PORTSMOUTH GASEOUS DIFFUSION PLANT, X-333 PROCESS BUILDING
3930 U.S. Route 23 South
Piketon vicinity
Pike County
Ohio

HAER OH-142-E

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WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240

HISTORIC AMERICAN ENGINEERING RECORD

PORTSMOUTH GASEOUS DIFFUSION PLANT, X-333 PROCESS BUILDING

HAER No. OH-142-E

<u>Location:</u>	Portsmouth Gaseous Diffusion Plant (PORTS), 3930 U.S. Route 23 South, Piketon vicinity, Scioto Township, Pike County, Ohio The X-333 Process Building is located at Ohio State Plane South coordinates at easting 1827545.162650 ft, northing 371204.126471854 ft and at Universal Transverse Mercator Zone 17N easting 327190.1529 m, northing 4320683.302 m. The coordinate represents the approximate center of the X-333 Process Building. This coordinate was obtained on June 19, 2019 by plotting its location in EnviroInsite 10.0.0.37. The accuracy of the coordinates is +/- 12 meters. The coordinate datum is North American Datum 1983.
<u>Date of Construction:</u>	1955
<u>Designer/Builder:</u>	Peter Kiewit Sons' Construction Company
<u>Previous Owner:</u>	N/A
<u>Present Owner:</u>	The Atomic Energy Commission (AEC) oversaw construction and operation of PORTS until 1974, when the Energy Research and Development Administration was established with responsibility for research and development duties from 1974-1977. In 1977, the U.S. Department of Energy (DOE) was established, overseeing operations at PORTS.
<u>Present Use:</u>	Uranium enrichment no longer occurs within the X-333 Process Building. The building is no longer in use and is awaiting demolition.
<u>Significance:</u>	The X-333 Process Building was used for the initial phase of the uranium enrichment process, low assay withdrawal, production, and distribution of plant dry air, and the cold recovery system. Enriched uranium from X-333 was further processed in the cascade in X-330 and X-326. This building is part of PORTS, which was a part of the U.S. Cold War nuclear weapons complex. PORTS' primary Cold War era mission was the production of highly enriched uranium (HEU) by the gaseous diffusion process for defense/military purposes. Uranium was enriched at PORTS from 1954 until May 2001. From the end of the Cold War in 1991 until production ceased in 2001, PORTS enriched uranium for the longest period of time and to the highest levels within the DOE complex.
<u>Project Information:</u>	Fluor-BWXT Portsmouth LLC photographed the site in August 2014. Gray & Pape, Inc., Cincinnati, Ohio, served as the primary author of the historical narrative and resource descriptions drawing from numerous historical records and reports, drawings, photographs and plans. For additional contextual information, see Portsmouth Gaseous Diffusion Plant,

HAER no. OH-142. This X-333 Process Building HAER was completed in 2021.

Part I. Historical Information

In support of this report, there are three appendices that are provided: Appendix A through C, which consist of survey photographs, historical photographs, and historical drawings, respectively.

Construction History of the X-333 Process Building:
The X-333 Process Building was built under a lump-sum subcontract. Peter Kiewit Sons' Construction Company awarded subcontracts for foundation work and underground installations, structural steel, roofing, siding, exterior doors, freight elevators, acoustic tile, refrigeration systems, glass and glazing, and numerous other tasks necessary for the building's operations.

The Eichleay Corporation began installation of the concrete footings, piers, grade beams, and walls in October 1953. Approximately 48,000 cubic yards of concrete were used in this work. The concrete floor was poured by October 1954 and required approximately 34,300 cubic yards of concrete and 548 tons of reinforcing steel. Column-encasement forming began in March 1954 and completed in September later that year. Column-encasement required over 10,000 cubic yards of concrete and 240 tons of reinforcing steel. Final pouring of the cell floor slab was in November 1954, which required approximately 47,000 cubic yards of concrete and 1,700 tons of reinforcing steel. Concrete pouring for the process equipment foundations was completed in December 1954, requiring approximately 7,400 cubic yards of concrete and 160 tons of reinforcing steel.

Bethlehem Steel Company erected the structural steel, which began in January 1954 and was complete by early September of that year. Approximately 36,000 tons of structural steel was erected. Brown and Kerr installed the metal roof deck, roof insulation, built-up roofing, gravity ventilators, and related sheet metal. These activities began in March 1954 and were complete by October 1954. Furnishing and installation of all corrugated cement-asbestos siding and related work was performed by Corrugated Asbestos Constructors. This work was completed during March through November 1954.

Peter Kiewit Sons' Company laid masonry blocks, face tiles, and ceilings from June 1954 through January 1955. Subcontracts were awarded for tasks such as lathing, plastering, painting, and the installation of tile ceilings, ceiling suspension systems and exterior doors. Installation of interior electrical systems, plumbing, heating and ventilation, air conditioning and alarm systems was complete by November 1955, as was the installation of air drying equipment, compressors, motors, converters, process gas and auxiliary piping, and instrumentation. The building was completed and turned over to the AEC in November 1955.

Historical photographs of the building's construction are located in Appendix B (Figures 10 through 21). Historical architectural drawings are located in Appendix C (Figures 22 through 30).

Part II. Site Information

A. Description of the X-333 Process Building:

The X-333 Process Building is located immediately east of the X-330 Process Building. The X-333 Process Building housed the initial phase of the uranium enrichment process and then continued in series to the X-330 and X-326 Process Buildings. The X-333 Process Building was used for the initial phase of the uranium enrichment process, low assay withdrawal, production and distribution of plant dry air, and the cold recovery system. Uranium was enriched at PORTS until May 2001. From the end of the Cold War in 1991 until production ceased in 2001, PORTS produced only low enriched uranium (LEU) for commercial power plants.

The building measures 970' wide by 1,456' long, stands 82' tall, and covers 32½ acres. It is comprised of eight, connected building units, and constitutes the largest building at the PORTS reservation. The equipment and systems within the X-333 Process Building are similar to those of the former K-33 Building at the Oak Ridge Gaseous Diffusion Plant. The X-333 Process Building, however, does not include the surge volume area or the feed vaporization facilities found within the K-33 facility.

Designed specifically for housing gaseous diffusion equipment, the X-333 Process Building is purely functional in its design and appearance (Appendix A, Figures 2 through 5). There are no stylistic details found anywhere on the building. From the outside, the building appears much like an immense box with no windows. The building is covered with large, white, corrugated cement asbestos panels, also known as transite panels. All interior finishes were kept to a minimum, as cleaning and sanitation took priority over appearance (Figures 6 through 9).

There are truck entrances in the north and south sides of the building, and railroad spurs within the depressed truck alleys in the east and west ends of the building. The east spur was used largely for construction purposes, while the west spur was required for the movement of converters and other equipment during the operation of the X-333 Process Building.

Like the other two process buildings (X-326 and X-330), the equipment in the X-333 Process Building is on two floors, with the auxiliary equipment, support equipment, and control rooms on the first floor, also known as the operating floor or ground floor. Process auxiliaries (e.g., steam, nitrogen and dry air distribution; coolant transport and recovery; heating and ventilation; electrical power) are ancillary systems used to facilitate the primary enrichment process. Support equipment (e.g., computer and communication equipment, sanitary and sewage utilities, security equipment) assist in process building operations, but are not directly associated with the enrichment process. The diffusion process equipment is located on the second floor, known as the cell floor.

The height between the ground floor and the cell floor allows for 12' of clearance for ground floor operations, as well as clearance for the installation of electrical work, mechanical duct work, and piping. The extreme height of the first floor enabled the numerous trades of construction workers to proceed with their tasks simultaneously. The building's height between the cell floor and the roof structure provides for clearance for the cell housings, which required the use of overhead cranes for changing out converters and supporting equipment.

Part III. Operations and Process

A. Operations:

At PORTS, uranium was enriched using a process called gaseous diffusion. Through the process of diffusion, gaseous uranium hexafluoride (UF_6) is passed through a conversion system to produce enriched, or diffused, uranium-235 and undiffused uranium-238. The process of uranium enrichment increases the proportion of uranium-235 to that of uranium-238. Enriched uranium contains uranium-235 at approximately 4 to 5 percent of the total uranium mass.

