NAVELEX
0967-437-9010
NAVFAC
MO-109a

MAINTENANCE MANUAL
FOR
ANTENNA GROUPS
OA-3967 (XN-1)/FRD-10(v) &
OA-3967/FRD-10(v)

DEPARTMENT OF THE NAVY
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON, D. C. 20360
AND
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20390

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ANTENNA GROUPS
OA-3967(XN-1)/FRD-10(v) and OA-3967/FRD-10(v)

This manual supersedes the Circularly Disposed Antenna Array Handbook, Interim Edition (undated).

Published by direction of Commander, Naval Electronics Systems Command and Commander, Naval Facilities Engineering Command.

1 November 1972

FOREWORD

This manual prescribes the policy, criteria, and procedures for inspecting, maintaining, and repairing the antenna groups OA-3967(XN-1)/FRD-10(v) and OA-3967/FRD-10(v). While these arrays are generally similar they differ in component hardware and details. This makes it difficult to establish standard maintenance procedures that apply directly to all of the arrays. The manual was therefore prepared in the concept that it would apply generally to all of the arrays and would provide sufficient guidance to enable proper maintenance of each array. If problems arise in which solutions are not covered in this manual, additional maintenance guidance and information may be obtained from the Naval Security Engineering Facility.

The standards prescribed have been established to protect government property with an economical and effective expenditure of maintenance funds. The manual is specifically prepared for the maintenance forces in the field who will do the work.

The use of systems and procedures described in this publication by personnel responsible for specifications, requisitions, procurement, inspection, storage, issue, application, and safety should assure uniform, economical, and satisfactory maintenance repair and operation of the antenna groups OA-3967(XN-1)/FRD-10(v) and OA-3967/FRD-10(v).

It is certified that this publication has been reviewed and approved for official use in accordance with Secretary of the Navy instruction 5600.16.

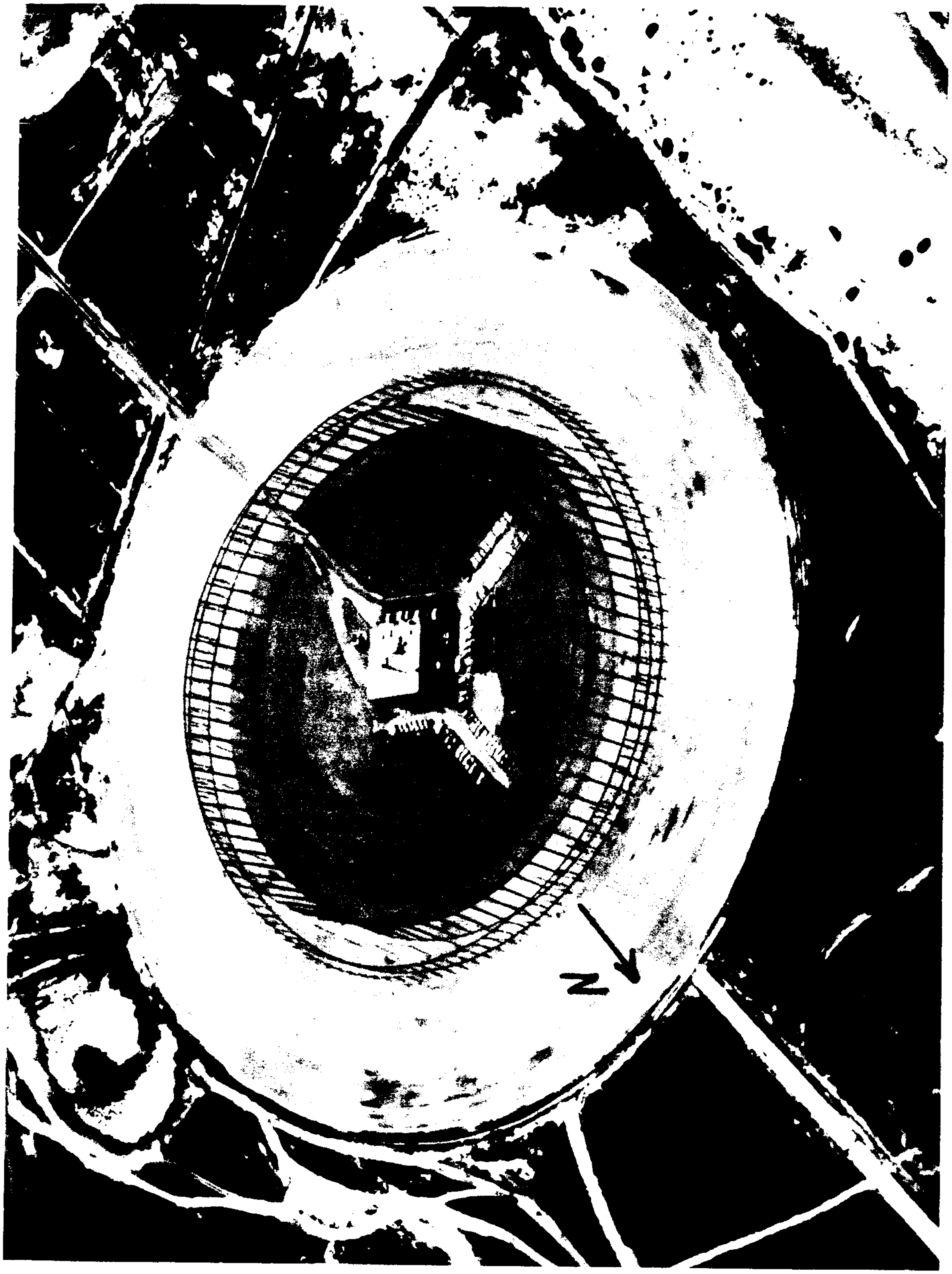


Figure 1-1 - Circulary Disposed Antenna Array, Imperial Beach, California

CHAPTER 1

INTRODUCTION

1.1 PURPOSE

This manual describes methods and procedures for maintenance of the antenna groups OA-3967(XN-1)/FRD-10(v) and OA-3967/FRD-10(v). These antenna groups are also known as the Wullenweber Antennas and are more commonly referred to as CDAA (circularly disposed antenna arrays). (See Fig. 1-1). Repair, minor construction, and budgeting procedures are presented within the limitations of maintenance personnel responsibilities.

1.2 IMPORTANCE OF MAINTENANCE

The latest cost estimate to construct a CDAA is between $800,000 and $900,000 (see App. A), but its true value is much more than the cost of construction. The CDAA is the heart of a sophisticated electronic system. At each station, electronic equipment valued at as much as 20 million dollars cannot properly function without reliable operation of its associated CDAA. Moreover, each CDAA plays an integral role in national security for which no dollar value can be assigned. Due to the physical properties of a CDAA and the manner in which the antennas are used, an array can operate maintenance free and appear normal until it has deteriorated to the point of being almost inoperative. Therefore, because it represents a large financial responsibility and an important portion of each station's operational mission, constant inspection and careful maintenance procedures are required to ensure peak operational performance.

1.3 RESPONSIBILITY FOR MAINTENANCE

The CDAA are installed at Naval Security Group activities and at Naval communications stations. NAVSECGRU 11014.1 series of instructions establishes policies for maintaining CDAA at Security Group activities, and COMMNAVCOM 11014.1 series of instructions pertains to communications stations. Normally, responsibility for CDAA maintenance at these stations is assigned to the public works office and the work is performed by a public works department, a nearby lead shop, a host activity public works, or by contract. Whatever the case, basic responsibility is outlined herein.

1.3.1 COMMANDING OFFICER. The commanding officer of the activity upon which the CDAA is located and on whose plant property account the CDAA appears has command and technical responsibility for the operation and maintenance of the CDAA.

1.3.2 PUBLIC WORKS OFFICER. The Public Works Officer (PWO) is normally delegated the responsibility of maintaining the CDAA. He is responsible for the antenna array and the RG-85 A/U transmission lines up to and including the RG-85 A/U cable termination panel located in the R. F. Distribution Room. Inspection, monitoring, and maintenance of structural tural and electrical components of the array are under his direct management. His functions include the following:

a. Inspecting the CDAA to determine its overall condition.

b. Recommending standard maintenance procedures for the upkeep of the physical components of the array.

c. Engineering advice for the repair and replacement of the physical components of the array.

d. Establishing preventive maintenance procedures.

e. Providing trained and qualified personnel to perform adequate maintenance.

f. Periodic supervisory personnel training, education, and certification in maintenance programs that utilize work improvement maintenance techniques.

g. Inspections and instructions to assure that labor, materials and equipment are used properly and safely in accordance with pertinent regulations and that operations are supervised by qualified personnel.

h. Coordinating with the EMO (Electronic Material Officer) to obtain technical guidance concerning the electronic properties of the CDAA.

i. Providing the EMO with complete listings of observations made during inspections nd of all maintenance performed.

j. Insuring that the architectural and engineering plans are kept in an up-to-date status.

.3.3 ELECTRONIC MATERIAL OFFICER. Because the CDAA is an integral part of the tations's operational system, the EMO has an interest in proper inspection and maintenance of the arrays. He provides qualified assistance and full cooperation to the PWO. Specifically, he EMO must perform the quality checks indicated in Chapter 5 and advise the PWO of iscrepancies noted. Where CDAA maintenance is performed by forces not assigned to the ctivity operating the antenna, the EMO will normally provide electronic maintenance personnel to assist as required.

.3.4 COOPERATION AND COORDINATION. CDAA maintenance activities will be directed by the Public Works Officer. Chapter 4 describes structural maintenance and provides guidance for public works personnel in conducting maintenance inspections and procedures. The fact that the CDAA provides sophisticated radio frequency signals to electronic equipment in the operations building requires periodic electronic testing to determine the condition of certain electronic characteristics. The quality tests are described in Chapter 5 and will be carried out by communication technicians or other qualified personnel designated by the EMO. If a fault is discovered in the array which lies at or beyond the RG-85 A/U termination panel in the R. F. Distribution Room, the antenna maintenance personnel shall be advised to take corrective action. Electronic maintenance personnel are responsible for cooperating and coordinating with the antenna maintenance personnel in attempts to determine the cause of the fault.

1.4 MAINTENANCE SCHEDULES

This manual stresses preventive maintenance by providing guidelines from which regularly scheduled inspections and electronic testing procedures can be planned. The schedules and procedures will vary among stations due to geographical location, climate, differences in construction, and availability of antenna maintenance personnel. Guided by information in this manual, each station should prepare its own maintenance schedules and conscientiously carry out the inspections and maintenance procedures. Accurate up-to-date records should be kept on inspection observations and maintenance performed.

1.5 PLANNING AND BUDGETING

1.5.1 PLANNING. Proper and timely inspection of the CDAA will provide information necessary to plan for future repairs or modifications. Routine maintenance and repairs under local funding should be scheduled in accordance with the importance of the CDAA to the activity mission. Projects of larger scope shall be submitted as special projects in accordance with OPNAVINST 11010.20 series of instructions to COMNAVSECGRU for CDAA located at Naval Security Group Activities and to COMNAVCOMM, with copy to COMNAVSECGRU for those located at communications stations.

1.5.2 BUDGETING. Budget submissions by an activity should include funds properly identified for antenna maintenance and repairs, supplemented by deficiency lists as appropriate for items which cannot be funded. NAVFAC MO-322 provides for annual submissions of unfunded facility deficiencies, and CDAA items should be included.

1.6 PERMANENT ANTENNA MAINTENANCE PERSONNEL

Several CDAA stations have obtained the services of permanent antenna maintenance personnel primarily concerned with maintenance of the CDAA. Thru experience these personnel have developed sound inspection and maintenance procedures which have led to an overall improvement in the condition of the structural and electronic properities of the CDAA at these stations. Since these personnel are not subject to periodic reassignment, they provide a vital continuity link with the PWO and EMO on the history of the array and maintenance procedures developed. This practice of using permanent antenna personnel is strongly recommended.

1.7 SUGGESTIONS FOR MODIFICATIONS

Suggestions for modifications to the CDAA to improve their structural or operational capabilities are encouraged. Before any modifications are actually performed, however, technical advice and permission from both NAVELECSYSCOM HQ and NAVFACENGCOM HQ must be obtained. The CDAA and its associated electronic equipment comprise an integrated, very sophisticated and sensitive electronic system in which the CDAA plays an integral part. Seemingly unimportant modifications to a CDAA to improve structural capabilities, reduce maintenance, or improve reception may interfere with the operational capabilities; therefore, all modifications must first be cleared with both headquarters.

CHAPTER 2

PHYSICAL DESCRIPTION

2.1 PURPOSE

This chapter presents a detailed physical description of the antenna groups OA-3967 (XN-1)/FRD-10(v) and OA-3967/FRD-10(v). Because of differences in geographical location and local climatic environment, the structural design and hardware vary greatly among the arrays of these antenna groups. The description given here is, therefore, somewhat general, and the architectural and engineering plans and the NAVFACENGCOM installation specifications of a particular CDAA should be consulted to determine the specific details of each array. This makes it particularly important that the architectural and engineering drawings be kept up to date to reflect the true as-build conditions of the array.

2.2 GENERAL PHYSICAL DESCRIPTION

The antenna groups OA-3967(XN-1)/FRD-10(v) and OA-3967/FRD-10(v) consist of circularly disposed antenna arrays used by the U.S. Navy to receive radio signals in the high frequency spectrum. An antenna group is composed of two circular concentric antenna arrays (see Figs. 1-1, 2-1, and 2-2). The inner array, for low-band radio signal reception (2 MHZ to 9 MHz), consists of 40 folded monopole antenna elements symmetrically arranged on a circle with a radius of 393.5 feet, and a 90-foot high circular reflecting screen with a radius of 366 feet. The outer array, for high-band radio signal reception (9 MHz to 32 MHz), consists of 120 sleeve-monopole antennas symmetrically arranged on a circle of 436.75 feet[1/] and a 24.3-foot high circular reflecting screen with a radius of 423.5 feet. A reflecting ground plane in the shape of an annular ring underlies both arrays. A high-band ground bus and a low-band ground bus are used to terminate, respectively, the bottom of the high-band and low-band reflecting screens to the reflecting ground plane. The outputs of the antennas are routed to the operations building by RG-85A/U[2/] coaxial cable transmission lines.

2.2.1 ANTENNA GROUP OA-3967(XN-1)/FRD-10(v). The antenna group OA-3967(XN-1)/FRD-10(v) located at Hanza, Okinawa is the experimental prototype of the antenna group OA-3967/FRD-10(v) arrays. Tests conducted at the Hanza array led to modifications which were incorporated into the subsequently constructed arrays. These changes involved the number of low-band antenna elements used, size of the circles on which the low-band and high-band antenna elements and reflector screens are located, height of the low-band screen, and size of the reflecting ground plane. Specific changes between the OA-3967(XN-1)/FRD-10(v) and the OA-3967-10(v) are listed in Appendix B.

2.2.2 QUADRATURE CONCEPT. To facilitate routing the RG-85A/U transmission lines from the antennas into the operations building, the arrays are divided into four 90-degree

1. The high-band antenna radius at Adak, Alaska; Skaggs Island, California; Edzell, Scotland; and Winter Harbor, Maine measures 431.75-feet.
2. NSGA Skaggs Island uses RG-306A/U.

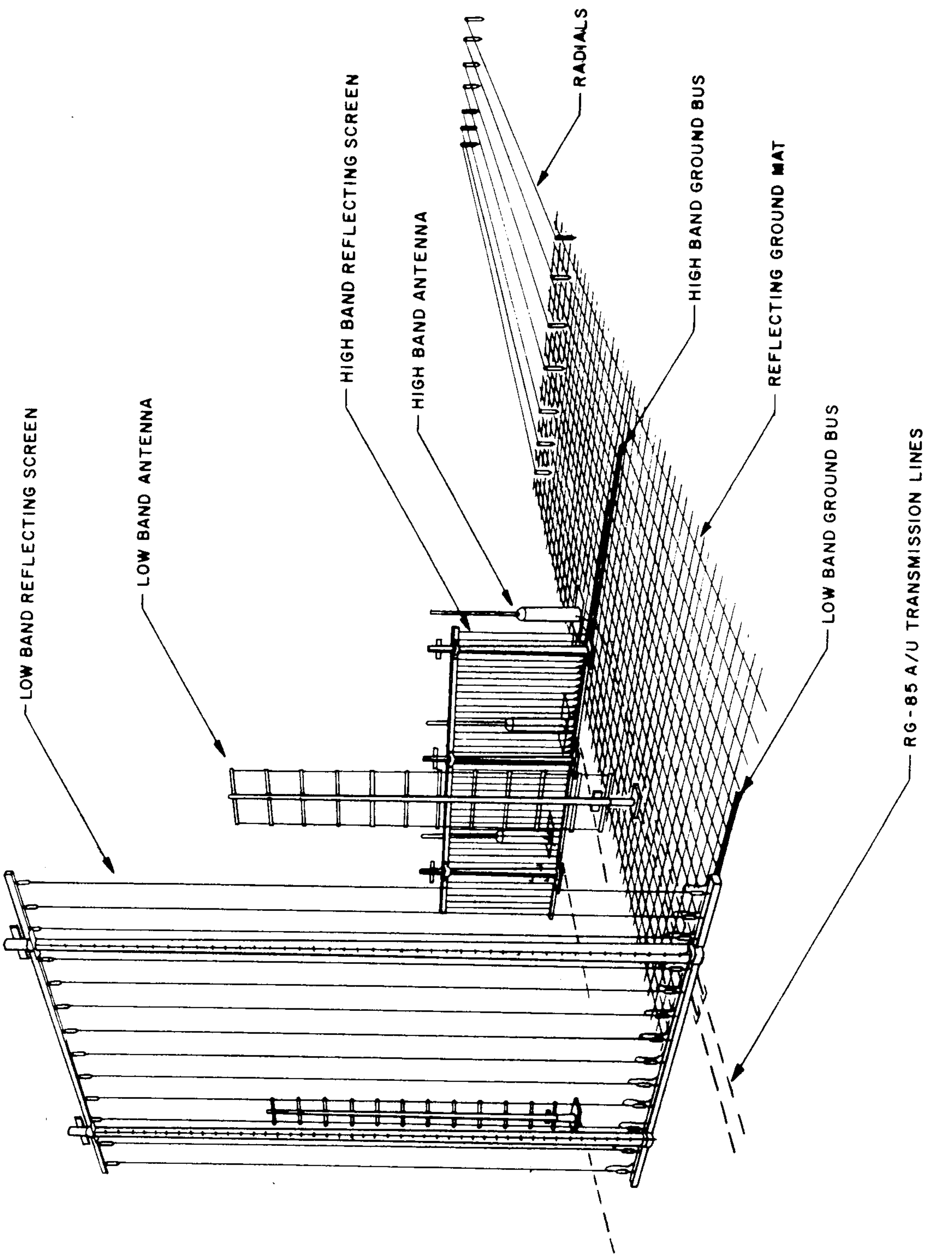


Figure 2-1 - Major Components of Typical CDAA

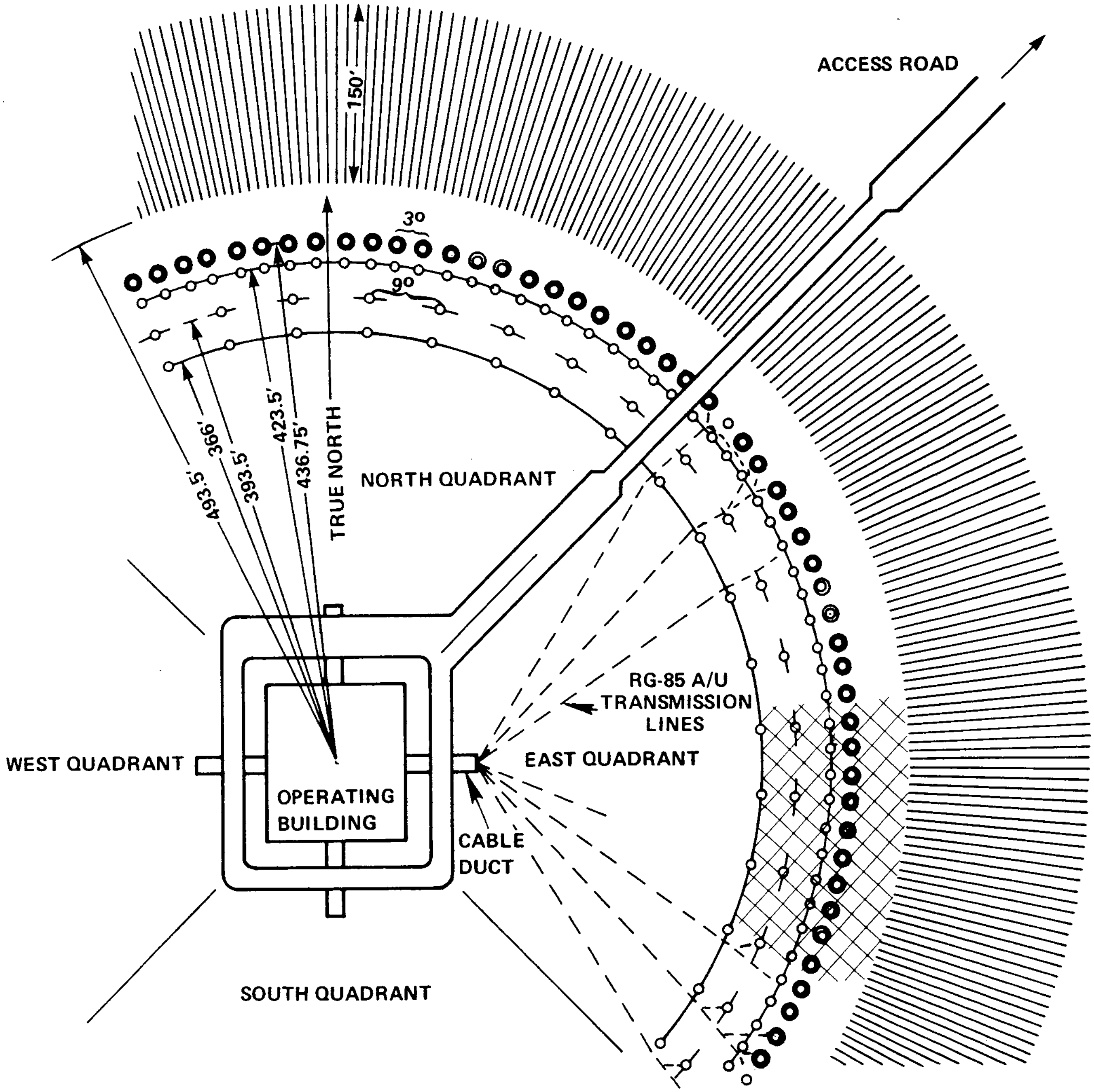


Figure 2-2 - Plan-View of CDAA

quadrants. Each quadrant faces a side of the building (see Fig. 2-2). Cable ducts extend outward from the building beneath the access road to a point just beyond the access road. The transmission lines from each quadrant are routed from the antennas into the appropriate quadrature cable duct. The cable ducts protect the cables against vehicular traffic on the access road. The walls of the operations building are orientated in one of two ways — either the walls face north, south, east, and west; or the corners of the building are pointed in a north, east, south, and west direction. In the former case the quadrants are designated north, south, east, and west. In the latter case they are designated northeast, southeast, southwest, and northwest.

2.2.3 ANTENNA IDENTIFICATION. Antennas of an array are identified as follows:

a. Beginning at a line from the center of the array toward true geographic north and traveling around the array in a clockwise direction (see Fig. 2-2) the antennas are identified as HB-1 through HB-120 (high-band antennas 1 through 120) and LB-1 through LB-40 (low-band antennas 1 through 40).

b. The antennas are also identified as to the position of the antenna within its respective quadrant. Traversing the north quadrant in clockwise direction, the high-band antennas are designated N-1 through N-30, and the low-band antennas are designated N-31 through N-40. The antennas in the east, south, and west quadrants are similarly designated E-1 through E-30, S-1 through S-30, and W-1 through W-30 for the high-band antennas; and E-31 through E-40, S-31 through S-40, and W-31 through W-40 for the low-band antennas.

Appendixes C and D list and cross reference the two antenna numonics for the low and high-band antennas, respectively. Column 1 lists the antennas by number; column 2 lists the azimuthal bearing measured from the center of the array. The information presented in these two columns is standard for all arrays except the low-band array at Hanza which has only 30 low-band antenna elements. Columns 3 and 4 list the antennas according to their quadrature numonics.

2.2.4 INSTALLATION ACCURACY. The construction of an array is held to very stringent physical tolerances. These close tolerances are of critical necessity for accurate functioning of associated direction-finding electronic equipment in the operations building. It is therefore necessary to maintain the physical tolerances within those given in the original installation specifications. Specified physical tolerances are given in Appendix E.

2.2.5 COMPONENTS. For simpliticity, the antenna group is described by components in the following order:

a. Low-band antenna

b. Low-band reflecting screen

c. High-band antenna

d. High-band reflecting screen

e. Reflecting ground plane

f. Coaxial R. F. transmission lines

g. Guying equipment

h. Access road

i. Antenna maintenance shop

2.3 LOW-BAND ANTENNA

The low-band antenna array (Fig. 2-3) includes 40 low-band folded-monopole antennas located at 9-degree intervals on the circumference of a circle 393.5-feet in radius. The antennas are so arranged that a line from the center of the circle toward the true geographic north bisects the angle between antenna number 1 and 40. Each low-band antenna consists of an aluminum mast with an attached base-insulator and bearing, supported by guy ropes or rods at three levels and mounted on a steel pedestal anchored to a concrete foundation. The mast itself as functions the principal RF element in the reception of radio signals; but its behavior in this respect is modified by a folded section consisting of an aluminum crossarm about 32 inches long at the top of the mast and two parallel aluminum or hard-drawn copper down wires spaced 30 inches apart and equally spaced on both sides of the mast for virtually its entire length. The wires are supported by 11 fiberglass crossarms. An output transformer matches the impedance of the antenna to that of the coaxial transmission line.

2.3.1 ANTENNA MAST. A low-band antenna mast consists of an aluminum alloy pipe 4 inches in outside diameter and 57 feet 5 inches in length. An aluminum plate is welded across the bottom of the mast to facilitate fastening the base insulator. A cap on top of the mast protects against the entry of water or other foreign matter. Should water accumulate in the mast, it drains off through a hole near the bottom of the mast.

2.3.2 MAST INSULATOR. A large ceramic insulator electrically isolates the antenna mast from the ground allowing it to function as the main RF element of a folded monopole. The base insulator is essentially cylindrical, approximately 11 inches long, 6 inches in diameter, with four circular overhanging ridges or corrugations to prevent build-up of moisture on the surface.

2.3.3 MAST BASE BEARING. The low-band element mast with attached insulator is supported on a hemispherical bearing of malleable iron. The bearing has somewhat the appearance of a small inverted bowler hat. The main body of the bearing is about 4 inches in diameter, but the top consists of a plate which is bolted to the bottom plate of the mast insulator. The hemisphere fits into a matching concave seat at the top of the mast pedestal, allowing the inevitable slight movements of the mast to occur under wind stress without risk of cracking the base insulator.

2.3.4 MAST PEDESTAL. Each low-band antenna mast with attached insulator and base bearing is mounted on a short pedestal consisting of an upper bearing plate of malleable iron and a steel baseplate both mounted on a length of steel pipe. The mast pedestal is mounted on a concrete foundation by means of four anchor bolts which pass through holes in the baseplate. The anchor bolts are embedded in the concrete of the foundation.

2.3.5 GUY RINGS AND SLEEVES. Each low-band antenna mast is held by three guys at each of three levels. Each set of three guys is attached to a guy ring, which is installed over the end of the mast guy during its assembly. Each guy ring is held at its level by guy-ring sleeves.

2.3.6 FOLDED SECTION OF ANTENNA. The folded section of a low-band antenna consists mainly of an aluminum crossarm at the top of the antenna mast, two No. 8 AWG aluminum-alloy or hard-drawn copper downwires, and two 200-ohm resistors. The 31.5-inch long crossarm assembly is welded to the top of the mast so that the arms extend equally on each side of the mast. The downwires are clamped or brazed to opposite ends of the crossarm and extend downward for all but about 8-inches of the length of the mast. The wires are held 30-inches apart, by 11 fiberglass crossarms at 5-foot 2-inch intervals.

Each crossarm (see Fig. 2-3) is made up of two parts, each of equal length with one end forming a semicircular clamp where the two ends meet to form the crossarm. The semi-circular clamps fit opposing sides of the mast and are bolted securely together. All cross-arms are the same length and all are fitted to the mast in the same plane. The mast is installed so that a line from one downwire through the center of the mast to the other downwire is tangent to the circle of masts forming the low-band array. The two downwires pass through and are held in place by notched retaining clamps at the ends of each crossarm.

Each downwire is tensioned and held by an additional clamp below the lowest cross-arm. The two 200-ohm resistors are mounted on the lowest crossarm, one on each side of the mast. The lower end of each downwire is looped up to connect to the resistor on its side of the mast. The other end of each resistor is connected to ground by No. 8 AWG soft-drawn copper wire. Two copper wires, one from each resistor, are brazed or bolted together just below the lowest crossarm; a single wire continues from the junction to a bracket on the side of the pedestal to which the TCA-85N connector-reducer is mounted. This bracket is electrically bonded to the ground plane of the antenna system.

2.3.7 OUTPUT TRANSFORMER. An output transformer is required for every low-band folded monopole to match the nominal 250-ohm antenna element output impedance to the 75-ohm impedance of the coaxial transmission lines. The transformer is housed in an inverted cylindrical aluminum can 2.375-inches in diameter by 2.84 inches high. The bottom of the can is formed by a Ø.125-inch thick circular insulator Ø.654-inch inside the open end of the can. A type UG-680/u output receptacle is mounted in the center of the flat insulator. The remaining space in the can is filled with an epoxy-resin potting compound.

The transformer can is mounted on the antenna mast by a clamping bracket which is spot-welded to the mast on the transformer side of the bracket. On initial installation the clamping bracket was secured only by bolts, but this allowed corrosion to form between the clamp and mast. To maintain good electrical contact, the bracket should also be spot-welded to the mast.

Although the architectual and engineering plans do not show specific tolerances for mounting the transformer, it should be mounted at the same relative point on the bottom of each mast. These transformers are specially designed and constructed for the CDAA. Replacement transformers may be obtained from Naval Electronic Systems Command Southeast Division, Charleston, South Carolina. Upon receipt of a replacement, the transformer being replaced should be returned to NAVELECSYSCOMSEDIV. The case and mounting of the transformer will be salvaged and reused.

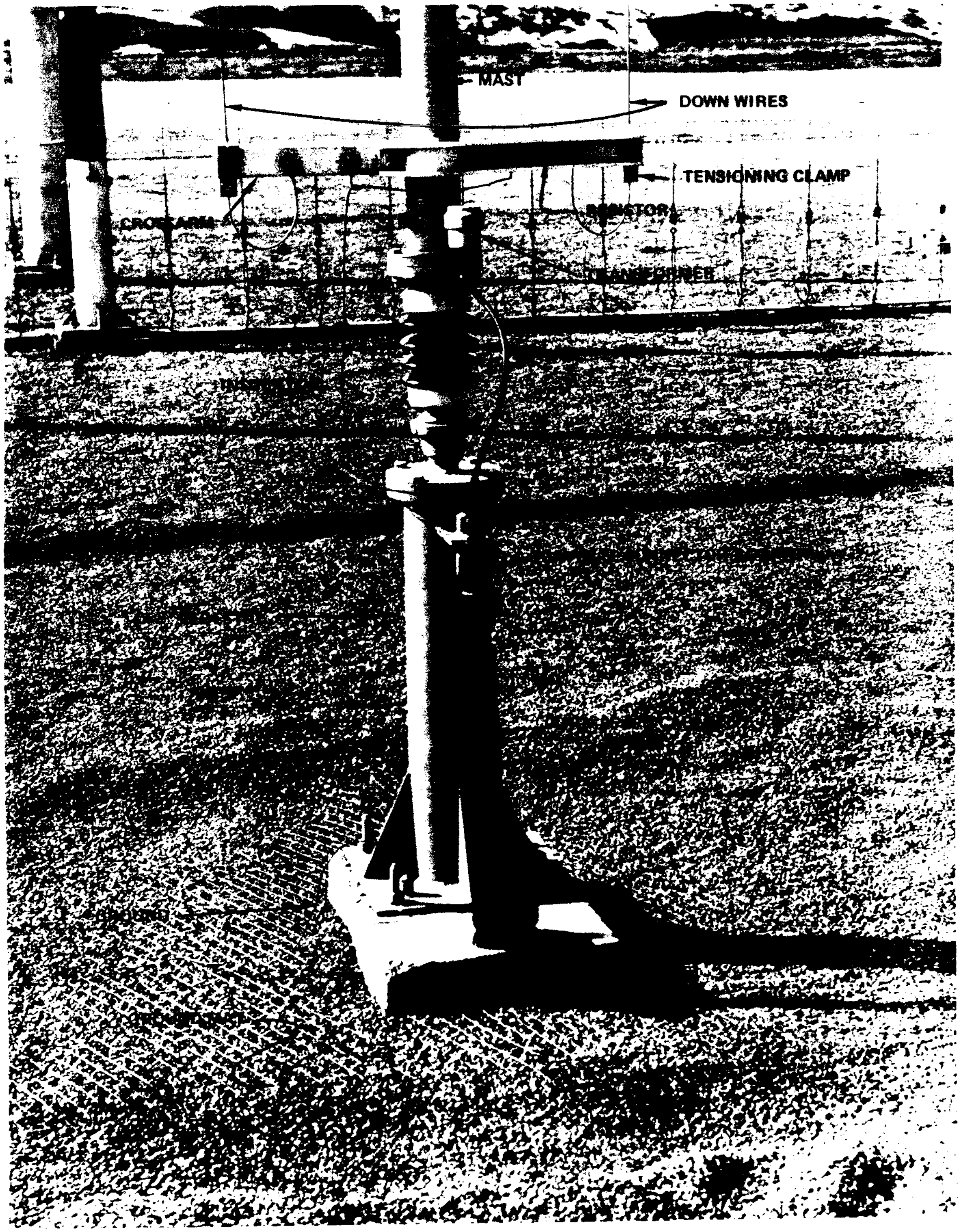


Figure 2-3 - Low-Band Antenna

CAUTION

Only RF currents shall be permitted to pass through the windings of the transformers. Equipment such as meggars or ohm meters may burn out the windings of the transformers or polarize the transformer core and shall not be used.

2.3.8 CABLE ADAPTER BRACKET. A slotted steel bracket mounted on the side of the pedestal (see Fig. 2-3) supports the TCA-85N connector adaptor of the RG-85 A/U coaxial transmission line. The TCA-85N permits connection of the short length of the RG-11 A/U cable from the output transformer to the RG-85 A/U transmission line. The adapter bracket is electrically bonded to the ground mat by copper bus or soft-drawn copper wire.

2.4 LOW-BAND REFLECTOR SCREEN

The low-band reflector screen (Fig. 2-4) is normally made up of 80 screen panels (some stations use 40) located 27.5 feet behind the low-band elements on a circle 366 feet in radius. The screen consists of supporting structures holding 640 vertical screen wires spaced at 1.77 arc-degree intervals (i.e. approximately 3.58 feet). The type and size of screen wire used varies from station to station; for those particular station the architectural and engineering drawings of that station should be consulted. The 90-foot screen wires, electrically insulated at their upper end, connect the high-band ground bus at their lower ends. The supporting structures consist principally of 80 (40 for the 40-panel arrays) selected 100-foot Douglas Fir or Southern Pine poles equally spaced on the 366-foot circle. Each pole is supported by two levels of three guy wires each. (See para 2.9). A horizontal wood boom board between each pair of poles is mounted on brackets near the top of each pole. The boom board supports the vertical screen wires. The screen wires should be maintained at a tension of 30 pounds. An improved laminated boom board has been designed for the low-band reflector screen (see BUDOCKS Drawing 80091-F-1046651 for arrays which have 40 low-band poles or towers and 80091-F-1046652 for arrays which have 80 poles or towers). This new type boom board is recommended for any required future replacement.

2.5 HIGH-BAND ANTENNA

The high-band antenna array (Fig. 2-5) includes 120 sleeve-monopole antennas at 3-degree intervals on the circumference of a circle 436.75-feet in radius. The antenna elements are so arranged that a line from the center of the circle toward true geographic north bisects the angle between antennas No. 1 and No. 120. The elements, extending 24 feet, $4\frac{1}{2}$-inches above the ground mat, are self-supporting and do not require guying.

