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COMPLETION REPORT ON THE TOWER SHIELDING FACILITY

BY THE

ENGINEERING AND MECHANICAL DIVISION

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
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OAK RIDGE, TENNESSEE

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DATE ISSUED

FEB 11 1955

OAK RIDGE NATIONAL LABORATORY
Operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

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COMPLETION REPORT ON THE TOWER SHIELDING FACILITY

SUMMARY

The Tower Shielding Facility is an experimental installation designed specifically to simulate special conditions for making shielding studies.

Experiments are to be conducted by mounting a small low-power reactor in a cylindrical steel tank and installing radiation detection devices in a square steel tank. These tanks will be suspended from a tall structural steel tower approximately 200 ft above ground; the tower is 315 ft high and consists of four steel columns. The entire structure is stabilized by guy cables extending diagonally from the top of the tower to guy anchors.

A concrete control house adjacent to the tower structure is located underground to provide biological shielding for operating personnel. Instrumentation, remote viewing equipment, and other equipment are located in this building.

A concrete reactor handling pool, a structural steel metal-sided building for housing hoisting equipment, and hoist control stations are spotted at strategic locations in the immediate tower area.

All the major structures and equipment items were planned, designed, and constructed to provide an economical means for obtaining accurate shielding data which are essential to the development of reactors.

Maps showing locality, topography, site plan, trimetric view, and test boring data are given in the Appendix. Also given are photographs showing the various stages of construction progress.

This report is presented chiefly to discuss the development and construction phases of the project. Reference to operating procedures and detailed descriptions of the reactor and accessory equipment have been held to a minimum in this report, as they have been discussed in other reports (ORNL-1273, ORNL-1740, ORNL CF-51-11-168, and ORNL CF-53-1-286).

SCOPE OF WORK

In general, the scope of the work required for this project included the development of the preliminary design premises, design criteria, definitive design, construction, and installation of the facility.

The preliminary design premises were established by Oak Ridge National Laboratory physicists and engineers, and through their efforts the final design criteria and the definitive designs were evolved. The Oak Ridge National Laboratory furnished design criteria for the tower, hoists, and tower foundations; the definitive design for the control house, reactor tank pool, reactor with associated instrumentation and shielding, access road, and utilities; procured hoists for installation by a contractor; fabricated and installed the reactor with associated instrumentation and shielding; and performed miscellaneous work to assist the contractors in the completion of the facility.

The Atomic Energy Commission made arrangements with the U.S. Corps of Engineers to perform site exploration work; awarded contracts for Titles II and III engineering services for the tower, tower foundations, and hoists; awarded contracts for the construction of the tower foundations, control house, hoist house, reactor tank pool, and access road; and awarded contracts for the fabrication and erection of the tower structure.

This project is the culmination of considerable exploration into possible methods for establishing reasonably accurate criteria for the designs of

[redacted]

special shielding. It was concluded that this facility would afford the surest, fastest, and cheapest method for conducting full-scale shielding experiments which would provide optimum designs for this particular type of shielding. The initial tests will be conducted to determine the effect of radiation leaving a particular side of the reactor shield. Later tests will be performed with mockup shields to determine the radiation dose in the detector compartment for a simple shield design.

DESCRIPTION OF WORK

Location

The facility is located on Copper Ridge approximately $2\frac{1}{4}$ miles south-southwest of the Oak Ridge National Laboratory plant area. The nearest inhabited area is approximately 1 mile south and is separated from the area of the facility by the Clinch River. This site was selected after detailed preliminary investigations, in the general vicinity, were made to determine the most advantageous location with respect to the surrounding topographical subsurface condition, accessibility, and nuclear safety.

General Topography

The facility is located at an elevation of 1066 ft above sea level on the crest of a knoll which projects from the south side of the main Copper Ridge range. The area in general is rugged and is characterized by steep-sided valleys to the east, southeast, and south. The sides of the valleys are moderately forested with scrub-oak, pine, and undergrowth, but the crest of the knoll is reasonably free of trees and undergrowth. The terrain surrounding the area varies in elevation from about 900 ft in the adjacent valleys to a peak of approximately 800 ft north of the installation, which is at an elevation of 3000 ft above sea level.

Site Geology

Underlying the site and exposed in the valley is gray, bedded, massive dolomitic limestone of the Knox formation interbedded with conspicuous chert zones. Without prominent faults in the vicinity of the site, this formation attains a thickness of approximately 2600 ft. The soil overlying the rock is a reddish silty clay with streaks, layers, and pockets of silty yellow clay interspersed with fragments of hard angular cherts varying in size from sand grains to small boulders.

Site Preparation

Field Exploration. Exploration by core drilling to determine the depth of satisfactory foundation material and the character of the underlying rock was performed during November 1952. In one core boring, rock was found at a depth of 64 ft below the surface and was cored to a depth of 76 ft. This core revealed dark-gray, fine-grained limestone interbedded with light-gray limestone and chert and tightly closed, nearly horizontal joints with some oxidation. Three other borings varying in depth from 45 to 60 ft revealed similar subsurface deposits. Data derived from this exploratory work were utilized in preparing the final design for the tower foundations.

Access Road. Access to the area was provided by improving approximately $1\frac{3}{4}$ miles of an existing road extending from the White Wing Road to the tower site. The work involved minor relocation of the road to eliminate hazardous curves, clearing and sloping the adjacent banks, widening the road, providing adequate drainage, and applying a 6-in. crushed stone surface.

Grading and Excavation. Rough and finish grading of the job site, including erosion control, was performed as required during the various stages of the construction work. Initially, the immediate site area was rough graded to provide the appropriate elevations and to permit easier access for the erection equipment and for the storage of materials.

Excavation and backfilling were required for the placement of the tower foundations and guy anchors and for the construction of the control house, the reactor tank pool, and the hoist house.

Fences. The fencing required for this project consisted in installing approximately 9400 lin ft of barbed-wire perimeter fencing surrounding the site on a radius of 3000 ft, clearing the right of way, and installing approximately 1800 lin ft of chain-link exclusion fencing on a radius of 600 ft. The installation of the fences and guard posts, including provisions for lighting along the exclusion fence, was performed in accordance with Atomic Energy Commission security regulations.

Utilities. Electrical, water, and telephone services were extended along a common 50-ft-wide, cleared right of way from the 7500 zone in the

X-10 area to the tower site, a distance of approximately $1\frac{1}{2}$ miles.

Electrical services consisted in the installation of a 13.8-kv transmission line and a 13.8-kv transformer substation at the site with power distribution provisions to the control house, guard post, hoist house, and the exclusion fence lighting circuit.

Water service was provided by the installation of a 4-in. galvanized steel water line, with accessory equipment, including a concrete surge tank, located at the 1250-ft elevation on Copper Ridge at a point approximately 800 ft from the tower site.

The Southern Bell Telephone and Telegraph Company installed the telephone line which extends from the Laboratory area to the tower site.

Structures

Tower Structure. This structure consists of two similar steel towers placed 200 ft apart and tied together at the top with prestressed 2-in.-dia steel guy cables. Each tower consists of two 9-ft-square lattice columns 315 ft high, joined at the top with a 9-ft-square lattice truss that spaces the columns 100 ft apart. The rectangle thus formed, 200 × 100 ft, faces due north and south, with the 200-ft dimension forming the longitudinal axis of the facility. Beginning at the northwest corner of this rectangle, the columns are numerically designated, in counterclockwise order, as legs I, II, III, and IV. An additional 9-ft lattice truss (instrument bridge) was installed 110 ft above the ground, between legs I and IV, to provide space for the installation of electronic equipment and a "take-off" point for various cables extending to the reactor and detector compartment. The structure is braced with 16 guy cables (2 in. in diameter) attached to the top corners of each tower and extending diagonally to 8 guy anchors. A personnel lift in leg IV affords access to the instrument bridge and to the top truss of the north tower section.

The foundations for the four tower legs are square reinforced monolithic concrete footings approximately 12 ft square by 3 ft thick supporting piers 6 ft square by 3 ft high. Embedded in each pier are eight 1-in.-dia anchor bolts and one 3-in.-dia anchor pin. All the foundations and piers are essentially of the same size, except for leg I which was constructed slightly larger to compensate for a variation in the foundation.

The eight guy anchors are rectangular blocks of reinforced concrete 20 × 12 × 8 ft thick with two 10-in.-wide flange H beams embedded in the block for guy cable ties.

Control House. The control house is a rectangular-shaped, reinforced concrete structure $118 \times 33 \times 11\frac{1}{2}$ ft (outside dimensions) with 18-in.-thick walls and roof. The entire building is situated underground, and the roof is covered with a minimum of $3\frac{1}{2}$ ft of earth fill. The building is located on the north side of the tower structure, adjacent to and equidistant between legs I and IV. Access is gained through two underground passageways: one is an entrance from the north end of the building, and the other, which provides access from the working area under the tower, is a ramp leading to the southeast corner of the building. Offices, toilet, and service facilities, remote control equipment, instrumentation, remote viewing equipment, and radiation measuring devices are all housed in this structure.

Hoist House. This building is situated approximately 200 ft west of the tower structure and houses four 11,000-lb and two 12,000-lb line-pull hoisting units. The building is a structural-steel-framed lean-to type of structure, 135 × 36 × 17 ft average height, with corrugated metal siding and roof.

Reactor Tank Pool. A reinforced concrete handling pool, consisting of two sections, provides shielding during the removal and storage of fuel assemblies. The large section of the pool is 20 ft square by 25 ft deep (inside dimensions), and the small section is 4 ft wide by 12 ft long by 22 ft deep (inside dimensions). The pool is located on the west side of the rectangular tower plan and between legs I and II.

Equipment

Hoists and Rigging. The six lifting hoists, mounted on reinforced concrete bases, are all of the single drum, variable speed, single-wrap type and have a starting load speed of approximately 16 fpm; the maximum safe operating speed is 22 fpm. An eddy-current controlled brake and two magnetic brakes are incorporated in each unit to ensure smooth and safe operation. In event of a power failure the magnetic brakes automatically lock the hoist in position and prevent further movement until the power is restored or until the brakes are released through an emergency d-c power source. A bank of batteries mounted in the hoist house and interconnected with the control stations provides the d-c power for remote emergency operation.

The sheaves and blocks are heavy-duty pulleys with deep grooves which reduce the possibility of cable hopping. Idlers mounted on reinforced concrete piers between the hoist house and the tower reduce the weight and drag on the hoist cables.

Positioning Hoist. This equipment, located approximately 50 ft northeast of the reactor tank pool, is utilized for changing the distance between the reactor tank and the detector compartment tank and prevents the rotation of the two tanks. The unit, which can be adjusted by hydraulic controls, exerts a constant line pull which may be varied to a maximum 5000 lb.

Hoist Controls. The operation of the six lifting hoists and the one positioning hoist is performed remotely from two locations designated as the "local station" and the "remote station." The local station is in the control house access ramp, the walls and roof of which afford partial shielding from radiation. The remote station is located adjacent to the reactor tank pool, which permits maximum visibility of the facility while the hoists are being operated. However, the operation of the hoists from this station will be performed only when the radioactivity level is within the permissible exposure limits. The mechanisms for the lifting hoists are of the lever-arm type, 5-stage (up-down), remote control switches keyed and interlocked to prevent the operation of both stations at the same time. Six of these units, one for each hoist, were installed at each station.

The positioning hoist motor can be operated by a hydraulic lever-arm type of control from either station; remote operation of this hoist is also provided inside the control house.

Reactor Shield Tank. The reactor shield tank was fabricated from $\frac{1}{4}$-in.-thick boiler plate shaped and welded to form a 12-ft-dia by $12\frac{1}{2}$-ft-deep water-tight vessel with a hemispherical bottom. Mounted on top of the reactor tank is a structural frame with flanged wheels attached which ride on the top rim of the tank. This frame can be rotated through an angle of 270 deg by means of a remotely controlled gear train. Two rails supported on the frame provide a track on which rides the reactor structure. This track thus permits the reactor to traverse the diameter of the tank in all directions.

During tests the tank is suspended by a series of cables and sheaves between legs I and II at approximately 200 ft above ground level; in this position the tank will be directly above the reactor tank pool. At the conclusion of an experiment the tank can be lowered into the pool for servicing the reactor and for changing the fuel elements, or it can be positioned in a supporting frame which is provided adjacent to the pool.

Detector Compartment Tank. This tank is a 5-ft-square, 7-ft-deep water-tight vessel fabricated from $\frac{3}{4}$-in.-thick boiler plate except for a panel approximately 3×5 ft in each side and a 3-ft-dia panel in the bottom, each of which is $\frac{1}{4}$ in. thick. This change in plate thickness was for the purpose of reducing the shielding effect. The tank is suspended by a cable arrangement similar to that used for the reactor shield tank. Two remotely operated gear and screw arrangements mounted on top of the tank permit positioning the detector both transversely and longitudinally within the tank.

During tests this tank will also be suspended approximately 200 ft above the ground by means of four hoisting cables. The position of the tank may be moved toward legs III and IV or to within 35 ft of the reactor shield tank. At the conclusion of an experiment the tank can be lowered to a concrete pad for servicing.

Lightning Protection. The entire tower area, bounded by the guy anchors, is encircled with a No. 1/0 base copper wire counterpoise buried approximately 18 in. below grade. Copper-clad ground rods were driven at each tower leg footing, at each guy anchor, and at intermediate points around the perimeter of the counterpoise. Four major cross connections, also of buried No. 1/0 bare copper wire, with ground rods driven at intervals, were installed at approximate right angles to the perimeter counterpoise and cross at about the center of the tower working area. The entire grounding system and the grounding connections to all equipment, hoists, electrical items, etc., are connected to the water supply line.

