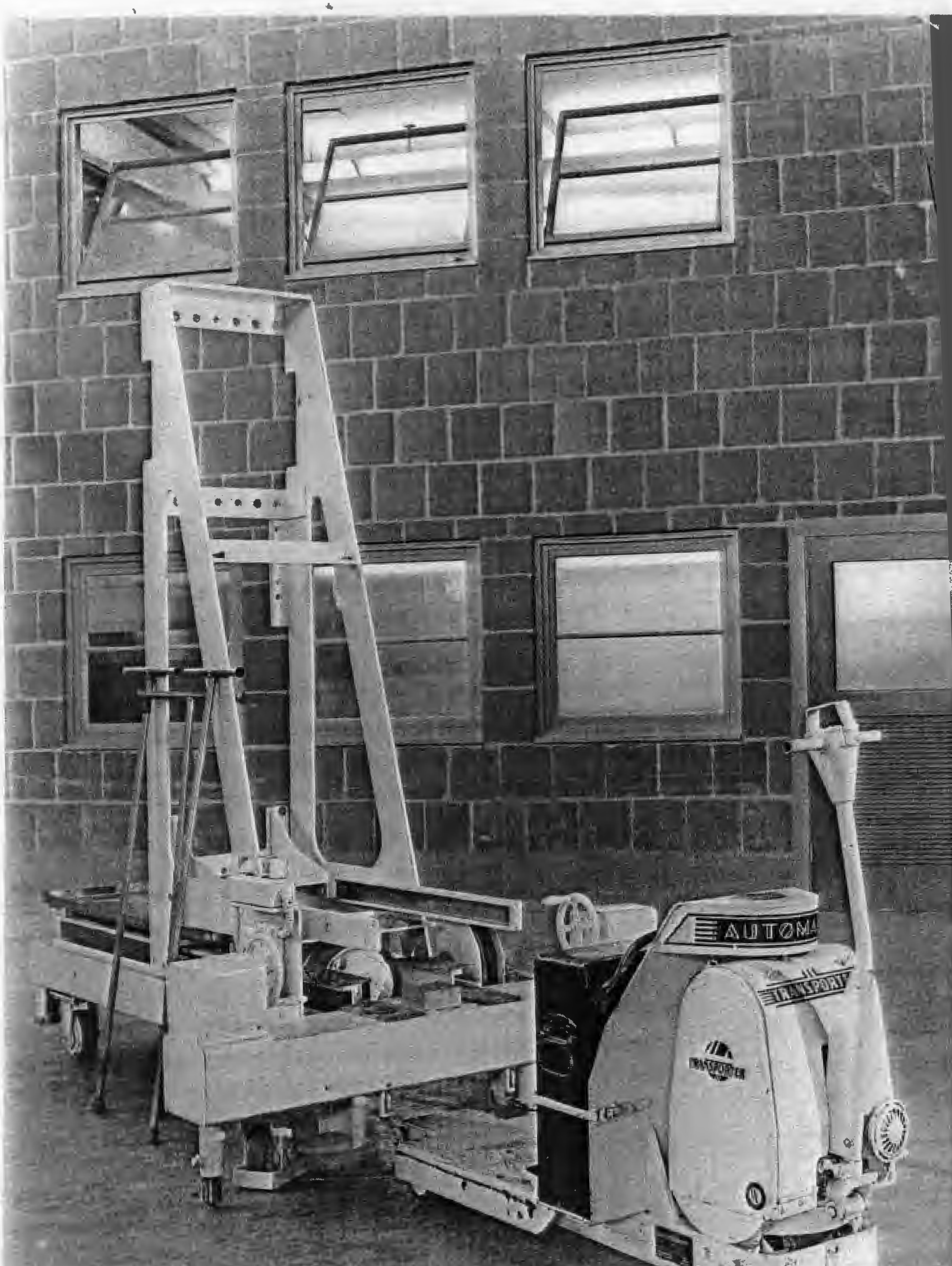
C34. <u>Beta Dolly</u>

Note long handled wrenches used in tightening doors in place in tanks.


AUTOMA
TRANSPORT

C35. <u>Vacuum Tube, GL893</u>

Compare size of 893 to that of normal size tube of your radio.

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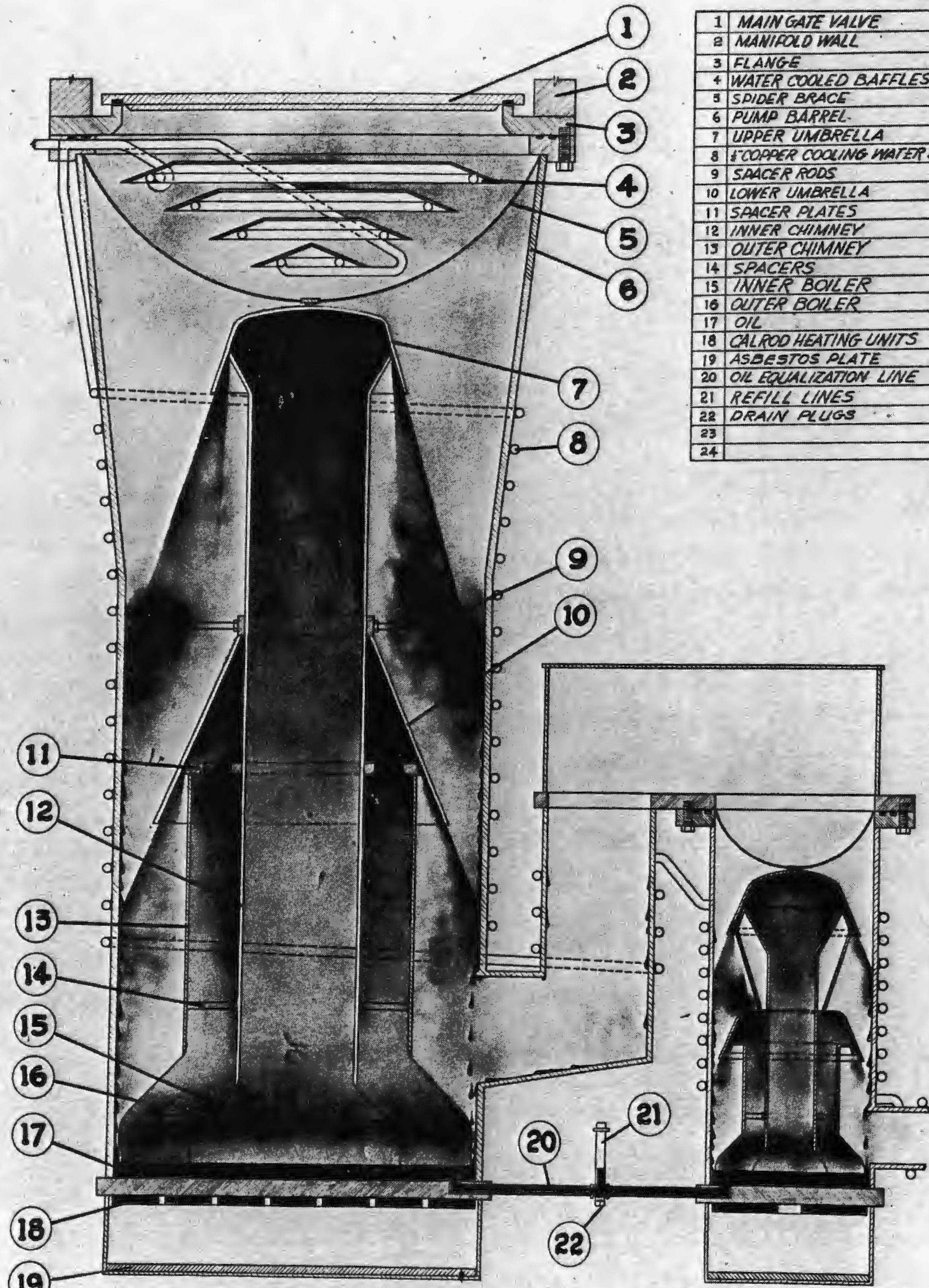
C58. Diffusion Pumps

Note that the large and small pumps are connected in series. In this artist's cross section view of the pump, the oil vapor may be seen as it comes out from under the umbrellas and starts to settle, carrying molecules of gas, or air, with it.

~~SECRET~~

LD-M-11
[redacted]

1	MAIN GATE VALVE
2	MANIFOLD WALL
3	FLANGE
4	WATER COOLED BAFFLES
5	SPIDER BRACE
6	PUMP BARREL
7	UPPER UMBRELLA
8	½" COPPER COOLING WATER LINES
9	SPACER RODS
10	LOWER UMBRELLA
11	SPACER PLATES
12	INNER CHIMNEY
13	OUTER CHIMNEY
14	SPACERS
15	INNER BOILER
16	OUTER BOILER
17	OIL
18	CALROD HEATING UNITS
19	ASBESTOS PLATE
20	OIL EQUALIZATION LINE
21	REFILL LINES
22	DRAIN PLUGS
23	
24	



DIFFUSION PUMPS

[redacted]

C37. <u>Beta Carbon Receiver</u>

A cutaway view showing the pockets or traps for containing uranium isotopes. Note the porcelain insulators which insulate the receiver and allow the metering of the isotopes. Observe the required intricate shapes and curves of the carbon.

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~~EXPORT CONTROLLED~~
~~INFORMATION~~

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~~OFFICIAL USE ONLY~~

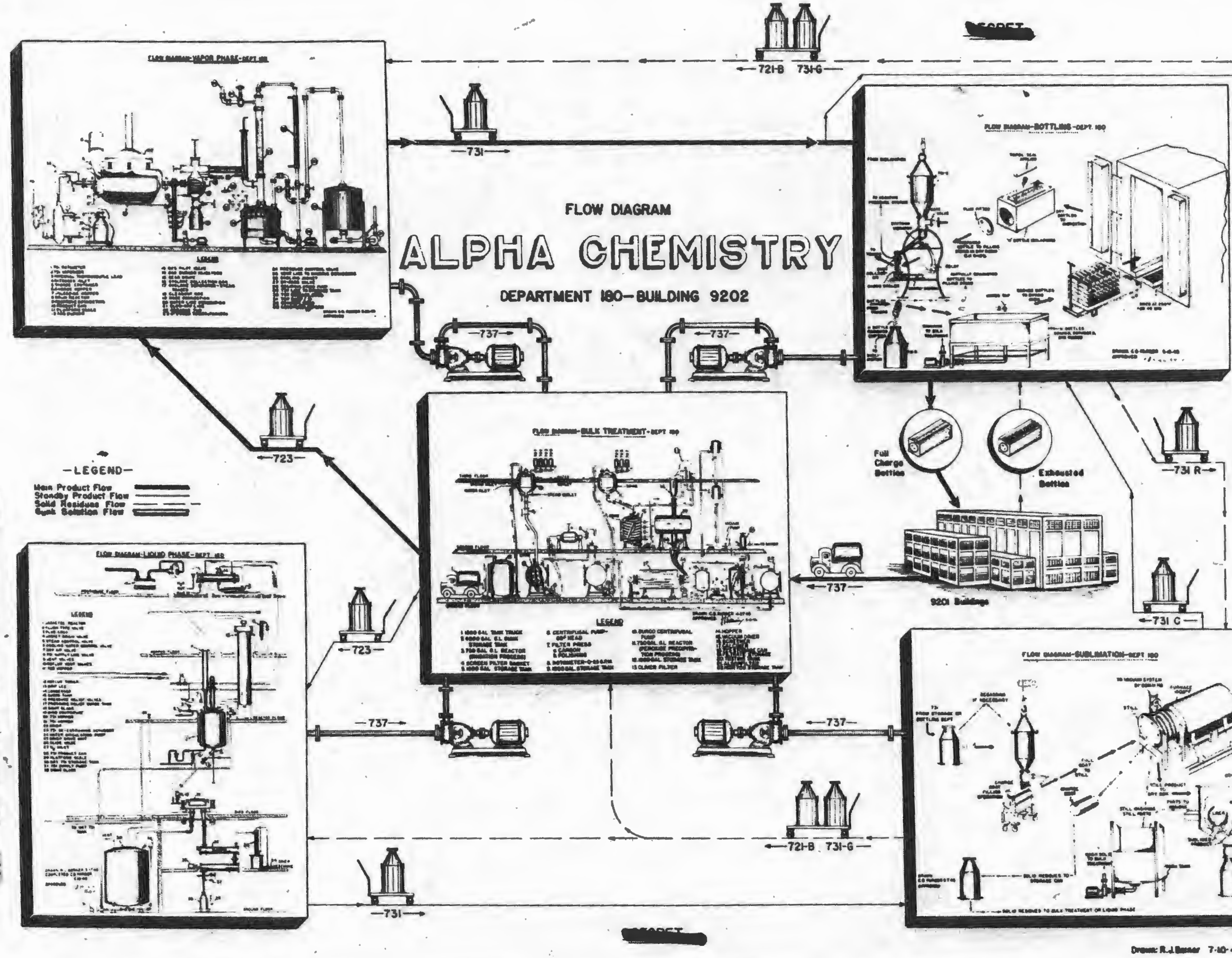
C38. <u>Alpha Chemistry Flow Diagram</u>

Departments and their relationship are shown. Code numbers and the materials they represent are listed below.

702 - Sulphuric Acid (H_2SO_4)
703 - Nitric Acid (HNO_3)
705 - Hydrogen Peroxide (H_2O_2)
707 - Ammonium Hydroxide (NH_4OH)
721 - Uranium Dioxide (UO_2)
723 - Uranium Oxide (UO_3)
731 - Uranium Tetrachloride (UCl_4)
731C- Sublimed Uranium Tetrachloride (UCl_4)
737 - Alpha Gunk Solution

For a discussion of this process, see paragraph 3-1a.

[redacted]



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C39. <u>Liquid Phase Reactor, Building 9202</u>

View of upper half of liquid phase reactor is shown. Item 11, 751 reflux line refers to carbon tetrachloride reflux.

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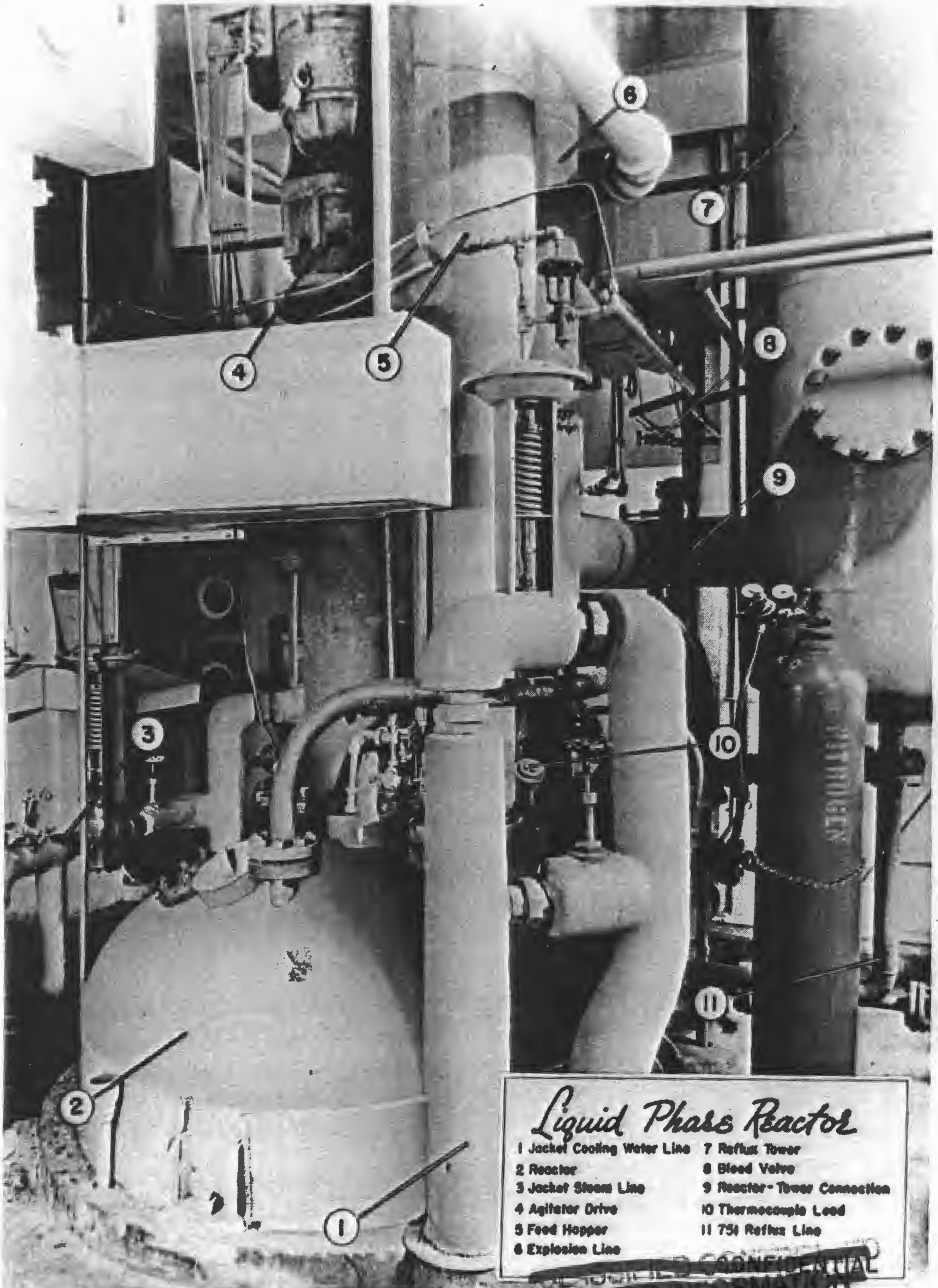
180-I-206 FIG. 6



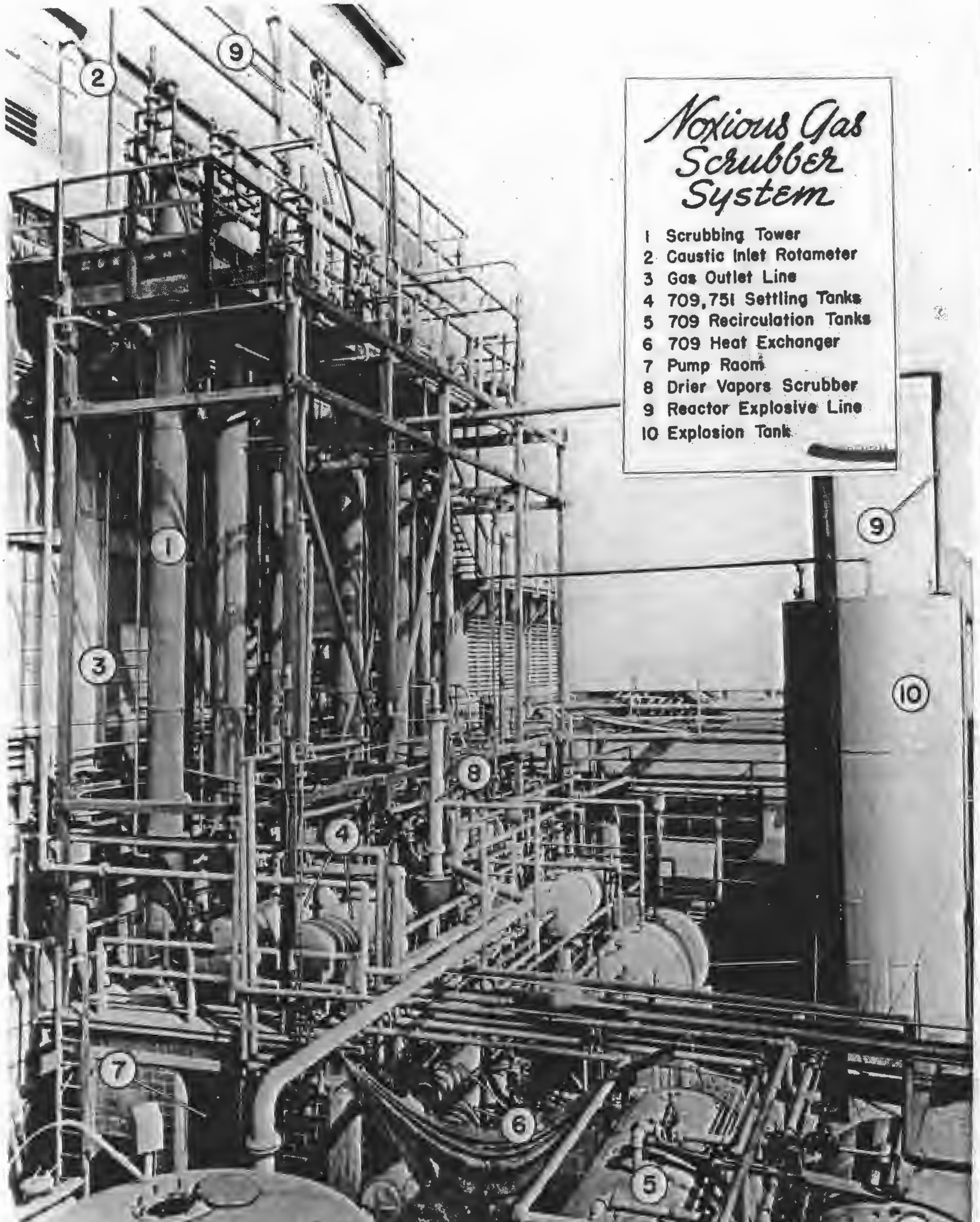
Liquid Phase Reactor

1 Jacket Cooling Water Line
2 Reactor
3 Jacket Steam Line
4 Agitator Drive
5 Feed Hopper
6 Explosion Line
7 Reflux Tower
8 Bleed Valve
9 Reactor-Tower Connection
10 Thermocouple Lead
11 75# Reflux Line

~~CONFIDENTIAL~~
~~NUCLEAR INFORMATION~~

C40. Noxious Gas Scrubber System, Building 9202

Equipment used to neutralize and make harmless the phosgene gas from Liquid Phase and Vapor Phase reactions is shown. Code chemical 709 is sodium hydroxide (NaOH) commonly called caustic or caustic soda. Code chemical 781 is carbon tetrachloride (CCl_4).


Noxious Gas Scrubber System
1 Scrubbing Tower
2 Caustic Inlet Rotameter
3 Gas Outlet Line
4 709,751 Settling Tanks
5 709 Recirculation Tanks
6 709 Heat Exchanger
7 Pump Room
8 Drier Vapors Scrubber
9 Reactor Explosive Line
10 Explosion Tank

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C41. Vent System for Noxious Gases

Part of the equipment within the plant (Bldg. 9202) is shown which leads to outside scrubber system (See App. C40). Code chemical 767 is phosgene ($COCl_2$) and code chemical 751 is carbon tetrachloride (CCl_4). Item 6 pH Electrode Chamber is part of an automatic recording device to measure acidity or alkalinity of the solution present.