Each high-band antenna consists essentially of an aluminum-tube upper section, which is mounted above and partly within a larger lower section. Connection between the two sections is by means of fiberglass insulators. The insulated upper section functions as the principle RF element in the reception of radio signals (para 3.4); although its functioning is modified by several coaxial sections, one of which is the sleeve portion of the lower mast that fits the lower end of the upper section. A welded base plate on each antenna is secured by anchor bolts in concrete. See Bureau of Yards and Docks Drawing No. 1046615, "Standard High-Band Antenna", for details of a high-band antenna and NAVELECSYSCOMSED

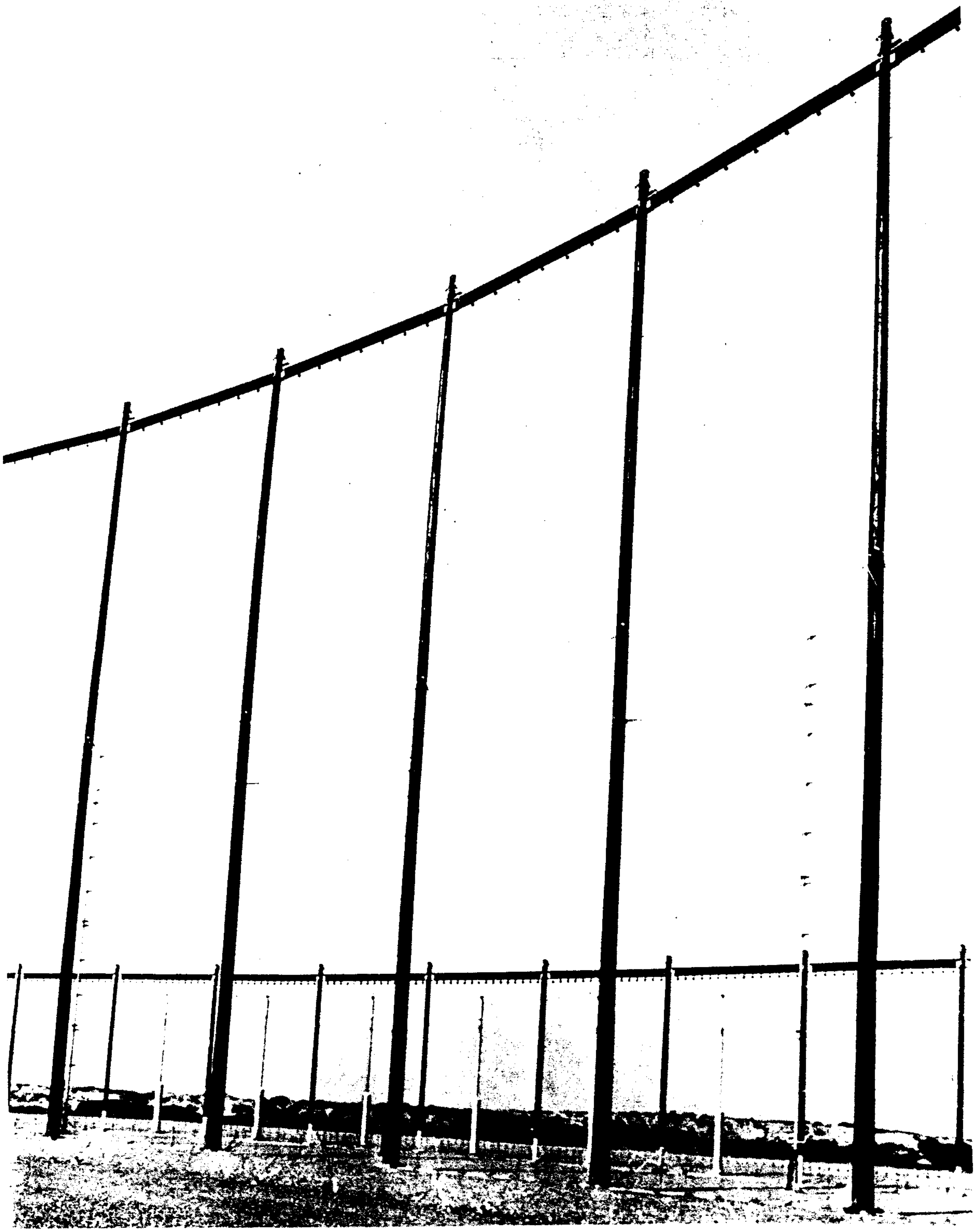


Figure 2-4 - Low-band Reflector Screen Panels

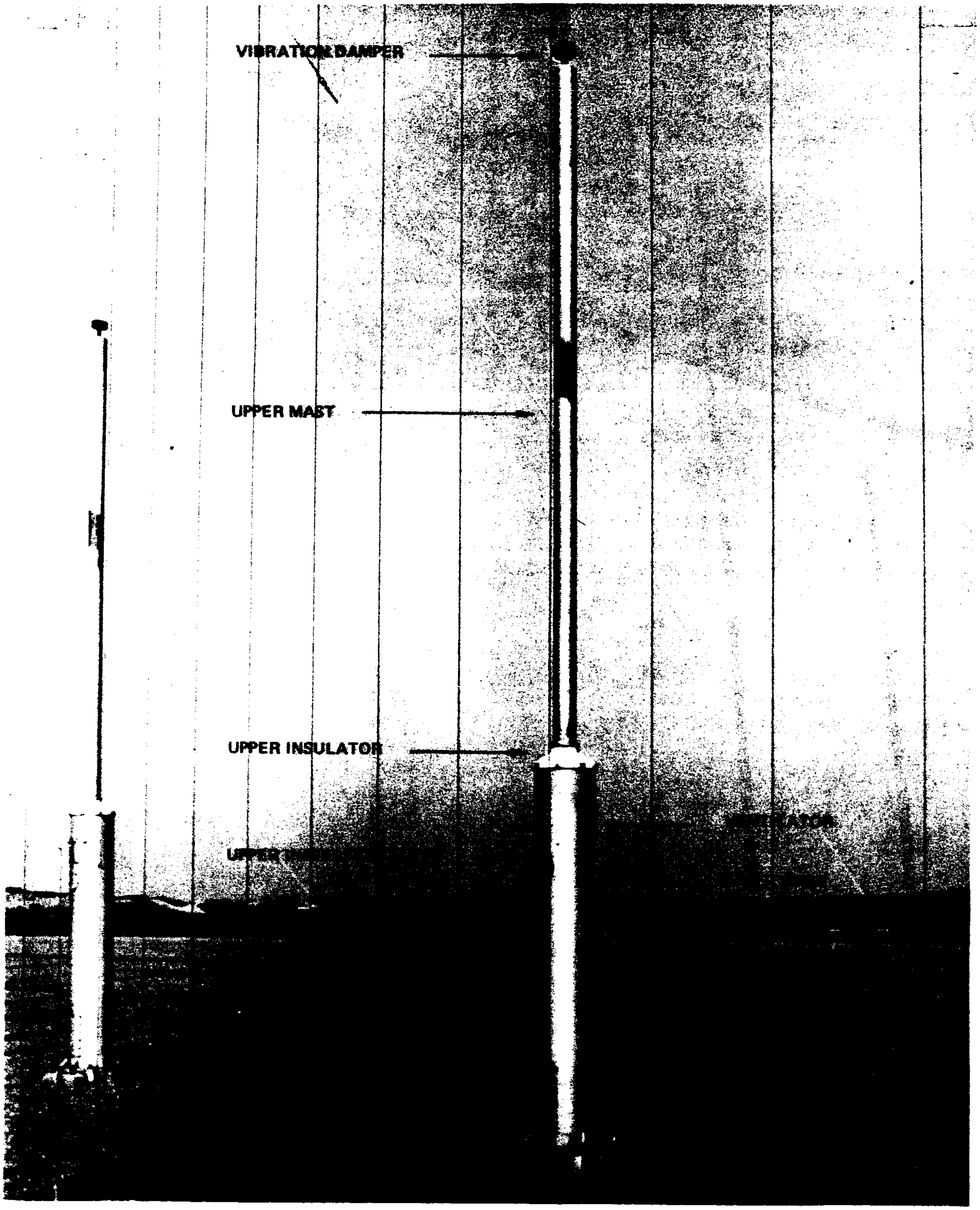


Figure 2-5 - High-band Antenna

Drawing RHA-6-F-35004, "High-Band Antenna Modifications", for modifications to the antennas. When the high-band antennas were first installed, each station was supplied with five spare high-band antennas.

2.5.1 UPPER MAST SECTION. The upper mast section consists mainly of 0.25-inch thick aluminum alloy tubing which has a 6-inch outside diameter and is 17-feet, 5.75-inches long. It is the main RF element in the reception of radio signals. An aluminum cover plate welded to the top of the mast, caps the antenna. The lower end of the upper mast is inserted 23.75 inches inside the larger lower mast.

2.5.2 LOWER MAST SECTION. The 8-foot, 3-inch long lower mast section of 0.25-inch thick aluminum plate tubing has a 16-inch outside diameter which fits snugly inside the support sleeve of the circular mounting base. The mast is welded to both the base ring and the sleeve, making a strong structure capable of supporting the entire antenna element without guys when firmly bolted to the concrete foundation. Four openings in the sides of the tube, two near the top and two near the bottom, permit working access inside the antenna element. The top cover plates have louvered rain shields to ventilate the antenna.

2.5.3 CIRCULAR MOUNTING BASE. The mounting base of a high-band antenna is essentially a 5/16-inch thick, 24-inch diameter annular ring of aluminum alloy; its inside diameter is 16 inches. Six equally spaced mounting holes in the base ring fit over six anchor bolts when an element is installed on its foundation. A 3-11/16-inch high base support sleeve of 5/16-inch thick aluminum alloy is concentrically aligned with the base plate and welded to it. The base support sleeve is then welded to the lower end of the lower mast section.

2.5.4 GROUNDING STRAPS. Six copper straps, each 2½-inches wide by 1/16-inch thick, ground each high-band antenna. These ground straps are brazed to the ground mat at one end. The tinned other end is attached to the underside of the circular mounting base. One of the six straps, extending under the mounting base to the interior of the antenna, is attached to the TCA-85N connector-adapter.

2.5.5 COAXIAL SECTIONS. A high-band antenna includes three coaxial sections, one of which is the sleeve of the lower mast that surrounds about 26 inches of the lower end of the upper mast. Another coaxial section is a central stainless steel rod 0.433 inches in diameter by 26.5 inches long. It is rigidly suspended from the center of a fixed circular shorting slug of one-inch-thick aluminum alloy. The shorting slug fits within the upper mast so that its lower surface is 26 inches above the electrically open lower end of the upper mast. A Ø.375-inch-thick circular nylon plate with three semi-circular cutouts holds the lower end of the rod concentric with the upper mast. Approximately 5 feet of RG-11A/U coaxial cable has an inner conductor which is connected to the central rod by an NT-62119 radio line section connector (more commonly called "the sparkplug"). The shield of the RG-11A/U is connected to the upper end of an aluminum-alloy pipe by a 7-inch long plastic coated No. 18 stranded jumper wire. Access to this connection is by a covered circular opening in the lower mast.

The cable passes down the pipe which is the central conductor of the third coaxial section. An adapter connects the cable to an RG-85A/U armored cable, which transmits the RF output of the antenna to the operations building. The central pipe of the third coaxial section projects upward from the center of a fixed aluminum-alloy shorting disc, 15.5-inches in diameter, welded inside the lower mast 3 feet, 9.68 inches below its upper end. The outside diameter of the pipe is 1.25 inches; its inside diameter Ø.875-inch. The pipe fits through a 1.25 inch-diameter hole in the shorting disc and through a similar hole in a stiffening collar, 4-inches in outside diameter, directly below and welded to the shorting disc. The functions of the coaxial sections are given in paragraph 3.4 of this manual.

2.5.6 VIBRATION DAMPER. In winds of about 5 knots it was found that the upper mast tended to oscillate (about 100 cycles per minute), enough to shear the bolts and crack the insulator holding it to the lower mast section. To overcome this a mechanical vibration damper is attached to the upper mast section. The vibration damper is a device having the appearance of a flat-topped mushroom. The top section is a 3-inch thick disc of neoprene rubber 6 inches in diameter. A cylindrical stem of the same material extends for 4 inches from the center of the lower surface of the disc. The stem, approximately one and one-half inches in diameter, connects to a neoprene cap which is epoxied to the top of the upper mast of the antenna.

2.6 HIGH-BAND REFLECTOR SCREEN

The high-band reflector screen shown in Figure 2-6 is composed of 120 screen panels located 13.25 feet behind the high-band antenna masts on a circle 423.5 feet in radius. The screen consists of a supporting structure holding 1,920 vertical wires spaced at 11.22 arc-minute intervals (i.e., approximately 16.625-inches). The type and size of screen wire varies from station to station; the architectural and engineering drawings should be consulted for a particular station. The screen wires which are 24 feet in length, are electrically insulated at their upper end, but are all connected to the high-band ground bus at their lower end. The supporting structure consists principally of 120 selected class 5 Douglas Fir poles approximately 30 feet long and from 10 to 12 inches in diameter at the butt. The poles are equally spaced with a horizontal wooden boom board mounted between each pair of poles on brackets near the top of the poles. The boom boards support the vertical screen wires. The vertical screen wires should be maintained at a tension of 30 pounds. The entire screen is self-supporting and does not require guying; the wooden poles being installed in and supported by metal sockets approximately 3 feet high. A girdle wire encircles the screen and is attached to each screen wire 7 feet above the ground mat.

2.7 REFLECTING GROUND PLANE

In addition to its two sets of antennas and their reflector screens, the CDAA includes an extensive reflecting ground plane. This reflecting plane, shown in Figure 2-7, provides the radio reflecting surface required for efficient functioning of both the high-band and low-band antennas or arrays. The reflecting plane network is installed on a prepared subgrade on which it is sandwiched between two 3-inch layers of small, smooth pea-sized gravel.

2.7.1 WIRE MESH GROUND MAT. The ground mat is a very large annular ring (inner radius 366 feet and outer radius 493.5 feet) of copper wire mesh constructed from mesh sheets. A mesh sheet is manufactured from No. 10 AWG bare soft-drawn copper or copperweld wire arranged in a grid consisting of 2-foot squares. The entire ground mat consists of approximately 110 of these mesh sheets, each initially 16-feet wide and 200 feet long, cut to fit the annual ring. The wires of each sheet are silver soldered at their cross-over points and the wires of each mesh section are cadwelded individually to the wires of the adjacent mesh section.

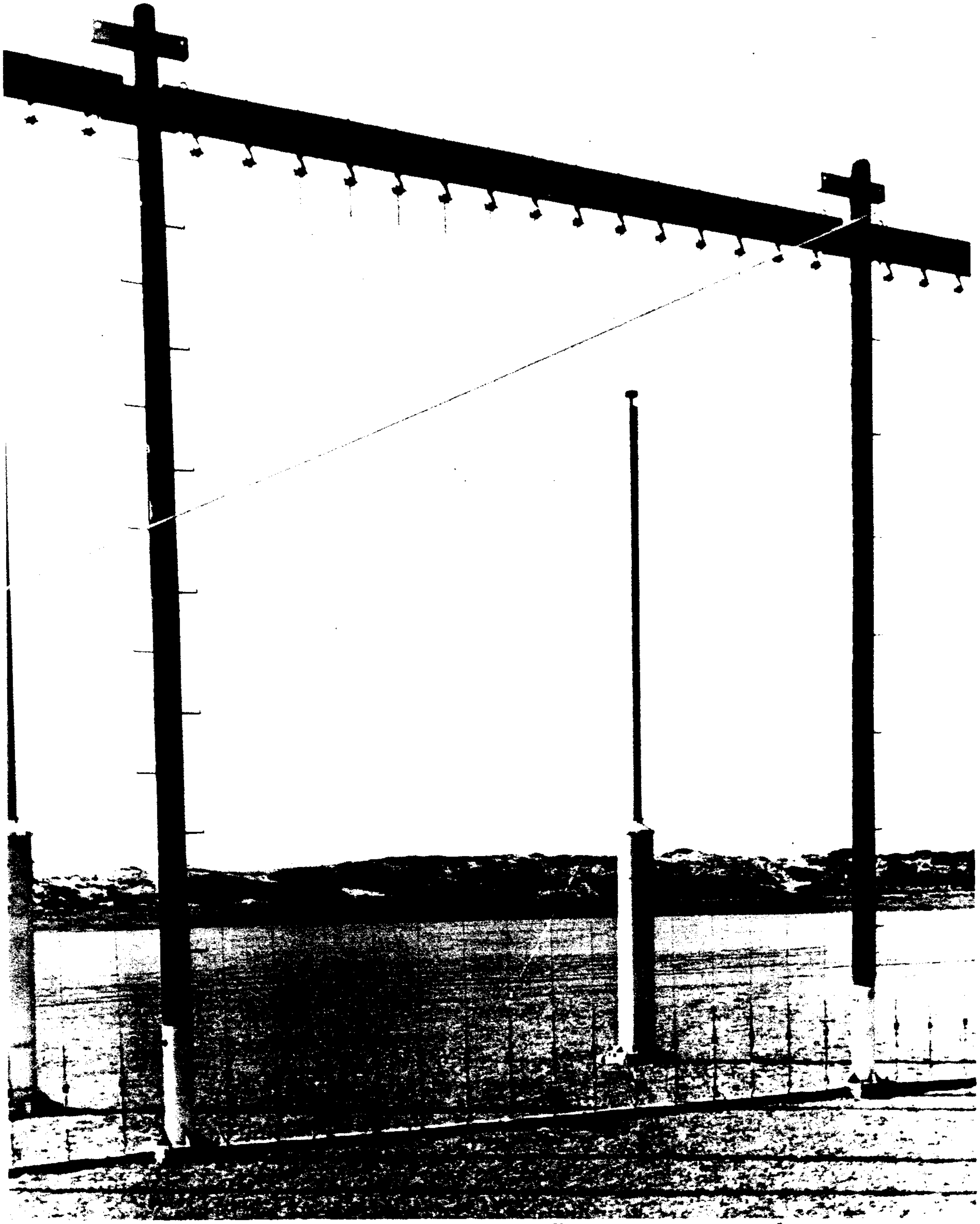


Figure 2-6 - High-band Reflector Screen Panel

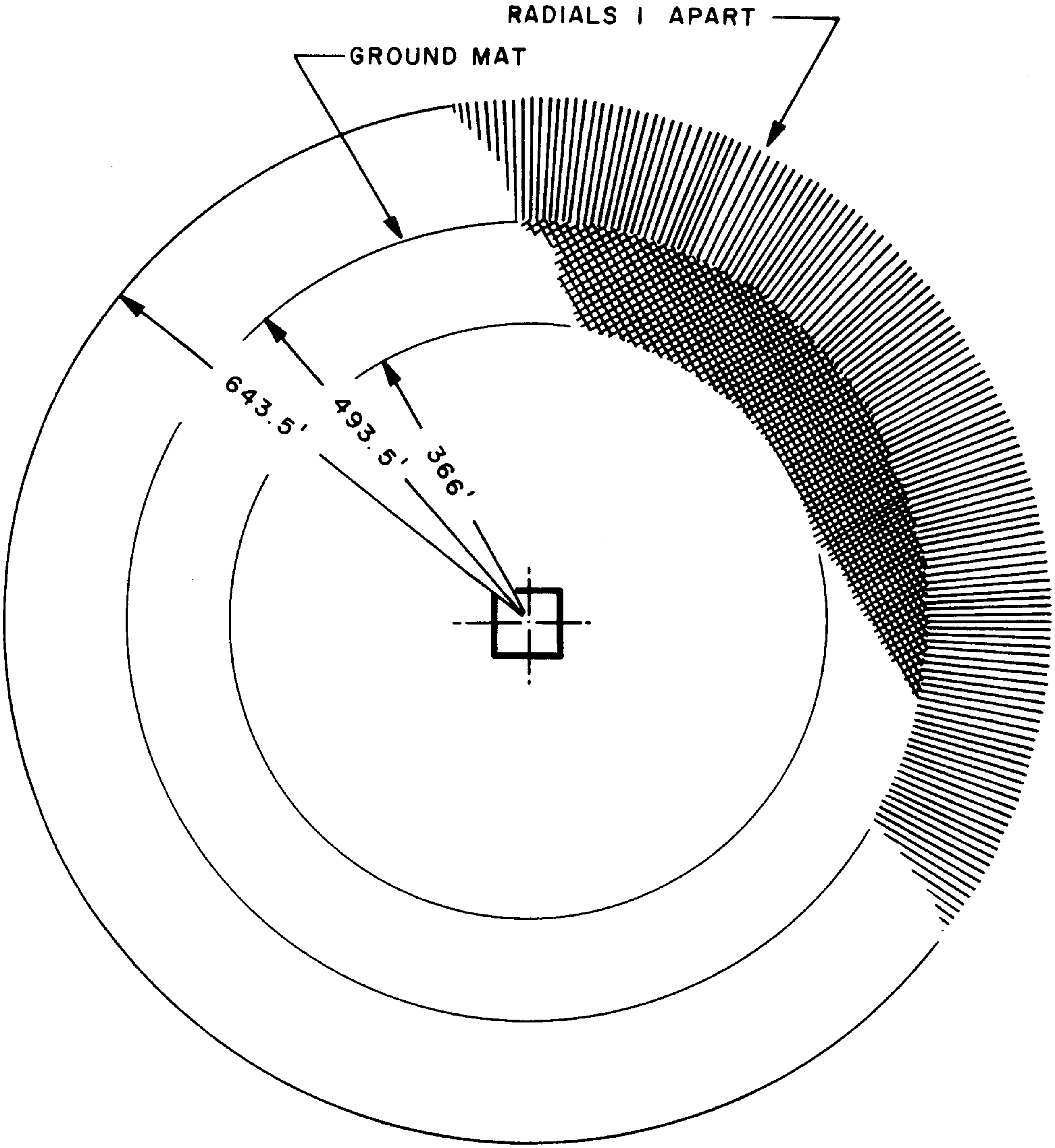


Figure 2-7 - Reflecting Ground Plane

2.7.2 RADIAL GROUND WIRES. A network of 360 radial ground wires greatly increases the area of the reflecting plane beyond that covered by the ground mat. The wires which are bare, No 8 AWG soft drawn copper, are cadwelded to the outer perimeter of the ground mat at their inner end and extend radially outward for 150 feet at 1 degree intervals. (Fig. 2-7). The outer end of each radial wire is held securely by a 2-inch by 2-inch wooden hold-down stake driven into the ground. The hold-down stakes are thus also used to locate the outer end of each radial wire after the pea-gravel surfacing is in place.

2.7.3 REFLECTOR SCREEN GROUND BUS. Two ground buses encircle the grounding system, one directly below the high-band reflector screen, and one directly below the low-band reflector screen. The ground buses provide a connecting point at which all screen wires and the ground mat are brought to a common terminal. Each grounding bus is made of soft copper which is cadwelded or brazed to the ground mat at every point where it crosses a wire of the ground-mat mesh. The type of termination used to connect the reflector screen wires to the ground buses vary from station to station. The architectural engineering drawings should be consulted for each station.

2.7.4 EXPANDED COPPER GROUNDING SHEET. The immediate area surrounding the base of every antenna in both the high and low-band arrays is covered by an 8-foot square piece of expanded copper sheet. In the manufacturing process, copper sheets have numerous rows of staggered 3-inch slits cut into them. The sheets are then pulled or expanded in a direction perpendicular to the slits until a mesh of diamond-shaped openings is formed. An opening is cut out of each of the 40 low-band copper sheets needed to accommodate the bases the low-band antennas and out of the 120 high-band copper sheets needed to accommodate the high-band antennas. The purpose of these expanded copper grounding sheets is to provide an area of extremely high conductivity in order that the stronger electro magnetic field in the immediate vicinity of the antenna will not lose energy in generating ground currents.

2.8 COAXIAL RF TRANSMISSION LINES

Coaxial cables are used in the antenna system to conduct the RF signals received by each antenna of the high-band and low-band antenna arrays (Fig. 2-8). These signals are fed into multicouplers located in the RF distribution room of the operations building. Three types of cables are used. RG-85A/U is the principle RF transmission cable. In addition, short lengths of RG-11A/U cable are used to connect the RG-85A/U cable to the antennas and, RG-12A/U cable is used to connect the other end of the RG-85A/U cable to the multicouplers in the RF distribution room. The RG-85A/U cable is exterior, direct burial type cable, which is installed under ground except for short exposed lengths at each end.

2.8.1 RG-11A/U ANTENNA CABLES. Short lengths of RG-11A/U coaxial cables are used for connecting the antennas to the main exterior antenna transmission lines (RG-85A/U) which are heavily armored and cannot accommodate small bends in making connections to the antennas. (Some arrays use RG-12A/U cables.) The RG-11A/U is a 75-ohm coaxial cable just under half an inch in diameter. Approximately 20 inches of this cable is used to connect the output transformer of each low-band antenna to the TCA-85N (or equal) connector-adapter on the RG-85A/U cables. The low-band RG-11A/U cables are usually fitted with RF 50-ohm N-type connectors to connect to both the transformer and the TCA-85N connector-reducer.

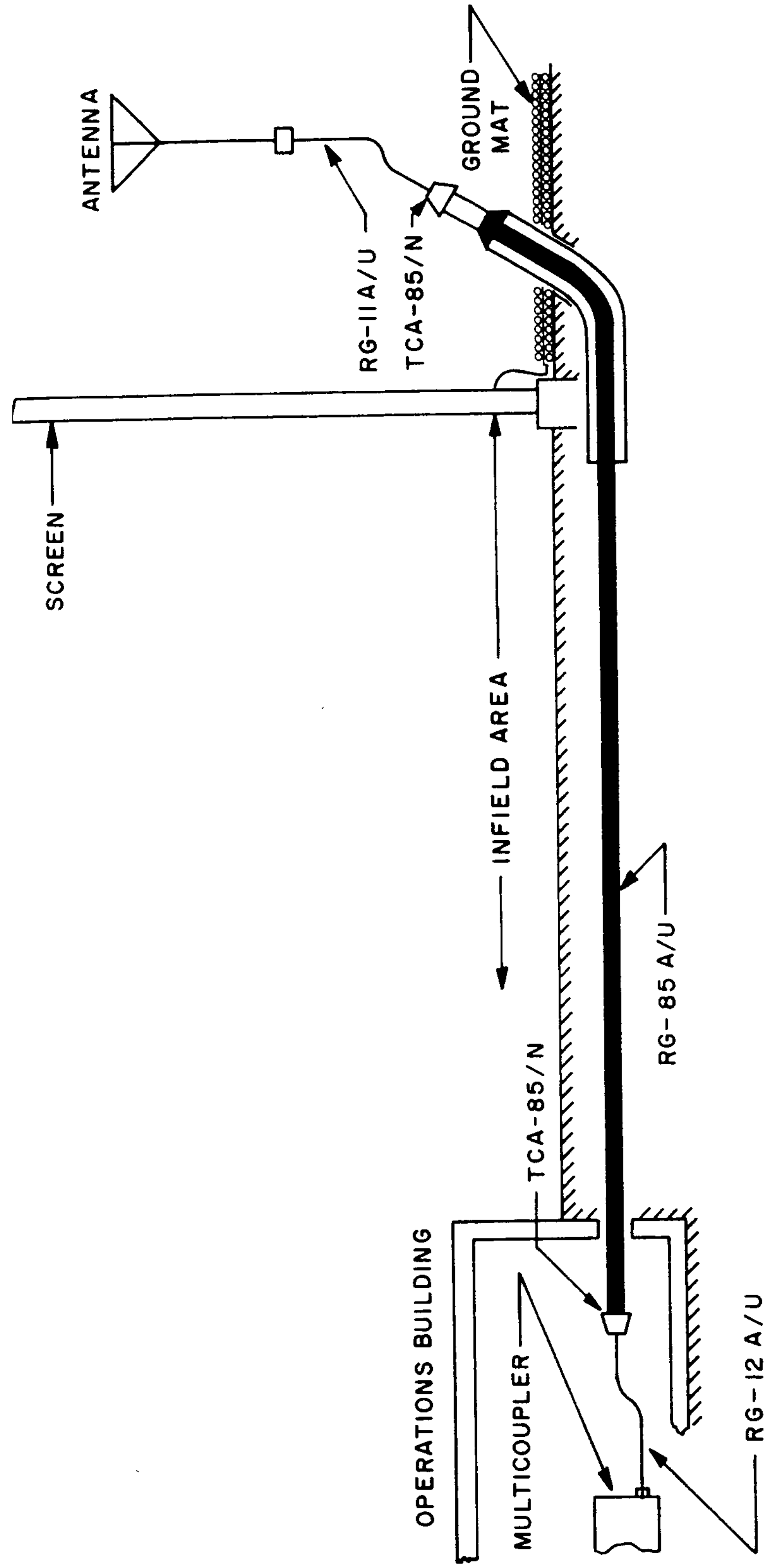


Figure 2-8 - Typical Transmission Line

(For exact connector type refer to station's architectural and engineering drawings). Approximately 5 feet of RG-11A/U cable is used for connecting a high-band antenna to the TCA-85N reducer-connector of the RG-85A/U transmission lines. The upper end of the cable is fitted with an NT-62119 line section, commonly referred to as the spark plug which is screwed into the antenna stub. It is important that the shell of the NT-62119 be electrically connected to the pipe. The lower end of this cable is fitted with an RF 50-ohm N-type connector for connection to the TCA-85N reducer-connector fitted to the RG-85A/U transmission line.

2.8.2 RG-85A/U ARMORED CABLES. Comparatively long lengths of RG-85A/U coaxial cable function as the principal RF transmission lines for conducting the received RF signals from the antennas to the operations building. RG-85 A/U is a steel armored direct burial 75-ohm coaxial cable approximately 1.5-inches in diameter. The cable is very stiff, having a minimum bending radius of 15-inches. A large TCA-85N connector-adapter is fitted to both ends of each cable. The TCA-85N at the antenna end of the low-band antenna is fitted into a keyed slot of a bracket which is mounted on the pedestal of the low-band antennas. At the high-band antennas the TCA-85N is fitted into a keyed slot of a bracket which is cemented into the concrete of the antenna base. From each antenna, the RG-85A/U cable passes through a 3 or 4-inch rigid conduit embedded in the concrete foundation of the antenna. The conduit continues underground to a point about 4-feet below the ground mat just inside the low-band screen. The purpose of the conduit is to facilitate the removal and installation of the RG-85A/U cables should the occasion arise. The cables can be removed and installed without disturbing the ground mat. Mastic seal is used to seal the conduit to prevent the entrance of water. Each of the 160 RG-85A/U transmission lines are installed, without splices. The cable for each frequency band should be from the same production run.

2.8.3 RG-12A/U MULTICOUPLER INPUT CABLES. The RF signals received by the antennas are conducted by the RG-85A/U coaxial transmission lines to the RG-85A/U termination panels. These panels are located just inside the four walls of the RF distribution room. From here RG-12A/U coaxial cables route the signals from the RG-85A/U cables to their associated multicouplers.

2.8.4 ELECTRICAL LENGTH. In order for the array to operate properly, it is important that the electrical length among the transmission lines be held to very stringent tolerances. The length to which the cables were initially cut and to which they should be maintained is within 3/4 of an electrical degree at 10 MHz for all cables of a single band. This equates to approximately ± 3/4 lineal inches. The method to be used for phase matching cables is the NRL sweep-null method, a copy of which is included in appendix F.

2.9 GUYING EQUIPMENT

Guying equipment includes the guys and guy system hardware required for guying the low-band reflector screen poles and the low-band antenna masts. The high-band antennas and the high-band reflector screen are self supporting and do not require guying support. Due to individualities of each station (location, climate, environment, etc.) the guying system for each station was designed to meet that station's requirements; consequently, the guying systems differ somewhat among stations. The architectural and engineering drawing should be consulted for the guying details of a particular station. Non-conducting type guys must be used in front of the low-band reflector screen. It is possible, if conductive type guys were used, for a guy to respond to the horizontal electric component of an oncoming wave front and to re-radiate a vertical component which, when picked up by the antennas, could cause direction finding errors. Therefore, non-conducting guys must be used. Tensions to which the guys are to be adjusted are provided in the architectural and engineering drawings. Improperly tensioned guys can lead to excessive vibration of the guys and their subsequent deterioration. It is, therefore, important that the guys be maintained at the tensions provided in the architectural and engineering drawings.

2.9.1 LOW-BAND ANTENNA GUYS. The low-band antennas are guyed at each of three levels by three guys at most stations. Non-conductive type guys are used in all cases. Fiberglass rod guys are used at most stations.

2.9.2 LOW-BAND REFLECTOR SCREEN. The low-band reflector screen poles are guyed at each of two levels by three guys. Two of the six guys are anchored in front of the reflector screen and four are anchored in back of the screen. The two guys in front of the screen must be non-conductive and in all cases fiberglass rod type guys are used. The four guys in back of the screen need not be of the non-conductive type. Wire-rope guys are usually used; however, at least two stations also use fiberglass rod in back of the screen.

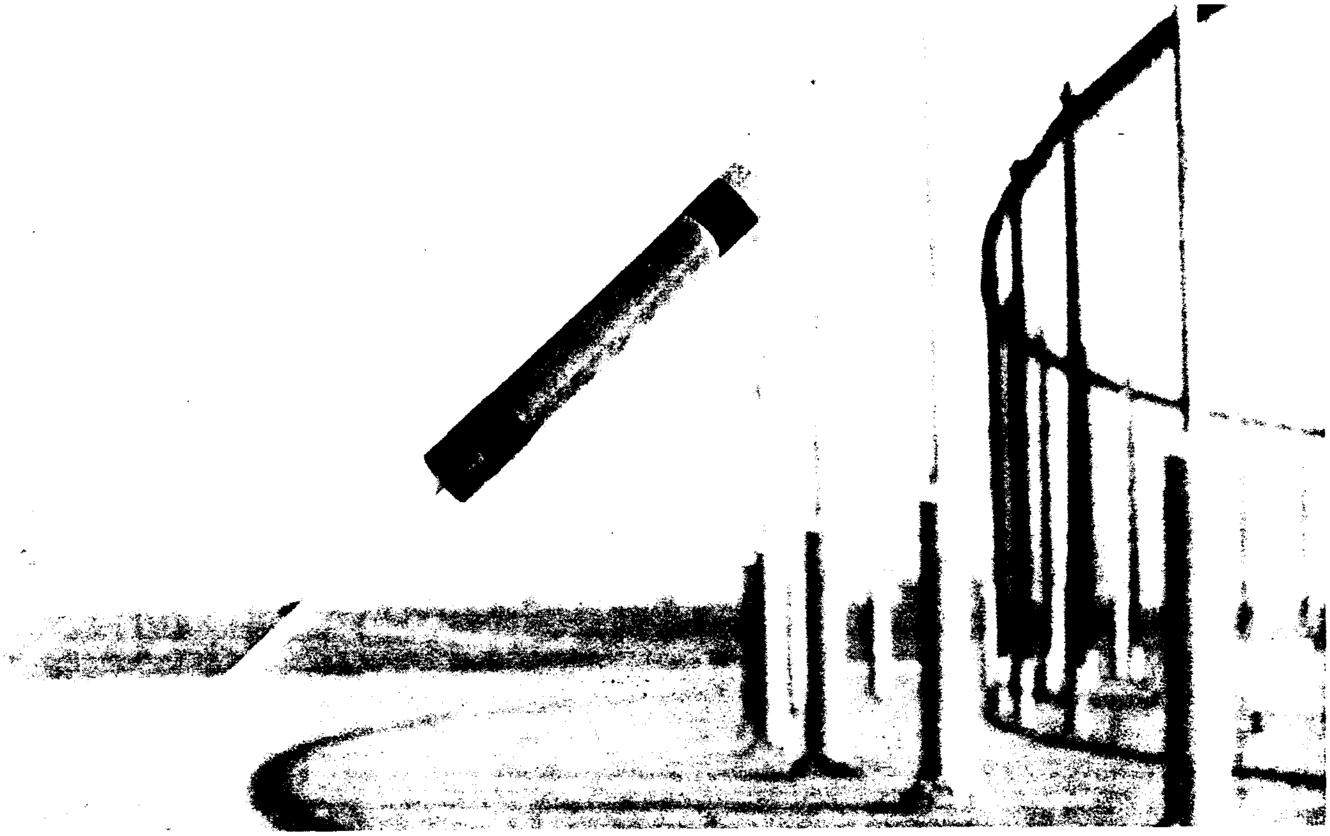
2.9.3 FIBERGLASS ROD VIBRATION DAMPERS. The fiberglass rods have proven to be reliable and few failures have occurred in the rods since they were initially installed at the various stations. The weak point of the fiberglass rod is where the rod enters the spelter socket. Experience has shown that when a rod has failed it is usually at this point. Excessive vibrations over a long period of time is the basic cause of this deterioration and failure. To reduce vibration, dampers (See Fig. 2-9) have been provided for the top outboard fiberglass guy rods of the low-band screen poles.

2.10 ACCESS ROAD

Each CDAA has an access road which permits vehicles to pass through the array to the vicinity of the operations building. The access road is located between quadrants of the array over an area in which none of the RG-85A/U transmission lines are buried. This insures that the road does not affect the environment in which the transmission lines are buried, and thus does not affect the electrical characteristics of the cable. The road continues to the operation building and in most cases encircles the building. Here again, precautions are taken to insure that the road does not affect the transmission lines. In this case, cable ducts or tunnels are constructed under the road. The transmission lines pass through these ducts on their way to the operations building.

2.11 ANTENNA MAINTENANCE SHOP

(See Figs. 2-10, 2-11, and 2-12) Three stations which employ permanent antenna rigger/maintenance personnel have found an antenna maintenance shop to be a convenient and advantageous part of an effective maintenance program. Views of a typical maintenance shop are shown in Figures 2-10, 2-11, and 2-12. The shop provides working spaces, protected from the elements, in which the necessary tools and equipment for maintaining the array can be installed. Additionally, spare components and material (e.g., RG-85A/U cable,



fiberglass guy rods, high-band antenna elements, boom boards, etc.) and miscellaneous hardware items required for maintenance can be stored. It is recommended that each station provide an antenna maintenance shop inside the array. The shop should include enough space for a small office with the necessary furniture (e.g., desk, file cabinet, and typewriter), sufficient office supplies to facilitate good record keeping, a large work bench, and ample storage space. The building should be ventilated, well lighted and heated/ air conditioned as required.

