Naval Computer and Telecommunications Area Master Station,
Eastern Pacific, Radio Transmitter Facility Lualualei,
Helix House No. 2 (Structure No. 87)
Base of Radio Antenna Structure No. 427
Makaha Vicinity
Honolulu County
Hawaii

HABS No. HI-310-B

HABS
HI
2-MAKA.V
1B-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Buildings Survey
National Park Service
Department of the Interior
San Francisco, California

HABS
HI
2-MAKA.V
1B-

HISTORIC AMERICAN BUILDINGS SURVEY

Naval Computer and Telecommunications Area Master Station,
Eastern Pacific, Radio Transmitter Facility Lualualei,
Helix House No. 2 (Structure No. 87)

HABS No. HI-310-B

Location: Radio Transmitter Facility (RTF), Lualualei is part of Naval Computer and Telecommunications Center Area Master Station, Eastern Pacific (NCTAMS EASTPAC) located on O'ahu, Hawai'i. NCTAMS EASTPAC consists of the transmitter site in Lualualei and a receiver site at Wahiawa, Oah'u. RTF-Lualualei covers 1,718.15 acres (695 hectares) within Lualualei *ahupua'a,* Wai'anae District, immediately adjacent to Naval Magazine, Lualualei.

Helix House No. 2 (Structure No. 87) is located at RTF-Lualualei at the base of a 1,500 foot high radio antenna (Structure 427). U.S.G.S. Honolulu 7.5' Quadrangle: Waianae; Universal Transverse Mercator Coordinates: 04-588020-2369380.

Present Owner: United States Federal Government under the jurisdiction of the U.S. Navy.

Present Occupant: Unoccupied.

Present Use: Not in use.

Significance: Helix House No. 2 (Structure 87) is an octagonal, cast-in-place concrete building constructed in 1945-46. It is nearly identical to the first Helix House (Structure 3) built at RTF-Lualualei in 1935. The copper-lined Helix House, named for the coiled wires in the equipment housed within, amplifies and tunes the frequency of the radio signal for optimal output. At the time of construction, these structures comprised an impressive and state-of-the-art radio facility, which was the only one of its kind in the Pacific region (Stiedl 1993). The complex represents the Navy's pioneering efforts in initiating new developments in radio-electronics and their leadership in the utilization of radio-electronics in military operations (Gebhard 1979: iii).

The Helix House (Structure 87) was constructed in an Industrial aesthetic with Italianate features. These features, such as pilasters, soffited eaves and relatively low-pitch hipped roof, merged with the large scale of the building and the high-tech function (for its time) make this a visually arresting structure. Along with the first Helix House (Structure 3) and Transmitter (Building 2), it forms a stylistically unified grouping which displays a relatively high degree of architectural merit representative of New Deal construction. Between 1945 and 1972, the RTF-Lualualei submarine broadcast facility consisted of a low-frequency transmitter building, two Helix Houses, and an array of eight 600-foot antennas. In 1972, the array was replaced by two 1,500-foot tall antennas (Structures 427 and 428). At this time, the second Helix House was no longer needed, and Structure 87 was removed from service.

PART I. HISTORICAL INFORMATION

A. Physical History:

1. Date of erection:
1945, according to the *Detailed Inventory of Naval Shore Facilities* (P-164) for RTF Lualualei. This date is confirmed by the earliest architectural drawings for the structure which are dated December 18, 1944. Although planning for this structure began during wartime, the building was not completed until after the end of the war (minor revisions were made to the construction drawings as late as April 1946).

2. Architect:
Unknown; initials given for the "Arch. or Engr." on the drawings appear to be "H.P.C."

3. Original and subsequent owners and occupants:
United States Navy.

4. Builder, contractor, suppliers:
Unknown.

5. Original plans and construction:
The original drawings, dated 12/18/44, illustrate an octagonal-shaped structure, 74'-0" in diameter and approximately 66' to the peak of the roof (60'-10 3/4" to the top plate). The construction is similar to the 1935 Helix House (Structure 3), with a cast-in-place, reinforced-concrete structural system, concrete pilasters, and a copper standing-seam, hipped roof. The building consisted of a single, copper-lined volume which housed a "Variometer" and three "Antenna Loading Coil Forms" (Drawing #OA-N04-3833). High on the east elevation is a 28-foot diameter "circular void", also identified as an "antenna trunk opening" (Drawings #OA-N04-3832 and OA-N11-388). A tall, flat roofed shed with an arched opening, approximately 28-feet wide and 50-feet high, was located on the east elevation to protect the large, round opening. Two electrical service rooms are located in the side walls of this shed. The main entrance is through a pair of doors on the south elevation of the building; access to the electrical rooms are through single doors on the south and north elevations. The roof of the structure is vented through a louvered clerestory. The exterior of the building appears relatively unchanged from the time of its original construction.

6. Additions and alterations:
1946: revisions to the original drawings indicate the construction of concrete masonry unit (CMU) enclosure with a shed roof beneath the round opening (Drawings #OA-N04-3832 and OA-N11-388). The plans indicate that this space was utilized as a "ladder room." This structure is evident in photographs taken of the building in 1955 (see figures 12 and 13).

ca. 1964: the "Variometer" and three concrete "Antenna Loading Coil Forms" are replaced with new equipment, identical to that presently located in Structure 3 (see figures 14 to 16).

date ?: the CMU shed is replaced with a cast-in-place concrete wall which encloses the arch-topped opening at the exterior of the structure. This space was utilized for storage. The circular opening remains evident only at the exterior of the structure.

1972: the original antenna field is replaced with two 1,500 antennas which are served by Structure 3; Structure 87 is no longer needed to tune the transmitter in Building 2 to the new antenna towers and is removed from service (Naehu 1996).

1982: Hurricane 'Iwa strikes the Hawaiian Islands, tearing the roofs off of both Helix Houses. Structure 3 is re-roofed with the present standing-seam copper roof at a cost of $500,000 (Naehu 1996). Structure 87 is abandoned and the valuable metals salvaged or scavenged. The building remains essentially unchanged from this time.

B. Historical Context:

1. History of the U.S. Navy in Hawai'i:

The earliest recorded U. S. military presence in Hawai'i was in 1814, when a captured British ship commanded by a U. S. Marine, LT. J. M. Gamble, visited Honolulu. The U. S. Navy followed in 1826, with a visit by the *USS Dolphin.* In 1840, the Navy first surveyed Pearl Harbor. The U. S. military's interest increased during the 19th century as the role of the Pacific region gained importance in the world political situation. For the next 50 years, Hawai'i was visited by various military sailing ships for purposes of shore leave and re-supply. There were no identified U. S. bases in Hawai'i, as food and water were purchased from the civilian sector. In 1872, Major General John M. Schofield, Commander of the Army Division of the Pacific, inspected O'ahu to evaluate its military potential for defense of the North American continent, concluding that Pearl Harbor should be developed as a U. S. military base. King David Kalakaua granted the U.S. Navy permission to develop and maintain a coaling and repair station at Pearl Harbor as part of the Reciprocity Treaty of 1876, which allowed Hawaiian sugar to enter U. S markets duty-free.

Beginning shortly after the 1898 annexation of Hawai'i, permanent military bases were established by the United States on the island of Oah'u. The Navy expanded ship repair facilities and began developing wharves and shoreside facilities in Pearl Harbor. By the end of world War I, all branches of the military were firmly established in Hawai'i.

The National Industrial Recovery Act (NIRA) of June 16, 1933 specifically authorized the president to utilize funds for military and naval construction. The Hawaiian Islands received $10 million of NIRA funds, which provided improved roads, and a Navy radio station and ammunition depot at Lualualei.

With the outbreak of war in Europe in September 1939, President Roosevelt declared a National Emergency and an extensive amount of construction began at Pearl Harbor and other Naval installations on O'ahu. After the December 7, 1941 attack on Pearl Harbor, tremendous expansion took place on O'ahu and the outer islands. Hawai'i became a major logistics and training complex for the Pacific war, and was the Navy's front line of defense until the Battle of Midway in 1942. At the peak of the war, over 600,000 acres of land was being used to support the war effort. This is roughly two and one-half times the area presently used by the military. Facilities were constructed on Hawai'i, Maui, Kaua'i and Moloka'i, with only the privately owned islands of Lana'i and Ni'ihau left relatively untouched.

By the time the Japanese government surrendered to the allied forces in 1945, Pearl Harbor and its affiliated Naval bases on O'ahu comprised the most extensive defense

installation in the world. The end of World War II brought to an end the major construction program of the Navy, and as weapons technology evolved, many of the facilities became outdated. There was a general phase-down following World War II which was temporarily suspended by the Korean War in 1950. Although some construction occurred to support the efforts in Korea, most construction work consisted of modernization or replacement of existing structures.

"Current" planning for the military in Hawai'i began with statehood in 1959. The Statehood Act established a five-year period, during which Federal agencies were to review their holdings to identify those required for retention. Land between needed facilities was declared surplus and released, so that the Navy now operates from several fragmented land parcels, such as those in the Lualualei area, as well as from the central Pearl Harbor area (U.S. Navy, Pacific Division 1990). By the end of this period (June 1964), all the branches of the military had reduced their land holdings to roughly what they are today (U. S. Navy, Pacific Division 1990).

2. NCTAMS EASTPAC Historical Background:

The Navy's radio communication system, which began to take form shortly after Marconi invented the wireless in the late nineteenth century, evolved rapidly in the period between World War I and World War II. By 1940, Naval communications encompassed a far-reaching network of high, medium, and low-frequency transmitting stations capable of encircling the globe; receiving stations; and a large number of supplementary stations, including numerous installations of air-navigational aids (U. S., Department of the Navy, 1947: 401).

The first Navy communications station in Hawai'i was activated in September 1916 at Hospital Point, Pearl Harbor. In 1920, a receiver station was constructed at Wailupe in East Honolulu. The station was capable of processing six messages simultaneously and was considered to be one of the largest in the world. As various naval activities moved into the Pearl Harbor area, expansion of the communications station at Hospital Point became impractical. In 1931, land was purchased in Lualualei Valley for construction of a new transmitter facility, which was activated in 1936.

With the outbreak of World War II and the Naval fleet expansion into the Pacific, improved radio communications became essential. When the Lualualei main transmitter, with towers over 600 feet high, proved not to be powerful enough, the Navy selected a new site just north of Wahiawa where the Pacific Naval Air Base (PNAB) Contractors built one of the world's largest radio installations on high ground. Complete military communications facilities for Oah'u would require the construction of a transmitter station more powerful than that at Lualualei.

> One more item was needed to give the Pacific Fleet full striking power: absolute certain means of radio communications with headquarters at Pearl. The new receiving station at Wahiawa amply met these requirements but the main Navy transmitter at Lualualei was not powerful enough for an all-ocean war. A giant sending station must be built that would reach not only to the waters of Australia and the Indian Ocean but also to every Allied submarine - *submerged* - especially if she were on the bottom of Tokyo harbor. [Woodbury 1946: 348-349]

> Almost at the center of the island, the Contractors were ordered to build a huge new radio station. A mile or so back of the village of Wahiawa the land swelled to a level hilltop - the highest ground for several miles. Wahiawa was to be the main receiving unit for the Pacific fleet - capable of picking up messages from the farthest corner of the ocean.
>
> . . . The layout was as complete as if the station had been on an empty Pacific atoll. Besides all necessary living quarters for several hundred men, there would be various operations buildings, garages, shops, a cold-storage plant, tennis courts and recreation hall, several miles of roads, sewers, and water lines. The main operations building and power plant were to be bomb-proofed . . . (Colette 1985: 457)

NCTAMS EASTPAC base construction in Wahiawa had begun in 1940 in anticipation of the war and was originally scheduled for completion in 1942. After the attack on Pearl Harbor, construction was expedited and the relocation of functions from Wailupe to Wahiawa was completed on December 17, 1941.

> The radio installation itself was to be as large as any in the world. A forest of wooden poles ranging in a complicated pattern over half a square mile of ground would support a grid of copper strands that could intercept signals no matter how weak from every direction. At the center all wires would be gathered together into cables and led to a vault deep under ground, where the receiving instruments would be protected from any possible bombing raid. [Woodbury 1946: 172-173]

A long-range transmitter was proposed for Ha'iku Valley (on the windward coast) based on a Dutch-designed facility in Java using high aerials between two mountain peaks. After an extremely difficult period of construction, Ha'iku Radio was commissioned by the Navy in August, 1943. The "keying" or actual message-sending from Ha'iku was to be done at Wahiawa, seventeen miles away (Woodbury 1946:362). A Naval communications station in the adjoining valley of He'eia was constructed at the same time. In 1943, the Communications Security Unit was established at Wahiawa under the Chief of Naval Operations, to assist in cryptographic security, traffic control, and analysis.