The gaseous diffusion process requires the use of UF_6 to separate the uranium-238 and uranium-235 isotopes. During diffusion, UF_6 gas is forced through a series of porous membranes, or "barriers" with microscopic openings. Barriers are used to achieve separation in the gaseous diffusion process. To maximize the amount of separation achieved, the porous barrier material must meet exacting standards so that "diffusive" flow occurs. Uranium-235 moved through the barriers more easily, increasing the concentration of uranium-235 as it moved through the process. The tendency for uranium-235 to pass through the barrier more quickly is the basis for the gaseous diffusion process.

The basic separation equipment for gaseous diffusion is a "stage." At PORTS, a stage consisted of a converter that contains porous separation media, a gas cooler, a compressor to move the UF_6 gas through the converter, and interconnecting piping and control valves to contain and control the gas flows. One stage was capable of only very slight enrichment. Stages operated in a cascading system, and thousands of stages in the process buildings were connected in series to produce HEU. The X-333 Process Building contains 640 stages.

Stages were grouped into "cells," which were the smallest groups of stages that could be removed from service, bypassed, and shut down for maintenance or other purposes. There are eight stages per cell in the cells in the X-333 Process Building, and the building housed 80 cells.

Cells were further grouped into "units," which were groups of cells that shared common auxiliary systems. Each operating unit within the building was divided into two groups of 10 cells. The 80 cells in the X-333 Process Building are grouped into eight units.

The process equipment, piping, and instrument lines that contained process gas were enclosed by cell housing and bypass housing. The cell housing for the X-333 process equipment has a steel frame and transite siding. The tops of the housings have removable hatches that allow for equipment removal.

Feed material entered the uranium enrichment process at the X-333 Process Building. The X-333 Process Building contains the largest pieces of gaseous diffusion equipment at PORTS. The size of process equipment in the X-333 Process Building was referred to as the X-33 size (i.e., “000”).

The purge and product area is located in the X-326 Process Building. Purging separated and removed light gas contaminants that leaked into the system during the diffusion process. The waste, or tails stream, of the enrichment process was withdrawn from the gaseous diffusion cascade and packaged into storage cylinders.

In the X-330 Process Building, one unit with X-29 sized equipment and two units with X-31 sized equipment served as the stripping section of the cascade. The stripping section consists of the stages located below the feed point of the cascade. From the X-29 sized unit, waste material was withdrawn from the cascade at the PORTS Tails Withdrawal Station.

The PORTS Tails Withdrawal Station is located in the X-330 Process Building. The waste, or tails, from the gaseous diffusion process consisted of depleted process gas. Depleted process gas from the enrichment process was withdrawn from the gaseous diffusion cascade, compressed, and condensed into a liquid that flowed by gravity to cylinders located on scales. Cranes were used to move these cylinders to cooling areas and load them for transport.

B. First Floor:

All of the auxiliary systems, electrical power substations, and control centers are located on the first floor of the X-333 Process Building. In addition to these supporting systems, the first floor also contains numerous enclosed areas for operating purposes. The building's unit substations and auxiliary equipment are located to the north and south of these enclosures. There are eight of these areas, each corresponding to one of the building's eight units.

Each side of the building includes an air intake or filter room for each of the eight units. Louvers on the exterior walls of the building provide for movement of air into the building. The louvers themselves comprise an entire wall of the filter room. Each room has a removable filter set in a steel frame. Air movement was performed by large intake fans. Air drawn in at the first floor supplied air to both the ground and cell floors.

The majority of the first-floor enclosures, as well as the stairwell enclosures, consist of cinderblock construction. Glazed structural tile was used in areas with specific sanitation requirements. Metal decking was used for the roofs of the maintenance, control area, and filter rooms. Concrete slabs were used for a number of the other X-333 Process Building enclosures.

Finishes within the interior of the X-333 Process Building reflect the need for sanitation and ease of cleaning and maintenance. Most floor surfaces consist of chemically hardened, smooth-finished concrete. The control areas are the only locations within the building that feature asphalt tile floors. All ferrous metal surfaces, such as exposed steel framing and doors, are painted. All the piping within the building is color-coded and marked for quick identification. The design of the enclosures for the various rooms within the X-330 Process Building follows the same basic plan as that for the X-326 and X-333 Process Buildings. All building finishes were designed for cleanliness and sanitation.

C. Second Floor (Cell Floor):

The X-333 Process Building's primary processing equipment is located on the cell floor. The X--33 equipment has eight units (80 cells and 640 stages). The cells extend across the width of the building and are located within a central bay.

The housing for the process equipment was designed to maintain operating temperatures during the gaseous diffusion process. This was accomplished by erecting a cement-asbestos-covered steel frame around the compressors and converters. The booster stations, evacuation station, and outside tie-lines feature similar enclosures.

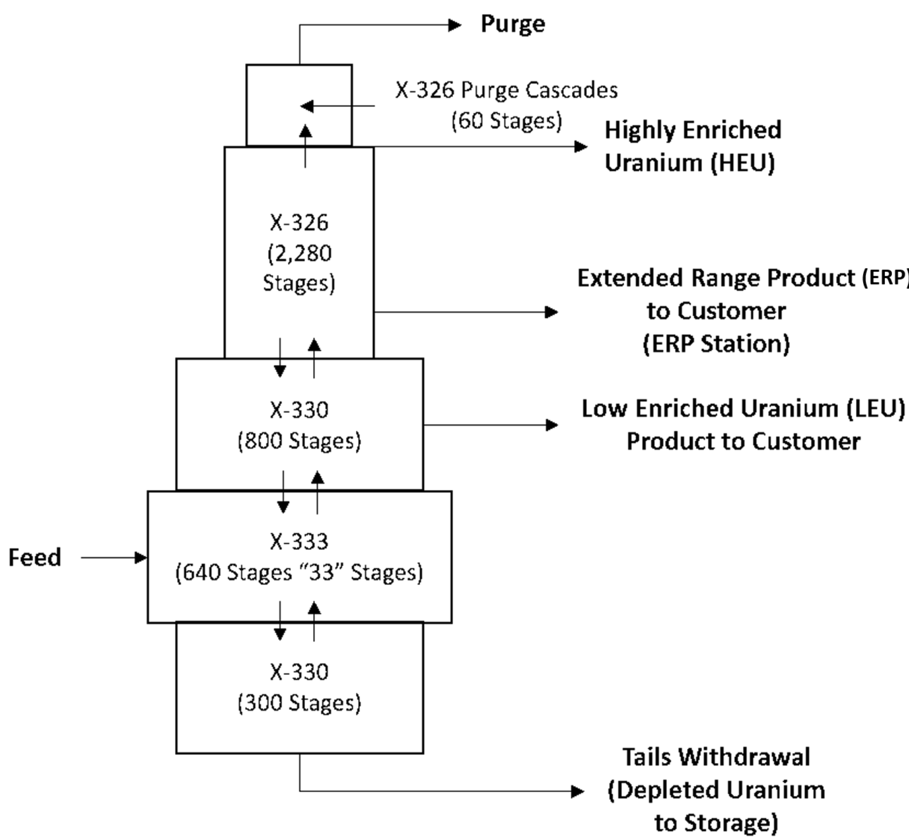
Access to the equipment is provided by a network of ladders, platforms, and catwalks. There are eight stairways that provide access to the roof, and 39 stairways that facilitate movement between the ground and cell floors. Each of the building's 21 bays contains its own overhead, electric crane.

The process units in the X-333 Process Building are very similar to those in the K-33 Building at Oak Ridge and consist of two types. The difference relates to the size of the compressor motors and their electrical switchgear. The overall system is divided into units of cells arranged in series and could accommodate different types of feed material from the feed plant. Originally, the X-342A Feed, Vaporization, and Fluorine Generation Facility served as the solitary source of feed for the gaseous diffusion cascade. However, the X-343 Feed, Vaporization, and Sampling Facility took over as the primary feed source for the cascade after it was completed in 1982.

Process gas removal for maintenance was accomplished via the evacuation system. This system enabled operators to remove gas from any of the cells and main piping system. Gas evacuated from the system entered into a recovery process. The gas recovery system (Cold Recovery) solidified the UF_6 while venting the light gas impurities. The recovered UF_6 was returned to a gaseous state to be held in drums and later returned to the diffusion cascade. The uranium enrichment process was initiated in X-333 and continued in series to X-330 and X-326. Materials were withdrawn from the cascade at the following three locations:

- X-326 Product Withdrawal Station (90 to 97 percent uranium-235 during HEU production, 2.0 to 5.0 percent uranium-235 during LEU production)
- X-326 Extended Range Product Station (0.7 to 5.0 percent uranium-235)
- X-333 Low Assay Withdrawal Station (1.0 to 5.0 percent uranium-235)
- X-330 Tails Withdrawal Facility (0.2 to 0.3 percent uranium-235 and 1.0 to 5.0 percent uranium-235).