2.11.1 EQUIPMENT AND TOOLS. The equipment and tools necessary to adequately maintain a CDAA will vary from array to array. The following is a suggested list of major equipment items and tools that should be considered when equiping a shop:

a. Major Equipment

(1) Drill Press

(2) Bench Grinder

(3) Cutting Torch

(4) Exothermic Welder

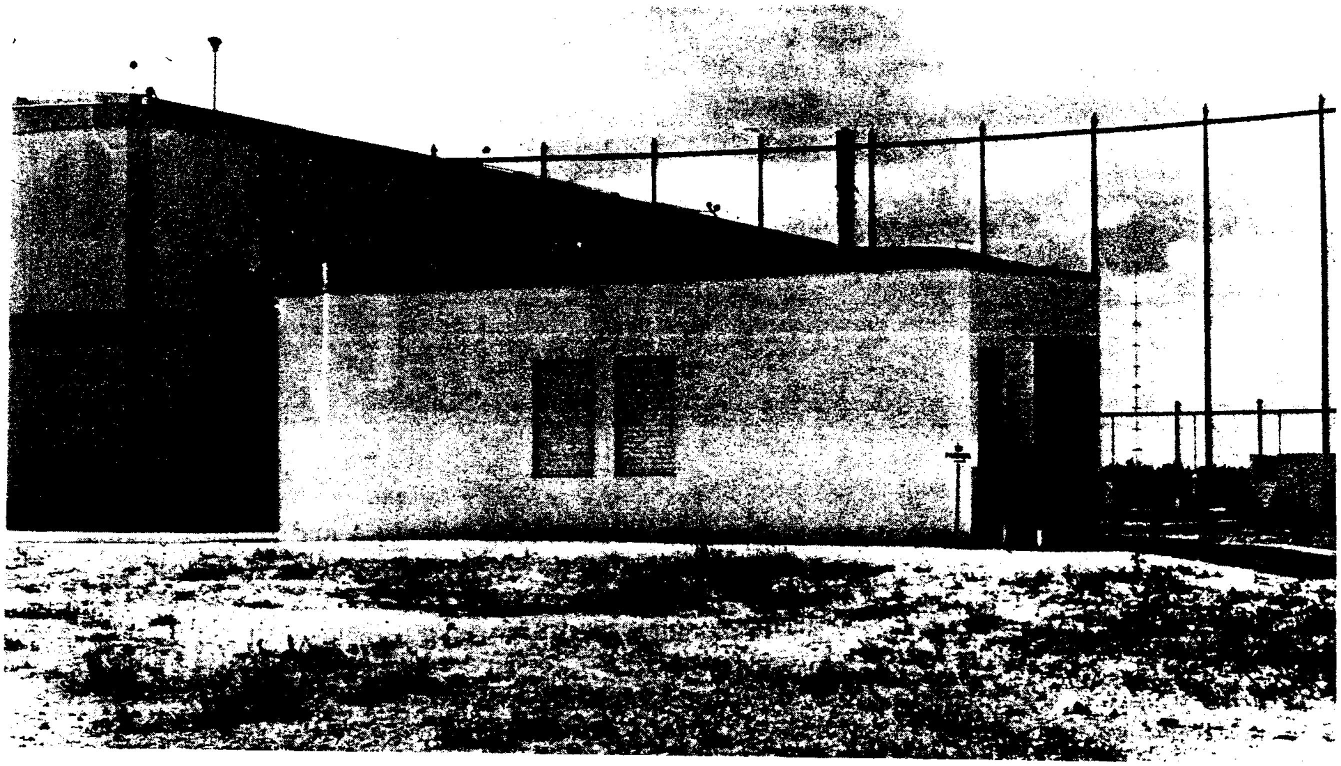


Figure 2-10 - Antenna Maintenance Shop at NSGA Homestead

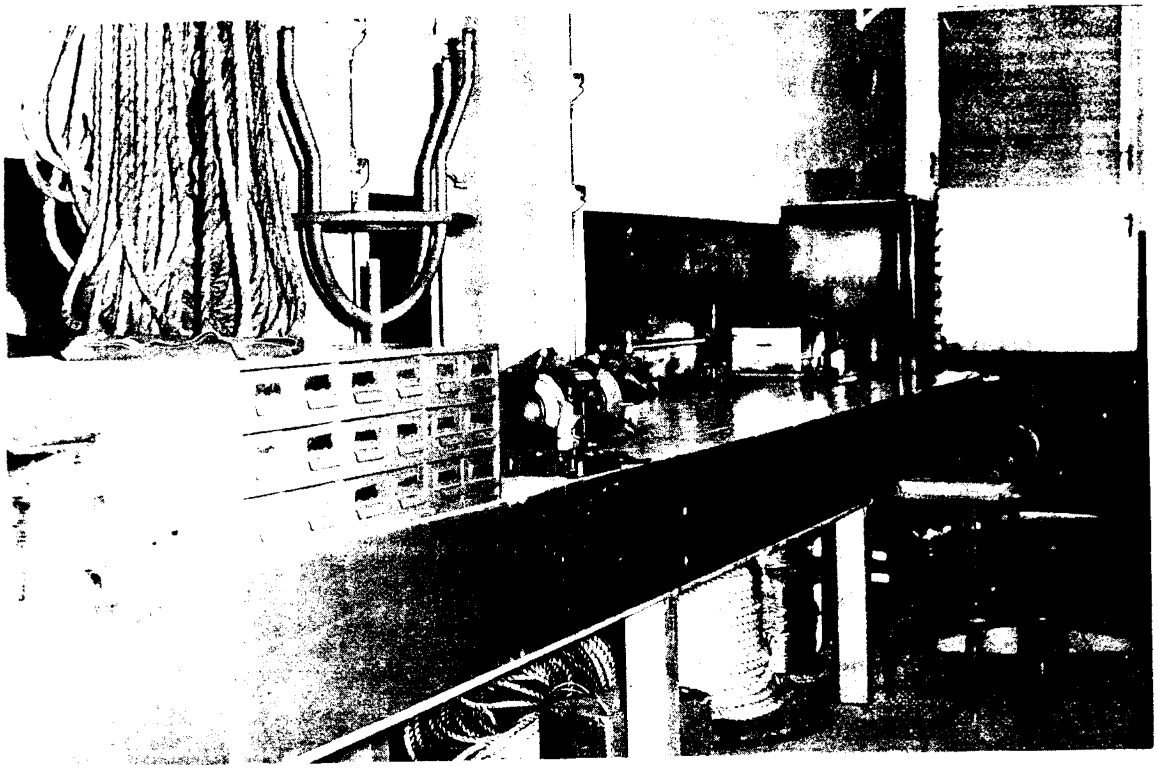


Figure 2-11 - Interior of Maintenance Shop

Figure 2-12 - Interior of Maintenance Shop

(5) Chain Hoist

(6) Sander Polisher

(7) Jig Saw

(8) Portable Generator

(9) Portable Compressor

(10) Vise

b. Tools

(1) Electric Drill, 3/8"

(2) Electric Drill, 1/8"

(3) Tap and Die Set to 1/4"

(4) Drill Set to 1/2"

(5) Two 6-foot step ladders

(6) Two 16-foot step ladders

(7) Two 30-foot step ladders

(8) Tripod or gin pole, 14 feet

(9) Two sets of block and tackle

(10) Dynamometers and tensioning devices

(11) Two surveyors transits and level rods

(12) Tool box with hand tools (e.g., hammers, screw drivers, and wrenches).

CHAPTER 3

PRINCIPLES OF OPERATION

3.1 PURPOSE

This chapter provides a simplified description of the principles of operation of the CDAA and a general description of the various components of which the array is composed. Its purpose is to give maintenance personnel a clearer understanding of how the CDAA functions so that they may perform their maintenance as expeditiously as possible. Due to the classified nature of much of the U.S. Navy equipment used in the internal facilities of the Operations Building, the description of certain aspects of their operational principles has been greatly simplified; however, this in no way alters the validity of the maintenance procedures described herein.

3.2 ARRAY

The term array, as applied to antennas, is an arrangement of several individual antennas so spaced and phased that their individual contributions to the antenna pattern add or strengthen signals in one or more preferred directions while cancelling signals in other directions. In an array, a stronger signal will be generated when a radio wave arrives from the direction in which the contributions are additive; and, conversely, a weaker signal will be generated when a radio wave arrives from the direction in which the contributions tend to cancel one another. The individual antennas of an array are sometimes referred to as Elements of the Antenna Array.

3.2.1 LINEAR ARRAY. In a linear (broadsided) array, a number of antenna elements are appropriately spaced in a straight line and the RF transmission lines which connect the antenna elements to a combining point are all of equal electrical length. A radio wave front, traveling in a direction perpendicular to the line on which the antennas are located, arrives simultaneously at each antenna and consequently arrives at each antenna in-phase. The equal length transmission lines ensure that the signals which the antennas receive are delivered to the combining point and summed in-phase thus producing a stronger signal than that which a single antenna would produce.

A radio wave arriving from a direction which is not perpendicular to the line of the antennas will cause signals to be delivered to the combining network which are not in-phase, and when summed will cause a reduction in the signal strength at the output of the combiner. This array produces a bi-directional characteristic pattern with the signal strength generated, and the beamwidth dependent upon the number of antennas used. (See Fig. 3-1). A few antennas will produce a wide beam, and as more antennas are added, a stronger, narrower beam is produced.

A properly spaced reflector screen placed in back of the array produces a unidirectional characteristic pattern by significently reducing the back lobe (See Fig. 3-2). Additionally, the reflector screen increases the gain of the array while reducing the beamwidth and the bandwidth. It can be seen that if the array were rotatable, it could be rotated until the maximum signal strength is achieved and, in effect, can be used to determine the direction from which the signal is being received.

3.2.2 CDAA. The CDAA is based upon the fact that a group of antennas placed on the arc of a circle can be made to respond in a manner similar to a simple linear array. In addition, by utilizing a rotatable goniometer, the CDAA can be made to appear to rotate and, thus, can be used to determine the azimuthal angle of arrival of radio signals. In effect, this means that the CDAA has the ability to radio-direction find.

3.2.2.1 Principles of CDAA Operations. If appropriate time delays are introduced into the feed paths of the antennas, antennas positioned on the arc of a circle can be made to appear to be located in a straight line similar to a linear array (See Fig. 3-3). The wave front arriving perpendicularly to a chord drawn thru antennas 4 and 5 first arrives at antennas 4 and 5, a short time later it arrives at antennas 3 and 6, then, a short time later, it strikes antennas 2 and 7; finally, a short time later, it arrives at antennas 1 and 8. Time delays are inserted into the feed paths of antennas 4 and 5 equal to t., the time it took the wave front to travel from antennas 4 and 5 to antennas 1 and 8. This means that the signals, and consequently the phase of the signals, from antennas 4 and 5 are delayed and delivered to the combining network in-phase with the signals from antennas 1 and 8. Antennas 4 and 5 appear to be located on a chord drawn from antennas 1 and 8. The same is true for antennas 3 and 6, and 2 and 7 except that their signals are delayed by amounts of t_2 and t_3, respectively.

All of these signals are delivered to the combining network in phase; the resulting pattern is a strong narrow beam pointing toward the direction from which the wave front arrived. In the CDAA, the time delays are located in a rotatable goniometer and capacitively coupled to the antenna feed lines. In this manner, the strong narrow beam can be "steared" around the array through 360-degrees. Additional techniques are utilized in the goniometer to reduce "chopping" and to generate a sharply pointed beam.

3.2.3 SYMMETRY. To insue that the characteristic beam points in the direction of the wave front, it is necessary to have symmetry about a vertical plane passing through the center of the array in a direction toward the on coming wave front. An imbalance in symmetry can cause variations in the gain and phase characteristics of the individual antennas, and tend to "skew" the direction in which the beam is pointing. This results in a direction finding error.

To insure that the phase and gain characteristics are maintained within tolerable limits, the array must be physically constrained to the tolerances shown in Appendix E, and the electrical length of the coaxial transmission lines must be maintained within the tolerances shown in paragraph 2.8.4. Maintaining the array within the prescribed physical tolerances ensures that the impedance characteristics of the antennas are all virtually identical. It thus follows that their gain and phase characteristics will also be virtually identical. The transmission lines are maintained within the prescribed tolerances to ensure phase continuity of the signals delivered to the goniometer from the antennas.

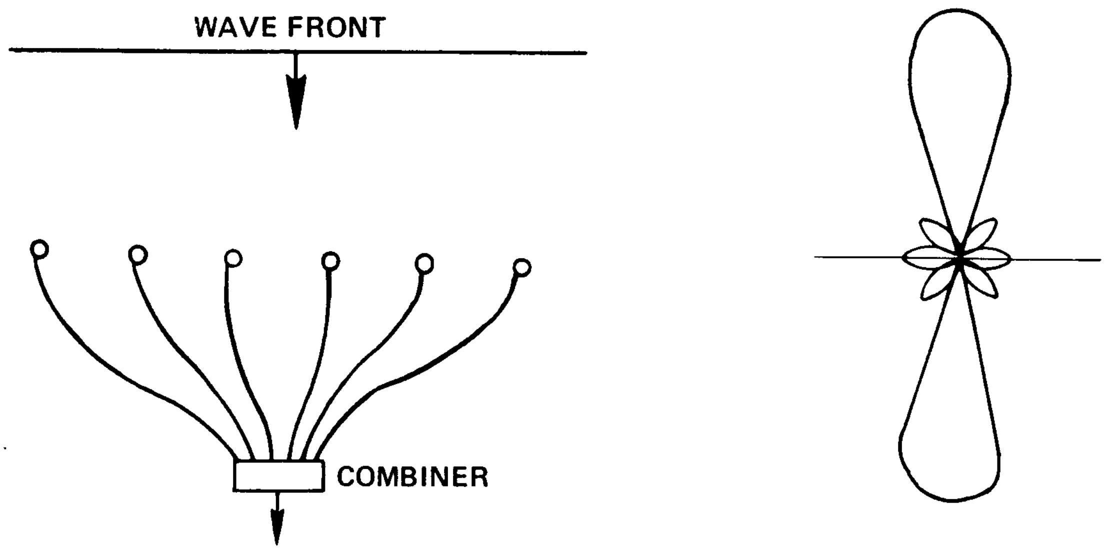


Figure 3-1 - Linear Array and Characteristics Pattern

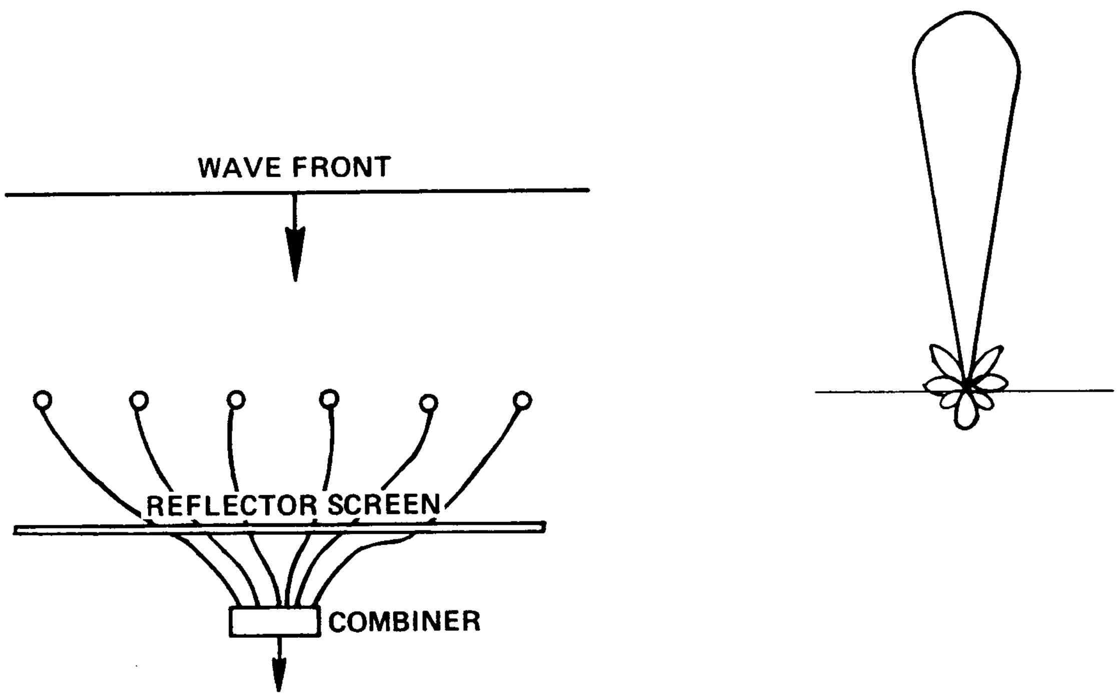


Figure 3-2 - Linear Array with Reflector Screen and Characteristic Pattern

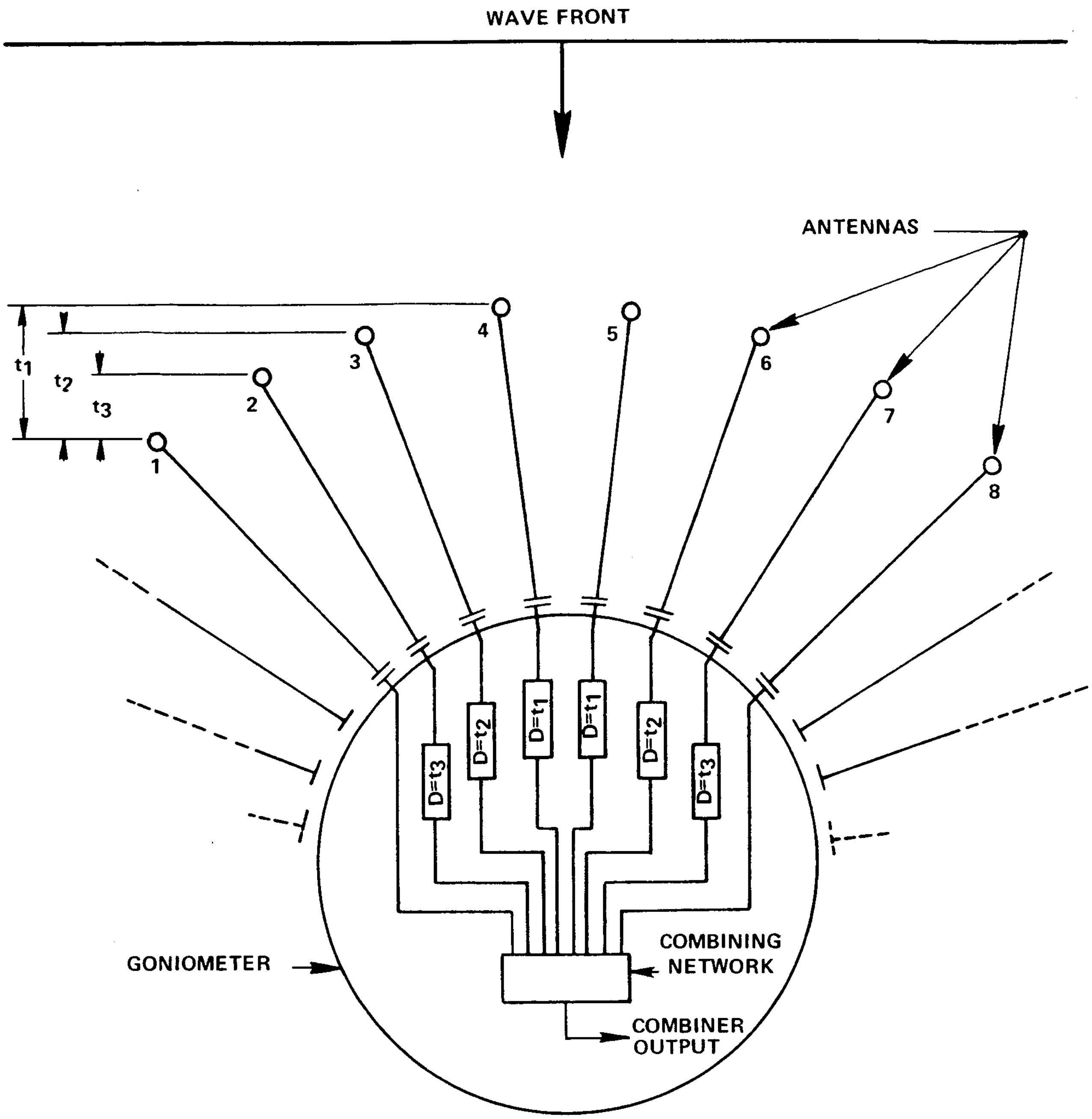


Figure 3-3 - CDAA Goniometer Principle

3.3 LOW-BAND ANTENNA

A vertical antenna is required for obtaining good low-angle reception of vertically polarized radio waves. To employ a basic half-wave dipole antenna as the low-band antenna would require a conductor approximately 178 feet tall for resonance in the middle of the band. However, the height of the antenna can be reduced to at least one-half this length by employing the ground as an electrical mirror to supply a mirror-image of half a dipole. Such a quarter-wave antenna is a monopole.

If a quarter-wave (monopole) antenna is to function as efficiently as a half-wave dipole antenna, the ground resistance must be very low. The reflecting plane utilized in the CDAA has negligible resistance and is the equivalent of a perfectly conducting ground. Since the antenna must function with reasonable uniformity across the entire low-band spectrum, a broadband antenna is required. Such an antenna must have a low Q. This is obtained by using a conductor of large diameter; in practice, a mast 4 inches in diameter is used. The effective diameter of the antenna is further increased by the use of a folded section consisting of two parallel sidewires (see Fig. 3-4). The length of the low-band antenna mast is such that the monopole is in quarter-wave resonance at approximately 4 MHz; its effective height varies from about one-eighth wavelength at 2 MHz to just over one-half wavelength at 9 MHz.

3.3.1 LOW-BAND ANTENNA IMPEDANCE. The antenna impedance comprises two principal components -- radiation resistance and reactance. The radiation resistance of a low-band mast without its parallel sidewires is about 10-ohms at the low end of the band, increasing to approximately 32-ohms at the quarter-wave-resonant frequency, and increasing further to several hundred ohms at the half-wave-resonant frequency. The reactance of the antenna is zero at the quarter- and half-wave resonant frequencies. The two parallel sidewires function as antennas of smaller diameter coupled to the main antenna mast; they have the effect of increasing the radiation resistance of the mast alone by a factor of about 10. Below the quarter-wave-resonant frequency, the reactance becomes capacitive. Above this frequency the reactance is inductive, becoming capacitive again at frequencies above half-wave resonance. The actual variations in values are minimized by the low length/diameter ratio of the folded monopole.

Since the coaxial transmission line from each antenna is connected to its respective 75-ohm multicoupler input in the "Operations" Building, the cable presents a 75-ohm resistive load. By means of an antenna-output transformer, the 75-ohm cable impedance is stepped up to 250-ohms, which is considered to be the best compromise value to use to represent the impedance of the antenna over the entire low-band spectrum. The 200-ohm resistors between ground and the low end of the two antenna sidewires are effectively in parallel and help to maintain a more uniform primary load on the output transformer.

3.3.2 ANTENNA OUTPUT TRANSFORMER. An output transformer is employed with each low-band antanna to match the nominal impedance of the antenna to the impedance of the coaxial transmission line. The significant electrical characteristics of the output transformer are listed below.

Impedance	
Primary	250 ohms nominal
Secondary	75 ohms

Frequency Response	
2 MHz to 9 MHz	Flat ± 1.0 db
Out of Band	6 db per octave maximum Roll-off relative to response at band edges
Insertion Loss	6 db over the 2 MHz to 9 MHz band

3.4 HIGH-BAND ANTENNA

Each high-band antenna consists of an upper mast and a lower mast capacitively coupled by the sleeve on the upper part of the lower mast which surrounds the lower end of the upper mast (Fig. 3-5). Vertical antennas are employed in the high-band array to obtain good low-angle reception of vertically polarized radio waves. This characteristic of vertical antennas is further enhanced by connecting the feed line to the antenna at a point elevated above ground. An elevated feed is particularly useful at frequencies in the top half of the high-band. An essential part of the high-band antenna is a large copper wire grounding network that supplies a mirror image of the antenna, which functions as a monopole in a manner similar to that described in paragraph 3.3.1. The use of large-diameter upper and lower masts (6 inches and 16 inches, respectively) results in a low-Q antenna, which is desirable because it provides reasonably uniform broadband operation across the high-band spectrum.

3.4.1 HIGH-BAND ANTENNA IMPEDANCE. Since the electrical resistance of the antenna masts is very low, the impedance of the antenna is composed of two components — radiation resistance and reactance. At the lower end of the band, where the antenna is less than a quarter-wavelength, the radiation resistance is quite low (approximately 13-ohms) increasing to about 35-ohms at the quarter-wave-resonant frequency (mid-point of mast), and further increasing to several hundred ohms at the top of the band where the upper mast is half-wave resonant. At the quarter- and half-wave resonant frequencies, antenna reactance is zero; becoming capacitive at frequencies below that of quarter-wave resonance and inductive at higher frequencies. The range of reactance values across the band is minimized by the antenna's low Q and by the compensating effect of the coaxial sections within the sleeve formed by the large-diameter lower-mast section.

.4.2 ANTENNA-TO-LINE IMPEDANCE MATCHING. The coaxial transmission line from each antenna is connected to its respective 70-ohm input multicouplers in the equipment building; therefore, the cable presents a 70-ohm resistive load to the antenna. The best compromise in the matching of the antenna impedance to the transmission line impedance is achieved by means of two coaxial sections located within the upper half of the lower mast (see Fig. 3-5). Both coaxial sections are shorter than a quarter-wavelength at even the highest frequency in the band. For this reason, they may be considered as inductors which, over much of the band, reduce antenna reactance and increase the antenna impedance to that of the coaxial transmission line. In addition to performing an impedance matching function, the lower of the two coaxial sections functions as a balun, allowing the connection of the grounded shield of the coaxial line to a point on the lower mast which is not at RF-ground potential.

.5 REFLECTOR SCREENS

As shown in Figure 3-6, the low-band and high-band reflector screens reflect the

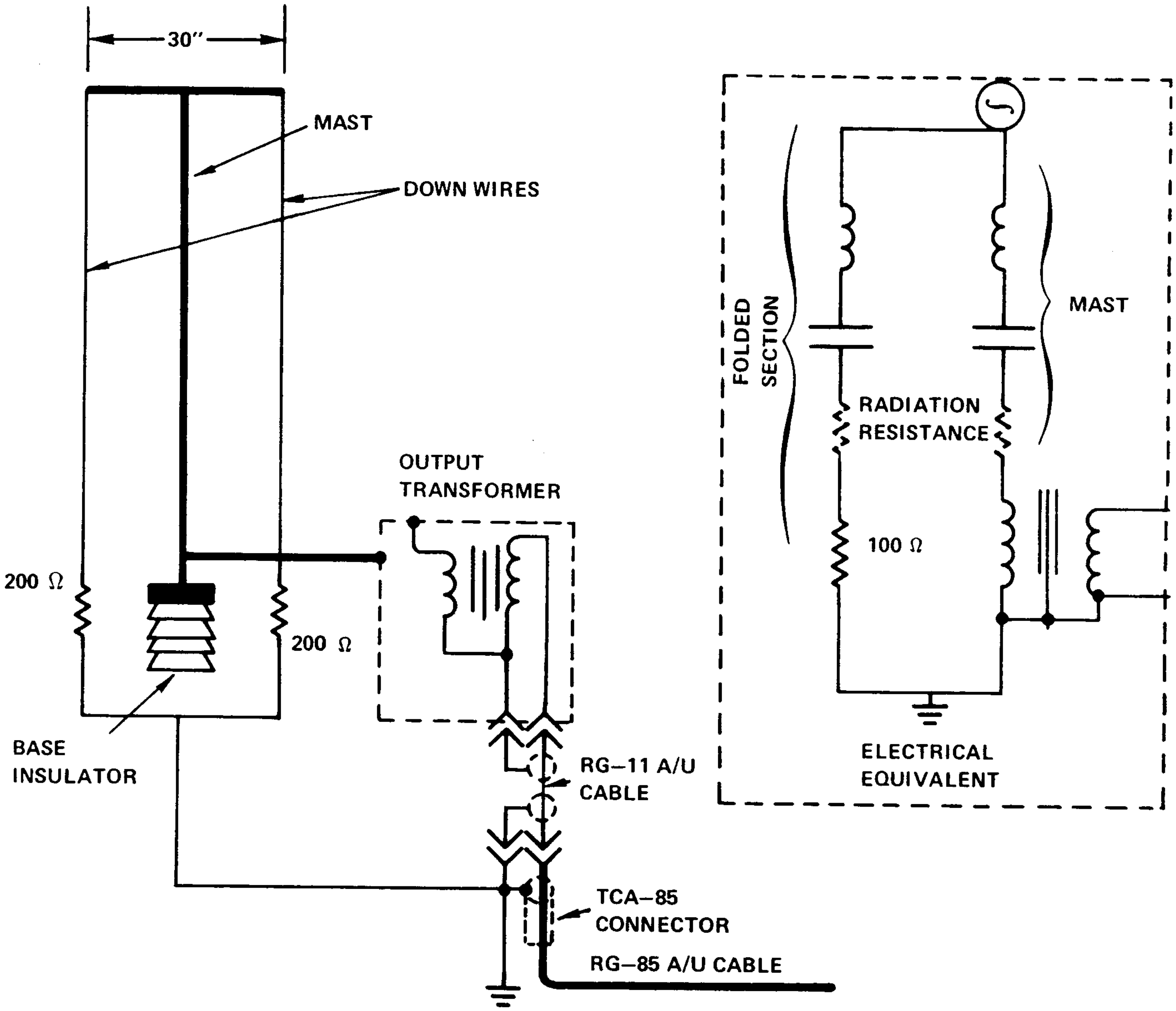


Figure 3-4 - Schematic of Low-band Antenna

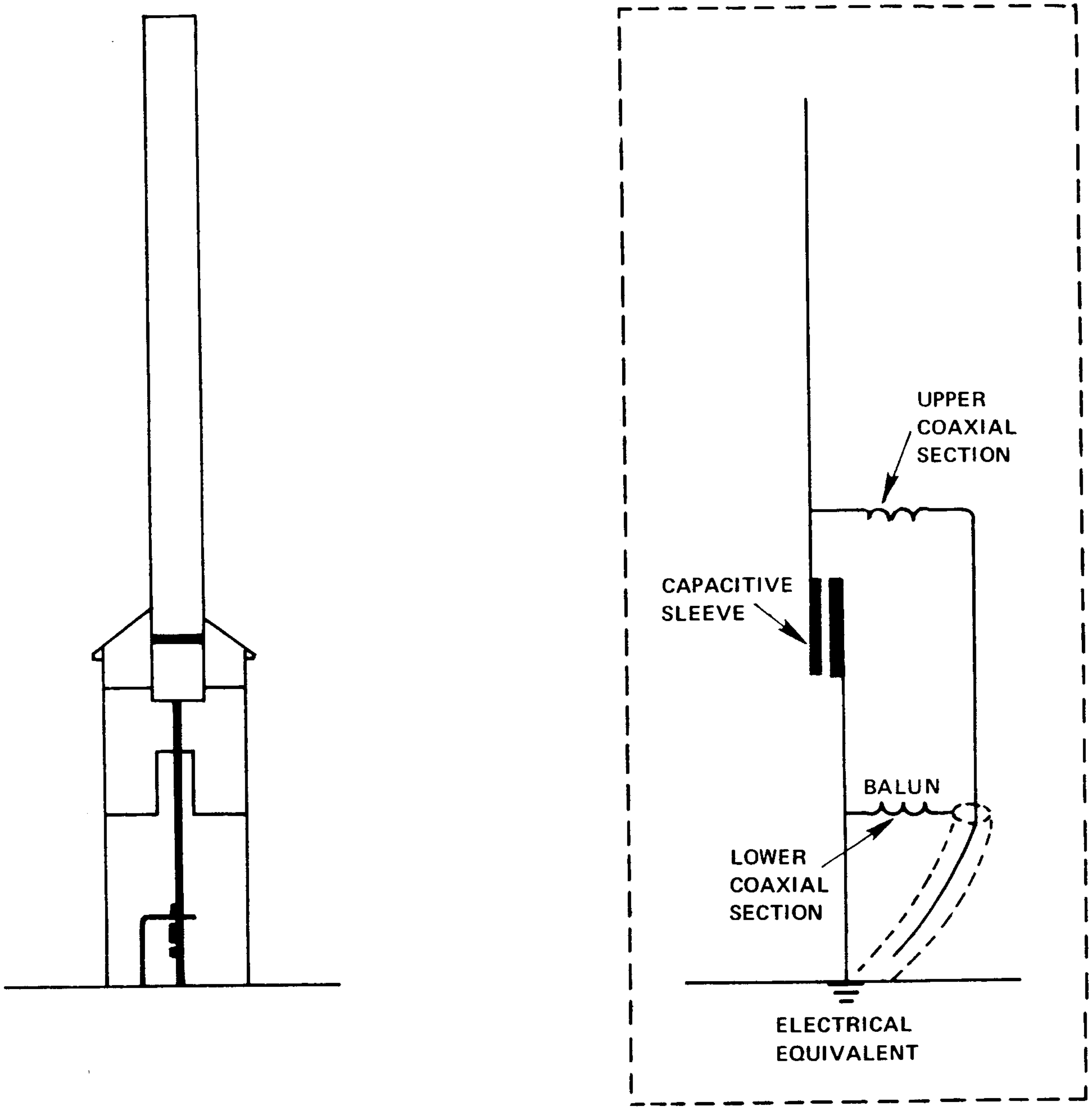


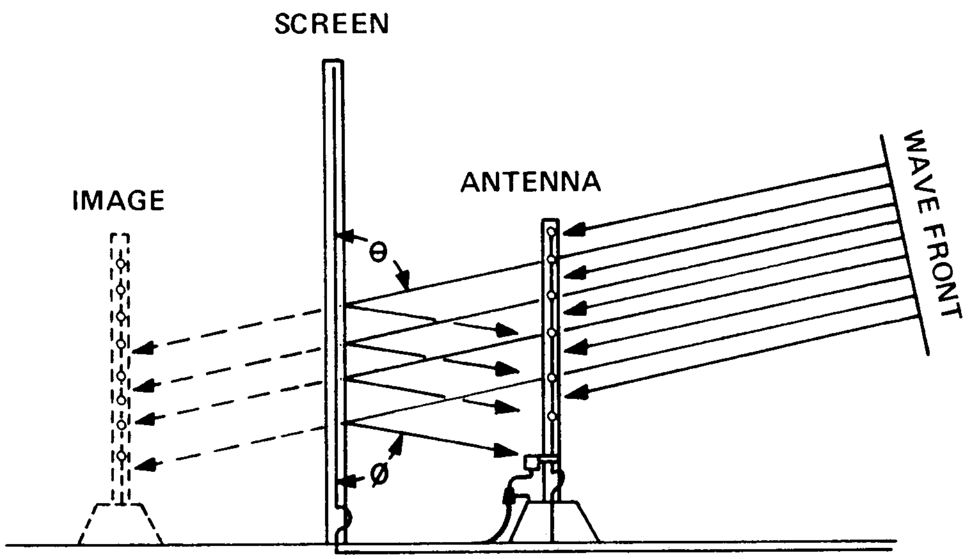
Figure 3-5 - Schematic of High-band Antenna vertically polarized incident wave in their respective bands. The vertically polarized waves generate currents in the screen wires which in turn re-radiate at an angle equal to the incident angle. The total current generated in the antenna is the vector sum of the currents generated by the direct wave and the reflected waves from the screen, and the reflecting ground plane (see para 3.6).

It is mathematically convenient to consider that the reflected wave from the screen induces currents in an image antenna located an equidistant behind the screen. Using this convenience, the antenna can then be treated as being two antennas whose outputs are summed. The overall effect of the reflector increases the gain and decreases the beamwidth and bandwidth of the characteristic pattern of the "two" antennas.

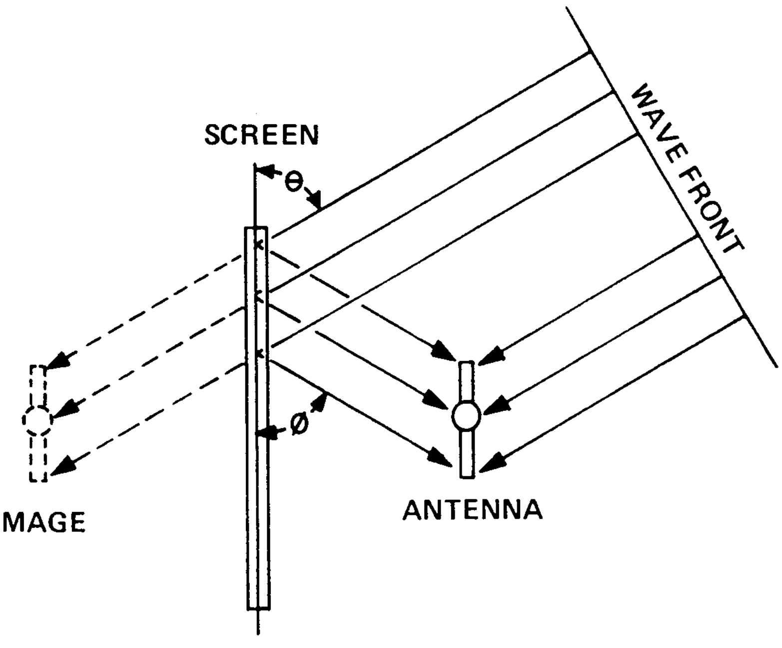
3.6 REFLECTING GROUND PLANE

The reflecting ground plane, which is common to both the high-band and low-band arrays, reflects the vertically polarized incident waves as shown in Figure 3-7. As in the case of the reflector screens, the vertically polarized waves generate currents in the ground plane which in turn re-radiates at an angle equal to the incident angle. The total current generated in the antenna is the vector sum of the currents generated by the direct wave front and the reflected wave from the ground plane, and the reflector screen (see para 3.3.3). It is mathematically convenient to consider that the reflected wave front from the ground plane induces current in an image antenna located below the surface of the ground plane as shown by the dotted lines in Figure 3-7.