Field measurements established the soil resistivity in the grounding area as 1800 ohm-ft. Based on these measurements the resistance to the ground of the entire system will not be more than 1 to 3 ohms.

Capacitors and lightning arresters at all motor terminals protect the equipment from abnormal electrical surges.

Instrumentation. The instrumentation for radiation measurements and the remote control mechanisms for operating the reactor and the detector in the tanks are located in the control house. This equipment is, basically, commercially available recording equipment and electronic data collecting devices that have been utilized as built or altered to the Laboratory's specifications. Special-purpose devices were fabricated to perform specific functions as dictated by the unique operating requirements of the facility.

Flexible cable leads were suspended from the reactor shield tank and the detector compartment tank to the instrument bridge.

DESIGN PREMISES

Tower Foundations

The unit pressure on the footings for the tower foundations was fixed initially at 2 tons per square foot. The resistance to penetration of soil samples indicated that the compressive strength of the soil was about 3 tons per square foot. Based on Terzaghi's formula for ultimate bearing capacity of shallow square footings, the ultimate bearing capacity was found to be 11.4 tons per square foot. With a factor of 3 applied for safety, the resistance to penetration was computed to be 3.8 tons per square foot.

On the basis of data obtained from the soil samples which were tested by the U.S. Engineering Department Soil Testing Laboratory, the tower foundations were designed for 1.9 tons per square foot loading with a maximum allowable differential settlement of 1 in. The allowance of 3 for a safety factor was used in computing the required values.

Tower Structure

The basic data for further studies and design of the facility were presented in "Tower Shielding Facility – Design Criteria," prepared and compiled by the Oak Ridge National Laboratory.

General designs and cost comparisons indicated that, of the semirigid structures that were investigated, one with longitudinal cable ties and pinned transverse trusses in the end bents offered the greatest opportunity for basic economy of structure, consistent with structural stability and safety, reasonable erection, and positioning of loads by the use of suitable hoisting and rigging procedures.

The recommended structure was developed on the basic concepts that:

1. there would be no structural framing or members, except lifting and guy cables, within a distance of 100 ft of either the reactor shield tank or the detector compartment tank;
2. the support for the two loads would be "open ended" – that is, there should be no structural framing beyond either tank in the line of action between them.

The guyed and braced design was therefore developed in complete detail in order to establish its essential validity, economy, and feasibility. The prestressed 2-in. cables were designed to carry loads of 40,000 and 76,000 lb in horizontal ties and inclined guys, respectively.

Live and Wind Loads. For the structural design, the following basic live loading conditions were established:

Case I

Dead load + live load + 20% impact (on 55-ton or 30- and 40-ton loads).

Case II

Dead load + 30 lb/ft^2; wind on $1\frac{1}{2}$ times projected area of members, with no suspended loads.

Case III

Dead load + live load + 20 lb/ft^2; wind on $1\frac{1}{2}$ times projected area of members and exposed areas of suspended loads.

Case IV

Dead load + live load + 0.05 seismic force.

The relationship between wind loads, as above, and the corresponding wind velocities is as follows:

30-lb wind equivalent to 105 mph
20-lb wind equivalent to 80 mph
2-lb wind equivalent to 25 mph

From a study of the Knoxville and Oak Ridge climatological records, it was established that the maximum wind of record was 71 mph (based on the fastest mile and a recorded period of 40 years). The average daily wind velocity for the year 1951 was 9.7 mph, corresponding to a wind load of 0.3 lb/ft^2. The maximum of 71 mph occurred in April 1944; other maximums occurred as follows: 1947, 61 mph; 1948, 68 mph; 1951, 57 mph. The Laboratory agreed that operation of the Tower Shielding Facility will be prohibited during wind velocities exceeding 20 mph (= 1.3 lb/ft^2).

Types of Steel. In the preliminary studies, as well as in the recommended design, it was assumed that A7 carbon steel would be used for the structural members of the tower. Welded construction was developed for the legs, trusses, and bracing members of the recommended design, with the field connections between sections of the legs and between legs and trusses, etc., being made with high strength bolts. For shipping and erection purposes, the tower legs were fabricated in sections of length (9 × 9 × 45 ft) that could conveniently be accommodated in a 50-ft open freight car or in a truck trailer.

In the earlier designs, in which the unit stress consideration was vital in the choice of the main sections, the use of A94 structural silicon steel was considered for the main material of the members. It was found that the resulting saving in total weight of structural metal and in construction cost would be reduced by the higher unit price required for the silicon steel. Also, it would not have been possible to have a fully welded design, since the silicon alloy is not readily weldable; and with a combination of riveted and welded fabrication, the weight of detail material at joints, etc., would have been increased.

While the use of the silicon material might have reduced the mass of the recommended structure somewhat and thus slightly have reduced the background scattering, the uncertainties outlined above and the doubt as to any real economy in the fabrication and cost led to the final decision to use conventional A7 carbon steel in the design.

Scattering Effects. The effect of background scattering was one which received considerable study during the design period. Several of the structural designs proposed for the tower, which included overhead truss systems, had to be rejected because of the excessive percentage of background scattering.

The approximate and exact formulas for background scattering were derived by Oak Ridge National Laboratory physicists. It was also established that a reasonable limit for the total effect would be approximately 15%; designs and geometry were limited by this factor (see report ORNL-1273, issued Oct. 15, 1952).

Based upon the formulas, the per cent of background scattering for the recommended design was calculated as follows:

Front tower legs, two at 2.8%	5.6
Rear tower legs, two at 2.7%	5.4
Upper end trusses, two at 0.60%	1.2
Instrumentation platform	0.88
	13.08

Hoists and Rigging

The magnitude of the lifted objects, the types of movement, the limitations on relative displacement and rotation of the objects, the positioning of objects with respect to each other and to elevation, the effect of rigging on scattering all influenced the proposed design of the hoists and the rigging. Such basic consideration, with flexibility for future loading and simplicity of operation, was satisfied in the proposed design which evolved from consideration of many methods of supporting the objects and rigging.

With the use of the recommended system of framing, the hoist capacities depend upon the angle between the operating cables and the tower legs. An increase in the tower height would result in a more costly tower structure, but the cost of the hoists would be reduced. Cost comparisons were made to secure the least expensive combination of hoist and tower.

A model built by Oak Ridge National Laboratory staff members, to a scale of approximately 1 in. = 40 ft, aided Oak Ridge National Laboratory and Knappen-Tippetts-Abbett-McCarthy personnel in studying the rigging and guying problems.

As finally adopted, the location of the hoisting sheaves on the tower and the inclusion of a constant tension positioning hoist operating a line between the reactor shield tank and the detector compartment tank provide a smooth operating arrangement for positioning both horizontally and vertically and, furthermore, prevents the rotation of the two tanks with respect to each other. Thus the arrangement as finally adopted provides a most satisfactory alternate to the rigid structure which had been given earlier consideration.

Control House

The design of the control house was developed to adhere to specific requirements for shielding the operating personnel. The known potential radiations emitted from the reactor governed the shielding requirements, and the location of the building, with respect to the distance from the reactor, governed the quantities of shielding materials required. After the location for the building was established, it was decided to construct it underground, which would minimize the shielding requirements by utilizing earth fill as a partial shielding medium. This arrangement effected a considerable saving in construction costs by eliminating the necessity of providing thicker walls for an above-the-ground structure.

Reactor Tank Pool

The design of the reactor tank pool was also developed to meet specific requirements for radiation shielding. The pool was made large enough for the tank to be covered with a minimum of 8 ft of water. Removal of the fuel assemblies will be done under water, and they will be stored in racks in the small section of the pool. Removal of the reactor from the reactor shield tank and moving it into the small section of the pool will be accomplished by means of a loading gantry mounted on rails along the top edge of the small section of the pool.

PARTICIPANTS

The participants in the project and a brief description of their functions are given below.

U. S. Atomic Energy Commission
Oak Ridge Operations Office
Oak Ridge, Tennessee

Oak Ridge National Laboratory, operated by
Carbide and Carbon Chemicals Company
A Division of Union Carbide and Carbon Corporation
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Oak Ridge, Tennessee
Operated under contract W-7405-eng-26, Mod. 33.

Knappen-Tippetts-Abbett-McCarthy
(architect-engineer)
62 West 47th Street
New York 36, New York
AEC fixed-price prime contract
No. AT-(40-1)-1528

Charles Hobson Company, Inc.
(construction contractor)
2923 Sutherland Avenue, NW
Knoxville, Tennessee
AEC fixed-price prime contract
No. AT-(40-1)-1381

Karl Koch Erecting Company, Inc.
(construction contractor)
362 Casanova Street
Bronx 59, New York
AEC cost-plus-fixed-fee prime
contract No. AT-(40-1)-1382

Whiting Corporation (equipment fabricators)
Harvey, Illinois
ORNL fixed-price purchase requisition
No. W36X-14855

Atomic Energy Commission

In accordance with their responsibilities with regard to the administration of lump-sum and/or fixed-fee prime contracts, the Oak Ridge Operations Office of the Atomic Energy Commission performed the following work:

1. made all arrangements with the U. S. Corps of Engineers for the site exploration work, including core drilling and testing of the soil samples,
2. reviewed all preliminary and final drawings and specifications,
3. performed all work leading to the selection of the architect-engineer and the construction contractors,
4. maintained liaison between the Laboratory and the prime contractors,
5. furnished general supervision of the contracts and participated in the final inspections of the completed facility.

Oak Ridge National Laboratory

The Oak Ridge National Laboratory's participation in this project consisted in the following services:

1. preparation and submission of the preliminary proposal, which outlined the entire scope and estimated cost of the project,
2. development of the design criteria for the tower foundations, the tower structure, and the hoisting equipment,
3. design, fabrication, and installation of the reactor shield tank and the detector compartment tank and associated equipment, including the reactor and controls,
4. preparation of working drawings and specifications on the control house, reactor tank pool, access road, utilities, and grounding system,
5. initiation of requisitions for the purchase of the hoisting equipment, the details of which were handled by the Carbide Purchasing Department,
6. provision of engineering services for the inspection of the control house, reactor tank pool, access road, and the utilities,

7. collection of data and preparation of this completion report.

Knappen-Tippetts-Abbett-McCarthy

The responsibilities of Knappen-Tippetts-Abbett-McCarthy in connection with the completion of the facility consisted in the following:

1. preparing the final design drawings and specifications for the tower structure, the tower foundations, and the hoisting equipment from criteria furnished by the Laboratory,
2. furnishing a field representative to maintain liaison with the Karl Koch Erecting Company and the Laboratory.

Charles Hobson Company

The Charles Hobson Company performed all work related to the site preparation, which consisted of the following items:

1. grading at the site,
2. access road,
3. all foundations,
4. reactor tank pool,
5. underground control house,
6. utilities, including guard houses and fences,
7. grounding system.

Karl Koch Erecting Company

The Karl Koch Erecting Company, in accordance with definitive design and specifications furnished by Knappen-Tippetts-Abbett-McCarthy, performed the following work:

1. erected the tower columns and installed the guy cables,
2. installed the lightning protection system,
3. installed the hoists,
4. erected the hoist house,
5. installed the hoist controls and rigging for the hoist cables,
6. installed the personnel lift,
7. installed all electrical services located above the tower footings.

CONSTRUCTION METHODS AND EQUIPMENT

Charles Hobson Company

Earth moving pans, bulldozers, and graders were utilized in the grading of the access road, and sheep's-foot rollers were employed to obtain the proper compaction.

The trench for the water line to the site was excavated with a trenching machine; a bulldozer was utilized for general leveling in advance of the trencher and for backfilling.

Power shovels with backhoe attachments, earth moving pans, and bulldozers were employed for the site excavation. Sheep's-foot rollers and pneumatic tampers were used for placing earth fill and for backfilling; a sprinkler truck was used in obtaining the correct moisture content.

Concrete forms were mainly of the prefabricated panel type; however, where conditions dictated their economy or convenience, built-in-place forms were used.

During the early part of the construction, concrete was delivered to the site in ready-mix trucks. However, difficulties developing from their delivery made it necessary for the contractor to use a small portable mixing plant for the remainder of the work. Chutes, wheelbarrows, and concrete buggies were used to place the concrete. Gas-engine-powered vibrators were utilized to assist in placing the concrete and to obtain void-free concrete.

Karl Koch Erecting Company

To facilitate handling, loading, and erection, the 9-ft-square tower legs were shop fabricated in sections 45 ft long, and the three 100-ft-long trusses were each fabricated in two sections. The major portion of these sections was transported directly to the site by motor truck trailers. However, because labor troubles delayed the truck shipments, a few sections of the tower were shipped by rail to Oak Ridge, unloaded at the rail siding with a motor crane, and trucked to the site.

A crawler crane equipped with a 100-ft boom was used to unload and to handle the sections at the site and to erect the lower two sections of each tower leg.

The tower legs were erected in pairs (legs II and III together and then legs I and IV). After the two lower sections had been erected, a twin-boom derrick was mounted at the top of each leg. The derrick and a multiple-drum hoist, anchored near the base of each leg, were used to hoist the next 45-ft section of each tower leg into position. As each succeeding section was secured in place with field erection bolts, the erection derricks, by means of rigging powered by a second multiple-drum hoist, were hoisted to the top of the structure. Temporary guy cables to support the legs were moved up as each section was erected. When the derricks reached the top of the respective pair of legs, the truss that connected the pair of legs, which had previously been assembled on the ground directly below its final position, was hoisted into position by the derricks.