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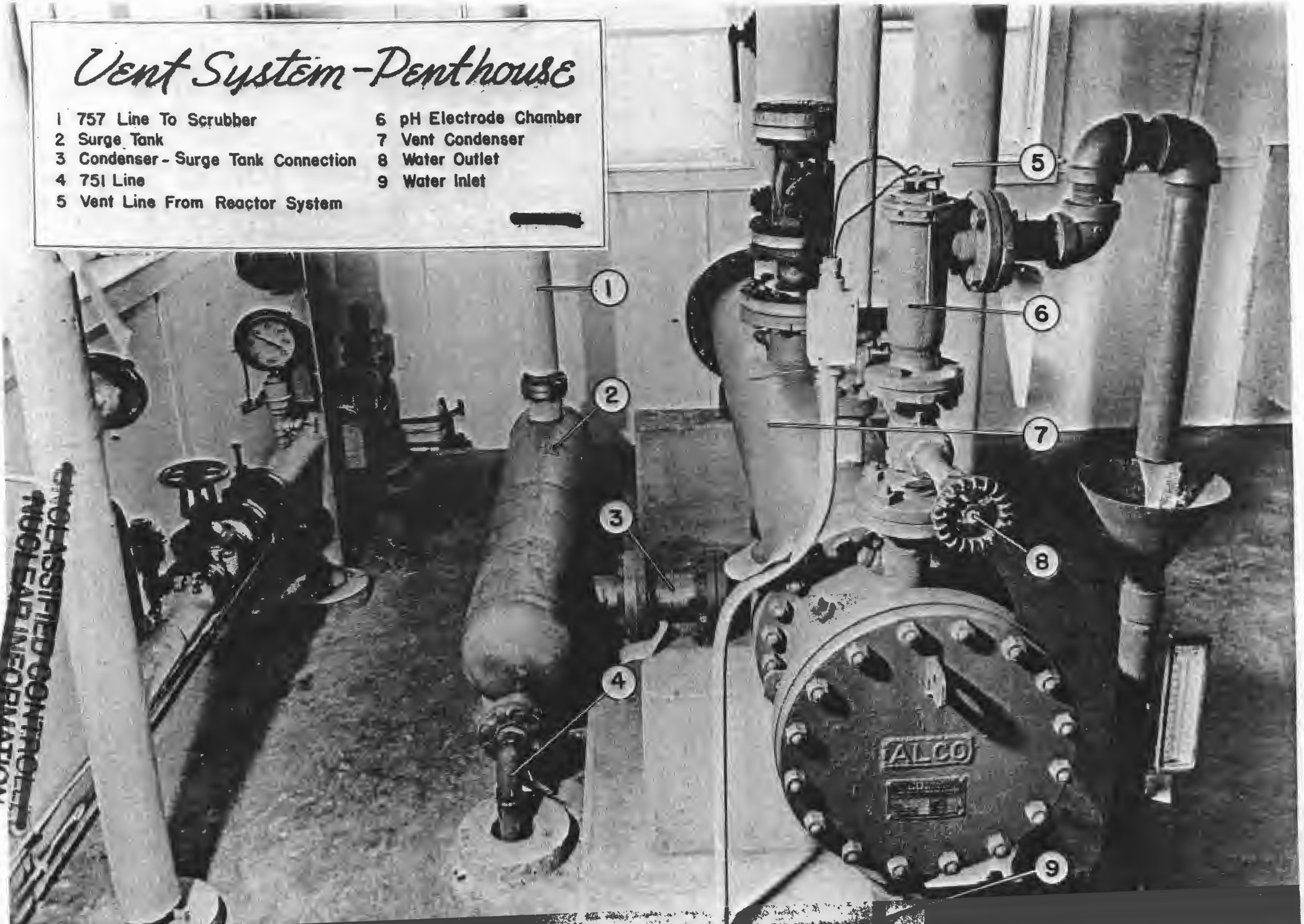
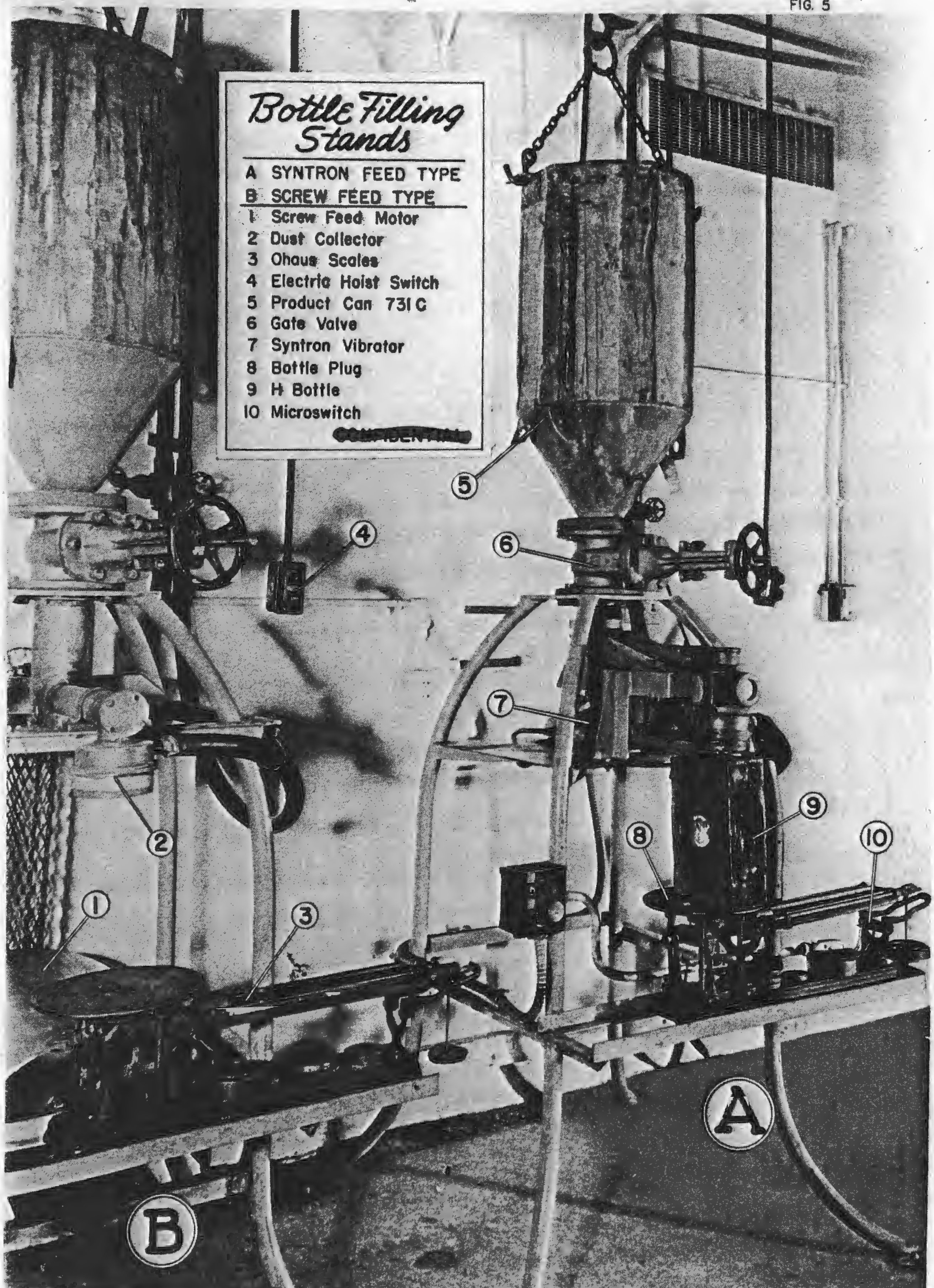

Vent System-Penthouse
1 757 Line To Scrubber
2 Surge Tank
3 Condenser - Surge Tank Connection
4 751 Line
5 Vent Line From Reactor System
6 pH Electrode Chamber
7 Vent Condenser
8 Water Outlet
9 Water Inlet
[redacted]
1
2
3
4
5
6
7
8
9
ALCO

042. <u>Bottle Filling Stands, Dry Room Facilities, Building 9202.</u>

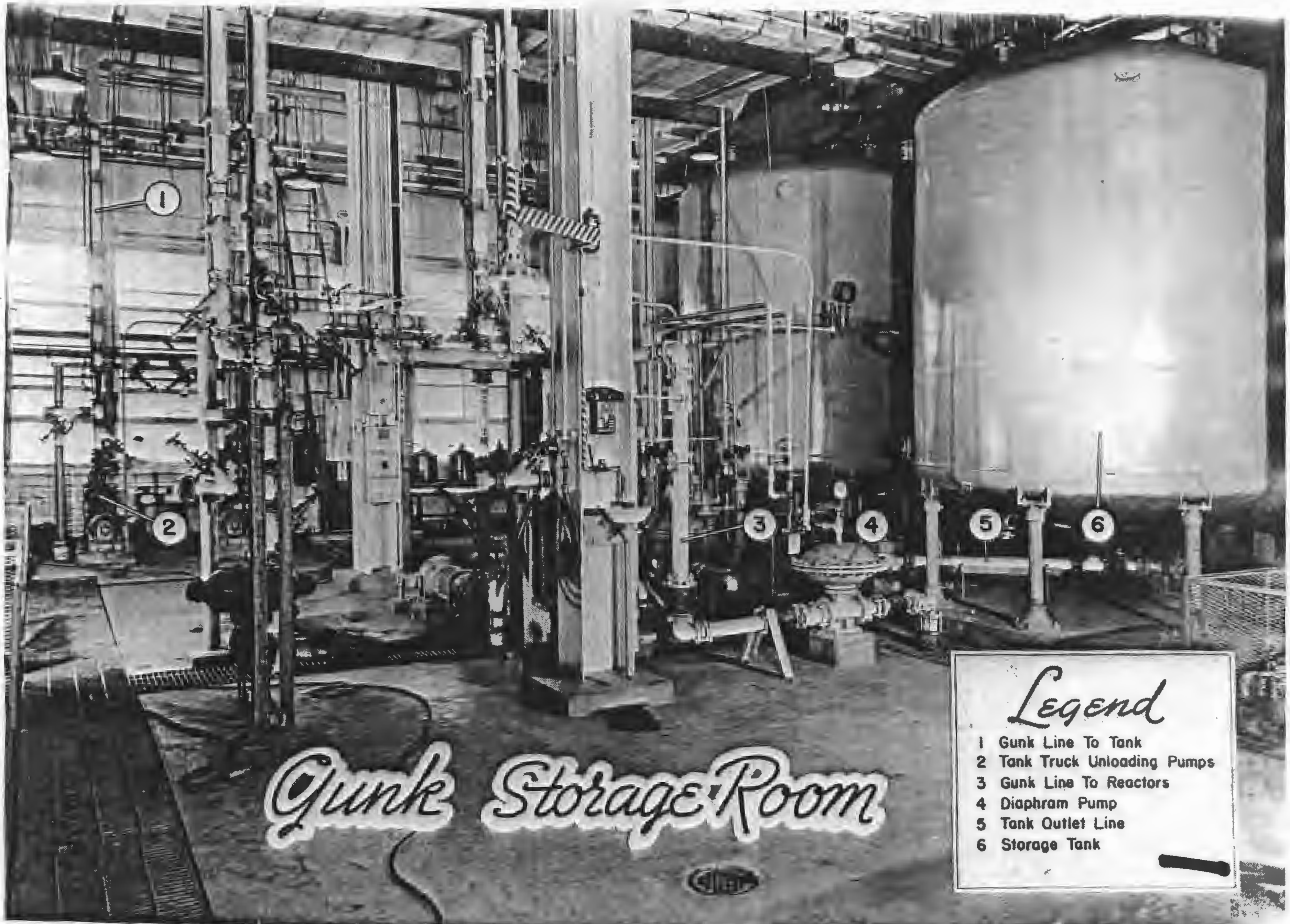
The items shown are part of the facilities provided in the dry room for the transfer of sublimed uranium tetrachloride (Code 731C) from stainless steel receiver cans (Item 5) to track charge bottles or H bottles (Item 9).

180-IV-204
FIG. 5



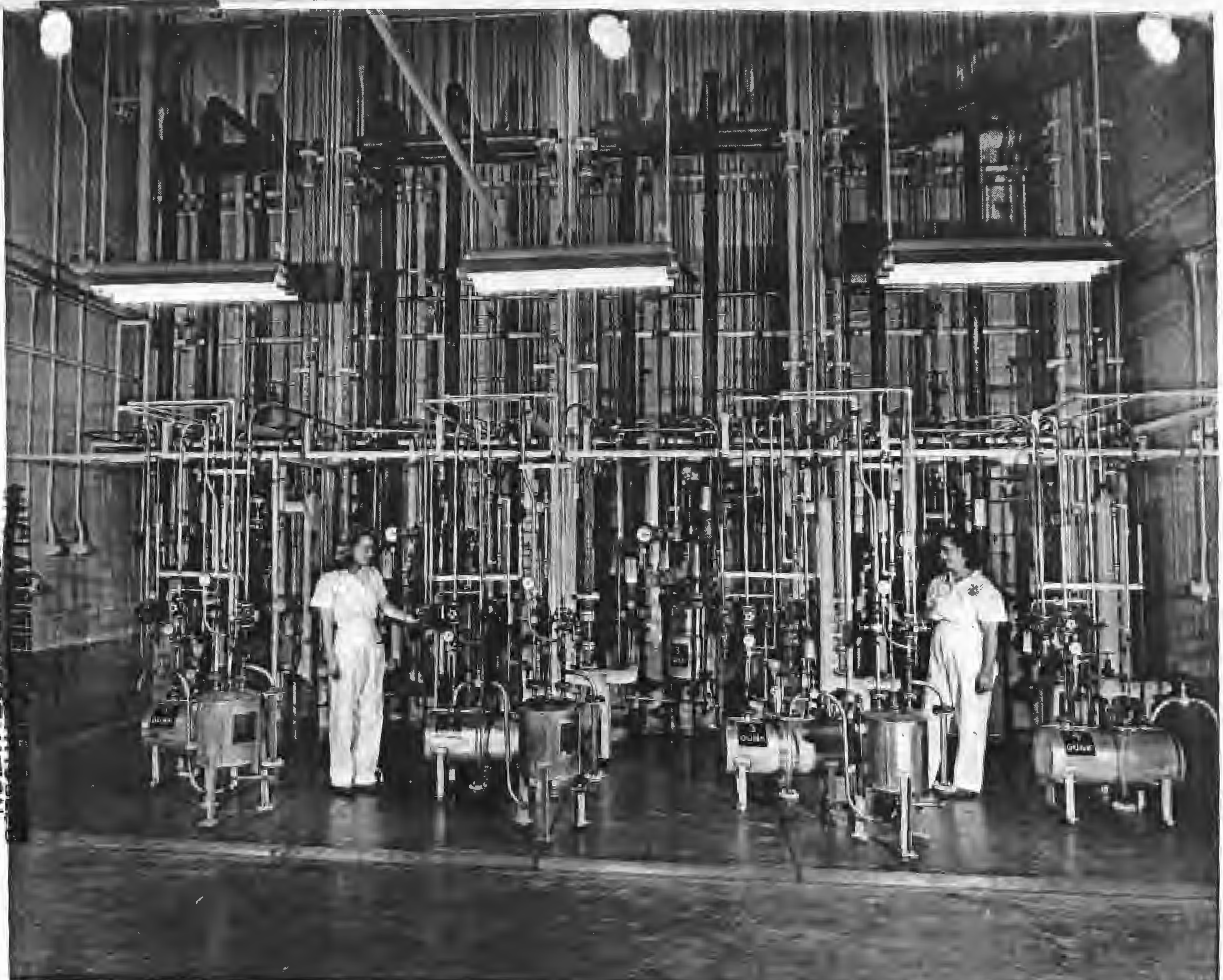
043. "Gunk" Storage Room, Building 9202

"Gunk" storage tanks and accessory equipment are shown. The tank truck receiving station is on outside of building. The tanks are glass lined (enamel) and most of the piping shown is porcelain with porcelain valves. Item 4, diaphragm pump, is commonly used for solutions containing varying amounts of solids (slurry). It is a "positive displacement" pump in which an impervious diaphragm is actuated by alternating vacuum and air flows, first filling a chamber with slurry when vacuum is applied and then forcing the slurry out of the chamber when air pressure is applied. Valves similar to "flap" valves prevent the slurry from being forced in the opposite directions of the desired flow.


1
2
3
4
5
6
Gunk Storage Room
Legend
1 Gunk Line To Tank
2 Tank Truck Unloading Pumps
3 Gunk Line To Reactors
4 Diaphram Pump
5 Tank Outlet Line
6 Storage Tank

C44. Ether Extraction Columns, Building 9206

The equipment shown for the ether extraction method of material recovery emphasizes the small volumes of material handled and shows the small pipe sizes and small tanks required by the process. The extreme precautions against loss are indicated by the stainless steel floor.



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045. Oliver Filter, Bulk Treatment Recovery, Building 9202.

The slurry of peroxide precipitates is pumped into the filter tank (Item 8) where the solids are pulled against the filter cloth (Item 7) by vacuum and upon revolution of the drum scraped into solids tray (Item 10).

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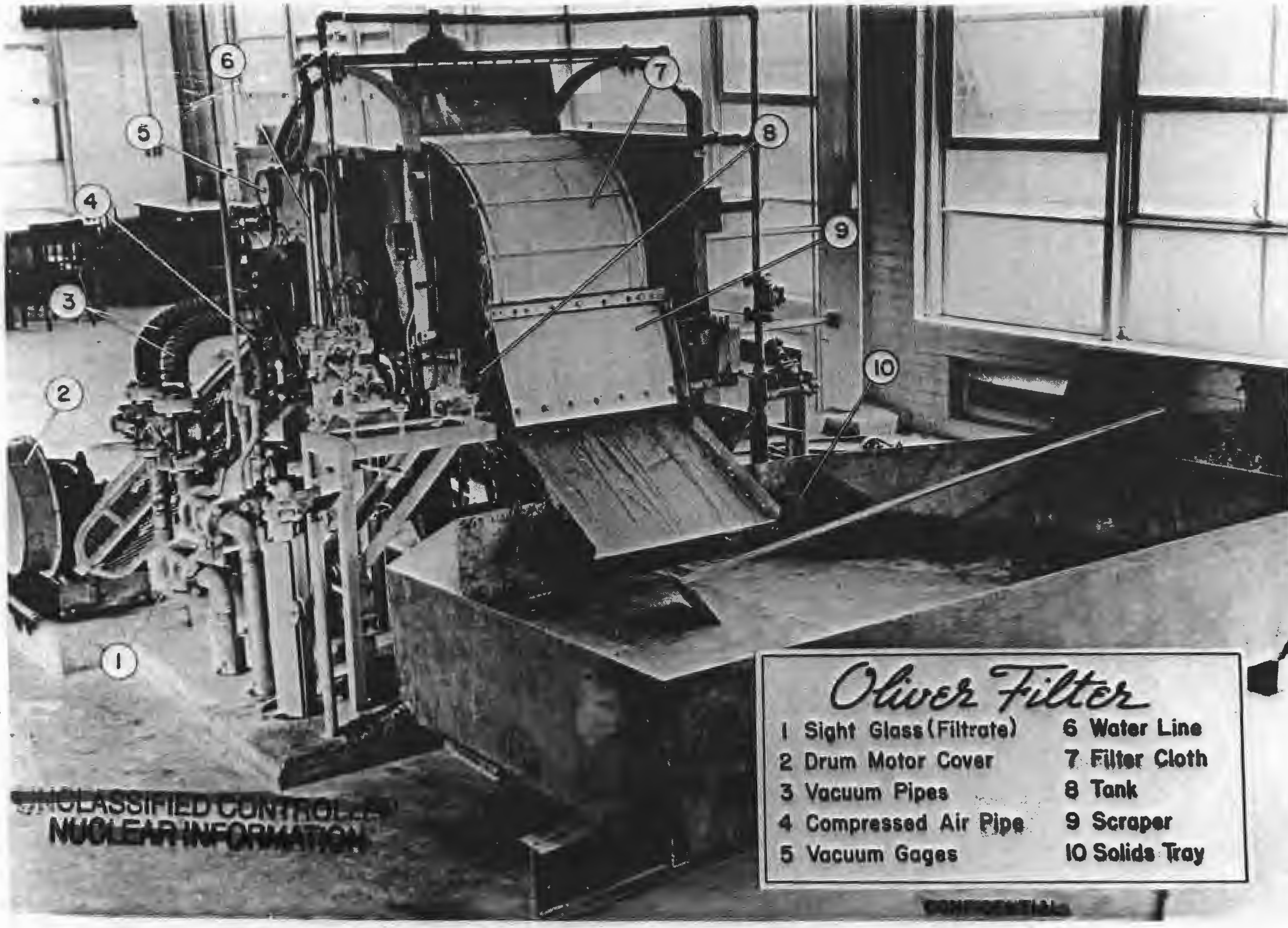
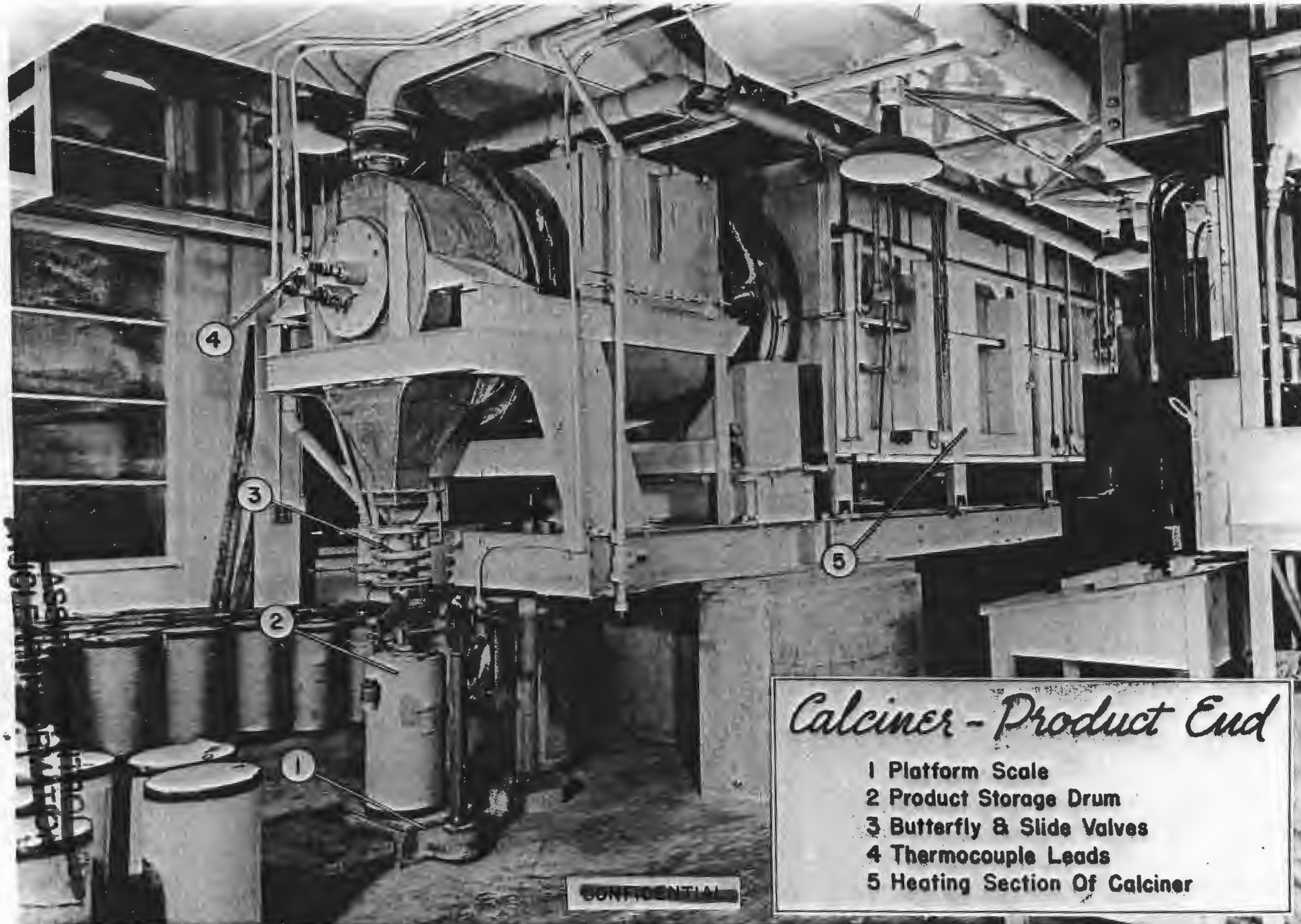


180-X-217
Fig 7

C46. Calciner, Bulk Treatment Recovery Dept.