Another NCTAMS EASTPAC site, the Opana Mobile Radar Station (Site 50-80-02-9745), played a critical role in the outbreak of the war. Located near Kahuku Point on the northern tip of Oah'u at 230 feet above sea level, the Opana site was one of six Army radar stations established along Oah'u's coastline in the November 1941. While at the Opana site on December 7, 1941 at 0702 hours, Privates Joseph L. Lockard and George E. Elliott observed "something completely out of the ordinary on the radar screen" (Layton 1985:308). They determined that more than fifty planes were bearing down on the island from approximately 130 miles to the north. Their call to the Information Center at Fort Shafter was handled by an inexperienced duty officer and the message was never routed to Naval Headquarters. Within the hour, Japanese planes attacked Pearl Harbor, an event that plummeted the United States into war. The Opana Radar site is listed on the State Register of Historic Places and has been nominated for the National Register of Historic Places, as well as for National Landmark status by the National Park Service. Opana is significant as the site where radar was utilized for the first time in a combat situation by the United States (U.S. Dept. of Interior 1991).

Following World War II, the Central Radio Station was returned to Pearl Harbor and Wahiawa was downgraded to a receiver site. In 1956, however, the central station was relocated back to Wahiawa. By 1959, the radio station at Heeia was turned over to the Marine Corps Air Station, Kaneohe, and the Haiku station was placed in non-operational status. Completion of the Communications Center Building (Building 261) at NCTAMS-Wahiawa (then called Naval Communications Area Master Station) in 1960 consolidated all communications command facilities. New communications technology rapidly evolved during this period. In 1967, the Automatic Digital Network (AUTODIN) system and the SATCOM facility (MSC-46) at Opana were activated.

In 1970, the Deputy Secretary of Defense directed the Navy to study the consolidation of radio communications facilities. Subsequent plans resulted in consolidation of all Army, Navy, and Marine Corps high frequency (HF) receiver facilities, and part of the Air Force receiver facilities at NCTAMS-Wahiawa. Technological developments since consolidation include completion of the two very-low-frequency (VLF) antenna towers at RTF-Lualualei in 1972. These 1,500 foot high towers were the tallest in the Pacific at the time of construction. The Naval Communications Processing and Routing System (NAVCOMPARS) was activated in 1974. A new SATCOM facility (FS-78) became operational in 1977. RTF-Lualualei was converted to contract operation in 1979 but reverted back to the Navy in 1981. Day-to-day maintenance is done by Public Works Center (PWC) Pearl Harbor.

3. Physical Evolution of RTF Lualualei:

a. RTF-Lualualei Land Tenure History:

Changes in land tenure and use in Hawai'i are documented from the 1850s. Most of these changes occurred during the period commonly referred to as the Mahele - the division of lands signaling the transition from traditional Hawaiian concepts of land ownership to the western concept of individual fee simple land ownership. The transition occurred in several stages between 1845 and 1854 (Chinen 1978:10). Initially, Kamehameha III divided the lands into four categories: 1) the lands belonging to the King, with the remainder divided among 2) the government, 3) chiefs and *konahiki* [headman of a land division], and 4) the commoners (Chinen 1978:15-16).

Kelly (1991) summarized the history of land use in Lualualei. The geographic and temporal boundaries for these uses overlap to a certain degree, and are outlined below:

Hawaiian:	From Polynesian arrival (ca. first to third century A.D.) until the present. This period spans Western Contact (1778), the Mahele (1848-1854).
Early Ranching:	Crown leases to Jarrett, Dowsett, Galbraith, and Paul F. Manini 1851-1902.
Plantation era:	Waianae Sugar Co. began operation 1878 in Wai'anae Valley. Three hundred acres of sugar cane were planted in central Lualualei by 1892. A railroad, irrigation ditches and flumes, and reservoirs were established. A plantation housing area (Cane Camp) was established adjacent to the railroad tracks by Niulii reservoir. Waianae Sugar Co. ceased operations in 1946.

Homestead Era: First Series, Lots 1 - 9 (back of valley), began 1903.

McCandless Ranch: Commencing circa 1908, L.L. McCandless leased or purchased most of First Series Homestead lots 1 - 9 by 1912 and sub-leased the use-rights of some areas to the Sandwich Island Honey Company for establishing apiaries. The ranch operated cattle operations until 1929 when U.S. Navy acquired 8,184 acres in Lualualei.

Homestead Era: Second Series, Lots 10 - 20 (coastal portion of Lualualei), began 1907.

Homestead Era: Third Series, lots 101 - 214 (north-central plain), began 1912.

Military Era: Began in 1923 with construction of Kolekole Pass Road, followed by 1929 acquisition of 8,184 acres; continues today. Initial construction and development of Naval Magazine-LLL and RTF-Lualualei occurred between 1930 and 1935 (refer to military history).

b. Building Development Patterns at RTF-Lualualei:
Base construction at RTF-Lualualei can be divided into four general phases. The first phase consists of the initial base construction (1935-1940), during which the first radio transmitters and antenna, housing units, and initial support facilities were built by local contractor E.E. Black.

The second phase consists of the World War II buildup (1941-1945), during which administration and support buildings were constructed to accommodate the increase in military forces. Many of these buildings were temporary wood structures and have since been removed from the base. Much of this work was completed under the CPFF (cost-plus-fixed-fee) contract with the Pacific Naval Air Base (PNAB) Contractors, a consortium of three construction companies, each a specialist in its own field (Bureau of Yards and Docks 1947: 121).

The third phase of construction was undertaken in the post-World War II period (1946-1950), in which additional communications and support facilities were constructed. Additional transmitter facilities, such as the Helix House No. 2 (Structure 87), were constructed during this period. Although planning for this structure began during wartime (the earliest drawings are dated December 1944) the building was not completed until after the end of the war (minor revisions were made to the construction drawings as late as April 1946).

The fourth phase incorporates the remaining construction to the present day (post-1951). Structures built during this period include the enlisted mens' housing and dining facilities (since abandoned), operational storage and additional support structures, as well as the majority of the transmitter structures.

4. General History of Helix House No. 2 in the Context of Naval Radio Communications:

At the beginning of the twentieth century, the U.S. Navy realized that radio communication would greatly aid tactics and strategy. Long distance communications with ships, previously impossible, would increase the effectiveness of its operations at

sea. The Navy began installing the best radio-communications equipment it could procure on its ships and at its shore stations. This program of improvement continues to the present day, and has resulted in the Navy becoming the principal sponsor of radio-electronics in this country and a pioneer in its early development (Gebhard 1979: 1).

The first electronic or electrical communications system to go into large scale use was Samuel F.B. Morse's telegraph which sent messages over wires. In 1897, Guglielmo Marconi developed a radio system which could transmit "wireless" Morse signals over distances of several miles. Prior to the development of the electron vacuum tube (ca. 1917-19), the earliest radio equipment utilized spark transmitters which radiated signals over a wide band of frequencies whose mid-point depended on the length of the antenna. As the number of transmitters increased, some with higher power to give improved range, instances of interference became commonplace as operators attempted to pass messages simultaneously (Price 1984: 5). Electron tubes made it possible to generate and amplify highly specific frequencies. The tubes were the primary distinguishing feature of radio equipment through the end of WW II, and made commercial radio broadcasting possible. It is from their development that the terms "electronic engineering" and "electronics" were derived (Devereux 1991: 25). In 1947, scientists at Bell Laboratories developed the transistor, which led to the miniaturization of radio equipment. Advances in digital electronics have begun to replace analog equipment.

The Russo-Japanese War (1904-06) was the first in which both naval forces used radio. In 1906, the U.S. Navy first installed a primitive radio direction finder on a ship with limited initial success. In 1915, American Telephone & Telegraph successfully transmitted speech signals across the Atlantic Ocean. A year later, the British conveyed a radio-telephone message to one of their aircraft. Radio communications remained unreliable and, during World War I, "naval captains had to keep their battle cruisers within site of one another at all times, communicating by 'search light flashes' and semaphore flags" (Lewis 1991: 279). Following the end of the war, the U.S. Naval Research Laboratory conducted experiments to improve communications between ground stations and ships at sea or aircraft. Eventually radio became as important at sea as telegraph was on land (Price 1984: 3).

Prior to the development of the high-frequency band (ca. 1927), the Navy relied upon low and medium frequencies in the range of 175 to 550 kHz for communication traffic from the shore stations. These low-frequency (LF) transmissions were much more stable and predictable both diurnally and seasonally (Gebhard 1979: 365). The Navy provided its ships with a capability of receiving the lower frequencies, particularly for Fleet broadcasts (Gebhard 1979: 137). The Navy was early to recognize the value of the very-low frequencies for long-distance communication from shore to its ships at sea. Very high power could be radiated from the huge antennas used at these very-low frequencies, which made world-wide coverage feasible.

Since its construction in 1935, the transmitter (Building 2) has been broadcasting in the low-frequency bandwidth (see note on Drawing #118781 indicating "Low Frequency Transmitter Building" adjacent to Helix House No. 1). At the outbreak of World War II, the Lualualei main transmitter was not powerful enough for an all-ocean war (Woodbury 1946: 362). Only very high-power, low-frequency transmissions can penetrate the sea sufficiently to make communication with submerged submarines practical. In 1943, a long-range transmitter was constructed 1,800-feet above the floor of Ha'iku Valley (on the windward coast) using high aerials between the tops of two mountains. The "keying" or actual message-sending from Ha'iku was done at Wahiawa, seventeen miles away.

By 1944, an additional Helix House (Structure 87) was proposed to serve an enlarged antenna array at Lualualei. However, this facility was not completed until after the end of the war. In 1964, the VLF transmitter and Helix House equipment at Lualualei were up-graded to service Cold War-era communication needs, and NCTAMS Wahiawa was developed as a receiver site.

The RTF-Lualualei VLF facility consists of a Transmitter Building (Building 2), a Helix House (Structure 3), and two 1,500-foot tall antennas (Structures 427 and 428). Prior to 1972, two Helix Houses (Structures 3 and 87) served an array of eight 600-foot antennas. After the array was replaced with the two antennas the second Helix House was no longer needed, and Structure 87 was removed from service. This structure and the concrete foundation pads of these earlier towers are still visible at the site, and give an indication of the size and layout of the original transmission system.

Presently, the VLF transmitter at RTF-Lualualei is one of six high-power, submarine broadcast facilities; other stations are located at Jim Creek, Washington; Cutler, Maine; Yosumi, Japan; Northwest Cape, Australia; and a new facility in the Bahamas (Naehu 1996). The stations are positioned to ensure complete, overlapping coverage of Naval broadcasts. Each of these facilities simultaneously transmits an identical coded data signal, generated in San Diego, at a different frequency. RTF-Lualualei transmits between 12-30 kHz, however, the actual frequency of the broadcast is classified information. The VLF communications transmitted from Lualualei can reach U.S. Naval submarines positioned half-way around the world.

The RTF facility utilizes an combination of radio-electronics technologies. The signal is amplified using vacuum tubes, a system developed prior to WW II, however, the entire transmission process is controlled by state-of-the-art digital computer and communications equipment. The present transmitter equipment consists of monitors (similar to a stereo receiver) to receive the small signal, and equipment to amplify and tune the frequency of this signal for optimal output. The amplified signal is transmitted to the two antennas, which in-turn transmit the signal to a copper wire grid below the ground. The signal is transmitted to submarines through the ground and below the surface of the water.

The most visually interesting element of this operation is the signal amplification and tuning equipment. This includes two banks of "power amplifiers" [PA 1 and PA 2] located in Building 2, and the remaining copper-sheathed Helix House (Structure 3). After the signal is received at very low power, it is fed through PA 1 and PA 2. These power amplifiers consist of twenty water-cooled vacuum tubes, each capable of handling 25,000 volts, and a series of gas-capped capacitors. Each bank of amplifiers generates 500,000 watts of power. The Lualualei facility distills its own water for use as coolant; the water leaves the vacuum tubes at 180 degrees Fahrenheit and cycles through large radiators at the rear of the Transmitter Building. The capacitors maintain the signal at the correct frequency during amplification. After passing through PA 1 and PA 2, the signal is combined, tuned again, and transmitted to the Helix House through a series of copper pipes which serve as wires for the very-low-frequency waves.

