U.S. NAVAL BASE, PEARL HARBOR, NAVAL RADIO STATION, AN/FRD-10 CIRCULARLY DISPOSED ANTENNA ARRAY
(Naval Computer & Telecommunications Area Master Station, AN/FRD-10 Circularly Disposed Antenna Array)
(Pacific NCTAMS PAC, Facility 314)
Wahiawa
Honolulu County
Hawaii

HABS No. HI-522-B

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN BUILDINGS SURVEY
U.S. Department of the Interior
National Park Service
Oakland, California

HISTORIC AMERICAN BUILDINGS SURVEY

INDEX TO PHOTOGRAPHS

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David Franzen, Photographer — October 2006

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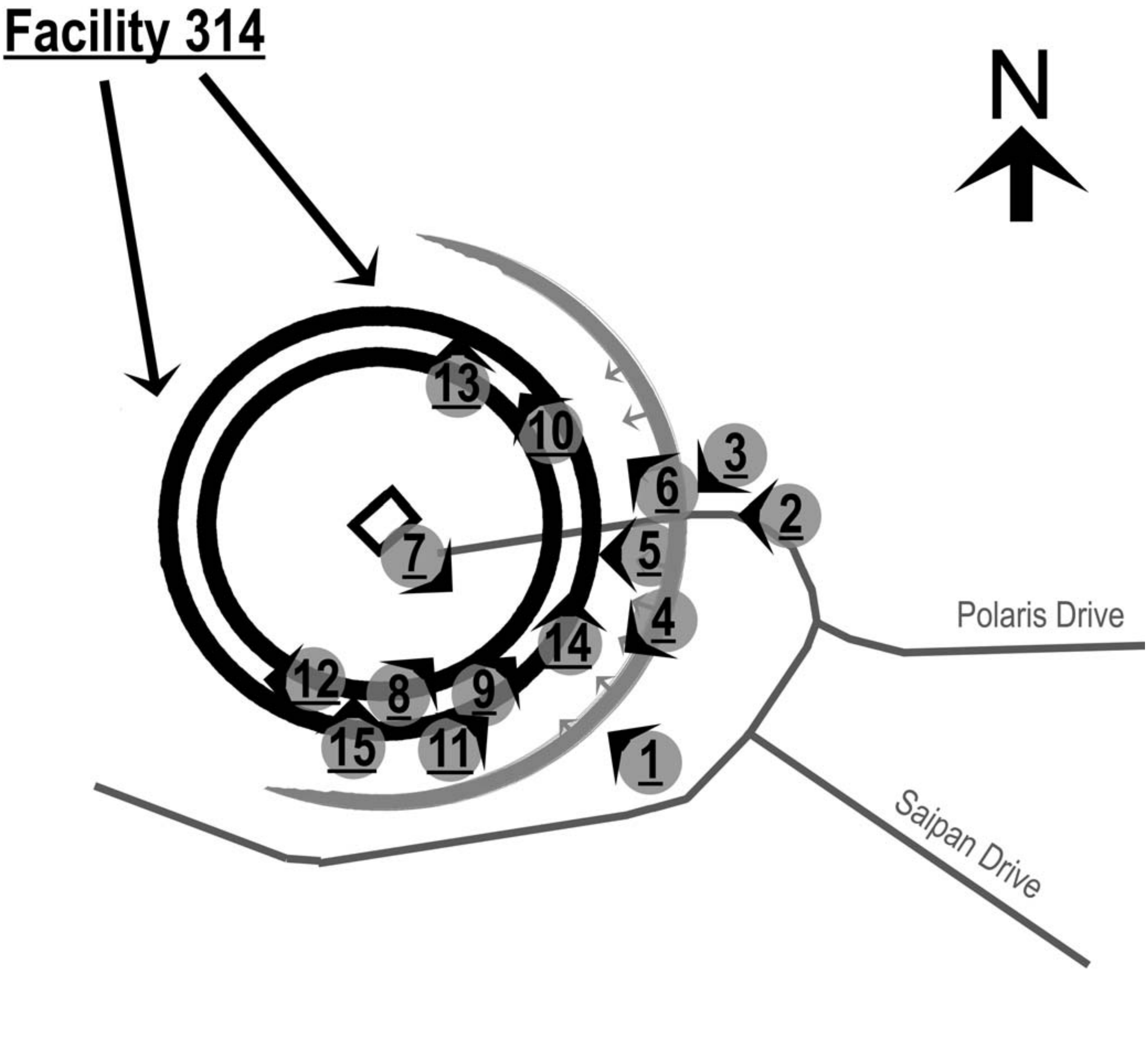
Facility 314
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Polaris Drive
Saipan Drive

HISTORIC AMERICAN BUILDINGS SURVEY

U.S. NAVAL BASE, PEARL HARBOR, NAVAL RADIO STATION,
AN/FRD-10 CIRCULARLY DISPOSED ANTENNA ARRAY
(Naval Computer & Telecommunications Area Master Station,
AN/FRD-10 Circularly Disposed Antenna Array)
(Pacific NCTAMS PAC, Facility 314)

HABS No. HI-522-B

Location: Wahiawa vicinity
City and County of Honolulu, Hawaii

USGS 7.5 minute series topographic map, Hauula, HI, 1992.
Universal Transverse Mercator (UTM) coordinates (for the center of the area enclosed by this circular facility): 04.602400.2380260.

Present Owner: United States Navy

Present Occupant: United States Navy

Present Use: Decommissioned

Significance: The AN/FRD-10 Circularly Disposed Antenna Array (CDAA) at NCTAMS (Facility 314) was a part of the United States' Cold War efforts to gather foreign intelligence information. Along with fourteen other FRD-10 CDAAs worldwide, it was a part of the Naval Security Group's Classic Bullseye network, a program for strategic signals intelligence (SIGINT) collection and transmitter locating. This CDAA technology, designed by the Naval Research Laboratory and deployed as the FRD-10, was a radical improvement in the performance of high-frequency direction finding. Its design is the Navy's adaptation of an antenna system using monopole and dipole elements uniformly spaced outside the rings of reflector screens. Thus, the system is able to intercept and detect the direction of high-frequency radio transmissions covering 360 degrees.

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PART I. DESCRIPTION

Facility 314 or the AN/FRD-10[1] Circularly Disposed Antenna Array (CDAA) is a large circular structure whose primary above-ground components have diameters ranging from 869' on the outside to an inner diameter of 732'. The above-ground components consist of four concentric rings, two rings of vertical antenna elements alternating with two rings of antenna reflector screens, not counting the additional rings of guy wire anchors. Underground, the CDAA facility has a ground mat, composed of a grid of wires that are covered by 3" of gravel, which reaches from the inner antenna reflector screen ring (at 732' diameter) to a diameter of 987'. Extending out past this mat is a system of radial ground wires that reaches out another 300'. There are 360 radial wires, at 1° intervals which are covered by 6" of earth. The mat is made of 10 gauge soft-drawn copper wires that are joined by brazing where they intersect, and the radial wires are 8 gauge copper wire, brazed where they join the mat (NAVFAC drwg 929473).

At the center of the CDAA is its operations building, Facility 294 (see HABS No. HI-522-A). The inner ring of the CDAA encloses an area of about 9.6 acres. A paved roadway 12'-0" wide leads through the rings from the east to a paved apron surrounding the operations building; a paved parking lot also extends south from the apron. A 1'-1" high and 1'-8" wide concrete curb that is formed with a u-shaped channel extends into the facility at the north edge of the roadway. The open top of the channel is covered with narrow sections of weather-resistant pressed board, each about 4' long. The channel carries a 4" diameter PVC water pipe towards the Operations Building, Facility 294.

There is little vegetation in proximity to Facility 314. The land around it was graded and grubbed during construction. Gravel was spread beneath the above-ground components of the structure: the antenna elements, reflector screens, and guy wire anchors. Some sparse low weeds have since sprouted through this gravel layer. The area enclosed by the CDAA structure is nearly level (0.5% grade sloping from the operations building to the outer edge of the ground mat) and planted with grass. The area outside of the CDAA's gravel ring has a slightly steeper slope (3.49%) to approximately the edge of the radial ground wires (1287' diameter). This grading required cutting into the hillside to the east of the structure. Now there is a steep slope with a height of about 20' to the existing grade above. The road which leads to Facility 314 is cut down through this slope. The low area to the west (downhill side) of Facility 314 was filled with the material taken from excavating into the slope.

Low-Band Antenna Reflector Screen Ring

The innermost ring of Facility 314 is an antenna reflector screen whose frame consists of a series of 80 vertical wood poles 94' high that are spaced evenly about 28'-6" apart in a circle about 732' in diameter. Horizontal wood beams, called wood boom boards (NAVFAC drwg 929480), about 6" square, are suspended between the tops of the poles. The beams are hung from their ends by metal eyes and ceramic insulators that are fixed to metal brackets at the top

[1] Many pieces of military electronic equipment are identified by numbers and letters which are assigned according to the Joint Electronics Type Designation System (JETDS). This nomenclature begins with the first two letters, AN, which stand for Army or Navy. Next are three more letters which stand for; the type of installation, the type of equipment, and its purpose. In the case of the FRD antenna this is; F=fixed ground installation, R=radio, D=direction finding. The last portion of the JETDS identifier is the equipment model number.

of each pole. The poles are about 1'-8" in diameter at the base where they are secured to a metal plate that is bolted to a concrete footing. A low concrete curb 5" wide extends between the concrete footings of each pole. The reflecting function is carried out by vertical wires that are strung from the horizontal wood beams at the tops of the poles to the concrete curbs near grade. There are seven of these vertical wires, spaced 3'-7" apart, between each 94' wood pole. An additional wire is run down the center of the outer face of each of the 94' poles. These wires are 10 gauge copper encased steel (NAVFAC drwg 929473), and are fixed to the wood beam at the top by securing them around a ceramic insulator that is held in a metal bracket fixed to the beam. At the bottom, the wires are tensioned by looping around the upper end of a bronze turnbuckle which is fixed to a metal ring imbedded in the concrete curb. The turnbuckles were added to the CDAA in 1976; before that the vertical wires were tensioned by a spring clipped to the metal ring in the curb (NAVFAC drwg #118376). The turnbuckle allows tightening of the vertical wire between the upper wood beam and the concrete curb.

The running end of the vertical wire does not end at the turnbuckle, but continues into the earth beside the outside edge of the curb. Before the wire moves underground, between the turnbuckle and the earth, there is a crimped connector secured on it. Below this connector the wire is 8 gauge copper (NAVFAC drwg 118376). Underground, the copper wire is secured, via brazing, to a metal cable about 3/4" in diameter which circles the concrete curb at its outer edge. Brazed to this cable is the ground mat of 10 gauge soft-drawn copper wire that extends in the area outside the concrete curb under 3" of gravel (NAVFAC drwg 1069077). This net is in a grid pattern, the wires spaced about 2'-0" apart and brazed where they intersect. The cable and wire net were exposed at a small part of the gravel ring.

At the point where the paved road crosses this ring, the vertical wires which would normally interfere with this driveway are angled outward from their anchors at the horizontal beam above to anchor points in the concrete curb at the sides of the driveway (NAVFAC drwg 929480).

The 94' vertical poles of the inner antenna reflector screen are steadied by a system of guy lines covered in black plastic sheathing and about 1/2" in diameter. The bottom of the guy lines are fixed to steel turnbuckles that are attached to galvanized steel eyes anchored in the earth. On the outer side of the circle of poles is a single guy line from the top of each pole to an anchor point at a diameter of 948'. One of these outside lines was broken and was observed to be non-metallic, composed of a synthetic fiber inner core covered by a black plastic sheathing. Original drawings specify that these guy lines were to be "glass reinforced epoxy resin rod" (NAVFAC drwg 929479). On the inner side of the circle of poles, each pole has four guy lines, two from the top and two from the midpoint. These extend out to the sides from each point on the pole, one line to the left and one to the right. The lines are anchored at a diameter of 660'. All the guy lines on the inside of the low-band reflector screen have a connector near their tops, about 6' from where they join to the wood pole. Drawings specify that below each connector the line is to be wire rope and above the connector a "glass reinforced epoxy resin rod" (NAVFAC drwgs 929479 and 7000164).