Building 9202 - a view of the electrically heated continuous feed calciner installed in Bldg. 9202 Extension is shown. The fiber-board containers for the calciner and product, uranium oxide (UO_3), were later changed in favor of stainless steel container.



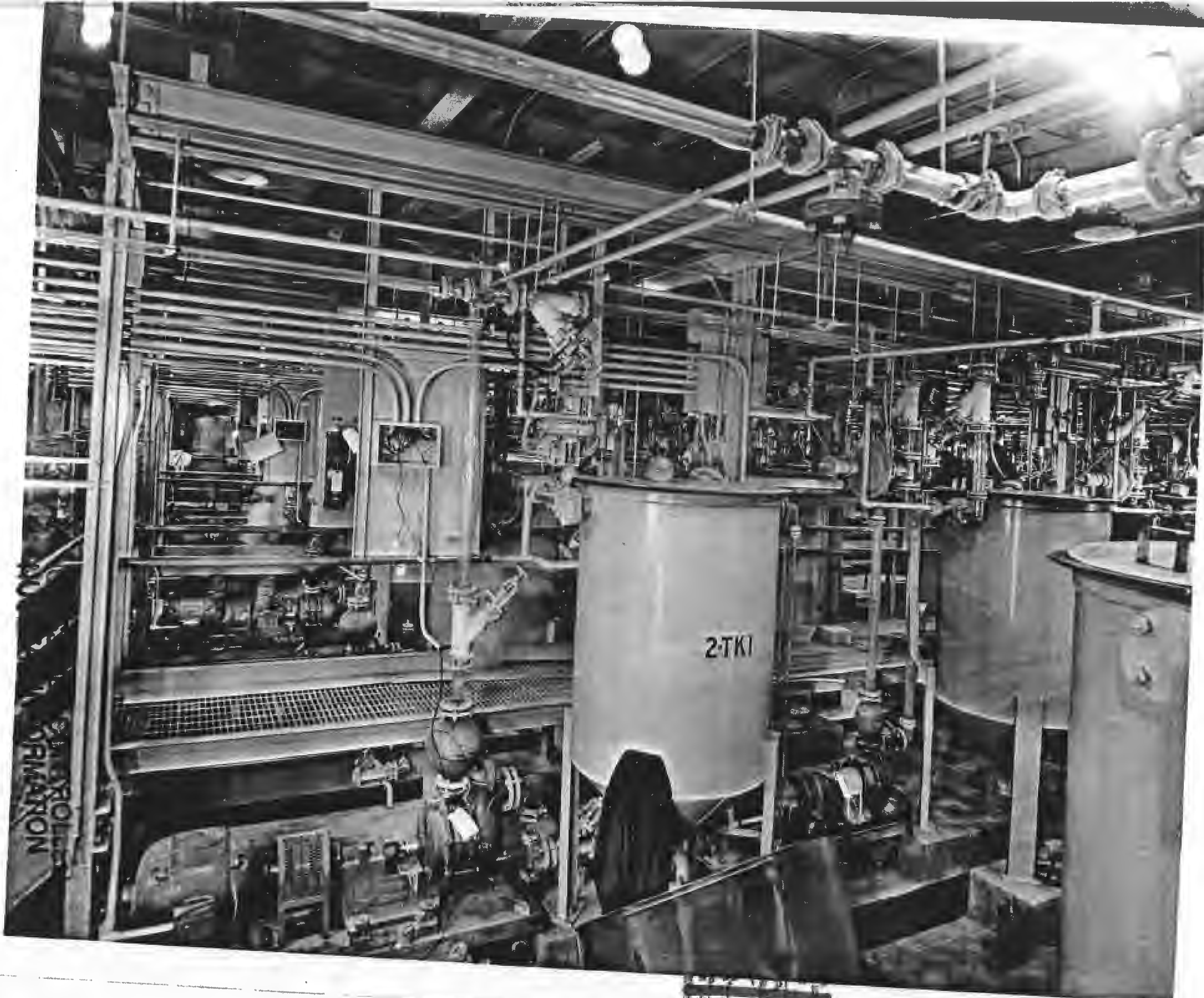
Calciner - Product End

1 Platform Scale
2 Product Storage Drum
3 Butterfly & Slide Valves
4 Thermocouple Leads
5 Heating Section Of Calciner

180-X-228
Fig. 12

047. **"Gunk" Storage, Building 9206**

A storage tank "set-up" in Building 9206 for enhanced Alpha "gunk" solutions is shown with associated equipment.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C48. Final Product Building

Note the double wire fence enclosing the building to increase security.

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MANHATTAN DISTRICT HISTORY

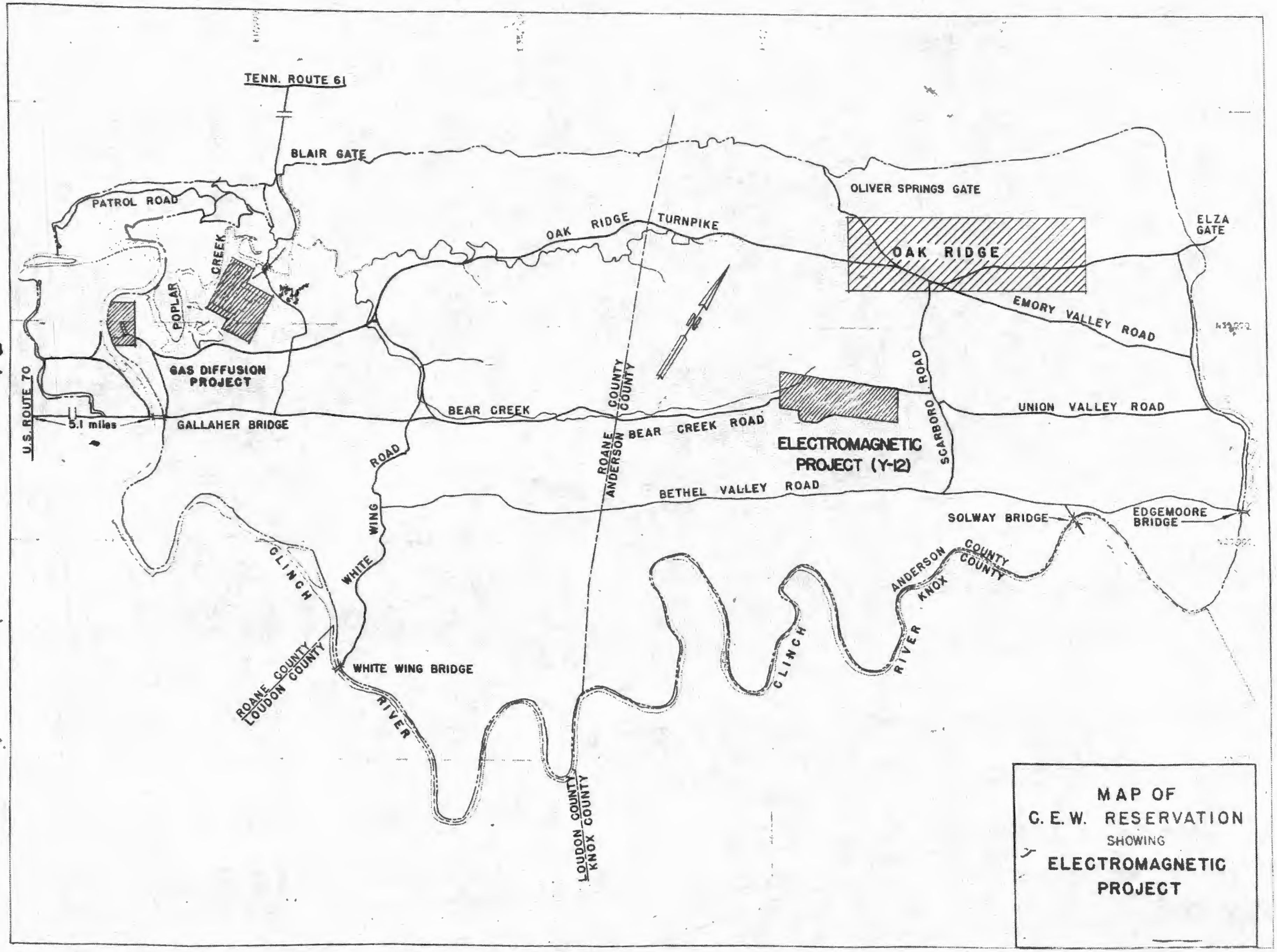
BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

APPENDIX "D"

MAPS AND CHARTS

No.	Description
1	Map of C.E.W. Reservation Showing Electromagnetic Project
2	Plot Plan
3	Floor Plans for Beta Chemistry Building 9206 and Explanatory Index
4	General Organization Chart of Electromagnetic Project
5	Stone and Webster Engineering Corporation Organization Chart



TENN. ROUTE 61
BLAIR GATE
PATROL ROAD
POPLAR
CREEK
OAK RIDGE TURNPIKE
OLIVER SPRINGS GATE
OAK RIDGE
ELZA GATE
EMORY VALLEY ROAD
GAS DIFFUSION PROJECT
U.S. ROUTE 70
5.1 miles
GALLAHER BRIDGE
BEAR CREEK
BEAR CREEK ROAD
ROANE COUNTY
ANDERSON COUNTY
SCARBORO ROAD
UNION VALLEY ROAD
ELECTROMAGNETIC PROJECT (Y-12)
WHITE WING ROAD
BETHEL VALLEY ROAD
SOLWAY BRIDGE
EDGEMOORE BRIDGE
ANDERSON COUNTY
KNOX COUNTY
CLINCH RIVER
ROANE COUNTY
LOUDON COUNTY
WHITE WING BRIDGE
LOUDON COUNTY
KNOX COUNTY
MAP OF
C. E. W. RESERVATION
SHOWING
ELECTROMAGNETIC
PROJECT

10

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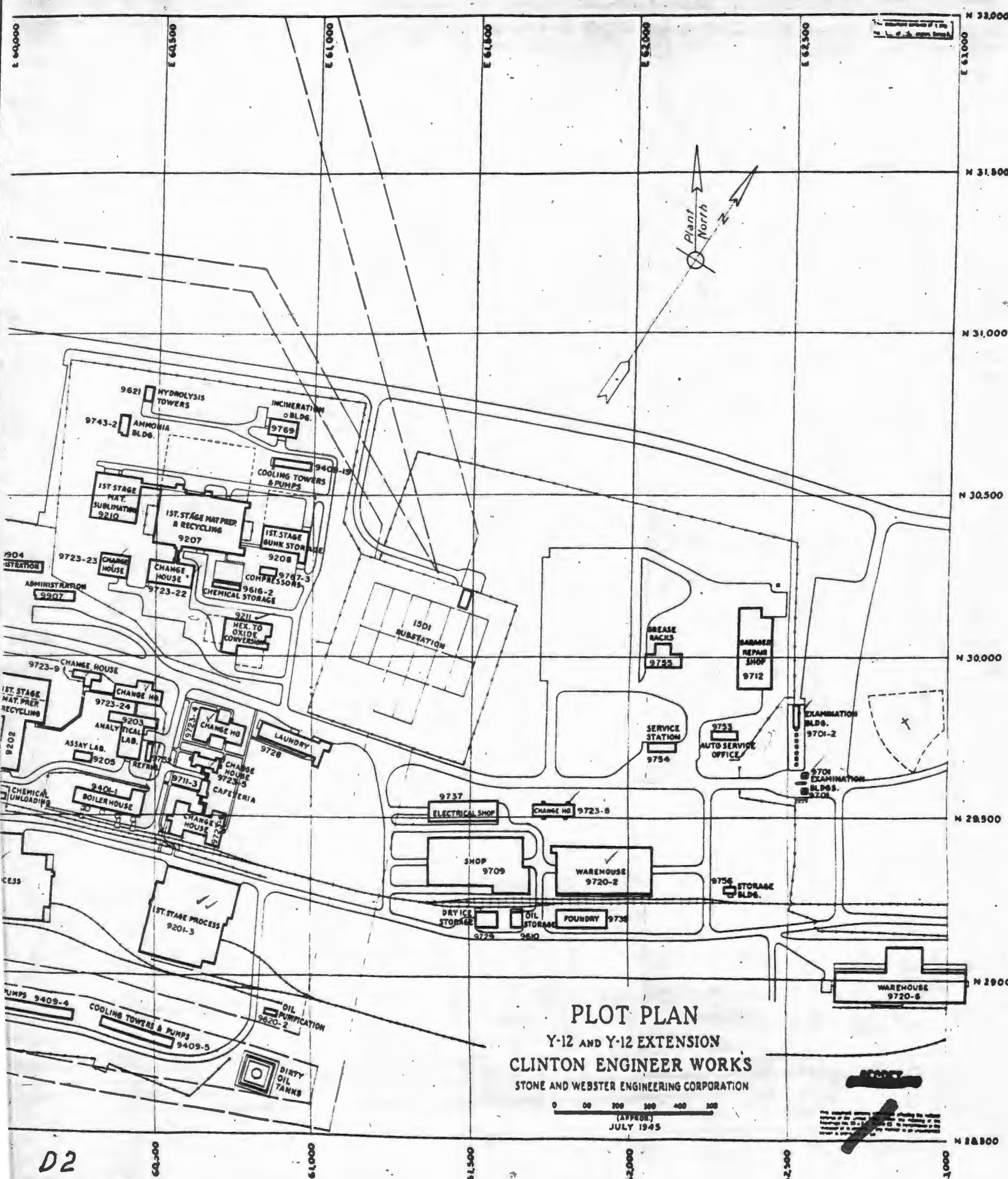

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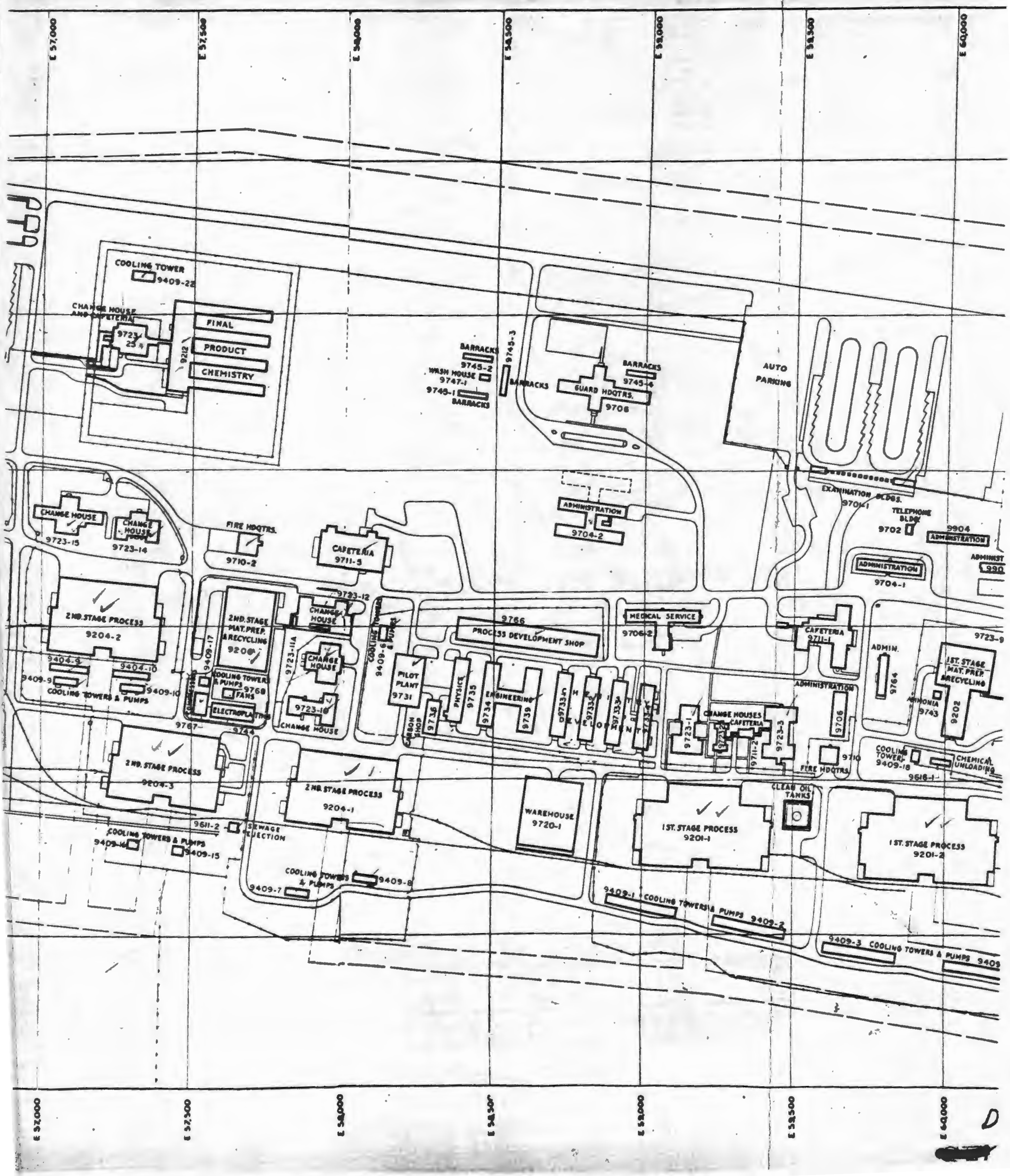

E 57,000
E 57,500
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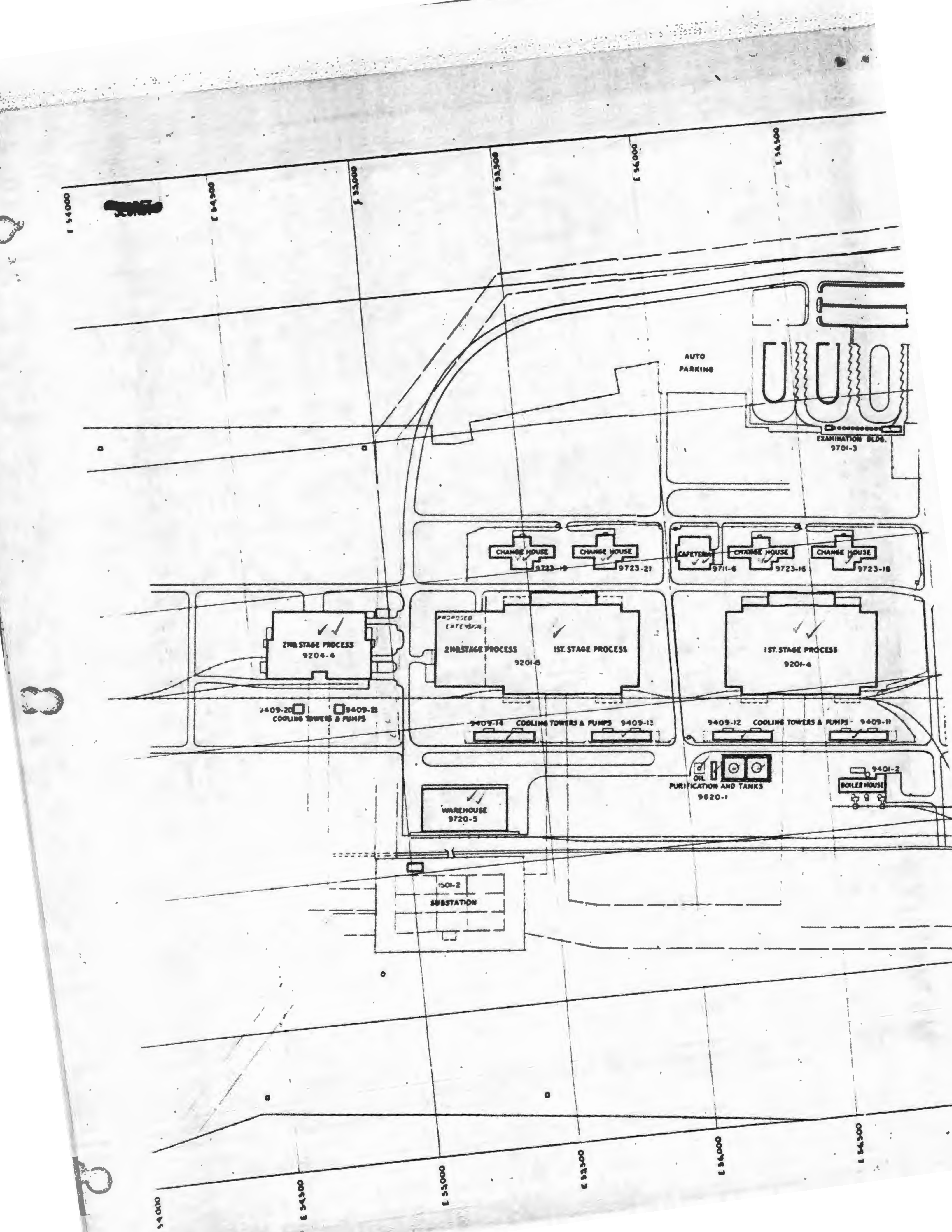
COOLING TOWER 9409-22
CHANGE HOUSE AND CAFETERIA
9723-25
9212
FINAL
PRODUCT
CHEMISTRY
BARRACKS 9745-2
9745-3
WASH HOUSE 9747-1
9745-1 BARRACKS
BARRACKS
BARRACKS 9745-4
GUARD HDQTRS. 9706
AUTO PARKING
EXAMINATION BLDGS. 9701-1
TELEPHONE BLDG. 9702
9904 ADMINISTRATION
ADMINISTRATION 9704-2
ADMINISTRATION 9704-1
CHANGE HOUSE 9723-15
CHANGE HOUSE 9723-14
FIRE HDQTRS. 9710-2
CAFETERIA 9711-5
9723-12
2ND. STAGE PROCESS 9204-2
2ND. STAGE MAT. PREP. & RECYCLING 9206
CHANGE HOUSE
9766 PROCESS DEVELOPMENT SHOP
MEDICAL SERVICE 9706-2
CAFETERIA 9711-1
9723-9
9404-9
9404-10
9409-9
9409-10
COOLING TOWERS & PUMPS
9409-17
COOLING TOWERS & PUMPS 9768 FANS
ELECTROPLATING
9723-11A
CHANGE HOUSE
COOLING TOWERS & PUMPS 9409-6
PILOT PLANT 9731
PHYSICS 9735
ENGINEERING 9734
9739
9733-1
9733-2
9733-3
DEVELOPMENT
ADMIN. 9764
1ST. STAGE MAT. PREP. & RECYCLING 9202
AMMONIA 9743
ADMINISTRATION 9706
CHANGE HOUSES CAFETERIA
9723-1
9711-2
9723-3
9723-10 CHANGE HOUSE
CARBON SHOP 9736
9767
9744
2ND. STAGE PROCESS 9204-3
2ND. STAGE PROCESS 9204-1
WAREHOUSE 9720-1
FIRE HDQTRS. 9710
COOLING TOWER 9409-18
CHEMICAL UNLOADING 9616-1
CLEAN OIL TANKS
1ST. STAGE PROCESS 9201-1
1ST. STAGE PROCESS 9201-2
9611-2 SEWAGE EJECTION
COOLING TOWERS & PUMPS
9409-16
9409-15
COOLING TOWERS & PUMPS 9409-8
9409-7
9409-1 COOLING TOWERS & PUMPS 9409-2
9409-3 COOLING TOWERS & PUMPS 9409
D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AUTO
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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
1ST. STAGE PROCESS
9201-5
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