The Helix House, named for the coiled wires in the equipment housed within, also serves to fine-tune the frequency of the signal. For optimal performance, maximum current (signal) must be transmitted at minimum voltage to the antennas utilizing a system known as an "L-C network" (Naehu 1996). The equipment in the Helix House, the Variometer and coils, are adjusted ("L") to match the capacitance ("C") between the top of the

antenna and the ground plain. The transmission line feed, a large steel tube with a "donut" at one end, transmits the signal from the Helix coils out of the building to the antennas. The entire system is protected from "stray" voltage, such as lightening, by two steel balls which would arc to ground if necessary. The building is sheathed in copper to prohibit the transmission of potentially damaging RF radiation.

PART II. ARCHITECTURAL INFORMATION

A. General Statement:

1. Architectural character:
The Helix House (Structure 87) was constructed in an Italianate style-influenced Industrial aesthetic. Italianate features, such pilasters, soffited eaves and relatively low-pitch hipped roof, merged with the large scale of the building and the high-tech function (for its time) make it a visually arresting structure. Along with the original Helix House (Structure 3) and Transmitter (Building 2), it forms a stylistically unified grouping which displays a relatively high-degree of architectural merit representative of New Deal construction.

2. Condition of fabric:
Good (cast-in-place reinforced-concrete structure); poor (remaining building elements, such as roof and doors).

B. Description of Exterior:

1. Overall Dimensions:
Structure 87 is an octagonal-shaped structure, 74'-0" in diameter and approximately 66' to the peak of the roof (60'-10 3/4" to the top plate). The rectangular shed housing the "antenna trunk opening" is 20'-0" by 44'-0" in plan, and 54'-6 1/4" tall.

2. Structural System; Foundation and Floors:
The exterior walls rest on cast-in-place concrete foundations, 16" thick and 8'-0" wide, at the perimeter of the building. The foundation is reinforced with 3/4"Ø steel bars laid in a grid 12" by 18" o.c. The adjacent shed structure sits on a similar perimeter foundation, 12" thick and 4'-9" wide, and reinforced with 3/4"Ø bars in a grid 9" by 12" o.c. All splices in the reinforcing steel are lapped and welded. The drawings indicate that footing reinforcing below each wall panel section "shall not contact footing reinforcing in any other panel" and that all non-ferrous metals should be grounded (Drawing #OA-N04-3834). The floor of the structure is a 5" thick reinforced-concrete slab-on-grade.

3. Structural System; Ceiling and Roof Framing:
The roof is framed with eight steel truss sections radiating from a central point. The trusses are fabricated from steel angles: the top chord from 2 - 4" x 3" x 3/8" angles; the bottom chord from 2 - 5" x 3 1/2" x 3/8" angles; the diagonal strut sizes vary according to location and stresses.

4. Structural System; Walls:
The exterior walls are 12" thick reinforced-concrete; the pilasters at each corner of the octagon are 24" thick. The walls are reinforced with 3/4"Ø steel bars at 18" o.c., each way. Additional reinforcing was added to the face of the pilasters to prevent cracking.

Bronze anchor bolts, 3/4"Ø x 8" at 48" o.c., were cast into the top of the concrete wall for connection to the roof framing.

5. Roof:
A low-pitch (1 1/2" per foot) hip roof caps the main section of the building; a very low-slope gable roof sits behind a parapet at the top of the adjacent storage area. The main roof is framed with steel trusses (see Structural System; Ceiling and Roof Framing). Additional wood members were utilized to attach the roof sheathing to the framing. 3" x 6" wood hip rafters are connected to the top chord of the truss with anchor bolts. 2" x 6" purlins at 24" o.c. support "matched roof boards" (decking). 2" x 8" wood ceiling joists span between the bottom chords of the trusses at 24" o.c. to receive furring for ceiling material. The trusses rest on a 2" x 8" ledger at the top of the wall, and a 2" x 8" fascia caps the ends of the trusses. The original copper standing seam roofing was removed after sustaining damage during Hurricane 'Iwa in 1982.

6. Openings
   a. Doorways and Doors: The entrance to the main space was through a pair of doors on the south elevation of the building; access to the electrical rooms was through single doors on the south and north elevations. An additional opening, 7'-0" x 12'-0", was cut into the east wall of the building to provide access to a storage area constructed in 1946. The exterior openings are presently in-filled with plywood and none of the original doors remain.

      The drawings indicate that the doors, as well as the jamb and head linings, were copper-clad (Drawing #OA-N04-3843). The doors were glazed with "extra thick shatter proof glass" and featured a bronze threshold. The transom, located above the entry doors, was constructed with copper louvers, a copper-clad frame, and copper mesh screening. None of this material remains.

   b. Windows: The building has no windows. The roof is vented through a screened and louvered clerestory located in the space above the ceiling. Several small openings were constructed in the adjacent electrical service rooms to accommodate the connections to the antenna array.

C. Description of Interior:

1. Floor Plans:
The building consists of a octagonal-shaped volume 74'-0" in diameter. A trench drain was cast into the floor along the entire perimeter wall. A rectangular shed on the east elevation, 20'-0" by 44'-0" in plan, housed the "antenna trunk opening with a storage room below. Two electrical service rooms were located in the side walls of this shed.

2. Flooring, wall and ceiling finish:
The interior walls to a height of 36-feet, as well as the circular opening on the east wall, were sheathed with copper panels on 2" x 3" wood furring at 24" o.c. The furring was attached to the structural concrete with bronze anchor bolts at 4'-0" o.c. The floor and ceiling were also entirely copper-sheathed.

3. Interior partitions:
None.

4. Equipment:
   a. Electrical Equipment: The original drawings, dated 12/18/44, indicate that a copper-sheathed pit, and pedestals constructed from "non-ferrous" concrete supported the radio/electrical equipment at the interior of the structure. No evidence of this pit or equipment-supports is evident in the structure at present. In 1964, new equipment was installed in both Helix Houses (Structures 3 and 87); it is possible that the concrete slab was re-poured or topped after the removal of the original equipment.

      Prior to its removal from service in 1972, the interior of Structure 87 was identical to Structure 3 and contained similar radio/electrical equipment (Naehu 1996). Structure 3 retains its copper lining, as well as the type of equipment that would have been found in S-87. Large frames constructed of olive wood, selected for its strength and termite resistance, support the Variometer and Helix Coils (see figures 14 to 16). A transmission line feed entered the building through the a small aperture in the circular cavity. Refer to Part 1, B-4 of this report: "General History of Helix House No. 2 in the Context of Naval Radio Communications" for a discussion of the operation of Transmitter and Helix Houses.

   b. Plumbing Equipment: None.

   c. Mechanical Equipment: None.

D. Site:

The Helix House No 2 (Structure No. 87) is located in a large, open field 2,100 feet from Helix House No. 1 (Structure 3). Originally, Structure 87 served the east end of the original antenna array, which was made up of eight 600-foot tall antennas. These towers were replaced in 1972 with two 1500-foot tall antennas. Presently, the structure sits near the base of the eastern-most antenna (Structure 427). In 1972, copper mesh (6" x 6") was installed 12-inches below grade in a 125-foot radius of the Helix House No. 1 (Strucuture 3) with #8 copper wires radiating approximately 2,500-feet in all directions (see Drawing #1282649).

PART III. SOURCES OF INFORMATION

A. Architectural Drawings:

The drawings for the Helix House No. 2 (Structure 87), the original 1944 design and the later modifications, as well as architectural drawings for the first Helix House (Structure 3) and the Transmitter (Building 2), are stored on microfiche at the PACDIV-NAVFACENGCOM Plan File room at Makalapa, Pearl Harbor, Hawai'i. The drawings pertaining to Structure 87 are listed below. Xerox copies of selected drawings are included as part of this report.

Drawing Number	Drawing Title	Drawing Date
OA-N04-3831	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Elevations & Plot Plan	12/18/44
OA-N04-3832	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Floor Plan & General Notes	4/18/46

OA-N04-3833	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Foundation Plan	4/10/45
OA-N04-3834	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Footing Details	4/07/45
OA-N04-3835	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Typical Cross Section & Details	3/09/45
OA-N04-3836	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Section Through Arch & Details	12/18/44
OA-N04-3837	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Reinforcing at Panels (Side)	12/18/44
OA-N04-3838	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Reinforcing at Panels (Side & Wing)	12/18/44
OA-N04-3839	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Reinforcing at Panels (Arched)	12/18/44
OA-N04-3840	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Typical Truss	3/20/44 (45?)
OA-N04-3841	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Steel Details	1/23/46
OA-N04-3842	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Misc. Details	12/18/44
OA-N04-3843	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Copper Details	12/18/44
OA-N04-3844	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Electrical Details	4/09/45
OA-N04-3845	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Additional Helix House: Antenna Extension Ground System for 500 kW Transmitter	4/07/45
OA-N11-388	14th Naval District, Pearl Harbor, T.H.; Lualualei, Oahu, T.H., Naval Radio Station, Modification to TAW Helix House 1 & 2: Enclosure for Steel Extension Ladder	5/13/46
1282637	Department of the Navy, Naval Facilities Engineering Command, Chesapeake Division, Washington D.C.; Naval Radio Station, Lualualei, Hawaii; VLF Antenna and Ground System: Site Plan and Vicinity Map	11/03/72
1282649	Department of the Navy, Naval Facilities Engineering Command, Chesapeake Division, Washington D.C.; Naval Radio Station, Lualualei, Hawaii; VLF Antenna and Ground System: Radial Ground System Details	11/03/72
1282700	Department of the Navy, Naval Facilities Engineering Command, Chesapeake Division, Washington D.C.; Naval Radio Station, Lualualei, Hawaii; VLF Antenna and Ground System: Site Plan, Electrical Distribution	11/03/72
1282704	Department of the Navy, Naval Facilities Engineering Command, Chesapeake Division, Washington D.C.; Naval Radio Station, Lualualei, Hawaii; VLF Antenna and Ground System: Helix House No. 2, Modification	11/03/72

B. Early Views:

The following historic photographs from the 14th Naval District collection were on file at RTF-Lualualei. Xerox copies of selected prints are included as part of this report.

Photo Number	Title/Description	Photo Date
RP3-088-5-55	"ANTENNA: NavRadSta LUALUALEI - Holding 5 yr. maint. on TAW Antenna." (View of S-87 from east showing men working on transmission feed line).	5/07/55
RP3-092-5-55	"ANTENNA: Nav Rd Sa LUALUALEI - Holding 5 yr. maint. on TAW Antenna." (View of S-87 from east with Bldg. 2 and S-3 at distance).	5/07/55
RP3-098-5-55	"TAW XMTR LUALUALEI: NavRadSta (T) Lualualei. Holding maintenance on antenna for TAW." (View of S-87 from east showing transmission feed line entering antenna trunk opening).	5/10/55
VSJ-1291-5-64	"VSJ-1291-5-64 INDUSTRIAL MANAGER, 14ND 5-11-64, (1) Variometer, (2) Transmission Line Feed Point, (3) Helix Coil, Helix House 1, NRS Lualualei" (Interior of Structure 3 with equipment labeled).	5/11/64
VSJ-2726-10-64	"VSJ-2726-10-64 INDUSTRIAL MANAGER, 14ND 10-08-64, Bldg. 2, NRS Lualualei" (View of Building 2 and Structure 3 from north with antenna at rear).	10/08/64
VNR-152L-5-8-64	(Interior view of S-3 or S-87 showing men installing electrical cable).	5/08/64
VNR-154L-5-8-64	(Exterior view of S-3 from north).	5/08/64
VNR-165L-5-20-64	(Interior view of equipment at S-3 or S-87).	5/08/64
VNR-192L-5-20-64	(Interior view of equipment at S-3 or S-87).	5/20/64
VNR-193L-5-20-64	(Interior view of equipment at S-3 or S-87 showing men installing electrical cable).	5/20/64
VNR-274L-6-22-64	(Interior view of equipment at S-3 or S-87).	6/22/64
VNR-287L-7-1-64	(Interior view of equipment at S-3 or S-87).	7/01/64
none	(Exterior view of S-87 from north).	none

C. Bibliography:

Armstrong, Warwick R., Editor
1983 *The Atlas of Hawaii.* University of Hawai'i Press: Honolulu.

Bureau of Yards and Docks
1947 *Building the Navy's Bases in World War II; History of the Bureau of Yards and Docks and the Civil Engineer Corps, 1940-1946 (2 Vols.). U. S.* Government Printing Office, Washington D. C.