<u>Dipole Low-Band Antenna Ring</u>
Moving outward from the ring of 94' poles is a ring of dipole antenna elements. There are forty of these dipole elements that are evenly spaced about 61'-6" apart in a circle 776' in diameter. Each of these dipole elements is about 58' high and consists of an aluminum mast 5" in

diameter that is set on a 2'-8" high concrete base that is 1'-6" square. Each aluminum mast has seven pairs of short 1'-0" arms which project out at right angles, at a tangent to the circle described by the masts. The uppermost pair of arms, at the top of the mast, is constructed of aluminum (NAVFAC drwg 929474). The remaining six pairs of arms are fiberglass. A vertical, plastic-coated wire runs down the outer ends of the arms, two wires per mast. The arms serve to hold the vertical wires taut, at a uniform distance, on opposite sides of the mast. At their lower ends, the vertical wires are looped around a small ceramic insulator, which is tensioned by wire to a screw eye in a metal bracket that is secured to the concrete base. The running ends of the vertical wires are routed through a small resistor (NAVFAC drwg 929474). Coming out of this resistor, the wires are no longer plastic coated; these then attach to a metal plate that is fixed to a conduit running into a smaller abutting concrete base. An insulated wire runs from the top of the conduit and is fixed to the aluminum mast. A large ceramic insulator about 6" in diameter and shaped like a series of four stacked disks is at the bottom of the mast, isolating it from its bolted mounting to the concrete base. The concrete base itself is covered with copper mesh similar in configuration to poultry netting. This mesh has been applied to closely fit the base and extends below grade to cover an 8' x 8' square area (NAVFAC drwgs 929472 and 929477).

Each dipole antenna element is steadied by a system of guy lines. These guy lines and their attachments are specified to be the same type and design (glass reinforced epoxy resin rods) as the guy lines on the outside of the 94' poles of the antenna reflector screen, described above, except that the dipole antenna elements have nine guy lines each (NAVFAC drwg 929479). On the outer side of the masts, each has six lines, two from each of three different heights. These extend out to the sides, one line to the left and one to the right from each of the three anchor points of the mast. These lines are anchored at points about 18' outside the ring of dipole antenna elements. Three additional guy lines are fixed to the inner side of the ring. The topmost of these runs horizontally from the top anchor point on the mast to a point about midway up the corresponding 94' wood pole of the inner reflector screen ring. The lower two guy lines on the inner side of the ring are fixed to an anchor in the concrete footing of the corresponding 94' wood pole.

<u>High-Band Antenna Reflector Screen Ring</u>
Facility 314's third ring, counting from the inside out, is another antenna reflector screen. This one consists of 120 wood poles about 25' high that are evenly spaced at 22'-0" forming a circle 847' in diameter. This ring is quite similar in design to the inner, 94' high reflector screen, described above. At their bases the wood poles of this ring are about 10" in diameter and each is fixed to a metal sleeve about 3' high and 8" in diameter that is bolted to a concrete foundation. Although the vertical wood poles of this reflector screen are only 25' high, they have the same arrangement of horizontal beams (wood boom boards) suspended from metal brackets by insulators and eyes at their tops as the 94' high reflector screen. The vertical wires suspended from the beams are the same design as the 94' high ring. They anchor identically into a concrete curb and are connected to the underground wire net of the ground mat. The 25' high reflector screen has fifteen vertical wires that are spaced about 1'-4" apart between each pole. At the point where the paved entry driveway crosses this ring, four of the vertical reflector wires which would normally interfere with the driveway have been omitted. Vertical wires at the sides of the gap created by the omitted wires are angled outward from their anchors at the wood

beam above to anchor points in the concrete curb at the sides of the driveway (NAVFAC drwg 929480). The 25'-high poles of the reflector ring have no guy lines to support them.

Monopole High-Band Antenna Ring

The outermost ring of Facility 314 consists of 120 monopole antenna elements that are evenly spaced 22'-9" apart to form a circle 873' in diameter. Each monopole element is about 22' high and is constructed of aluminum. The lower 8'-6" portion of each monopole is 1'-4" in diameter and is bolted to a concrete footing. The upper portion of each monopole is a section of 6" diameter aluminum mast that is topped with a cap and a narrow (approximately 1" diameter) stalk about 4" high which supports a disk, approximately 6" diameter. At the bases of the monopoles, each mounting bolt secures a thin metal strip about 2" wide that extends below grade at the edges of the concrete footing. Beneath each high-band antenna element is an underground section of 8' x 8' square copper mesh similar to the mesh around the low-band elements (NAVFAC drwgs 929472 and 929477).

The monopole elements have no guy wires. Each element rests on a concrete foundation which is set on one end of a 16'-3" long reinforced concrete footing that is 3'-0" wide and 1'-0" thick. This footing is 2'-0" below ground and extends toward the center of the CDAA. The opposite end of each footing supports the concrete foundation of the corresponding 25' high wood pole of the high-band antenna reflector screen (NAVFAC drwg 929478).

Underground Coaxial Cables

Original drawings show that the signal from each antenna element, low band and high band, is sent through an underground section of coaxial cable, described as RG 85 A/U cable on original drawings (NAVFAC drwg 929472). A section of this cable extends from the base of each of the antenna elements to the goniometer room at the center of the operations building. Each cable is routed through one of four underground concrete cable trenches which reach out from the edge of the operations building to points about 120' from the center of the goniometer room. The cable trenches are oriented to the northeast, southeast, southwest, and northwest. Each trench receives the coaxial cables from the antenna elements in its quadrant and carries them to the goniometer. Because precise timing of the arrival of signals to each antenna element was important to the accuracy of the FRD-10, the length of each cable from the element to the goniometer had to be identical. Tolerances for the length of the cables was less than an inch (Proc 2006, [12]) and any excess cable was to be taken up by "snaking" it in its run between the antenna element and the operations building (NAVFAC drwg 929472). The antenna cables were specified to have a minimum 12" of earth cover over them (NAVFAC drwg 929472).

PART II. HISTORICAL CONTEXT

For more information see HABS HI-522-A, a report on the Operations Building, Facility 294 at Naval Computer and Telecommunications Area Master Station, Pacific (NCTAMS PAC).

Construction drawings for Facility 314 were produced by Indenco Engineers, Inc. of Honolulu for the 14th Naval District Department of Public Works and were approved by the Bureau of Yards and Docks on April 20, 1962. The signature of the Indenco chief engineer on the drawings is difficult to read, but appears to be R. W. Ganse. Work on the project was begun by October 3,

1962. Aerial photos taken that date (NARA RG 428-GXA #1077671) show the large circular site had been cleared. Indenco expected that the entire project would take 324 days to complete (NAVFAC drwg 929526). This corresponds with Navy information that gives 1963 as the construction date. Before Facility 314 and 294 (the CDAA direction finder and its operations building) were built some World War II structures and antennas within the site were removed. This included a cluster of eleven 255' x 615' rhombic antennas, their associated operations building, underground cables, and a 100' long Quonset hut (NAVFAC drwg 929457).

Signals Intelligence Collection

Throughout the post World War II years, advancing technology helped to shift the means of intelligence gathering by the United States, from networks of agents operating on the ground in foreign lands to electronic and over flying systems that could gather data from much greater distances. Although human intelligence gathering efforts continued, technical collection of information came to be relied on more and more. An important time for this was the 1950s as the United States began to build a network of signals intelligence (SIGINT) stations to collect information, and also to experiment with aerial reconnaissance over the Soviet Union (Richelson 1995, 256). SIGINT, which is often referred to as "reading someone else's mail," can be divided into two categories. The first, Communications Intelligence (COMINT) is the covert interception of foreign communications. This involves regular message traffic: voice, radio-telephone, facsimile, or Morse code, either transmitted in the clear or encrypted. The second, Electronics Intelligence (ELINT) refers to non-communications signals, such as the emanations from foreign radar, and signals sent back from missiles or satellites that indicate performance and operation during a flight. The FRD-10 CDAA (Facility 314) at NCTAMS Wahiawa and other CDAAs of the same design were used for gathering COMINT signals intelligence.

In 1952 an antenna system was activated in Scotland for intercepting Soviet transmissions, and there the performance of various configurations was evaluated. In 1953 efforts were made using that system to intercept radio transmission from military and commercial traffic near Murmansk by the Air Force Security Service's 37th Radio Squadron Mobile, known as USA-55. By 1955, USA-55 was intercepting signals concerning the new Soviet radar systems that were replacing older Lend-Lease units. Turkey was another area that was especially conducive to monitoring the Soviet Union. By the mid 1950s Karamursel in Turkey was selected for the location of a mobile radio squadron which would prove valuable in gathering information on the Soviet Naval Training ground in the Black Sea and launches of the Soviet missile program.

Over flights of Soviet territory to collect intelligence also began during this period. First flights were in 1951 by RB-45 jet aircraft over the Soviet Union at Sakhalin Island. By 1954 over flights of the Murmansk and Kola Peninsula areas had been accomplished, as well as over Siberia and Wrangell Island. Losses of airmen from flights over the Soviet Union during this period were significant. In October 1952, an RB-29 with a crew of eight was lost in a flight originating in Hokkaido. In July 1953 only one airman from a crew of nine was rescued when an RB-50 was shot down by Soviet MiG-15s over the Sea of Japan. Before the end of 1955 there were five additional incidents which claimed the lives of thirteen crewmen. On November 24, 1954 President Eisenhower approved a program to build thirty high-performance aircraft for over-flight intelligence gathering. These aircraft would become the U-2 reconnaissance plane, codenamed IDEALIST, which flew its first Soviet over flight on July 4, 1956. The aircraft was designed to take photographs while flying at altitudes above 68,000 feet, then thought to make it immune to air-defense missiles and interceptors.

Although the Soviets launched the first earth-orbiting satellite (Sputnik I in 1957), it was the United States that moved ahead in the use of that technology for photo-reconnaissance. On August 19, 1960, less than four months after Francis Gary Powers' U-2 was brought down when flying over the Soviet Union, the United States recovered its first reconnaissance satellite payload (Project CORONA) which contained photos of a Soviet air base. Later CORONA missions in 1960 returned with photos showing that the "missile gap" between the US and Soviet ICBM inventory did not exist. The first successful Soviet photo-reconnaissance satellite was launched in early 1962. By 1964, the year after the FRD-10 CDAA was constructed at Wahiawa, US satellite reconnaissance (codenamed KEYHOLE) had returned photos with a resolution of eighteen inches (Richelson 1995, 301). Also by the end of that year, the existence of the SR-71 reconnaissance aircraft (codenamed OXCART) was made public by President Johnson. This plane, capable of flying at 92,500 feet at a speed of mach 3.5, would make its first operational flight in May 1967 over North Vietnam.

Other SIGINT schemes from the period range from the mundane, such as the use of small, slow ships, or spy trawlers, which patrolled the Soviet coast, to the exotic, like Project FLOWER GARDEN which collected Soviet signals from radar installations after they had bounced off the moon (Richelson 1995, 305). Amid this carnival of moonbounce, satellites, spy trawlers, and mach 3 aircraft, the United States also pursued the strategy of making more effective antennas to gather SIGINT, such as the high frequency FLR-9[2] and FRD-10.

<u>High Frequency</u>

High-frequency (HF) radio waves were the most common system of telecommunication before the early 1960s. In a curious twist of nomenclature, a high-frequency (HF) signal is actually considered a part of the low-frequency band (which includes Extremely Low Frequency or ELF, Very Low Frequency or VF, Low Frequency or LF, as well as High Frequency or HF). "Messages transmitted at lower frequencies (ELF, VLF, LF, HF) travel for long distances since they bounce off the atmosphere and will come down in locations far from the transmitting and intended receiving locations. In contrast, data sent at higher frequencies will 'leak' through the atmosphere and out into space" (Richelson 1999, 183). HF transmitters and receivers were especially popular with the military and for diplomatic communications, such as between an embassy and its mother country. HF signals are useful for these types of communications because of their ability to bounce off the ionosphere, the upper region of the earth's atmosphere which begins about 50 miles above its surface. This means that they are able to be transmitted to receivers that are over the horizon, behind the curvature of the earth from the emitter. A powerful HF signal has the ability to travel around the entire planet for reception, which makes it a good choice for global endeavors and also makes it extremely vulnerable to interception (Campbell 1999, 8). Another name for high frequency radio (operating between the frequencies of 2,310 kHz and 30 MHz [30,000 kHz]) is shortwave. This is because there is an inverse relationship between frequency and wavelength; high frequencies are associated with short wavelengths.

[2] JETDS identifier; F=fixed ground installation, L=countermeasure equipment, R=receiving or passive detecting purpose.