The permanent guy cables were placed in position as soon as possible following each stage of the erection.

(Note: As a result of the well-designed erection equipment, the excellent planning and scheduling of the work, and the expeditious handling of the field erection, the entire construction problem was handled in an exemplary manner.)

Oak Ridge National Laboratory

The hemispherical bottom reactor tank was fabricated at an outside shop and then shipped to Oak Ridge National Laboratory. The rotating spider-frame work, the movable carriage that supported the reactor, and the reactor and reactor controls were all fabricated in the Laboratory shops; these items of equipment were assembled and were installed in position on the reactor tank and then subjected to test operations in the shop. When the tower and hoisting equipment had been completed, the entire assembly was transported to the site on a low wheel trailer.

The detector compartment tank was fabricated in the Laboratory's shop, as was the associated gear and screw positioning mechanism. As with the reactor and reactor tank, the detector compartment tank and the associated equipment were assembled and test operated in the shop before being transported to the site. As many of the electronic controls and as much of the instrumentation equipment as possible were procured from commercial sources. However, because of the unique requirements of the facility, it was necessary to modify many of the commercial items and to design and fabricate in Oak Ridge National Laboratory shops many specialized instruments. To as great an extent as possible these items and instruments were assembled and tested in advance of the installation in control house at the tower site.

The procurement and the delivery of the hoists were handled directly by Oak Ridge National Laboratory; however, the installation was performed by the tower erection contractor under the supervision of an erection engineer from the Whiting Corporation, the hoist fabricators. The unusual size of the hoist drums presented some difficulties in locating machine tools large enough to handle those parts; there were also some difficulties experienced in the procurement of satisfactory electrical controls from the General Electric Company. These slight difficulties resulted in a delay in delivery.

The planning and scheduling of the Laboratory's participation to permit the fabrication, assembly, and testing of the reactor, detector compartment, and instrumentation to proceed concurrently with the field construction of the facility reduced to the lowest minimum the period required for the field installation of the items furnished by the Laboratory. This resulted in the utilization of the facility at a much earlier date than would have been otherwise possible.

APPRAISAL OF CONSTRUCTION CONTRACTORS' WORK

Charles Hobson Company

The quality of the work performed by the Hobson forces was generally very good. In some instances, however, it was necessary for this contractor to discuss with some of his subcontractors the quality of their work; then good results were usually effected without delay. His rate of progress was also good, and, except when slow deliveries of materials hindered, all phases of work were finished on time. Hobson's cooperation was excellent, especially in dealing with Koch in that company's concurrent erection operations; all their mutual "problems" were examined carefully, and with considerable discretion, before any action was taken, and the problems were solved to their mutual satisfaction.

Karl Koch Erecting Company

The quality of the work by Koch was excellent; this rather unusual job of erection was handled with dispatch and facility. The rate of progress was far ahead of schedule throughout, except as delayed by slow deliveries of hoists and by later modifications in connection with electrical work. Cooperation in connection with Hobson's concurrent work was excellent; there were no occasions when problems in connection with their overlapping interests were not coordinated with good results. The supervision throughout was well handled.

OUTLINE OF RECORD OF WORK PROGRESS

The work progress is given below:

Oak Ridge National Laboratory design	
Start	July 1952
Knappen-Tippetts-Abbett-McCarthy design	
Start	Oct. 10, 1952
Charles Hobson Company	
Start	March 27, 1953
Partial acceptance	Jan. 15, 1954
Complete	Feb. 5, 1954
Karl Koch Erecting Company	
Start	July 31, 1953
Complete	Feb. 20, 1954
Whiting Corporation	
Start (on job)	Nov. 4, 1953
Complete	Feb. 20, 1954

RECORD OF UNUSUAL CONDITIONS

Charles Hobson Company

The time lost during the construction period as a result of strikes is given below:

May 1, 1953 to May 20, 1953	General strike, all construction suspended
July 27, 1953 to July 30, 1953	Because of a strike in the X-10 Area of Oak Ridge National Laboratory, electricians and pipefitters did not report for work
November 9, 1953 to November 16, 1953	Because of a strike of sheetmetal workers at K-33, the electricians, pipefitters, and sheetmetal workers did not report for work

Inclement weather caused only two days of working time to be lost prior to December 16, 1953; from that date until the completion of the project, however, there were several days at intermittent intervals when it was necessary to halt or to interrupt work on certain phases of the project.

On December 14, 1953, a transformer in the substation at the facility exploded. The delay in replacing electrical service to the project resulted in one day of lost time for all construction.

The extremely dry weather made it necessary to advance the schedule for the installation of the water line to the site so that water would be available for providing the proper moisture content for the earth backfilling operation.

The unusual experimental and developmental nature of the project and the fact that the design of the reactor, detector compartment, and related instrumentation was in progress during the construction of the tower, control house, and other field work made it necessary to make several design changes, particularly on the electrical installation. As a result, there were some delays and some interruptions; however, by adjusting the work schedule to meet the demands of these changes, the contractor was able to meet the established completion date.

Karl Koch Erecting Company

During the construction period it was necessary to make adjustments to work schedules to compensate for interruptions caused by strikes and weather conditions. However, by efficient planning, the contractor was able to complete the work within the established time.

Labor difficulties at the Truitt Manufacturing Plant in North Carolina caused a three-day delay in the shipping schedule.

Labor trouble at the truck transport companies made it necessary for some of the units to be shipped by rail to Oak Ridge, where they were loaded on trucks and hauled to the job site. This arrangement resulted in some delays.

Only two days of working time were lost because of inclement weather between July 31, 1953 and the structural completion of the tower on Nov. 23, 1953.

Whiting Corporation

An order for the hoisting equipment was placed with the Whiting Corporation on March 18, 1953 and specified that delivery be made by October 1953. However, material procurement difficulties delayed the delivery of the major items until December 1953.

Field tests on the complete hoist installation were made on February 10, 1954. These tests revealed that modifications to the electrical controls were required to incorporate features to effect greater operating flexibility. The modifications to the controls were completed in June 1954.

DISPOSAL OF JOB RECORDS

The disposition of the job records is given below.

1. Prints of contract drawings, specifications, and the original tracings are filed in a vault in the Design Engineering Department at Oak Ridge National Laboratory.

2. Copies of equipment catalogs and manuals are filed at the tower site, in the Mechanical Department office and in the Engineering Department.

3. Guarantees are filed in the Engineering and Mechanical Division office at Oak Ridge National Laboratory.

4. Still photographs of construction progress are on file in the Laboratory Records Department at the Oak Ridge National Laboratory.

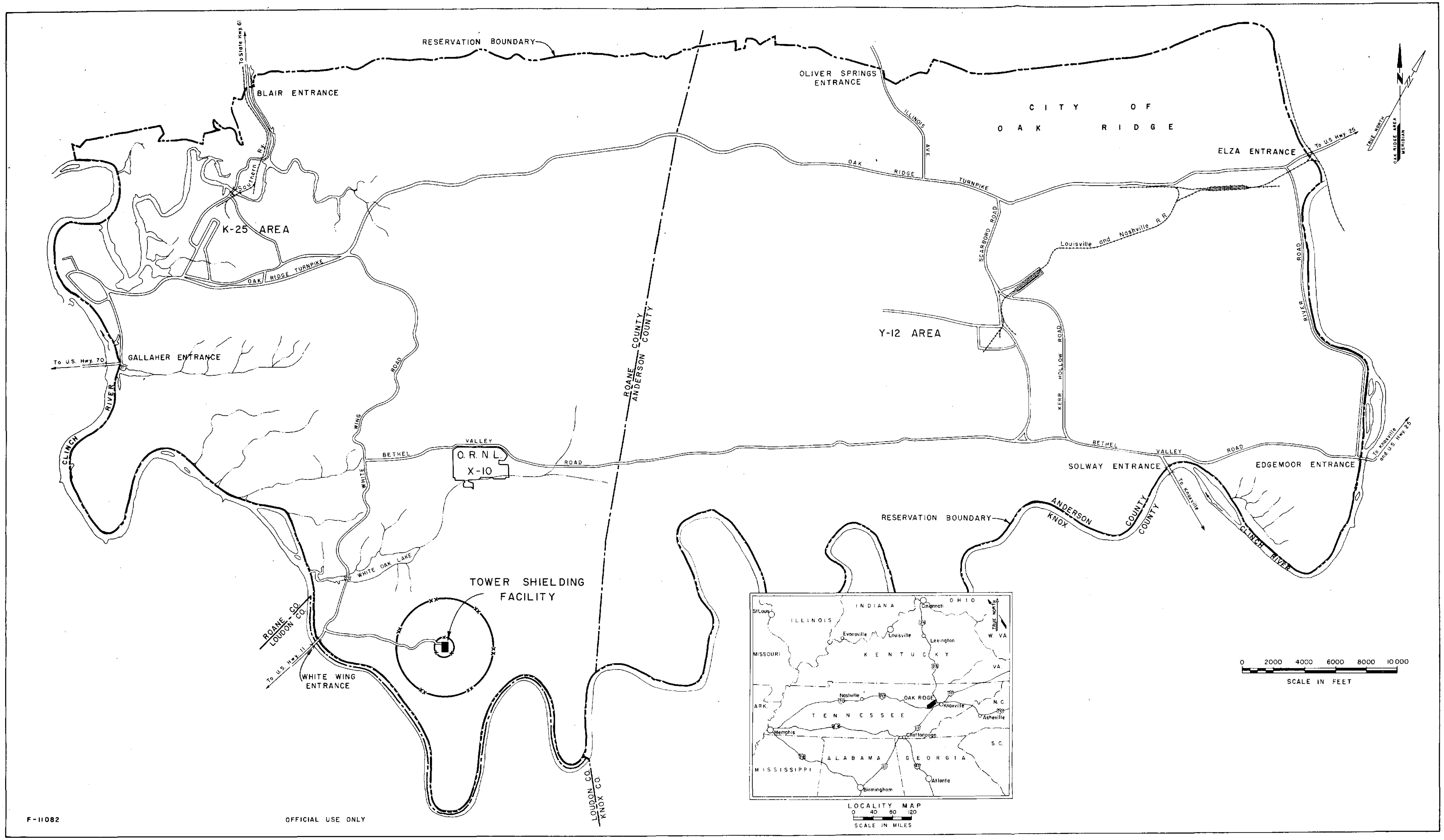
5. A motion picture film depicting phases of construction is on file in the Laboratory Records Department at Oak Ridge National Laboratory.

PROJECT COST SUMMARY

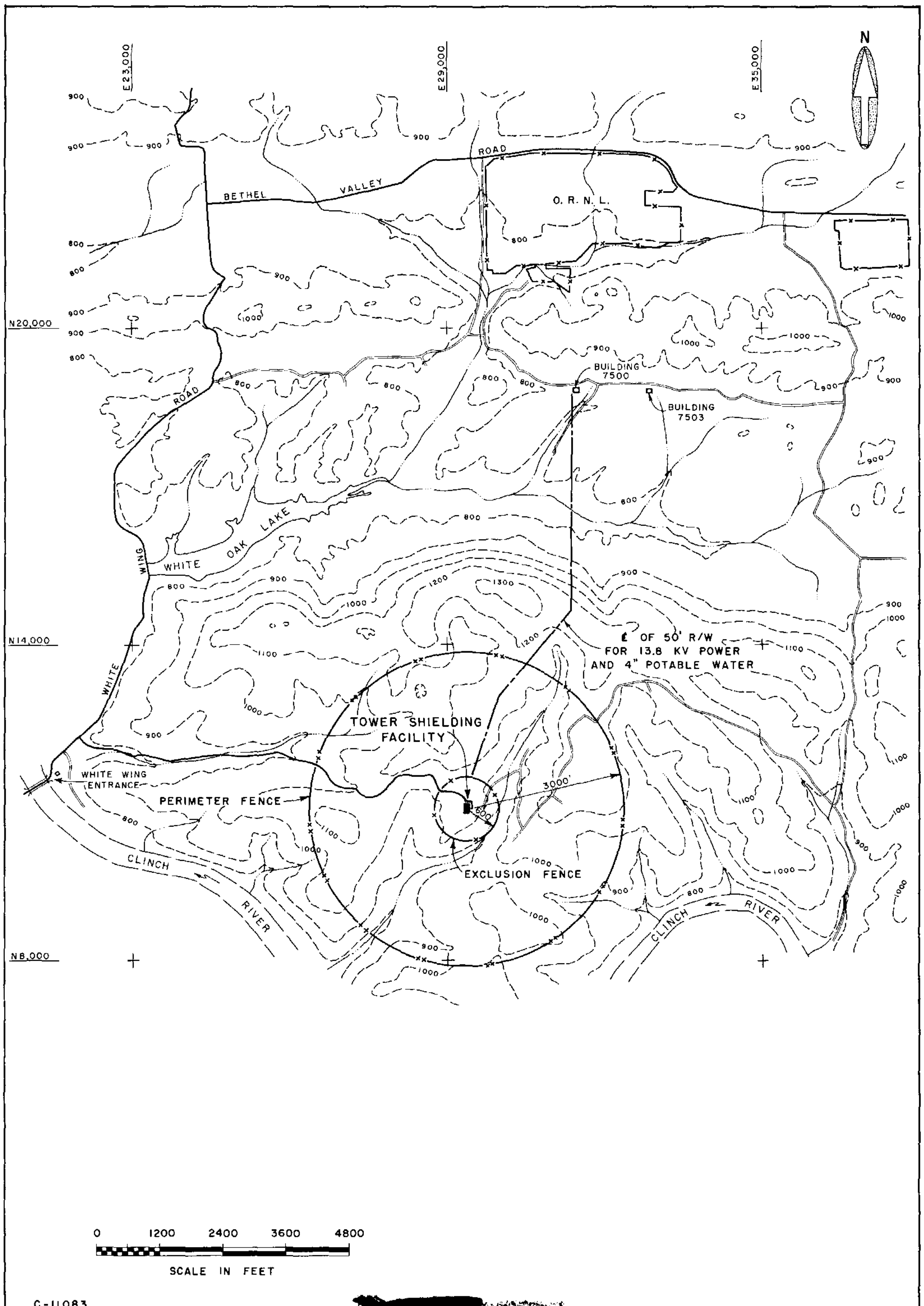
A summary of the project cost is presented as follows:

Participant	Cost
Engineering and Inspection	
Atomic Energy Commission site investigation	$ 5,155.00
Oak Ridge National Laboratory	204,217.00
Knappen-Tippetts-Abbett-McCarthy	106,250.00
Total	$315,622.00
Procurement and Construction	
Charles Hobson Company	$ 508,624.72
Karl Koch Erecting Company	527,817.00
Oak Ridge National Laboratory (Whiting)	248,550.00
Oak Ridge National Laboratory (fabrication and installation)	397,000.00
Total	$1,681,991.72
Grand Total	$1,997,613.72
Authorized Project Funds, Atomic Energy Commission Directive	$2,000,000.00

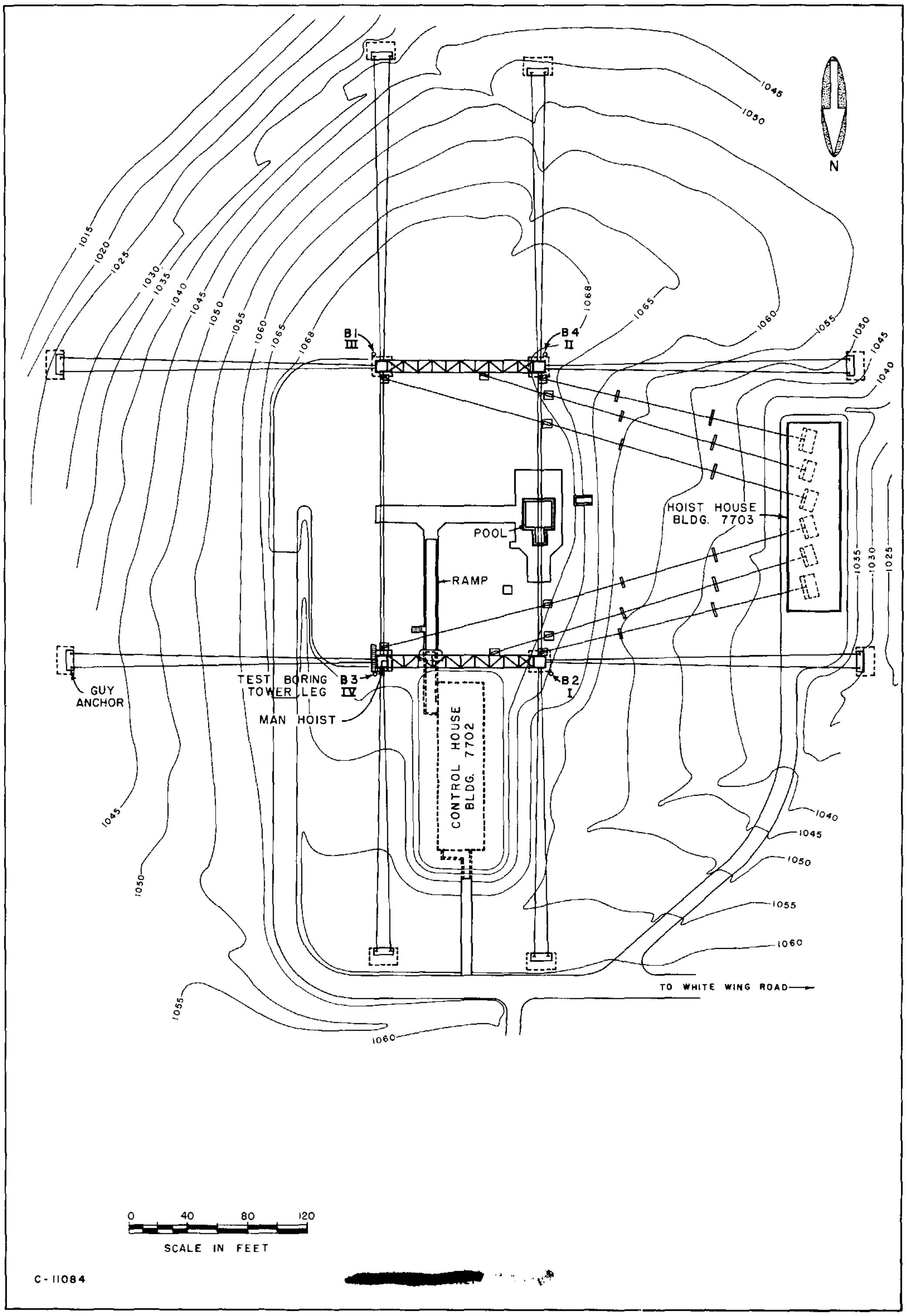
APPENDIX



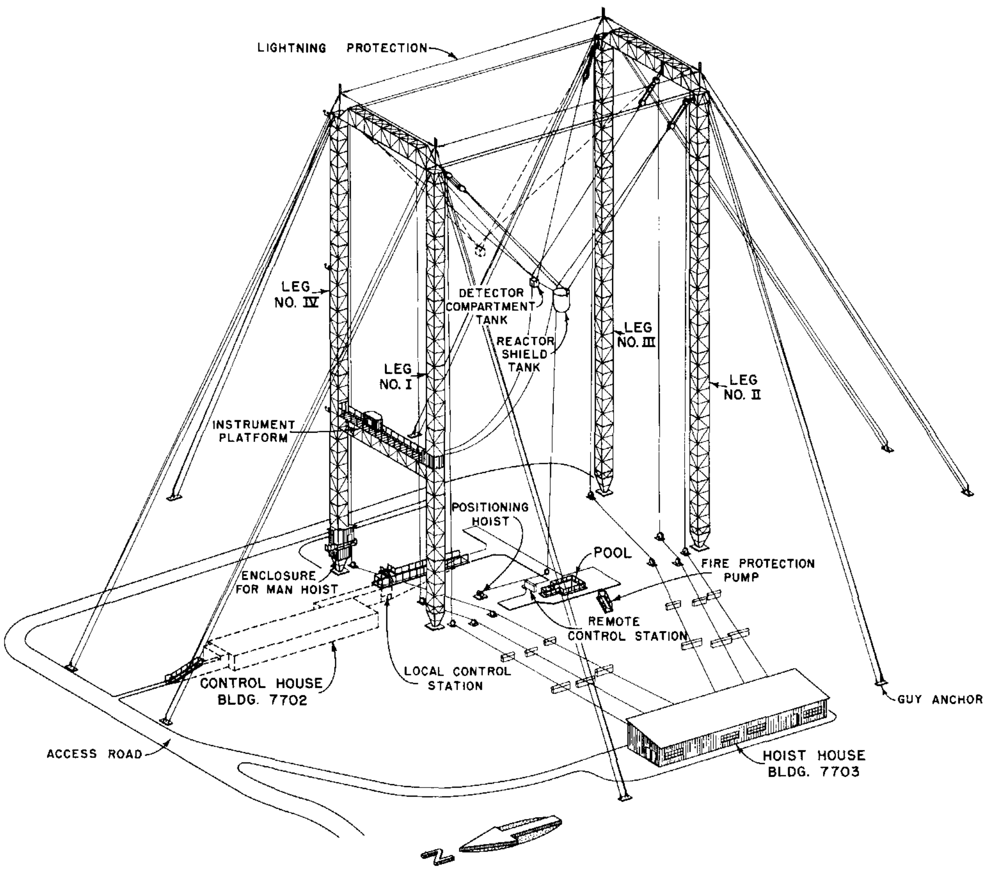
Map A – Locality of Tower Shielding Facility Site Placement in Oak Ridge Area.



Map B – Area Topography of Adjacent Related Features.

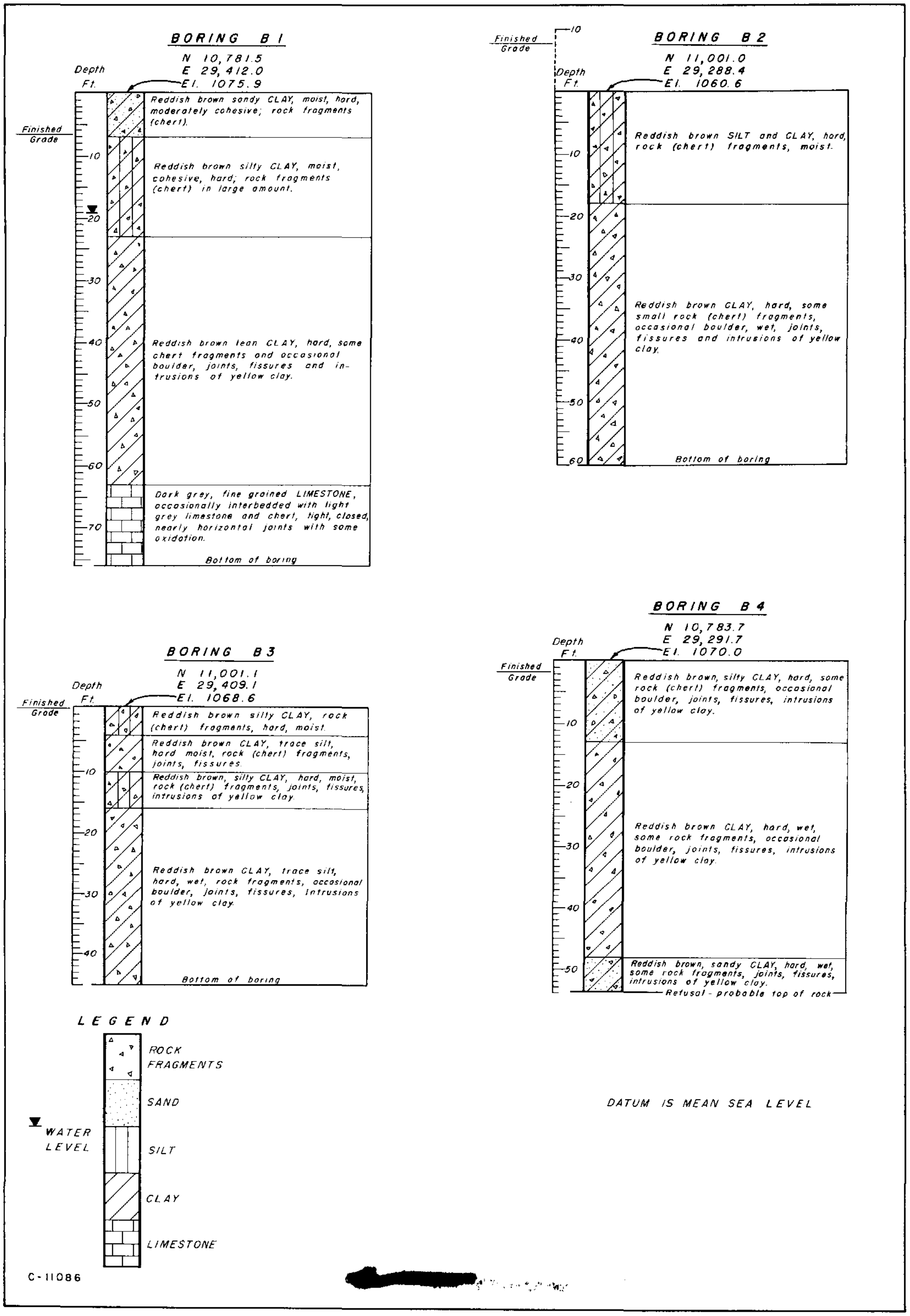


Map C – Site Plan of General Placement of Elements.



C-11085 [redacted]

Map D – Trimetric View of General Placement in Three Dimensions.



Map E – Test Boring Data.

Fig. 1. Construction Progress.