Chinen, Jon J.
1978 *The Great Mahele: Hawai'i's Land Division of 1848.* University Press of Hawai'i: Honolulu.

Coletta, Paolo; Editor
1985 *United States Navy and Marine Corps Bases, Domestic.* Greenwood Press, Westport, Connecticut.

Devereux, Tony
1991 *Messenger Gods of Battle, Radio, Radar, Sonar: The Story, of Electronics in War.* Brassey's Ltd., London, England.

Gebhard, Louis A.
1979 *Evolution of Naval Radio-Electronics and Contributions of the Naval Research Laboratory (NRL Report 8300).* Washington, D.C: Naval Research Laboratory.

Kelly, Marion
1991 Notes on the History of Lualualei. In "An Archaeological Survey of the Naval Magazine and Naval Communications Area Transmission Facility, Lualualei, O'ahu, Hawai'i." Report 100191 prepared for Naval Facilities Engineering Command, Pearl Harbor, Hawai'i, by the Public Archaeology Section, Applied Research Group, Bishop Museum: Honolulu.

Landrum, Jim, Robert Drolet, and Katherine Bouthillier
1993 Preliminary Report: Cultural Resources Management Overview Survey of the Naval Magazine Lualualei, Island of O`ahu, Hawai'i. Report prepared for the U.S. Navy, Pacific Division, NAVFACENGCOM, by Ogden Environmental and Energy Services, Inc., Honolulu.

Landrum, Jim, Robert Drolet, and Barbara Shideler
1994 Preliminary Report: Cultural Resources Management Overview Survey of the Naval Computer and Telecommunications Center Area Master Station, Eastern Pacific (NCTAMS EASTPAC), Island of O`ahu, Hawai'i. Report prepared for the U.S. Navy, Pacific Division, NAVFACENGCOM, by Ogden Environmental and Energy Services, Inc., Honolulu.

Layton, Edwin T.
1985 *"And I was there": Pearl Harbor and Midway - Breaking the Secrets.* William Morrow, New York.

Lewis, Thomas S.W.
1991 *Empire of the Air: The Men Who Made Radio.* New York: Harper Collins Publishers.

Naehu, Moses (VLF Supervisor, RTF-Lualualei).
1996. Personal conversations with Barbara Shideler, October 2 and 23, 1996.

Price, Alfred.
1984 *The History of U.S. Electronic Warfare, Vol. I: "The Years of Innovation - Beginnings to 1946."* Westford, Massachusetts: Murray Printing Company for the Association of Old Crows.

Stiedl, ETC Chief
1993 Personal conversation with Barbara Shideler, June 10, 1993.

U. S. Navy, Pacific Division, Naval Facilities Engineering Command
1987 *Final Master Plan for NAVCAMS EASTPAC, O'ahu, Hawaii.* Facilities Planning Department, U.S. Navy

1990a P164 Detailed Inventory of U.S. Naval Shore Facilities.

1990 *Navy/Marine Corps Activities: Regional Profile.* Facilities Planning Department, U. S. Navy.

U. S. S. Arizona Memorial Photographic Collection
various Historical photographs of NCTAMS EASTPAC and its structures.

PART IV. PROJECT INFORMATION

This project was undertaken in October 1996 by Spencer Mason Architects, Inc., as a subcontractor to Paul H. Rosendahl, PhD., Inc. (PHRI), under HPS-SOW No. 961 to Contract N62742-93-D-0502. Jeffrey Dodge, Historic Preservation Specialist with Pacific Division Naval Facilities Engineering Command (PACDIVNAVFACENGCOM), is the Contract Manager for this project. The project architectural historian was Barbara Shideler, AIA of Spencer Mason Architects, who undertook the field investigations, 35 mm photography, research, and report writing. Jeff Dodge provided several of the architectural drawings from the PACDIVNAVFACENGCOM plan files. The large-format photographs were produced in accordance with HABS standards by David Franzen of Franzen Photography.

Figure 1. Map of Oahu indicating location of RTF–Lualualei.

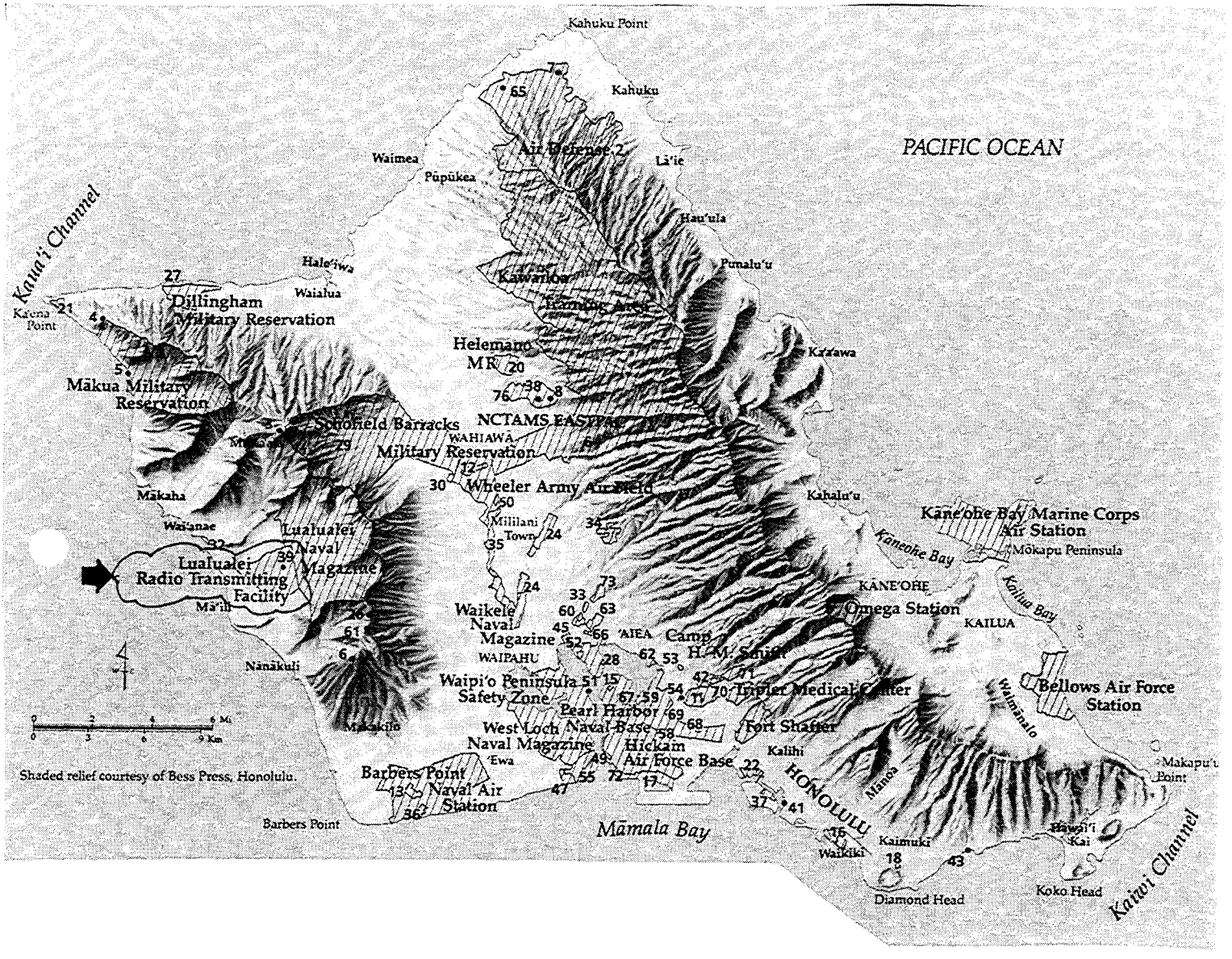


Figure 2. Base Map, RTF–Lualualei.

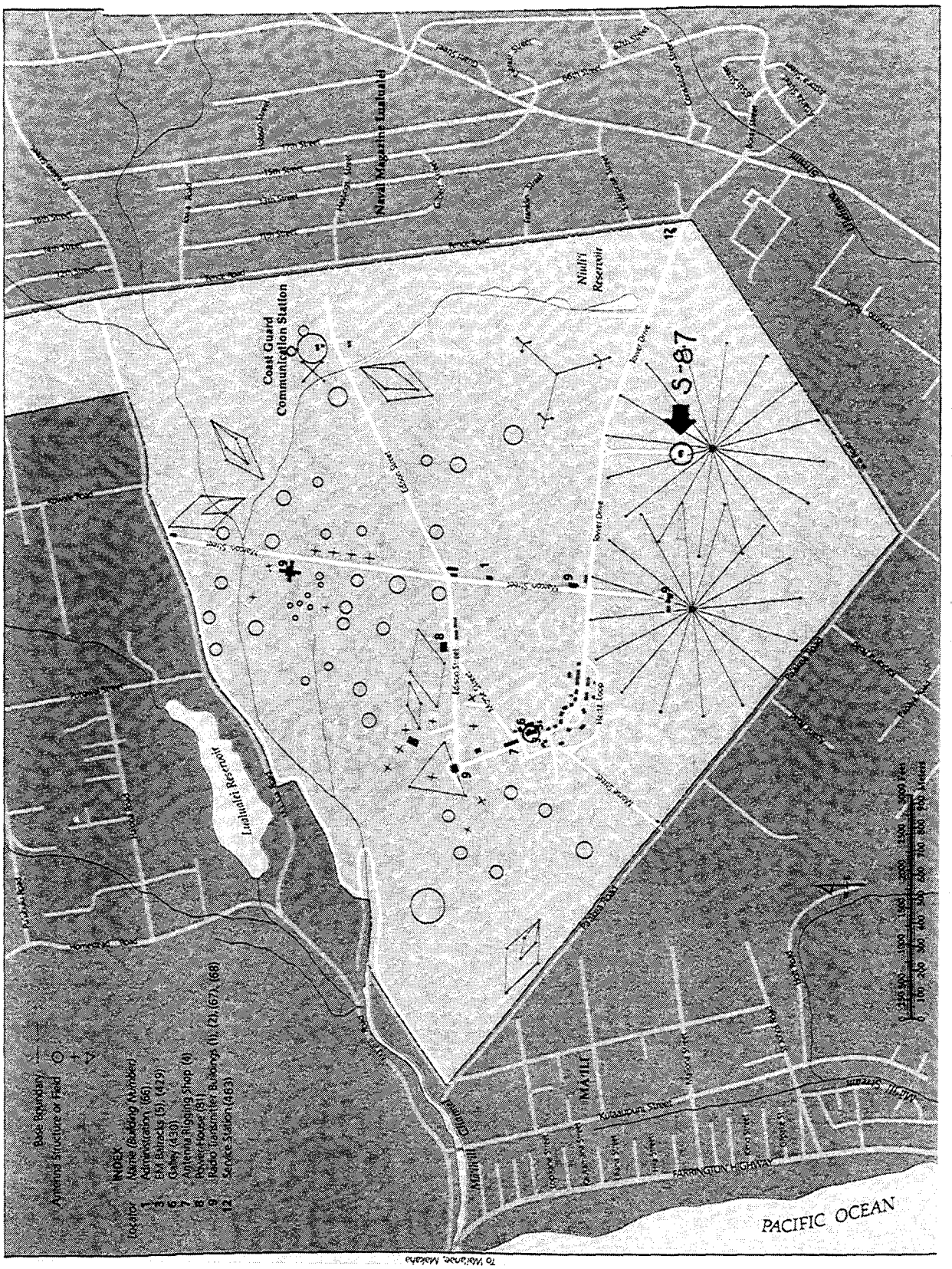
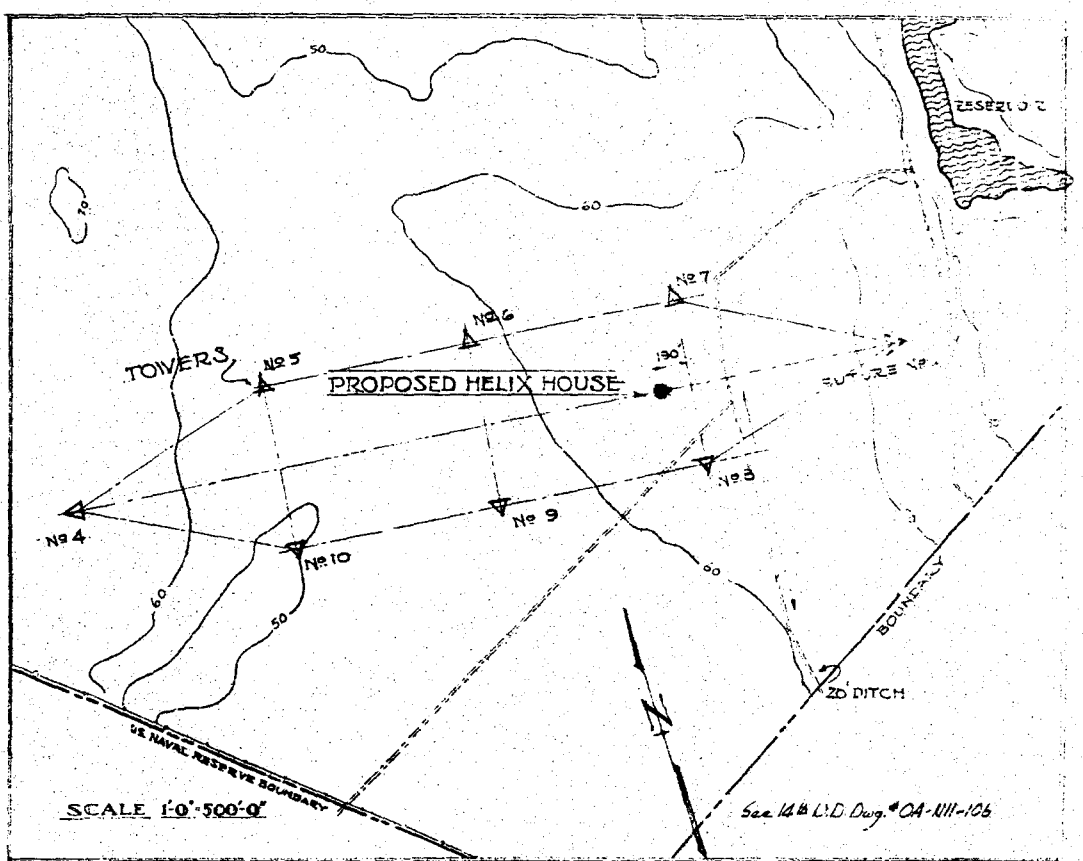