A diagram showing the gaseous diffusion "cascade" at PORTS is shown below.



PORTS Gaseous Diffusion "Cascade"

D. Structural Design:

The structural framing of the X-333 Process Building was based on the design used for the K-902 Building Unit within the K-33 at Oak Ridge, and the C-333 Building at Paducah. Some minor alterations to the design were necessary for the building's foundations, which engineers tailored specifically for soil conditions at PORTS. In addition, the X-333 Process Building would feature an interior instrumentation tunnel, as well as auxiliary facilities specific to the X-333.

The immense size of the building created unique conditions with regards to expansion and contraction. To accommodate movement, engineers divided the steel framing into 40 structural units, each separate from the other. The roof structure rests atop purlins (horizontal boards supporting roof rafters), which in turn rest atop trusses and beams.

The ground floor of the X-333 Process Building is comprised of a 6" thick, floating concrete slab that was designed for wheel loads of 7,000 pounds per square foot. In areas that were designed to support heavy transformers, engineers specified 8" concrete. The floor was built with methods and equipment typically used for highway construction, with reinforced, highway-type joints. This type of construction permitted heavy load transfers between expansion joints in the slab.

The cell floor is supported by steel columns that have been encased in a minimum of 1" thick concrete. The cell floor (the 2nd floor) itself was designed to withstand the effects of the cell equipment, which operated at 1,200 rpm, generating a frequency of 20 cycles per second. The exterior framing for the cell floor is comprised of light, steel beams and struts, which support the transite tiles on the side of the building.

Part IV. Sources of Information

Benedict, Mason and Clarke Williams. *Engineering Developments in Gaseous Diffusion Process*. New York: McGraw-Hill Books Company, Inc., 1949.

Department Of Energy. *The Role of the Portsmouth Gaseous Diffusion Plant in Cold War History*. Piketon, OH: U.S. Department of Energy, 2017.

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Department Of Energy. *Engineering Evaluation/Cost Analysis for the Plant Support Buildings and Structures at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0207&D4. Piketon, OH: U.S. Department of Energy, October 2011.

Department Of Energy. *National Historic Preservation Act Section 110 Survey of Architectural Properties at the Portsmouth Gaseous Diffusion Plant in Scioto and Seal Townships, Piketon, Ohio,* DOE/PPPO/03-0147&D1. Piketon, OH: U.S. Department of Energy, January 2011.

Department Of Energy. Highly *Enriched Uranium: Striking a Balance, A Historical Report on the United States Highly Enriched Uranium Production, Acquisition, and Utilization Activities from 1945 to September 30, 1996*, Revision 1. Washington, D.C.: National Nuclear Security Administration, U.S. Department of Energy, 2001.

Giffels & Vallet, Inc. *Gaseous Diffusion Plant at Portsmouth, Ohio, Project History and Completion Report* (Redacted). Washington, D.C.: U.S. Atomic Energy Commission, 1957.

Portsmouth Gaseous Diffusion Plant Virtual Museum – accessed at http://www.portsvirtualmuseum.org/ operated and managed by Fluor-BWXT Portsmouth for DOE.

Appendix A: Survey Photographs

Figure 1: Location and Orientation of Exterior and Interior Photographs (A-2 through A-9)

Figure 2: North Side of the X-333 Process Building, August 2014, Facing Southwest

Figure 3: North Side of the X-333 Process Building, August 2014, Facing Southeast

Figure 4: South Side of the X-333 Process Building, August 2014, Facing Northwest

Figure 5: South Side of the X-333 Process Building, August 2014, Facing Northeast