Site #14 442

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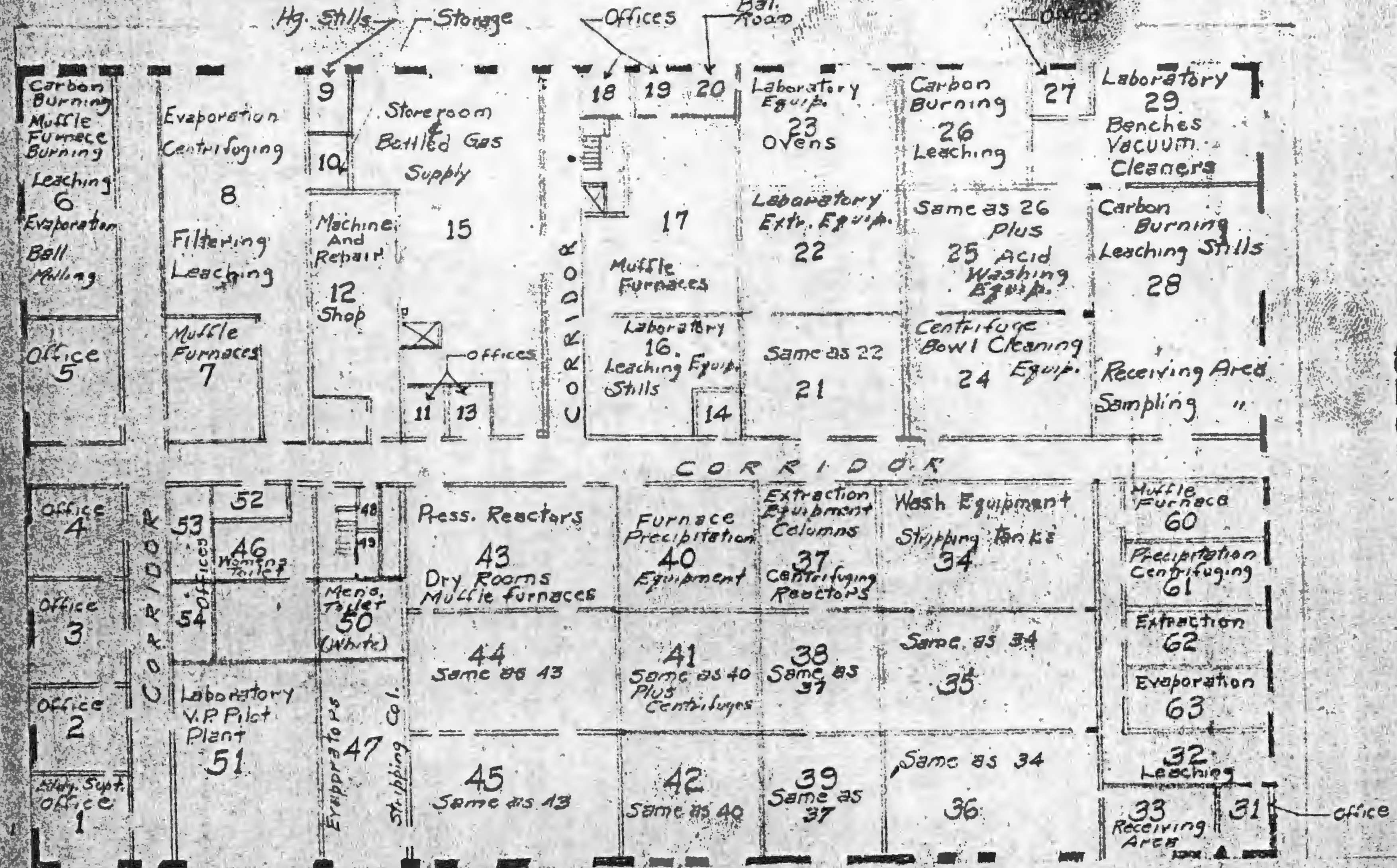
D3

SECRET



N

FIRST FLOOR PLAN
Scale 1/64" = 1'-0"

9206

SECRET

SHL JUN 25 1945

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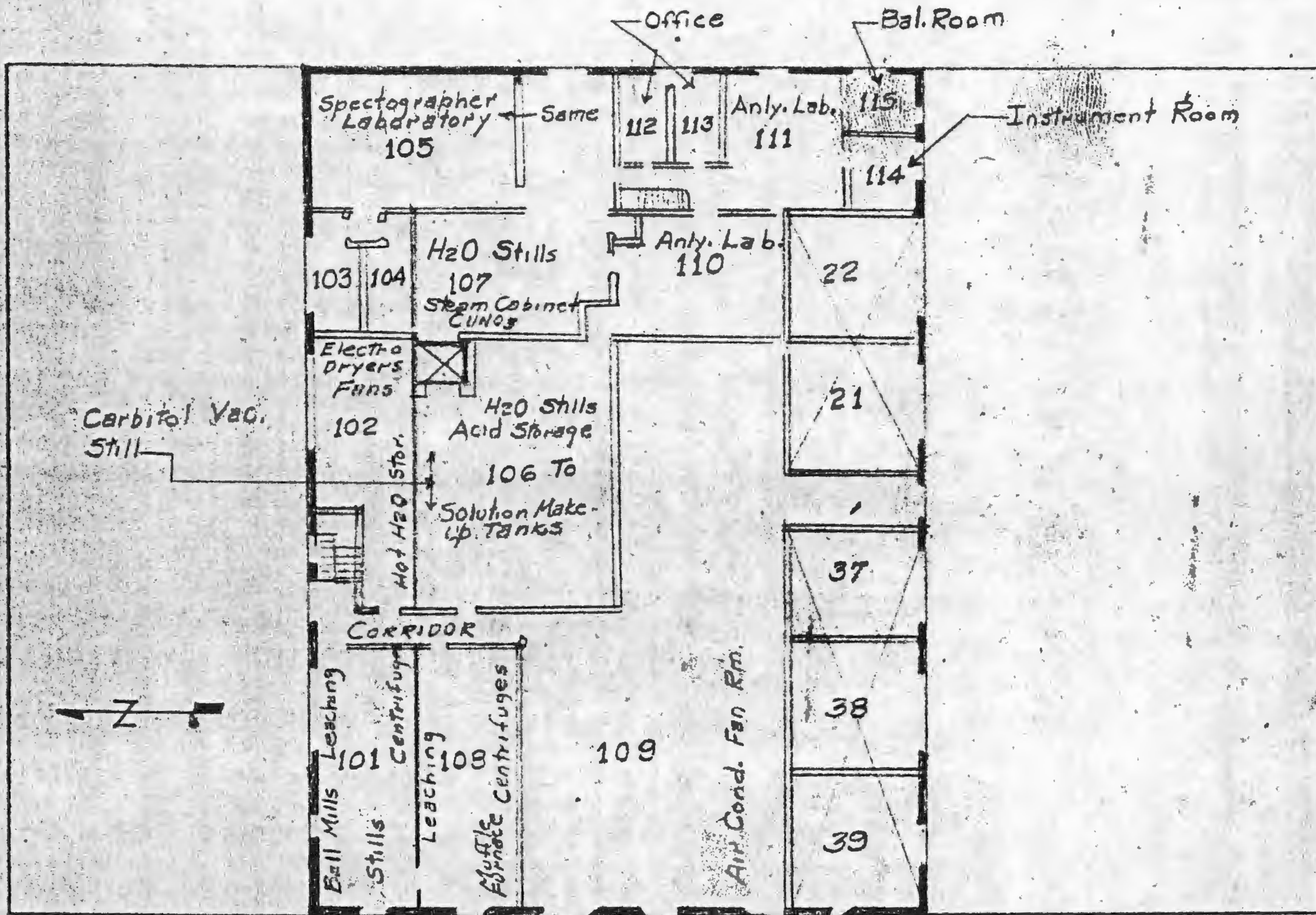

SECOND FLOOR PLAN
Scale 1/64" = 1'-0"

9206

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CHEMISTRY BUILDING 9206

ROOMS AND OPERATING EQUIPMENT

Room No.	Operations and Equipment
1 through 5	Offices
6	Salvage - carbon burning, muffle furnaces, leaching, evaporation, ball mills, grinders
7	Salvage, muffle furnaces, storage
8	Salvage, evaporators, centrifugation, filtration, leaching
9	Salvage, gas fired mercury stills (not used)
10	Salvage, Store room
11	Office
12	Machine shop and repair shop
13 - 14	Offices
15	Sub-stores
16	Final product salvage operations
17	Final product fluoride conversion
18 - 19 - 20	Offices
21 - 22	Final product extraction and evaporation
23	Final product oxide preparation
24	Beta recycle, centrifuge bowl cleaning (centrifuge product from Beta wash processing at Beta process buildings)
25	Beta "Q" carbons (waste U-238 collectors) burning, leaching, acid washing)
26	Beta "R" carbon (U-235 collectors) burning, leaching.
27	Office
28	Salvage - carbon burning, evaporation
29	Beta "R" receiver dismantling ("Q" separated from "R")
30	Rest room
31	Office
32	Residue leaching (Residues from filtered Alpha product receiver washes)
33	Alpha product - receiver - receiving room
34 - 35 - 36	Alpha product - receiver acid wash
37 - 38 - 39	Beta recycle extraction and back washing
40 - 41 - 42	Beta recycle oxide calcination and batching reactors, centrifuges
43	Beta feed uranium hexafluoride coversion (K-25 material)
44 - 45 - 46	Chloride conversion (liquid phase,) pressure reactors, dry rooms, muffle furnaces
47	Chloride conversion salvage concentration
48 - 49 - 50	Rest rooms
51	Vapor phase pilot plant - Development and Research Laboratory
52	Rest room
53	Office
54	Switch board and power feed

~~SECRET~~

Room No.	Operations and Equipment
60	Alpha product oxide calcination
61	Alpha product precipitation and centrifugation
62	Extraction of Alpha product solutions
63	Evaporation and concentration of Alpha product solutions
	SECOND FLOOR
101	Salvage - leaching, calcium precipitation, evaporation, centrifugation, filtration
102	Services (dry air, ventilating fans, hot water heaters and storage tank)
103	Spectrograph instrument laboratory and office
104	Spectrograph dark room
105	Spectrograph laboratory
106	Dibutyl carbital purification
107	Storage
107 A	Office - Laboratory
108	Salvage - ignition, centrifugation, leaching, filtration, small batch processing
109	Air conditioning fan room
110	Final product laboratory
111	Laboratory
112	Office
113	Laboratory
114	Instrument room and records office
115	Balance room

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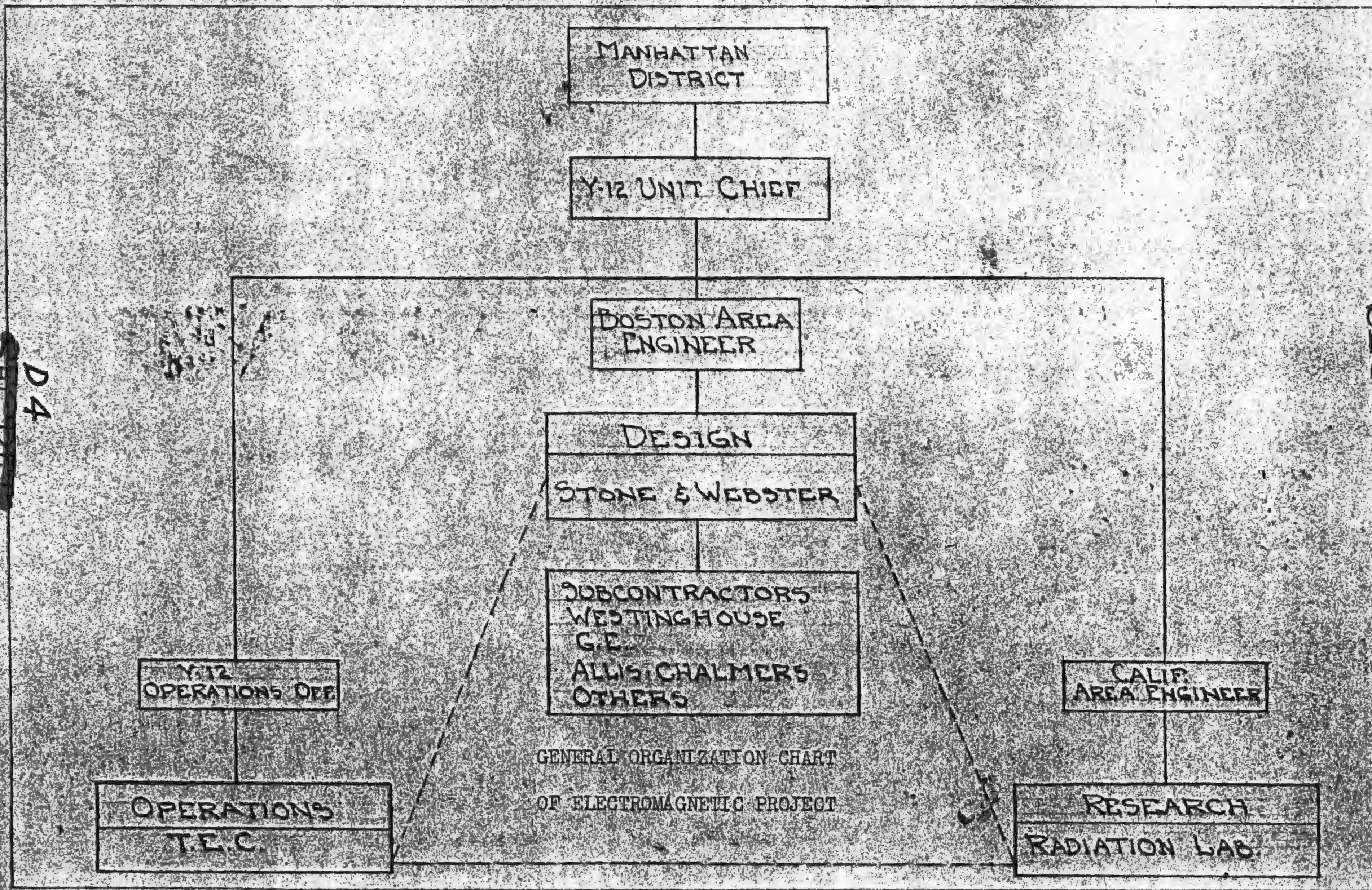

GENERAL ORGANIZATION CHART

OF ELECTROMAGNETIC PROJECT

D 4

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This document consists of 1 page.
No. 1 of 4 copies, Series A

ORGANIZATION CHART
STONE & WEBSTER ENGINEERING CORPORATION
CLINTON ENGINEER WORKS
Y12 & Y12 EXTENSION

JUNE 1944

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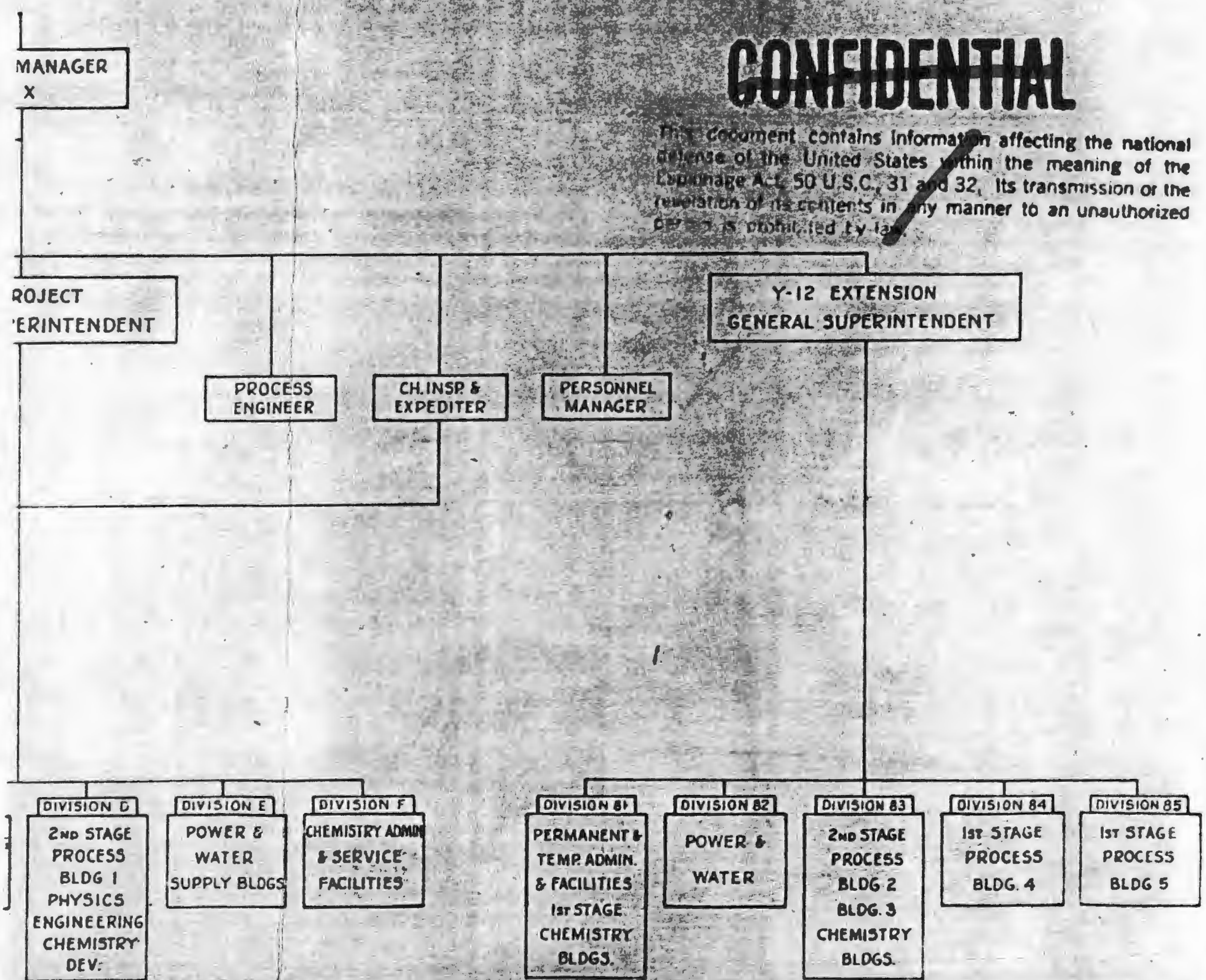