Evolution of the FRD-10

Early work on circularly disposed antenna array (CDAA) systems was undertaken by the German navy's signal intelligence research and development center early in World War II. It was during this time that CDAA was given the name, Wullenweber, or Wullenweber Antenna. Jurgen Wullenweber was the mayor of Lubeck, Germany from 1533 to 1537. He was an opponent of injustice and a supporter of the Protestant cause who became a legendary figure. Considered a martyr after he was killed in 1537, his name was chosen as a cover for the German CDAA program of World War II. After the war, some of the German CDAA technology was appropriated by the Soviets, who deployed 20 CDAAs during the post-war period when the United States military showed little interest in them. Two CDAAs were built by the Germans; the one in Denmark was destroyed after the war. The other, at Langenargen, Germany, was dismantled, re-erected at the University of Illinois, and studied by Professor Edgar Hayden of the Electrical Engineering Department. Two of the CDAA antenna designs which resulted from Hayden's research were the AN/FLR-9 system that was used by the U.S. Army and Air Force, and the AN/FRD-10 (Facility 314) system that was used by the Navy. In 1994, an aging Wullenweber direction finder that was used by the University during the 1950s and 60s for development of the U.S. Navy CDAA system, was still located at the University of Illinois facility near Bondville, Illinois. This antenna (unknown if it was the original CDAA re-erected after WWII) had been abandoned around 1980 by the University after the completion of their developmental work (Swenson 1994).

During the 1950s and 1960s the Naval Research Laboratory (NRL) worked on ways of improving the capabilities and performance of high-frequency direction-finding (HFDF) equipment. One product of this research was the refinement of circularly disposed wide-aperture direction finding arrays, or circularly disposed antenna array (CDAA). These circular arrangements of concentric antennas markedly boosted the ability of HFDF systems to locate and collect signals (De Young 1998, 28). Before the circular concept was built, the NRL experimented with a wide-aperture linear antenna 1100' long at Fox Ferry, Maryland around 1952. This device operated well only within the narrow range of its orientation, but was able to determine bearings of transmissions up to 1200 nautical miles away to an accuracy of 0.25 degree (Gebhard 1979, 311). By 1957 the NRL had modified this linear-type antenna into a circular version about 400' in diameter that was built at Hybla Valley, Virginia. This direction finder was used to determine the orbit of the first man-made earth-orbiting satellite, Sputnik I, launched on October 4, 1957 (Gebhard 1979, 313).

Another product of the NRL work on HFDF equipment was the development of retrospective direction finding, or the ability to locate the position of a transmitter after the transmission had been completed. This was accomplished by the use of a high-speed recording device that was coupled with the CDAA system (Bamford 2001, and DeYoung 1998, 28). The first use of this technology was during Project Boresight in 1960, which used an early CDAA system, the AN/FLR-7. This was a 1300' diameter circular array, 200' high. Project Boresight was initiated after November 1960 when National Security Agency (NSA) operators, who had been routinely intercepting daily HF signals from Soviet submarines suddenly noticed no signals. The missing signals proved a mystery until about a month later when it was determined that the Soviets were compressing the signals and shooting them out in a fast burst that was too quick to be pinpointed. The rapidly developed retrospective direction finding system was coupled with the FLR-7 to accurately locate the source of the signal and record it for de-coding (Bamford 2001).

Even before the FLR-7 achieved notoriety in Project Boresight, a successor CDAA, the FLR-9 was under development. The FLR-9 was used by the Air Force and the Army. The first contract to construct two 1200'-diameter FLR-9 Air Force antennas was awarded in 1959 to Sylvania. These were completed in 1962 at San Vito, Italy and another at RAF Chicksands, Great Britain. The FLR-9 antenna had three concentric antenna rings and such installations, as well as the later FRD-10 CDAA, were often referred to as "elephant cages." The outer two rings of antenna on the FLR-9, placed at diameters of 1198' and 1116', were assisted by a reflecting screen of vertical wires that was placed at a diameter of 1076', inside the middle antenna ring. The third ring of antenna, the innermost ring, was placed at a diameter of 334' and had its reflecting screen at a diameter of 314'. The entire array was built on a ground screen about 1443' in diameter. At the center of the array was a building which housed only the system electronics; operators were located in a separate building. The FLR-9 was considered the most advanced CDAA of its period, capable of intercepting and getting a bearing on "as many directions and on as many frequencies as may be desired" (Campbell 1999, 9). Additional FLR-9 antenna were constructed at; Misawa Air Base, Japan; Clark Air Base, Philippine Islands; Elmendorf Air Base, Alaska; Karamursel Air Station, Turkey; Augsburg, Germany; and Udon Thani, Thailand. During its operational history the world-wide network of FLR-9 CDAA was known as program "Iron Horse" and was used for signals intelligence gathering, or eavesdropping, on foreign government communications. The Misawa station monitored "diplomatic communications, communications involving Soviet or Chinese strategic nuclear forces, and Soviet satellite communications (Richelson 1987, 94). Operation Ladylove, using the FLR-9 at Misawa intercepted communications signals from Soviet geosynchronous satellite systems: Molniya, Raduga, Gorizont (Richelson 1989, 183, and Elliston 2004). The FLR-9 at Misawa Japan can "pick up a Russian television broadcast in Sakhalin or an exchange of insults between Chinese and Soviet soldiers on the Sino-Soviet border" (Beech 1980, 17.) By 1996 all but three FLR-9 CDAAs had been dismantled, Elmendorf and Misawa were still standing, and Augsburg was to be turned over to the German government in 1998.

The Navy's version of the CDAA, the FRD-10, was slightly smaller than the FLR-7 and FLR-9. Its Navy predecessor, the AN/GRD-6[3], was a small system of only eight monopole antenna elements that was developed in 1951 (Gebhard 1979, 310). The network of FRD-10s was developed to plot the locations of Soviet submarines and other HF radio transmitters and was managed by the Naval Security Group (NSG). Unlike the Army/Air Force FLR-9, the FRD-10 had only 2 rings of antenna, located at about 870' and 780' diameters. Each ring was backed by a reflecting screen of vertical wires that was placed inside its diameter. While the third ring of dipole antenna elements on the FLR-9 gave the unit a wider frequency, its horizontal polarization interfered with its omnidirectional capabilities, and was difficult to operate. The FRD-10 was an improvement by offering a "truly omnidirectional pattern" (Cummings 2000, [4]). The FRD-10 was designed as an outward-looking array, with its high-band antenna elements on the outside, backed by a dedicated reflector screen. This is in contrast to the inward looking FLR-9 which had its high-band elements on the inside of its circular structure (Cummings 2000, [4]).

[3] JETDS identifier; G=general use ground installation, R=radio equipment, D=direction finding purpose.

Construction of the Navy's FRD-10 CDAAs was undertaken between 1962 and 1964. During that time a total of 16 were built, one each at the following 14 locations: Adak, AK; Marietta, WA; Skaggs Island, CA; Imperial Beach, CA; Wahiawa, HI (NCTAMS); Guam, Mariana Islands; Hanza, Okinawa, Japan; Winter Harbor, ME; Northwest, VA; Homestead, FL; Sabana Seca, PR; Galeta Island, Panama; Edzell, Scotland; and Rota, Spain. Two additional FRD-10 CDAAs were built in a side-by-side configuration at Sugar Grove, VA. These were used for ship-to-shore communications. All of these CDAA have been removed except for Waihiawa and Imperial Beach (both slated for removal in 2007), Galeta Island (equipment removed and turned over to the Panamanian Government), and Guam (abandoned). The FRD-10 antenna system was used at Homestead AFB in Florida to monitor "Cuban military communications as well as Soviet activity in Cuba" and "all communications involving Cuba and Soviet air activity originating or destined for Cuba." (Richelson 1989, 186). Also FRD-10 at Guantanamo Bay and at Sabana Seca, Puerto Rico, "intercept Cuban and Soviet military communications in and around Cuba and the Caribbean Basin" and "target internationally leased carrier (e.g. INTELSAT) and diplomatic communications for all of Central and South America" (Richelson 1989, 186). The FRD-10 was built in two different variations. After the first one was constructed at Hanza, Okinawa, there were some dimensional changes that were incorporated in later units, such as the diameters, heights, spacing, and number of antenna elements (Cummings 2000, [5]).

The FRD-10 CDAA has a normal range of 3200 nautical miles. This distance corresponds to one or two bounces of a HF signal off the ionosphere. While it is often possible to monitor multi-bounce signals, the direction-finding accuracy is generally compromised. However, under good conditions for the propagation of signals, a transmission can be monitored from all around the earth (Granite Island 2006, 2). CDAA antennas are designed for optimal performance with incoming wave angle of 10-30 degrees or 45-60 degrees. Although these antennas are omni directional, their locations were likely chosen to place it "purposeful[ly] relative to the intended spying target(s)" (Cummings 2000, [2]).

<u>Classic Bullseye and the NSG</u>

The AN/FRD-10 CDAA at NCTAMS (Facility 314) was built in 1963 as part of the network of 14 land-based, high-frequency direction finders of the same design that were used in the Classic Bullseye program. This Department of Defense program gathered strategic intelligence and determined the location of transmitters. Classic Bullseye was managed by the Naval Security Group (NSG) Command. The High-Frequency Direction-Finding (HFDF) FRD-10s were used to intercept and locate voice transmissions and message traffic that were broadcast on short-wave (HF) channels (Pike 2001). In the late 1960s, an FRD-10 CDAA was constructed at Canadian Forces Station Masset, located on the north coast of Graham Island in British Columbia's Queen Charlotte Islands. This station officially opened in February 1970, and became a station of the United States' Classic Bullseye program. By 1978 a permanent detachment of about ten NSG personnel were at Masset as part of a joint Canadian Forces/U.S. Navy exchange program. Canadian technicians would also train at the NSG's school in Pensacola Florida (Proc 2006 [8]). The station's official role in Classic Bullseye was to "a/ participate in the Canada/United States HF DF search and rescue net, b/ support in the collection of data for research into basic problems on ship/shore and shore/ship communications, c/ HF DF assistance to search and rescue operations." The station was "believed to listen to the Soviet naval base at

Petropavlovsk and to the Vladivostok headquarters of the giant Soviet Pacific ship and submarine fleet" (Granite Island Group 2006). Also under Classic Bullseye, the Masset station eavesdropped on Soviet spy trawlers.

The Naval Security Group was the portion of the Navy which conducted radio intercept (intelligence gathering) and crypto analysis between its formation in 1935 and 2005, the year it was disestablished. Some of the first radio intercept activities undertaken by the Navy date from 1923 in the Pacific when the Office of Naval Intelligence directed all ships in the Asiatic Fleet to forward Japanese and commercial coded traffic which was intercepted (Grobmeier 2006). By the following year Japanese radio messages were being intercepted by the Navy in Shanghai, China. In March 1935 the forerunner of the NSG was formed, the Communication Security Group. This entity dealt with the Navy's radio intelligence and cryptology operations. Over the next 20 years the Communication Security Group expanded, and in 1955 the title Naval Security Group was applied. The mission of the NSG was to "perform cryptologic and related functions." It also "manages the Navy High Frequency Direction Finding System and associated communications support" (Pike 1997). The 2005 disestablishment of the NSG was part of a reorganization, and the commands formerly under the NSG were renamed Navy Information Operations Command (NIOC), whose mission continued to be to "conduct information operations and to provide cryptologic and related intelligence information" (NIOC 2006).

<u>Operation of the FRD-10</u>

The two rings of antenna in the FRD-10 CDAA are set up to each operate optimally in a different high-frequency (HF) wavelength range. The outer ring of 120 sleeved monopole antennas was designed to receive shorter HF wavelengths from 8-30 MHz and the inner ring of 40 folded dipole antennas the longer HF wavelengths between 2-8 MHz (Proc 2006, [12]). A folded dipole antenna gives enhanced performance over a standard dipole by allowing an increase in feed impedance and wider bandwidth capabilities. The two screens of vertical wires that are suspended from the wood poles serve to shield the antenna elements on one side of the CDAA from interference that would be created by signals crossing from the other side. The wire shield buried in the ground also serves to isolate the incoming signal for better results.

The individual antennas of the ring were sequentially connected to radio receivers in the operations building in the center of the array. A contiguous number of antenna elements which spanned a segment of the circle of the CDAA were usually connected at any given moment. This segment of activated antenna formed a pattern which swept rapidly around the ring, covering all points of the compass. An antenna which sweeps its beam using electronic pulses moving across its face is termed "phased." This is in contrast to a manually swept antenna, such as a rotating satellite dish. By monitoring the signal strength and precise timing as the activated segment moved around the circle, the direction of a radio signal could be very accurately determined. Each ring of the antennas was relayed through a goniometer (an instrument that allows a precise determination of the angle of a rotating object or signal). The goniometer switches the antenna elements sequentially alternating connected and disconnected elements to produce a beam that swept around the CDAA and covered all directions. The details of the phasing of the antenna elements and the goniometer circuitry are "presumed to be classified" (Proc 2006, 12).