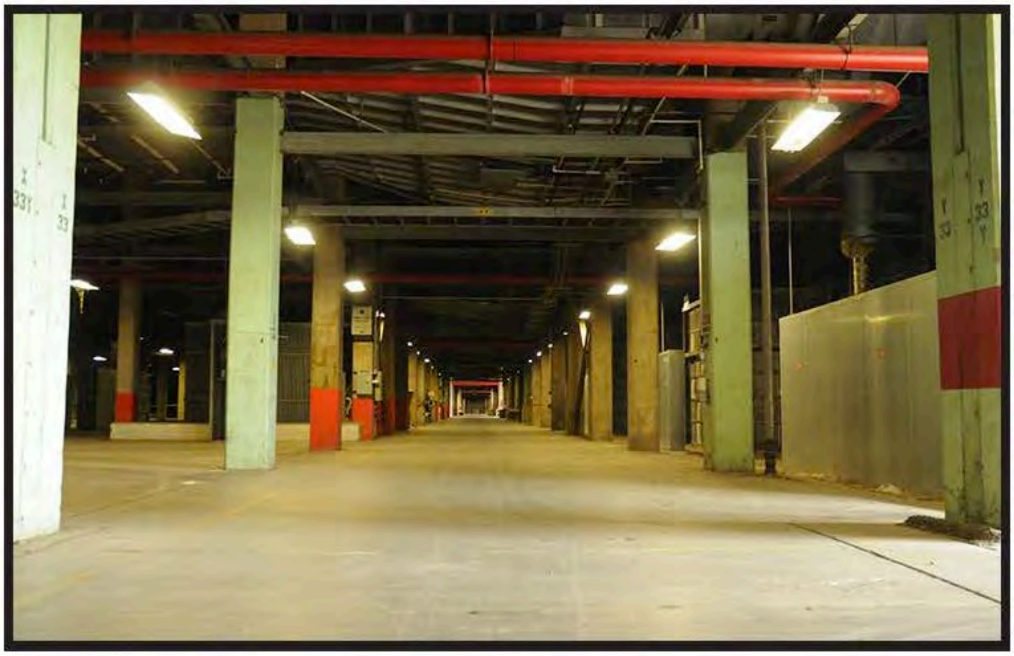

Figure 6: Interior View of the X-333 Process Building, August 2014, Facing West

Figure 7: Interior View of the X-333 Process Building, August 2014, Facing South

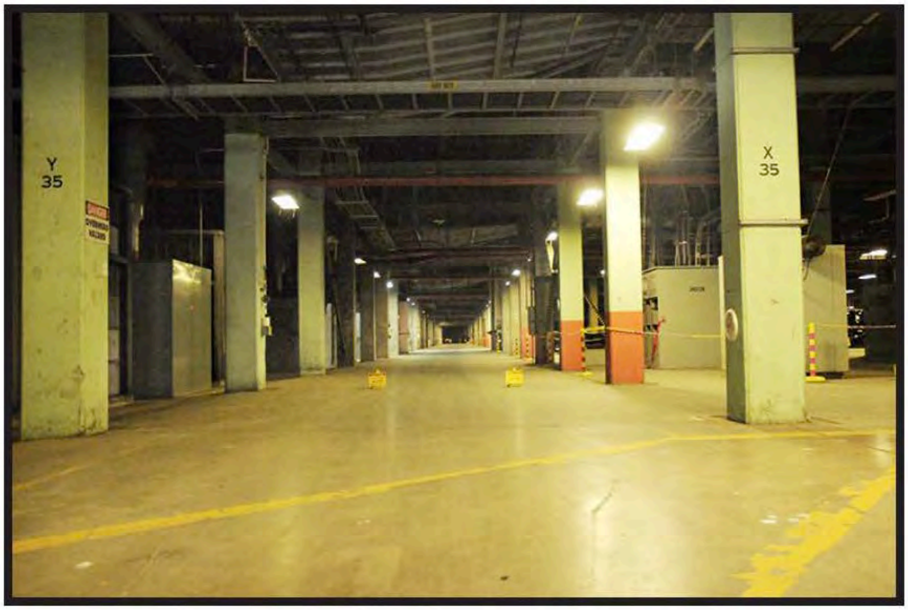

Figure 8: Interior View of the X-333 Process Building, August 2014, Facing East

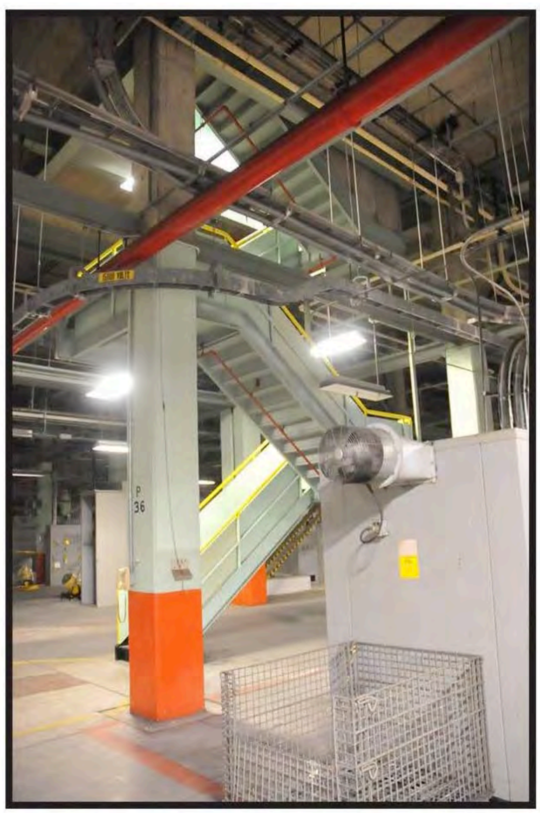

Figure 9: Interior Staircase Leading to the Cell Floor Inside the X-333 Process Building, August 2014

Appendix B: Historical Photographs

Figure 10: Site of the X-333 Process Building, Looking East, August 1953

Figure 11: Overview of the X-333 Process Building Site, January 1954

Figure 12: Steel Framework for the X-333 Process Building, April 1954

Figure 13: Bethlehem Steel Company Iron Workers, June 1954

Figure 14: Bethlehem Steel Company Foremen and Managers, June 1954

Figure 15: View of Ground Floor of the X-333 Process Building, June 1954

Figure 16: View of Cell Floor of the X-333 Process Building, July 1954

Figure 17: Looking Northeast at the X-333 Process Building, September 1954

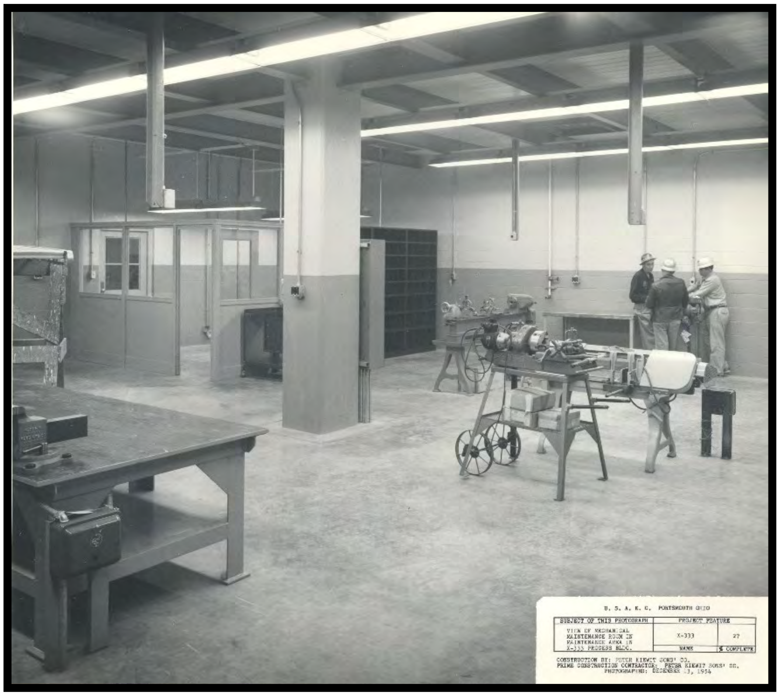

Figure 18: View of Mechanical Maintenance Room in the X-333 Process Building, December 1954