3.6.1 FUNCTIONS. The ground plane performs three basic functions. First, it provides a mirror image for the monopole antennas (see para 3.3.1 and 3.3.2) and thus reduces the height of the antenna by one-half (necessary to cover the frequency band). Second, the ground plane provides a good conducting plane for wave fronts arriving at a low angle to the horizontal. Because of this good conducting plane, the wave loses very little energy to ground currents, and the overall effect is to lower, in the vertical plane, the characteristic pattern of the antenna and thus provide better low angle coverage. The third function of the ground plane is to reduce polarization errors. Polarization error is caused by inconsistencies in the ionosphere which induce some degree of horizontal polarization to the vertically polarized wave. This horizontal component produces an error when an attempt is made to direction find such a wave. A level ground mat reduces the horizontal component and reflects only the vertical component thereby reducing the polarization error to a minimum.



(A) SIDE VIEW



(B) TOP VIEW

Figure 3-6 - Principle of CDAA Reflector Screen

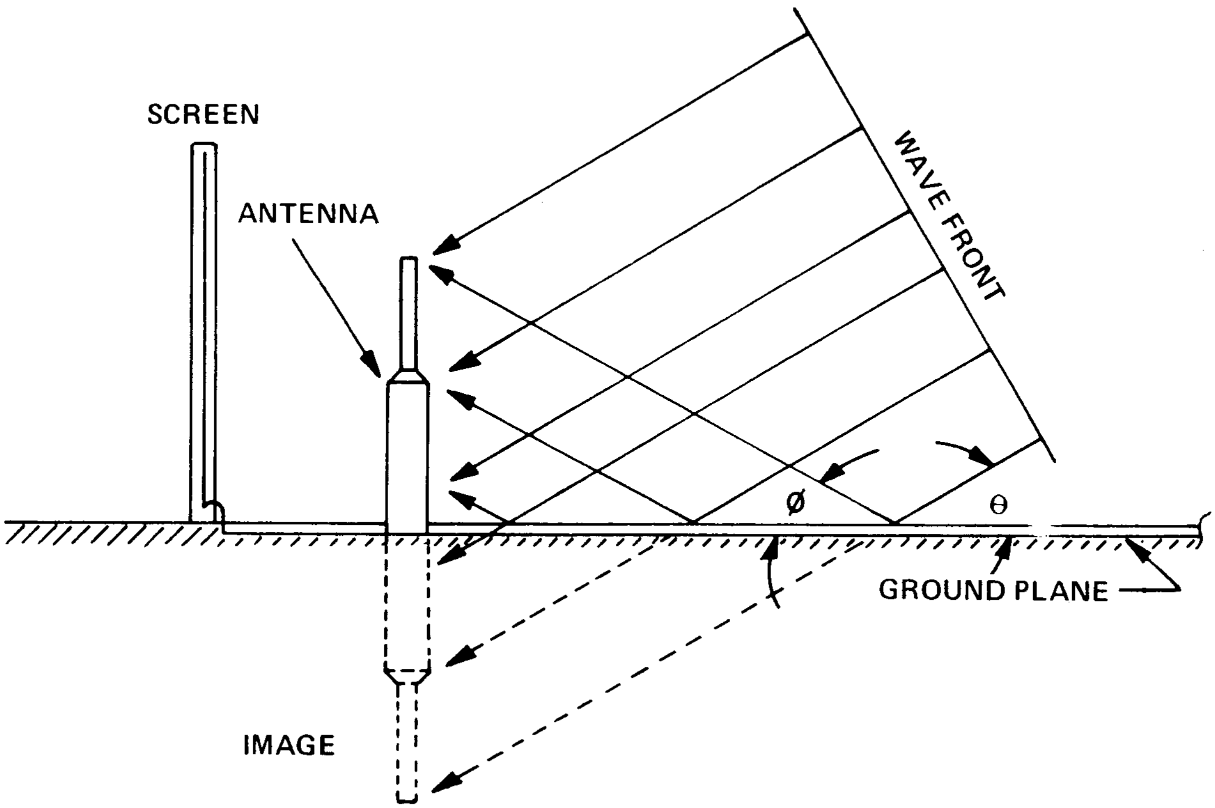


Figure 3-7 - Principle of CDAA Reflecting Ground Plane

CHAPTER 4

CDAA STRUCTURAL AND MECHANICAL MAINTENANCE

4.1 INTRODUCTION

This chapter describes the CDAA structural and mechanical maintenance procedures to be used by qualified personnel under direct control of the Public Works Officer. The Public Works Officer is responsible for maintenance of the CDAA and the RG-85A/U transmission lines.

Cooperation and coordination as outlined in section 1.3.4 with electronic material personnel who conduct electronic quality checks on the CDAA is necessary to implement an effective and efficient maintenance program. Personnel conducting the structural and mechanical maintenance presented in this chapter should therefore be familiar with the information presented in Chapter 5, CDAA Electronic Maintenance.

4.2 SCOPE

Structural and mechanical maintenance includes all functions involved in inspecting and maintaining the physical properties of the CDAA up to and including the RG-85A/U cable termination panel located in the R.F. Distribution Room of the operations building (see section 1.3.2). A structural/mechanical maintenance program is necessary to insure that all components of the CDAA are maintained in a reliable operating condition. Without proper maintenance, a CDAA will gradually degrade. Its operational performance will become less and less efficient over a period of time due to deterioration of component parts (i.e. moisture or corrosion in coaxial fittings, dirty insulators, loose or broken screen wires and ground connections, out of plumb, antennas, etc.). An effective maintenance program, by detecting deterioration trends at an early stage will allow time necessary to program and budget for repairs and minimize operation degradation. A structural/mechanical maintenance program should include the following:

a. Regularly scheduled routine inspections of all components.

b. Routine preventive maintenance of all components, this includes examining, adjusting, applying protective coating and making repairs as required.

c. Cooperation with electronic material personnel in correcting defects and degradation detected with electronic testing equipment.

This chapter is divided into two sections. Section 4.3 provides structural/mechanical maintenance guidance and information which will

CHANGE 1

assist in maintaining a CDAA. Section 4.4 provides schedules for conducting inspections and maintenance to be performed on a routine basis. Accurate, up-to-date records should be compiled on all inspections conducted and maintenance performed.

4.3 MAINTENANCE INFORMATION

This section contains information which will enable antenna maintenance personnel to perform inspections and maintenance in order to maintain a CDAA in a high degree of readiness. All inspections and maintenance should be performed by qualified, experienced maintenance personnel. The ability of the maintenance personnel to detect conditions requiring immediate attention is a key element to a successful program. The inspections and maintenance should be performed on schedules as outlined in section 4.4 in order to insure early detection of deficiencies. Early detection of deficiencies can result in correction of deficiencies through simple maintenance practices instead of major repair. All tools and equipment needed to inspect, repair and replace component parts should be available and kept in good condition. Complete records of all inspections and maintenance performed should be prepared and retained by the PWO for use by the maintenance forces conducting a continuous on-going maintenance program.

4.3.1 GENERAL MAINTENANCE INFORMATION. The following is general maintenance information which will assist antenna maintenance personnel in maintaining a CDAA.

4.3.1.1 MISCELLANEOUS PROTECTIVE COATINGS AND THEIR APPLICATION. This section provides information on protective coating, material and substances that will enable antenna maintenance personnel to maintain connectors, hardware and component parts in good condition. Included is the procurement source, approximate cost, description and application procedures for material and substances.

4.3.1.1.1 Coricone 800.

Procurement Source	Cost
Vanguard Pacific Inc. 1655 Ninth Street Santa Monica, CA 90404 Phone: (213) 451-1749	$28 per gallon $127.50 per 5 gallon Shelf life - 1 year

4.3.1.1.1.1 Coricone 800 is a protective coating particularly developed for surfaces requiring maximum resistance to weathering, salt air, chemical attack and severe abrasion. Surfaces of the upper fiberglass insulator of the high-band antennas and the fiberglass cross arms of the low-band antennas can be refurbished by application of Coricone 800. The surface of these fiberglass insulators will deteriorate due to weathering causing a reduction in their insulating properties during damp weather conditions. Application of Coricone 800 to these insulators will restore their insulating properties for a period of about 5 years.

CHANGE 1

One gallon is sufficient to coat approximately 30 upper fiberglass insulators or 45 sets of cross arms.

4.3.1.1.1.2 Coricone 800 can easily become contaminated resulting in an inferior coating on the insulators. The spray gun used for applying Coricone 800 must always be thoroughly cleaned before beginning and after completing an operation. It is also important that a fine spray be used to obtain a fine smooth consistent finish. A pressure of about 40 lbs/sq. inch is recommended. Practice in applying Coricone 800 is necessary to acquire sufficient experience to obtain a smooth, even, consistent coat.

4.3.1.1.1.3 Following is a description of the steps necessary for applying Coricone 800 to the above fiberglass insulators:

a. Wash insulator thoroughly with a stiff fiber brush and toluene (FSN 6810-290-0048, approximate cost $3.17 per 5-gallon can) to remove all dirt, salt etc., from the surface of the fiberglass. Bake in oven until thoroughly dry (several hours). An oven can be constructed from a wooden box lined with asbestos approximately 4' X 3' X 2' in size. Two 200 watt light bulbs installed in the base of the box are used as a heat source.

b. Remove insulator from oven and, while still warm, sand smooth with a small agitating sander (not a disk sander) with medium fine sand paper. Flint paper is preferred. Sand all surfaces.

c. Upon completion of sanding, brush insulator clean with a clean, dry paint brush.

d. While fiberglass is still warm, apply primer coat of Coricone 800 thinned sufficiently with toluene to make a fine spray. Spray one quick coat using a pressure of about 40 lbs/sq-inch. The purpose of this coat is to seal the pores of the fiberglass. Allow to dry at room temperature.

e. If the surface of the fiberglass is smooth (i.e. with no glass fibers protruding) apply a second coat of coricone 800 and allow to dry for 30 minutes at room temperature and allow to cure (7 - 8 days at room temperature or several minutes in the oven at from 250°F to 375°F).

f. If the surface of the fiberglass is not smooth after the primer coat of coricone 800 has been applied, allow the fiberglass to cure overnight at room temperature and repeat the sanding operation with fine sand paper as outlined in paragraph b. above. Apply a second primer coat of coricone 800 and allow to dry for 30 minutes at room temperature. Continue by applying the final coat of coricone 800 as outlined in paragraph e. above.

4.3.1.1.2 Adhesive sealant RTV-102 white (FSN 8040-225-4548 approximate cost $2.58 per 12 oz. tube). RTV-102 is a high-dielectric silicone rubber which can be used to seal out moisture and prevent corrosion. RTV-102 is often used as a protective coating to weather seal connectors; however, it is a "gooey" substance and difficult to apply properly. In addition, it dries to a rough textured surface to which salt, dirt, grit, etc, readily adheres and reduces its dielectric properties. In a CDAA, RTV is used as a seal to prevent entrance of moisture between the upper mast and the upper fiberglass insulator of the high-band antennas. To weather seal connectors, the application of Duricone 3100 and the installation of shrink tubing as described in Sections 4.3.1.1.6 and 4.3.1.1.9 is recommended.

4.3.1.1.3 Silicone Compound. (FSN 6850-880-7616 - approximate cost $1.14 per 8 oz. tube). This silicon compound, often referred to as "Dow Corning Insulating Compound", is used as an effective protective coating on bolt hardware. A very thin coat of this grease applied on the threads of bolt hardware will prevent seizing of the threads. This is particularly true of the TCA-85N connector adapters of the RG-85A/U cables. A thin coat of silicon compound applied to the threads of these connectors prior to assembly will greatly facilitate disassembly at a later date.

4.3.1.1.4 Corrosion preventive cutback compound (FSN 8030-231-2345. Approximate cost $1.60 per gallon). Often referred to as "Braycoat", this is an excellent protective coating for all hardware. It is a bituminous substance which can easily be applied with a brush or rag and easily removed with mineral spirits or paint thinner. It's main uses as a protective coating on the CDAA are as follows:

a. On screen wire hardware at the base of the reflecting screens.

b. On ground level guy hardware.

c. On exposed portions of the RG-85A/U cables (i.e. portions of the cables which protrude above the ground).

d. Lower part of the TCA-85N connector adapter.

4.3.1.1.5 Permagum (Plastic Duct Seal)

Procurement Source	Approximate Cost
Graybar Electric Co. 420 Lexington Ave. New York, New York 10017	$2.10 per 5 lbs.

A soft plastic weatherproofing mastic compound used to keep out moisture.

CHANGE 1

Readily workable, it can be thumbed into openings and formed for sealing around inspection plates, conduits, openings etc. In the CDAA, permagum is used to seal and prevent entrance of moisture into the openings where the RG-85A/U cable emerges from the rigid conduit at the base of both the high and low-band antennas.

4.3.1.1.6 Duricon 3100

Procurement Source	Approximate Cost
Vanguard Pacific Inc. 1655 Ninth Street Santa Monica, CA 90404 Phone: (213) 451-1749	$36.00 per 12 aerosol cans

Duricon 3100 is a clear, low viscosity, liquid dielectric sealer and bonder. A thin coat properly applied on clean, dry, non-ferrous metal surfaces and allowed to dry results in an excellent bonded coating which prevents moisture and oxygen from penetrating to the metal and causing corrosion. Duricon 3100, which comes in a convenient aerosol can, is used as a protective coating as follows:

a. On the mechanical terminations of the resistors on the low-band antennas. After the Duricon 3100 drys (a period of several minutes should be sufficient) a coat of scotchkote is applied to insure a long lasting corrosion free protective coating (see section 4.3.1.1.7).

b. On the RG-11A/U and RG-85A/U coaxial cable connectors at the base of both the high and low-band antennas. After the connectors are assembled and terminated, application of a thin coat of Duricon 3100 followed by installation of shrink tubing on the RG-11A/U cable connectors (see section 4.3.1.1.9) and "Braycoat" on the RG-85A/U cable connectors (see section 4.3.1.1.4) results in a virtual moisture free connector termination.

4.3.1.1.7 Scotchkote Electrical Coating. (FSN 9G 5970-962-3335 - approximate cost 97¢ per 8 oz. can.) Scotchkote is a fast drying sealant and strong bonding agent which resists oil moisture and aliphatic hydrocarbons. Scotchkote is applied to the resistors and their mechanical terminations at the base of the low-band antennas after the application of duricon 3100. The combination of duricon 3100 and scotchkote when applied to clean, dry surfaces presents a virtual corrosion free mechanical terminations.

4.3.1.1.8 1,1,1 - Trichloroethane (FSN 6810-930-6311 approximate cost 39¢ per 12 oz. aerosol can). An excellent solvent and general cleaning compound. The aerosol can sometimes referred to by a commercial trade name "Inhibisol", is convenient for many types of cleaning work in the field. In particular, Inhibsol is used to clean the porcelain insulator of the low-band antennas.

4.3.1.1.9 Shrink Tubing

Procurement Source	Approximate Cost
Americal Pamcor Inc. Valley Forge, PA	Part No. 603116 $1.30 per 12-inch tube

This thick wall shrink tubing has a sealant on the inside wall which is excellent for moisture sealing connectors. When the tubing is heated the tubing shrinks and the sealant flows into the adheres to the crevices of the connector forming a good moisture seal. It is used to seal the RG-11A/U cable connectors which connect to the TCA-85N connector adapter at the base of the high-band and low-band antennas. Each 12-inch section can be cut into 3 4-inch sections to seal 3 connectors.

4.3.1.1.9.1 The heat source used to shrink the tubing may be an electric gun or propane or butane torch. A temperature of about 250°F is required. The following is a description for installing the tubing:

a. Slide shrink tubing over cable.

b. Connect connector and apply coating of Duracone 3100 as outlined in section 4.3.1.1.6.

c. Slide shrink tubing over connector.

d. Shrink tubing by applying heat by any of the above methods.

e. When tubing has shrunk sufficiently to assume configuration of the part to be covered, discontinue heating. Additional heating will not make tubing shrink more tightly.

4.3.1.2 MAINTENANCE OF WOODEN COMPONENTS. Wooden components of the CDAA consist of reflecting screen support poles and screen panel support boomboards. All wooden components should have been pressure treated with creosote or pentachlorophenol prior to installation. Any preservative used for field treatment to the wooden components should be the same as that used in the original treatment. All cuts, holes and injuries of the surface of the treated material should be protected by brushing, spraying, dipping, shaking or coating. Care should be taken to assure that all injuries such as abrasions or nail and spike holes are thoroughly saturated with a field treated solution. Holes bored in pressure treated material should be poured full of preservative. Horizontal holes may be filled by pouring the preservative into them with a bent funnel. The use of a bolt hole treater capable of applying the preservative under pressure is recommended. All unused bore holes and spike holes should be poured full of preservative and plugged with tightfitting treated plugs. Laminated boomboards that show signs of bleeding or after close inspection show signs of soft or decayed wood in the area of bleeding should have the softwood chiseled away and a liberal application of a grease-type preservative containing pentachlorophenol applied. NAVFAC Publication MO-312, wood preservation, provides additional information pertaining to maintenance to wood products.

4.3.1.2.1 Wooden Poles. The wooden poles should have been pressure treated with preservative prior to installation. Subsequent drying out causes the poles to twist and vertical fissures to occur. Normally the fissures are not a problem; however, if the fissures penetrate beyond the penetration depth of the preservative, wood rot may occur. Fissures which have penetrated beyond this depth should have any wood rot removed and the fissure filled with type C wood filler. All wooden poles should be inspected yearly or after any severe storm, high winds, or icing conditions. The following checks should be made in an effort to locate deficiencies.

a. Any splits or signs of damage to the poles.

b. Any signs of decay or termite infestation.

c. Any damaged or missing pole caps.

d. Any signs of decay in poles that are seated in metal support sockets. Check to insure that the metal support socket is well filled with a pentachlorophenol, grease-type preservative.

4.3.1.2.2 Boomboards. All boomboards should be inspected at least yearly and after any severe storm, high winds, or icing conditions. Stations that have had a history of boomboard deficiencies should inspect more frequently. Check for the following:

a. Any splits, cracks or signs of deterioration.

b. Any evidence of loose bolts or damaged insulators.

c. Any signs of unusual deflections.

d. Any signs of slippage or twisting of poles caused by faulty boomboard seats or connecting members.

e. Any signs of discoloration or moisture entering the core of the wood.

CHANGE 1

4.3.1.3 MAINTENANCE OF CONCRETE. Concrete components of the CDAAs consist of high and low-band antenna foundations, wooden pole foundations, reflecting screen grade beams, guy anchor foundations and, at those stations which utilize metal towers, tower foundations. All concrete components, with the exceptions of the guy anchor foundations which should not be disturbed (see section 4.3.7.2), should be inspected yearly. Small cracks, spalls and anchor bolts or straps that have become loose should be cleaned, patched and packed with an epoxy base grout. Colma-DUR is one such product.

4.3.1.4 MAINTENANCE OF METAL TOWERS. Three stations use metal towers to support the low-band reflector screen. The towers should be thoroughly inspected each year, and after any severe storm, high winds, or icing conditions. Checks should be made for the following deficiencies.

a. Loose bolts or damaged connections.

b. Signs of cracked welds.

c. Loose or damaged insulators.

d. Signs of rust or deteriorated galvanized or painted surfaces.

e. Signs of metal distress or fatigue such as a bent or twisted member.

f. Signs of clogging of drain holes.

All areas of damaged paint or coating and all rusting areas including areas where rust discoloration shows through the existing paint or zinc coating should be cleaned to bare metal. It is recommended that cleaning be accomplished by means of power wire brush. Immediately after cleaning and before any new rust has formed, the bare area should be spot primed and finish painted as required. Finish paint when required should be an alkyd gloss enamel colored as appropriate It may be applied as a touch up coat over spot primed areas or as an overall coat if so desired. Sufficient time should be allowed between coats to assure thorough drying.

4.3.1.4.1 Information is provided for the procurement of paints as follows:

a. Primer paint to be applied on ferrous surfaces (non-galvanized) FSN 8010-169-7419.

b. Primer paint zinc chromate alkyd type (two coats should be applied) Federal Spec TT-P-645.

c. Primer paint to be applied on zinc coated surfaces (galvanized) FSN-8010-165-8560.

d. Primer coating, zinc dust-zinc oxide conforming to Type I Federal Spec TT-P-641.

CHANGE 1

e. Finish coat, enamel, alkyd, gloss (for exterior and interior surfaces) class A drying, Federal Spec TT-E-489.

Color:	Medium Gray	FSN 8010-286-7731
	White	FSN 8010-664-4761
	International Orange	FSN 8010-527-3200

4.3.2 MAINTENANCE OF LOW-BAND ANTENNAS. (See Section 2.3 and Figure 2.3). Section 3.2.3 describes the importance of symmetry in the operation of the array and indicates the antennas must appear physically nearly identical in order to achieve symmetry. Figure 4.1 indicates physical defects which can affect the operational performance of the low-band antennas.

4.3.2.1 PORCELAIN INSULATOR. The porcelain insulator at the base of the antenna mast isolates the active antenna mast from ground potential. In order for the antenna to operate properly the porcelain insulator must be kept clean of all foreign matter and free from scratches and cracks. Foreign matter, such as salt and dust accumulations, reduces the insulation properties of the insulator during damp weather conditions. The insulator should be washed weekly with "inhibsol". All cracked or scratched insulators should be replaced.

4.3.2.2 FIBERGLASS CROSS ARM. The fiberglass cross arms are used to space the downwires uniformally 30 inches from the mast and must possess good insulating properties. The cross arms are coated with a protective coating of epoxy resin to prevent physical deterioration. Weathering of the epoxy resin allows the glass fibers on the surface of the cross arm to separate from the matrix bond which holds the fibers together and to appear as a fuzz on the surface of the cross arm. Salt and dust readily accumulate on this deteriorated surface and during damp weather conditions reduce the insulating properties of the cross arm. Coricone 800 should be used to refurbish the surface of the cross arms and restore their insulating properties. Section 4.3.1.1.1 provides instructions for application of Coricone 800. The cross arms should be inspected yearly for cracks and deterioration of the protective coating (i.e., appearance of loose glass fibers). Cross arms which are cracked should be replaced, and the cross arms which show deteriorated protective coating should be coated with Coricone 800.

ours have turnbuckels

4.3.2.3 MECHANICAL TERMINATIONS. Mechanical connections include the terminating resistor connections to the downwires and to the grounding harness. These connections should be inspected weekly for signs of corrosion. When corrosion is detected, the connection should be disassembled, thoroughly cleaned, reassembled, coated with Duracon 3100 and finally coated with Scotchkote.

4.3.2.4 GROUNDING HARNESS. The wire harness which connects the terminating resistors to the ground plane should be inspected yearly. The harnesses should each be maintained uniformly with no sharp bends in the wire. The gravel should be removed from the point at which the harness is bonded to the expanded metal to facilitate visual inspection of this terminati .

CHANGE 1

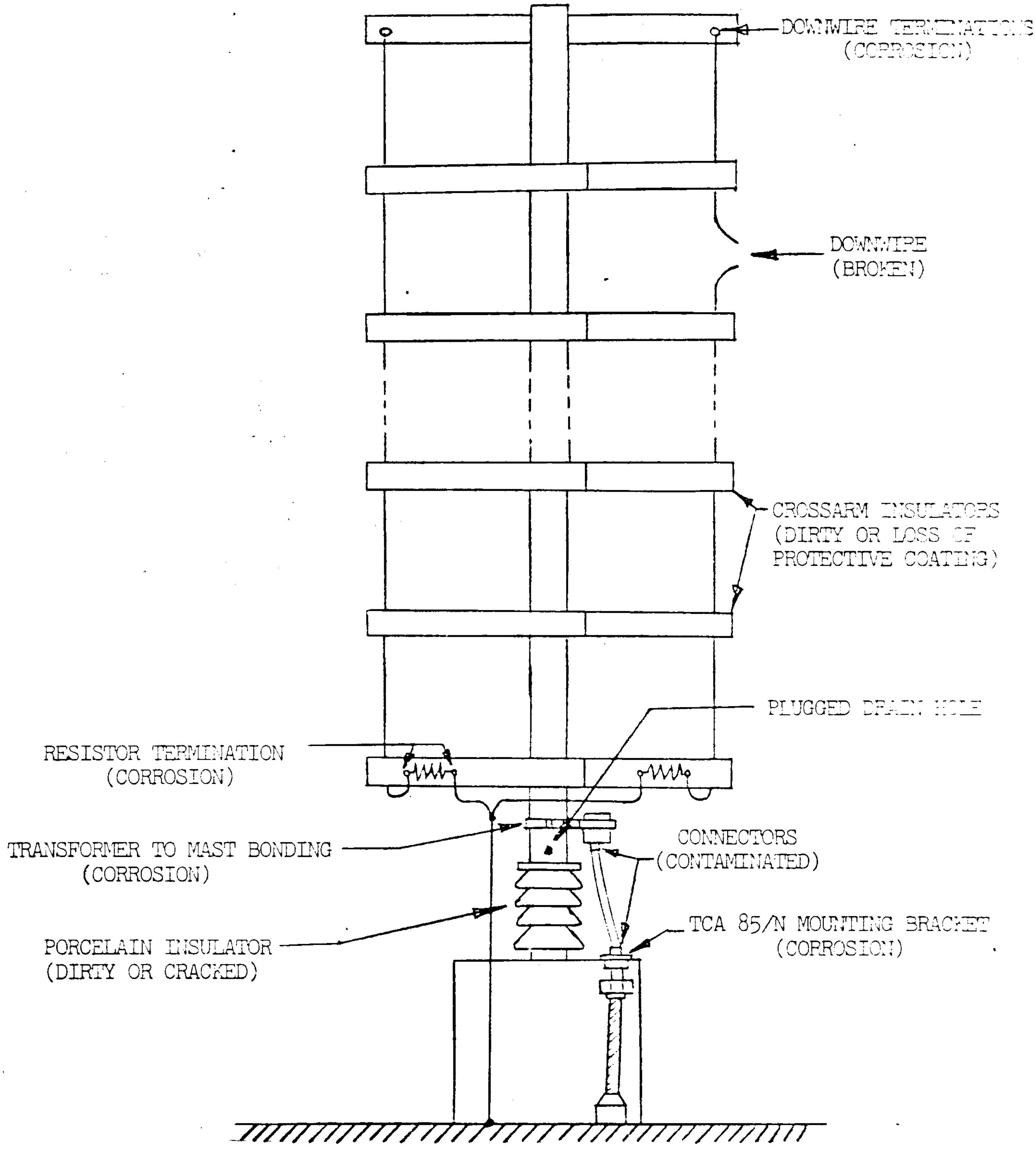


FIGURE 4-1 TYPICAL DEFECTS OF LOW-BAND ANTENNAS.

CHANGE 1

4.3.2.5 TRANSFORMER. In order for the antenna to operate properly, the transformer must make a good electrical connection to the mast. If the transformer is bonded to the mast, the bonds should be inspected yearly to insure the welds are not cracked and a good electrical connection is made. If the transformer connection to the mast is made by set screws, the set screws should be removed quarterly, thoroughly cleaned and replaced.

CAUTION

Only RF currents shall be permitted to pass through the windings of the transformers. Equipment such as meggars or ohm meters may burn out the windings of the transformers or polarize the transformer core and must not be used.

CAUTION

CHANGE 1

4.3.2.6 DRAIN HOLE. A small hole is drilled into the base of each antenna mast to facilitiate draining of any water which may accumulate inside the mast. Accumulated water inside the mast may freeze during cold weather conditions and cause the mast to crack or during windy conditions the added mass to the mast may lead to increased sustained oscillations and subsequent failure of the mast. The drain hole should be inspected quarterly to insure the hole is not obstructed.

4.3.2.7 ANTENNA BASES. All antenna bases should be inspected quarterly and after any severe storm, high winds, or icing conditions. A check should be made for the following deficiencies:

a. Any signs of settlement, tilting or frost upheaval.

b. Any signs of cracks, spalling or other deterioration of the concrete.

c. Any signs of looseness or rusting of the anchor bolts or straps.

4.3.2.8 PROCEDURE FOR TAKING DOWN A LOW-BAND ANTENNA.

4.3.2.8.1 Scope of Work. This paragraph provides a procedure for lifting an installed low-band antenna off its pedestal and for lowering the antenna to a horizontal position on the ground in the event that this operation is deemed necessary. Using a crew of six men, the antenna is lifted by means of a block and tackle attached to a rope stretched from a low-band screen pole to the top of one of the high-band screen poles. The two screen poles are selected so that the rope can pass as close as possible to the low-band antenna being repaired (see Fig. 4-2). The following equipment is required:

a. 30-foot ladder.

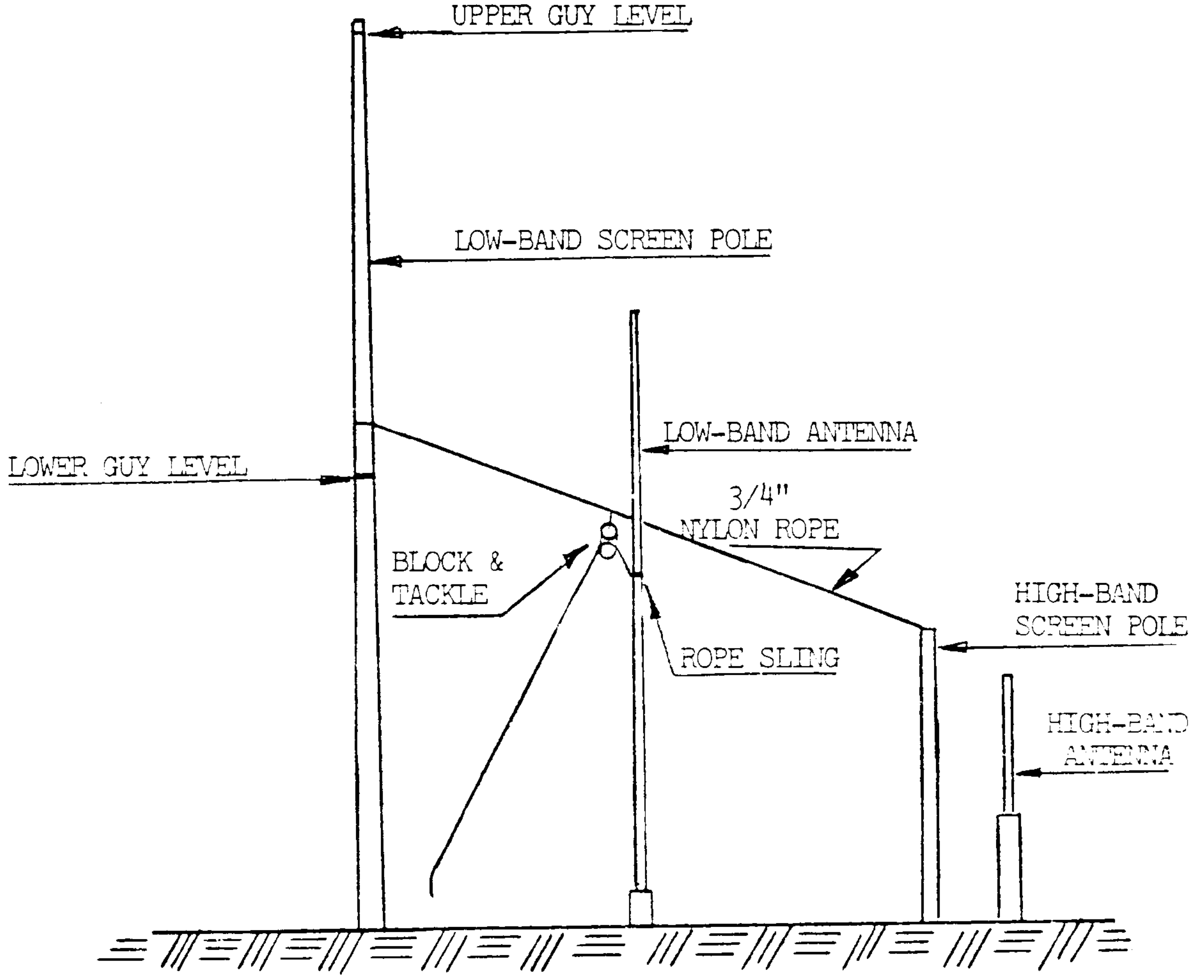
b. Block and tackle - 400 pound capacity.

c. Nylon rope - 100 feet long by 3/4 inch diameter.

d. Rope - 50 feet long by 1/2 inch diameter.

e. Scaffolding (Scaffolding to permit access to the upper portions of the low-band antennas is expected to be provided to each station in the near future.)

CHANGE 1



HOISTING LOW-BAND ANTENNA

FIGURE 4-2. METHOD OF HOISTING LOW-BAND ANTENNA

CHANGE 1

f. Plywood platform (4' X 4' X 3/4")

4.3.2.8.2 Procedure. The low-band antenna mast is lifted and lowered to the ground using the following procedure:

a. Securely fasten one end of a 100 ft, 3/4 inch, nylon rope at a point near the top of the selected high-band screen pole.

b. Lay out the nylon rope on the gravel in the area of the ground screen mat. Carry the rope past the low-band antenna in a straight line to the low-band screen pole selected as initially stated above.

c. Securely fasten one end of a coiled 50-foot rope to the base of the hook that is part of the upper pulley block. For later use, allow 2 feet of the rope to extend beyond the hook. Then, carrying the untied end of the 3/4-inch nylon rope and the block and tackle with its additional attached rope, climb the steps of the low-band screen pole to a position above the level of the first guying eyebolts, or climb to this level first and pull up the required items by means of a hand line.

d. Pass the end of the nylon rope around the screen pole and pull it as tight as possible so that it passes the low-band antenna at a convenient attachment point at or above the mid guy level. If necessary have another member of the crew release the nylon rope from its point of attachment at the high-band pole and thread the end of the rope between the vertical side wire and the mast of the low-band antenna at the point of intersection of rope and mast and refasten the rope to the base of the high-band screen pole. Securely fasten the nylon rope to the low-band screen pole.

e. Place the upper pulley block hook over the nylon rope and pay out the coiled rope so that the block and tackle slides down the nylon rope to a position close to the antenna mast. Tie the restraining rope securely around the screen pole to prevent further sliding of the block and tackle hook.

f. Errect the scaffolding to height of Block and Tackle.

g. Climb scaffolding and using the 2 foot of rope extending beyond the block and tackle hook (or some other short rope), tie the hook securely to the nylon rope.

h. Attach a rope sling around the antenna mast. Attach the lower pulley block to the rope sling and adjust the block and tackle in preparation for hoisting the mast.

i. Disconnect the RG-11/U cable from the RF transformer and the TCA-85N connector and lay aside in a safe place to protect cable and connectors.

j. Disconnect the ground wire or strap from the antenna's lowest cross arm.

k. Uniformly slacken all guys supporting the antenna so that the hemispherical bearing at the bottom of the mast insulator may be lifted out of its base-mounted socket..

l. Between the low-band antenna and one of the two screens, place a 4 by 4-foot piece of 3/4-inch plywood on the gravel with one edge against the antenna foundation. The plywood provides a clean, solid surface on which to rest the hemispherical bearing after the mast is lifted off its base. It also prevents the bearing from accidentally cutting through the gravel and possibly damaging the buried ground mat.

m. With two men of the work crew operating the block and tackle and another man ready to maneuver the bottom of the antenna, raise the mast sufficiently to lift the hemispherical bearing clear of the socket on the top of the base pedestal. Then, push the mast away from the pedestal and carefully lower the antenna until the bearing rests on the plywood platform.

n. With one man of the work crew stationed at the anchor location of the rear guys, and another man at the anchor location of the front guys, disconnect the two top guys at their turnbuckles so that these guys may be used as tag lines to control the lowering of the mast to a horizontal position. The antenna is to be lowered so that its top end moves towards the anchor location of the lateral guys.

o. Transfer one man of the work crew from block and tackle operation to assist the man at the bottom of the antenna mast. Then, with most of the antenna's weight held by the block and tackle, move the bottom of the mast in a direction away from the lateral guying anchor. Do not allow the hemispherical bearing to drag in the gravel.

p. Continue to move the base end of the antenna as stated.

q. By means of the block and tackle and the two controlling tag lines (guys), slowly lower the top end until the antenna is in a horizontal position on the gravel.

4.3.2.9 PROCEDURE FOR REPLACEMENT OF LOW-BAND ANTENNA PORCELAIN INSULATOR.

4.3.2.9.1 Scope of Work. This paragraph provides a detailed procedure for replacing the large porcelain insulator at the base of a low-band antenna after the antenna has been lowered.

4.3.2.9.2 Procedure. The following steps should be employed in the replacement of the base insulator.

a. If the insulator's terminal hardware is in satisfactory condition, remove from the bottom end of the insulator the large, threaded, steel stud holding a circular plate and the hemispherical bearing. Set aside the bottom hardware items for attachment to the replacement insulator.

b. Unscrew the defective insulator from the large aluminum stud (or vice versa) which holds the insulator to a circular mounting plate.

c. Note that one end of the base insulator is fitted with a threaded aluminum socket 2 inches in diameter; the other end has a similar steel socket. Screw the aluminum socket of the replacement insulator onto the threaded aluminum stud (or vice versa) which projects through the circular top plate.

d. By means of the threaded steel stud previously set aside, attach the circular plate and hemispherical bearing (also set aside previously) to the bottom of the replacement insulator. Ensure that both top and bottom studs are tightened securely.

4.3.2.10 PROCEDURE FOR THE INSTALLATION OF A LOW-BAND ANTENNA.

4.3.2.10.1 Scope of Work. This paragraph provides a detailed procedure for reinstalling a new or existing low-band antenna. The crew and equipment required is as indicated in paragraph 4.3.2.8.