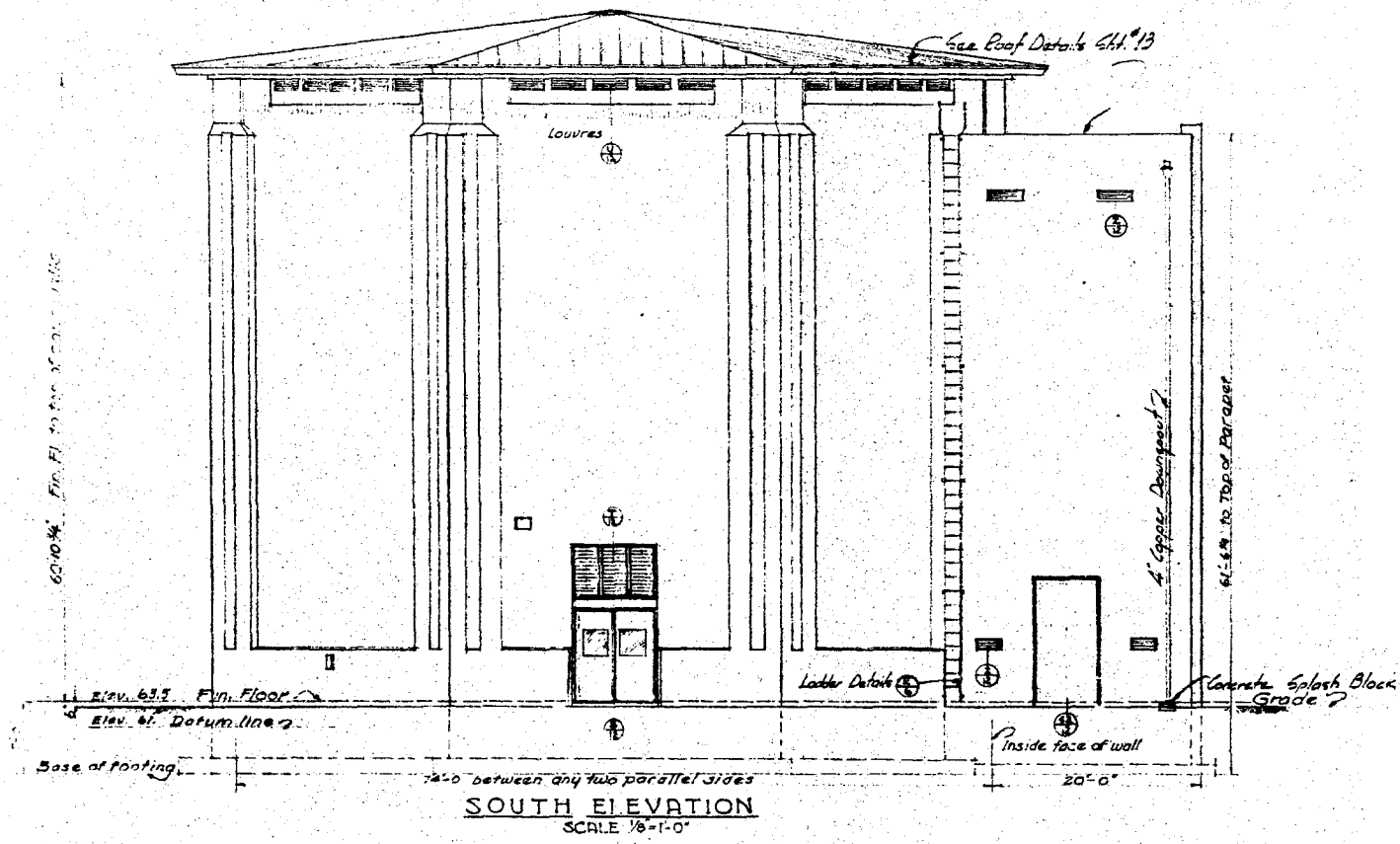
Figure 3. Drawing No. OA-N04-3831 (partial): Plot Plan (reduced).

HABS, HI, 2-MAKA.V, 18-

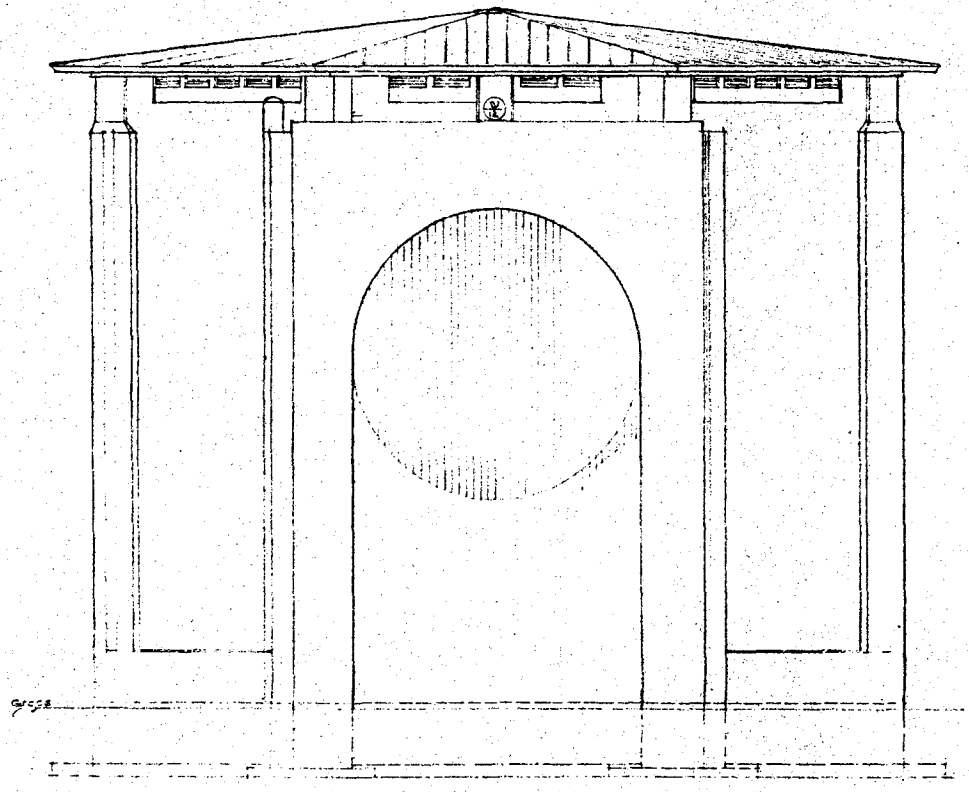


PLOT PLAN

Figure 4. Drawing No. OA-N04-3831 (partial): Elevations (reduced).



SOUTH ELEVATION
SCALE 1/8"=1'-0"



EAST ELEVATION
SCALE 1/8"=1'-0"

Figure 5. Drawing No. OA-N04-3832 (partial): Floor Plan (reduced).