Figure 19: View of the Cell Floor of the X-333 Process Building, January 1955

Figure 20: Looking South at the X-333 Process Building, May 1955, Facing West

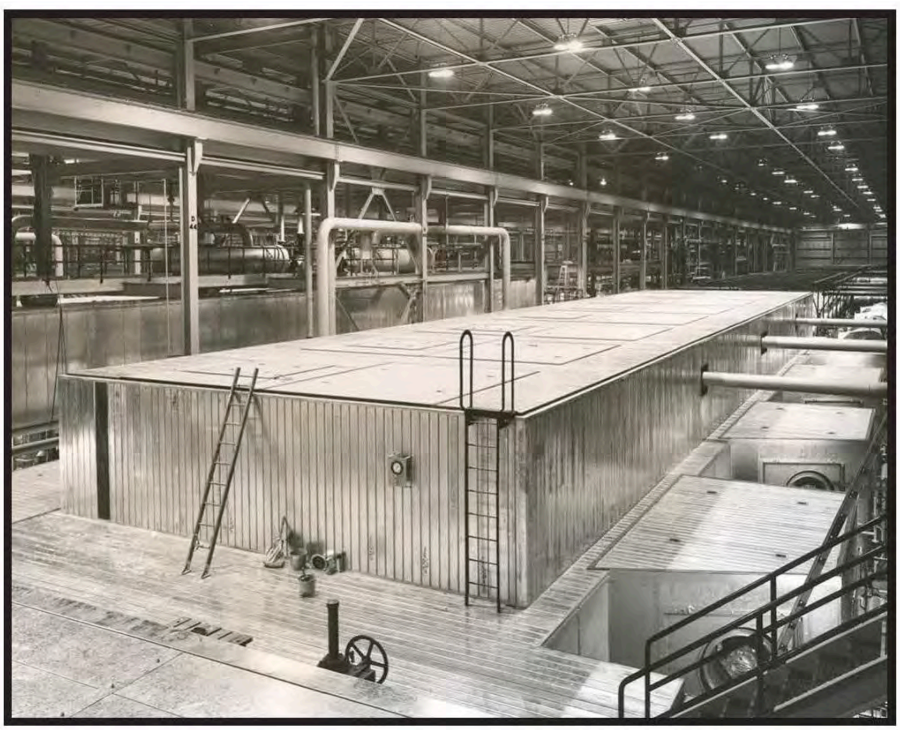

Figure 21: Interior View of the X-333 Process Building, October 1955