4.3.2.10.2 Procedure. Listed below are the procedural steps to be followed in this operation:

a. If the guys attached to the existing antenna are in good condition, use them to support either the new or existing antenna. If any guy is unfit for reuse, replace it with a new equivalent guy. If a new antenna is to be installed disconnect all nine guys from the antenna mast. Lay out the guys in an orderly manner, far enough from the antenna so that they will not be walked on or otherwise damaged.

b. If a new antenna is to be installed, detach the hoisting sling from the old antenna and set it aside for use in erecting the new replacement antenna; then, move the old antenna out of the work area. Bring in the new antenna and place it on the gravel in the location previously occupied by the old antenna. Reconnect the nine guys previously removed from the old antenna.

c. Using a torque wrench, tighten to 45 inch-pounds the nuts on the four bolts holding the bottom cross arm to the mast. Tighten to 40 inch-pounds the nuts holding all other cross arms.

d. Tension the antenna's two sidewires while the antenna is still on the ground by adjusting the floating clamp at the lower end of each wire to its normal position below the end of the lowest cross arm. Then, fit the lowest cross arm clamp over the wire to hold it in a permanently tensioned condition.

e. Attach the hoisting sling to the antenna mast.

f. Clean out the hemispherical socket at the top of the antenna pedestal and apply a coating of lubricant to the inside surface of the socket.

g. Station one man of the work crew at the anchor location of the rear guys and another man at the anchor location of the front guys. Each man should be ready to use the top guy as a tag line in controlling the erection of the antenna.

h. With two men of the work crew operating the block and tackle and one or two other men at the base of the antenna, begin to hoist the antenna to its final vertical position. As the antenna is lifted move the base of the antenna toward the pedestal while pulling the two top guys in the opposite direction. Do not drag the hemispherical bearing through the gravel as it may become damaged or inflict damage on the buried ground mat. When the mast is roughly vertical and its bottom end is higher than the pedestal, verify that the hemispherical bearing is clean, then, maneuver the antenna over the pedestal and carefully lower it until the hemispherical bearing fits into its socket at the top of the pedestal.

i. Reconnect the top rear and top front guys to their respective turnbuckles. Using the procedures outlined in paragraph 4.3.7.5 adjust all guys to the tension specified on the original architectural and engineering drawings. While adjusting guy tension keep the mast vertical by checking as specified in the procedures outlined in paragraph 4.3.4.7.

j. Reconnect the RG-11A/U cable to the RF transformer mounted on the antenna mast and seal with Duricon 3100 and shrink tubing as indicated in Section 4.3.1.1.9. Verify that the antenna is functioning properly.

4.3.3 MAINTENANCE OF HIGH-BAND ANTENNAS. (See Section 2.5 and Figure 2.5). Section 3.2.3 describes the importance of symmetry in the operation of the array and indicates the antennas must appear physically nearly identical in order to achieve symmetry. Figure 4-3 indicates physical defects which can affect the operational performance of the high-band antennas.

4.3.3.1 ANTENNA GROUNDS. The base of the antenna must be well grounded. For this purpose six large copper straps 2 1/2-inches wide by 1/16-inch thick, are brazed to the expanded metal sheet at one end and

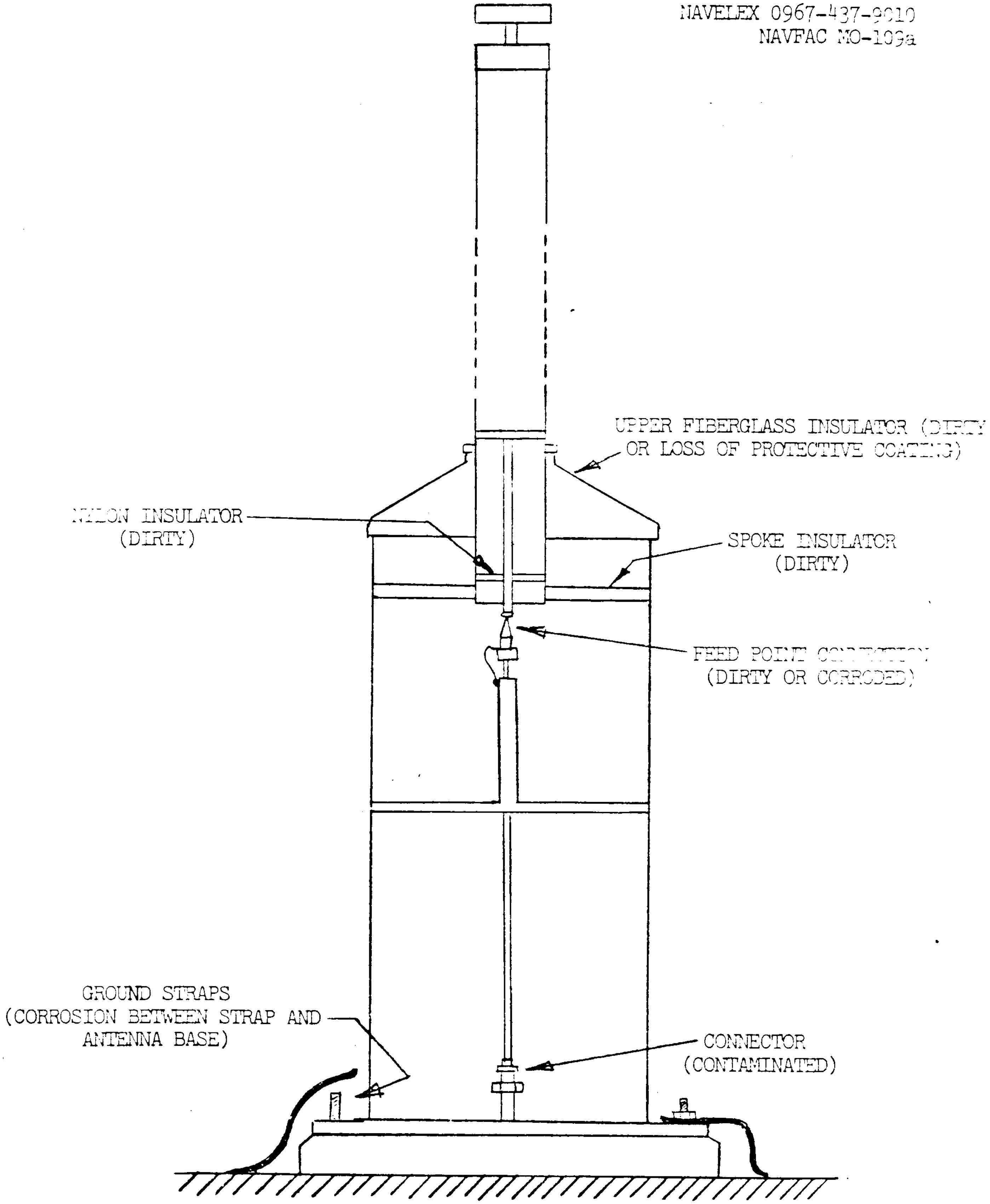


FIGURE 4-3 TYPICAL DEFECTS OF HIGH-BAND ANTENNAS

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mechanically connected to the upper side of the antenna base at the other end. Electrolytic action between the aluminum antenna base and the copper straps causes corrosive substances to accumulate which in turn cause the electrical grounds to deteriorate. These straps should be inspected yearly to insure a good electrical connection exists between the antenna and the expanded metal. Should the end of the straps which connect to the antenna show signs of corrosion, this end of the strap should be thoroughly cleaned with a wire brush and emery cloth and tinned with solder and installed on top of the antenna base.

4.3.3.2 VIBRATION DAMPER. A mushroom shaped neoprene vibration damper is installed on top of the mast to reduce vibrations and thus reduce stresses placed on the upper fiberglass insulator by vibrations. These dampers are very effective. They should be inspected quarterly to insure that they are securely attached to the mast.

4.3.3.3 UPPER FIBERGLASS INSULATOR. The upper fiberglass insulator supports the mast concentrically inside the sleeve. These insulators are coated with an epoxy resin to prevent physical deterioration of the fiberglass. Weathering of the epoxy resin exposes the fiberglass on the surface of the insulator and allows the glass fibers to separate from the matrix bond which holds the fibers together. They appear as fuzz on the surface of the insulator. Salt and dust readily accumulate on the deteriorated surface and during damp weather conditions reduce the insulating properties. Coricone 800 (see section 4.3.1.1.1) should be used to refurbish the surface of the insulators and restore their insulating properties. During dry periods the insulators should be washed monthly with a mild detergent solution to remove salt and dirt accumulations. The insulators should be thoroughly inspected yearly for cracks and deterioration of the protective coating, i.e., appearance of loose glass fibers). Cracked insulators should be repaired/replaced,and the insulators which show deteriorated protective coating should be coated with Coricone 800.

4.3.3.4 NYLON AND SPOKE INSULATORS. The nylon insulator concentrically positions the tuning stub inside the mast. The spoke insulator concentrically positions the mast within the sleeve. In order for the antenna to operate properly, these insulators must be kept clean of all foreign matter such as salt, dust, etc, which can reduce their insulating properties during damp weather conditions. The insulators should be washed semi-annually with inhibisol.

4.3.3.5 VENTILATOR. A ventilator consisting of a louvered cover plate scre and rain shield is installed over the top access hole of the antenna sleeve. This allows air to circulate and reduces condensation inside the antenna. The screen should be inspected yearly and cleaned as required.

4.3.3.6 ANTENNA BASES. All antenna bases should be inspected quarterly and after any severe storm, high winds, or icing conditions. A check should be made for the following deficiencies:

a. Any signs of settlement, tilting or frost upheaval.

b. Any signs of cracks, spalling, or other deterioration of the concrete.

c. Any signs of looseness or rusting of the anchor bolts or straps.

4.3.3.7 PROCEDURE FOR TAKING DOWN A HIGH-BAND ANTENNA.

4.3.3.7.1 Scope of Work. This section provides a detailed procedure for lifting an installed high-band antenna off its base and lowering it to a horizontal position on the gravel in the event that this is deemed necessary. Using a three-man crew, the antenna may be lifted by means of a block and tackle attached to the top of a gin pole anchored by ropes to two high-band screen poles as illustrated in Figure 4-4. Equipment required for this operation is as follows:

a. Gin pole - 14 feet long

b. Guy ropes - 2 pieces of 3/4-inch rope, 35 feet long.

c. Block and tackle.

d. Hoisting sling.

e. Step ladder - 6 feet.

f. Plywood platform - 4 by 4 feet by 3/4-inch thick.

4.3.3.7.2 Procedure. The sequence of operations required to accomplish this operation are listed below:

a. Between the high-band antenna and the high-band screen pole behind it, place the piece of plywood on the gravel with one edge against the antenna foundation. The plywood provides a clean, solid surface on which to place the base of the gin pole, and on which to rest the antenna vertically after it has been lifted clear of its foundation.

b. On the plywood platform, set the bottom of a 14-foot gin pole with block and tackle and two guy ropes attached to its top end. Set the gin pole in line with the antenna and the nearest screen pole so that it is one foot from one edge of the plywood and about three feet from the foundation of the antenna. Securely tie the lower end of the two ropes to the base of the two high-band screen poles, respectively, one immediately to the left and one immediately to the right of the pole directly behind the antenna (see figure 4-4). Adjust the guy ropes so that the block and tackle hangs directly over the outer rim of the lower antenna mast section.

c. Using a step ladder, climb to a convenient working height and tie a 10-foot by 1/2-inch rope around the top of the large, lower section of the high-band antenna. Tie the rope just below the large insulator, forming a non-slip loop in the rope into which the block and tackle can be hooked. Take up the slack in the block and tackle and readjust the gin pole guy ropes if necessary.

d. Remove the rectangular cover from the access window near the base of the antenna. Set aside the cover and its screws and lockwashers for reuse, then disconnect the short RG-11/U cable from the large TCA-85/N connector-adapter inside the mast.

e. Remove the six nuts and washers used to hold the antenna to its foundation. If they are reusable, set them aside for use during reinstallation of the antenna.

f. With two men of the work crew operating the block and tackle and another man ready to maneuver the bottom of the antenna, raise the mast straight up until it clears the armored cable bracket and connector-adapter inside. Then, allowing the bottom of the mast to move toward the gin pole, carefully lower the mast until it rests vertically on the plywood platform.

g. The block and tackle are not required for lowering the antenna to a horizontal position; therefore, to simplify the operation, unhook the block and tackle and move the gin pole out of the way. Then, with one man of the work crew controlling the bottom of the antenna and two men ready to control the upper end as it comes down, push the antenna in the appropriate direction to start it falling in a slow, controlled descent. The two men controlling the upper part of the antenna work toward the top as it comes down. The descent of the top is not difficult to control as most of the antenna weight is in the lower section.

4.3.3.8 PROCEDURE FOR INSTALLING HIGH-BAND ANTENNA.

4.3.3.8.1 Scope of Work. This paragraph provides a detailed procedure for installing a new antenna or reinstalling an existing antenna. The crew size and equipment required for this operation are the same as suggested for taking down the antenna (see paragraph 4.3.3.7).

4.3.3.8.2 Procedure. Following are the suggested sequence of events to be used during installation or reinstallation of antennas:

a. Verify that the grounding at the top of the antenna foundation is in good condition and perfectly level.

b. If a new antenna is to be installed, detach the hoisting sling from the existing antenna and set it aside for use in lifting the new replacement antenna onto its foundation, then move the old antenna out of the work area. Bring in the new antenna and place it on the gravel in the location previously occupied by the old antenna.

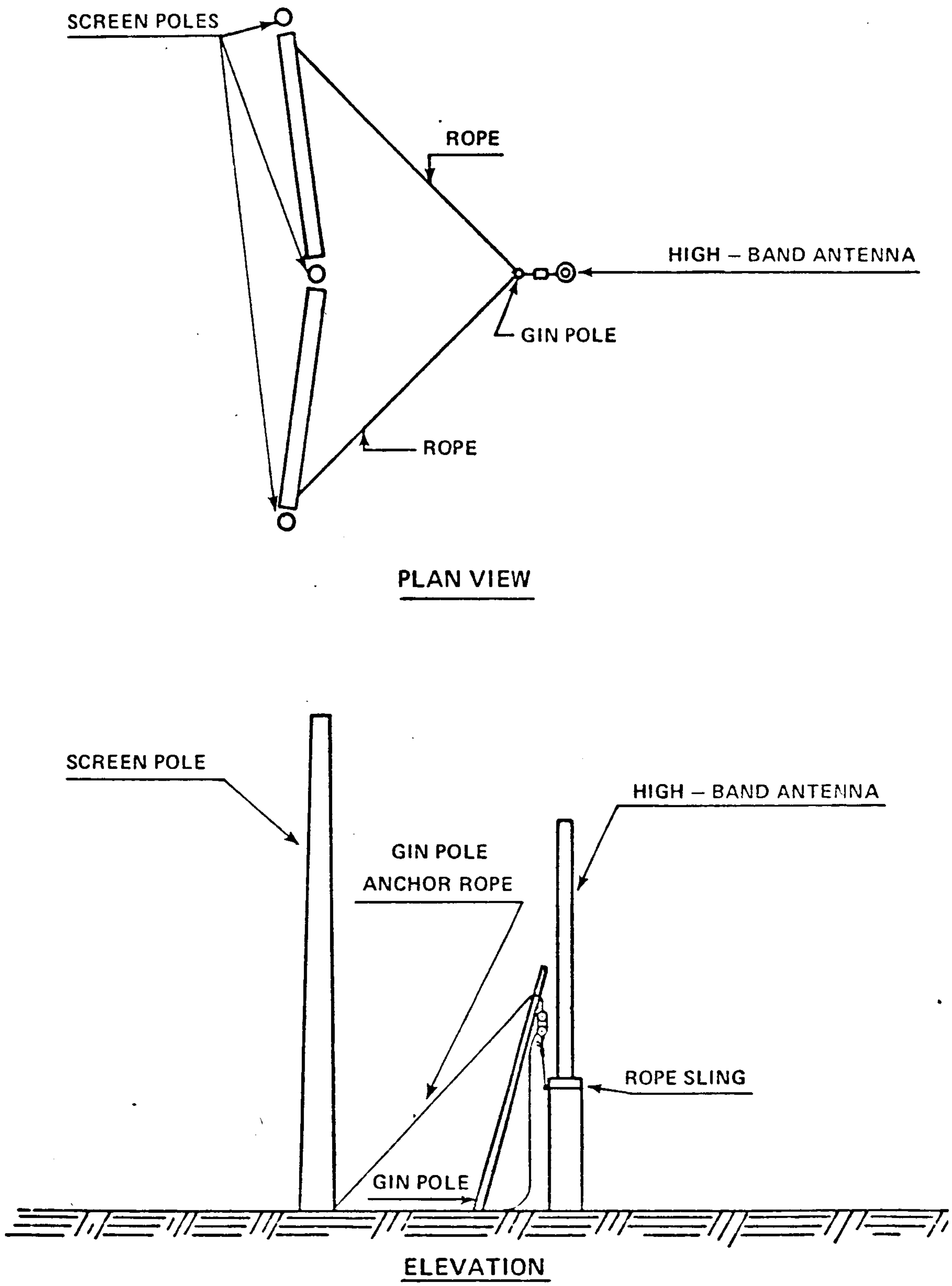

Figure 4-4 Method of Hoisting High-band Antenna

c. With one man controlling the bottom end of the antenna and two men at the top end to lift, raise the top end and walk toward the base as the top goes up. Continue lifting and pushing the upper part of of the antenna within reach until the antenna is in a vertical position on the plywood platform.

d. Return the gin pole with attached block and tackle to the position it was in while the old antenna was being lifted off its foundation.

e. Using a step ladder, climb to a convenient height and attach the hoisting sling to the upper portion of the larger section of the new antenna (its position should be corresponding to its former position on the old antenna). Hook the block and tackle into the hoisting sling.

f. With two men of the work crew operating the block and tackle and another man ready to maneuver the bottom end of the antenna, raise the antenna straight up until it is able to clear the armored cable bracket and connector-adapter in the center of the foundation pier. Then, pushing the bottom of the antenna over the foundation, carefully lower the antenna so that the six anchor bolts pass through the holes in the mounting ring.

g. Install the washers and nuts on the anchor bolts and tighten the nuts securely. Remove the hoisting sling and move the gin pole out of the way.

h. Verify that the antenna is vertical within 10 minutes of arc (wind not over 15 mph) using the procedure outlined in paragraph 4.3.4.7. If the antenna is not vertical within the specified tolerance, loosen the nuts on the mounting bolts and insert shims made of 1/16- and or 1/8-inch aluminum sheet to raise one side of the base as required. The shims can be 3 or 4-inch square and should be placed under the base ring between appropriate mounting bolts.

i. Install the required RG-11/U cable inside the large, lower section of the high-band antenna. Seal it with Duricon and shrink tubing as indicated in Section 4.3.1.1.9.

4.3.4 MAINTENANCE TO REFLECTOR SCREENS. (See Sections 2.4 and 2.6 and Figures 2.4. and 2.6).The high and low-band reflector screens play an important role in the operation of the CDAA. It is important that the screen wires be uniformally spaced around the array, maintained in a true vertical position,and well bonded to the ground bus.

4.3.4.1 BROKEN OR DOWNED SCREEN WIRES. A daily check should be conducted to insure that no screen wires are broken or down. Any broken or down screen wires should be repaired or replaced, as soon as possible.

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4.3.4.2 SCREEN WIRE TERMINATIONS. The screen wire must be well bonded to the ground buss. A monthly inspection should be conducted to insure that the terminations are in good condition. Bonds which look suspicious or show signs of corrosion should be rebonded. All necessary repairs should be performed as soon as possible.

4.3.4.3 GRADE BEAM. The grade beam at the base of the reflecting screens is used to support termination hardware for the lower ends of the screen wires. The grade beams should be kept clear of all foreign matter such as earth, gravel and vegetation. Such foreign matter tends to accumulate and hold moisture which accelerates deterioration of hardware. The grade beams should be inspected quarterly for the accumulation of foreign matter and all such matter should be removed.

4.3.4.4 SCREEN HARDWARE. All screen hardware should be inspected quarterly for signs of corrosion and broken or defective hardware. Binoculars can be used to observe the top of the low-band screen. Main items to look for are corrosion and loose or deteriorated hardware. All corroded areas should be cleaned with a wire brush and an appropriate protective coating applied. Defective or broken hardware should be repaired or replaced as necessary.

4.3.4.5 ANNUAL INSPECTION. In addition to the inspection of Section 4.3.4.4, a very thorough inspection should be conducted yearly. This should include climbing to the top of the screens, conducting a close visual inspection and performing the following:

a. Checking of all hardware located on the upper portions of the poles to ensure that it is in a good state of repair. This check should include an examination of the climbing steps (employed at most stations) to ensure that they are securely embedded into the poles. Retighten or replace any climbing steps that are found loose. Pole tops should be examined for signs of top rot. Sheet metal pole caps should be installed if the tops of the poles are not cut with a slanted roof providing good drainage.

b. Examination of the hardware mounted on the screen pole and associated boomboards for excessive wear. Replace any worn hardware item that would place the screen in jeopardy under adverse weather conditions or that would adversely affect screen operation at and time. Examine the boomboard and pole hardware for signs of rust. Clean rusted areas with a wire brush and coat the cleaned hardware with an appropriate primer paint. Check for loose pole and boomboard hardware, retighten as required.

c. Examination of the boomboards for evidence of excessive drying out. Fill any cracks or checks of appreciable size with wood filler. Paint dried out wooden boomboards with two coats of pentachlorophenol wood preservative applied hot.

d. Inspection of the concrete foundation of the screen pole and verification that the concrete is not cracked or spalled. Patch small cracks and spalls with an epoxy base mortar.

Pack anchor bolts that have become loose with an epoxy base grout. Report any foundation that shows signs of tilting, movement or excessive settlement to the appropriate NAVFAC EFD for engineering determination of the necessary corrective action.

e. Check on the operation of all turnbuckles and coat them with a covering of braycoat to ensure continued free adjustment action. Check to ensure that all locking nuts, pins and safety wires are snug.

f. Inspection of the welds holding the eyes formed on the top end of the guying anchor rods. Reweld any eyes which are opening up. Clean and coat welded areas with an appropriate primer paint.

g. Verification that the screen poles are not out of plumb by more than 10 minutes of arc under a wind condition of not over 15 miles per hour. This is to be done using two surveyor transits as described in paragraph 4.3.4.7. If an adjustment is required to retore a low-band screen pole to a true vertical position, adjust the supporting guys as required. Whenever guys are adjusted, their tensions should be rechecked as described in paragraphs 4.3.7.5 and 4.3.7.6.

h. Examination of all hardware associated with the screen wires for excessive wear, and the replacement of any worn components that might break under adverse weather conditions. Examine all hardware associated with the screen wires for signs of rust. Clean rusted areas with a wire brush and coat the cleaned areas with an appropriate primer paint.

i. Check for loose screen wire hardware and retighten as required. Examine the screen wire for signs of wear. Replace any worn wires that might break under adverse weather conditions and retension in accordance with the tension shown on the original installation drawings. Paragraph 4.3.4.8. contains a suggested procedure for checking the tension in the vertical screen wires. All broken screen wires should be replaced as soon as possible. NAVFAC drawings 80091-1046651 and 80091-1046652 are the standard design for a replacement laminated boomboard. Screen wires should be replaced in accordance with the details shown on these drawings whenever existing boomboards are replaced with new laminated boomboards.

4.3.4.6 PROCEDURE FOR REPLACEMENT OF A DAMAGED SCREEN WIRE.

4.3.4.6.1 Scope of Work. This paragraph provides a detailed procedure for replacing any of the vertical wires of either the low-band or high-band screen. The following equipment will be required:

a. Hard drawn copper wire, #6 AWG.

b. Wire cutter

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c. Properly sized vise grip dead end hardware (if existing needs replacement).

d. Ladder, 30 feet (for high-band screen).

e. Tension gage.

4.3.4.6.2 Procedure. Following is a step-by-step procedure to be used in the replacement of damaged screen wires:

a. Obtain the required length of wire and one or two of the dead end grips required. (See NAVFAC Standard Drawings 80091-1046651 and 80091-1046652).

b. Carrying the installed grip on the end of the wire, climb to the location of the dead end bracket into which the grip is to be fitted. Climb to the upper boomboard of the high-band screen by means of a ladder. Climb to the upper boomboard of the low-band screen by using the steps installed in the pole nearest to the site of the repair. Use all necessary safety precautions when working away from pole on the upper boomboard.

c. Remove the pin and the porcelain spool from the dead end bracket. Remove the spool from the damaged screen wire. Fit the spool into the loop on the end of the replacement wire and reinstall the spool in the dead end bracket. Then, return to the gravel.

d. Pull the screen wire straight and install a dead end fitting near its lower end. Install the grip at a position on the wire that will allow correct tension to be set with the turnbuckle adjusted to approximately its greatest usable length. Leave several feet of screen wire extending beyond the dead end grip. The extra wire will not be tensioned, but some of it is required for connection to the buried ground mat.

e. Using the procedures outlined in paragraph 4.3.4.8 adjust the screen wire tension to the value specified in the A & E drawings.

4.3.4.7 PROCEDURE FOR CHECKING THE VERTICALITY OF SCREEN POLES AND ANTENNA MASTS.

4.3.4.7.1 Verticality. Screen poles and antenna masts should be maintained vertical and not be out of plumb by more than 10 minutes of arc under a wind condition of not over 15 miles per hour. The verticality of screen poles and antenna masts should be checked by using at least two surveyor's transits or equivalent instruments simultaneously.

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4.3.4.7.2 Procedure. The steps to be taken in checking verticality are as follows:

a. Position the surveyor's transits a convenient distance away from and separated by approximately 90° of arc measured from the center of the pole or mast being plumbed.

b. Set up and level the transits.

c. Site and set the vertical cross hair of the transit's telescope on the pole or mast at its base. Set and lock the horizontal axis of the transit. The procedure should be duplicated with each transit.

d. Site and traverse the transit's telescope about its vertical axis taking note of the alignment of the pole or mast with respect to the vertical cross hair as the telescope traverses the length of the pole or mast. This procedure should be duplicated with each transit.

4.3.4.8 PROCEDURE FOR SETTING TENSION IN VERTICAL SCREEN WIRES

4.3.4.8.1 Retensioning. The low-band screen wires should be tensioned as indicated in the A & E drawing and the high-band screen wires to 30 pound. one type of cable tension meter made by Tensitron Incorporated can be used to measure the tension in the screen wires. This instrument operates on the principle of measuring the amount of force required to deflect a wire under tension, a predetermined distance. The intensity of the force is calibrated through instrumentation to indicate the tension in the wire in pounds.

4.3.4.8.2 Tensioning Procedure. The steps in retensioning vertical screen wires are as follows:

a. Adjust the calibration of the cable tension meter in accordance with the instructions accompanying the tension meter being used.

b. Fit the cable deflection type tension meter on to the screen wire.

c. Operate the lever and note the value of tension indicated on the meter.

d. Adjust the turnbuckle at the bottom of the screen wire to increase or decrease the tension to obtain the value specified on the installation drawings.

e. Repeat steps c. and d. as necessary.

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4.3.5 MAINTENANCE TO GROUND PLANE. (See Section 2.7 and Figure 2-7). The ground plane area should be maintained in good condition and kept free of foreign matter at all times. Finding pieces of wood, wire, nuts, bolts or other hardware should be eyed with suspension. This could be an indication of physical deterioration to the antenna or intrusion into the area by unauthorized personnel.

4.3.5.1 VEGETATION. At most installations, vegetation is not permitted to grow in the area of the ground plane. Where necessary or desirable, appropriate herbicides and soil sterilants should be applied in order to restrict vegetation growth. NAVFAC Manual MO-314 and the special assistant for applied biology from the appropriate NAVFAC EFD should be consulted for recommendations prior to applying any soil sterilant or herbicide. At those stations where, due to unsurmountable problems, vegetation is permitted to grow in the area of the ground plane, the vegetation should be kept neat and well trimmed. The ground plane area should be inspected quarterly for uncontrolled growth of grass, weeds, or other vegetation.

4.3.5.2 VEHICULAR TRAFFIC. In general, vehicular traffic should not be allowed over the ground mat and radial wire area. Whenever vehicular traffic is required for maintenance and inspection purposes, special protection such as planking or special vehicles with crawler tracks or large balloon tires should be used. Vehicles which distribute their weight to less than 100 pounds per square foot normally will not harm properly buried ground mats and wires. Additional caution should be exercised at sites where the underlying soil is very soft or where the soil may have become soft due to long soaking rains. If any unauthorized vehicle should happen to drive over the area without the use of protective devices, the underlying wires and mat should be exposed and inspected for damage. All necessary repairs should be made immediately.

4.3.5.3 GROUND PLANE LEVELNESS. The ground mat and radials should be kept flat and level. Check monthly to ensure that the wires have not been exposed due to unauthorized vehicular traffic, careless digging, or forces resulting from frost upheaval. All loose or broken connections should be repaired and all exposed portions should be leveled and recovered.

4.3.5.4 EROSION. Erosion of the ground mat cover may result from high winds or unusual rain water runoff. Any severly eroded areas should be repaired as soon as possible by replacing the lost material. The replaced material should, if practicable, match that of the existing cover. In any event it should consist of aggregate with no sharp jagged edges. The filled area should be graded to an elevation slightly above the grade of the surrounding area in order to allow for settlement. The restored material should be well compacted and stabilized. All large stones or boulders should be removed from the surface. Some sites have drainage ditches with sloping banks around the perimeter of the array. A quarterly check of the sloping bank should be made for evidence of erosion. This type of inspection is particularly important after heavy rainstorms or periods of heavy runoff from melting snow.

Where required, repairs should be made as soon as possible.

4.3.6 MAINTENANCE OF TRANSMISSION LINES. (See Section 2.8 and Figure 2-8). Transmission lines, composed of RG-85A/U, RG-11A/U and RG-12A/U coaxial cables, are used to transmit the RF energy received by each antenna to the RF Distribution Room located in the operations building.

4.3.6.1 PERMAGUM SEAL. The RG-85A/U cables emerge through PVC (polyvinylchloride) tubing at the base of each antenna. The PVC tubing is packed with permagum sealing compound at the point where the cables emerge to prevent the entrance of water into the PVC tubing. The permagum should be inspected quarterly and repacked as required to insure that no water is permitted to enter the tubing.

4.3.6.2 OAKUM/JUTE WRAPPING. The RG-85A/U cable is direct burial cable and possesses a steel armour which is protected by oakum caulking wrapped in jute. The jute wraping, of the cables extending out from the PVC tubing, tends to weather and the jute separates from the steel armour. To insure that the steel does not become exposed and corroded, coat the cable with "Braycoat" and replace the jute. The braycoat will act as an adhesive to hold the jute in place. See Section 4.3.1.1.4.

4.3.6.3 PROCEDURE FOR REPLACEMENT OF RG-85A/U TRANSMISSION CABLE. Under no circumstances shall the RG-85A/U transmission cables be spliced. If damage to a cable is sufficient to require splicing or if for some other reason one requires replacing, the cable shall be dug up and replaced with a new RG-85A/U cable. During removal care must be exercised so as not to disturb other RG-85A/U cables. The new cable should be placed in the trench of the removed cable. It should then be phased matched to the longest RG-85A/U cable in that band of the array. The "NRL sweep-null method of cable matching" provided in Appendix F should be used in this operation. The trench is then filled. The cable should be allowed to settle and age for a period of two weeks. During this period, the settling and aging of the cable may affect its electrical length. For this reason, the cable should be phased matched again to determine if the cable still lies within the tolerable limits of the band. If the cable is found to be electrically out of tolerance, correction can be made to the RG-11A/U cable located at the antenna. This correction will make the combination of the RG-85A/U cable and RG-11A/U cable phase with the other RG-85A/U cables and their associated RG-11A/U cables of the band.

4.3.7 MAINTENANCE OF SUPPORTING GUYS. Guys support the low-band antennas and the low-band screen poles. It is important that these guys be well maintained to prevent catastrophic failure should severe or unusual conditions occur.

4.3.7.1 FIBERGLASS ROD VIBRATION DAMPER.
The fiberglass rods have proven to be reliable, and few failures have occurred in the rods since they were originally installed at the various stations. The weak point of the fiberglass rod is where the rod enters the spelter socket. Experience has shown that when a rod has failed it is usually at this point. It is believed that excessive vibration of the fiberglass rod over a long period of time contributes significantly to deterioration and failure. To reduce vibrations, dampers have been provided for the top outboard fiberglass guy rods of the low-band screen poles. The damper consists of a cylindrical section of neoprene rubber with a hollow interior which is larger in diameter than the outside of the fiberglass rod. The damper is positioned on the fiberglass rod at a point where the vibrating standing wave reaches its maximum amplitude. It is affixed to the rod by inserts at each end and held in place by clamps. When the rod begins to vibrate, the movement of the middle of the damper lags the movement of the rod and thus dampens the amplitude of the rod movement.

4.3.7.2 ANCHORS AND TIE RODS. All anchors and tie rods should be inspected quarterly and immediately after any severe storm, high winds or icing conditions. During this inspection do not dig or disturb the soil around an anchor. The following areas of possible deficiencies should be checked:

a. The guy cables for obvious signs of slackness.

b. The area around and above anchors for signs of movement or soil upheaval.

c. The tie rods for signs of rusting, especially at the point where the rod enters the earth.

d. The welds holding the eyes formed at the top of the anchor rods for signs of cracking or opening up of the eye.

All noted deficiencies should be recorded and reported immediately to the PWO. All needed repairs and adjustments should be accomplished as soon as possible.

4.3.7.3 SUPPORTING GUYS, MONTHLY INSPECTION. All structural guys should be inspected once a month; however, in the event of a severe storm, high winds, or icing, they should be inspected as soon after these occurrences as possible. Using binoculars as required, check for the following possible deficiencies:

a. Cable slackness or signs of lost tension.

b. Loose or broken fittings.

c. Proper turnbuckle operation.

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d. Broken cable strands.

e. Cracks in coated fiberglass rods.

f. Signs of wear at points of intersection of guys with other guys or obstructions.

g. Signs of rust forming in fittings or other areas.

All noted deficiencies should be recorded and reported to the PWO. All needed repairs or adjustments should be accomplished by the maintenance forces immediately.

4.3.7.4 SUPPORTING GUYS, ANNUAL INSPECTION. In addition to the above, the guys should be inspected yearly and the following should be performed:

a. Check of all hardware items for each guy, and replace any worn hardware that would put the guy in jeopardy under advserse weather conditions. Examining all guying hardware for signs of rust. Clean rusted areas with a wire brush and coat the cleaned hardware with an appropriate primer paint. Retighten loose guying hardware, i.e. loose nuts, etc., as required.

b. Verify that all dead end grips are securely attached to their respective guys. If the ends of a dead end grip are not tightly clipped around the guy, they should be sprung into place with a blunt tool that will not scratch the galvanized surface. Check to see that the thimble used with dead end grips on steel guys is not deformed. Examine all guy cables that cross one another to ensure that they are protected from abrasive wear with a chaffing sleeve or cable spacer. Existing chaffing sleeves and underlying cables should be examined for hidden signs of corrosion or weakness caused by trapped moisture.

c. Examine all fiberglass rods for signs of wear. Any areas of the rods that have had the surface coatings chipped or worn away should be examined for glass fiber deterioration. Deterioriation is indicated by areas of loose glass fibers appearing as a fuzz over the surface ~~or~~ areas of delamination or indentations. The fiberglass rods should be closely examined for signs of weakening at the point of entrance of the rods into the end fittings. Any rod that shows signs of excessive wear or weakness should be replaced.

4.3.7.5 PROCEDURE FOR SETTING TENSION IN FIBERGLASS RODS.

4.3.7.5.1 Retensioning. Retensioning operations must be performed on a complete set of guys simultaneously. A complete set of guys comprises all of the guys at one level of attachment to a single low-band reflector screen pole, or a combination of the low-band reflector

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screen pole and low-band antenna mast guys. The procedure for tensioning wire rope guys (paragraph 4.3.7.6) should be used in combination with this system at levels where both fiberglass and metalic wire ropes constitute a set of guys at one level.

4.3.7.5.2 Tensioning Devices. The special tensioning devices shown in Figures 4-5 and 4-6 should be used for tensioning the antenna fiberglass guys. At most stations this equipment was specified to be part of the original installation equipment and was to be left on site by the installation contractor upon completion of the contract. At least three sets of devices are required at most sites. Those sites that have all fiberglass rods instead of wire rope guys on the inner circle of the array require at least four sets of devices. Each set consists of an upper device bar assembly, two dynamometers, and lower device bar assembly. Following is a description of these devices:

a. The upper device bar assembly consists of a galvanized steel upper bar and two 5/8-inch by 6-inch eyebolts and nuts. The bar is fashioned to fit over the socket of the lower guy line piece.

b. Traction type dynamometers (see Figure 4-5) with a capacity of 0 to 500 pounds are utilized in pairs to measure the guy tension load. The mechanism of the dynamometer includes a deflection beam and a custom-built gauge movement. Load is transmitted to the mechanism by means of clevis attachments at each end of the beam. The mechanism never required lubrication; however, it is recommended that a light lubricant be applied sparingly to the shackle pins occasionally. A special fine thread adjustment screw is provided for setting the dynamometer at zero. The screw is located beneath a small opening at the top of the mechanism case. When adjusting dynamometer for zero, use care to ensure that the screwdriver does not slip and jam into the mechanism. Always turn adjusting screw in the direction that will return pointers to zero through least degree of travel.

c. The lower device bar assembly consists of a galvanized steel lower bar and two 5/8-inch by 9-inch turnbuckle assemblies. The eye ends of the turnbuckle attach through the lower device bar and the clevis ends attach to the lower dynamometer clevises. A crescent slot is machined in the upper surface of the bar for adjustment of the guy anchor eye.