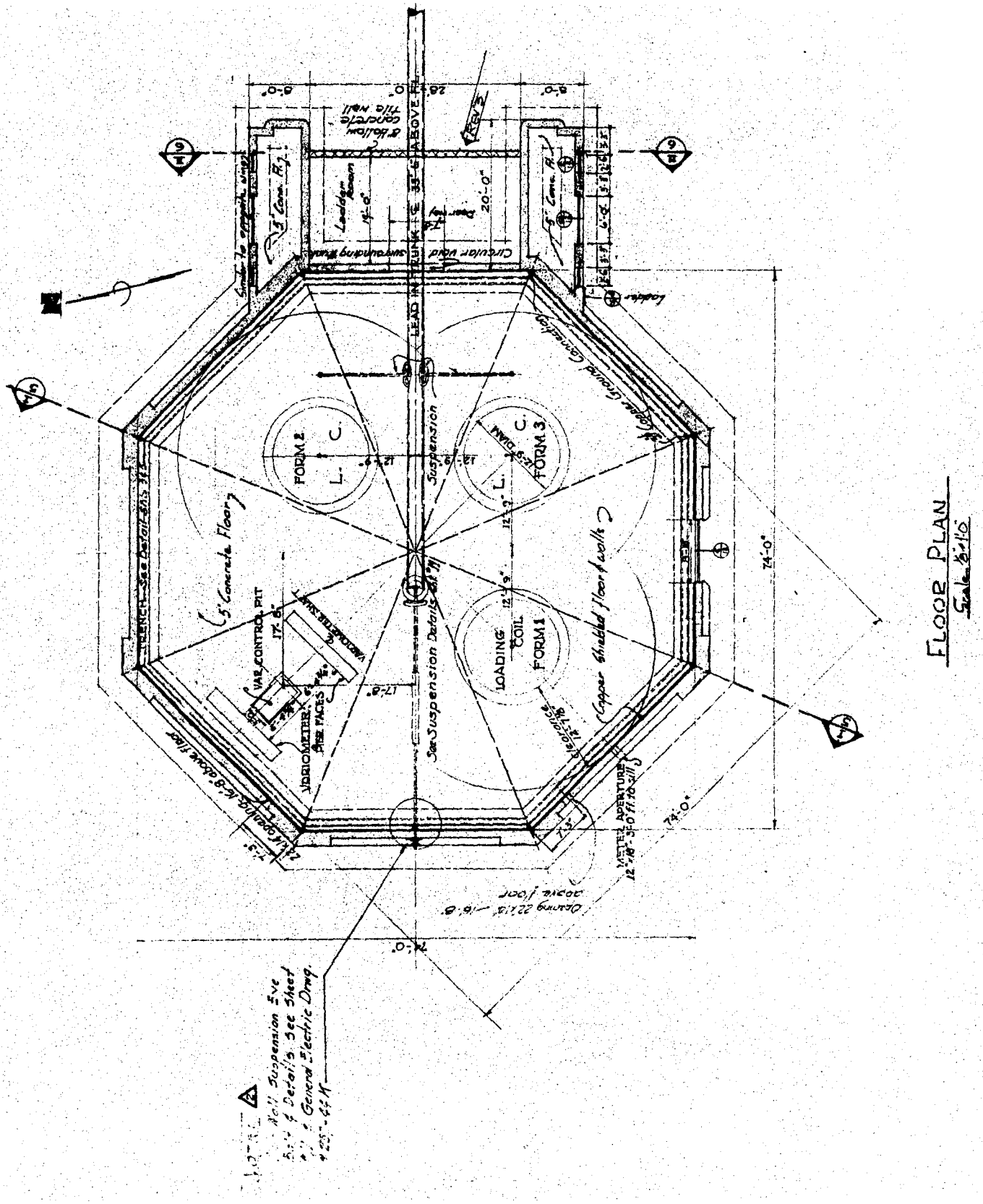
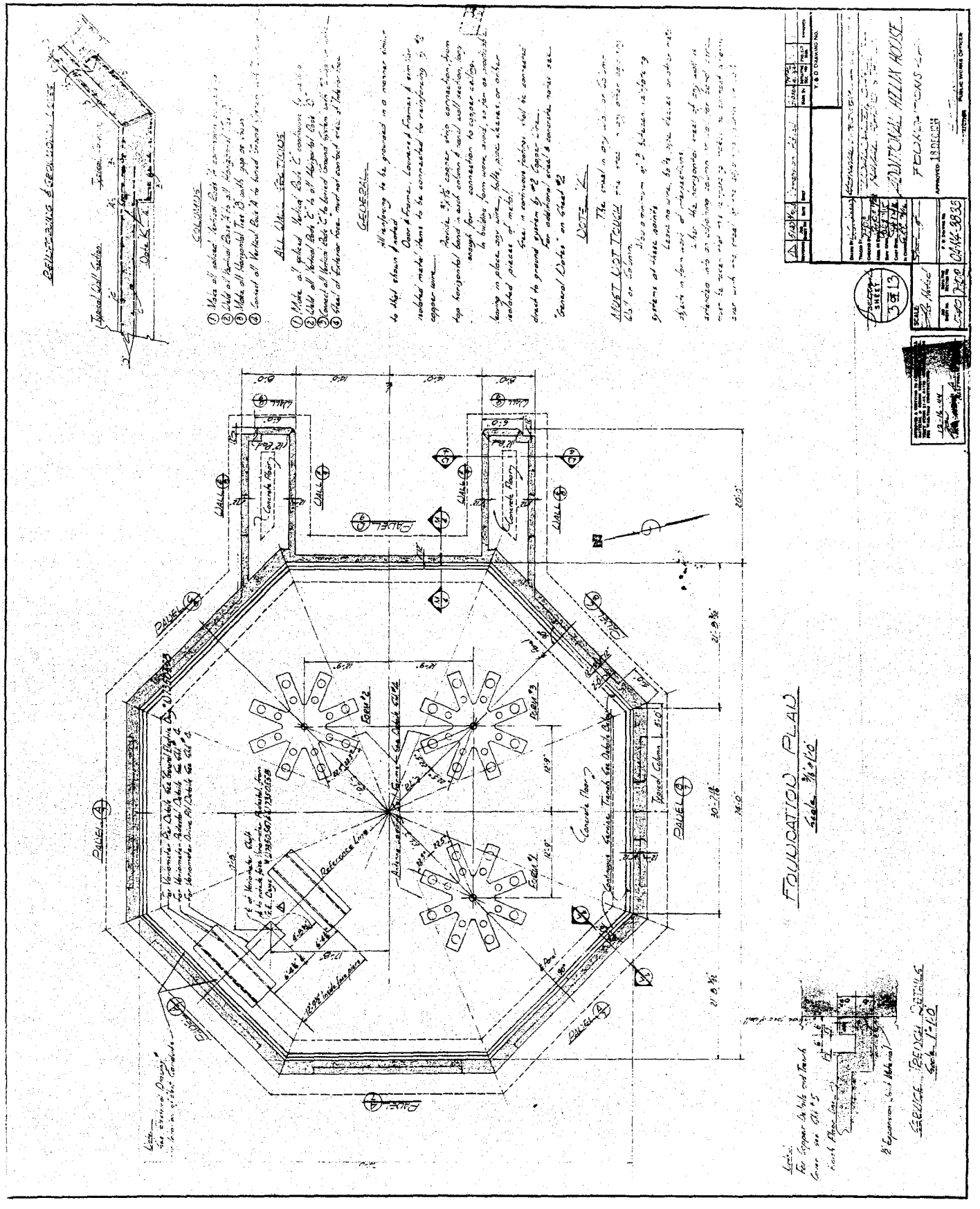


Figure 6. Drawing No. OA-N04-3833: Foundation Plan (reduced).



. Figure 7. Drawing No. OA-N04-3834: Footing Details (reduced).

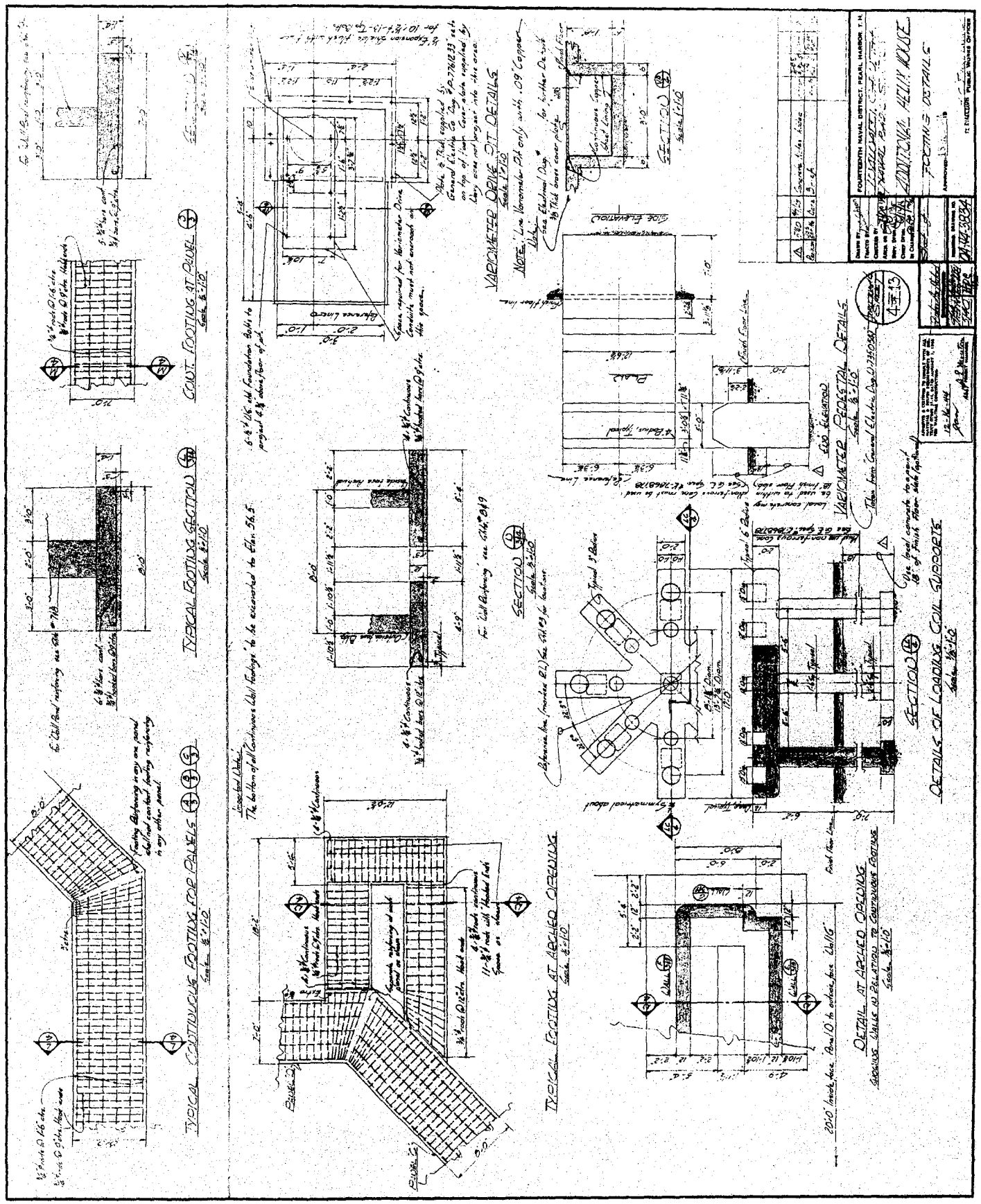


Figure 8. Drawing No. OA-N04-3835: Typical Cross Section & Details (reduced).

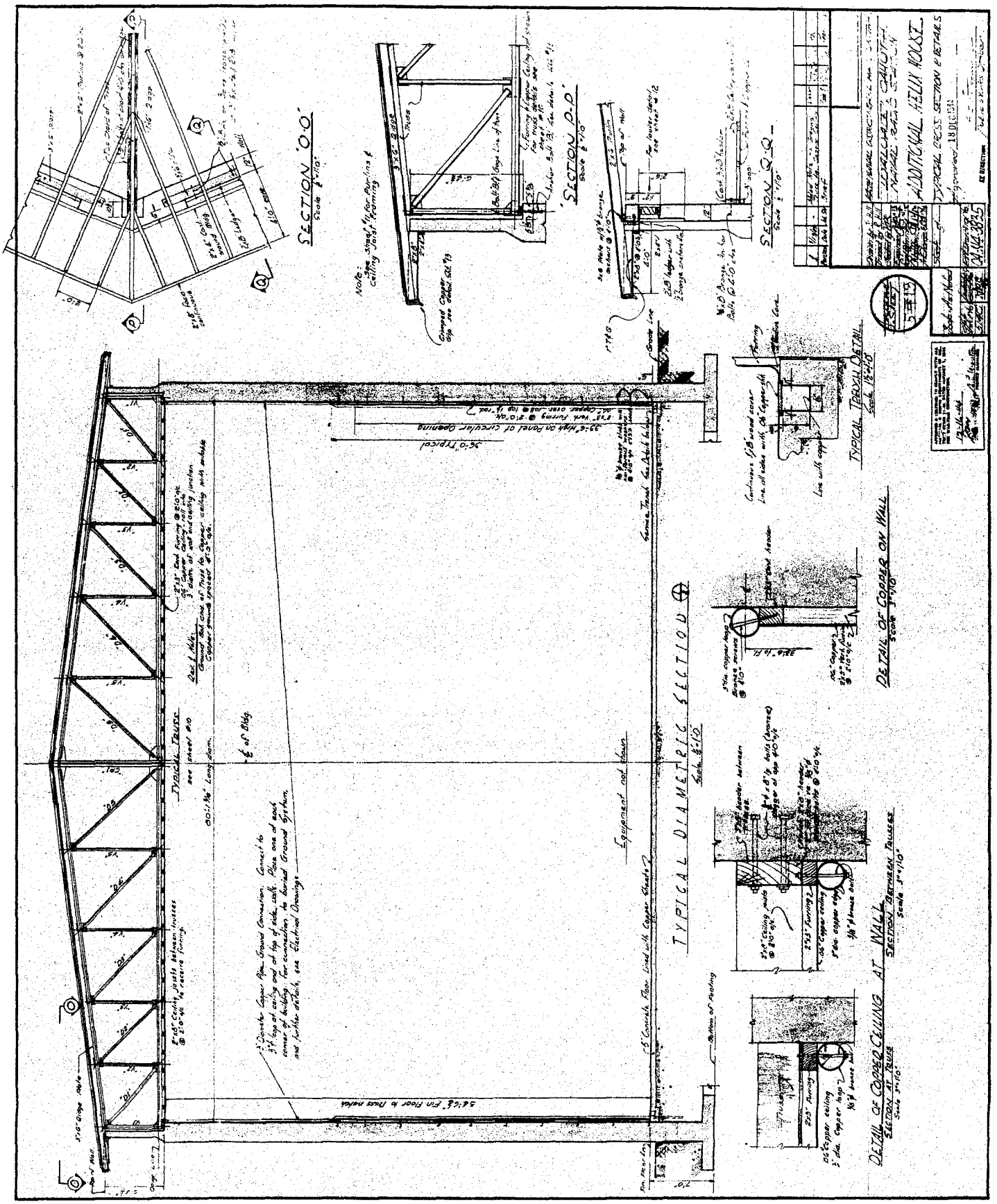


Figure 9. Drawing No. OA-N04-3840: Typical Truss (reduced).