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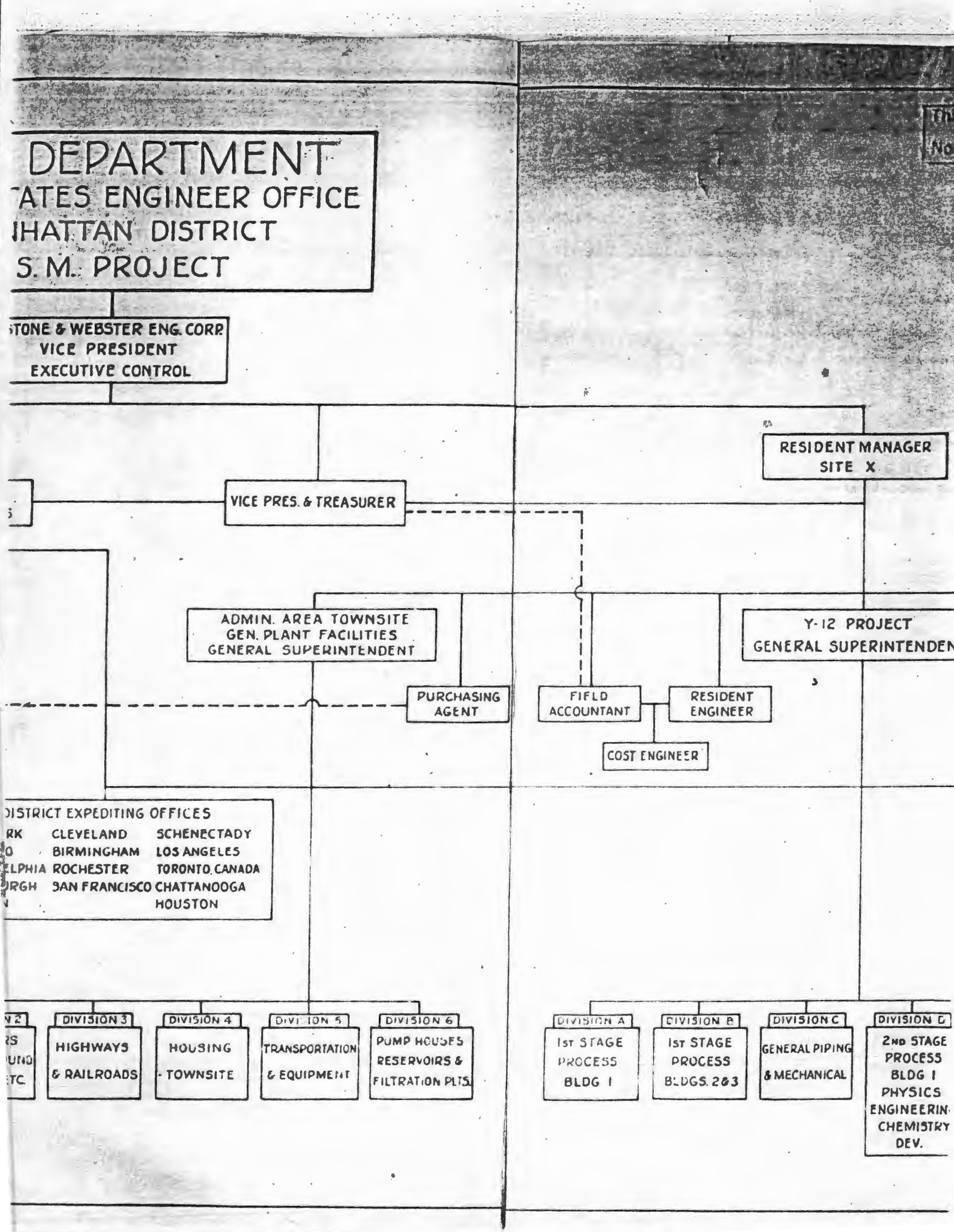
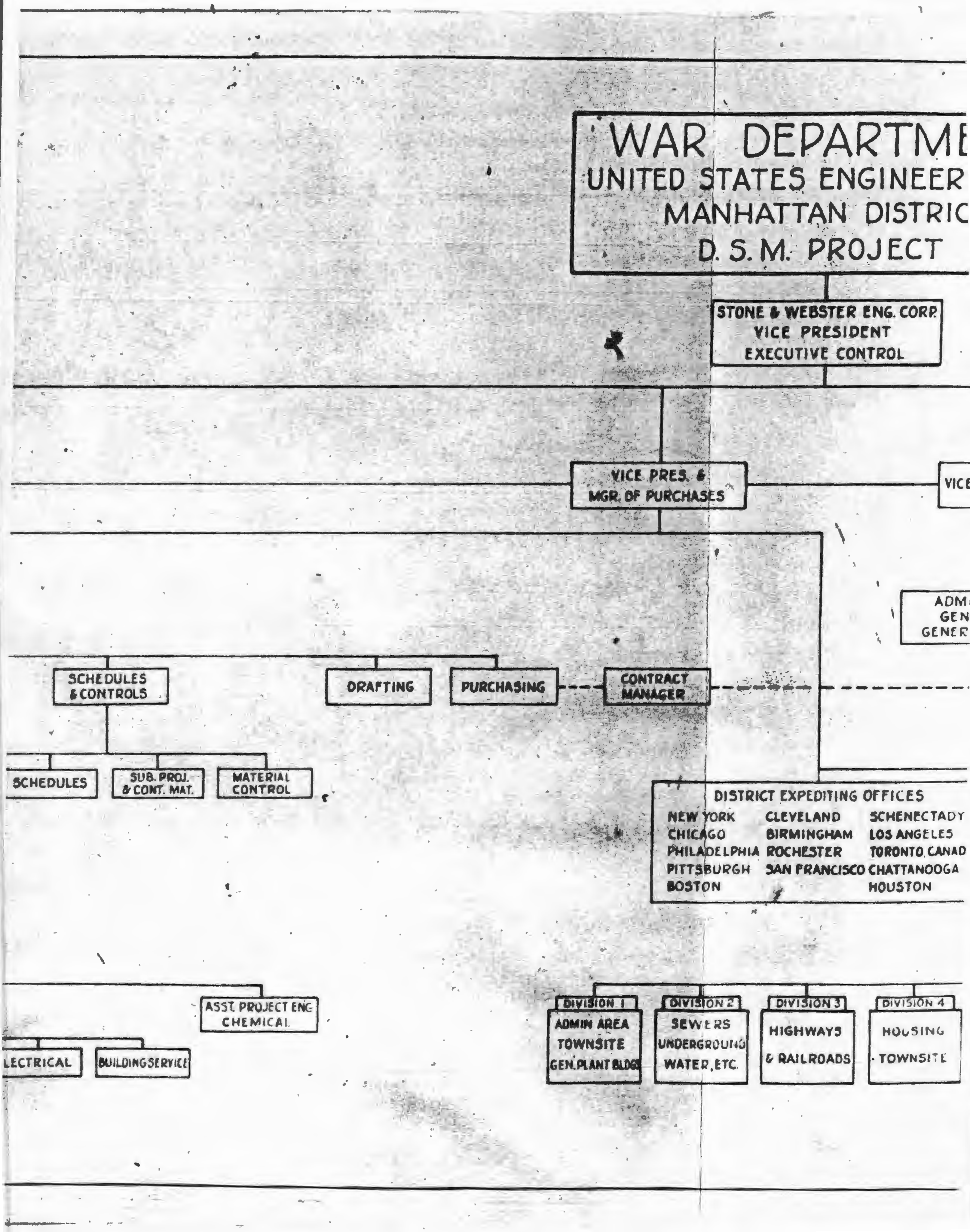


DEPARTMENT
ATES ENGINEER OFFICE
HATTAN DISTRICT
S. M. PROJECT
TONE & WEBSTER ENG. CORP.
VICE PRESIDENT
EXECUTIVE CONTROL
VICE PRES. & TREASURER
RESIDENT MANAGER
SITE X
ADMIN. AREA TOWNSITE
GEN. PLANT FACILITIES
GENERAL SUPERINTENDENT
Y-12 PROJECT
GENERAL SUPERINTENDEN
PURCHASING AGENT
FIELD ACCOUNTANT
RESIDENT ENGINEER
COST ENGINEER
DISTRICT EXPEDITING OFFICES
CLEVELAND
SCHENECTADY
BIRMINGHAM
LOS ANGELES
ROCHESTER
TORONTO, CANADA
SAN FRANCISCO
CHATTANOOGA
HOUSTON
DIVISION 3
HIGHWAYS & RAILROADS
DIVISION 4
HOUSING - TOWNSITE
DIVISION 5
TRANSPORTATION & EQUIPMENT
DIVISION 6
PUMP HOUSES RESERVOIRS & FILTRATION PLTS.
DIVISION A
1st STAGE PROCESS BLDG 1
DIVISION B
1st STAGE PROCESS BLDGS. 2&3
DIVISION C
GENERAL PIPING & MECHANICAL
DIVISION D
2nd STAGE PROCESS BLDG 1 PHYSICS ENGINEERIN CHEMISTRY DEV.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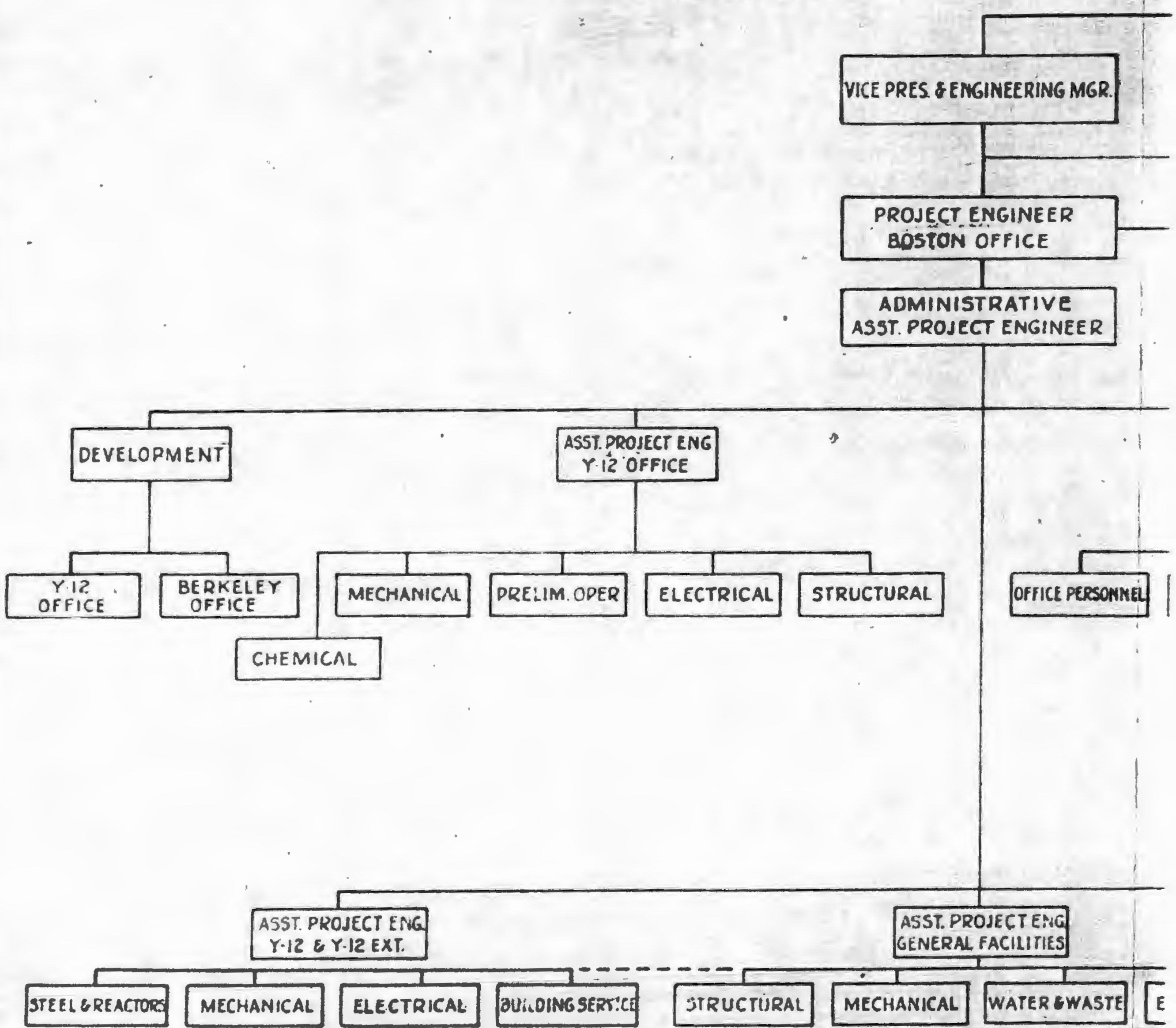

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

APPENDIX "E"

GLOSSARY OF TECHNICAL TERMS

✓<u>Alpha Stage</u>. - The primary separation step whereby the concentration of U-235 in the charge material is increased from .7% to an intermediate level. Also called Alpha step; first stage; first step; or production step.

<u>Autoclave</u>. - An apparatus for cooking or sterilizing under pressure using superheated steam. Liquid Phase reactors.

✓<u>Beta Stage</u>. - The second and final separation step whereby the concentration of U-235 in the charge material is increased from a medium enrichment to final product. Also called Beta step; second stage; second step; or process step.

<u>Centrifuge Process</u>. - A means of separating materials of different densities by using centrifugal force.

✓<u>Charge Material</u>. - The chemical compound of uranium and chlorine suitably purified for introduction into the electromagnetic separation machinery. Also called feed material.

<u>Cold Source Unit</u>. - The "E", or source unit, having a stream of electrons originating from a filament at zero volts, or ground potential.

✓<u>Control Equipment</u>. - The electrical circuits and mechanisms required to control the operations taking place within the process bins.

<u>Critical Mass</u>. - The quantity of accumulated U-235 necessary to produce spontaneous nuclear fission.

✓<u>Cubicle</u>. - The metal structure which houses the control equipment and the operator's control panel.

✓<u>"D" Unit</u>. - The main door of a process bin for an Alpha I unit having a source, a receiver, and a liner attached.

<u>Dibutyl Carbitol</u>. - An organic compound of the glycol series with which uranium can be extracted from water solutions.

<u>Diethyl Ether</u>. - The common anesthetic known familiarly as "ether", and used here in the same way as dibutyl carbitol.

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Down Factor. - A percentage of the whole estimated to be out of operation due to repairs of normal maintenance.

Electromagnetic. - That which is magnetized by passage of an electric current and which retains the magnetism only so long as the current is flowing.

Emission Limiting. - To regulate or control the flow or emission of electrons from a filament.

Enhanced Feed. - Charge material in which the concentration of the U-235 has been increased above 0.7%. Also called enriched feed.

Enriched Material. - See enhanced feed.

Ether Extraction Method. - Procedure in which ether (diethyl ether) is used to remove uranium compounds from impure water solutions by selective solubility, thus purifying and concentrating the uranium compounds.

Ethyl Cellosolve Method. - Organic solvent of the ether series used for extraction of uranium from water solutions.

Excitation Equipment. - The electrical mechanisms necessary to energize the magnet coils.

Feed Material. - See charge material.

First stage process. - See Alpha stage.

Ground Potential. - The accepted standard of zero volts.

Gunk. - The name given to the charge material which has passed through the ionization chamber without being ionized and has condensed on parts of the separation mechanisms.

Hot Source Unit. - A source unit in which the filament, or source of electrons, is at a high voltage, i.e., 35 KV.

Isotopes. - Atoms of the same chemical element having different atomic weights.

"J". - The code letter given to the ionization chamber and its housing.

Liner. - The copper or stainless steel duct fastened to the inside of the main door containing the ionized beams from source to receiver. Also called the "L" unit or the main door.

Potheads. - The insulated terminals for conductors at transformers and other high voltage electrical equipment.

__Process Bin.__ - The rectangular container in the magnet gap which houses the separation mechanisms and, when covered by the main door, provides a space in which the vacuum is created.

__Racetracks.__ - The oval or rectangular structure containing the magnet coils and the process bins.

__Receiver.__ - The part of the separation mechanism used to catch and contain the separated uranium isotopes. Also called the "E" unit or the "E" subdoor.

__Roughing Pump.__ - The 15 h.p. rotary pumps used to remove a large amount of air from the tanks in a minimum of time.

__Run.__ - The period of time from the removal of a set of separation mechanisms from the process bin until the next source unit and receiver unit have been removed.

__Second Stage Process.__ - See Beta stage.

__Source Unit.__ - The portion of the separation mechanism which contains the charge and the ionization of chamber. It is the source of the ionized beams. Also called the "M" unit or the "M" subdoor.

__Tanks.__ - See process bins.

__Vacuum Sublimation.__ - A process whereby a substance is changed from a solid to a gas under vacuum without going through the liquid state.

__Voltage Transients.__ - A sudden and momentary change in voltage due to circuit conditions. In this case, a rapid increase.

MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PLANT

VOLUME 3 - DESIGN

INDEX

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C20. Beta Liner on a Dolly

View showing liner with the "M" and "B" subdoors in place, on the handling dolly in position to be put in the bin. Note the cleanliness of floor and equipment.

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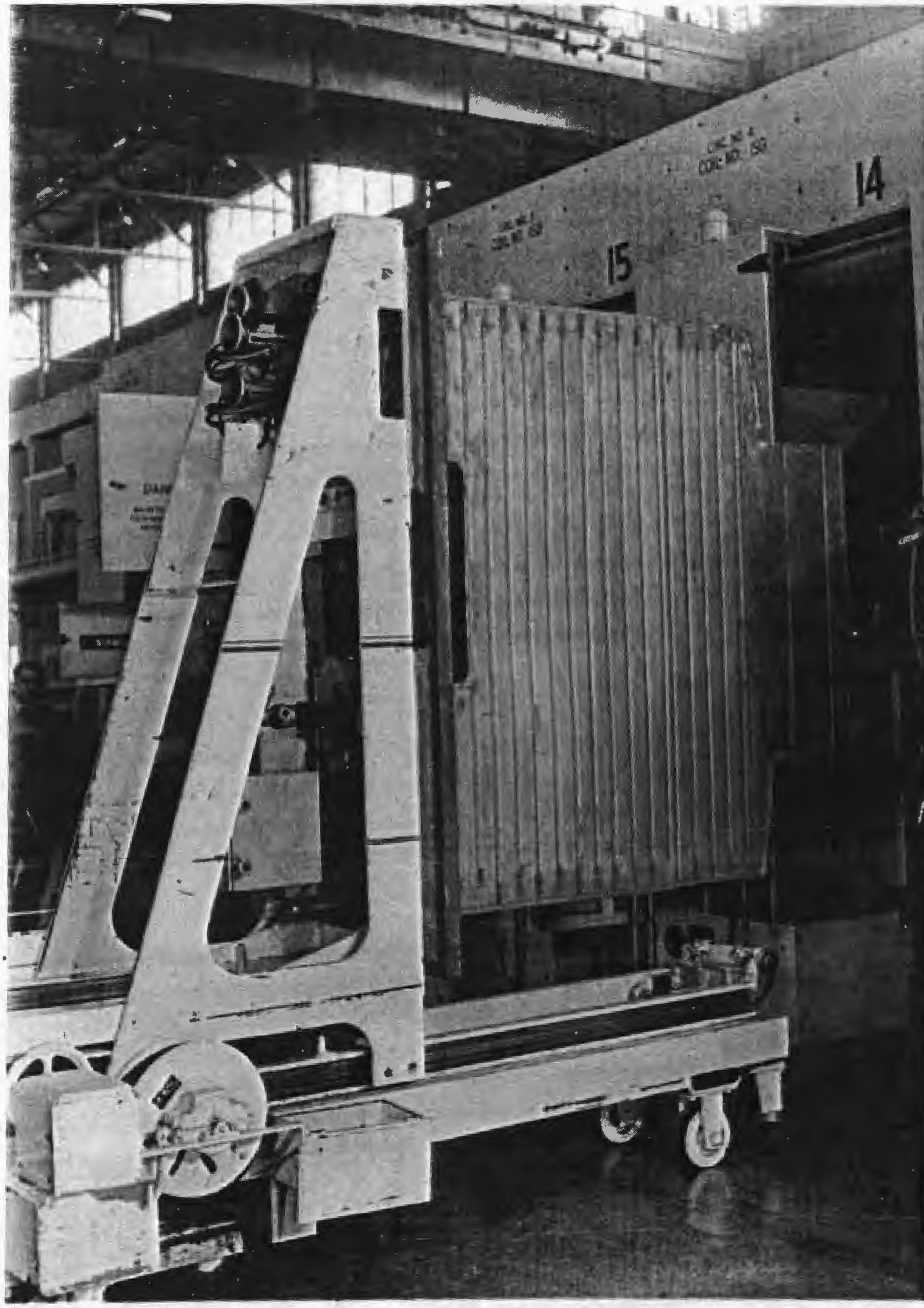
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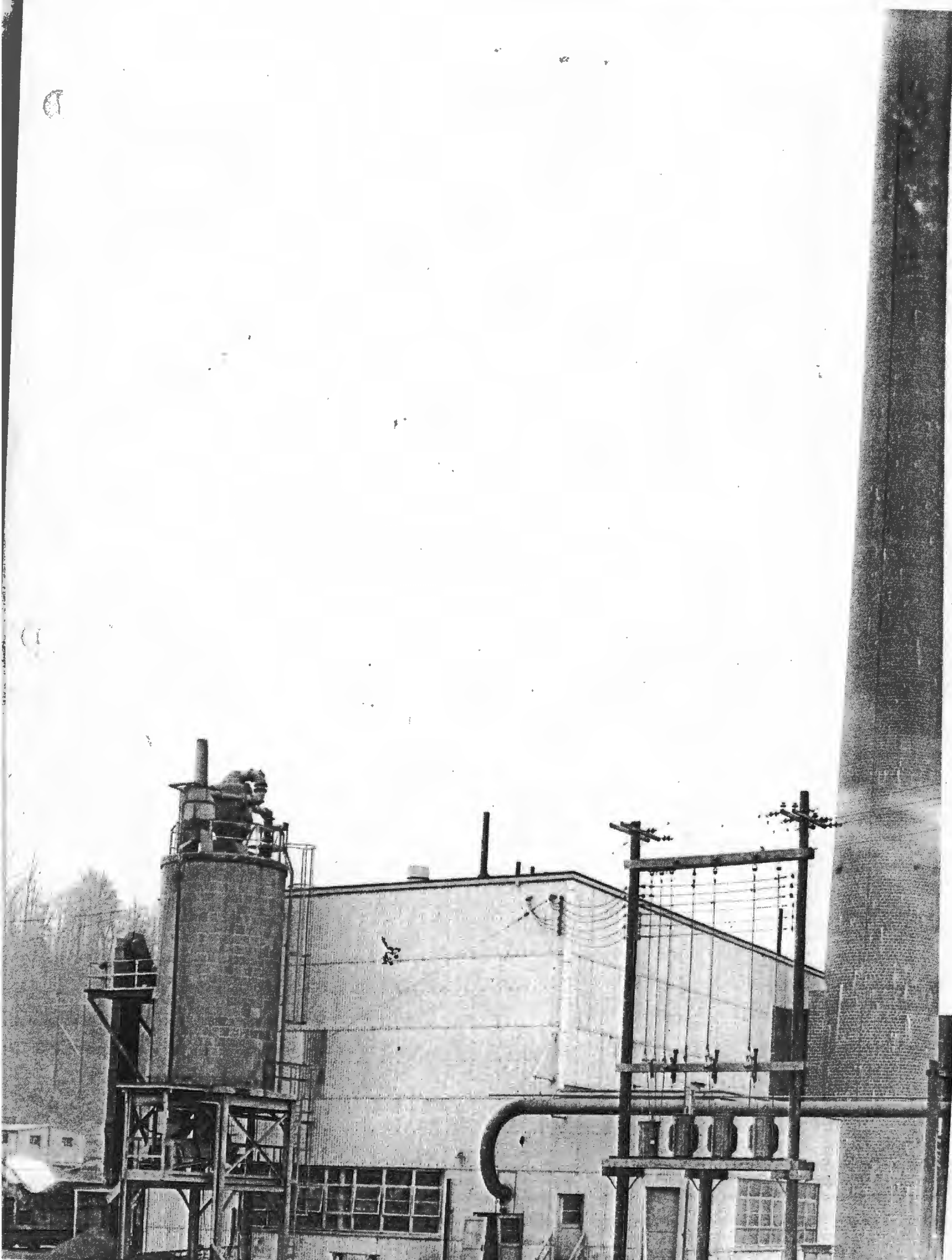
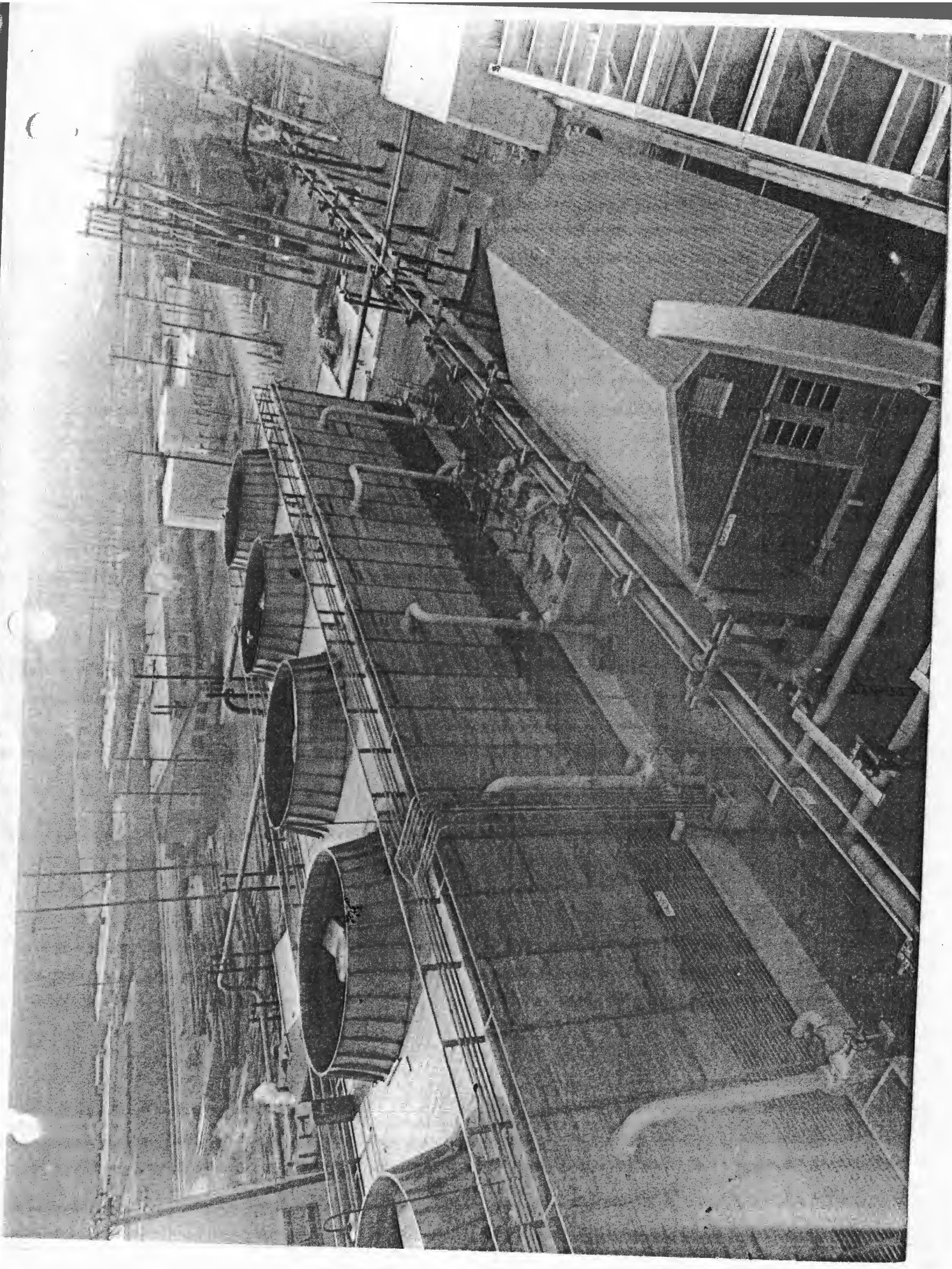
C21. Y-12 Extension Steam Plant.