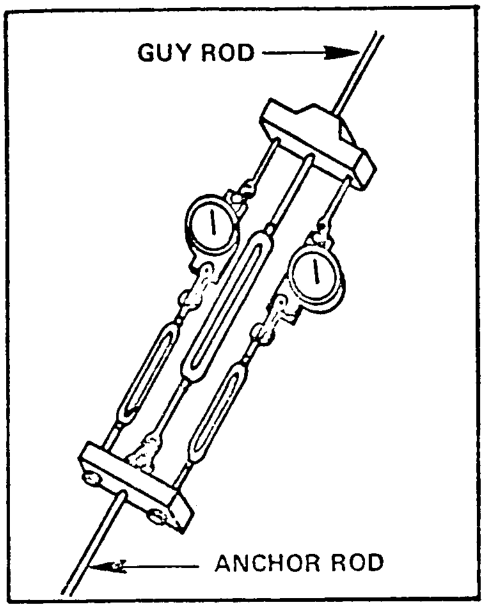
4.3.7.5.3 Tensioning Procedure. Following is the prescribed tensioning procedures.

a. Working with one complete set of guys at a time loosen guy turnbuckles until all guy lines at one level are made slack.

b. Adjust dynamometer for zero as required.

d. Assemble tensioning devices (see Figure 4-5 and 4-6). When assembling the tensioning devices, make certain the proper dynamometers are used. Certain dynamometers are especially calibrated for tensioning guys requiring loads of 100 pounds or less. Refer to

CHANGE 1



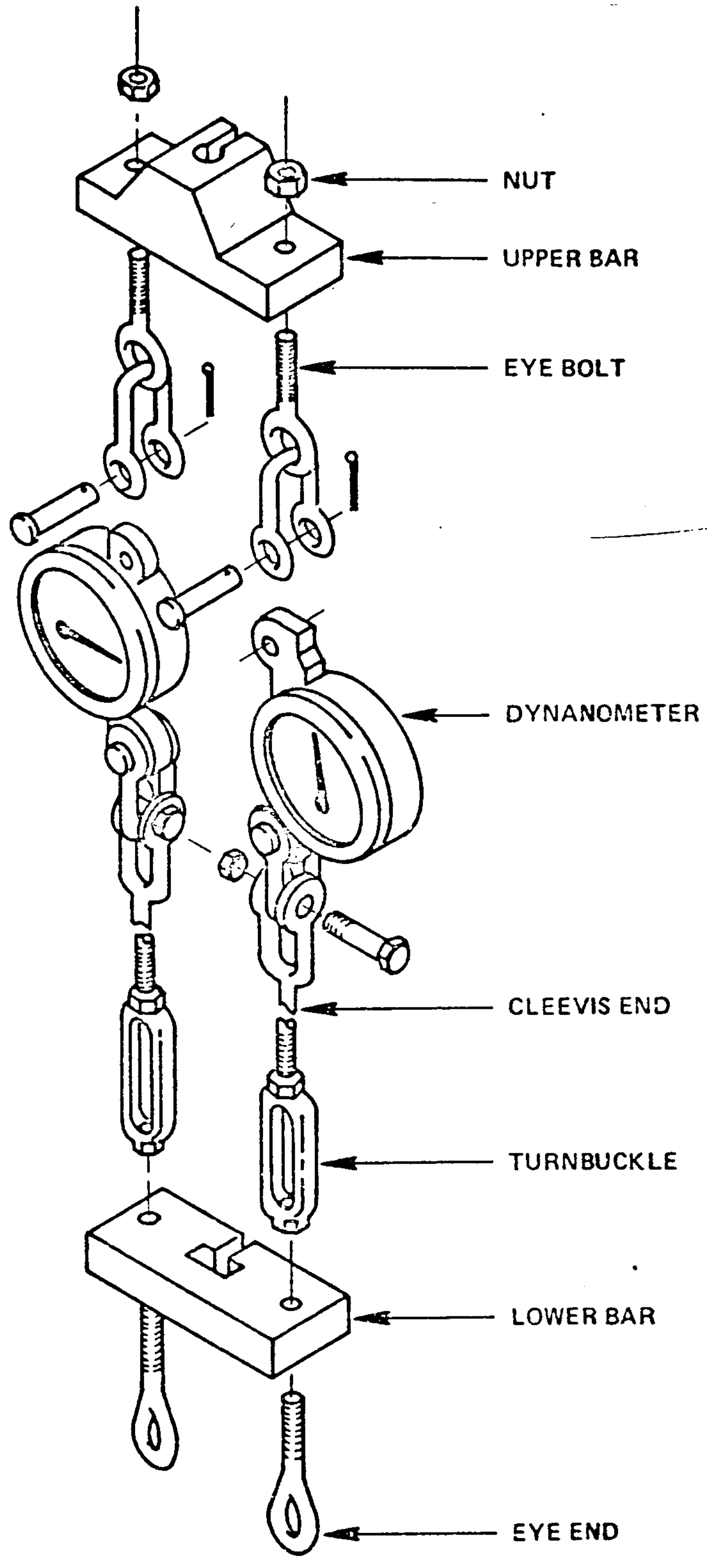
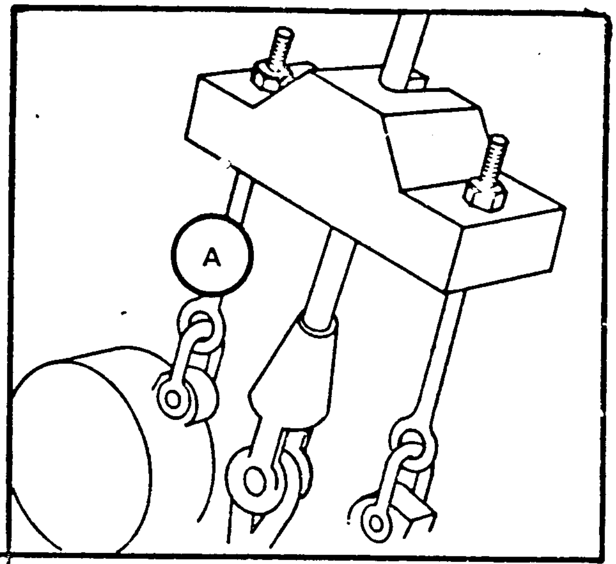
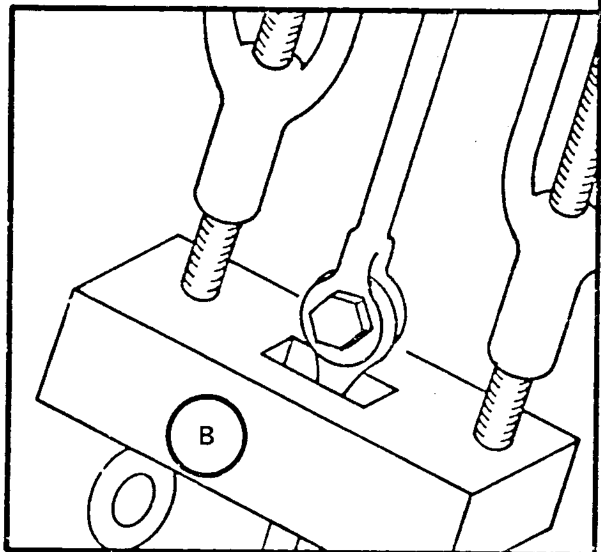


Figure 4-5 - Details of Dynamometers for Measuring Tension in Fiberglass Rods

CHANGE 1

LIFT DEVICE ASSEMBLY SUFFICIENTLY SO THAT UPPER BAR IS INSTALLED OVER GUY ROD ABOVE THE SOCKET SLEEVE.





ADJUST GUY TURNBUCKLE AS NECESSARY TO KEEP CLEVIS END FROM BEARING ON LOWER DEVICE BAR.

HOLD EYE END OF TURNBUCKLE SECURE TO ENSURE NO TWIST IS INTRODUCED IN GUY LINE DURING ADJUSTMENT.

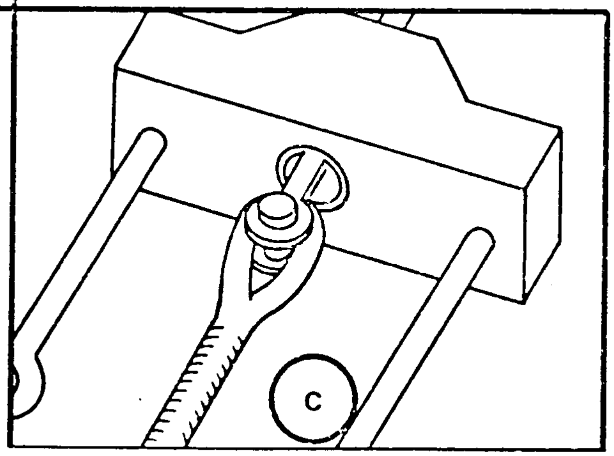


Figure 4-6- Details for Installing Dynamometers for Measuring Tension in Fiberglass Rods

CHANGE 1

original architectural and engineering drawings for specific values of tension to be set on each guy.

d. Position upper device bar over guy socket. To preclude damaging sleeve, lift device assembly sufficiently so that upper bar is installed over guy rod above the socket sleeve. Carefully lower device bar on socket (see View A of Figure 4-6).

e. Place lower device bar in position on guy anchor rod.

f. Note dynamometer readings before applying any load to guy. The reading noted in this step is the static weight of the device assembly and must be added to the required guy tension load.

g. Position guy line pieces in line with each other so that no twist is imposed on any piece.

h. Adjust device turnbuckles evenly until required load (indicated on the original installation drawings for the guy being worked on) is obtained and poles and/or masts are plumb. See paragraph 4.3.4.7 for method of checking verticality of poles and mast using surveyor transits. Make certain that allowances are included for static weight of device assembly.

i. Note that the tension load is the total of both dynamometers. Tensioning must be performed on a complete set of guys simultaneously. As the device turnbuckles are tightened adjust the guy (center) turnbuckles as necessary to keep the clevis end from bearing on the lower device bar, but do not impose any load on the guy. (See View B, Figure 4-6).

j. Tighten all guy (center) turnbuckles simultaneously until load is relieved from post tensioning device. Hold eye end of turnbuckles secure (See View C of Figure 4-6) to ensure that no twist is introduced in guy lines during adjustment.

k. Remove tensioning devices.

4.3.7.6 PROCEDURE FOR SETTING TENSION IN WIRE ROPE GUYS.

4.3.7.6.1 Retensioning. Retensioning must be performed on a complete set of guys simultaneously. A complete set of guys comprises all the guys at one level of attachment to a single low-band reflector screen pole or a combination of the low-band reflector screen pole and low-band antenna mast guys. The procedure for tensioning fiberglass rods (paragraph 4.3.7.5) should be used in combination with this system where both metallic wire ropes and fiberglass rods constitute a set of guys at one level. Figure 4-6 shows the arrangement of equipment for measurement of tensions in wire rope guys. The system consists of a dynamometer directly in series with a conventional chain hoist and a cam action cable grip. At least two of these systems are required at most sites and should be used in combination with one fiberglass rod tensioning device as described in paragraph 4.3.7.5

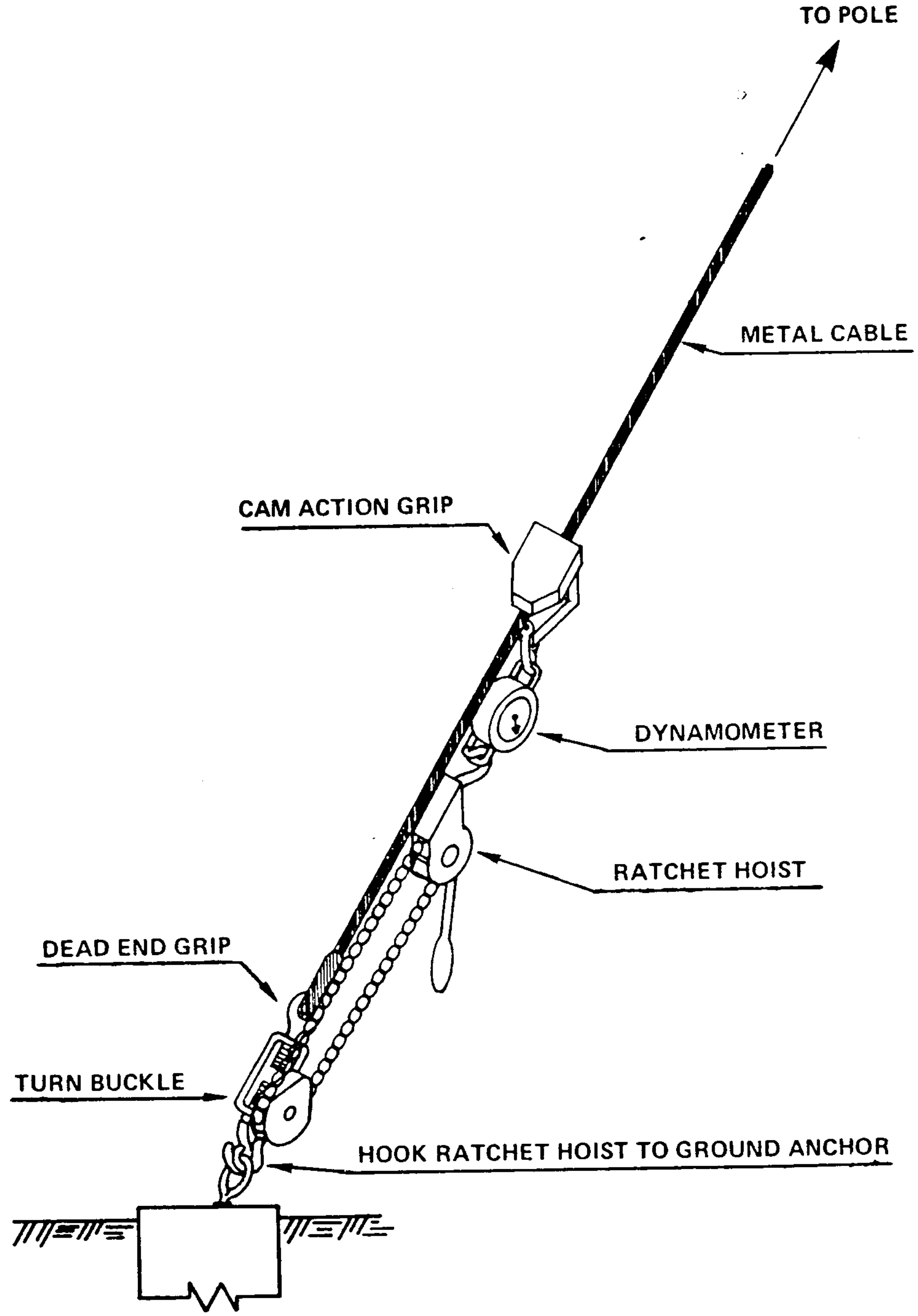


Figure 4-4 - Method of Measuring Tension in Wire Rope Guys

CHANGE 1

4.3.7.6.2 Tensioning Procedure. Following are the steps to be taken during retensioning:

a. Attach the cam action grip to the wire rope approximately 5 feet above the dead end grip at the bottom of the guy.

b. Attach a dynamometer of suitable range (as indicated by post tension values shown on the original installation drawings) to the cam action grip.

c. Attach a chain hoist between the anchor eye and the dynamometer.

d. Operate the ratchet of the chain hoist until the dynamometer indicates the specified tension.

e. Tighten the turnbuckles until the chain hoist slackens and the dynamometer reads essentially zero.

f. Verify by means of two survey transits (see paragraph 4.3.4.7 that the screen pole is vertical within 10 minutes of arc (wind not over 15 mph).

g. Slacken the chain hoist itself until it can be unhooked from the anchor eye.

h. Remove the dynamometer and the cam action grip.

i. Tighten the turnbuckle locknuts or safety wires.

4.3.8 MAINTENANCE RECORDS. An important part of the structural/mechanical maintenance program is keeping accurate, up-to-date records on all inspections and maintenance performed. The records reflect a history of the CDAA and provide a valuable continuity link over the years. These records should be analyzed to detect areas of degradation and maintenance problem areas. A complete set of records should include the following:

a. Detailed records of all inspections conducted.

b. Detailed records of all maintenance performed.

c. Detailed records of all funds expended.

d. "Daily Log" recording all major happenings and events.

4.3.8.1 Figure 4-8 and 4-9 are the type record forms recommended for keeping track of all inspections and maintenance performed. The form shown in Figure 4-8 is a working form which antenna maintenance personnel can conveniently carry into the field when performing inspections and maintenance. The form shown in Figure 4-9 (NAVSHIPS Form 536) is a permanent record card on which the information can be transferred from the working form for permanent record purposes.

4.3.8.2 A separate NAVSHIPS form should be maintained current for each component of the array as follows:

a. Each high-band antenna.

b. Each high-band screen panel.

c. Each low-band antenna.

d. Each low-band screen panel.

e. Ground plane.

4.4 INSPECTION AND MAINTENANCE SCHEDULES.

The following inspection and maintenance schedules are provided as a guide for antenna maintenance personnel to plan and prepare their work during the continuous on-going maintenance program necessary to insure the CDAA remains in peak operational condition. This schedule has been prepared thru visual inspection and electronic testing at numerous CDAA stations while considering the climatic conditions in which the CDAAs were located. Some stations may eventually determine that it is necessary to modify the schedule somewhat to meet local needs.

4.4.1 DAILY. A daily inspection should be conducted to detect any serious distress. This should consist of a walk around the array to detect signs of deficiencies as follows:

a. Broken or obviously slack guys.

b. Broken screen wires.

c. Other signs of obvious structural distress.

CHANGE 1

CHAPTER 5

CDAA ELECTRONIC MAINTENANCE

5.1 INTRODUCTION

This chapter describes the CDAA electronic maintenance procedures to be performed by qualified personnel under direct control of the electronic material officer.

5.2 SCOPE

Electronic maintenance of the CDAA includes all the functions involved in inspecting and testing the electronic properties of the array and its components to insure peak operational performance, prevent system deterioration and avoid costly repairs resulting from inadequate maintenance.

5.3 ELECTRONIC TESTING MAINTENANCE

The AN/FRM-19(v) antenna test set and the TDR (Time Domain Reflectometer) are test equipment used to measure certain electronic characteristics of the antenna and their associated transmission lines. The AN/FRM-19(v) is used to compare the phase and amplitude characteristics of one antenna and its associated transmission line with the phase and amplitude characteristics of another antenna of the same frequency band and its associated transmission line. An impedance change in an antenna/transmission line will cause a change in the phase and or amplitude characteristics of a received radio signal. When the AN/FRM-19(v) is used and such an impedance change is found to exist which causes the phase and/or amplitude characteristics to be outside of the defined tolerable limits, the TDR can be used as an aid to determine the cause and location of the impedance change.

5.3.1 AN/FRM-19(v) ANTENNA TEST SET. The AN/FRM-19(v) antenna test set shown in Figure 5-1 is special test equipment designed for use in maintaining the CDAA. Chapter 3 describes why each and every antenna and its associated transmission line must possess nearly identical impedance characteristics in order for the phase and amplitude characteristics to remain within tolerable limits. The AN/FRM-19(v) provides simulated high-and low-band signals which are used to test the phase/amplitude characteristics of the high-and low-band antennas and their associated transmission lines and multicouplers. The test set propogates a signal of a given frequency down a selected transmission line to the antenna. The antenna radiates the signal which is absorbed by the immediate neighboring antenna on each side. This signal is then rerouted through the antennas associated transmission lines and multicouplers back to the test set. The test set measures the difference between the amplitude and phase of the two signals and displays the differences in decibles and degrees on an oscilloscope. A plastic overlay on the oscilloscope is used to determine if the phase and amplitude of the two signals are within the cumulative tolerable limits of their respective bands.

5.3.1.1 Function. The AN/FRM-19(v) indicates by a digital display which antenna has been selected as the radiating path. It indicates and compares the amplitude and phase characteristics of the adjacent antennas and their associated transmission lines and multicouplers. For the purposes of this description, it is assumed that the phase 1 amplitude characteristics

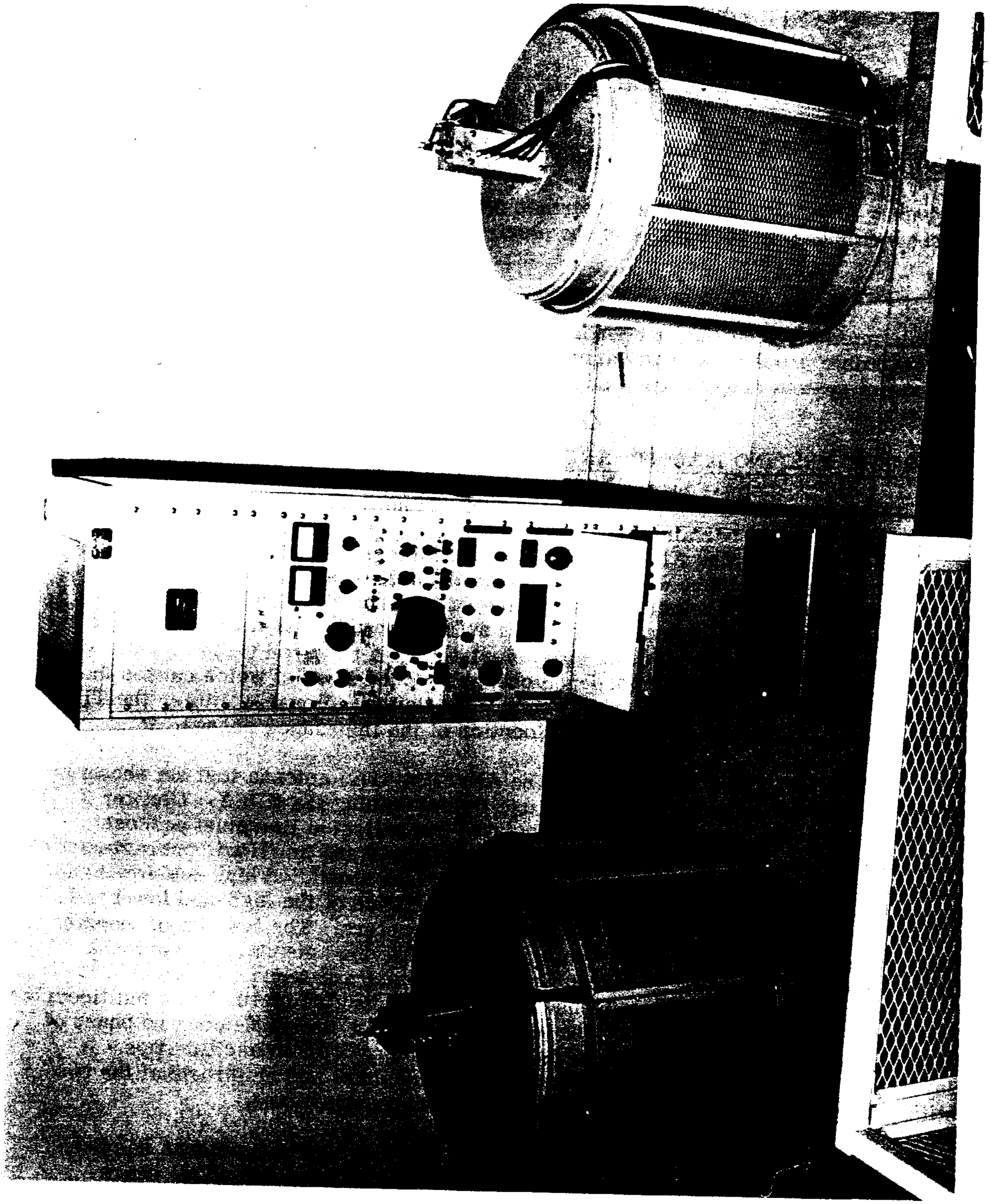
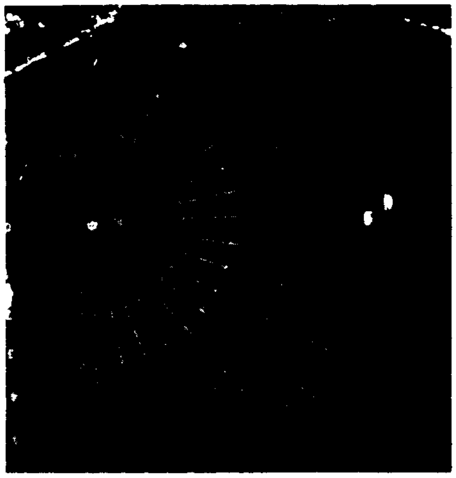
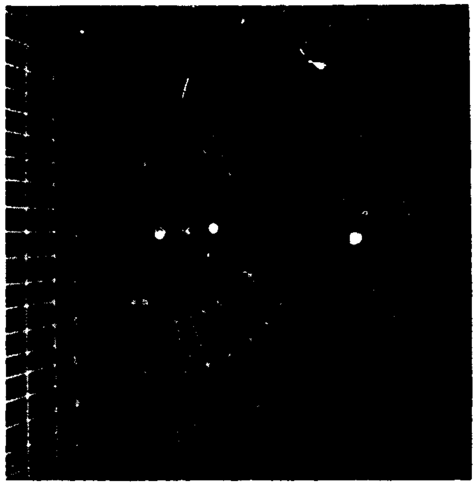


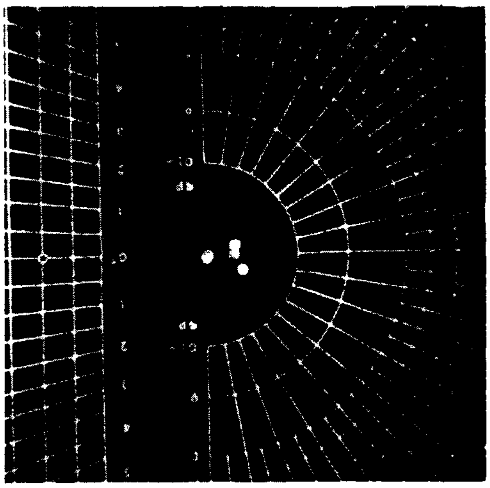
Figure 5-1 - AN/FRM-19(v) Antenna Test Set



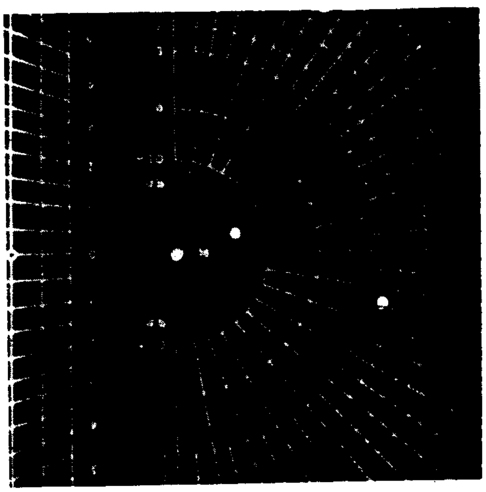
(a) HIGH BAND 27



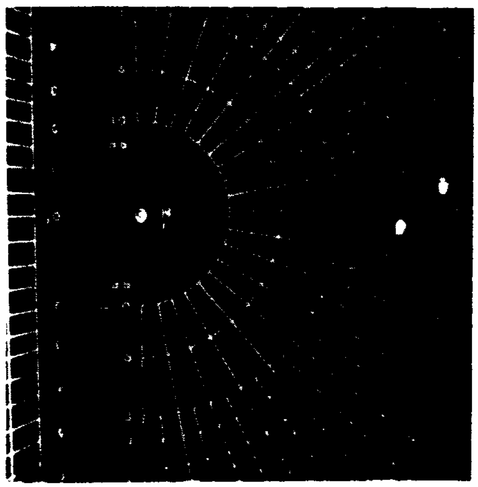
(b) HIGH BAND 28



(c) HIGH BAND 29



(d) HIGH BAND 30



(e) HIGH BAND 31

Figure 5-2 - Oscilloscope Presentations of AN/FRM-19(v)

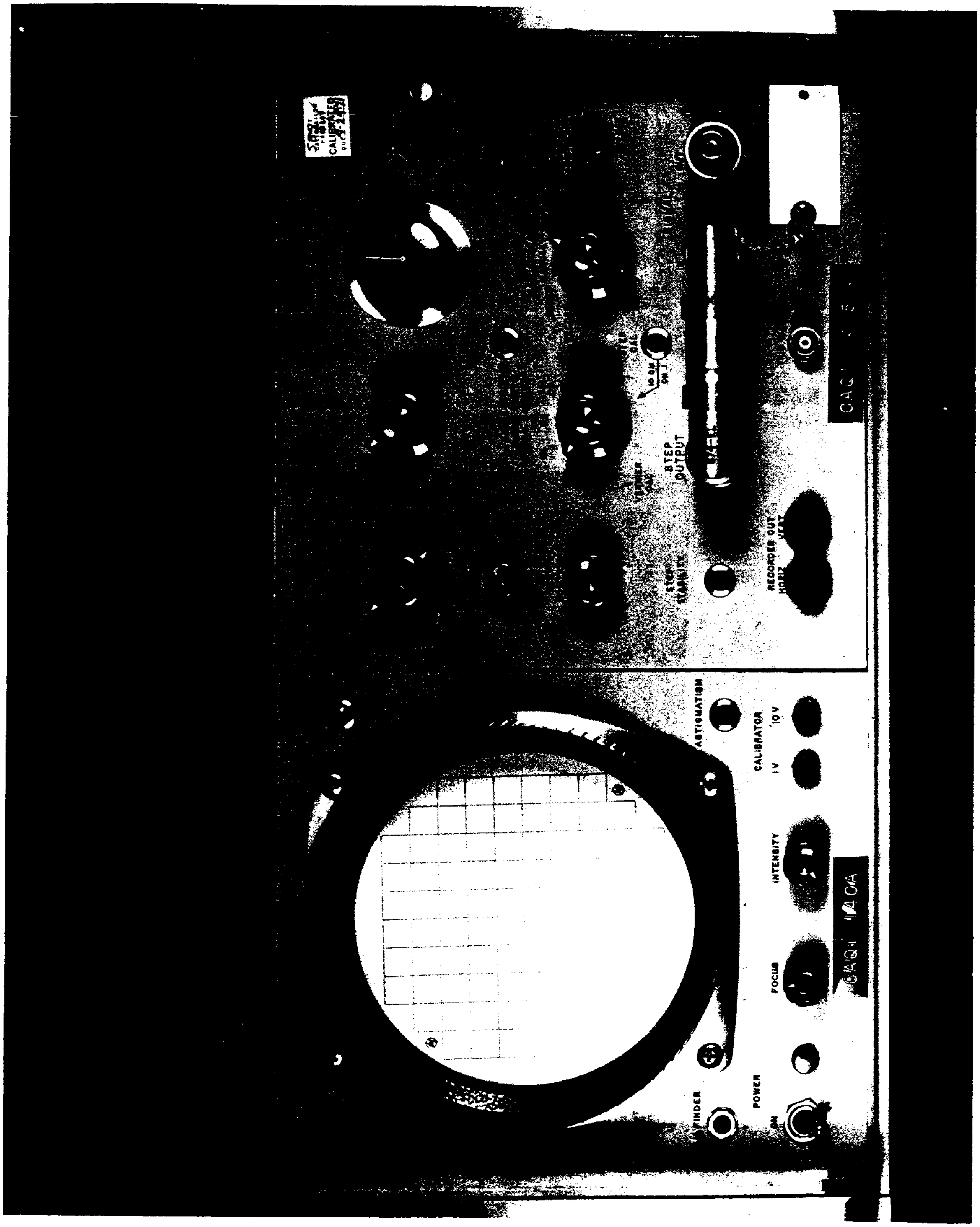
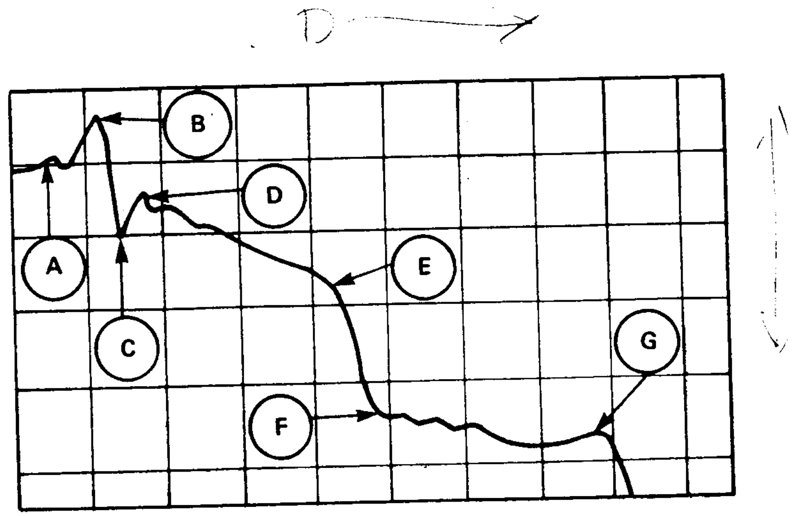
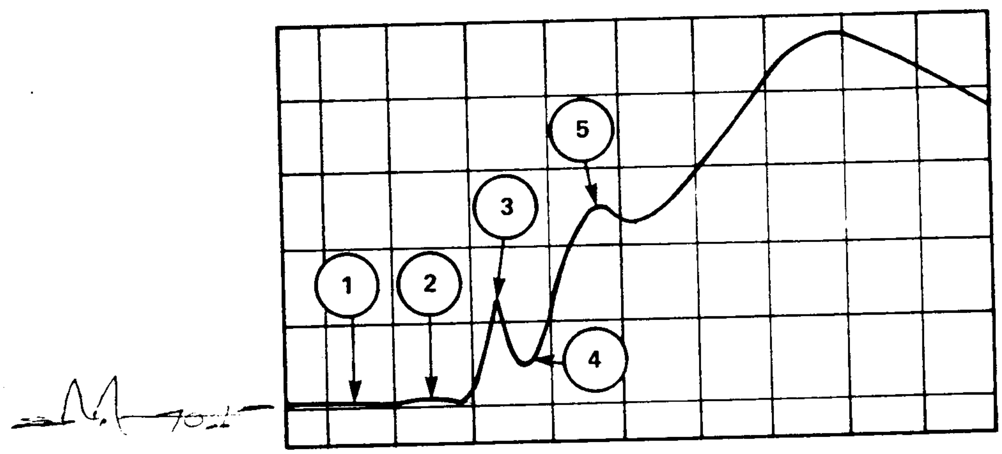


Figure 5-3 - HP1415A Time Domain Reflectometer



(A)
LOW–BAND ANTENNA



(B)
HIGH–BAND ANTENNA

Figure 5-4 - Typical TDR "Signatures"

of the multicouplers are within their tolerable limits. (Before running the test on the antenna, the AN/FRM-19(v) should be put in the coupler mode and the multicouplers tested. This insures that any defects found when in the antenna mode will be in the antennas or transmission lines and not in the multicouplers.) If a defect exists in either path, the phase/amplitude of the returning signal will lie outside of their tolerable limits on the oscilloscope display. The process of elimination is then used to determine which of the two paths is defective; by comparing these two paths with two adjacent antennas the defective path will again be detected.

The following series of photographs (Fig. 5-2) provide an example of how these defects are detected. Antennas 26 through 32 are compared. Antenna 29 (Fig. 5-2c) is the only one having a defect. Figure 5-2a, radiating on antenna 27 with paths 26 and 28 being compared, is a good presentation. In Figure 5-2b, a good path 27 is compared to defective path 29. A drastic difference in gain is observed. In Figure 5-2c, the defective path of antenna 29 is used to radiate upon. Very little signal is received on either paths 28 or 30. This process is then repeated in reverse as antenna 30 and 31 are used as the radiating paths. By observing patterns such as these it is possible to determine which path contains the defect. Each path affects the presentation in three successive positions. Defects of various kinds and degrees in several paths in one area will produce somewhat more complex patterns than here illustrated, but analysis is still possible. For more information on the analysis of the oscilloscope presentations refer to the AN/FRM-19(v) technical manual.

5.3.1.2 Application. The AN/FRM-19(v) should be used daily to test the antenna array and transmission lines. A quick check with the AN/FRM-19(v) in the normal mode of operation and the index drive in the continuous position can be performed in about half an hour. A more elaborate test in which readings are taken and recorded should be conducted weekly. These weekly records can then be studied for signs of deterioration trends.

5.3.2 TIME DOMAIN REFLECTOMETER. The Hewlett-Packard Model 1415A TDR (Time Domain Reflectometer) shown in Figure 5-3 is off the shelf test equipment which is used to determine the location of undesired impedance mismatches which may occur in the antenna and their associated transmission lines. These impedance mismatches can be caused by such malfunctions as open connectors, moisture, crushed cables, open resistors, etc. In most cases the location and cause of the impedance mismatch can be determined by use of the TDR.

5.3.2.1 Function. Upon discovery of a defect, the TDR is used to determine the location and cause of the defect. The TDR measures and displays on an oscilloscope the impedance characteristics of each antenna and its associated transmission line. The oscilloscope, utilizing an artificially generated time base, is calibrated to display the impedance level versus the electrical length of the antenna and its transmission line. Henceforth, such an oscilloscope display, since it is unique to a particular circuit, will be referred to as the "signature" of the circuit. The oscilloscope CRT can be photographed, recording the impedance characteristics for future use. A chart recorder can also be used for this function.