> The real unique use of the CDAA antenna is that certain elements can be selectively chosen and electronically added or subtracted in phase effectively synthesizing an array that behaves as if the elements were in a linear end-fire array with substantial gain. This permits the construction of electronic "sector" beams that are 30 degrees wide or "monitor" beams that are 15 degrees wide (Cummings 2000, [3]).

The FRD-10 is designed to react to incoming signals as if it were a linear array. This is accomplished with the sophisticated circuitry and relays of the goniometer. As the incoming signal hits the array it reaches a single antenna element first and then subsequently triggers pairs of elements sequentially moving outward as the wave moves over the array. The signals are evaluated at the goniometer and combined with a delay so that each element's signal arrives simultaneously at the receiver, performing as if the circular array were linear and oriented almost directly at the source of the signal. "The goniometer permits the user to in effect electrically steer the phasing/delay lines by selecting a given arc of [antenna elements] on demand. The resulting pattern is very narrow and the gain very high. It shines in allowing the listener to electronically steer the beam and change the pattern shape at will" (Cummings 2000, [7]).

The various FRD-10 sites around the globe were in contact with one another which enabled triangulation of the source of the signal by comparing bearings from two or more FRD-10s. "The FRD-10 provided a near instantaneous bearing of any signal that appeared on the radio spectrum for even a fraction of a second. When combined with the information from other FRD-10 sites operating in real time, a bearing could be obtained immediately and it would be virtually impossible to hide any HF transmissions (Proc 2006, [12]).

For the Navy, the FRD-10 CDAAs were a big improvement over their earlier HF direction finding unit, the GRD-6 from 1951. They allowed transmissions to be recorded for subsequent direction finding. The bearings obtained were up to four times as accurate as previous antennas, with results of better than 0.5 degree. Signal amplitude (gain) was four times greater, and the FRD-10 was better able to filter out interfering signals and noise (Proc 2006, [15]). "The improvement expected as a result of deploying the FRD-10s was a combination of more accurate and reliable fixes, producing reduced search areas in ocean areas of prime responsibility so fresh in time, as to enable maritime commanders to deploy their forces more economically and with much greater prospect of making contact with the target than is now the case" (Proc 2006, [15]).

<u>History of Communication and Signals Intelligence at NCTAMS</u>
The development of the Naval Computer and Telecommunications Area Master Station, Pacific (NCTAMS PAC) at Wahiawa was begun in 1940 as a temporary radio transmitting station and radio direction finder. The need to expand the Navy's receiving capabilities on Oahu in anticipation of war led to the incorporation of receiving facilities at the Wahiawa installation. Prior to the development of this base, the main Oahu communication stations for the Navy were the Naval Radio Station on the west shore at Lualualei, and a receiving station at Wailupe on the south shore. The Wailupe station was the site of the intercept facility for Station Hypo, which had been intercepting Japanese communications in an attempt to break their code (Helber Hastert & Fee, Planners 2006, 5.2.1). The Lualualei and Wailupe stations receiver

functions were consolidated at the Wahiawa location by the end of 1941 (Global Security) and in 1942 the designation for this installation was "Naval Radio Station for the 14th Naval District" (14th Naval District 1942).

During World War II, this base was "the principal radio receiving station in the Hawaiian Islands: with its associated transmitting stations, it constitutes the main link in the naval-communication chain between Washington and the Pacific combat area" (CPNAB A-856). The facility sent messages and also had units responsible for cryptographic security, message traffic control, and message traffic analysis.

After the war, the Naval Research Laboratory (NRL) continued work which was carried out by the Army's Signal Research and Development Laboratory in 1946; this consisted of reflecting radar signals off the moon. The NRL conducted investigation into the possibility of using signals bounced off the moon for relaying military communications. In early 1956, NCTAMS participated in relaying communications between Wahiawa and Washington D.C. via the moonbounce of signals. That year NCTAMS became a station (along with the radar site at Opana on Oahu's north coast) for the Navy's Communication Moon Relay (CMR) system which sent teletype and facsimile transmissions between Washington D.C. and Hawaii. The equipment consisted of two 84' diameter dish antennas, one each for transmitting and receiving. The NCTAMS antenna was located north of Polaris Drive (Helber Hastert & Fee Planners 2006, 5.2.3). The CMR system became operational in January 1960 when a message was sent from Washington to the Commander of the Pacific Fleet. The CMR system operated between Hawaii and Washington until the mid 1960s. It was reliable, its main limitation being the position of the moon. Operators manned the system for a period of four to eight hours daily, the time from moonrise in Hawaii to moonset in Washington.

NCTAMS also became the site of a satellite tracking station (station number 100) in the Navy's Tranet system, which determined orbiting position by detecting signals transmitted from the satellites. The Tranet system had seventeen stations in the early 1960s. When the Navy's Transit system (a fore runner of the Global Positioning System) became operational in 1967, the Tranet station at NCTAMS was switched to a tracking station for it. Transit was a satellite navigation system that employed "four or five" satellites and ultimately gave users accuracy of about 25 meters by determining position in relation to any two of the satellites (Federici 1997, 2.2). The Transit system was ended in December 1996.

In 1964 the Navy established the Technical Research Ship Special Communication System (TRSSCOM). This was the first ship-to-shore satellite communication system and was designed to support Navy SIGINT surveillance ships that were operating in the field gathering intelligence. The TRSSCOM name was chosen to remain in keeping with the ships' cover story that they were involved, not in surveillance, but in technical research (Federici 1997, 2.3.1). When the CMR moonbounce link between Hawaii and Washington was shutdown, the CMR facility antennas at NCTAMS were cycled to TRSSCOM (Federici 1997, 1.6.2.1), going operational in 1964. TRSSCOM was ended in the fall of 1969.

In 1967 President Johnson denied a Soviet claim that two of their ships had been damaged when the United States bombed Haiphong Harbor in Vietnam. Upon having to eat crow when the Soviets produced photos of the damage, the President mandated that in the future he was to personally view military photos from Vietnam. He also wanted the photos sooner than they could be courier-delivered from the field. The response to his order was an operation, called Compass Link, which transmitted photos from Vietnam via satellite to NCTAMS and then on via satellite to an NRL 60' dish antenna at Waldorf, Maryland. Compass Link was used until the end of the war in Vietnam.

NCTAMS is a transmitting and receiving station for the Fleet Satellite Communication (FLTSATCOM) System. This was a project undertaken with the Air Force and begun in 1971 that allowed almost worldwide communication via a system of four geosynchronous satellites. The involvement of NCTAMS, along with the other stations for FLTSATCOM (Washington D.C., Norfolk, VA, and Finegayan, Guam), has made it "one of the most vital fleet communications centers in the Navy" (Helber Hastert & Fee Planners 2006, 5.2.4). On February 18, 1977 NCTAMS was officially designated the site for a Super High Frequency Satellite Facility, the largest facility of this kind. "In 1980, Wahiawa was the largest communication facility in the world" (ibid.).

Ground-Based Signals Intelligence at the End of the Cold War

The end of the Cold War and the dissolution of the Soviet Union in 1991 brought a series of dramatic cutbacks in Signals Intelligence networks as threats of a conflict between the Soviet Union and the United States vanished. During the late 1980s and the 1990s a number of major United States SIGINT stations that previously monitored the Soviet Union were closed: in Italy (San Vito), Germany (Augsburg and Berlin), United Kingdom (Chicksands), and Turkey (Sinop). By 1999 "the National Security Agency [had] established three regional SIGINT Operational Centers to received data from manned and unmanned SIGINT sites in particular regions" (Richelson 1999, 197-8). A center at Lackland, Texas was focused on Latin America, Fort Gordon, Georgia had a station concentrating on Europe and the Middle East, and a station at Kunia, Hawaii was focused on Asia.

In the early 1990s a tactical HFDF, the AN/TSQ-164[4] (Code named DRAGONFIX) was being experimented with. This system was field-transportable and operated within a frequency of 1.6 to 30 MHz. It was able to determine the angle at which signals bounced off the ionosphere to arrive at the receiver. This enabled a single TSQ-164 receiver to not only get a bearing, but to also calculate the position of the transmitter without any triangulation (Proc 2006, [16]).

Beginning in the mid-1990s the NSG, noting the absence of Soviet targets and wanting to cut costs and change the focus of its SIGINT collection, began closing FRD-10 sites. As of 1999 the FRD-10 at NCTAMS Wahiawa was still being used to peer into the communications of various entities around the Pacific region. The most specific information available on this indicates that the FRD-10 was used "to monitor naval traffic around the Hawaiian Islands as well as to collect international leased carrier (e.g. INTELSAT) and other communications for the Pacific Region" (Richelson 1999, 200-201). This seems to indicate that the elephant cage was tuned to the sky and listening to any targets deemed interesting by its commanders. At this date the FRD-10s at Imperial Beach CA and in Guam were also operating. They have since been closed.

[4] JETDS identifier; T=ground transportable installation, S=Magnetic special type equipment, Q=special or combination types purpose.

Undoubtedly, since the September 11, 2001 terrorist attack on the World Trade Center and the Pentagon, listening posts have gained importance and most likely increased in number and sophistication. The FRD-10 CDAA at NCTAMS Wahiawa ceased listening in August 2004; it can only be assumed the closure occurred because there was a better way to do it.

PART III. SOURCES OF INFORMATION

A. Architectural Drawings:

Historic drawings are available as electronic scans only, were viewed on the NAVFAC Pacific Plan File data base at Building 258, Makalapa, Pearl Harbor. Scans can be viewed and printed on 11" x 17" paper only. Drawings for this facility are indexed under both Facility 314, and under its associated operations building, Facility 294. Original (1962) drawings were produced by Indenco Engineers Inc., of Honolulu, HI and the 14th Naval District Public Works Office.

B. Early Views:

Aerial photos taken during the time of construction (1962-63) are located at the Still Photo section of the National Archives and Records Administration (NARA) in College Park, Maryland. They are filed as RG 428-GXA: #s 1077670 thru 1077673, and 1077694. Other Navy aerial photos dated August 20, 1964 are filed as RG 428-N: #s 1108494 thru 1108496, and another photo dated April 26, 1966 is RG 428-N: # 1118376.

An aerial photo dated December 5, 1969 is found in the Hawaii State Archives, Folder PPA-52-3, photo 5203-5. Photos of later dates can be found on the website maintained by Joseph Glockner (www.navycthistory.com).