This plant is designed to produce 548,200 pounds of steam per hour. Note the cylindrical tile tank at the lower left used for ash disposal.



C22. <u>Alpha II Cooling Towers</u>

Note the large fans in the top of the towers for circulating air through the towers. Towers for other tracks may be seen to the right.



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C23. Alpha II Water Pump House.

Pumps housed in this small building circulate the cooling water for the racetracks. The tower and its tank are used to maintain a required pressure as well as to provide storage capacity.

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C24. Alpha II Oil Circulating Pump

This is a pump used in circulating the cooling oil for the magnet coils. It is driven by the 200 horsepower motor in the foreground. Note the small treated water booster pump to the left.

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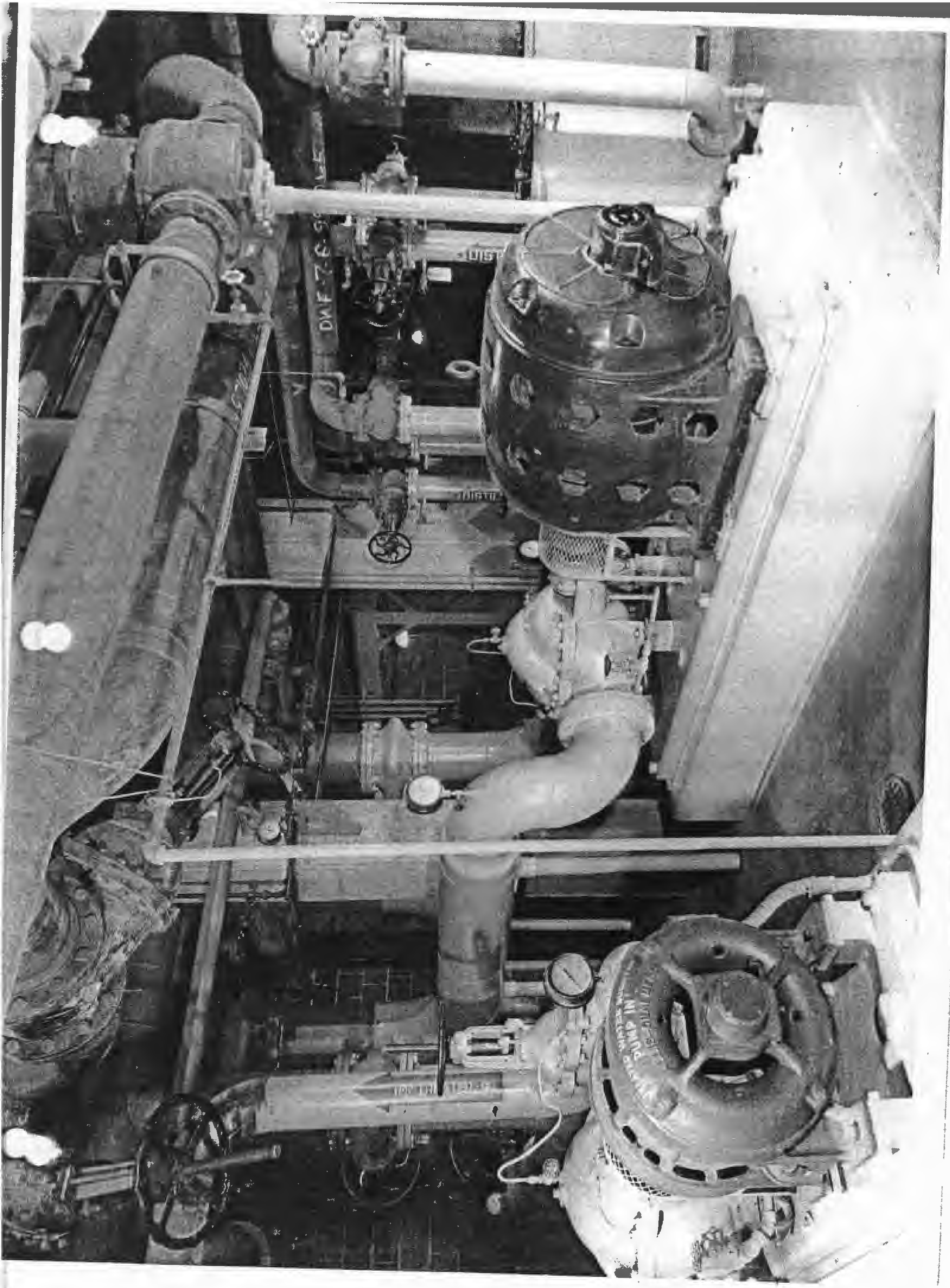

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C28. <u>Interior View of Alpha Development Plant</u>

This shows workmen preparing a tank for installation between the magnet coils to the right rear.

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C26. Modified Alpha and Alpha II "E" Subdoor

This is an artist's drawing of the "E" subdoor, or receiver. Here again note the code names used in nomenclature. The four receivers fastened to the subdoor may be accurately positioned by the in and out hand wheel and the tilting wheel. See paragraph 3-3.

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C27. Beta "M" Subdoor

This shows the two hot sources of this type unit.

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C28. <u>Beta Double Collector Type Receiver</u>

This view is taken looking at the inside of "E" subdoor from the beam direction. Note the small slits which the ionized particles must hit.

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C39. <u>Beta Vacuum System</u>

This view was taken looking along the vacuum headers under the track floor. Note the numerous Chapman Valves used.

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C30. Alpha II Recovery Liner

Observe the opening at the right in the main door for the receiver (or B subdoor) Laminations of the racetrack may be seen in the background.

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C31. <u>Beta Control Cubicles</u>

Four cubicles may be seen, one of which is open to allow some of the apparatus to be seen. Note the large vacuum tubes exposed in the open cubicle. The four meters in the upper right hand corner of the open section are "J" meters.

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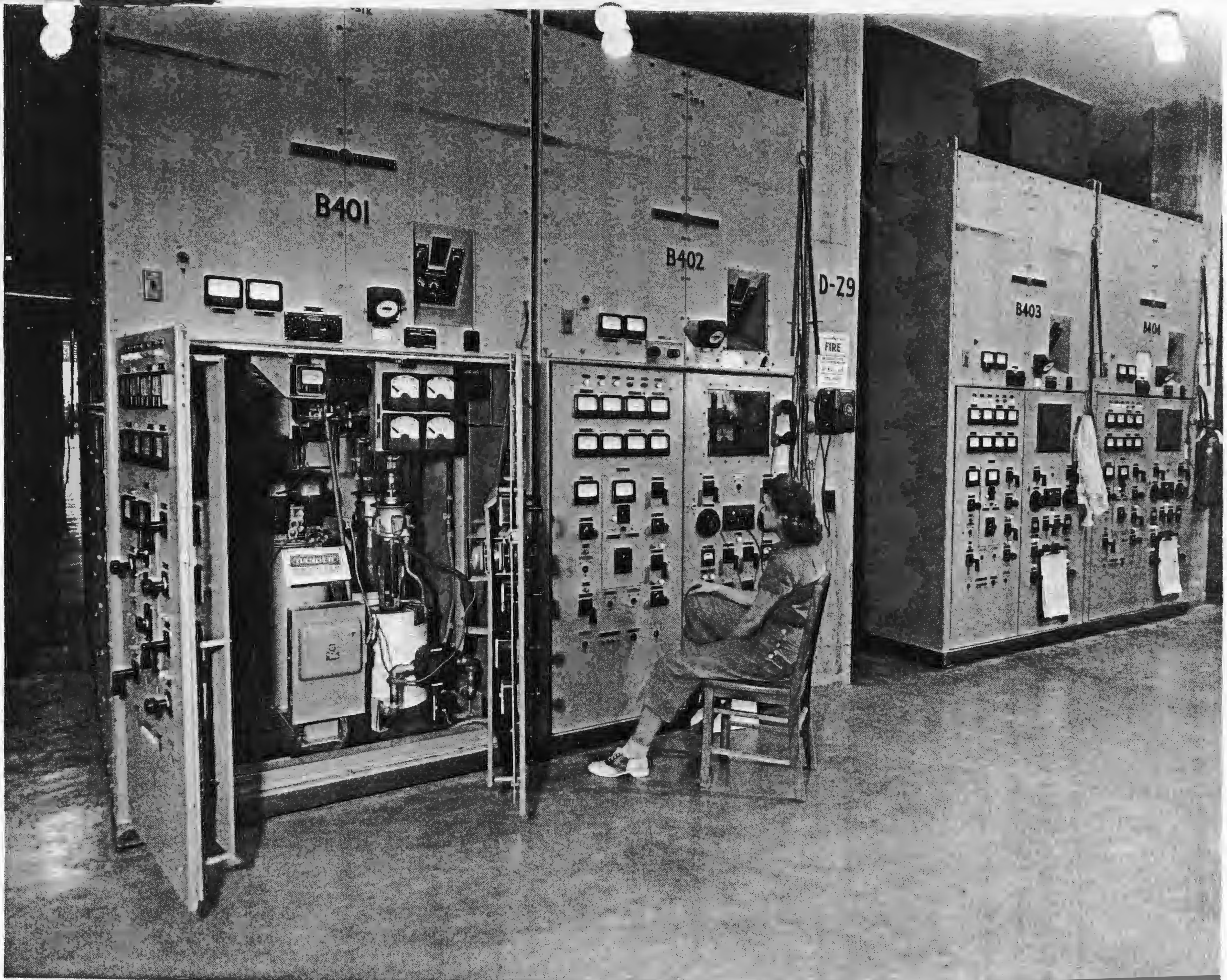

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C32. Alpha II Face Plate and Reactor Panel

This is an artist's conception of the electrical and water jumpers necessary for connections at the tank.

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No.	Description	Location
B-152	Letter 21 July 1945 - Lt. Col. M. G. Fox to E. W. Seckendorff, Facilities for Beta Salvage Operations, Building 9211.	Manhattan District Classified Files
B-153	PE-2355, 9 November 1944, Pilot Plant Bldg. 9202, Conversion of Chemical 735 to Chemical 723.	Manhattan District Classified Files
B-154	Ext. PE 2384, 28 December 1944, Emergency Provisions for Hex Conversions.	Manhattan District Classified Files
B-155	Ext. PE 3298, 2 March 1945, Temporary Conversion of 2 B. T. Lines, Bldg. 9207, to special Chemical Conversion Liners.	Manhattan District Classified Files
B-156	Ext. PE 2977, 7 February 1945, Emergency Provisions for Hex Conversion.	Manhattan District Classified Files
B-157	PE 2413, 8 December 1944, Peroxide Method for Recovery of Enhanced Material from Beta Machine Washing (Larson Method).	Manhattan District Classified Files
B-158	PE 2391, 25 November 1944, WR 5103 Conversion to Precipitation - Product Recovery Process in Bldg. 9204-1.	Manhattan District Classified Files
B-159	Letter 10 March 1945 - Dr. J. G. McNally to Lt. Col. J. R. Ruhoff, See B-113.	Manhattan District Classified Files
B-160	Ext. PE 2183, 13 December 1944, Conference Notes on Conversion to Larson Process.	Manhattan District Classified Files
B-161	WA-1, 6 February 1945, Conversion of B. T. in Building 9202 to the Cold Precipitation Process.	Manhattan District Classified Files
B-162	WA-3, 9 February 1945, Conversion of B. T. Ext. to the Cold Precipitation Process - Bldg. 9202 Ext.	Manhattan District Classified Files

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No.	Description	Location
B-163	Ext. PE 2360, 27 December 1944, Rooms 37 to 42, Bldg. 9206.	Manhattan District Classified Files
B-164	MA-159, 9 April 1945, Chemistry Bldg.	Manhattan District Classified Files
B-165	Stone & Webster Engineering Reports D. S. M. Project.	Manhattan District Classified Files
B-166	Report on Building 9207 Chemical Group Y-12. 27 November 1945. Prepared by Major M. E. Gates.	Manhattan District Classified Files

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MANHATTAN DISTRICT HISTORY

BOOK V - ELECTROMAGNETIC PROJECT

VOLUME 3 - DESIGN

APPENDIX "C"

PHOTOGRAPHS

No.	Description
1	Panoramic View of Y-12
2	Vacuum Distillation Still Bldg. 9202
3	Vacuum Distillation Still and Associated Equipment, Bldg. 9202.
4	Alpha Material Preparation Building
5	Bulk Treatment Recovery Department, Bldg. 9207
6.	Alpha I Racetracks
7	Installing Alpha I Main Door
8	Alpha I Main Door
9	Alpha I Main Door (Artist's Conception)
10	Alpha I Control Room (cubicles)
11	Alpha II Racetrack
12	Alpha II - "M" Subdoor
13	Alpha II - Main Door
14	Modified Alpha Liner
15	Alpha Receiver Washing Department, Bldg. 9206
16	Beta Charge Preparation Department
17	Beta Wash Recovery Equipment in Beta Process Buildings.
18	Beta Wash Recovery Equipment in Beta Process Buildings.

[redacted]

No.	Description
19	Beta Racetracks
20	Beta Liner on a Dolly
21	Y-12 Extension Steam Plant
22	Alpha II Cooling Towers
23	Alpha II Water Pump House
24	Alpha II Oil Circulating Pumps
25	Interior View of Alpha Development Plant
26	Modified Alpha and Alpha II "E" Subdoor
27	Beta "M" Subdoor or Source Unit
28	Beta Double Collector Type Receiver
29	Beta Vacuum System
30	Alpha II Recovery Liner
31	Beta Control Cubicles
32	Alpha II Faceplate and Reactor Panel
33	Beta Handling Equipment, (Loaded)
34	Beta Dolly
35	Vacuum Tube (No. GL 893)
36	Diffusion Pumps
37	Beta Carbon Receiver
38	Alpha Chemistry Flow Diagram
39	Liquid Phase Reactor (Bldg. 9202)
40	Noxious Gas Scrubber System (Bldg. 9202)
41	Vent System for Noxious Gases
42	Bottle Filling Stands (Bldg. 9202)

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No.	Description
43	"Gunk" Storage Room (Bldg. 9202)
44	Ether Extraction Columns (Bldg. 9206)
45	Oliver Filter, Bulk Treatment Recovery (Bldg. 9202)
46	Calciner - Bulk Treatment Recovery Department
47	"Gunk" Storage (Bldg. 9206)
48	Final Product Building (Bldg. 9212)

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61. <u>Panoramic View of Y-12</u>

This view is taken looking southwest across the plant. In the left foreground are the shops. Looking from left to right, we see the shops, Elza No. 1 substation and the Alpha I process buildings, the Building 9207 group is next with the Beta process buildings in the background, and at the extreme western end of the project are the large Alpha II buildings.