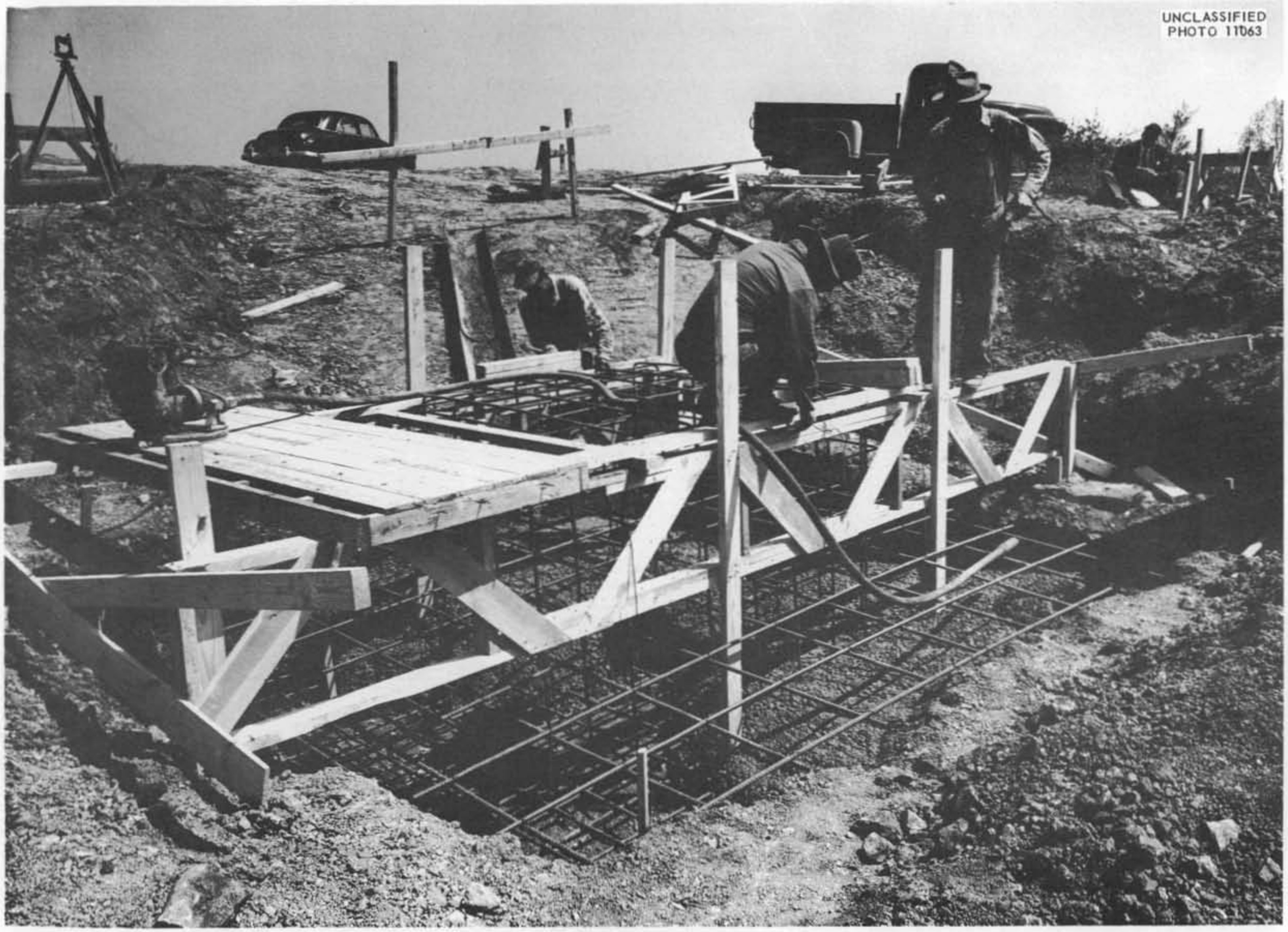


Fig. 2. Typical Foundation Under Construction.

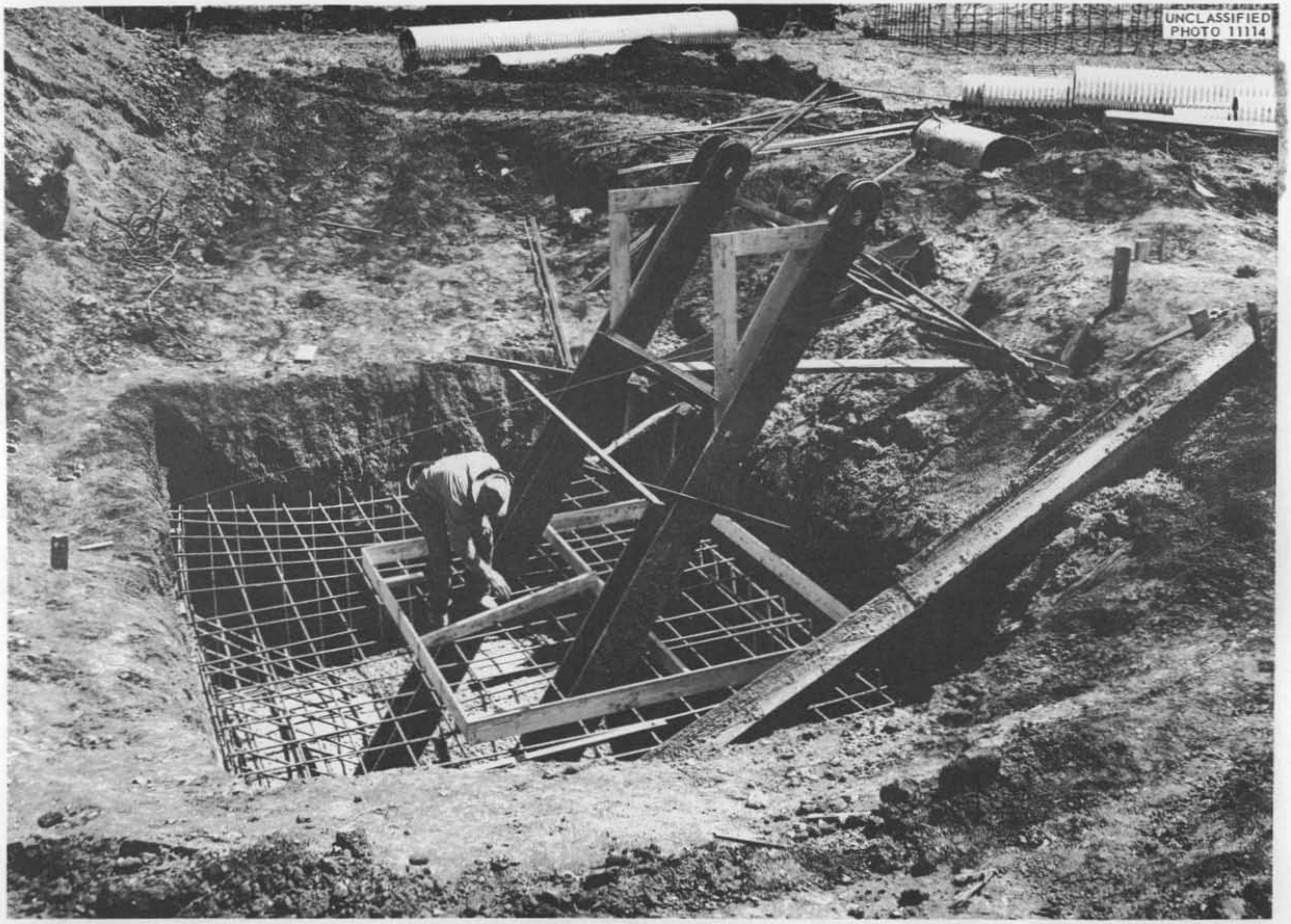


Fig. 3. Typical Guy Anchor Under Construction.

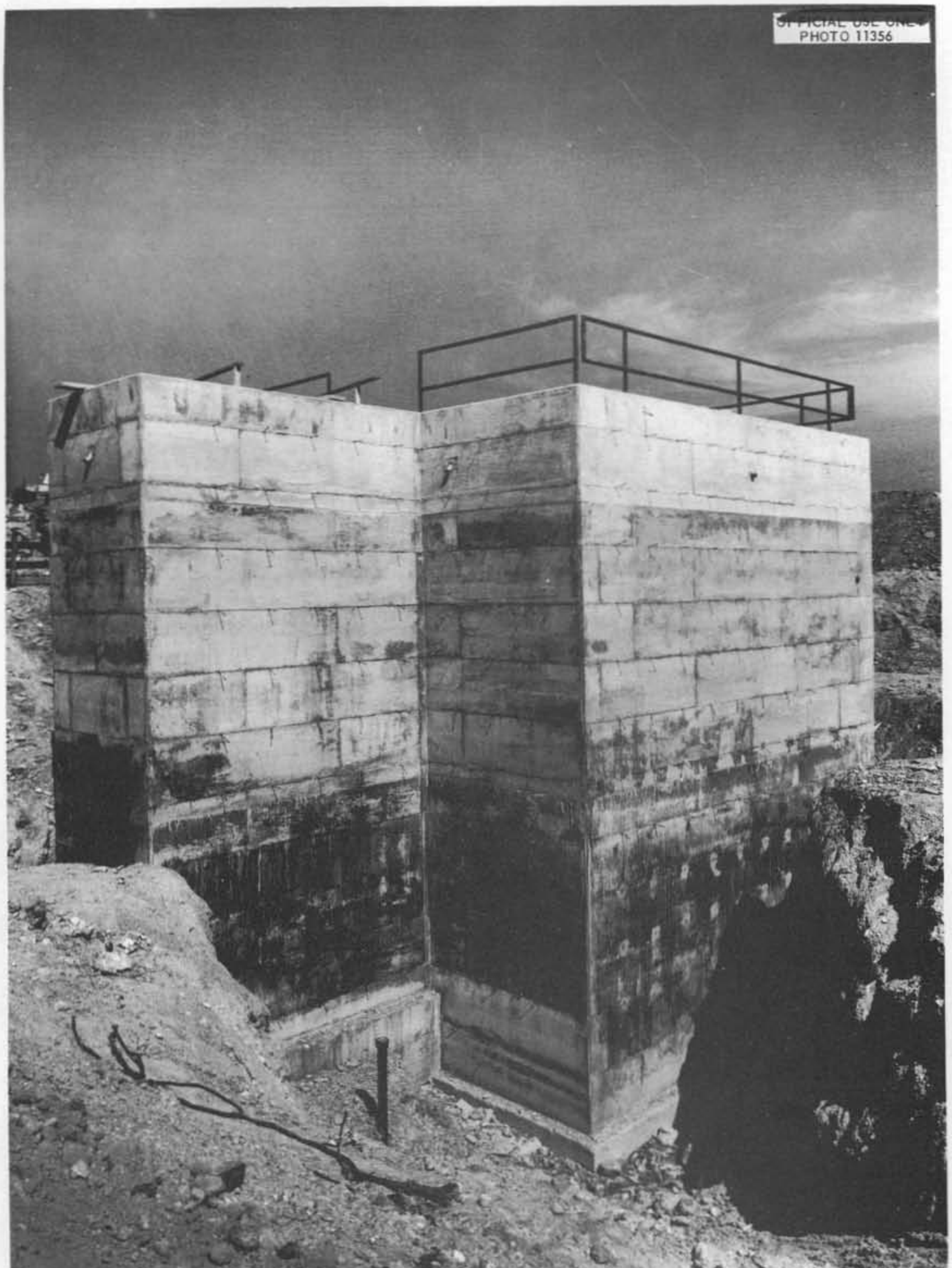


Fig. 4. Reactor Tank Pool Before Backfill.

Fig. 5. Construction Progress.

Fig. 6. Reactor Tank Pool, Leg I Base and Control House.

Fig. 7. Construction Progress.

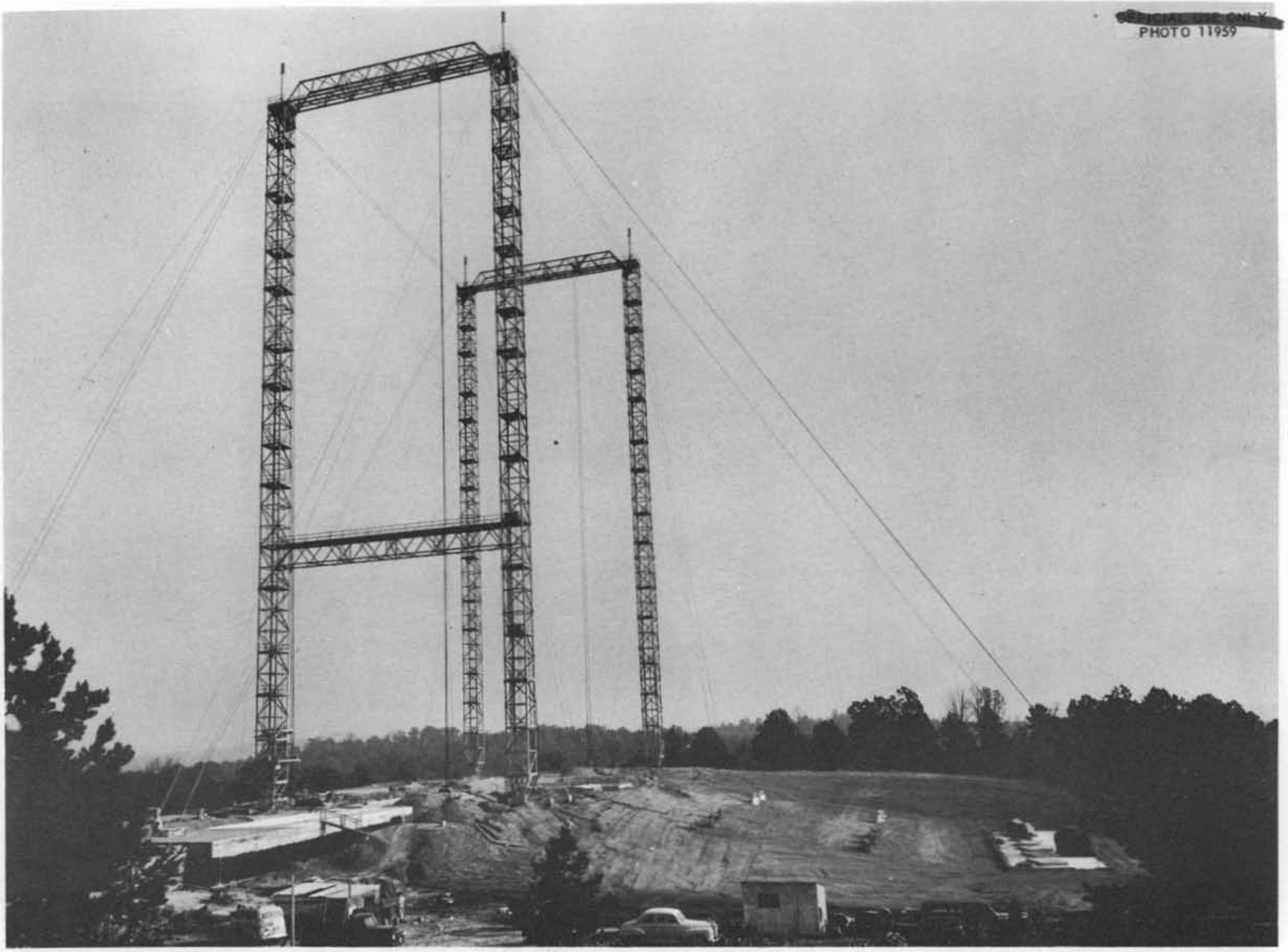


Fig. 8. Construction Progress.