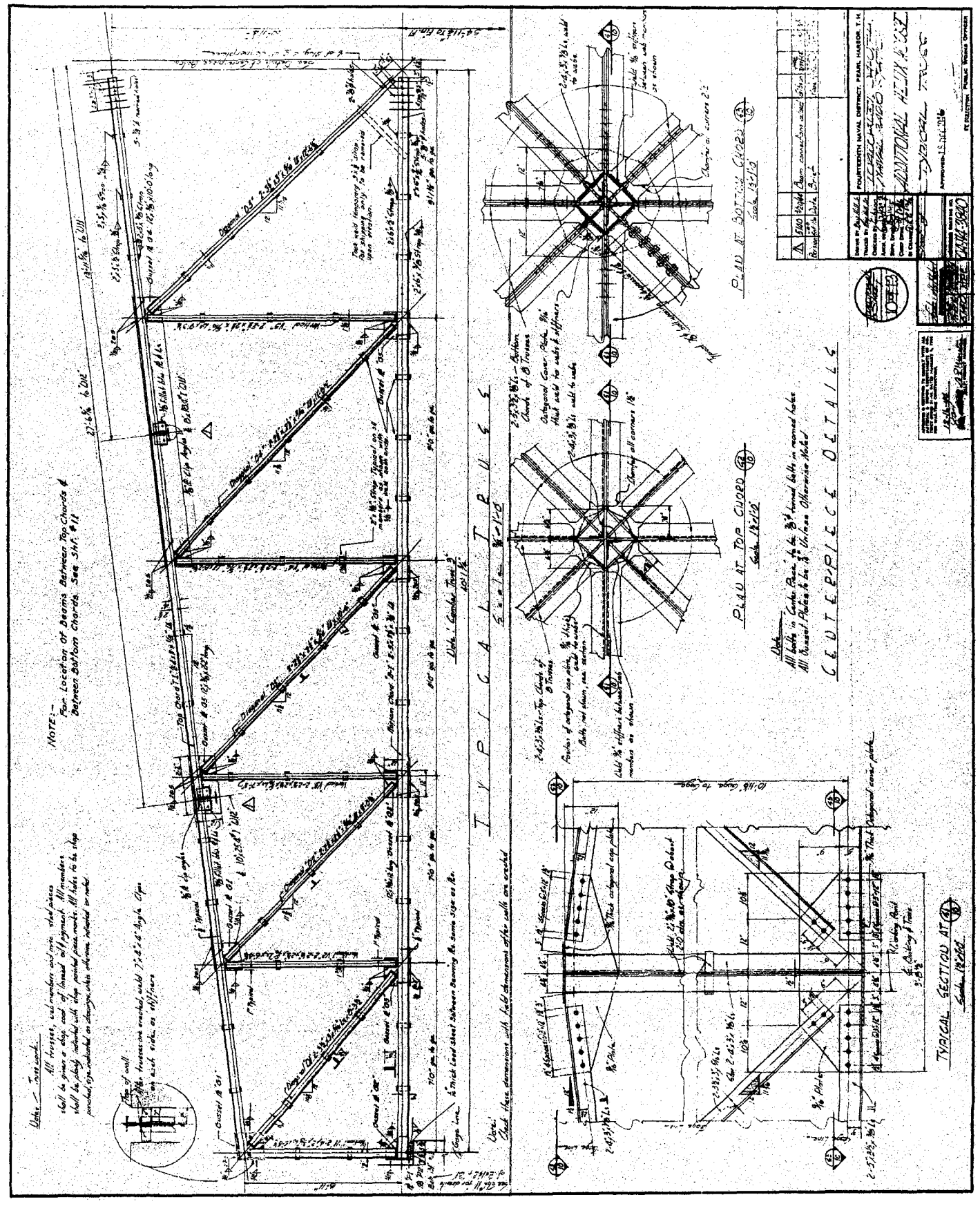


Figure 10. Drawing No. OA-N04-3841: Steel Details (reduced).

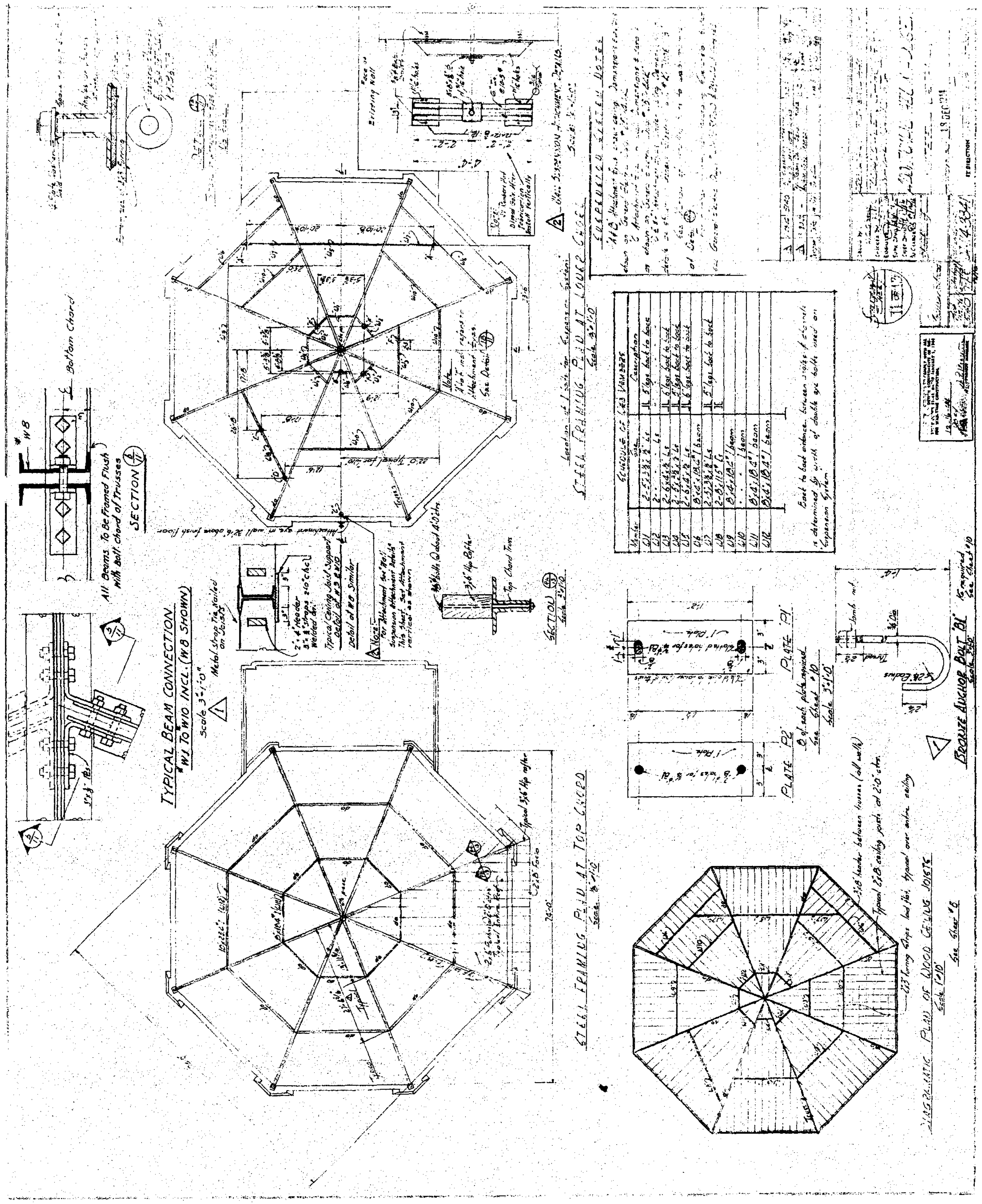


Figure 11. Drawing No. OA-N04-3842: Misc. Details (reduced).

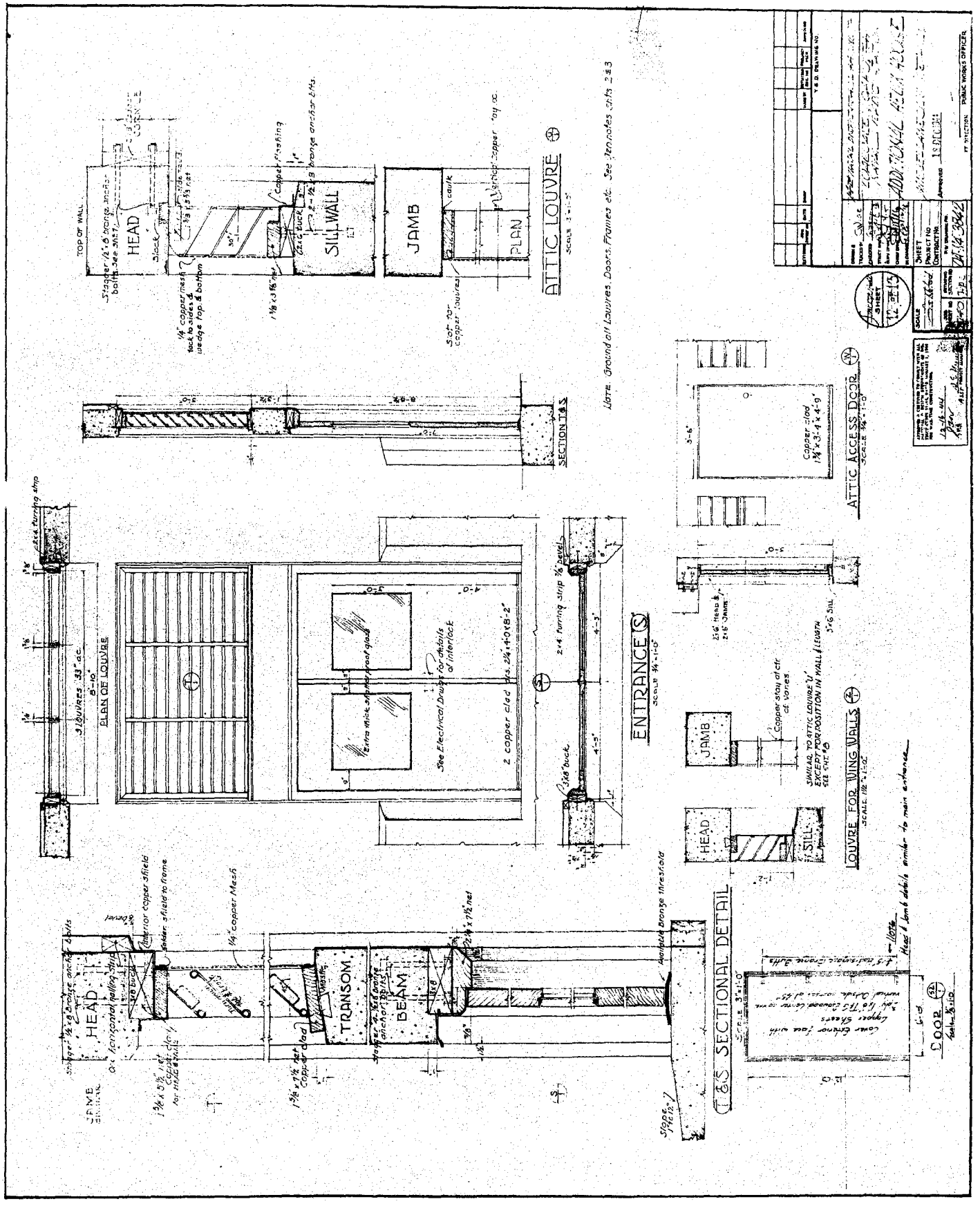
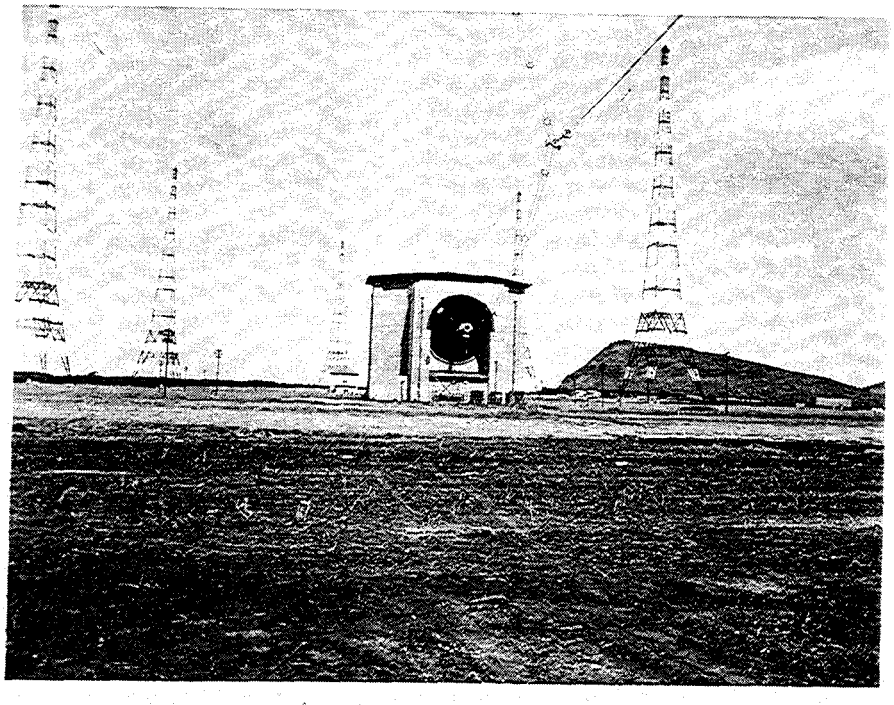


Figure 12. Photograph No. RP3-092-5-55 - "ANTENNA: Nav Rd Sa LUALUALEI - Holding 5 yr. maint. on TAW Antenna," dated 5/7/55 (RTF-Lualualei Collection).