Appendix C: Historical Drawings

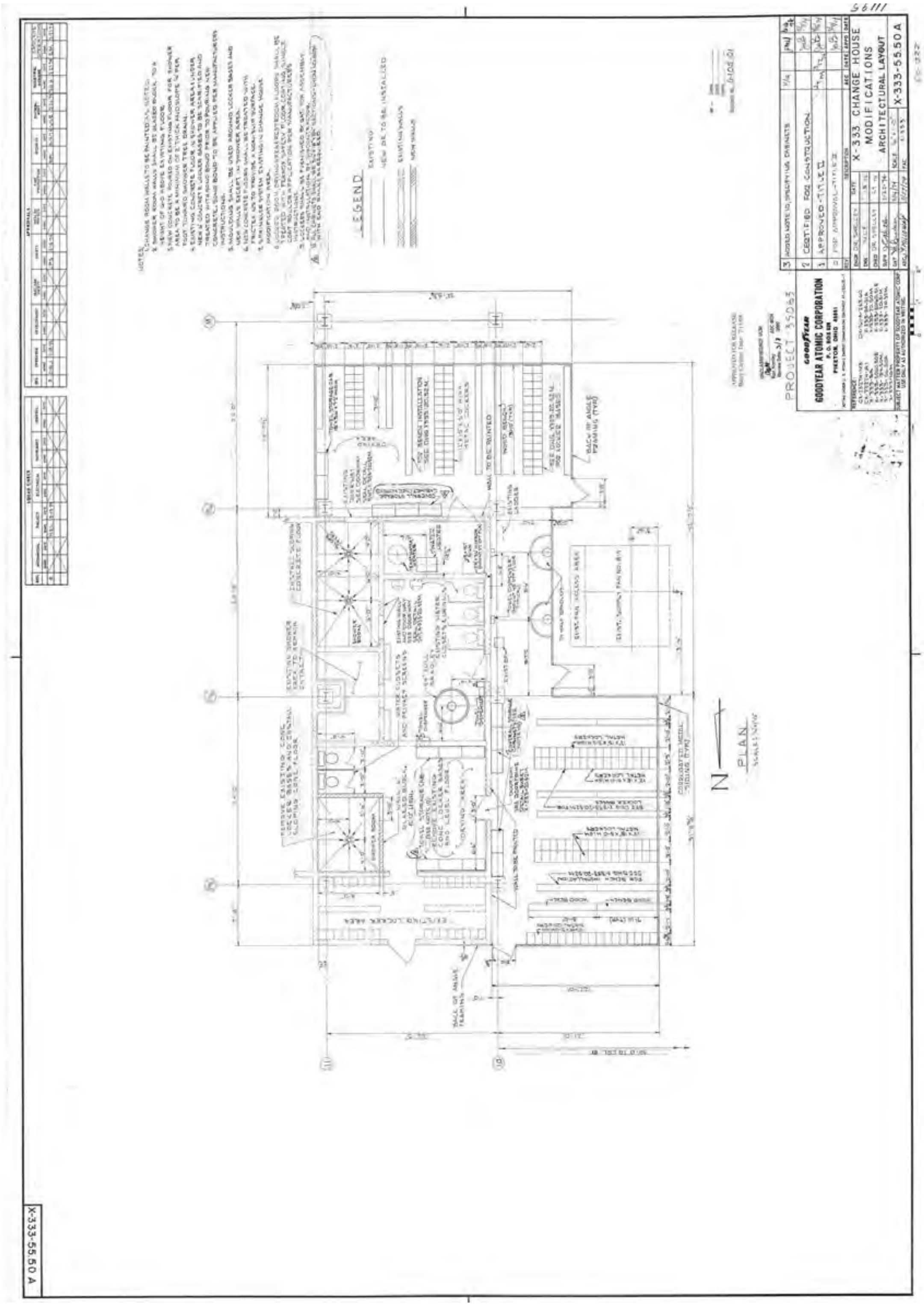

Figure 22: Change House Modifications

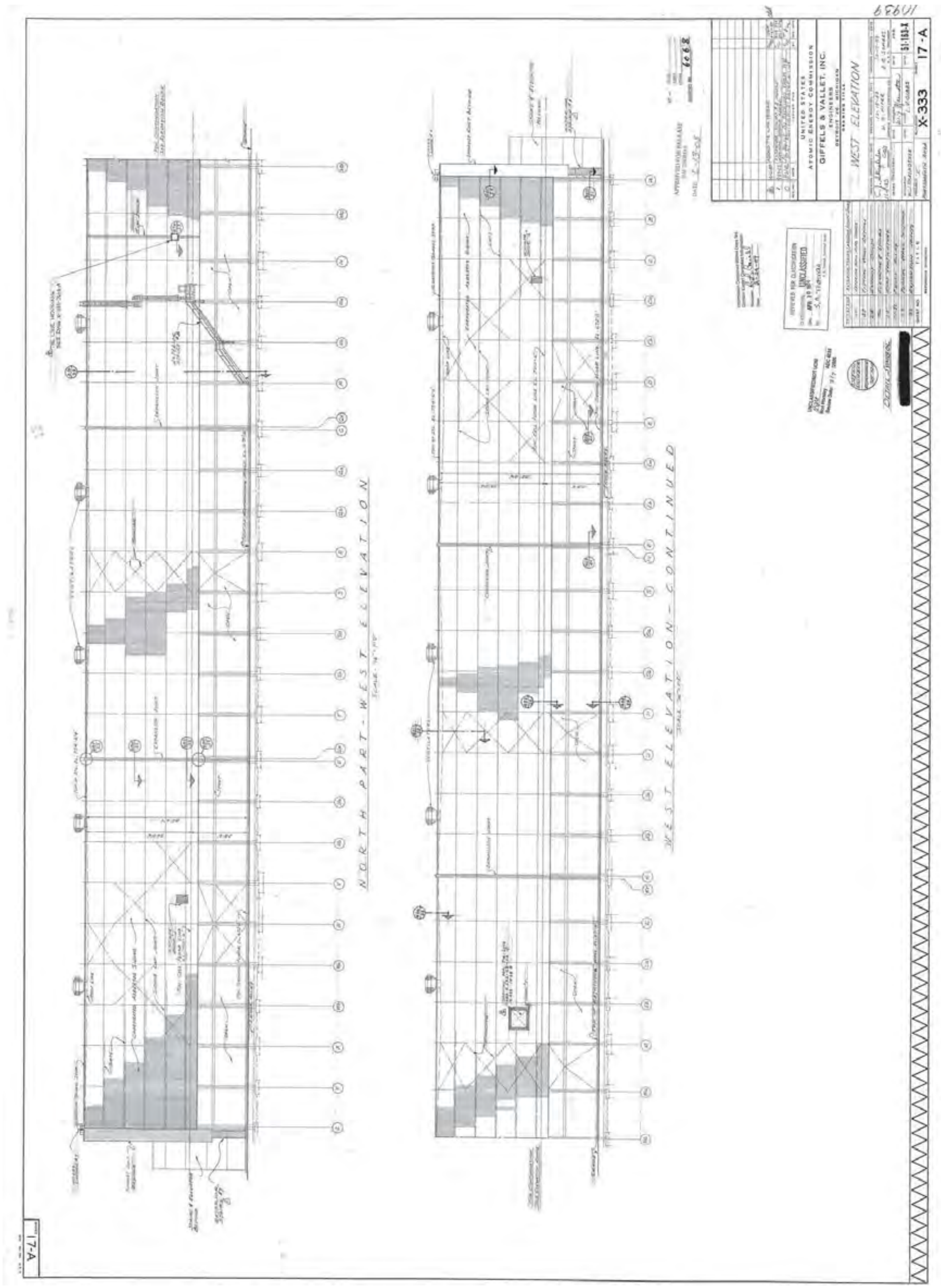

Figure 23: West Elevation