Figure 5-4 illustrates the TDR response signatures to representive low-band and high-band antennas (Fig. 5-4a and 5-4b). In Figure 5-4a, "A" represents the characteristic impedance of the RG-85A/U cable. "B" represents the inductive response to the coupling transformer. "C" indicates the negative "kick" that is unexplained at this point in time. "D" indicates the point at which the mast begins to be seen. At point "E" it is not certain what point in the antenna is represented here but it may be the top of the mast. At point "F" the terminating resistors are encountered, and at point "G" an inductive "kick" is shown just before dropping to ground. This inductive "kick" was caused by a wire-wound inductive resistor which is not recommended for CDAA usage. In the high-band diagram "1" represents the characteristic impedance of the RG 85A/U cable, "2" the connection of the RG 85A/U cable to the RG 11A/U cable, and "3" the connector which screws into the antenna. "4" indicates the bottom of the upper mast of the antenna, and "5" is the top of the antenna. The rest of the trace is reflection caused by an unterminated path. If a defect is present in the transmission line or the antenna the change in impedance will cause energy to be reflected back up the line and cause a change to occur on the signature. Paragraph 5.3.2.2, following, shows the affects on the signature of several defects which have been intentionally inserted into the paths to illustrate the use of the TDR.

5.3.2.2 Typical Defects

a. Figure 5-5 presents the signatures of some typical low-band antenna defects. with the TDR setting as follows:

Distance/Time:	2000 cm/cm
Magnitude:	5
Reflective Coefficient	Ø.1

Figure 5-5a is the signature of a good low-band antenna, Figure 5-5b is that of a shorted resistor, Figure 5-5c is an open resistor, and Figure 5-5d is the signature when both resistors are open.

b. Figure 5-6 presents the signatures of some typical high-band antenna defects with the TDR settings as follows:

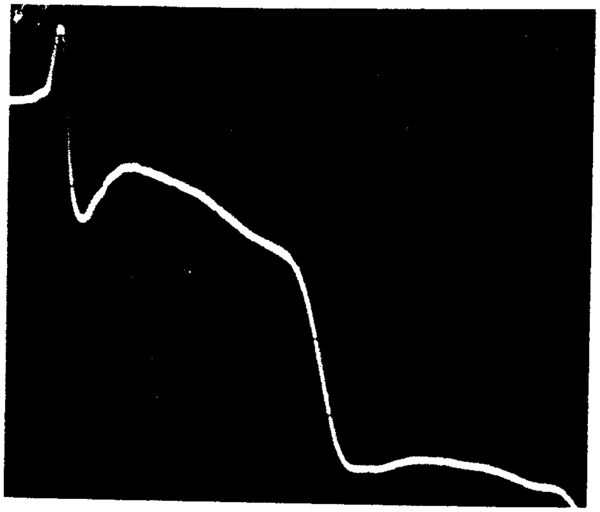
Distance/Time	2000 cm/cm
Magnitude	20
Reflective Coefficient	Ø.1

Figure 5-6a illustrates a good high-band antenna, Figure 5-6b is an open gound at the antenna end of the RG 11A/U jumper cable, and Figure 5-6c is a high resistance between the RG 11A/U jumper cable and the RG 85A/U cable.

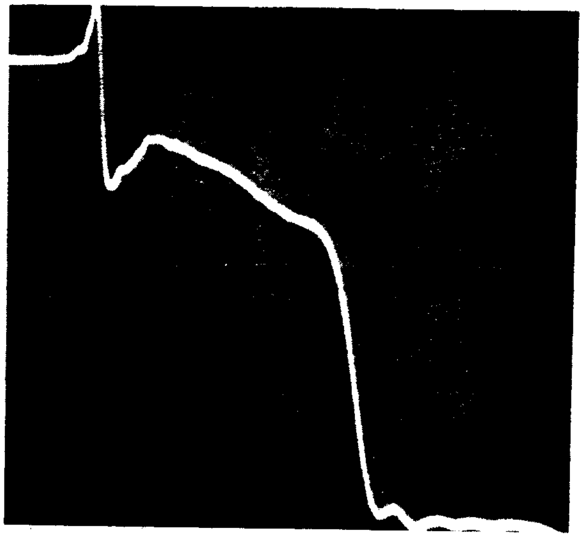
5.3.2.3 Application. The TDR is recommended for use under the following conditions:

a. To obtain pictures of the signatures of each of the antennas and file for future reference. If at some time in the future, an antenna is suspected of being defective, its signature may be compared with its reference signature to see if a change has occurred.

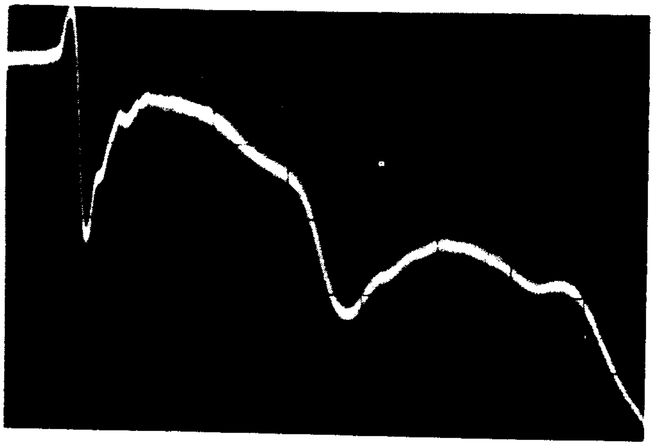
b. To obtain a picture of the signature each time an antenna is found to be defective. When the cause of the defect has been determined, the signature can be associated with the defect. If in the future another defect is encountered with a like signature, the defect will probably be of the same type. For this reason a file should be kept on the signatures of all defects encountered. These files can be used to aid in determining the cause of the defect.



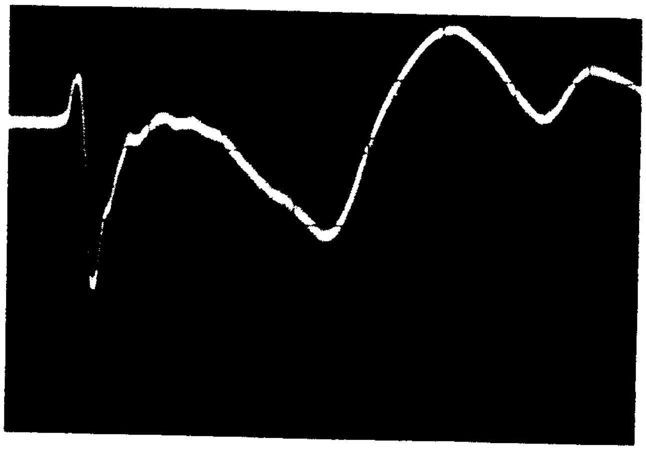
(a) GOOD LOW-BAND ELEMENT



(b) SHORTED RESISTOR

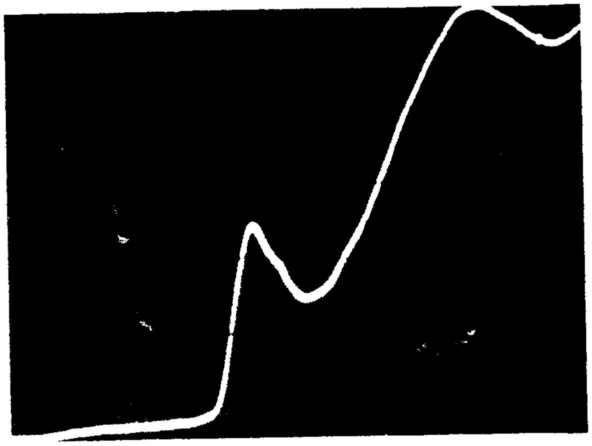


(c) ONE RESISTOR OPENED

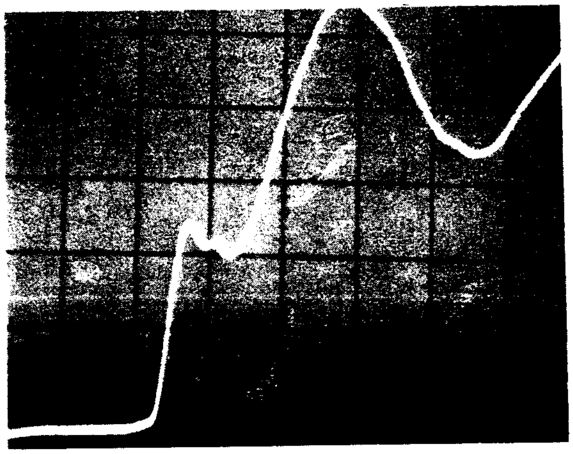


(d) BOTH RESISTORS OPENED

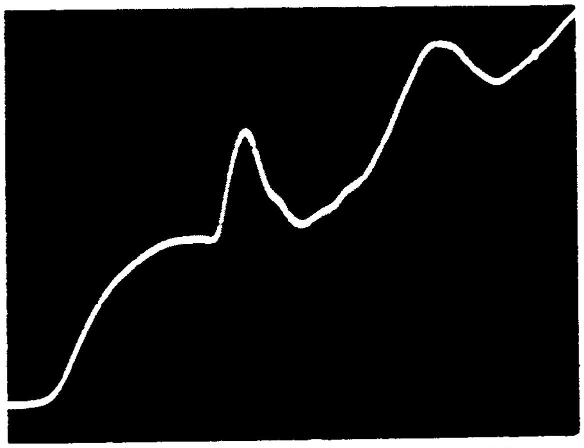
Figure 5-5 - TDR "Signatures" of Low-band Antenna Defects



(a) GOOD HIGH-BAND ELEMENT



(b) OPEN GROUND IN THE RG-11 JUMPER



(c) HIGH RESISTANCE BETWEEN RG-11 JUMPER AND RG-85A/U CABLE

Figure 5-6 - TDR "Signatures" of High-band Antenna Defects

APPENDIX A

CDAA CONSTRUCTION COST ESTIMATE

The following is the latest (1970) cost estimate to construct a CDAA. The cost will vary from station to station due to geographical location, climate, local labor costs, etc. However, the dollar value indicated may be used as a guide in programming and budgeting for any work to be performed on the CDAA in the near future. Cost estimates include hardware and installation.

COMPONENT	WITH L.B. POLES	WITH L.B. TOWERS
Site Preparation	$200,000	$200,000
Low-Band Screen	131,000	200,000
Low-Band Antennas	63,000	63,000
High-Band Screens	89,000	89,000
High-Band Antennas	81,000	81,000
Transmission Cables	149,000	149,000
Ground Mat and Radials	106,000	106,000
	$819,000	$888,000

APPENDIX B

DIFFERENCES BETWEEN ANTENNA GROUPS OA-3967(XN-1)/FRD(v) AND OA-3967/FRD(v)

ITEM	Antenna Group OA-3967(XN-1)/FRD-10(v)			Antenna Group OA-3967/FRD-10(v)		
	RADIUS (ft)	HEIGHT (ft)	QUANTITY	RADIUS	HEIGHT	QUANTITY
L. B. SCREEN	215'	120'		366'	90'	
L. B. ANTENNA	260'		30	393.5'		40
H. B. SCREEN	300'			423.5'		
H. B. ANTENNA	311'			436.75'		
GROUND MAT	215'-365'			366'-493.5'		
RADIALS	365'-515'			493.5'-643.5'		
L. B. FREQUENCY	2-8 MHz			2-9 MHz		
H. B. FREQUENCY	8-32 MHz			9-32 MHz		

APPENDIX C

LOW-BAND ANTENNA DESIGNATIONS AND AZIMUTHAL BEARINGS

ANTENNA DESIGNATION	BEARING (degrees)	NUMONIC A	NUMONIC B
1	4.5	N-36	NE-31
2	13.5	N-37	NE-32
3	22.5	N-38	NE-33
4	31.5	N-39	NE-34
5	40.5	N-40	NE-35
6	49.5	E-31	NE-36
7	58.5	E-32	NE-37
8	67.5	E-33	NE-38
9	76.5	E-34	NE-39
10	85.5	E-35	NE-40
11	94.5	E-36	SE-31
12	103.5	E-37	SE-32
13	112.5	E-38	SE-33
14	121.5	E-39	SE-34
15	130.5	E-40	SE-35
16	139.5	S-31	SE-36
17	148.5	S-32	SE-37
18	157.5	S-33	SE-38
19	166.5	S-34	SE-39
20	175.5	S-35	SE-40
21	184.5	S-36	SW-31
22	193.5	S-37	SW-32
23	202.5	S-38	SW-33
24	211.5	S-39	SW-34
25	220.5	S-40	SW-35
26	229.5	W-31	SW-36
27	238.5	W-32	SW-37
28	247.5	W-33	SW-38
29	256.5	W-34	SW-39
30	265.5	W-35	SW-40
31	274.5	W-36	NW-31
32	283.5	W-37	NW-32
33	292.5	W-38	NW-33
34	301.5	W-39	NW-34
35	310.5	W-40	NW-35
36	319.5	N-31	NW-36
37	328.5	N-32	NW-37
38	337.5	N-33	NW-38
39	346.5	N-34	NW-39
40	355.5	N-35	NW-40

APPENDIX D

HIGH-BAND ANTENNA DESIGNATIONS AND AZIMUTHAL BEARINGS

ANTENNA DESIGNATION	BEARING	NUMONIC A	NUMONIC B
1	001.5°	N-16	NE-1
2	004.5°	N-17	NE-2
3	007.5°	N-18	NE-3
4	010.5°	N-19	NE-4
5	013.5°	N-20	NE-5
6	016.5°	N-21	NE-6
7	019.5°	N-22	NE-7
8	022.5°	N-23	NE-8
9	025.5°	N-24	NE-9
10	028.5°	N-25	NE-10
11	031.5°	N-26	NE-11
12	034.5°	N-27	NE-12
13	037.5°	N-28	NE-13
14	040.5°	N-29	NE-14
15	043.5°	N-30	NE-15
16	046.5°	E-1	NE-16
17	049.5°	E-2	NE-17
18	052.5°	E-3	NE-18
19	055.5°	E-4	NE-19
20	058.5°	E-5	NE-20
21	061.5°	E-6	NE-21
22	064.5°	E-7	NE-22
23	067.5°	E-8	NE-23
24	070.5°	E-9	NE-24
25	073.5°	E-10	NE-25
26	076.5°	E-11	NE-26
27	079.5°	E-12	NE-27
28	082.5°	E-13	NE-28
29	085.5°	E-14	NE-29
30	088.5°	E-15	NE-30
31	091.5°	E-16	SE-1
32	094.5°	E-17	SE-2
33	097.5°	E-18	SE-3
34	100.5°	E-19	SE-4
35	103.5°	E-20	SE-5
36	106.5°	E-21	SE-6
37	109.5°	E-22	SE-7
38	112.5°	E-23	SE-8
39	115.5°	E-24	SE-9
40	118.5°	E-25	SE-10
41	121.5°	E-26	SE-11
42	124.5°	E-27	SE-12

ANTENNA DESIGNATION	BEARING	NUMONIC A	NUMONIC B
43	127.5°	E-28	SE-13
44	130.5°	E-29	SE-14
45	133.5°	E-30	SE-15
46	136.5°	S-1	SE-16
47	139.5°	S-2	SE-17
48	142.5°	S-3	SE-18
49	145.5°	S-4	SE-19
50	148.5°	S-5	SE-20
51	151.5°	S-6	SE-21
52	154.5°	S-7	SE-22
53	157.5°	S-8	SE-23
54	160.5°	S-9	SE-24
55	163.5°	S 10	SE-25
56	166.5°	S-11	SE-26
57	169.5°	S-12	SE-27
58	172.5°	S-13	SE-28
59	175.5°	S-14	SE-29
60	178.5°	S-15	SE-30
61	181.5°	S-16	SW-1
62	184.5°	S-17	SW-2
63	187.5°	S-18	SW-3
64	190.5°	S-19	SW-4
65	193.5°	S-20	SW-5
66	196.5°	S-21	SW-6
67	199.5°	S-22	SW-7
68	202.5°	S-23	SW-8
69	205.5°	S-24	SW-9
70	208.5°	S-25	SW-10
71	211.5°	S-26	SW-11
72	214.5°	S-27	SW-12
73	217.5°	S-28	SW-13
74	220.5°	S-29	SW-14
75	223.5°	S-30	SW-15
76	226.5°	W-1	SW-16
77	229.5°	W-2	SW-17
78	232.5°	W-3	SW-18
79	235.5	W-4	SW-19
80	238.5°	W-5	SW-20
81	241.5°	W-6	SW-21
82	244.5°	W-7	SW-22
83	247.5°	W-8	SW-23
84	250.5°	W-9	SW-24
85	253.5°	W-10	SW-25
86	256.5°	W-11	SW-26
87	259.5°	W-12	SW-27
88	262.5°	W-13	SW-28
89	265.5°	W-14	SW-29

ANTENNA DESIGNATION	BEARING	NUMONIC A	NUMONIC B
90	268.5°	W-15	SW-30
91	271.5°	W-16	NW-1
92	274.5°	W-17	NW-2
93	277.5°	W-18	NW-3
94	280.5°	W-19	NW-4
95	283.5°	W-20	NW-5
96	286.5°	W-21	NW-6
97	289.5°	W-22	NW-7
98	292.5°	W-23	NW-8
99	295.5°	W-24	NW-9
100	298.5°	W-25	NW-10
101	301.5°	W-26	NW-11
102	304.5°	W-27	NW-12
103	307.5°	W-28	NW-13
104	310.5°	W-29	NW-14
105	313.5°	W-30	NW-15
106	316.5°	N-1	NW-16
107	319.5°	N-2	NW-17
108	322.5°	N-3	NW-18
109	325.5°	N-4	NW-19
110	328.5°	N-5	NW-20
111	331.5°	N-6	NW-21
112	334.5°	N-7	NW-22
113	337.5°	N-8	NW-23
114	340.5°	N-9	NW-24
115	343.5°	N-10	NW-25
116	346.5°	N-11	NW-26
117	349.5°	N-12	NW-27
118	352.5°	N-13	NW-28
119	355.5°	N-14	NW-29
120	358.5°	N-15	NW-30

APPENDIX E

PHYSICAL CRITERIA AND TOLERANCES FOR MAJOR CDAA COMPONENTS

In order for the CDAA to operate properly, and continue to perform its designed function, all of its components must be maintained at a high level of readiness. Following are some of the major maintenance areas wherein specific criteria and tolerances must be observed:

1. LOW-BAND ANTENNAS

The low-band antennas shall be maintained equidistantly spaced on the perimeter of a circle with a radius of 393.5 feet plus or minus 2 inches. The circle shall be maintained concentric with the low-band screen, and the base of each antenna shall be maintained at 27.5 feet plus or minus one inch in front of the screen. The angular separation of the antennas shall be maintained at 9 degrees plus or minus 2 minutes of arc measured from the center of the circle. The tops of the antennas shall be maintained at 61.5 feet above the ground mat with the difference between the tops of adjacent antennas maintained at less than 3 inches. The tops of the antennas on opposite sides of the array shall be maintained to exhibit a uniform variation not greater than 1/4 of one degree on any diameter of the circle. The antennas shall be maintained in a true vertical position of plus or minus one degree.

2. LOW-BAND SCREEN

The polygon formed by the low-band screen panels is inscribed in a circle. The radius of this circle shall be maintained at 366 feet plus or minus 2 inches. The screen height shall be maintained at 90 feet with a minus zero to plus five feet tolerance. The screen shall be maintained in a true vertical, plus or minus one degree. Elevations of the tops of the screen panels shall be maintained at less than 3 inches between adjacent screen panels, and the tops of the screen panels on opposite sides of the array shall be maintained to exhibit a uniform variation not greater than 1/4 of one degree on any diameter of the circle. Angular tolerances of the reflector pole locations shall be plus or minus zero degrees two minutes of arc. The screen grounding wires shall be maintained so as not to contain any sharp bends and their horizontal components shall be minimized. The screen wires shall be maintained taut and in a true vertical position of plus or minus one degree.

3. HIGH-BAND ANTENNAS

The high-band antennas shall be maintained equidistantly spaced on the perimeter of a circle with a radius of 436.75 feet, on the same radials as the screen support poles, and 13.25 feet plus or minus one inch in front of center of pole measured at the base. The angular separation of the antennas shall be maintained at 3 degrees plus or minus 2 minutes of arc measured from the center of the circle. The tops of adjacent antennas shall be maintained within 3 inches and the elements on opposite sides of the array maintained to exhibit a uniform variation not greater than 1/4 of one degree on any diameter of the circle. The elements shall be maintained in a true vertical position of plus or minus one degree.

4. HIGH-BAND SCREEN

The polygon formed by the high-band screen panels is inscribed in a circle. The radius of this circle shall be maintained at 423.5 feet plus or minus 2 inches. The screen height shall be maintained at 24 feet with a minus zero to plus 6 inches tolerance. The screen shall be maintained in a true vertical, plus or minus one degree. Elevations of the tops of the screen panels shall be maintained at less than 3 inches between adjacent screen panels, and the tops of screen panels on opposite sides of the array shall be maintained to exhibit a uniform variation not greater than 1/4 of one degree on any diameter of the circle. Angular tolerances of the reflector pole locations shall be plus or minus zero degrees two minutes of arc. The screen grounding wires shall be maintained so as not to contain any sharp bends and their horizontal components shall be minimized. The screen wires shall be maintained taut and in a true vertical position of plus or minus one degree.

5. GROUND MAT/REFLECTING GROUND PLANE

In order to insure peak operational performance, the ground plane should be kept as flat as possible. In that the ground mat and radials must be sandwiched between 3-inch layers of gravel in order to provide mechanical protection, it is therefore virtually impossible to determine with any degree of accuracy, the degree of flatness and levelness of the plane without first removing huge amounts of gravel over a very large area. The naked eye must therefore be utilized to estimate flatness and levelness.

APPENDIX F

MODIFIED NRL SWEEP-NULL METHOD OF CABLE MATCHING

Test Equipment Required for NRL Sweep-Null Method of Cable Matching

Quantity	Description	Nomenclature
1	RF Sweep Freq. Generator	Jerrold Model 602
1	RF Detector	Jerrold Model D-86
1	Wide-Band Comparator	Jerrold Model FD-30
1	RF Signal Generator	SG-85/URM-25D or equivalent
1	Oscilloscope	Hickok, OS-82A/USM-105 or equivalent
1	Line Stretcher	General Radio, Type 874-LT
2	GR/BNC Jack Adaptor	General Radio, Type 874-QBJL
2	GR/N Jack Adaptor	General Radio, Type 874-QNJL
1	6db Pad	
1	3db Pad	
1	40'-0"±1/8" Coaxial Cable	RG-11A/U
1	"T" Connector	
	Graph Paper	
	Straight Edge	
	Assorted Cables	

MODIFIED NRL SWEEP-NULL METHOD OF CABLE MATCHING

1. THEORY

a. The Modified NRL sweep-null method of cable-matching involves the use of an RF sweep frequency generator, an RF/DC detector, an oscilloscope and a cable stretcher.

b. As illustrated in Figure F-1, the equipment is connected so that the RF energy from the sweep generator travels through the detector and along the cable under measurement. The short circuit at the far end of the cable provides a sharp impedance discontinuity, thus the energy is reflected back up the cable, building up standing waves. When the frequency of the generator is adjusted to a relationship that provides a half wavelength (or multiple thereof) between the detector and the short circuit, the reflected impedance at the detector will be at a minimum, and therefore the voltage output to the scope will be at a minimum. As the frequency is adjusted to a relationship that provides an odd quarter wavelength between the detector and the short, the impedance presented to the detector (and voltage to scope) will be at a maximum.

c. Since the change in impedance with respect to a given change in frequency is greatest at the null, or low impedance condition, the null is selected for use in these measurements. As the frequency of the generator is swept across a wide band of frequencies, the presentation on the scope will show numerous nulls and maxima, the greater the sweep width the more nulls will be indicated, conversely, the less the sweep width, the wider will be the individual null presented.

d. In the first cut or approximate method to be described, it will be noted that a half wavelength null of a low order is selected. This is done to remove the possibility of an error of greater magnitude when the final, or accurate cut, is to be determined. If, for example, the thirty-second null is selected to gain accuracy between electrical degrees and lineal length for the final cut, there is a possibility that some cables might be cut at the thirty-first or thirty-third null, making an error of approximately 10 lineal feet. Another precaution is added to the approximate method; i.e., only 90 percent of the calculated length to be removed is actually cut off. The reason for this is as follows: in case the velocity constant of that portion of the cable being removed is appreciably different than the average, it could cause an error that would result in an excessive length cut.

e. When the final cut is to be made with the precise method, any calculated length in excess of one foot should be treated as the approximate method, and again, only 90 percent of the calculated length is to be removed from the cable, otherwise an excessive length could be removed. Only when each cable shows a length less than one foot to be removed, is 100 percent of the calculated length to be removed from the cable.

f. When a null has been selected that is to be used on all cables, the sweep width is narrowed and the center frequency adjusted to include only the null desired. The horizontal and vertical gain is adjusted to fill the scope screen. The marker generator is adjusted to provide a symmetrical "W" pattern, the counter is activated and the frequency read and recorded with each cable number. (See Fig. F-8 and F-9).

g. In the precise method, several frequencies (nulls) are used for measurement and the results averaged, to assure matched cables throughout the spectrum which they must operate. The following simple procedure will determine the null on which the cable is operating: by measuring the frequency of successive nulls with the marker generator and the counter, the primary null can be determined. The following example will serve to illustrate:

Lowest null on scope	3.5 mc
Next higher null	4.2 mc
Next higher null	4.9 mc
Next higher null	5.6 mc

In the above, it will be noted that each successive null is 0.7 mc above the previous null, therefore the primary null would be at 700 kcs and the illustrated 3.5 mc null would be the fifth and the 4.9 mc null would be the seventh, etc. (Measurements and calculations should be made to three significant figures. Frequencies, to six (or seven if possible) significant figures would exist where subtraction is involved.)

2. PRELIMINARY SET-UP

Prior to making measurements, the following conditions should be set up:

a. Have each cable marked showing the antenna cable number and its length if known. (If not known it must be approximated by calculation.) An additional band of tape, with this number repeated, approximately 25 feet from the inboard end should be put on the cable to keep from accidentally cutting the cable number off. Additional space should be left on this tag or band to add data on lengths that have been cut from the cable (as this data can sometimes get lost). A felt tipped marking pen can be advantageously used for this purpose.

b. Short circuit the antenna end of each cable.

(1) The low-band cable ends in a short length of RG-11 with connector to fit the antenna transformer. Disconnect this connector from the transformer and jam (with a wooden tool) the connector full of aluminum (household) foil until a good inner-outer conductor short is obtained. Weather seal the connectors (both antenna and cable) with "Saran Wrap" (household) or similar weatherproof material and secure with wire or rubber bands.

(2) The high-band cable must be disconnected from the upper monopole, inner and outer conductors cleaned and wrapped with aluminum foil and secured with bonding wire or equivalent to insure a good coaxial short circuit. Close the access plate on the base matching section to keep the section weathertight.

(3) Check all cables external to the building to be sure they are in position in trenches and have rested in place for at least one week. This is essential to preclude any physical stretching after measurement.

c. Position the equipment shown in Figure F-1 in the center of the room with the raw ends of RG-85 A/U cables and lay out all antenna cables in sequence, low-band first. Upon completion, repeat with the high-band cables.

d. A quick-connect adaptor-connector to attach the RG-11/U test cable to the RG-85/U cable should be made up. Place gland and ring on each cable before proceeding as follows:

(1) Since the RG-85 steel cable is hard to handle into its ring when short, this cable should be bared for at least 6 inches on all cables by taping the jute 6 inches from end, removing outside jute and bending back all steel wires. Cut inner jute 5 inches, the lead 4 inches and the poly-cover 3 inches, the copper shield 2 inches, the poly 1-1/2 inches and the center conductor as required.

(2) These cuts will allow attachment of UG-982/U connector-adaptor when band is held together for each test.

(3) The above dimensions can be varied to suit the team.

(4) When cutting each RG-85 cable, do not remove as much steel cable as is required of inner and outer conductor. This will allow longer steel wires to work with and make it easier to band around the securing ring.

e. Personnel using the sweep-null or modified sweep-null method of matching should practice on the technique for several hours before actually making cuts on the cable. The team of personnel making the sweep-null matching measurements should consist of the following:

(1) One Supervisor-Coordinator (optional)

(2) One Instrument Man

(3) One Data Logger and Calculator (with data sheets and slide rule).

(4) Mechanics/Technicians as required to attach RG-85/TG-11 adaptor connector and to cut cables.

Upon becoming proficient with the instrumentation and technique described, this team should be able to complete one station antenna matching in 300 to 400 man hours.

f. Since the tolerance of unbalance between cables should not exceed 3/4 of one electrical degree at ten megacycles, this means approximately plus or minus 3/4 of an inch in lineal length. Therefore extreme care in final cut must be exercised to preclude greater error. The specification requirement which calls for a final cut of less than one foot will allow accomplishment within this tolerance.

3. APPROXIMATE METHOD

a. It may be advantagoues to insert a 3 db (70 ohm) pad in one of the test cables to aid in identifying the two cables on the scope screen (see Fig. F-1, F-6 and F-7).

b. The following explanation of the desired results is in order before proceeding:

(1) Find the shortest (highest frequency) cable and identify it as the STANDARD CABLE to which all other cables of this band are to be matched.

(2) Determine the approximate electrical length of each cable.

c. Cut two lengths of RG-11/U 70 ohm coaxial cable to 25 feet in length. Electrical identity is desirable. Fit them with coaxial connectors compatible with the coaxial switch on one end and short the other end.

d. Match the test cables (RG-11) to obtain electrical identity (length) with 3 db pad in one cable.

(1) With the coaxial switch deactivated, and one RG-11 test cable attached, adjust the sweep generator to center frequency near 13 mcs and expand the sweep to obtain a null on the scope, narrow the sweep and adjust center frequency to center the null on the scope, insert a marker signal near 13 mcs and adjust until a symmetrical "W" pattern is obtained. See Figure F-9 for details or proper scope presentation. When the pattern is symmetrical on one cable, read counter, attach and switch to the other RG-11 test cable. Repeat above, and determine amount to be removed from the longer of the two. Cut the longer (lowest frequency) cable and recheck both. When identical in frequency, activate the coaxial switch and view both patterns on the scope. If the pattern is superimposed and identical, (except for lower amplitude on the 3 db pad cable) place connectors on the ends that will fit RG-85/RG-11 adaptor connector. One of the reasons for this measurement is to gain practice in technique and to illustrate the degree of accuracy in terms of lineal length that can be achieved. Additionally, these cables should be as nearly identical as possible to reduce possibility of errors in approximate method to those not under the control of the operators. To get an idea of the accuracy of the measurements, temporarily add short lengths of cable to one or the other cable and view patterns.

e. Using the method described in paragraph 1g, above, determine the fundamental frequency of No. 1 antenna cable and thus determine the seventh null approximate frequency. This null will be used in the approximate method on all cables of the low-band. Attach one low-band antenna cable to one of the test leads.

f. Determine which antenna cable is the STANDARD at the seventh null frequency of each cable.

(1) Place the marker generator in the seventh null, retain its identification by adjusting the center of the sweep and the sweep width to allow only the seventh null (see Fig. F-3) to be seen on the scope. Attach another antenna cable on the second test lead, activate the coaxial switch and determine if this second cable is longer or shorter by its position. (The cable to the right on the scope will be the higher frequency, therefore, the shorter.) Remove the lower frequency cable and attach test lead to the third antenna cable. If the shortest cable is always placed on the test lead containing the 3 db pad, it can always be recognized on the scope. As a cable shows up shorter than the previous short one, keep the shortest and continue through all forty cables of the low band retaining the shortest cable in all cases. Some cables may be nearly identical in electrical length to the STANDARD.

In this case it may be necessary to decrease the sweep width and position the marker generator in each to determine which of the two is actually the shorter. (See precise method of determining.) At this juncture the test team should know the shortest (electrically) cable which will become the STANDARD CABLE to which all the other 39 low-band cables will be matched. Repeat if in doubt.

(2) Determine the frequency (seventh null) of each cable.

(a) Disconnect the coaxial switch as shown in Figure F-2 and connect the STANDARD CABLE determined.

(b) Adjust sweep to narrow as shown in Figures F-8 and F-9 and center the marker generator as shown in Figure F-9a, read and record the frequency and cable number. (See Fig. F-4 for Sample Data Sheet.)

(c) Connect each cable of the low-band array in succession, read and record frequency and cable number. Recheck the STANDARD after each ten cables to assure no change in the STANDARD characteristic. If the STANDARD changes, change the frequency (Fs) in the formula below; however, since it should take less than one minute per cable, no appreciable change should be detected due to heating, cooling, etc.

(d) PRIOR to CUTTING, RECHECK any doubtful measurements and calculations - it's easier to recheck than to try to STRETCH a short cable.

g. Compute the lengths of cable to be removed from all but the STANDARD CABLE.

(1) Calculate the physical length of the STANDARD CABLE. If known within 6 inches, this step need not be calculated. (Include test cable.)

$$L_s = \frac{492 \times 7 \times 0.661}{F_s}$$

Where: L_s = Length of STANDARD CABLE in feet

492 = A constant

7 = Number of null used.

0.661 = Velocity factor in RG-85 cable (average)

F_s = Frequency in mcs of the STANDARD CABLE. (at 7th null)

(2) Compute the length of cable to be removed from each cable.

$$L_c = \frac{L_s \times 0.9}{F_s} \times (F_s - F_x)$$

Where: L_c = Length to be cut from cable No. X (in feet)

L_s = Length of STANDARD CABLE (in feet)

F_s = Frequency of STANDARD CABLE in mcs (at 7th null)

F_x = Frequency of cable No. X in mcs (at 7th null)

0.9 = Safety factor to keep from cutting too much on approximate cut. Omit this factor for final cut.

It should be noted that L_s, F_s and 0.9 (for one band and null number) are constants for all cables to be cut by the approximate method, therefore a graph on rectangular coordinate paper can be made up that will show amount to be cut to be read directly from $(F_s - F_x)$. This will speed up the work and possibly reduce errors. See Figure F-5 for an example.

NOTE: Before proceeding to the precise method or final cut, certain additional cuts might be made. When first cuts are in excess of 8 feet, the possibility of having second cuts greater than one foot is fairly good. Recheck all cables which had first cuts in excess of 8 feet and if second $(F_s - F_x)$ measurement indicates a cut greater than one foot, make another approximate cut. However, if the approximate cut indicates a first cut of less than 8 inches, do not cut, but leave for precise cut method.

h. Cut approximate length calculated from each cable except the STANDARD.

i. Upon completion of the precise cut of the low-band array, repeat the same procedure at the seventh null for the approximate cut on the high-band array. The STANDARD CABLE of the high-band array need not be the same as the low-band array since the high-band array is independent of the low-band array. When measuring the high-band array, since there are more cables involved, recheck the STANDARD often to assure the correct amount of cable is removed. Once matched, should the cables change their characteristics, they will change together and remain matched within tolerable limits.

4. PRECISE METHOD

a. The low-band cables will be checked at five (not harmonically related) null frequencies between the lowest available null, with instrumentation specified and frequency at 9 megacycles. The high-band will be checked at 5 null frequencies between 7 and 30 megacycles. The final cut is to be taken as 100 percent of calculated length only when the length to be cut is less than one foot. To determine the proper null for the STANDARD CABLE and all others of a group, proceed as follows:

b. With STANDARD CABLE connected as shown in Figure F-2, place center of sweep (on the low-band), such that 4 to 9 mcs can be swept, place the marker generator successively in each null and calculate primary null, determine the lowest null and successively count up the spectrum until null desired is reached, retain marker in this null while decreasing the sweep and adjusting the center frequency. See Figures F-6, -7, -8 and -9 for photos of typical scope patterns. In Figure F-8, if the lowest null is the sixth, then the marker is shown in the thirteenth null.

(1) Adjust cable stretcher to the calibrated reading of "O". Adjust center frequency and reduce sweep to show only null desired. Adjust marker to symmetrical "W" pattern (Fig. F-8b shows unsymmetrical pattern and Fig. F-8c shows marker centered). Read counter, record frequencies and cable number.

(2) Change test lead to cable #1. Do not touch equipment settings. Adjust the cable stretcher until the exact symmetrical pattern is seen on the scope. Read directly from the cable stretcher (calibrated marks) the difference in length between the standard cable, and cable #1. Record frequency, cable number and mount (in inches and fractions thereof) to be cut from cable #1.

(3) Complete first five cables (#1, 2, 3, 4 and 5) as instructed in paragraph 4b(2) and then recheck the STANDARD CABLE, repeating step in paragraph 4b(1).

(4) Measure all cables in increments of five, rechecking STANDARD CABLE after each group of five.

(5) Average the nine readings (excess indicated on direct reading from stretcher) and calculate the lengths to be removed from each cable.

(6) Repeat the above on all five nulls previously specified in paragraph 4a above.

(7) When five null frequencies have been investigated for the 40 low-band cables, average the lengths to be cut from each, cut those lengths that are less than one foot, take only 90 percent calculated length if over one foot, remeasure, recalculate and cut again.

(8) Upon completion of low-band precise cut, repeat the procedures of approximate and precise methods for the high-band array.

NOTE: NULLS TO BE TAKEN BETWEEN SEVEN AND THIRTY MCS FOR THE HIGH BAND.

. Terminate all RG-85/AU cables in TMC RG-85/RG-12 adaptor connector on the metal plate of each quadrant. Measure the length required for RG-12/U cable between this adaptor connector and the most remote antenna multicoupler via route that must be taken in final installation, add 10 feet for safety and for matching cut. Attach the 160 lengths (physically equal) to the RG-85/AU adaptor connectors and label each RG-12/U cable with proper antenna number. Lay in raceway or cable tray in final position to appropriate assigned multicoupler position. Check prints to be sure proper antenna cable is terminated at proper multicoupler, as the AN/FRD-10 manufacturer will use the multicouplers as assigned.