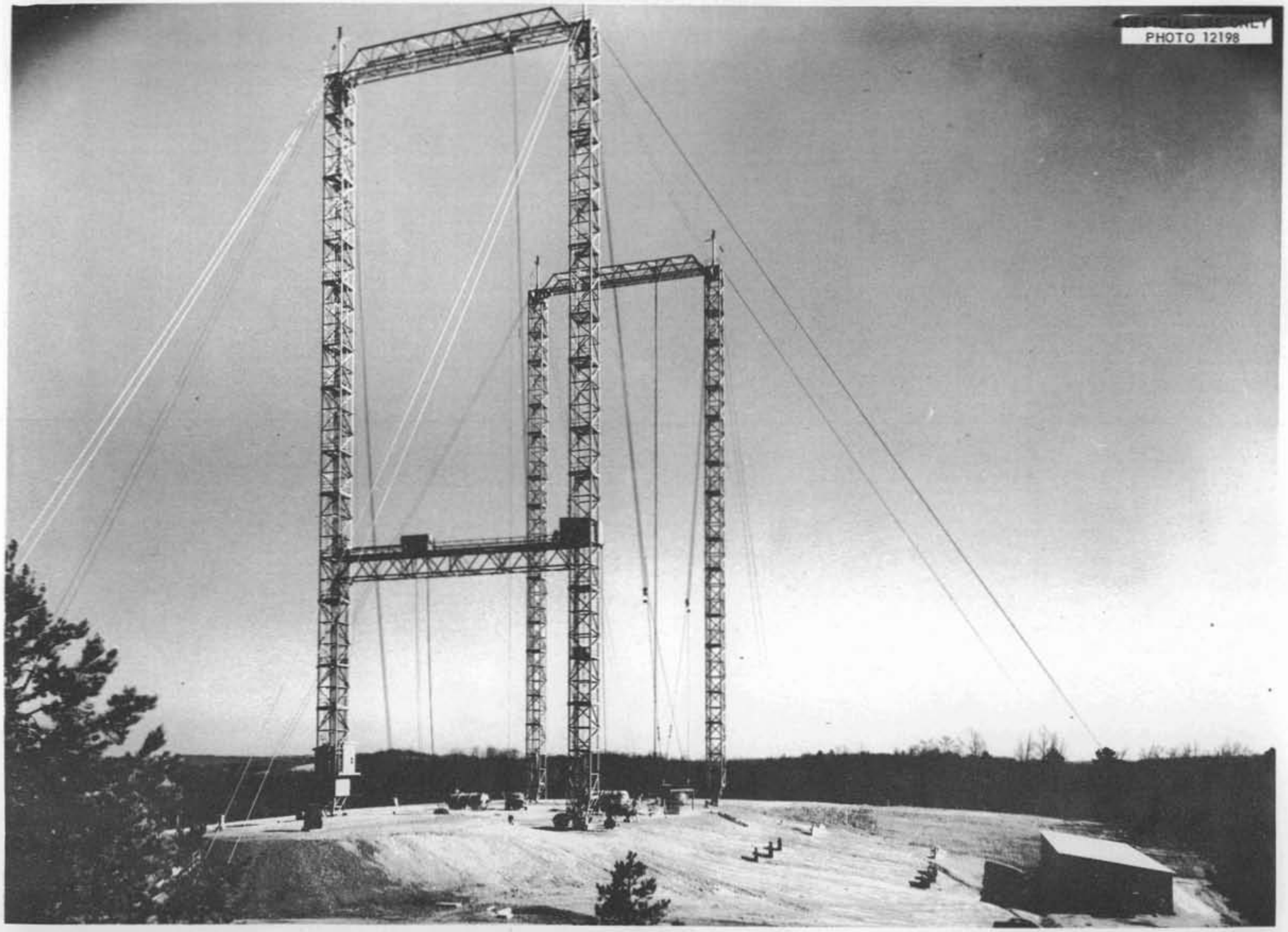


Fig. 9. Construction Progress.

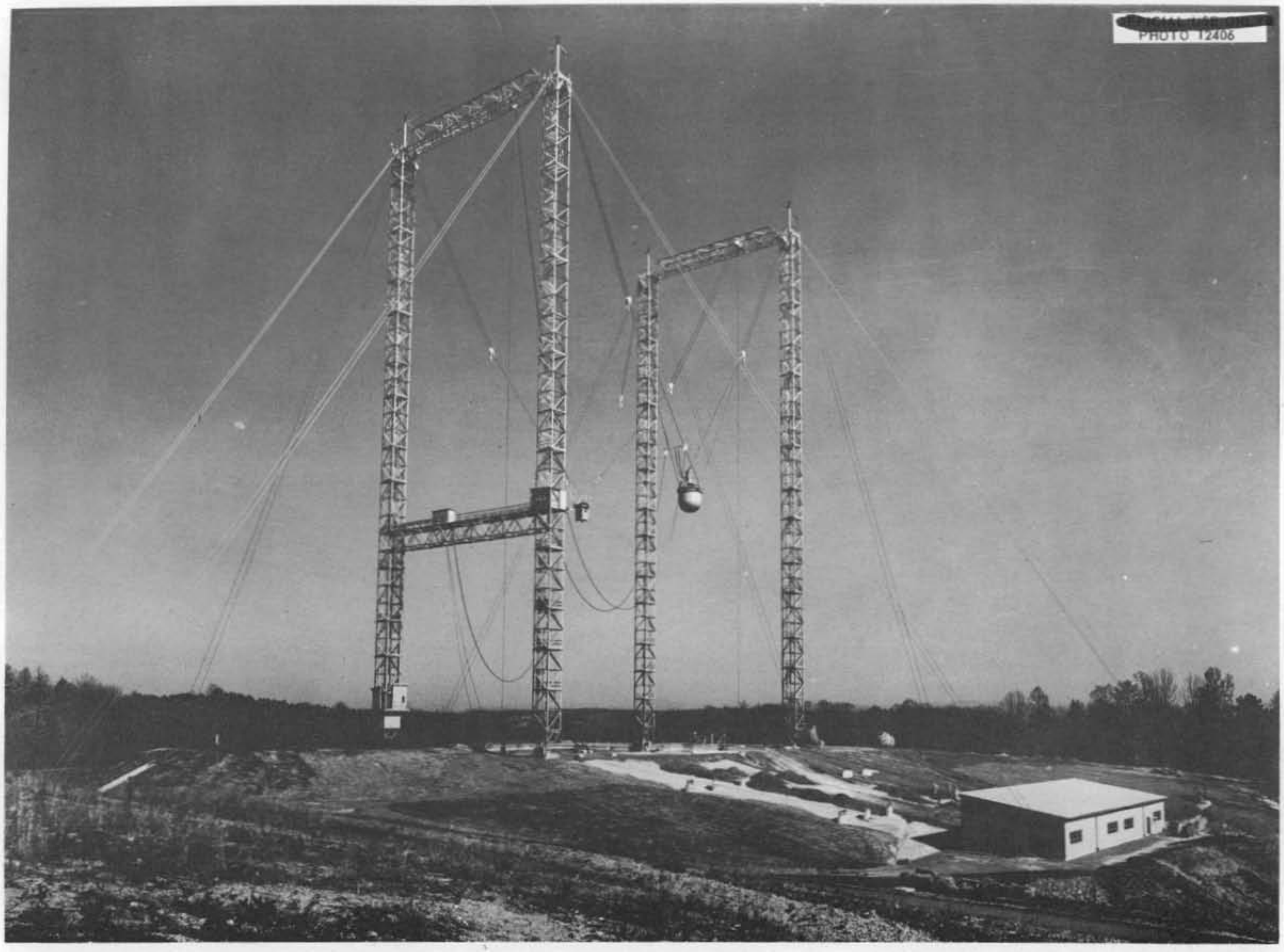


Fig. 10. Completed Facility.

Fig. 11. Reactor Shield Tank from Remote Control Station.

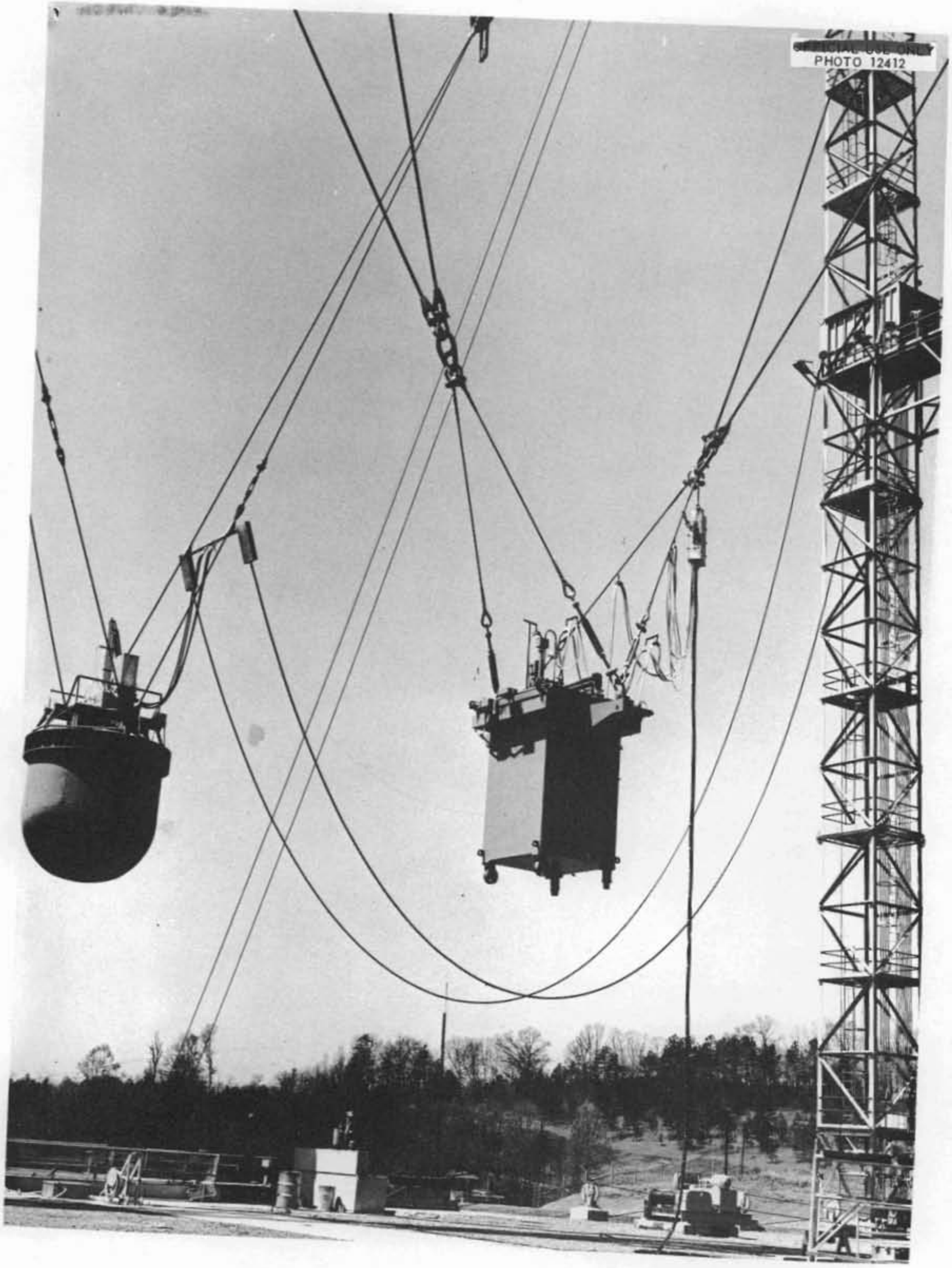


Fig. 12. Reactor Shield Tank and Detector Compartment Tank – Suspended.