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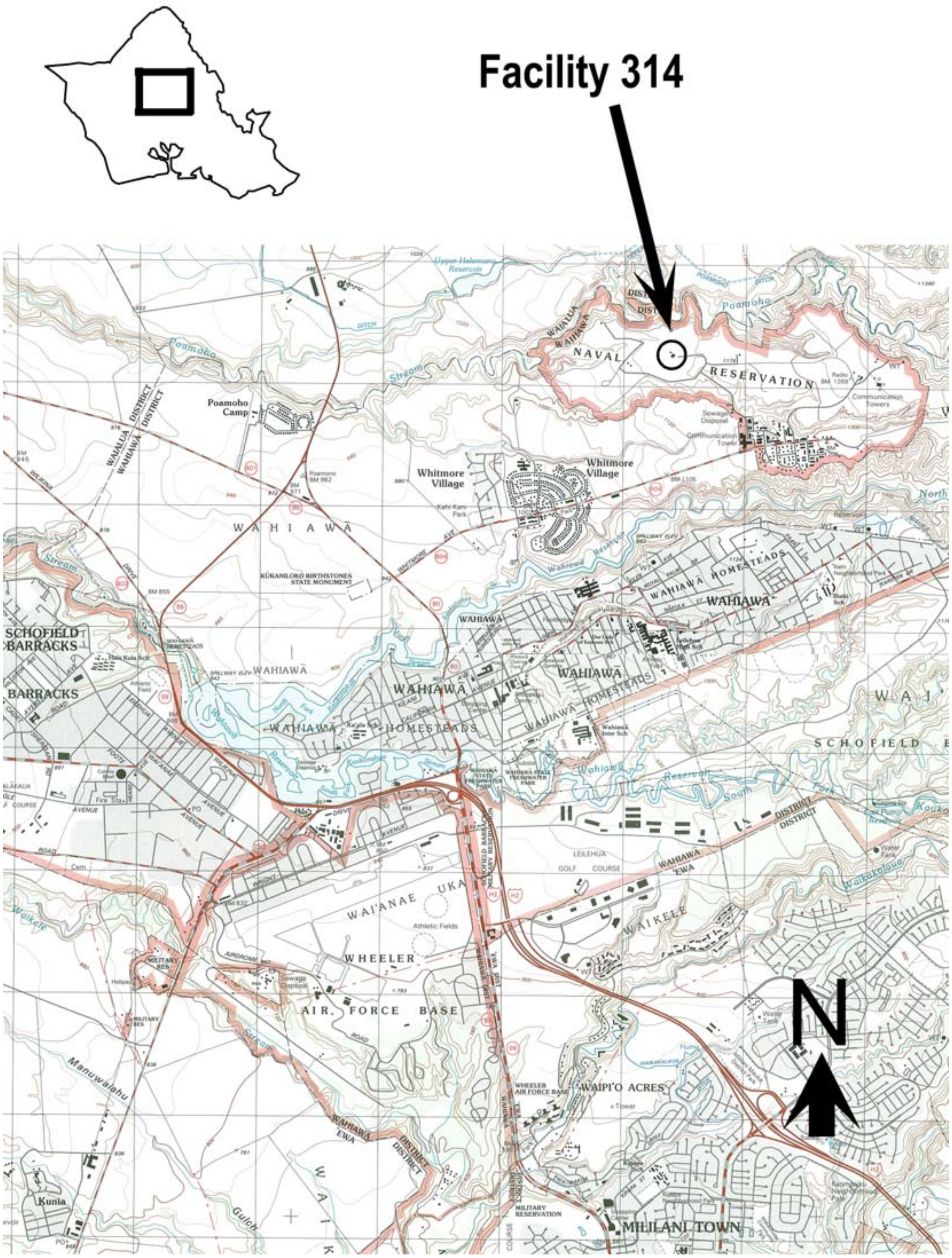
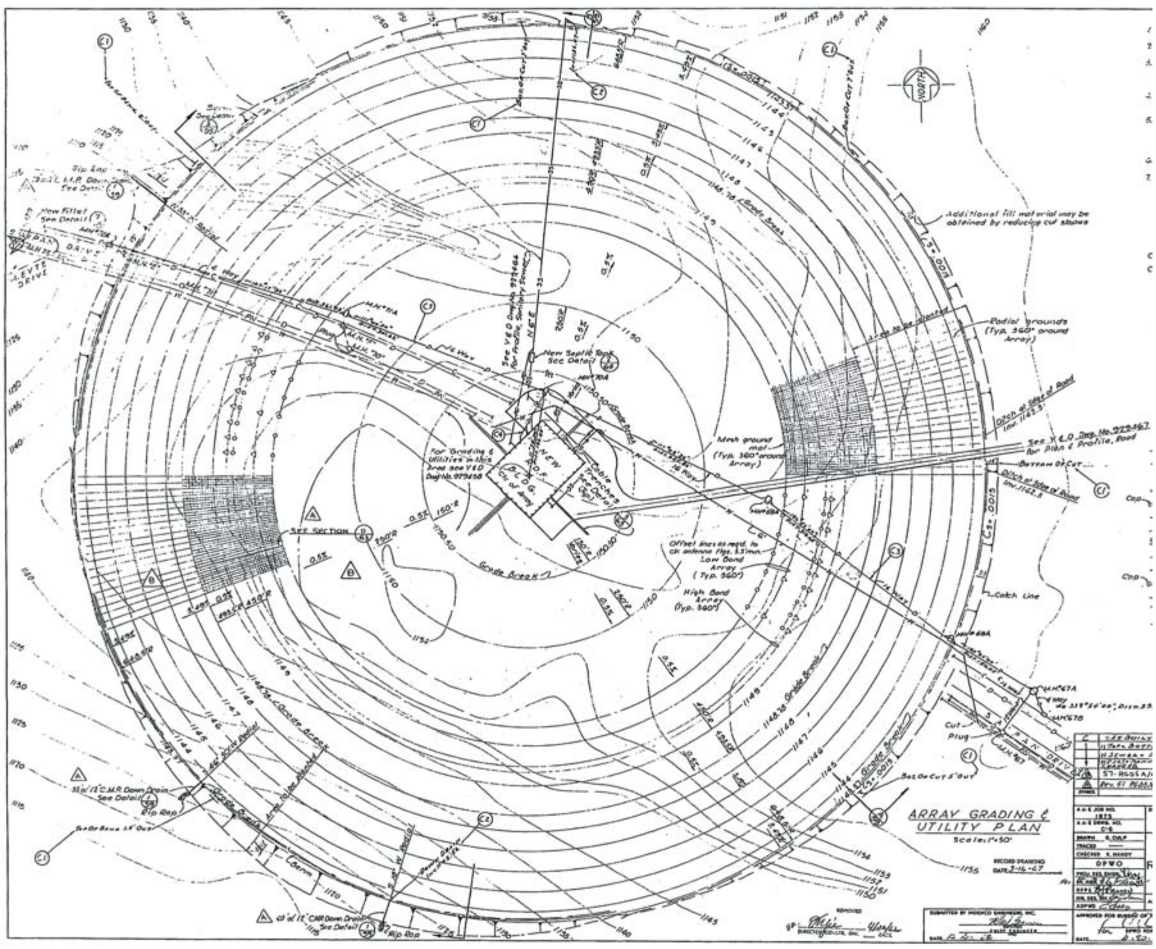
PART IV. PROJECT INFORMATION

This documentation is being undertaken after consultation with the Hawaii State Historic Preservation Officer and prior to the demolition of CDAA (Facility 314) and its associated operations building, (Facility 294). The site will be used for the Hawaii Regional Security Operations Center (HRSOC). The large-format photographs were taken on October 23, 2006 by David Franzen of Franzen Photography. The report was researched and written by Dee Ruzicka, Architectural Historian at Mason Architects, Inc., Honolulu, Hawaii.

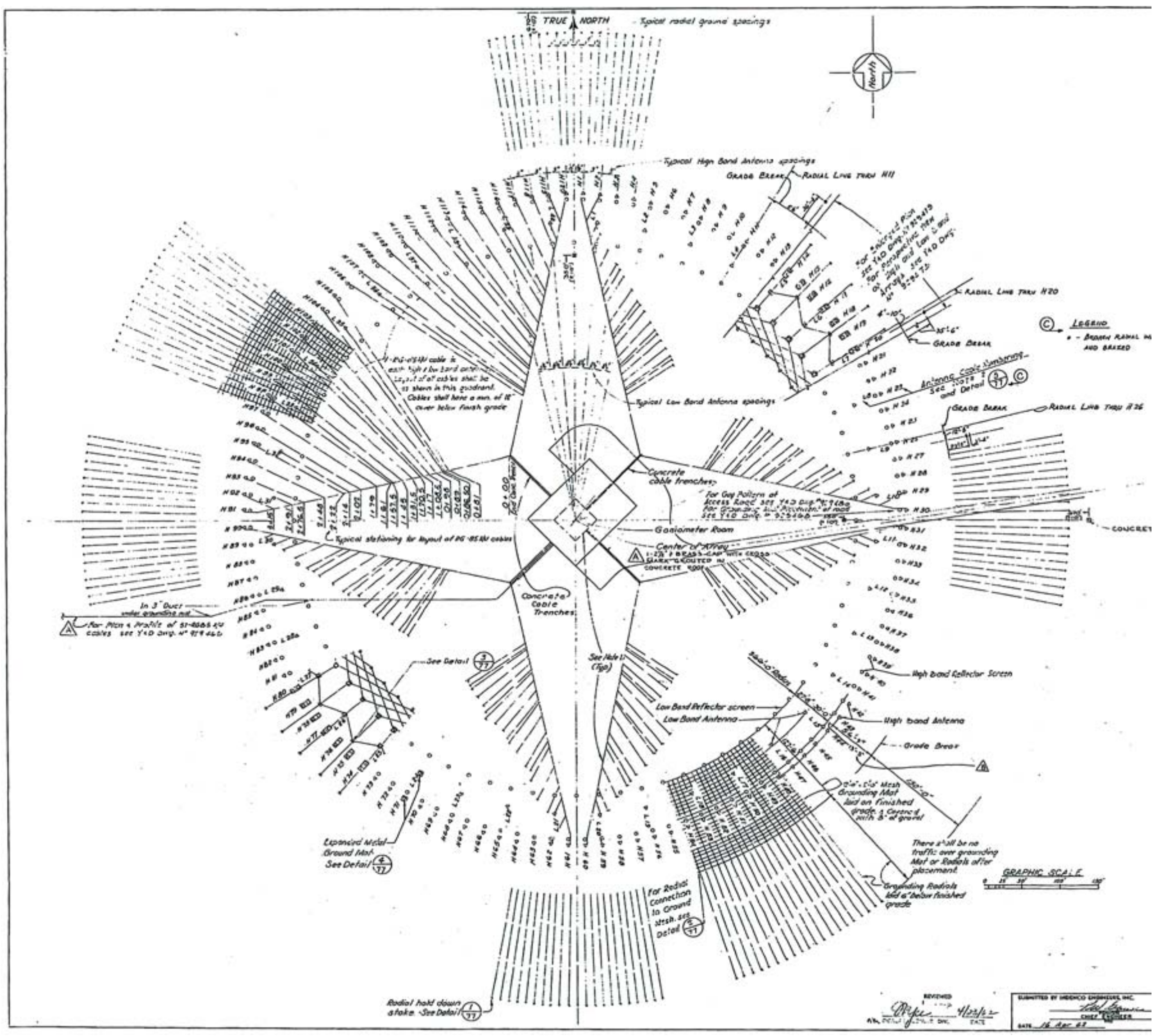
Location map.



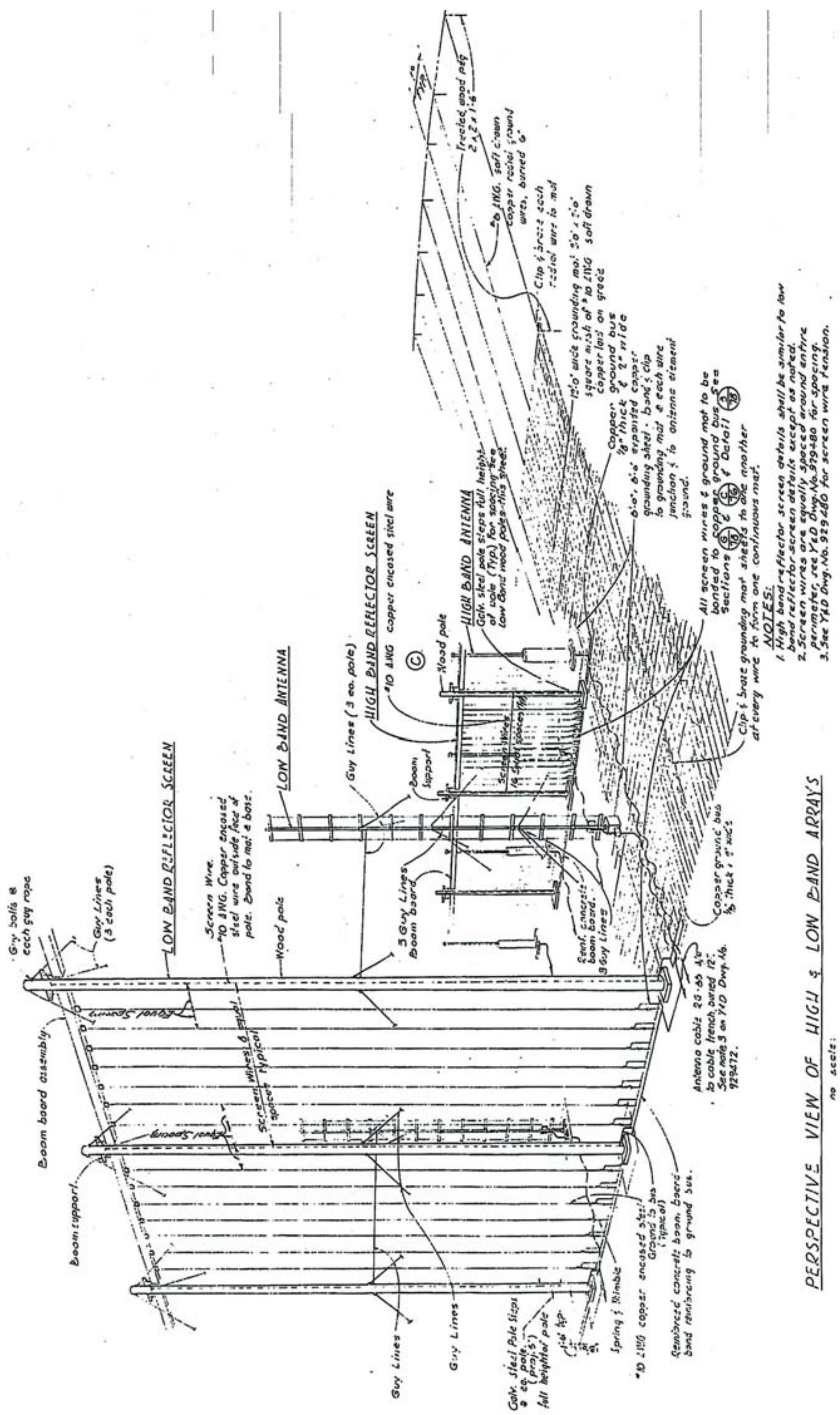
Portion of drawing dated April 20, 1962 showing the grading plan for Facility 314. Note the radial ground wires extending out from the area covered by the mesh ground mat. NAVFAC drwg 929457.