PHOTOGRAPH RECORD
14ND-GEN-260
NAVY—PEARL HARBOR, T. H.

SUBJECT: ANTENNA

NEGATIVE NO.: RP3-092-5-55 | DATE: 7 May 1955

TITLE: NavRadSta LUALUALEI - Holding 5 yr. maint. on TAW Antenna.

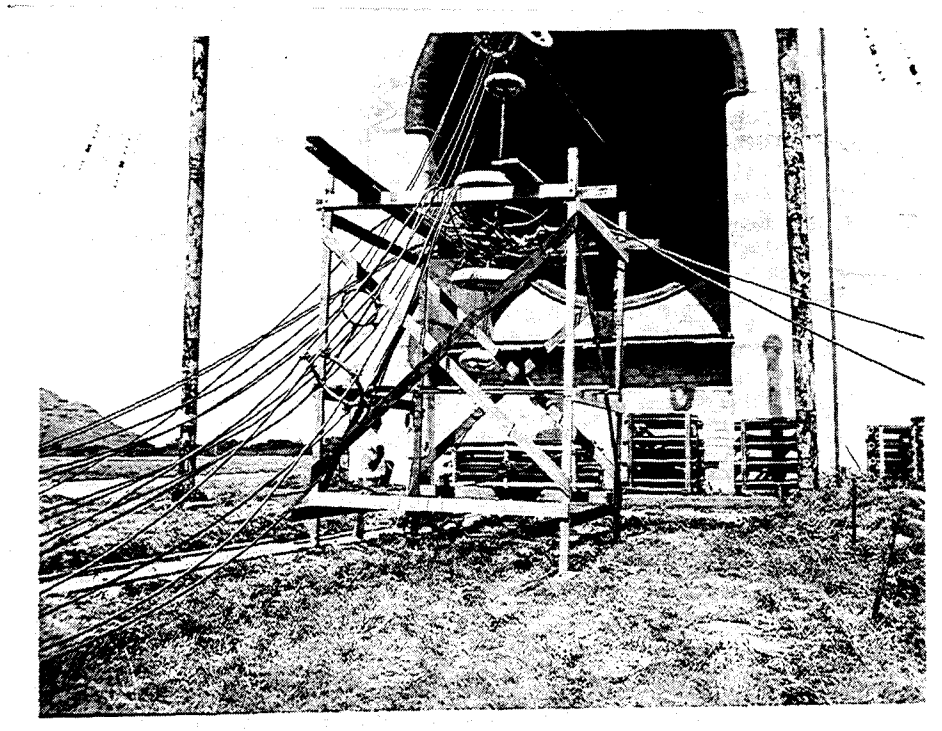
CROSS FILE:

REMARKS:

RESTRICTED | RELEASED

OTHERS SIMILAR

Figure 13. Photograph No. RP3-098-5-55 - "TAW XMTR LUALUALEI: NavRadSta (T) Lualualei. Holding maintenance on antenna for TAW," dated 5/10/55 (RTF-Lualualei Collection).



PHOTOGRAPH RECORD

14ND-GEN-260
NAVY—PEARL HARBOR, T. H.

SUBJECT: TAW XMTR LUALUALEI

NEGATIVE NO.: RP3-098-5-55 | DATE: 5-10-55

TITLE: NavRadSta (T) Lualualei. Holding maintenance on antenna for #4 TAW.

CROSS FILE:

REMARKS:

RESTRICTED | RELEASED

OTHERS SIMILAR:

Figure 14. Photograph No. VSJ-2726-10-64 - "Bldg. 2, NRS Lualualei," dated 10/08/64 (RTF-Lualualei Collection).

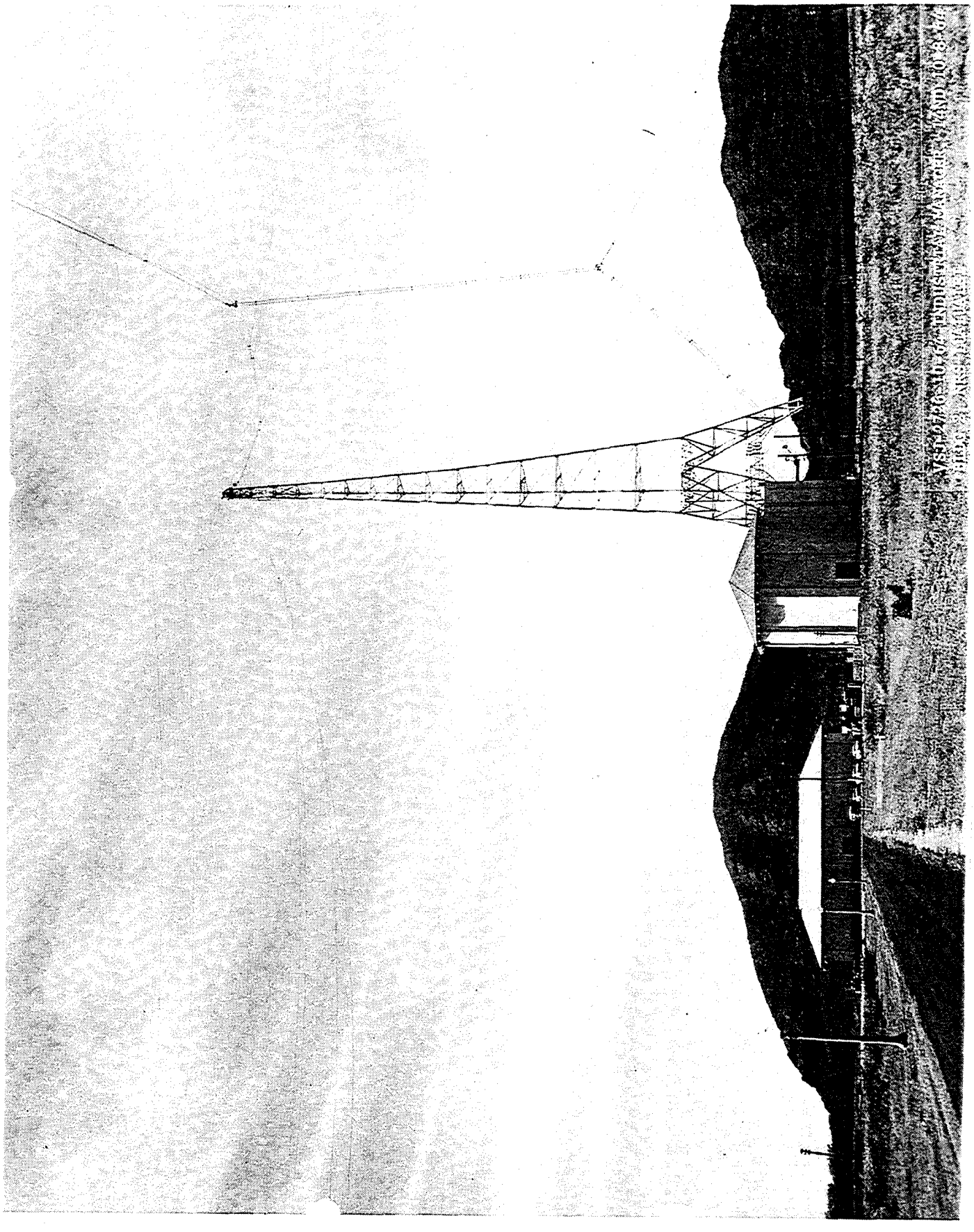


Figure 15. Photograph No. VSJ-1291-5-64 - "(1) Variometer, (2) Transmission Line Feed Point, (3) Helix Coil, Helix House 1, NRS Lualualei," dated 5/11/55 (RTF-Lualualei Collection).

Figure 16. Photograph No. VNR-193L-5-20-64 - (Interior view of S-3 or S-87; workmen installing electrical cable), dated 5/20/64 (RTF-Lualualei Collection).

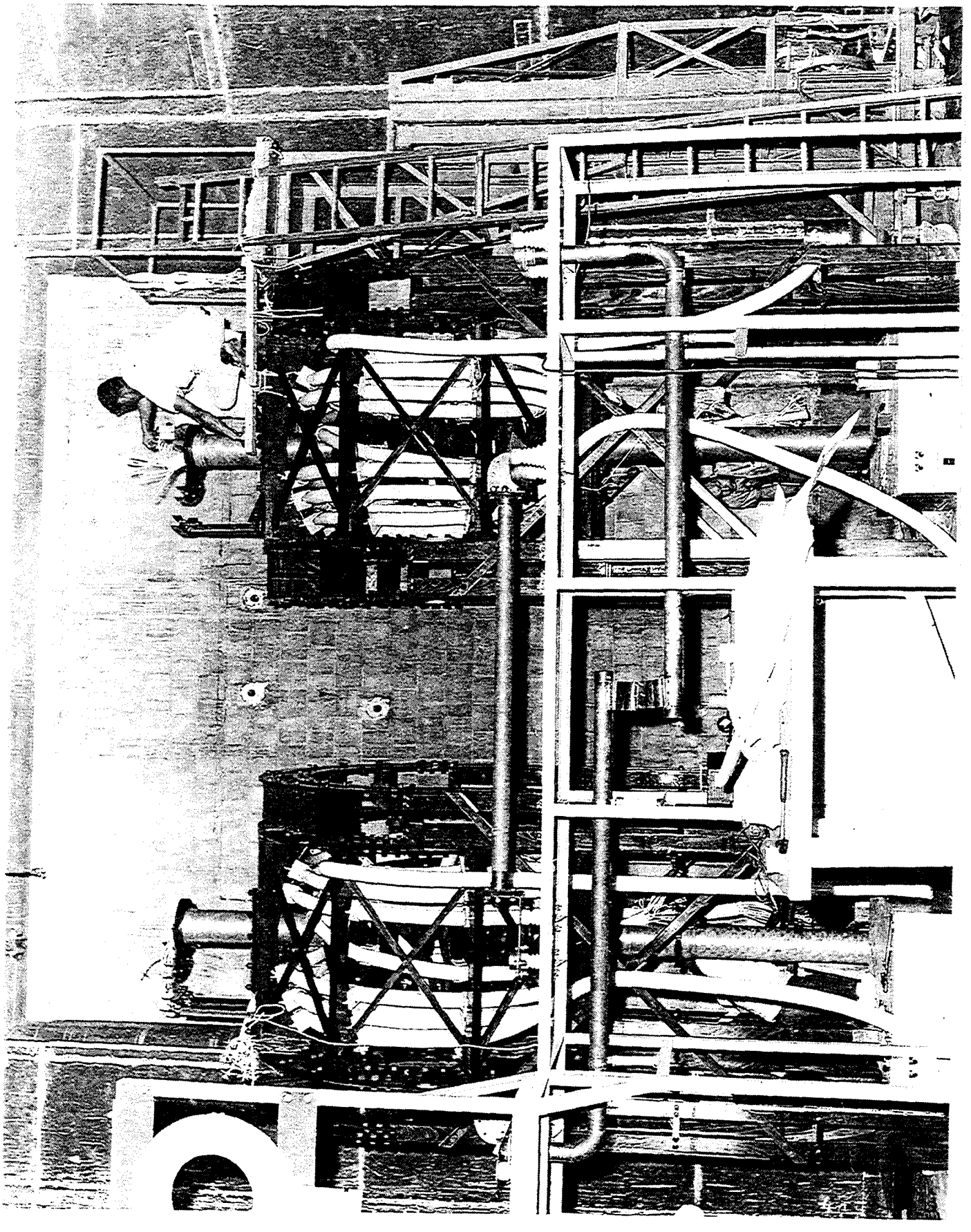


Figure 17. Photograph No. VNR-152L-5-8-64 - (Interior view of S-3 or S-87; workmen installing electrical cable), dated 5/08/64 (RTF-Lualualei Collection).