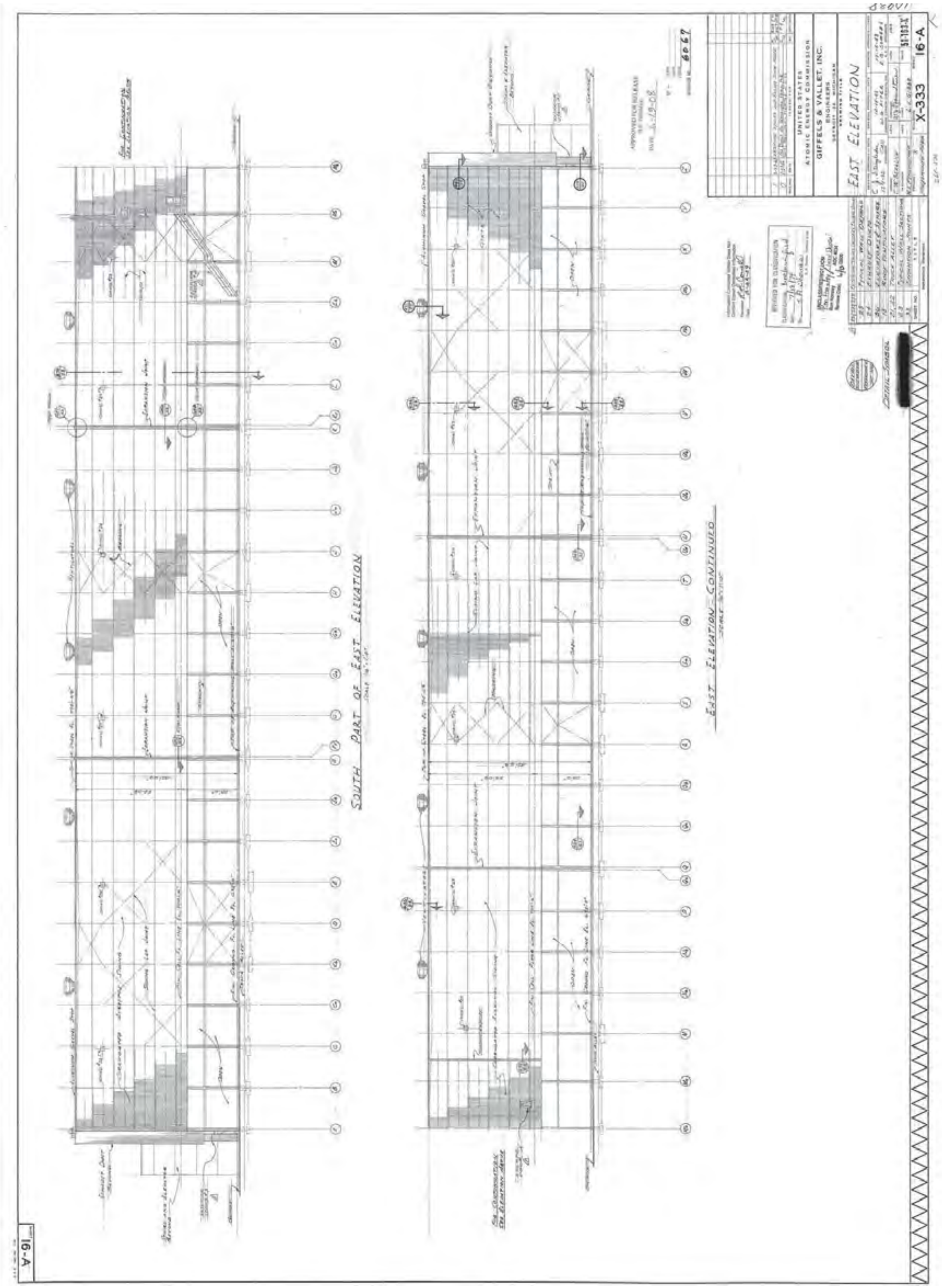

Figure 24: East Elevation

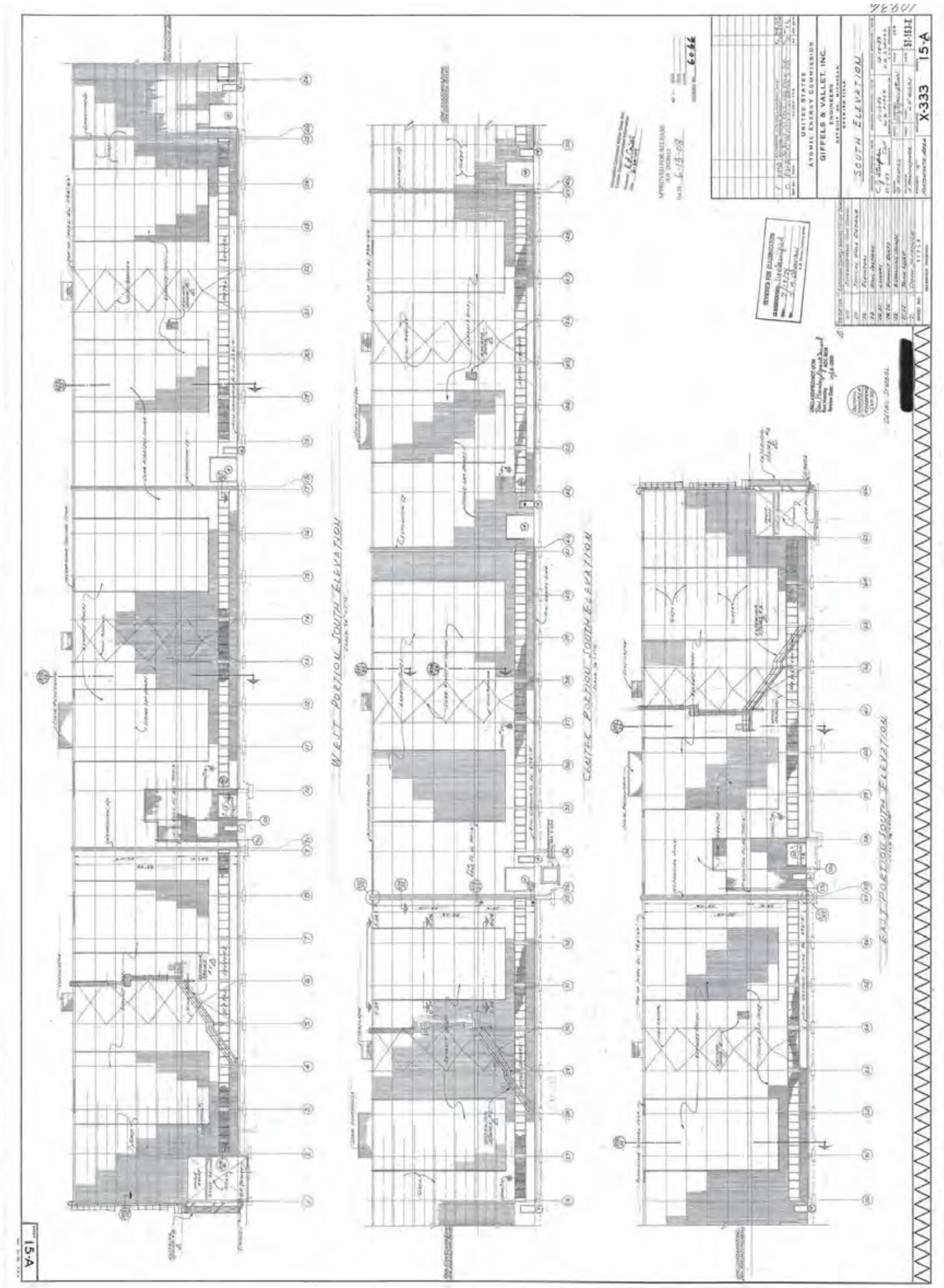

Figure 25: South Elevation

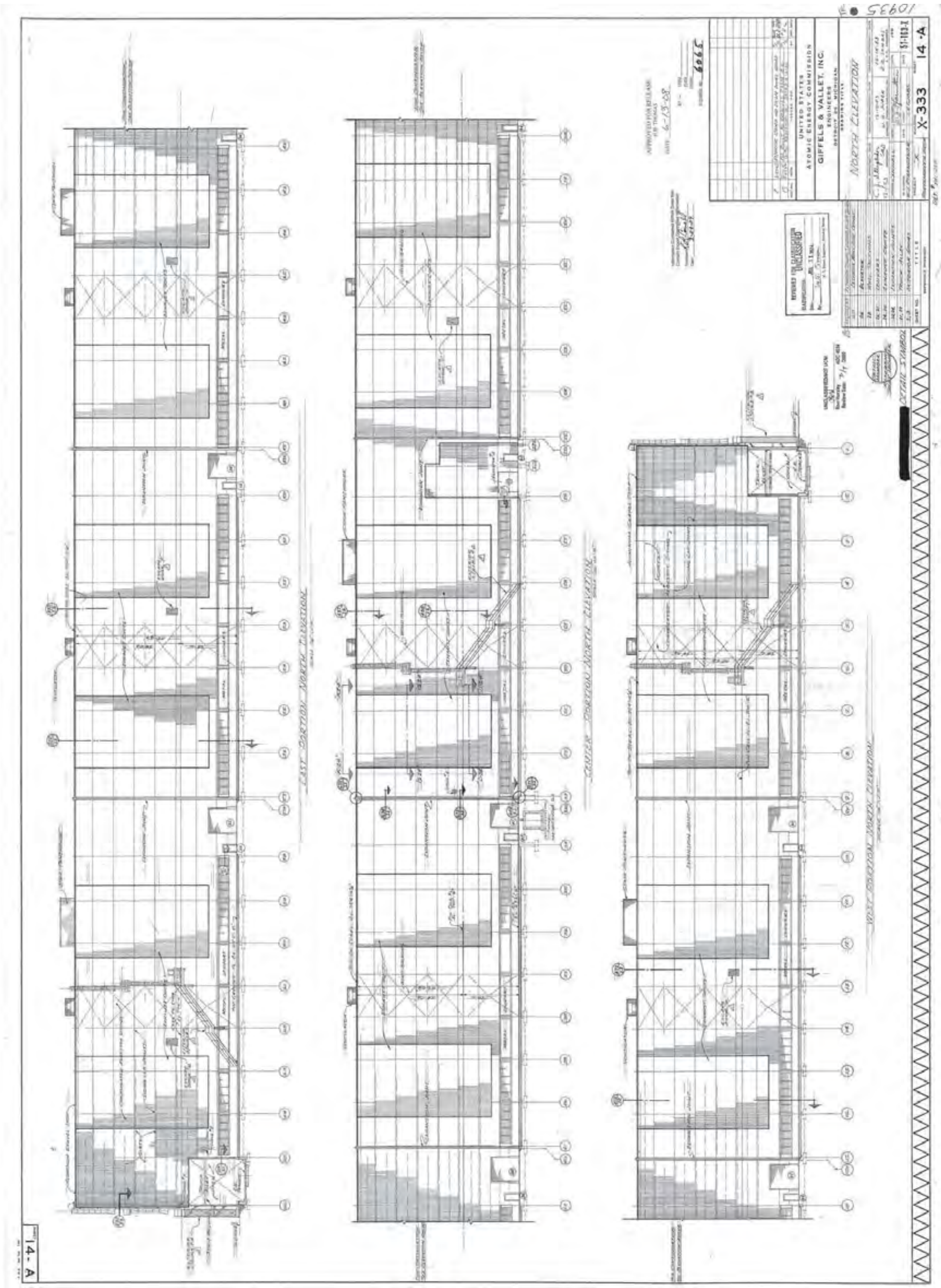

Figure 26: North Elevation

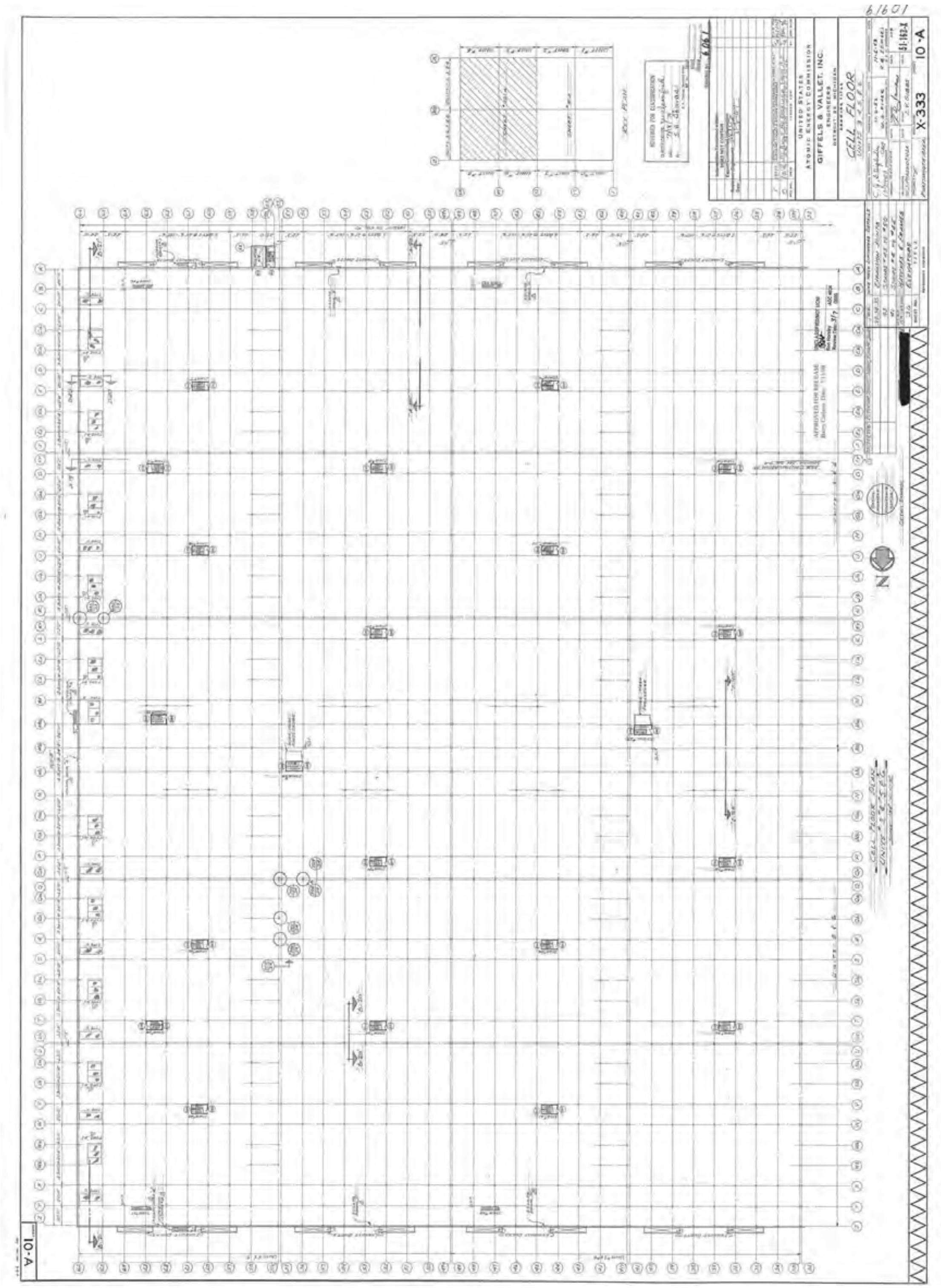