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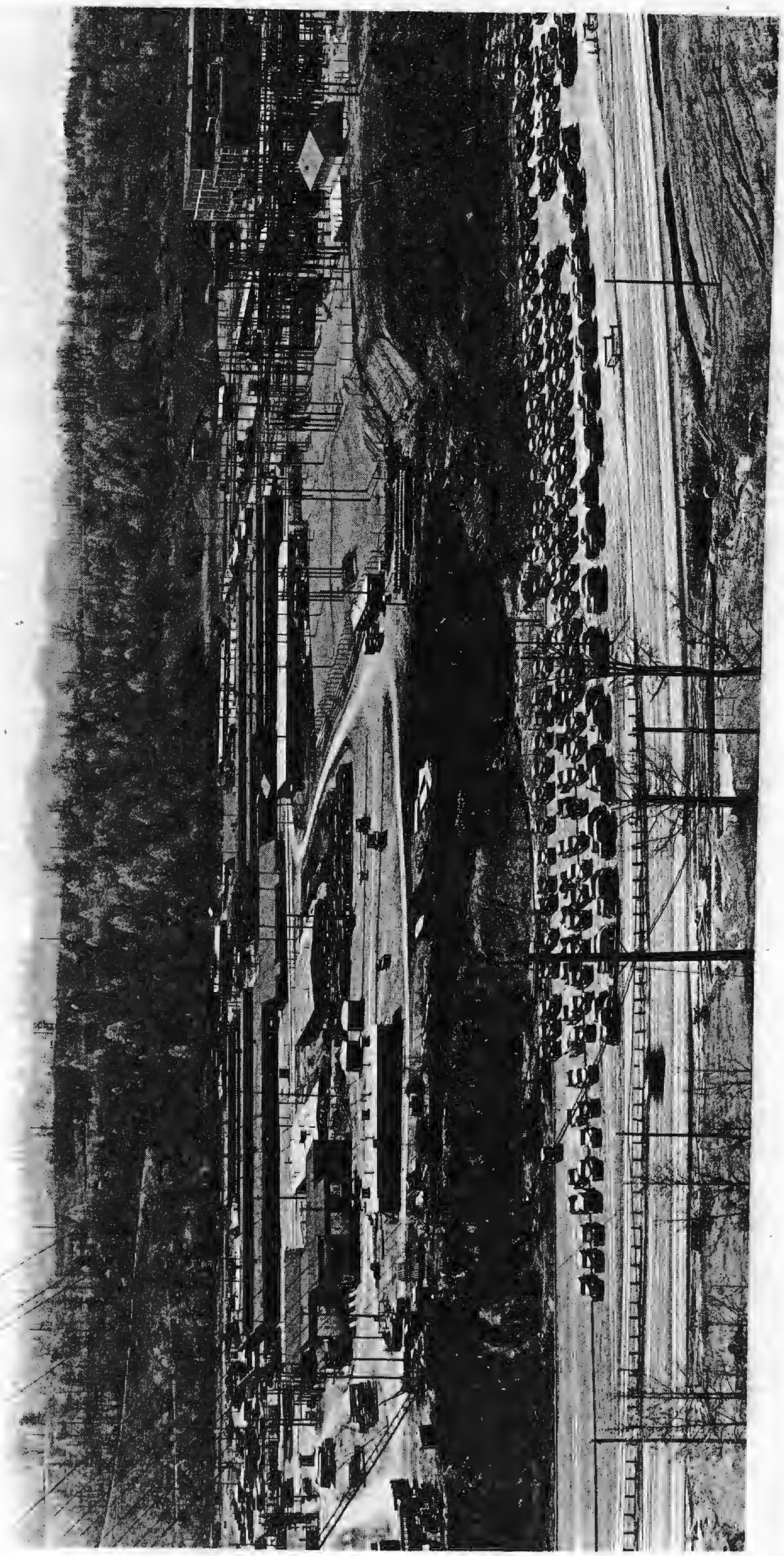
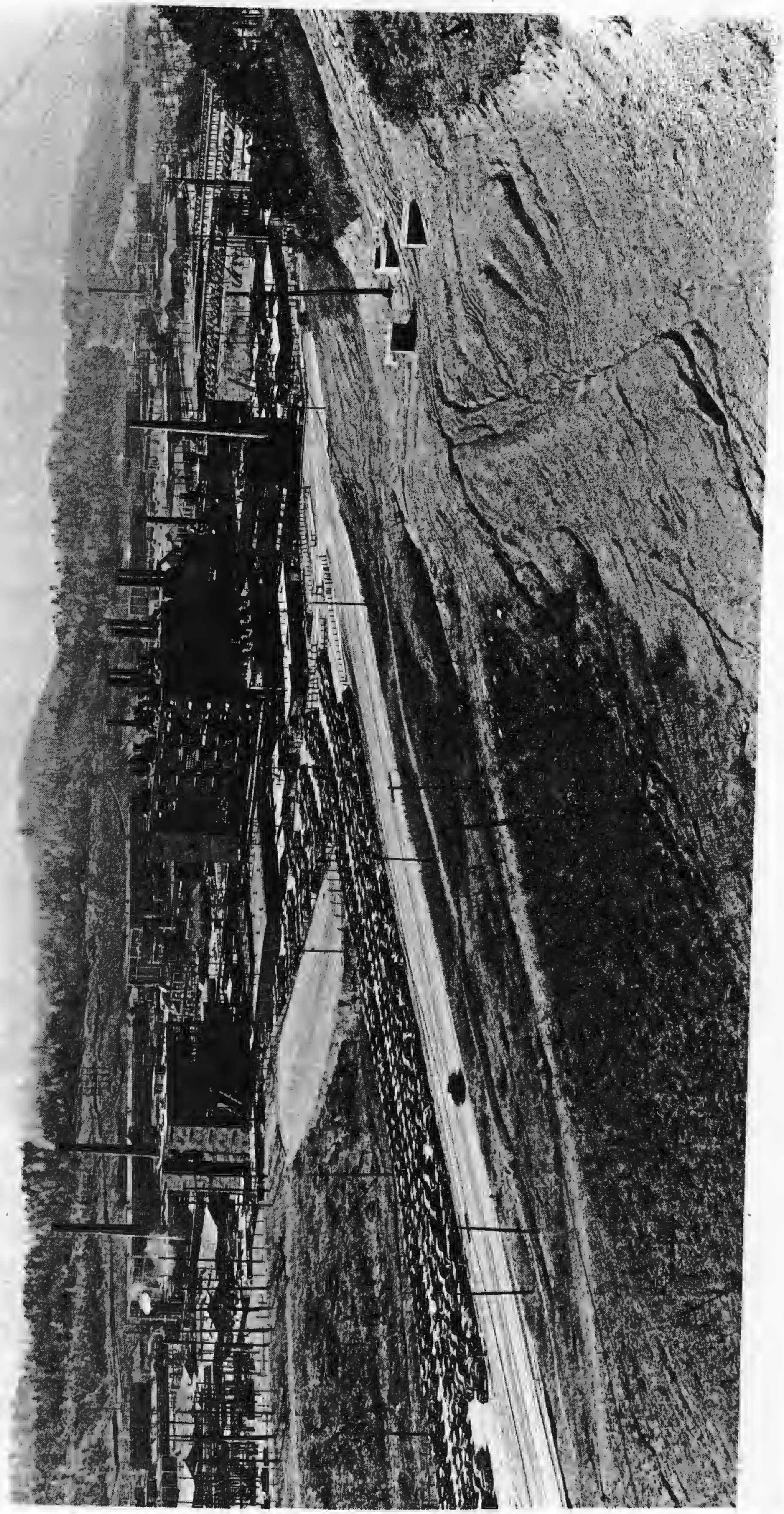
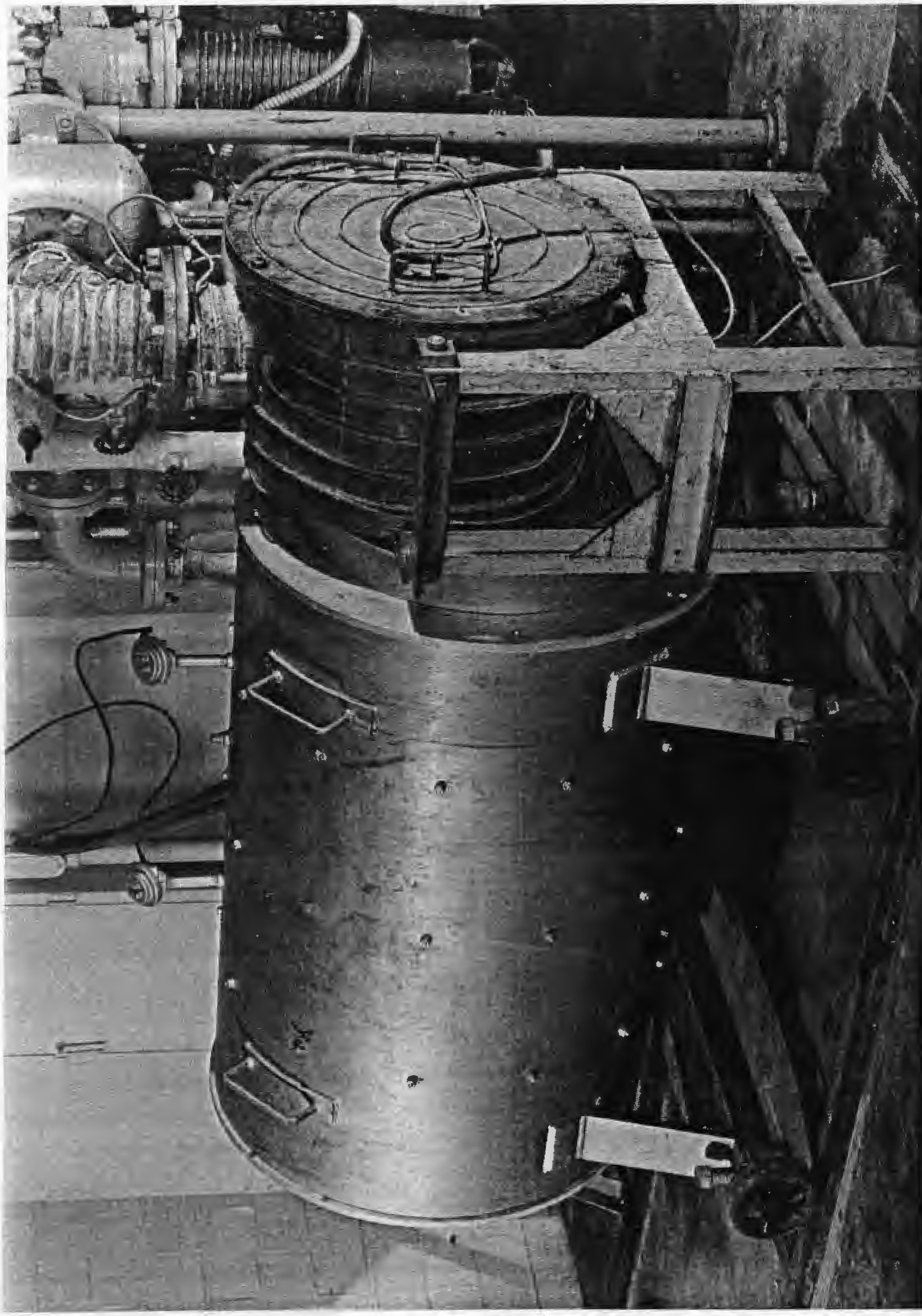




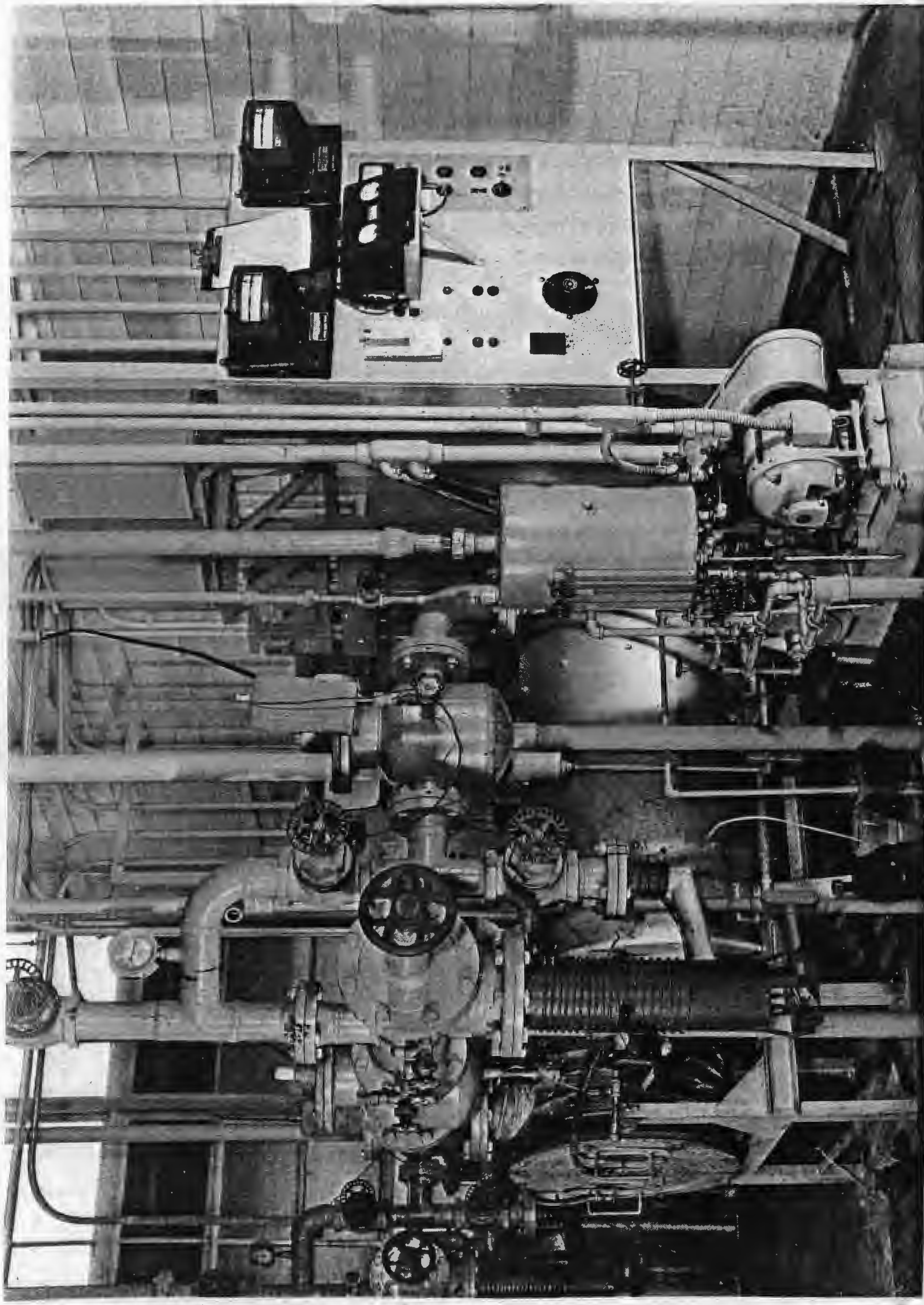
G2. <u>Vacuum Distillation (Sublimation), Bldg. 9202</u>

Still showing electrically heated oven, left, and water cooled receiver, right. The oven is mounted on rollers so that it may be rolled away from "boat", or retort attached to receiver.



C3. <u>Vacuum Distillation (Sublimation), Bldg. 9202</u>

Still and associated equipment as used in Alpha feed preparation.



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C4. Alpha Material Preparation Building

View looking south across Y-12 plant with building 9207 in center foreground and Hexafluoride conversion building (9211) in the left foreground. Large buildings in the background house the racetracks.

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C5. <u>Bulk Treatment Recovery Department, Building 9207</u>

Typical reactor, left, with reagent feed tanks, center permitting supply of reagents by gravity flow. Reactor is glass-lined (enamel) and feed tanks are stainless steel, aluminum, and iron. Process piping shown is of Pyrex, stainless steel and iron, while valves are stainless steel, iron and porcelain. Glass bottle sitting over reactor is part of an automatic recording system to determine the exact ratio of acidity and alkalinity of the solution within the reactor. Panel boards, right center, contain recording charts, gages, and interlock indicating lights.

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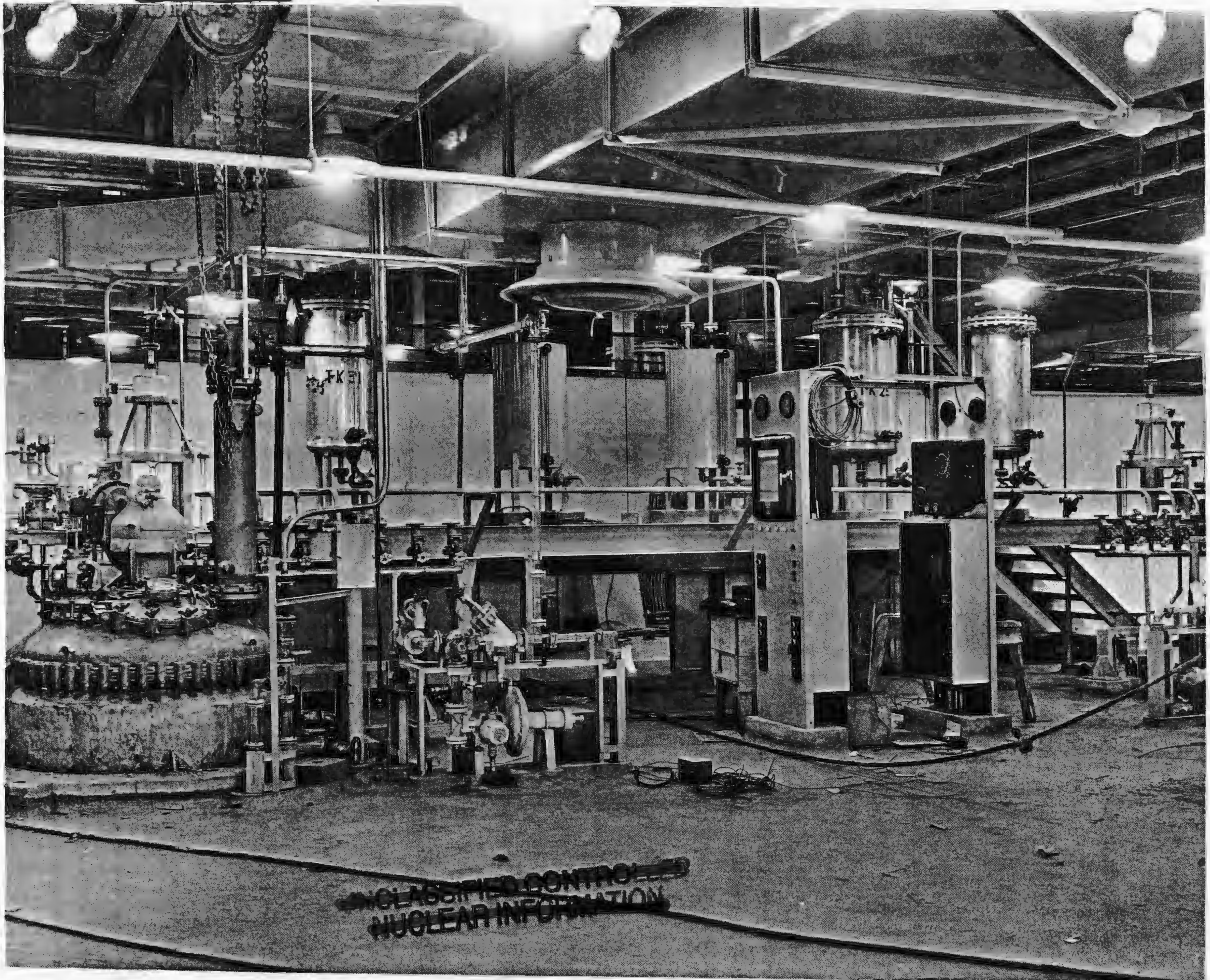

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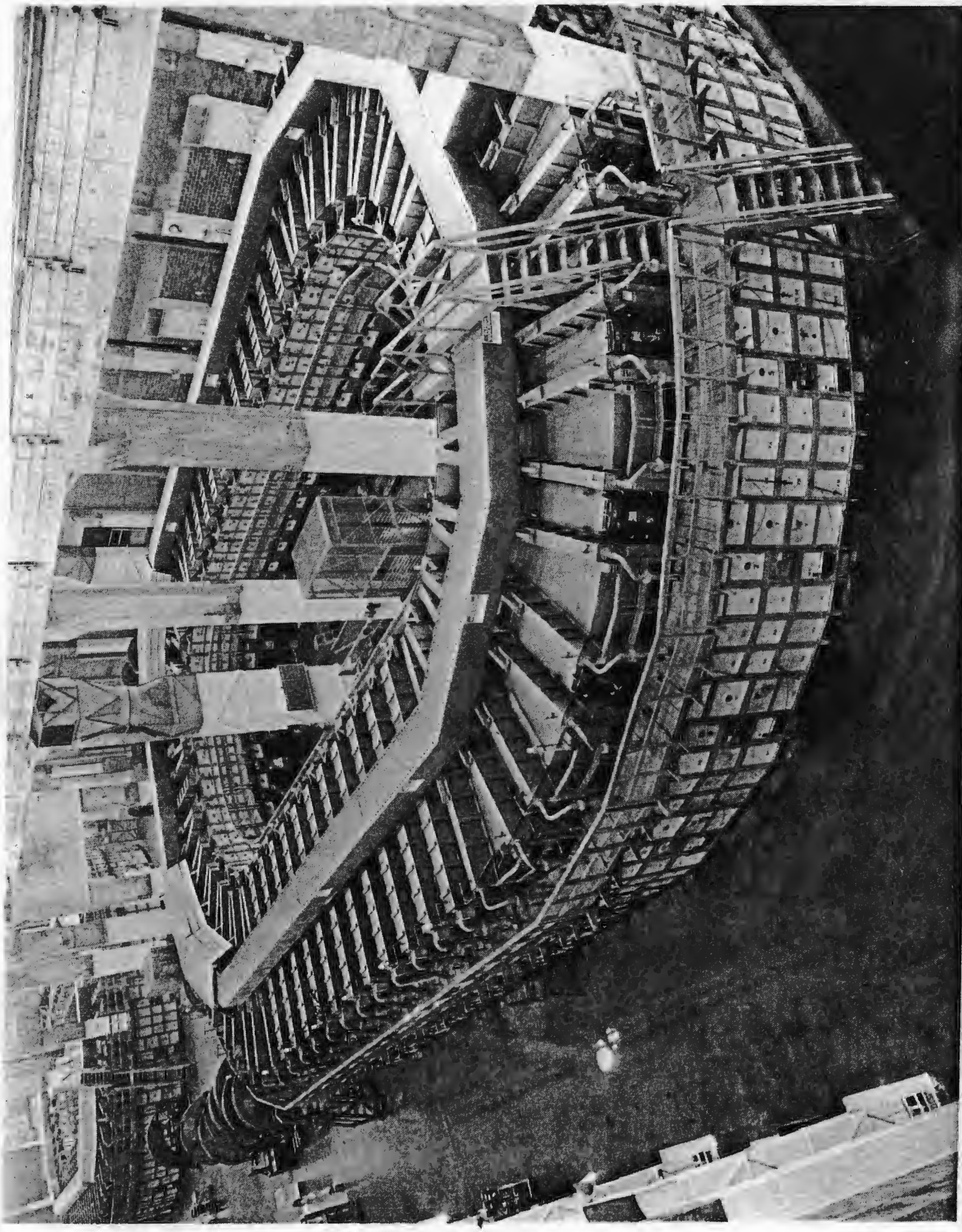
C6. Alpha I Racetrack

View inside an Alpha I building looking over one track toward the second. The view shows inside and outside tank fronts with inclosed bus running along the top of the tracks. Spare "tank units" may be seen on the floor between the tracks.



67. <u>Installing Alpha I Main Door</u>

View showing a main door, or "D" unit, being placed in the tank by means of the Link-belt handling equipment.

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C8. <u>Alpha I Main Door</u>

View showing main door on a dolly with some plates and shields removed to expose the sources and collector. Man has his hand on the face plate at the receiver end.

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C9. Alpha I Main Door

Artist's conseption of the "D" unit with plates and shields removed to expose the source and collector.

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C10. <u>Alpha I Control Room</u>

This view shows the cubicles in the control room with the attentive operators at work. Note books required for necessary records. Phones on cubicles are for communication with the track and vacuum operators.

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C11. Alpha II Racetrack

View looking south on track six. Note absence of inside tanks. Rectangular inclosure running along top of track houses silver bus bar. Note heavy steel laminations at ends and center of track.