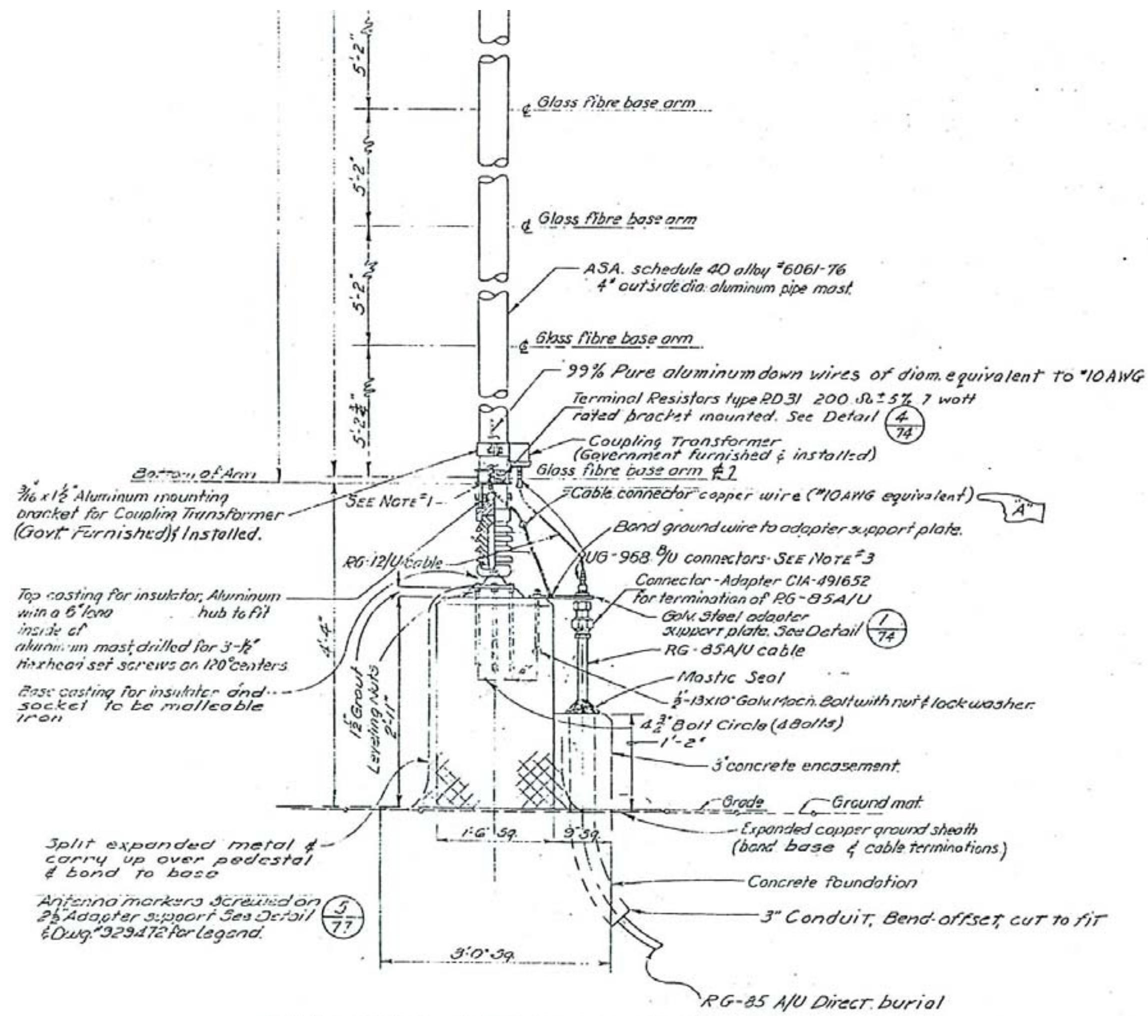
Portion of drawing dated April 20, 1962 showing the layout of coaxial cables from the individual antenna elements to the cable trenches that lead to the operations building at the center of the array. NAVFAC drwg 929472.



Portion of drawing dated April 20, 1962 showing a perspective view of a typical section of Facility 314. NAVFAC drwg 929473.

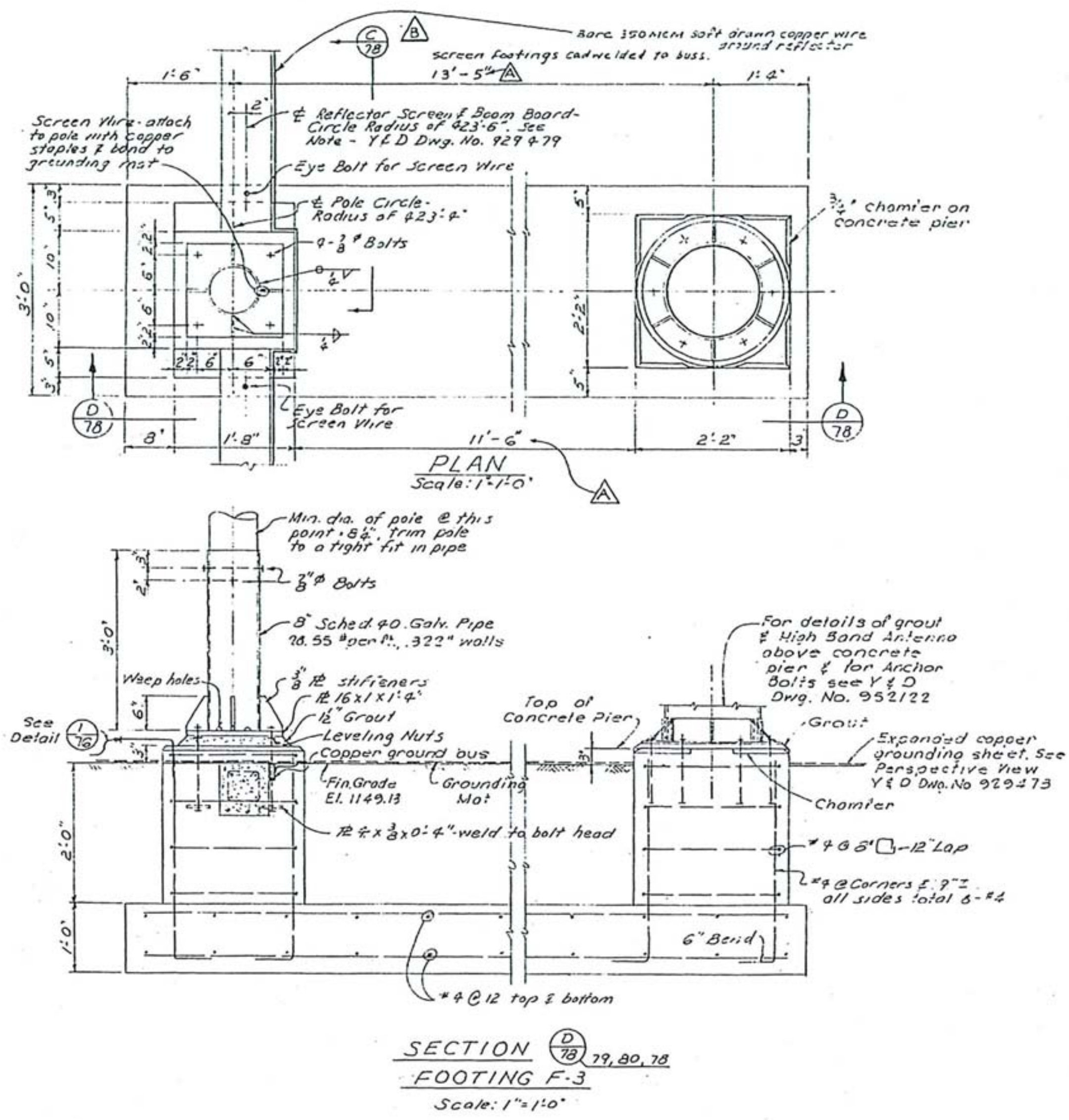


Portion of drawing dated April 20, 1962 showing a detail of the base of a typical low band dipole antenna element. NAVFAC drwg 929474.