Figure 27: Cell Floor Plan

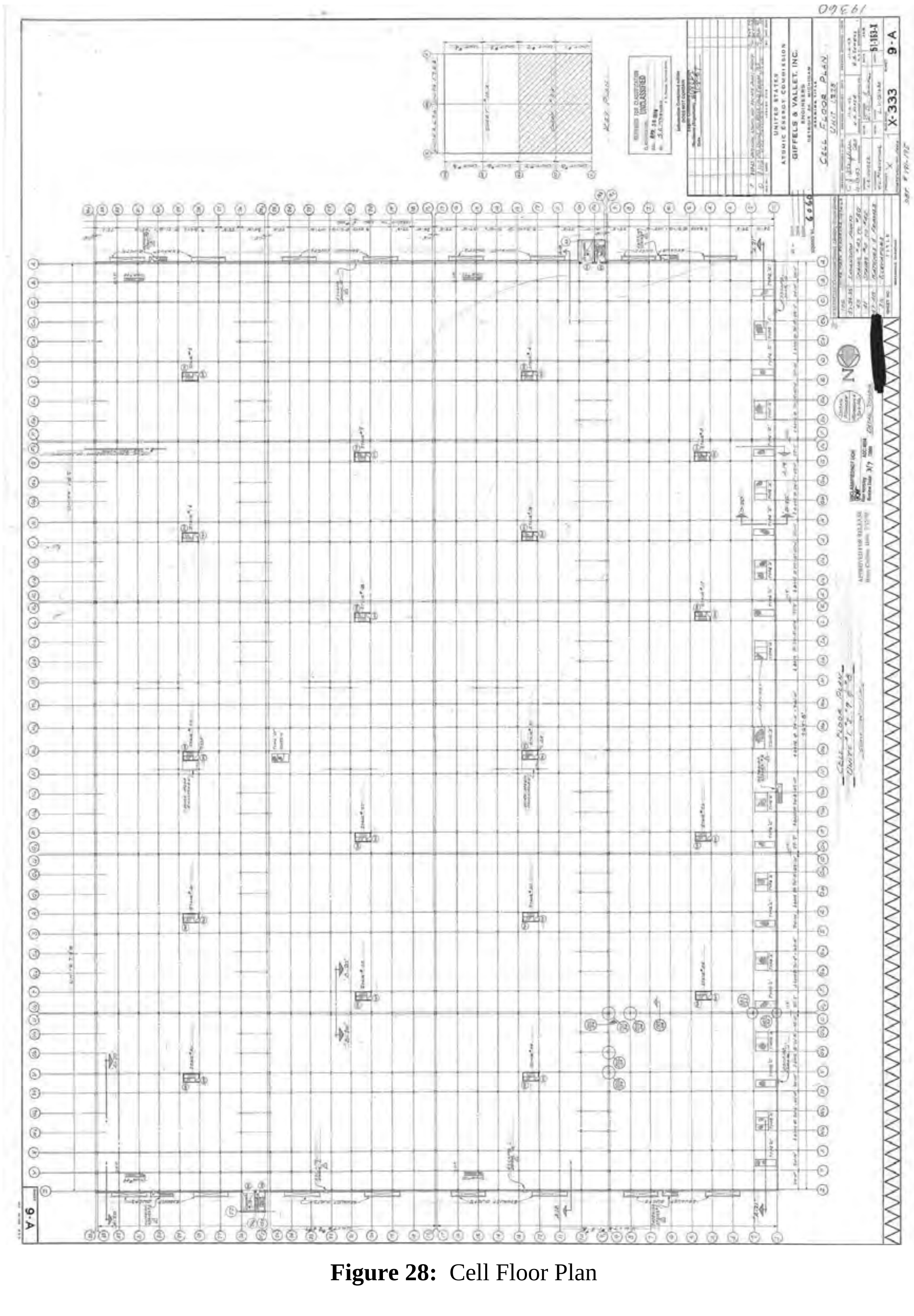

Figure 28: Cell Floor Plan

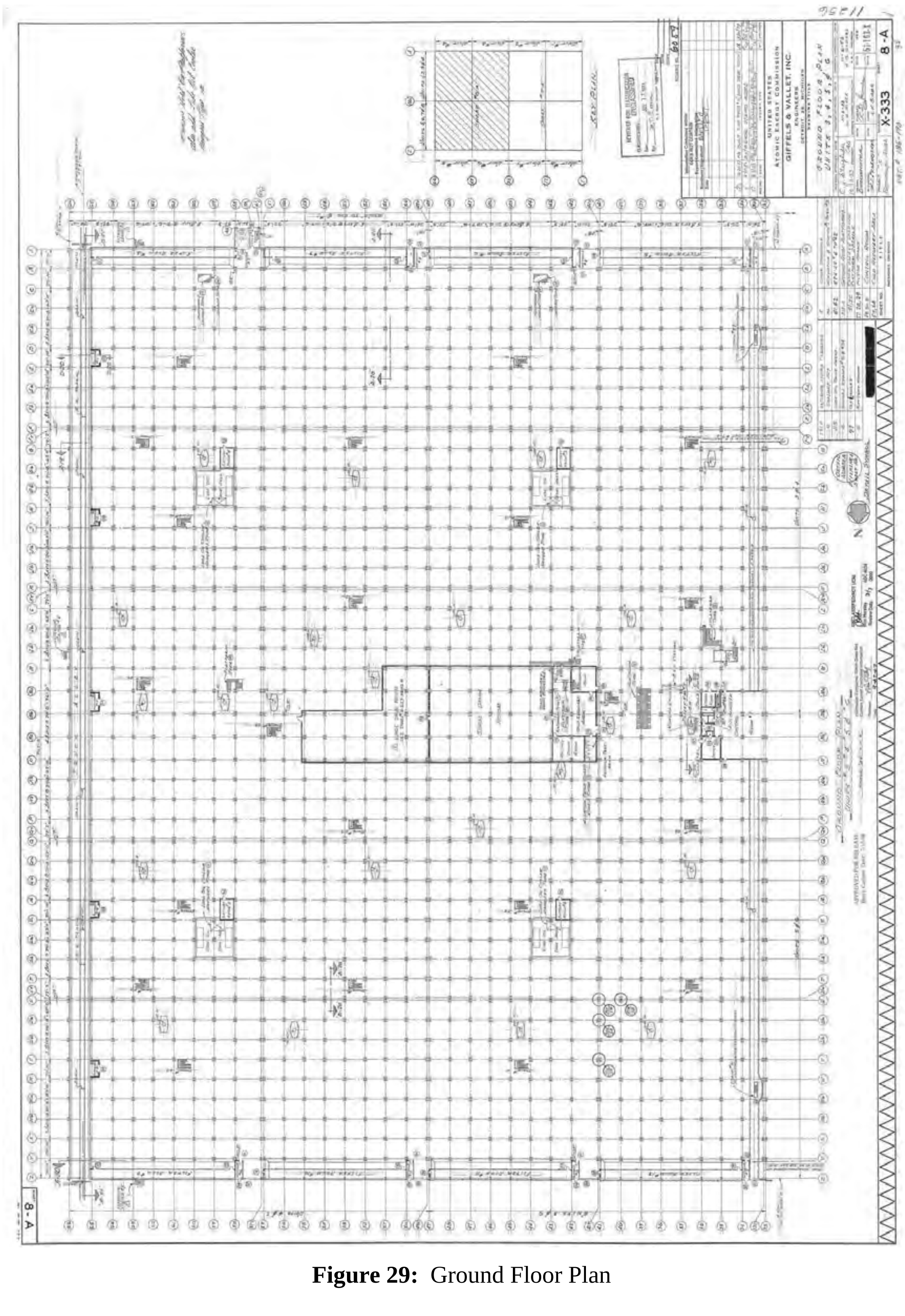

Figure 29: Ground Floor Plan

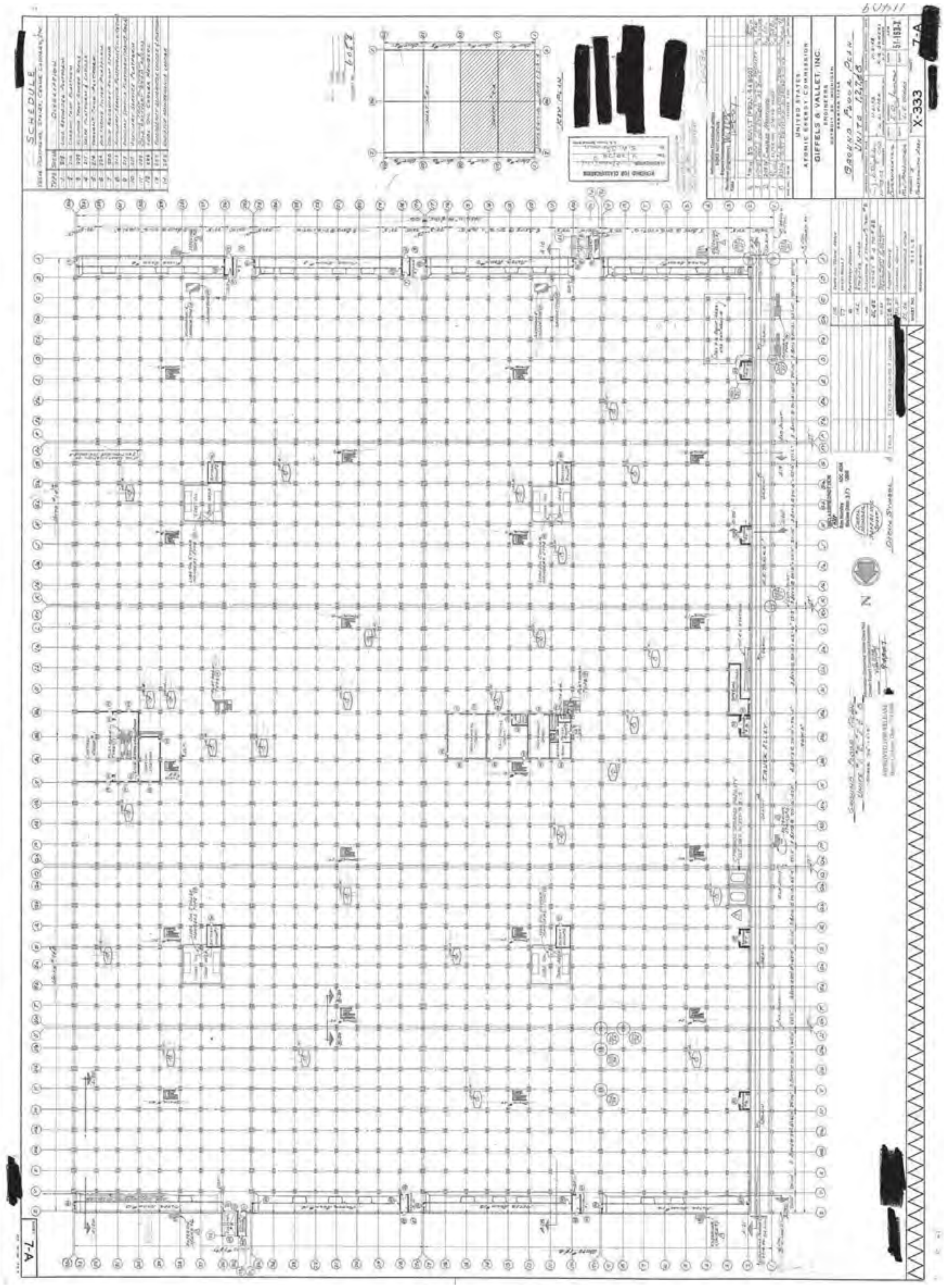

Figure 30: Ground Floor Plan