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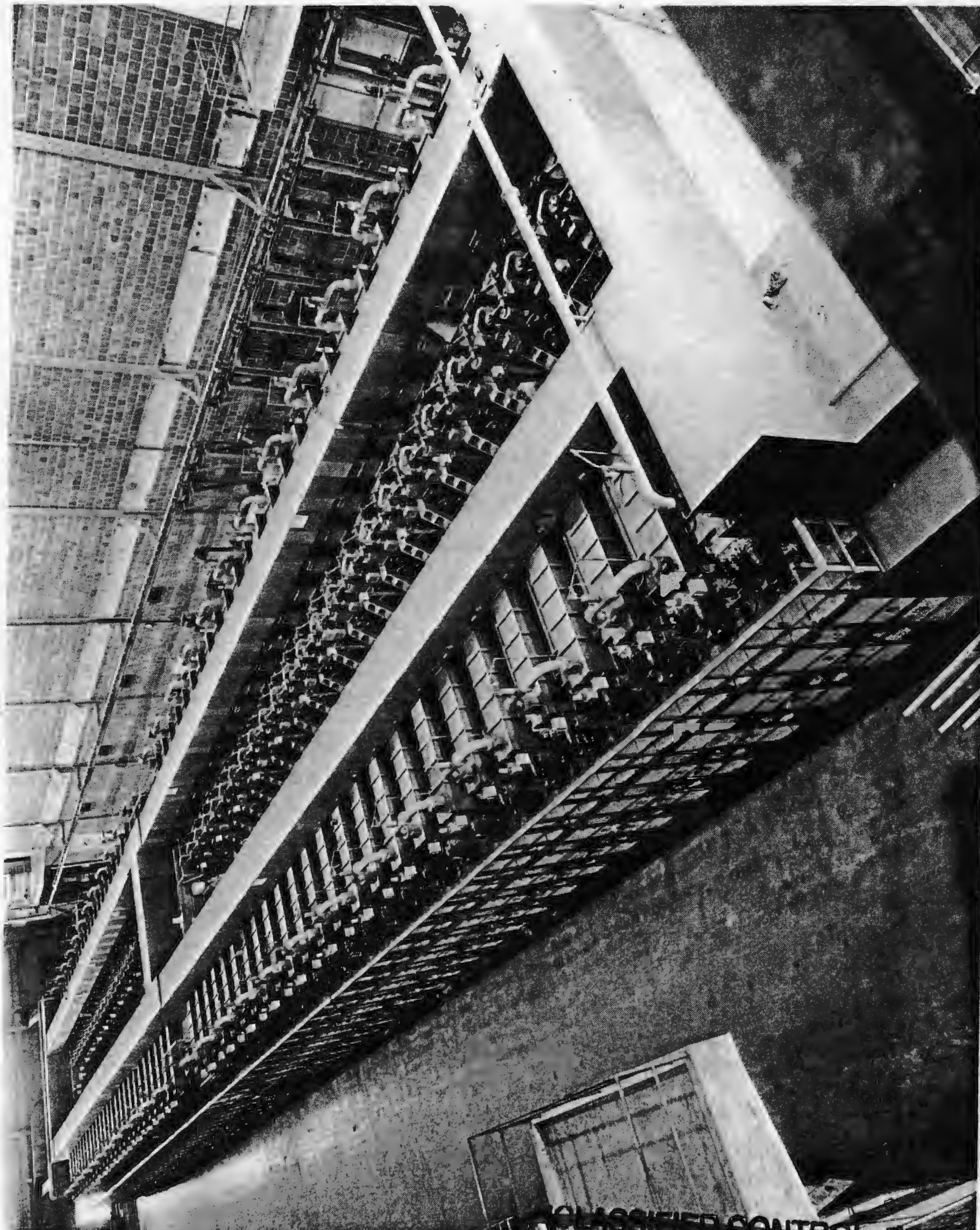

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C12. <u>Alpha II "M" Subdoor</u>

Artist's conception of the source unit for Alpha II. Note code names (Letters) used for all parts. The charge bottles (34) are fastened to the two J manifolds (28) which pass the vapor into the four J blocks (28), or ionization chambers. See paragraph 3-2.

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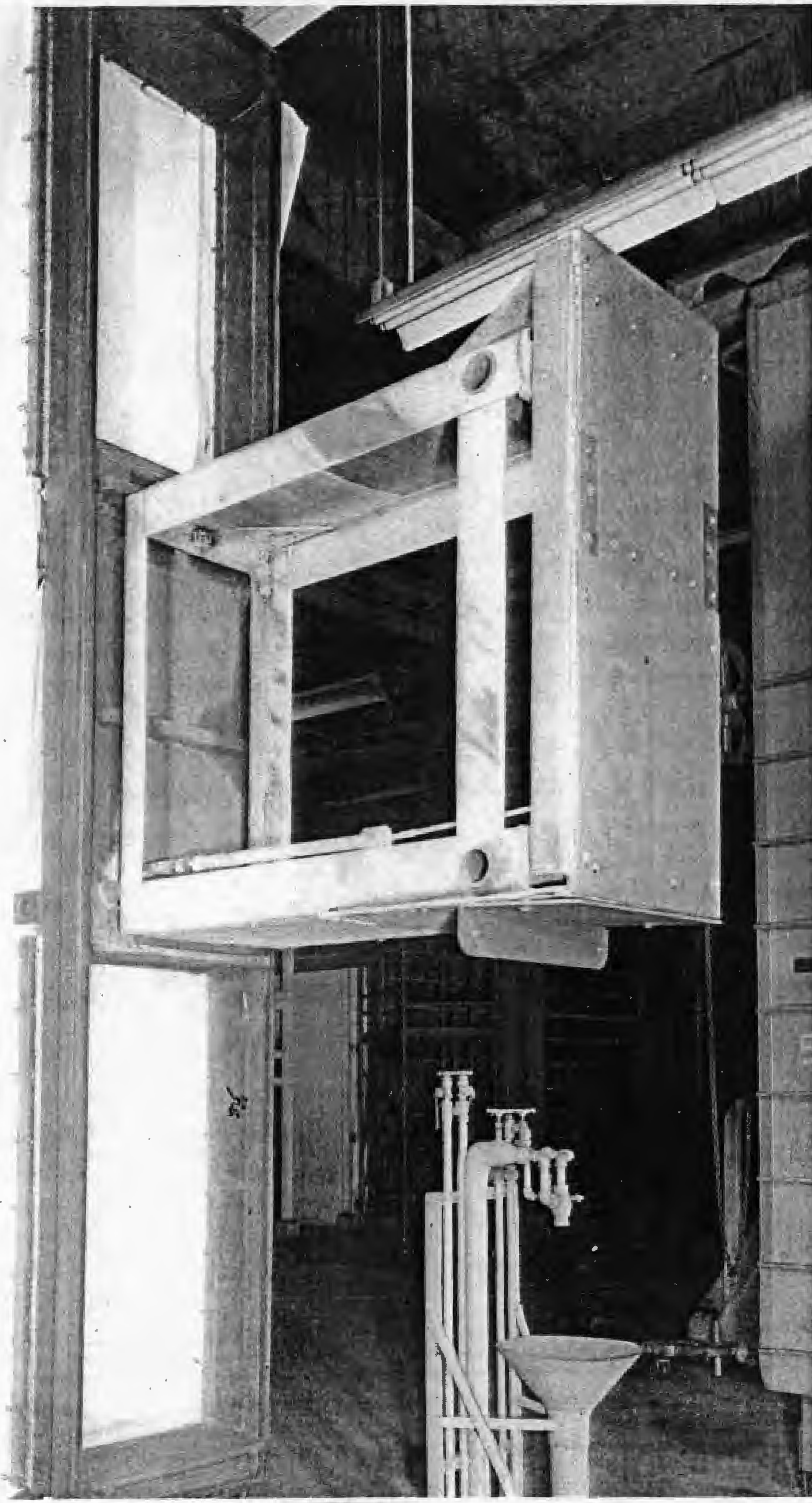
C13. Alpha II Main Door

This, the original Alpha II Liner, shows clearly the openings for the main door for the source and receiver subdoors.



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C14. <u>Modified Alpha Liner</u>

This liner, used only on track five, is shown in a partially stripped state with the "M" and "E" subdoors removed.

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C15. <u>Alpha Receiver Washing Department, Building 9206</u>

One of three identical rooms (Rms. 34, 35, 36) where the Alpha product receiver is washed to remove the valuable material. Stainless steel equipment is used throughout. Receivers are placed in spray chambers directly in front of operators and hoods shown are lowered over time chambers. A spray of nitric acid solution is pumped over the receivers by means of small pumps under the stand. Stand in back of tray has split-type ventilation to remove nitric acid fumes while spray chambers are in operation. Operators are protected from corrosive solutions by means of impervious aprons and gauntlets. All such protective clothing and uniforms are washed in facilities that contain equipment for salvage of material accidentally splashed or picked up.

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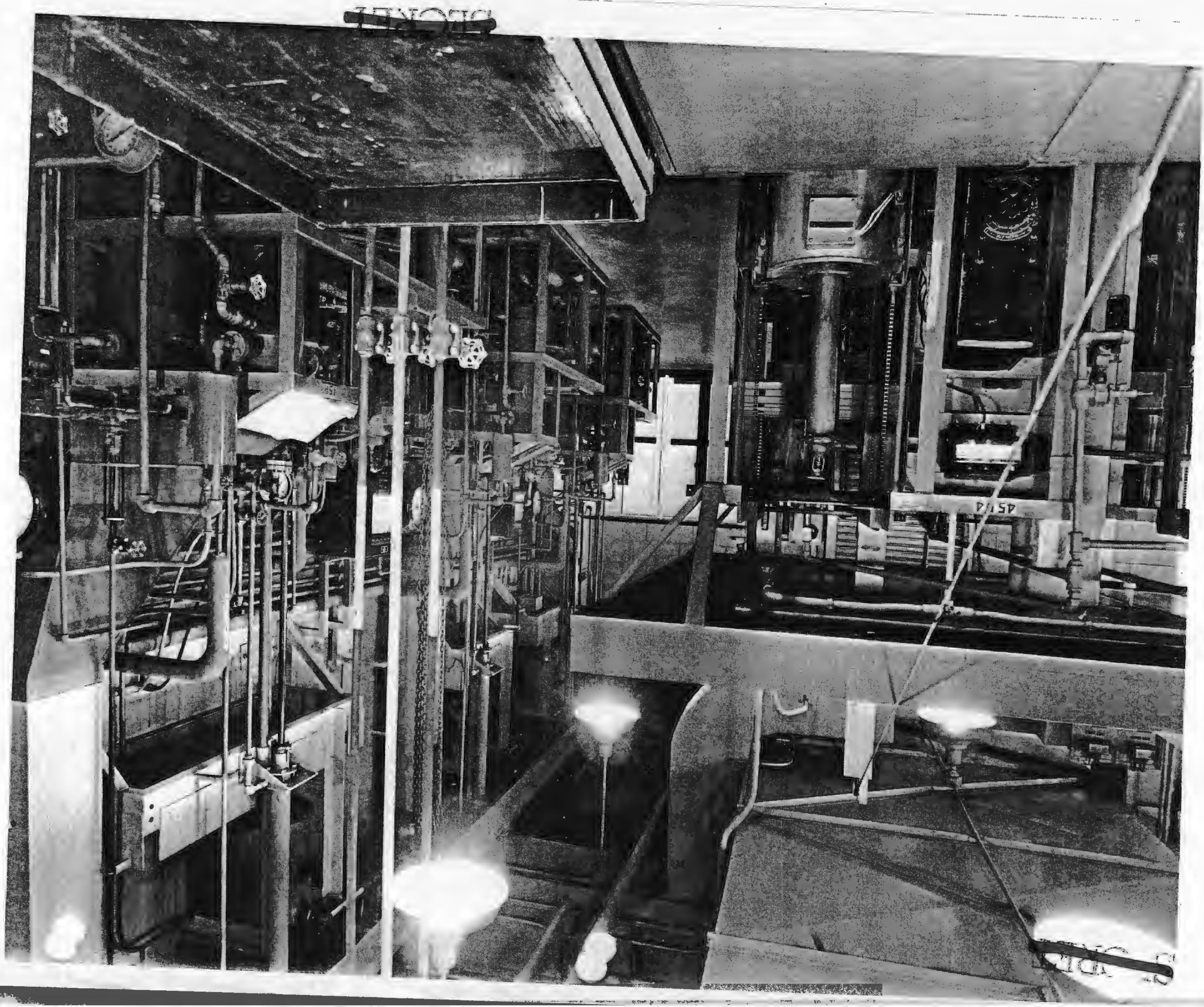
C16. <u>Beta Charge Preparation Department</u>

Three liquid phase reactors are shown along wall on the right with associated piping and equipment. Left center shows decomposer ovens and their controls.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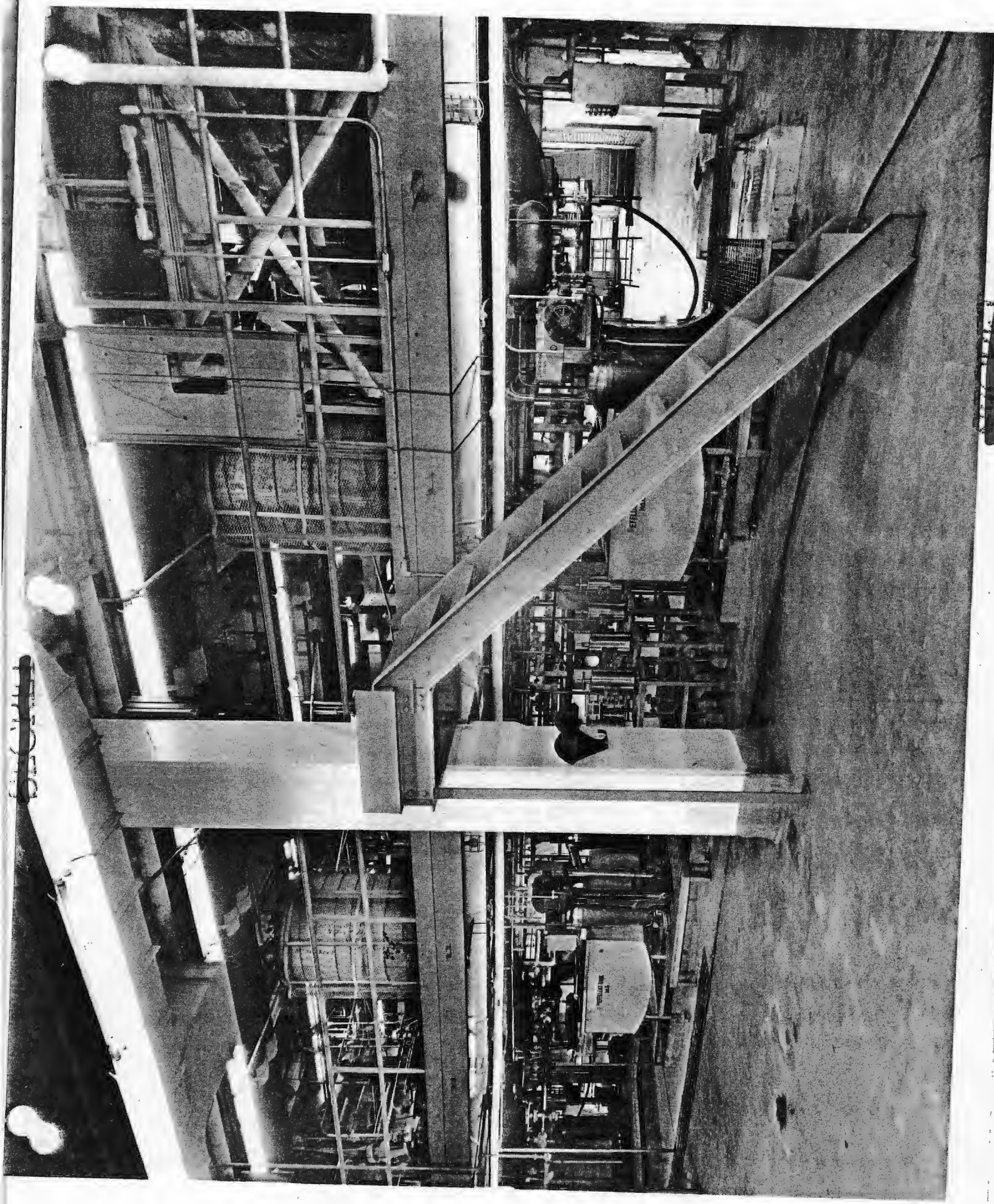
C17. Beta Wash Recovery in Beta Process Bldgs.

Cold precipitation equipment shown on mezzanine and bottom floors. Wash areas are on floor above and not shown. Evaporator feed tanks are shown in mezzanine foreground. On bottom floor can be seen Sharples centrifuges beside effluent or weir tanks with small Alsop filters behind column in center.



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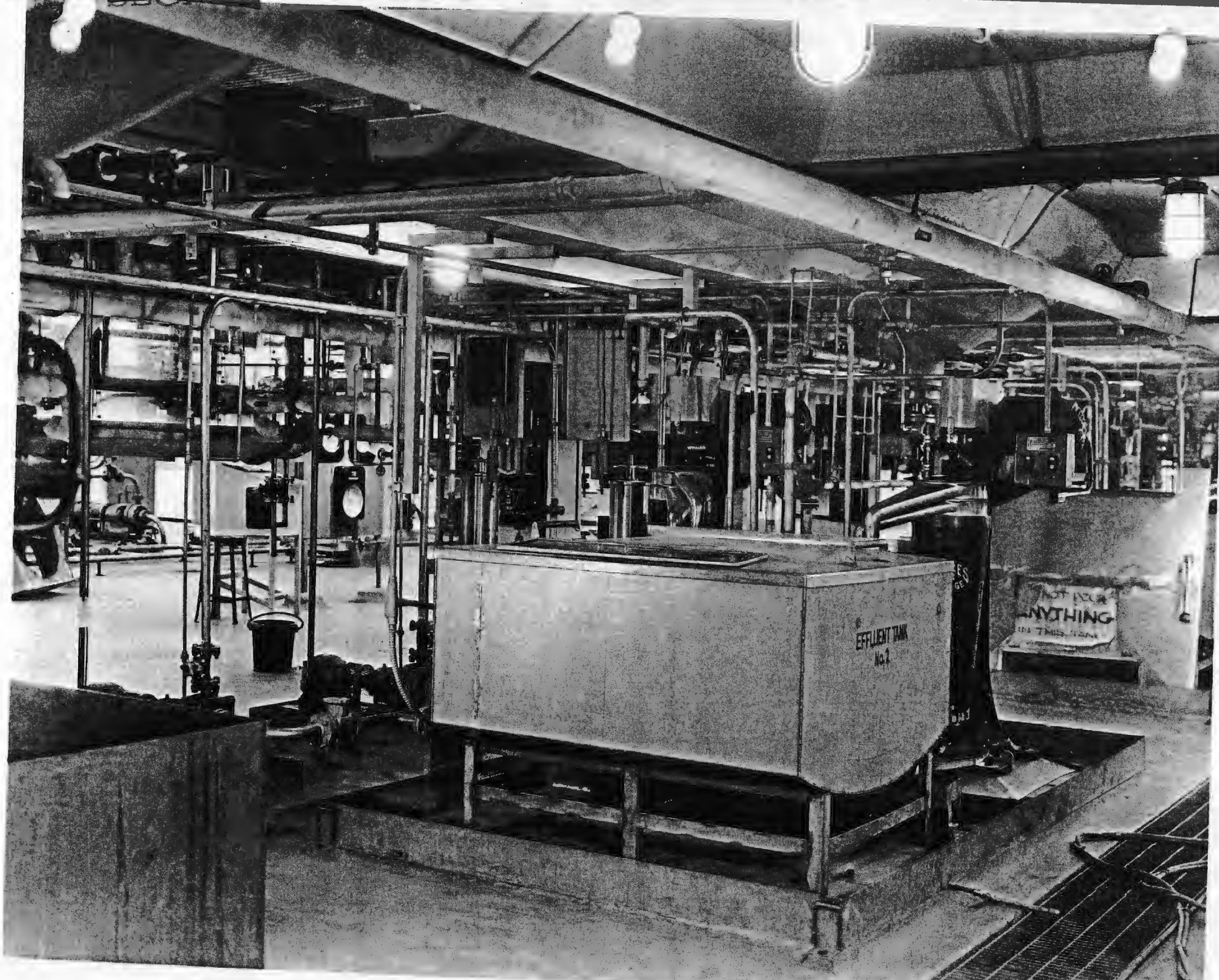
C18. Beta Wash Recovery in Beta Process Buildings

Closeup of Sharples centrifuges and stainless steel effluent tanks.



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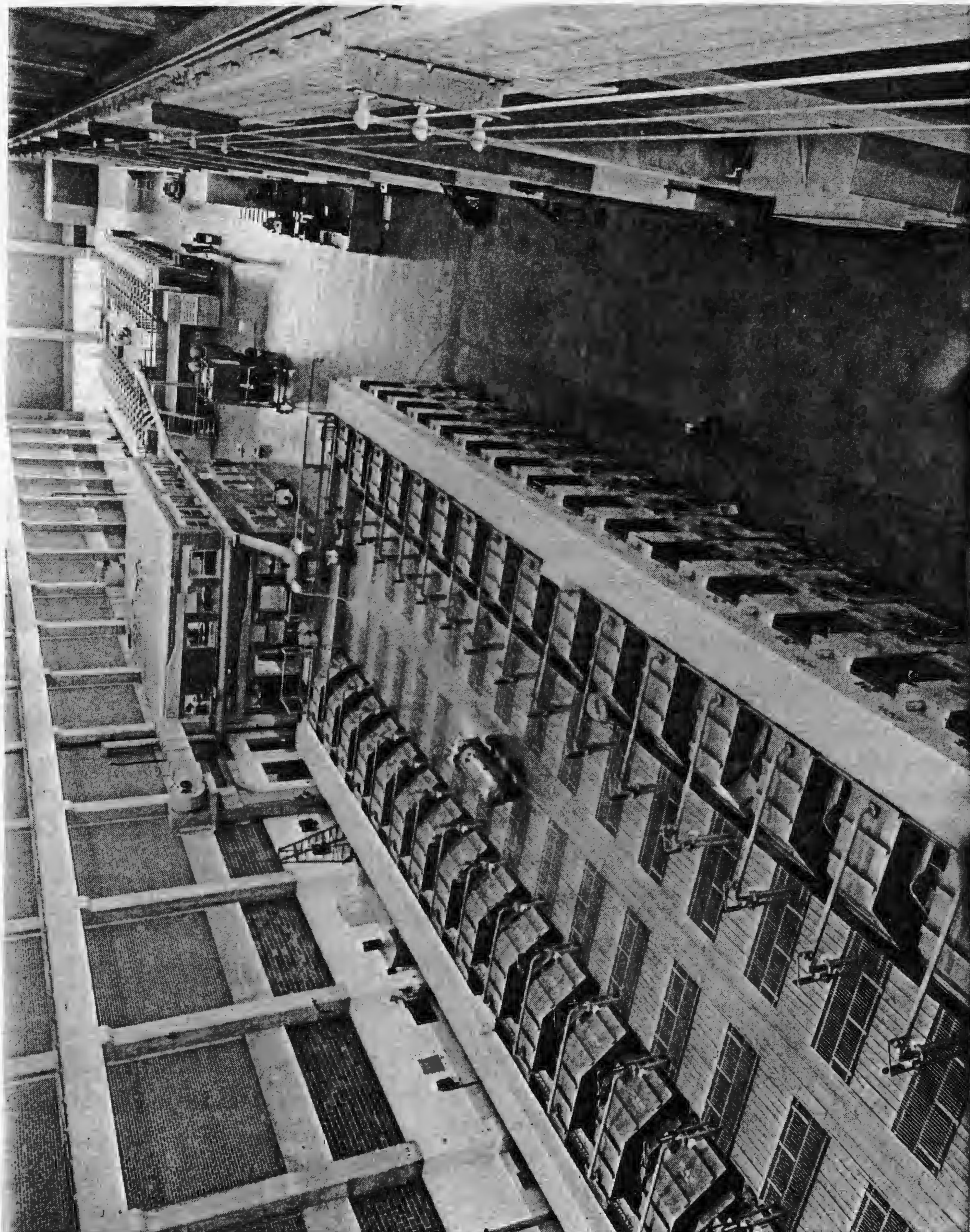
G19. <u>Beta Racetracks</u>

View looking west in the first Beta building showing the two tracks. Note the two manifolds and their diffusion pumps on handling trucks between the tracks. Penthouse offices, shown against left wall, were omitted from the third and fourth Beta buildings by direction of General Groves.



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