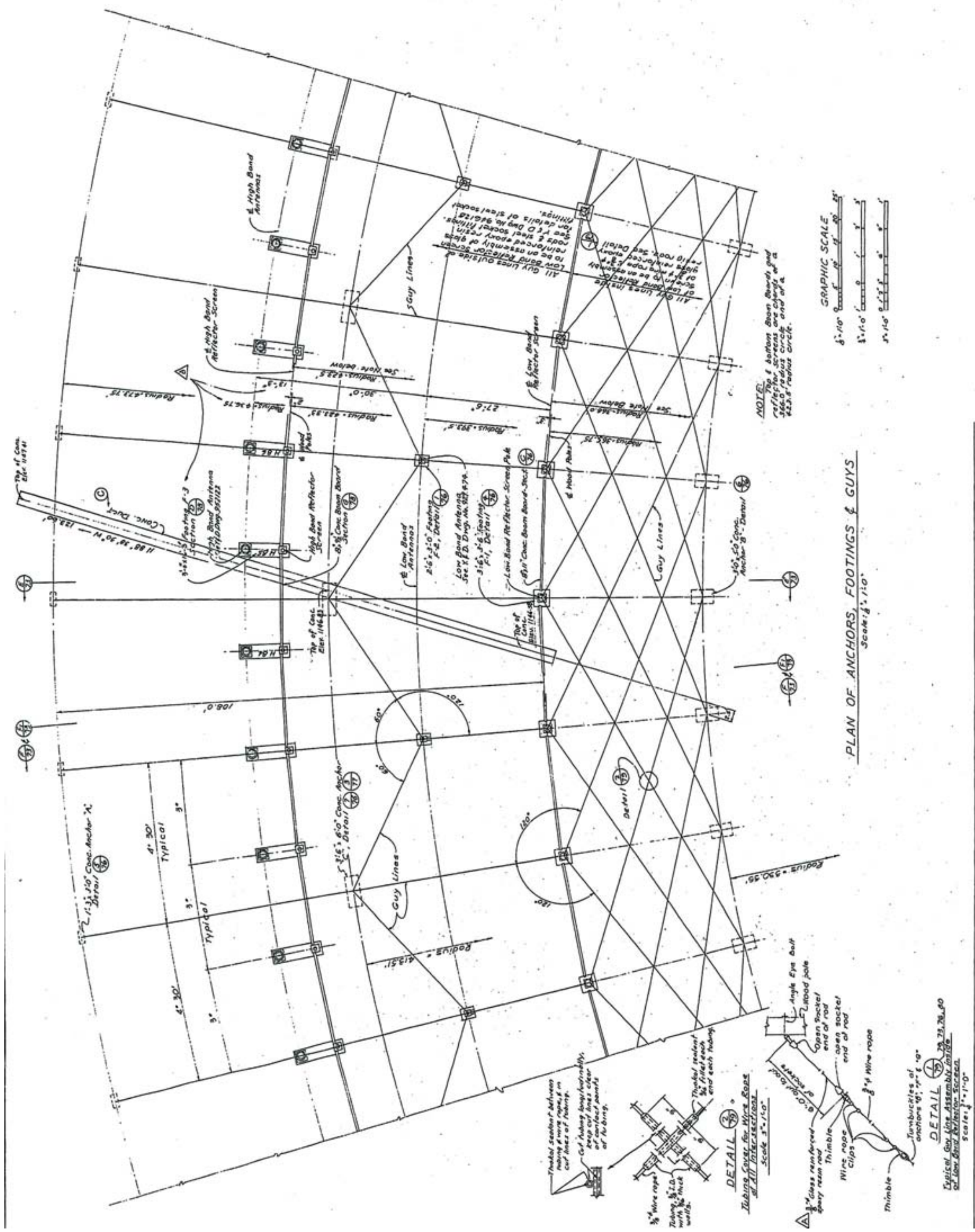


ASSEMBLY - LOW BAND ANTENNA
No Scale

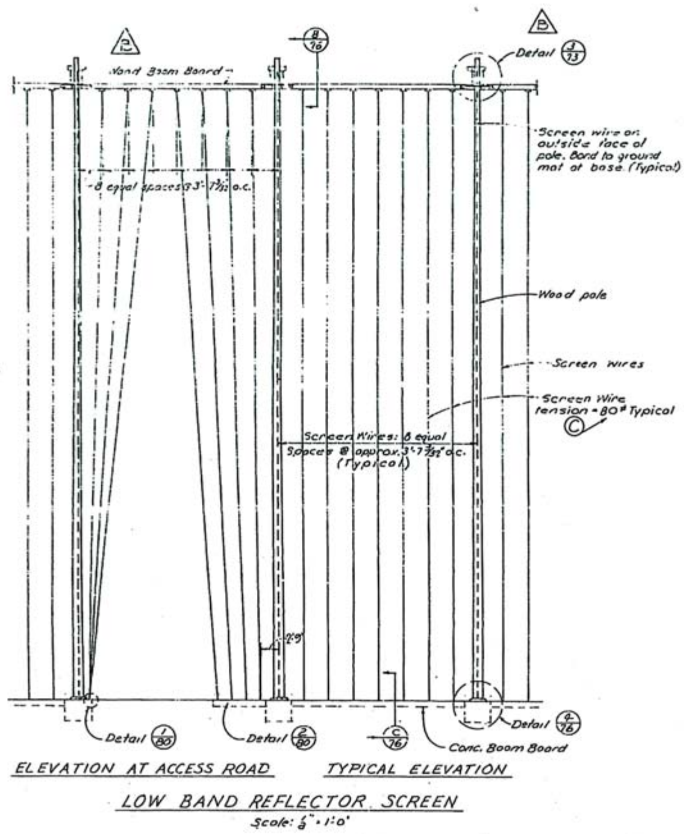
Portion of drawing dated April 20, 1962 showing a detail of the concrete footing under the monopole high band antenna elements and reflector screen poles. NAVFAC drwg 929478.

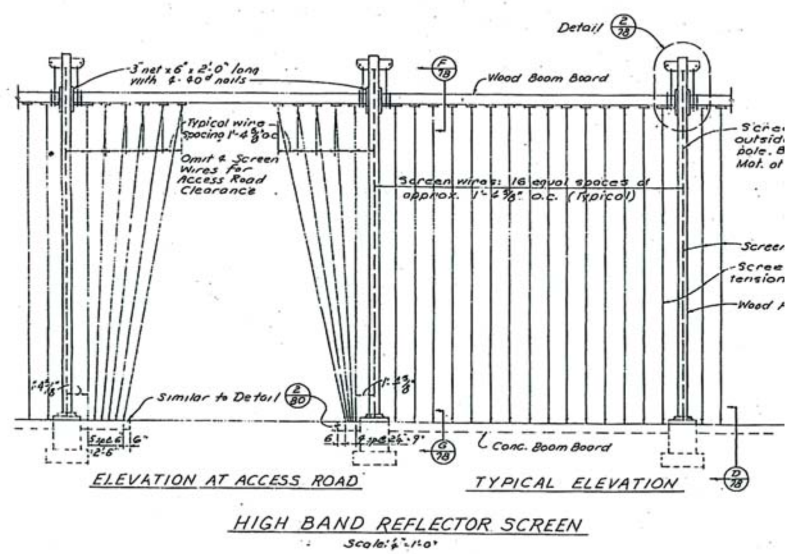


Portion of drawing dated April 20, 1962 showing a plan view of the footings, guy lines, and guy anchors for a typical section of Facility 314. Note the detail in the lower left showing the 6' sections of glass reinforced epoxy resin rod at the tops of the inside guy lines. NAVFAC drwg 929479.



Portion of drawing dated April 20, 1962 showing elevations of typical sections of the antenna reflector screens. NAVFAC drwg 929480.





HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

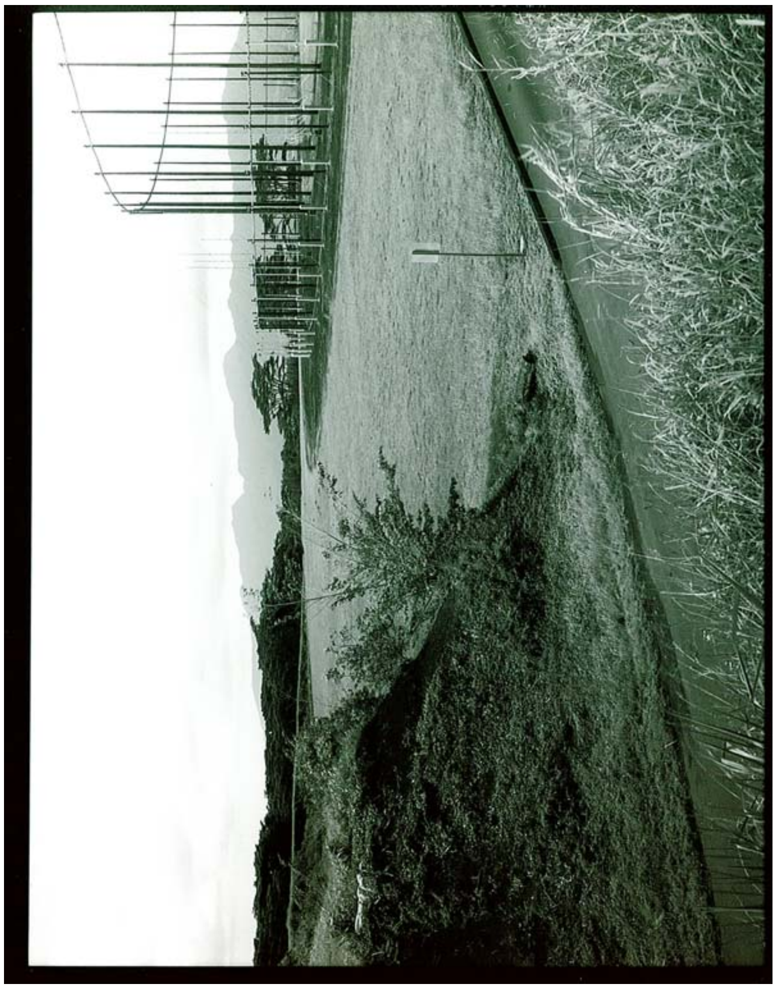
HABS No. HI-522-B-1

HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

HABS No. HI-522-B-2

HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

HABS No. HI-522-B-3



HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

HABS No. HI-522-B-4

HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

HABS No. HI-522-B-5

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HABS No. HI-522-B-6

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HABS No. HI-522-B-8

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HABS No. HI-522-B-10

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HABS No. HI-522-B-11

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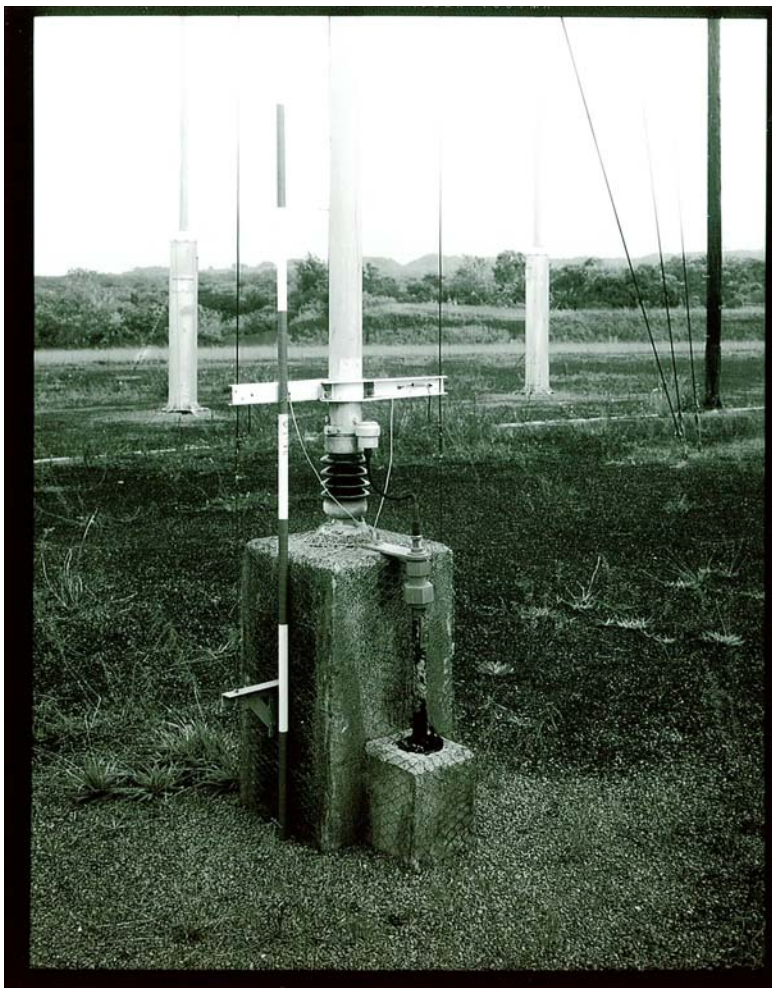
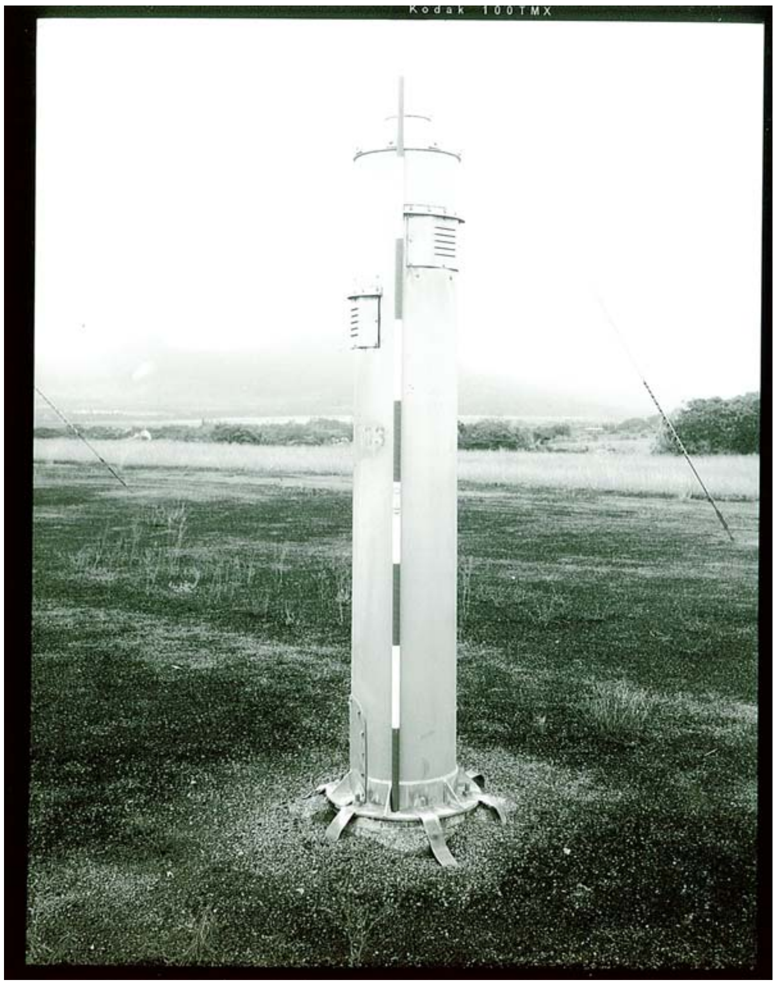
HABS No. HI-522-B-12



HISTORIC AMERICAN BUILDINGS SURVEY
SEE INDEX TO PHOTOGRAPHS FOR CAPTIONS

HABS No. HI-522-B-13



HISTORIC AMERICAN BUILDINGS SURVEY
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HABS No. HI-522-B-14