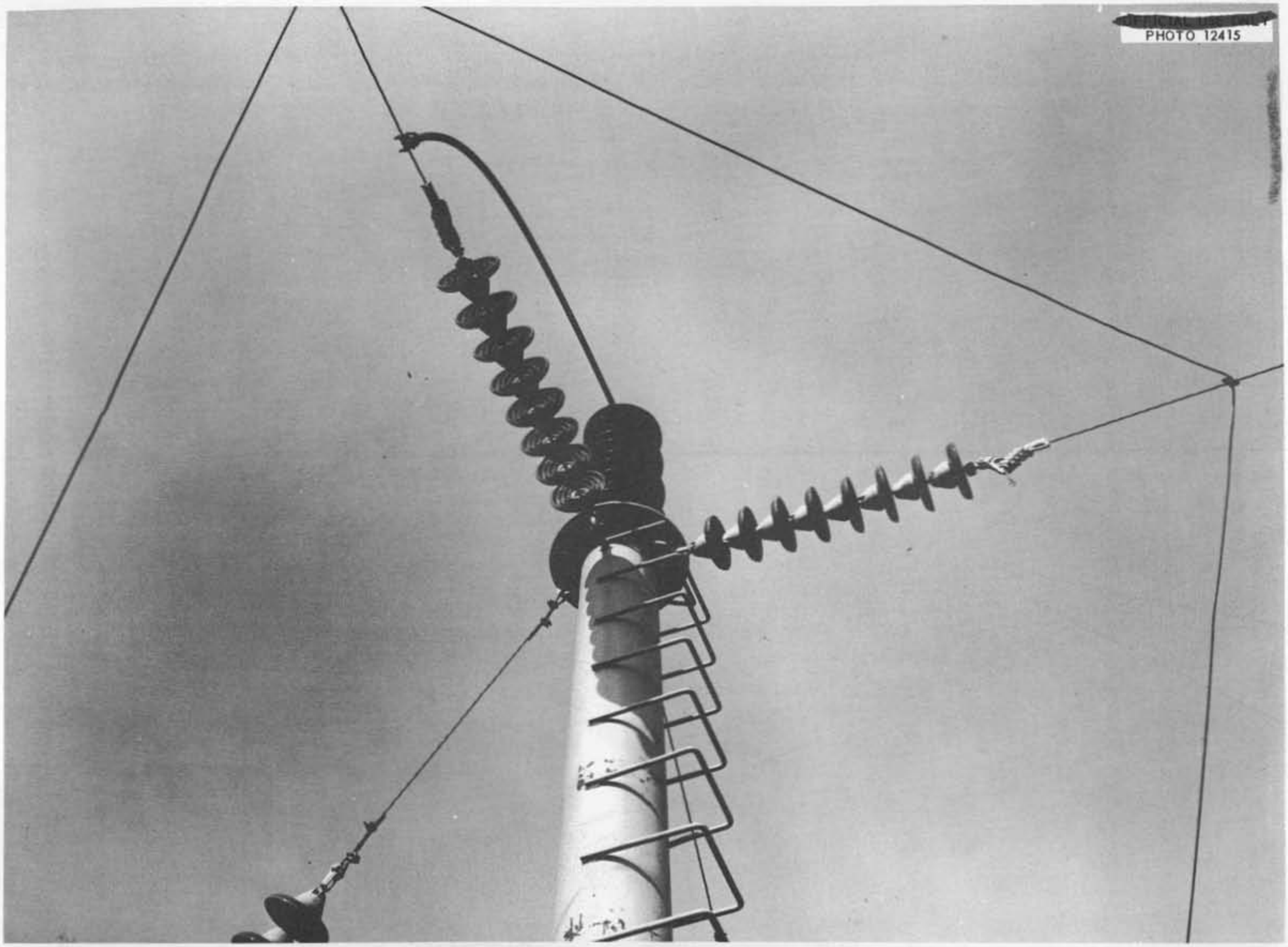


Fig. 13. Typical Lightning Protection – Top of Tower Leg IV.

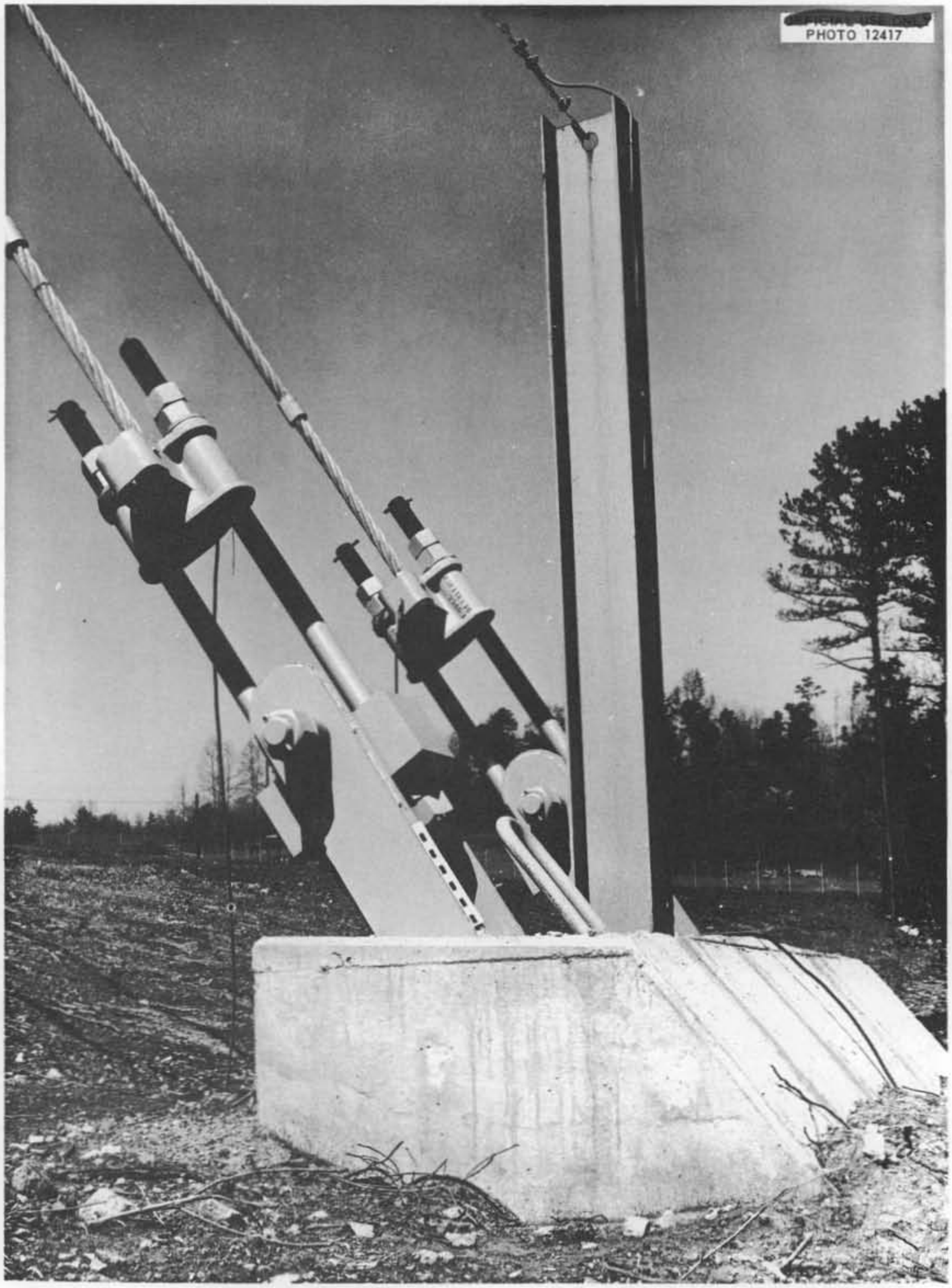


Fig. 14. Typical Guy Anchor – Completed.

Fig. 15. View from Top Truss.

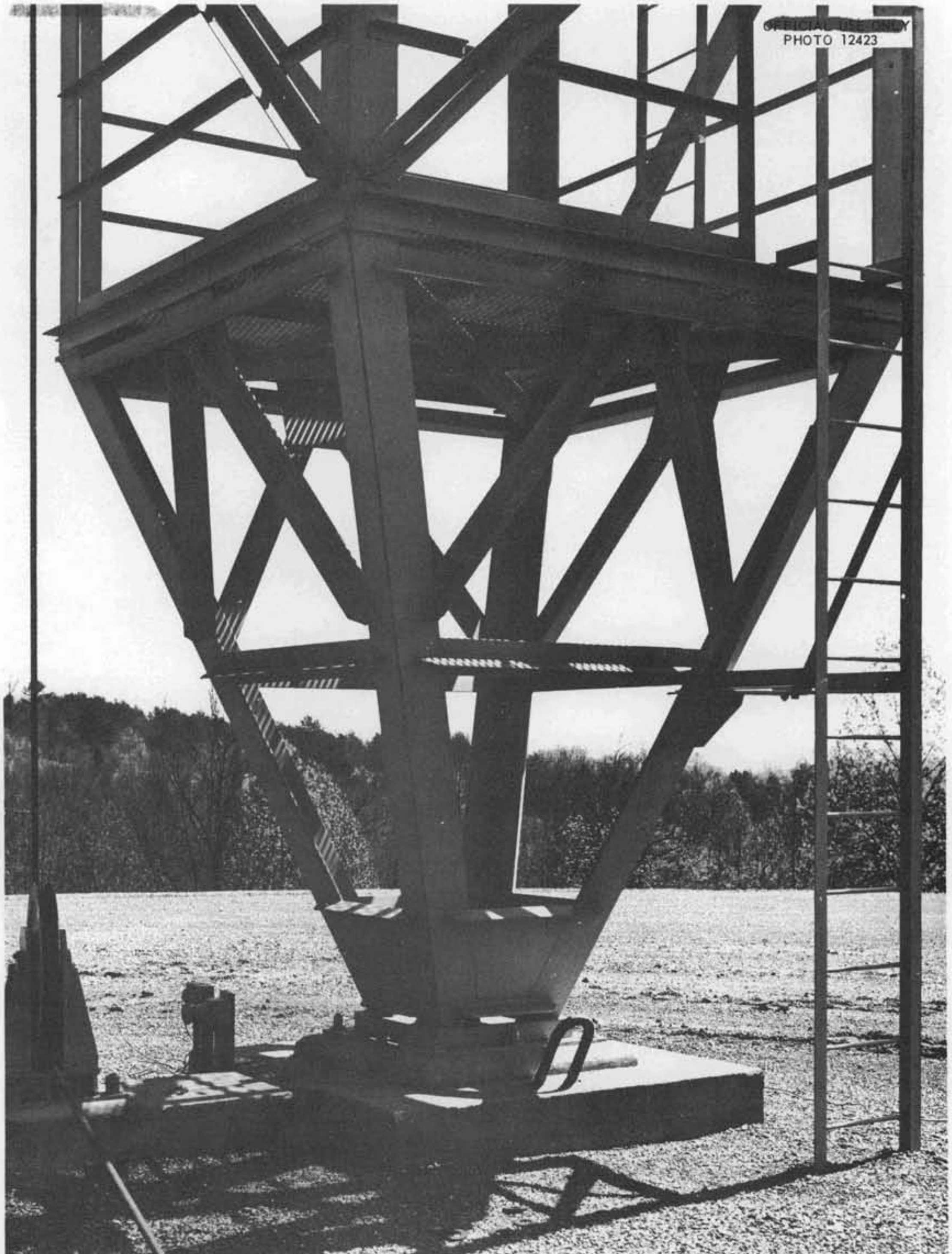


Fig. 16. Typical Tower Base – Leg III.

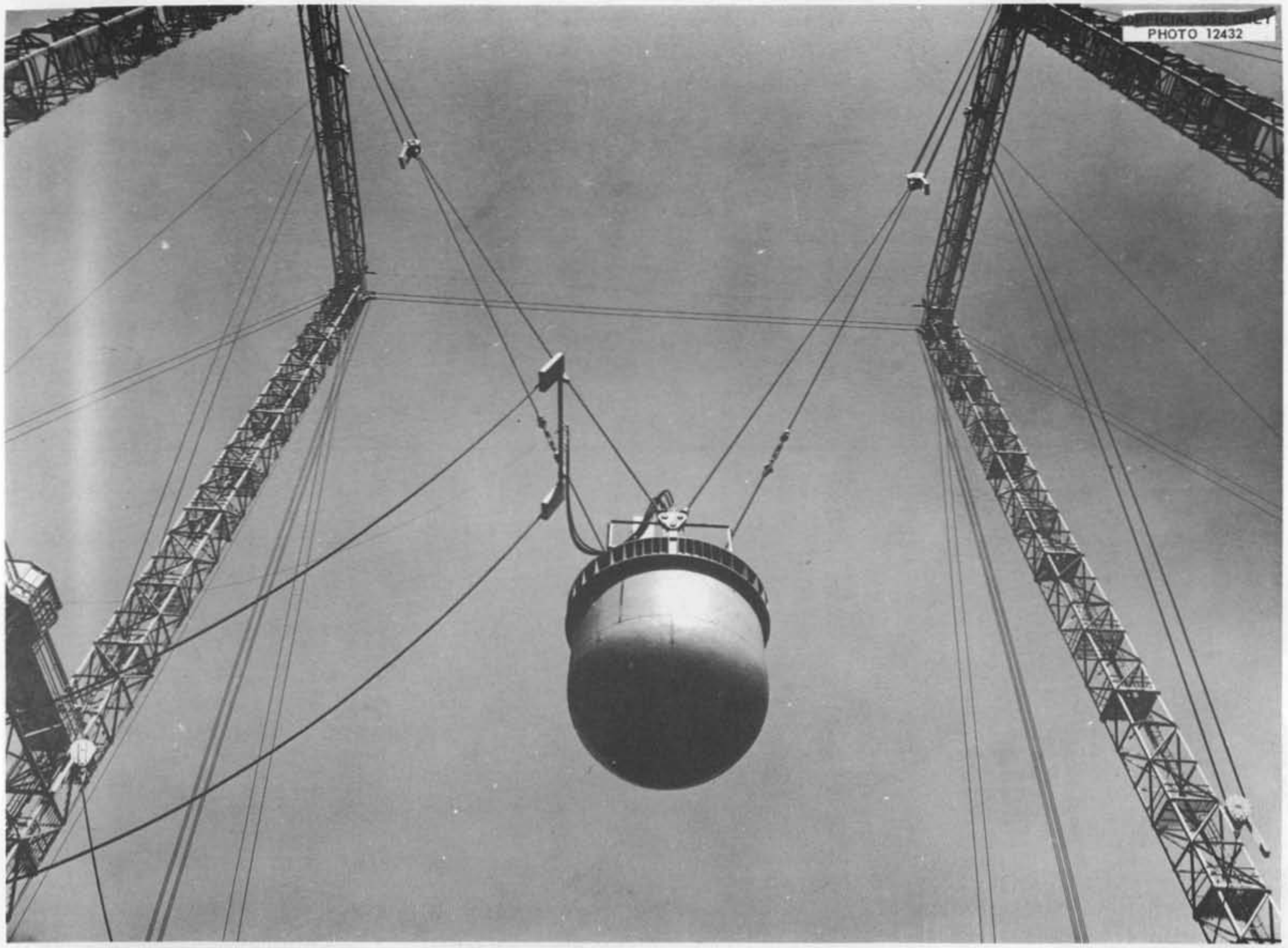


Fig. 17. Reactor Shield Tank – Suspended.

Fig. 18. Reactor Shield Tank Suspended Over Reactor Tank Pool.

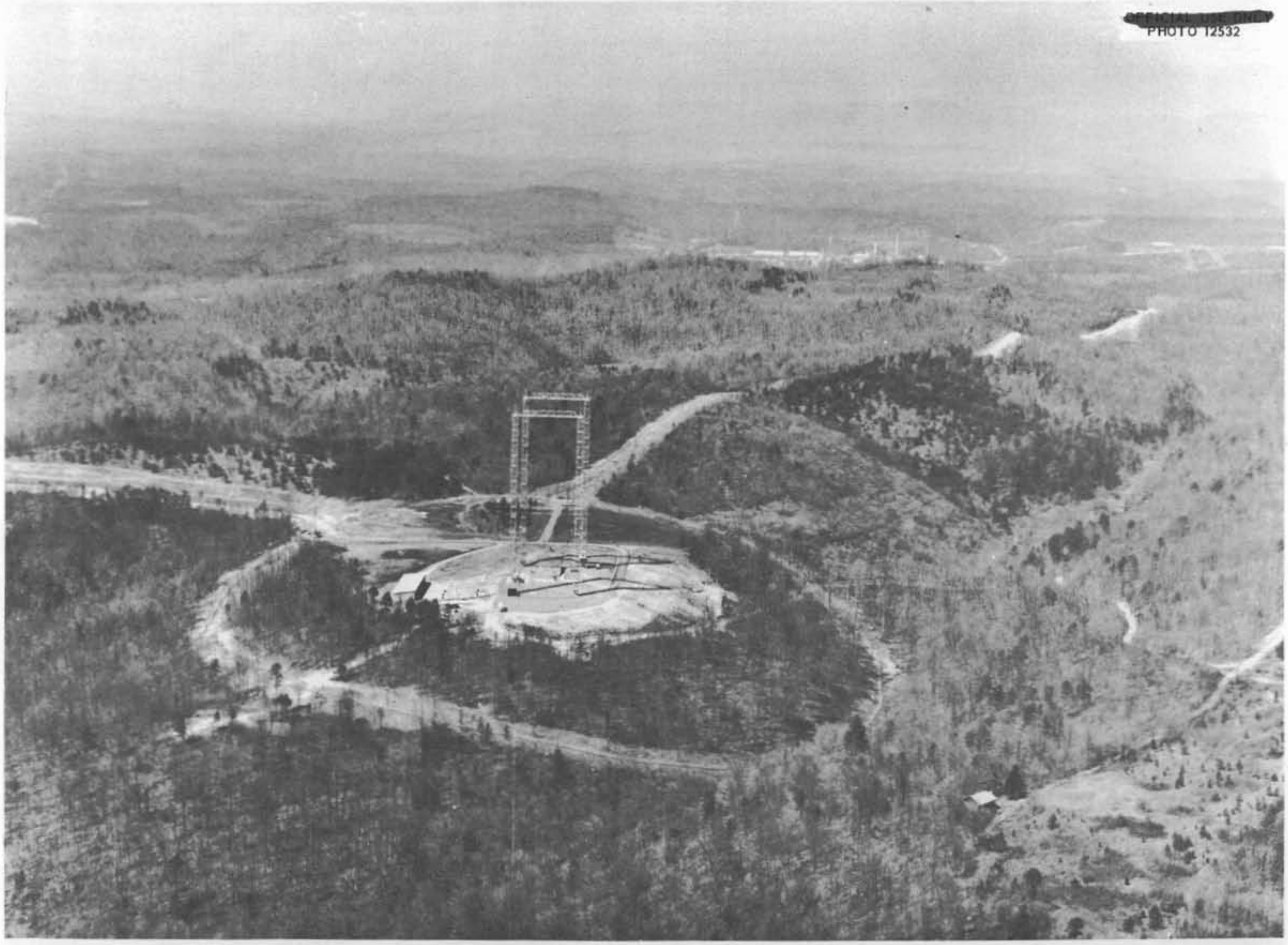


Fig. 19. Aerial View – X-10 Area in Background.

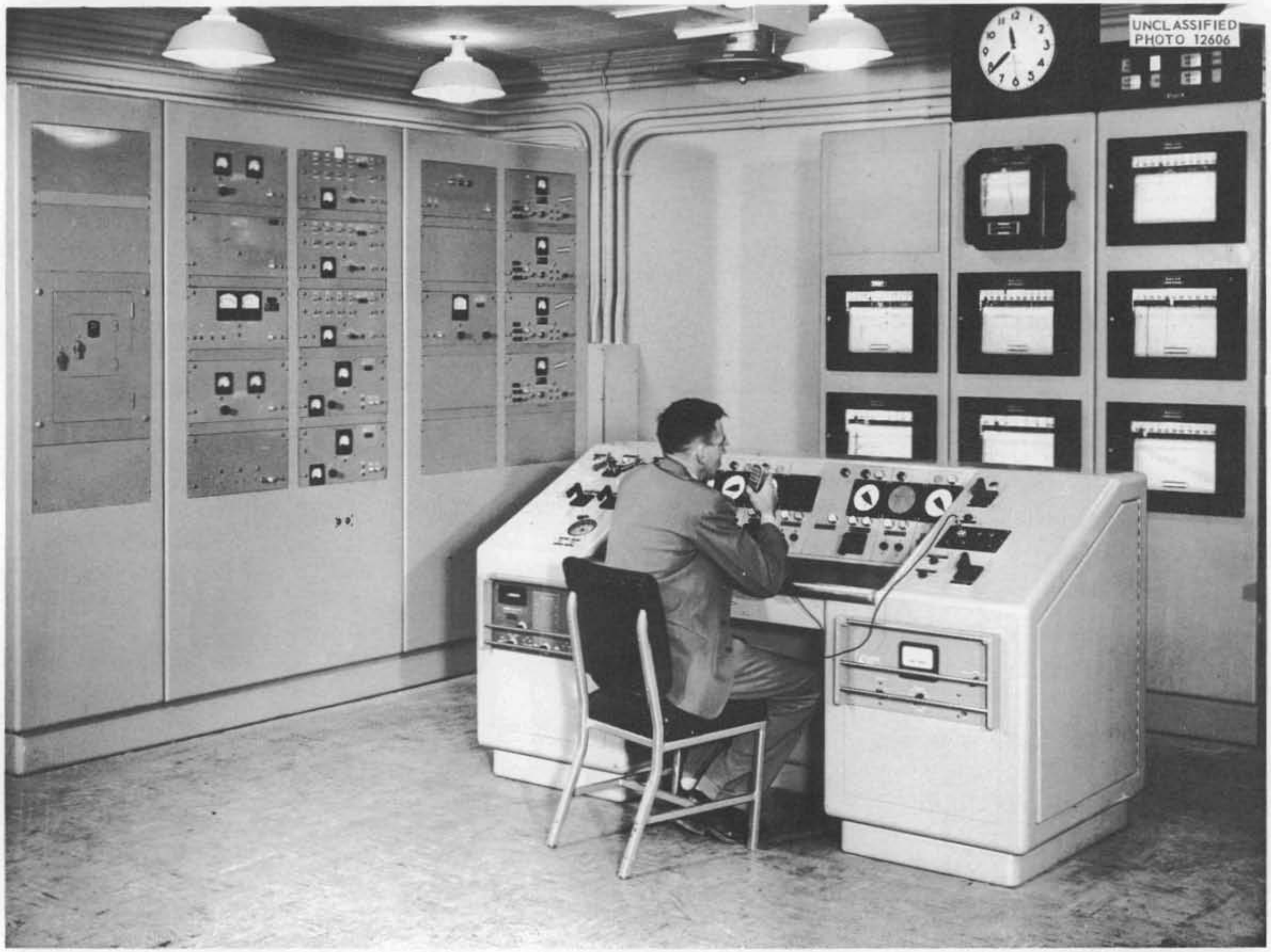


Fig. 20. Instrument Console – Control House.

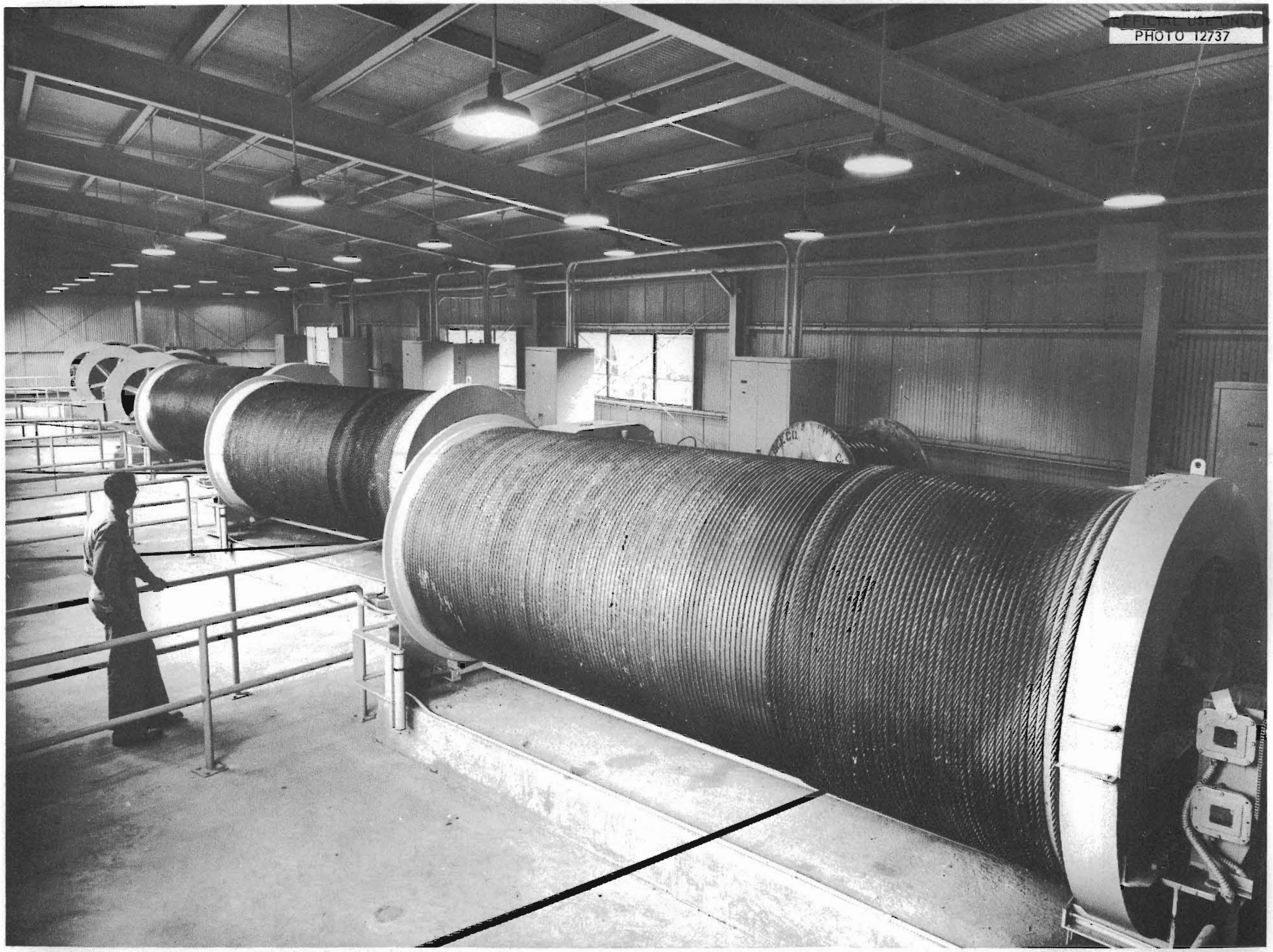


Fig. 21. Interior of Hoist House.