HISTORIC AMERICAN BUILDINGS SURVEY
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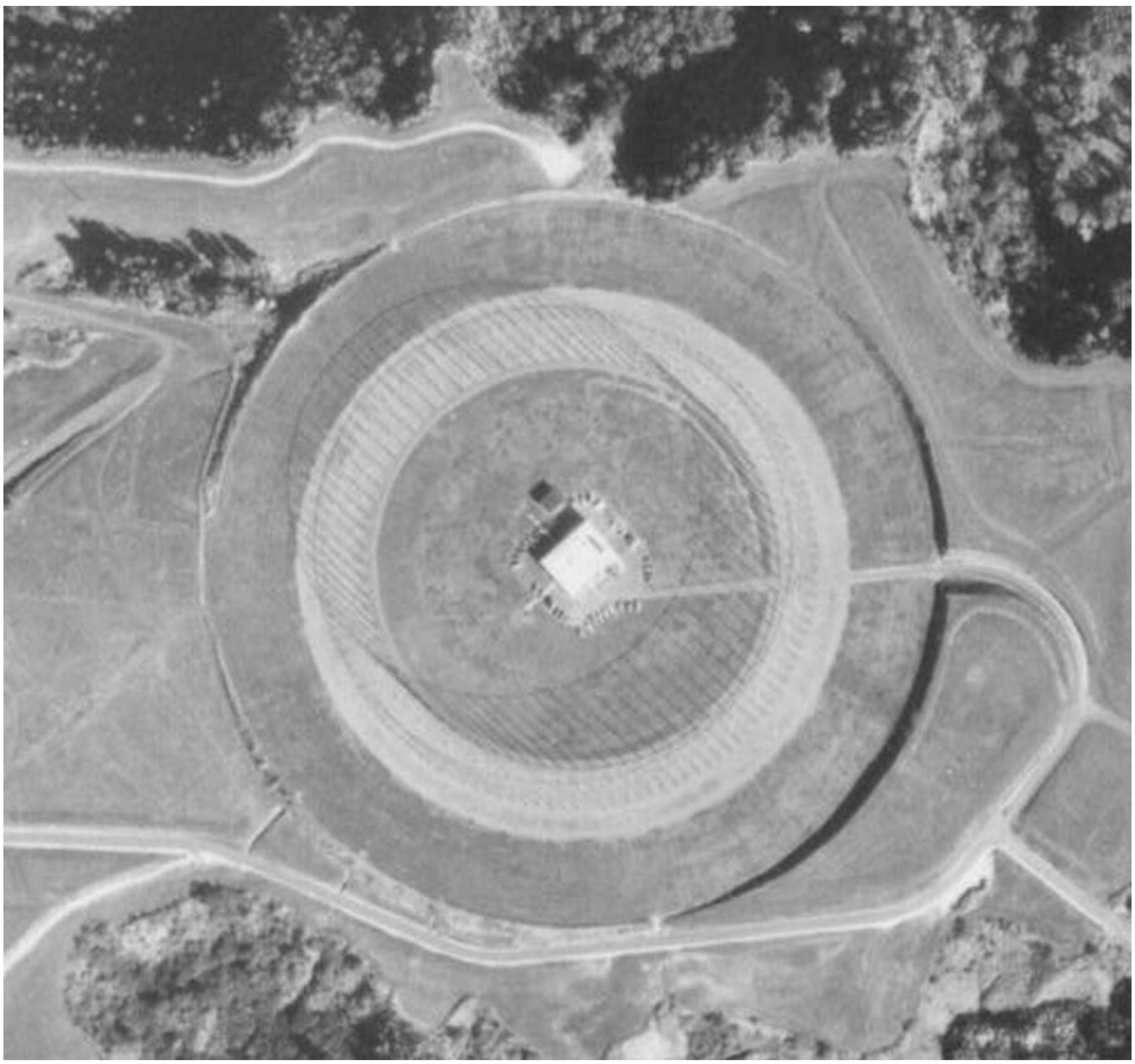
HABS No. HI-522-B-15

Portion of photograph dated December 5, 1969 showing Facility 314 with Facility 294 (Operations Bldg) at the center. Top is north. From Hawaii State Archives, folder PPA-52-3, photo 5203-5.



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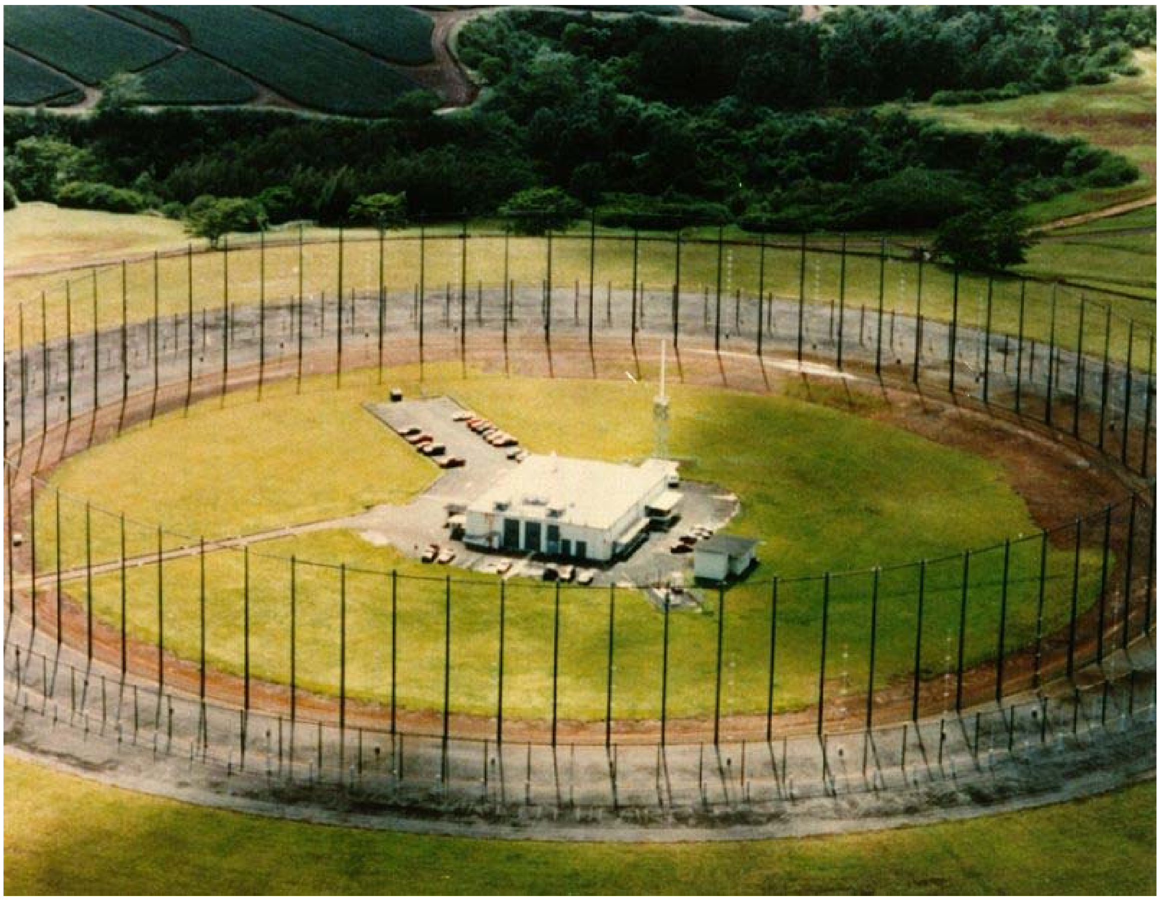
Photograph ca. 1988 of Facility 314 (FRD-10 CDAA) and its operations building Facility 294. View looking southwest.
From website www.navycthistory.com/images/CDAA_wahiawa_craig_rudy_big.jpg.



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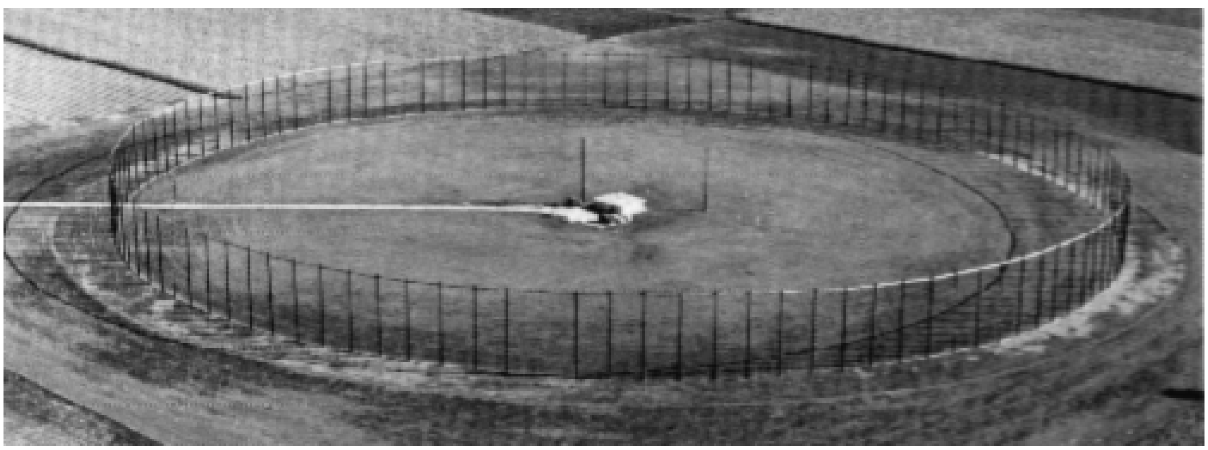
Photograph dated October 1960 of the CDAA at the University of Illinois, Bondville Road Field Stadium. This CDAA used 120 antennas and was about 1000' in diameter. From website www.ece.uiuc.edu/pubs/spotlight/wullphoto.htm accessed on November 12, 2006.



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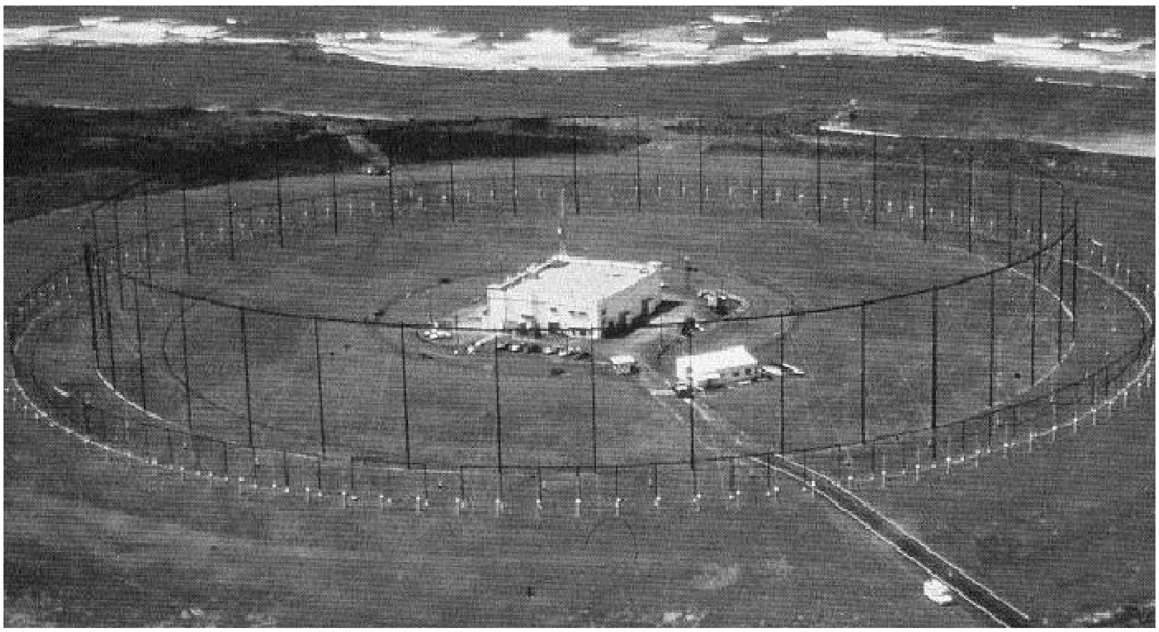
Photograph, date unknown, of the FRD-10 CDAA at Galeta, Panama. From Finnigan 1994, 63.



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