6. Place test equipment in the center of the RF distribution room. Using same procedures for approximate and precise methods, the antenna cables will be completely rematched to include the RG-12/U.

a. For L_s, add the length of the RG-12/U to the previous length of RG-85/U and test lead in the calculation of the physical length of the STANDARD CABLE.

b. The primary null will be lower in frequency than previously determined, therefore all null frequencies will have to be redetermined.

c. The number of the five nulls used will have to be readjusted in the precise method to assure coverage in the 4 to 9 mcs spectrum of the low-band and 7 to 30 mcs spectrum of the high-band.

d. Upon completion of test of all cables to the multicouplers including the multicoupler UG-349/U connector; recheck each cable and record the electrical degree error in match at a frequency (null) near 10 megacycles. Record all data on each cable marker, and retain a copy for file. For convenience, the following method of arriving at the electrical degree error is given: Determine the frequency difference in cycles between the null below and the null above the one (near 10 mcs) selected above. This will give the frequency (cycles) for one full wavelength (two nulls) or 360 electrical degrees, divide the frequency difference (m cycles) by 360. The result will be the cycles per electrical degree. A graph of - one electrical degree versus cycles will facilitate this conversion. The electrical degree error should be added to the data on each cable and the work sheets retained in file.

e. Upon completion of all measurements, take the aluminum foil short circuit from the antenna end of all cables and restore to normal connection, weatherproofing as called for in original specifications.

f. Adjust excess physical lenghts of all cables using care not to distort the physical lengths.

g. Secure the antenna field inside the screen.

7. The technique described above may seem verbose, but it is deemed necessary to assure accuracy and to obtain uniformity between sites.

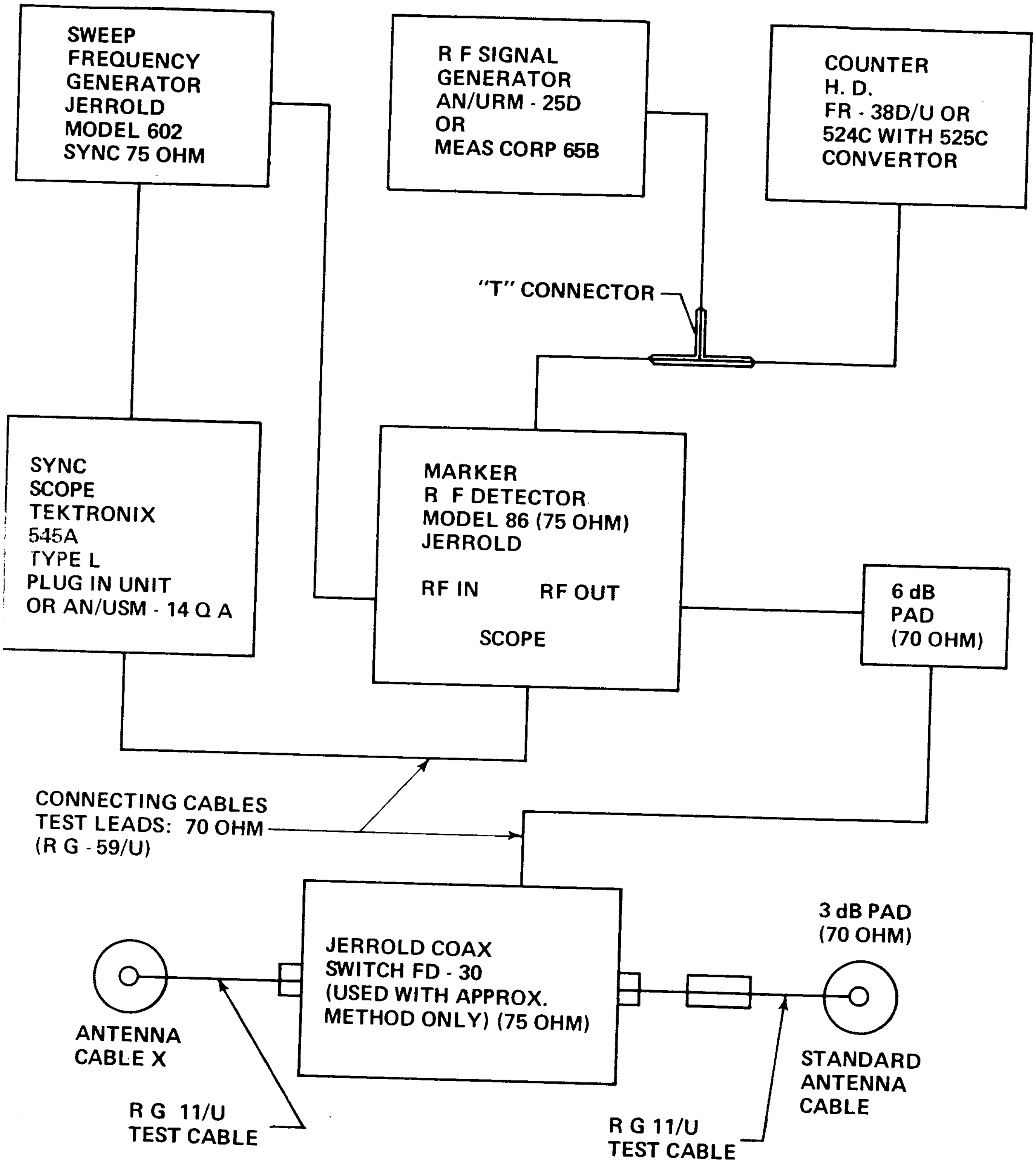


Figure F-1 - Cable Matching, Approximate Method

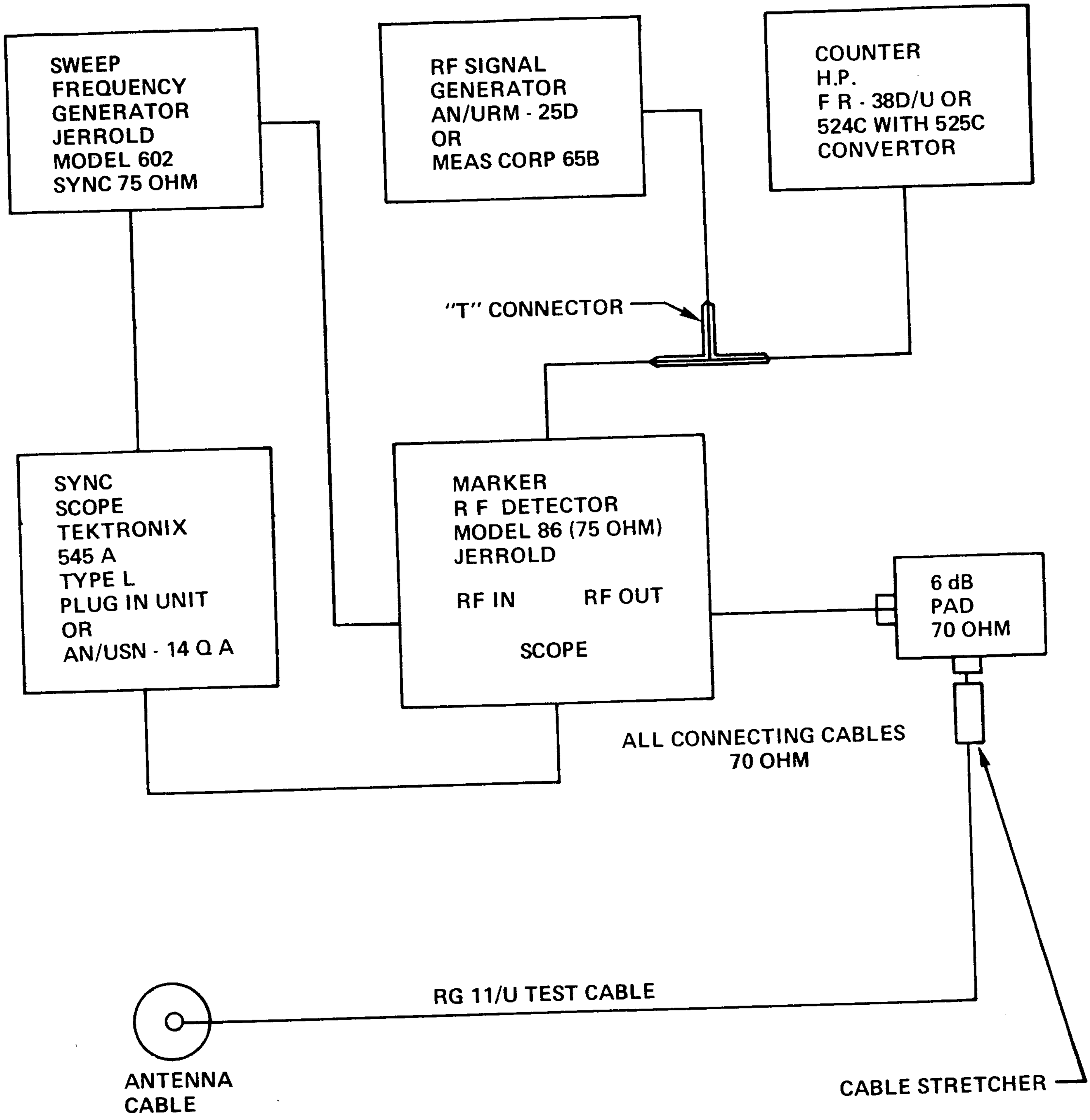
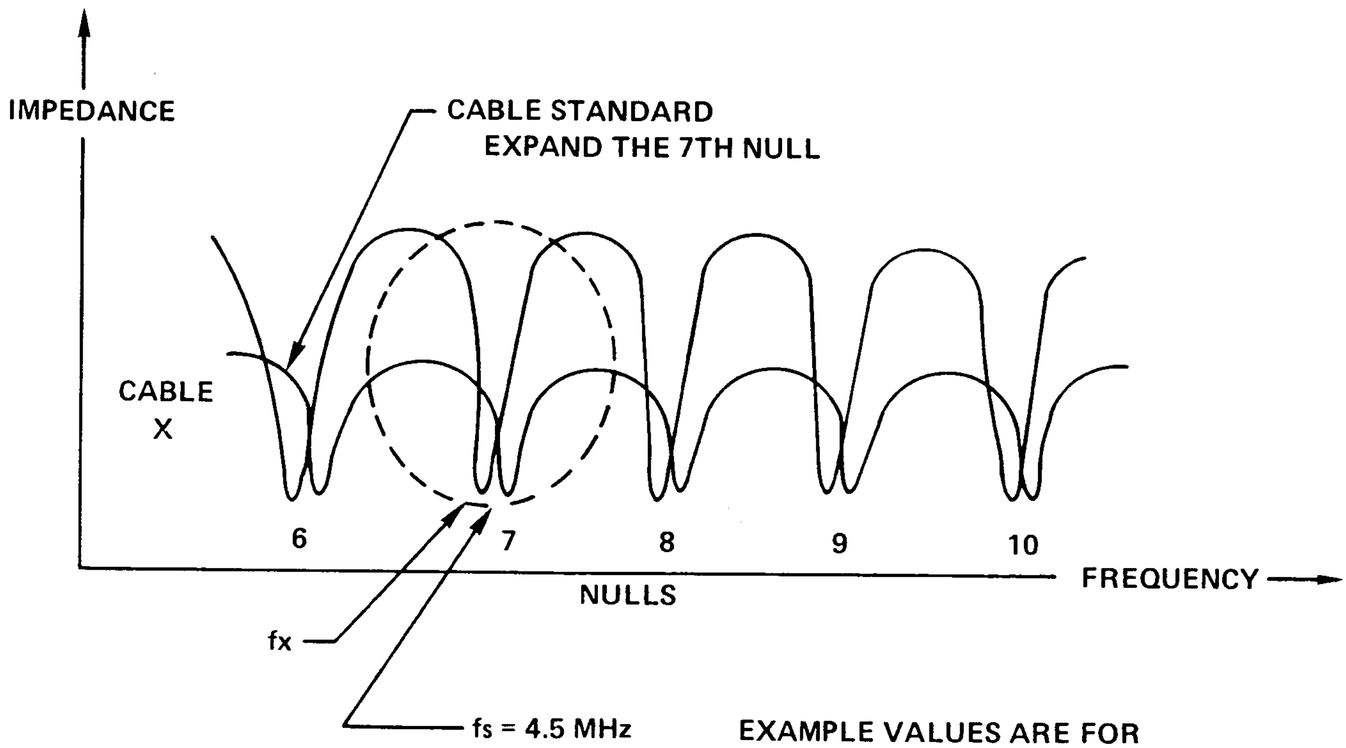


Figure F-2 - Cable Matching, Precision Method

SCOPE PRESENTATION



EXAMPLE VALUES ARE FOR

Ls = 500 FT & V = 0.661

$$Lc = \frac{Ls \times 0.9}{fs} \quad (fs - fx)$$

WHERE Lc = APPROXIMATE LENGTH TO BE REMOVED FROM CABLE X IN FEET MHZ
fs = FREQUENCY AROUND 4.5 MHZ AT WHICH CABLE S PRESENTS LOWEST IMPEDANCE
fx = FREQUENCY AROUND 4.5 MHZ AT WHICH CABLE X PRESENTS LOWEST IMPEDANCE
Ls = LENGTH OF STANDARD CABLE IN FEET (EITHER MEASURED OR CALCULATED)

Figure F-3 - Scope Presentation of Reflected Nulls

CABLE NUMBER	________ BAND											
	NULL NO. ____		NULL NO. ____		NULL NO. ____		NULL NO. ____		NULL NO. ____		AVERAGE L_c	
	fs – fx	L_c	fs – fx	L_c	fs – fx	L_c	fs – fx	L_c	fs – fx	L_c	FEET	IN
1												
2												

Figure F-4 - Sample Data Sheet

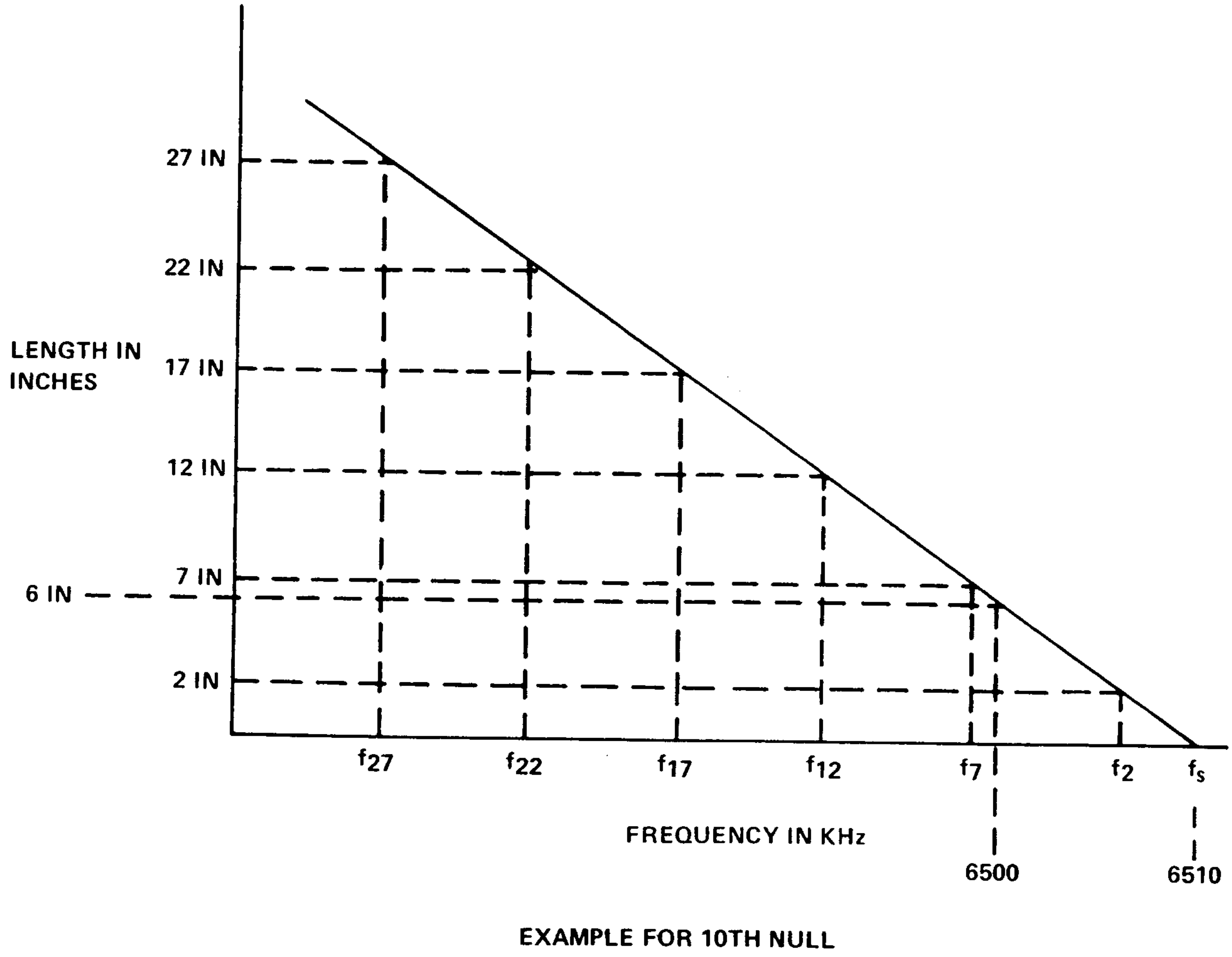


Figure F-5 - Example for 10th Null, Frequency vs Length

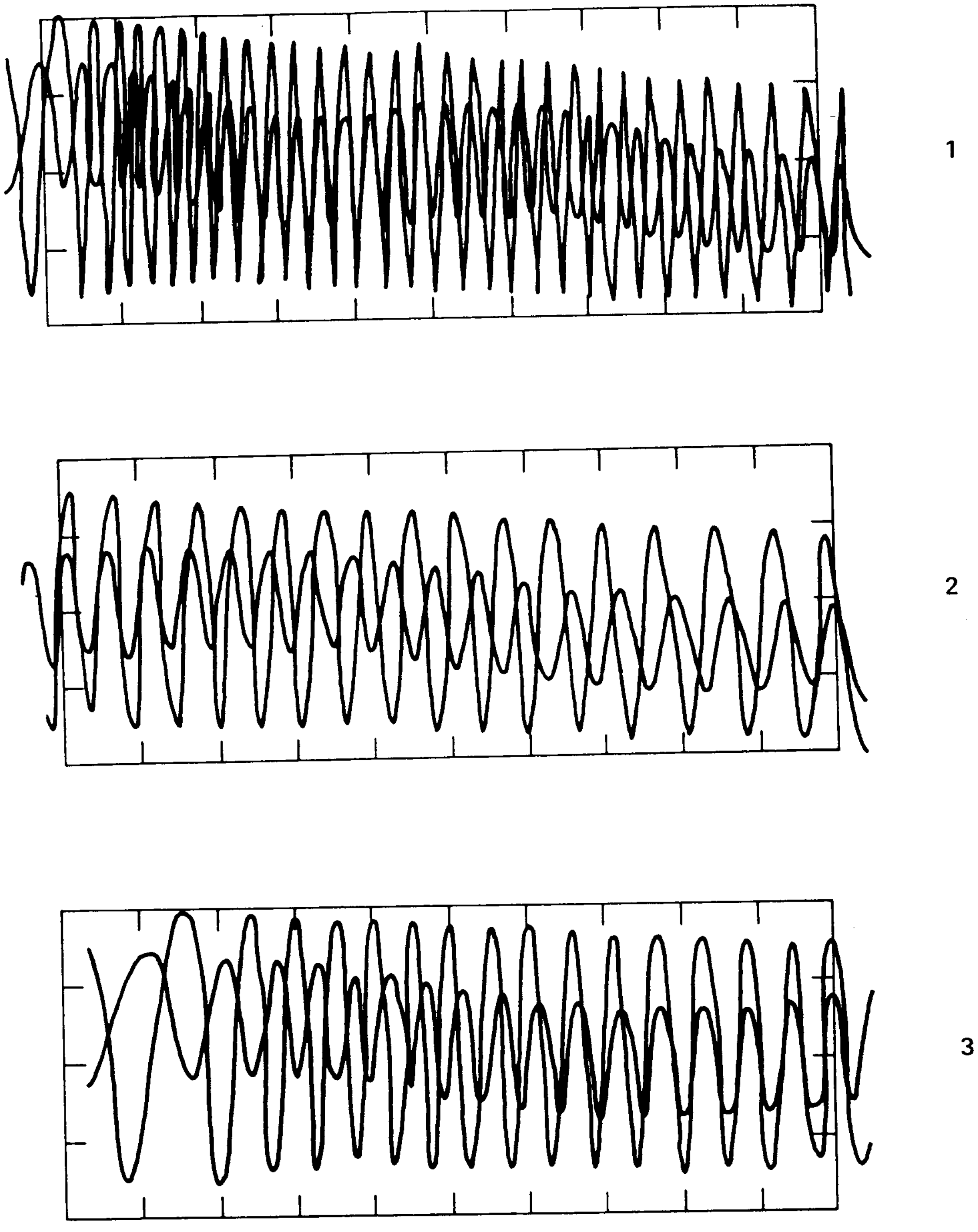


Figure F-6 - Typical Scope Presentations

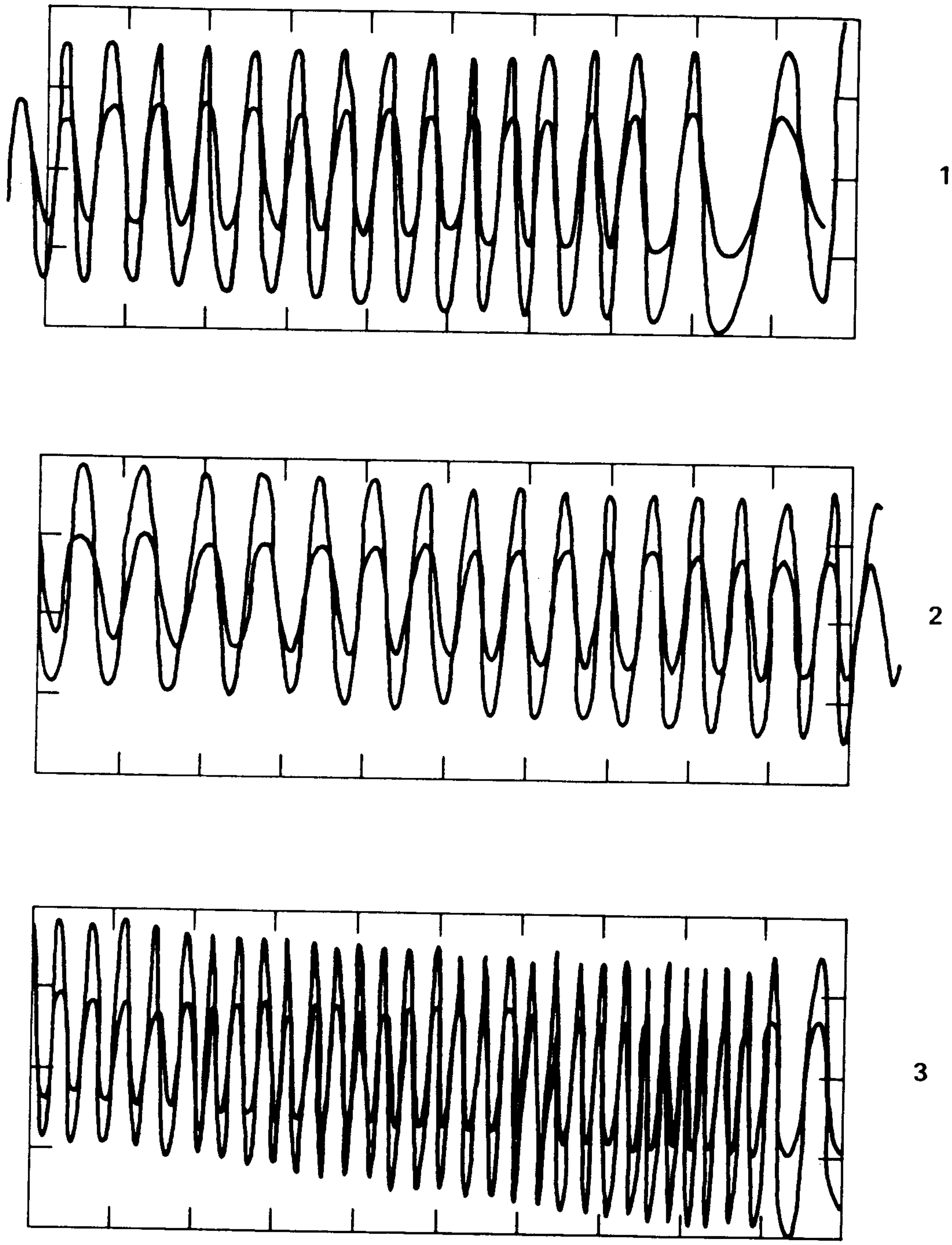


Figure F-7 - Typical Scope Presentations

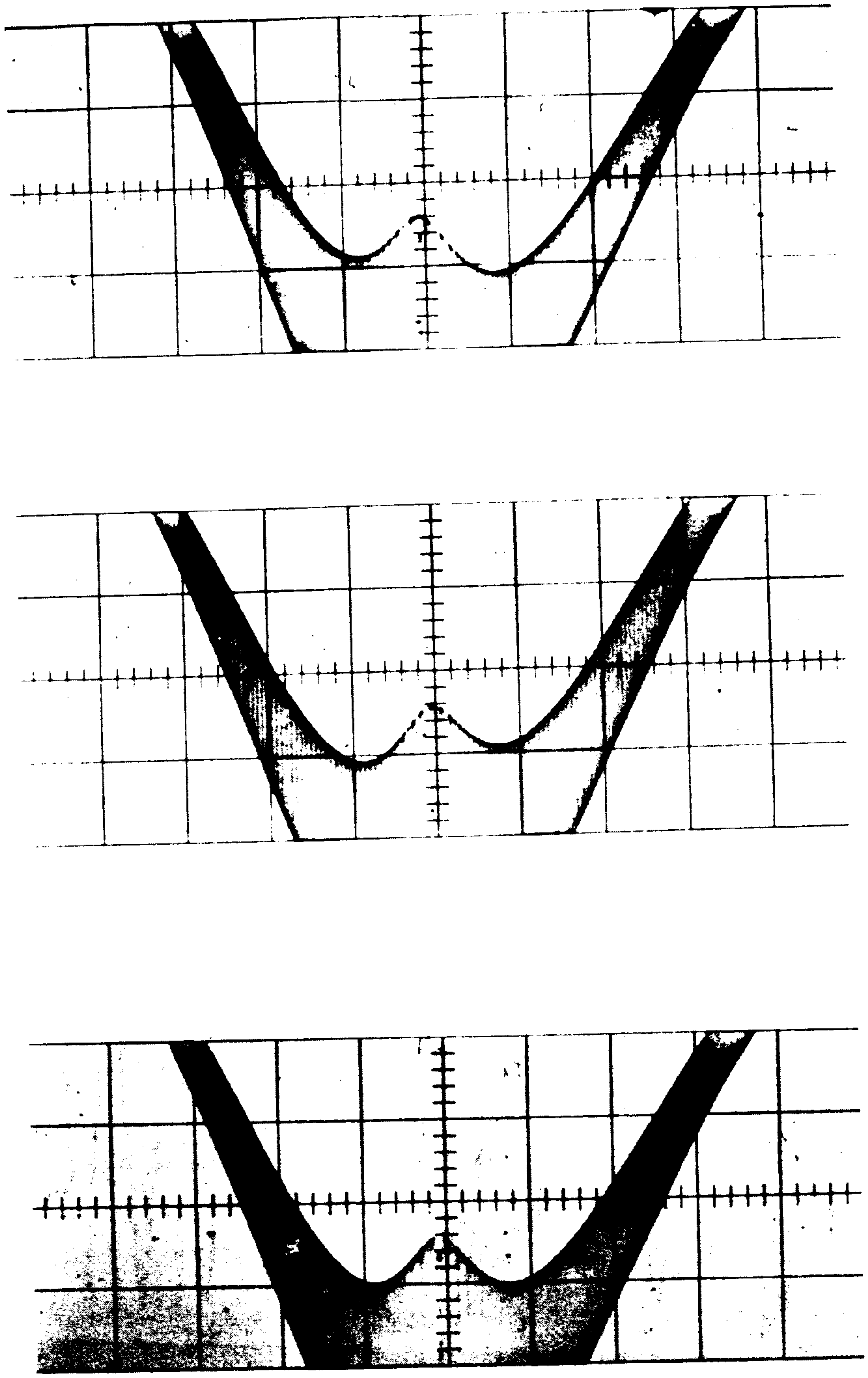


Figure F-8 - Typical Scope Presentations

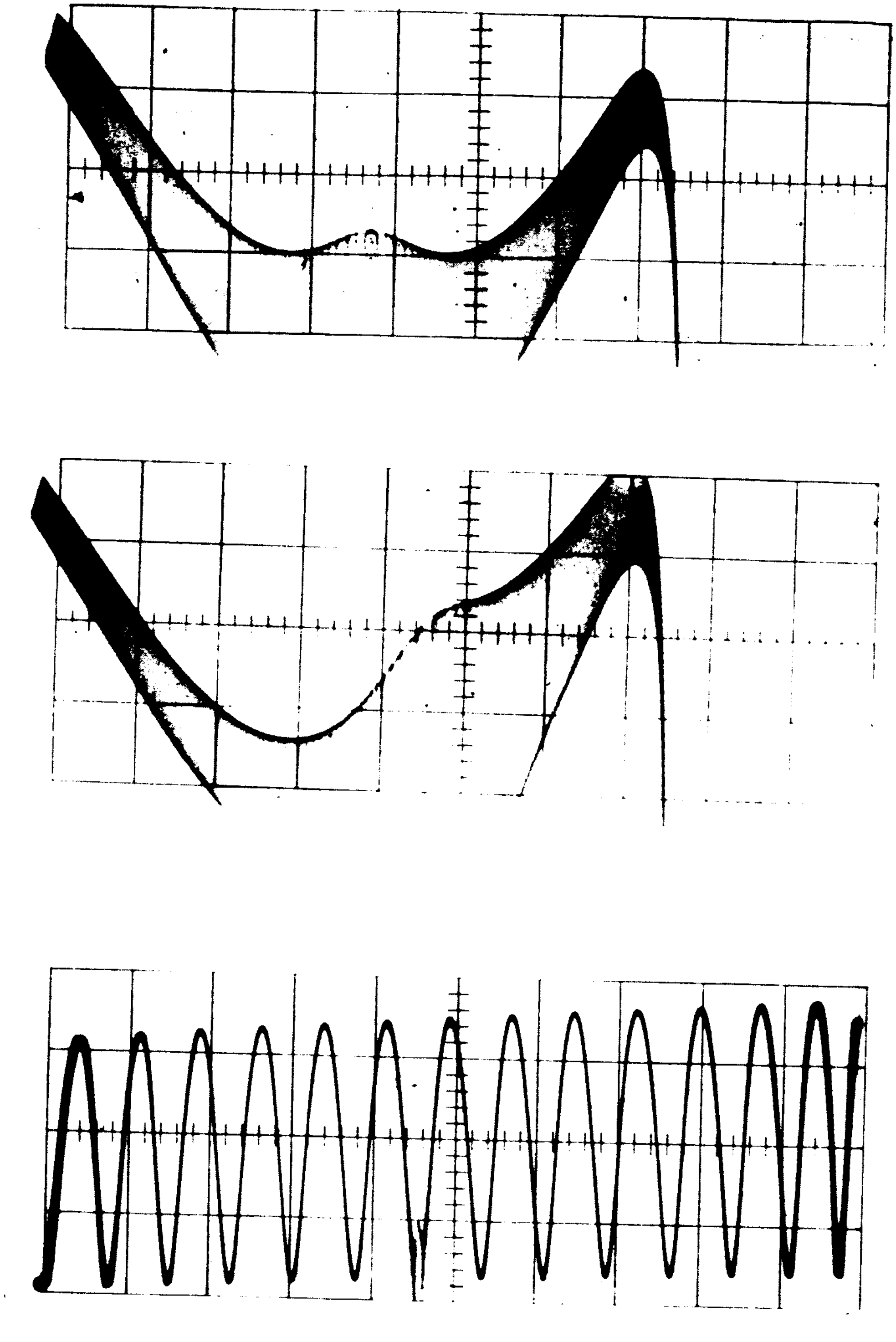


Figure F-9 - Typical Scope Presentations

APPENDIX G

REFERENCE LIST OF NAVFAC MAINTENANCE MANUALS

NAVFAC MO-100	Maintenance of Grounds
NAVFAC MO-101	Maintenance of Miscellaneous Ground Structures
NAVFAC MO-102	Maintenance of Pavements
NAVFAC MO-110	Paints and Protective Coatings
NAVFAC MO-200	Electric Power Distribution System-Maintenance
NAVFAC MO-306	Corrosion Prevention and Control
NAVFAC MO-307	Corrosion Control by Cathotic Protection
NAVFAC MO-312	Wood Preservation
NAVFAC MO-314	Herbicide Manual

APPENDIX H

TABLE OF SUGGESTED PROTECTIVE COATINGS FOR VARIOUS COMPONENTS OF THE CDAA

MATERIAL	COMPONENT	FED SPEC, MIL SPEC OR TRADE NAME PRODUCT	FEDERAL STOCK NO.	COMMENTS
Wood	Poles Boom boards	Creosote: FED SPEC TT-W-571 Wood Preservative Treating Practice Pentachlorophenol MIL-W-13518 Wood Preservative, Tetrachlorophenol and Pentachlorophenol, surface sealing compound	Consult the special assistant for applied biology at the appropriate NAVFAC EFD for recommended field applied preservatives.	Preservative for field treatment should be the same as that used in the original treatment. All cuts, holes and injuries of the surface of the treated material should be field protected by brushing, spraying, dipping, soaking or coating. Care should be taken to assure that all injuries such as abrasions, nail and spike holes are thoroughly saturated with a field treated solution. Holes bored in pressure treated material should be poured full of preservative. Horizontal holes may be filled by pouring the preservative into them with a bent funnel. The use of a bolt hole treater capable of applying the preservative under pressure is recommended. All unused bore holes and spike holes should be poured full of preservative and plugged with tight fitting treated plugs. Laminated boom boards that show sign of bleeding and after close inspection show signs of soft or decayed wood in the area

MATERIAL	COMPONENT	FED SPEC, MIL SPEC OR TRADE NAME PRODUCT	FEDERAL STOCK NO.	COMMENTS
Wood				of bleeding should have the softwood chiseled away, and a liberal application of a grease-type preservative containing pentachlorophenol should be applied.
Steel	Turnbuckles Schackles Thimbles End Fillings	Krodeproof coating or Kool-seal coating Silicone Compound MIL-S-8660B		Asbestos filled aluminum pigmented asphalt roof coating. This coating may be applied as an added protection against corrosion in areas of harsh environments.
Steel	Fittings Plates Shapes Bars	Primer Paint: To be applied on ferrous surfaces (non-galvanized) FED SPEC TT-P-645 Primer Paint, Zinc-chromate Alkyd Type Two coats should be applied.	FSC 8010-169-7419	General: All areas of damaged paint or coating and all rusting areas, including areas where rust discoloration shows through the existing paint or zinc coating should be cleaned to bare metal. It is recommended that cleaning be accomplished by means of powered wire brushing. Immediately after cleaning and before any new rust has formed, the bare area should be spot primed and finished painted as required.
Steel	Fittings Plates Bars Shapes	Primer Paint: To be applied on zinc coated surfaces (galvanized)	FSC 8010-165-8560	Finish Coat: Finish paint when required should be an alkyd gloss enamel colored as required. It may be applied as a touch up coat over spot primed areas

MATERIAL	COMPONENT	FED SPEC, MIL SPEC OR TRADE NAME PRODUCT	FEDERAL STOCK NO.	COMMENTS
		FED SPEC TT-P-641 Primer Coating, Zinc Dust - Zinc Oxide conforming to Type I		or as an overall coat if so desired. Sufficient time should be allowed between coats to assure thorough drying.
		Finish Coat: FED SPEC TT-E-489 Enamel, Alkyd, Gloss (for exterior and interior surfaces) Class A Drying	Color: Medium Navy Gray: FSC 8010-286-7731 White: FSC 8010-664-4761 International Orange: FSC 8010-527-3200	
Fiberglass	Rods	Nupla Corporation Structural Glass Division 11912 Sheldon Street Sun Valley, Calif. 91352 Product: Nupla coat #6180		The protective coating of rods that have been damaged or deteriorated should be replaced with a mixture of non-chalking titanium dioxide pigment in a suitable epoxy resin. Nupla Corporation "Nupla coat #6180" is one such product.
Copper-clad steel & other electrical connection points	Wires Cables Fittings	Sealing Compound: MIL SPEC: MIL-C-16173 Corrosion Prevention Compound Solvent Cutback, Cold Application Grade I	FSC 8030-721-8927	Broken ground mat and ground bus wires and cables should be repaired by brazing, soldering, exothermic welding or clamping as required. After the connection has been made the joint should be thoroughly coated with a liberal application of a corrosion prevention compound.

MATERIAL	COMPONENT	FED SPEC, MIL SPEC OR TRADE NAME PRODUCT	FEDERAL STOCK NO.	COMMENTS
Concrete	Foundations Anchor Blocks Pedestals	Sika Chemical Corporation P.O. Box 899 Passaic, N.J. 07056 Product: Colma-DUR		Small cracks, spalls and anchor bolts or straps that have become loose should be cleaned, patched and packed with an epoxy base grout. Sike Chemical Corp. "Colma-DUR" is one such product.
Steel and Aluminum-clad steel	Guy Cables	Preformed Line Products Company P. O. Box 91129 Cleveland, Ohio 44101 Product: Plastic Wire Guard		Guy wires that are in contact with each other should be protected from wear by chafing sleeves. A guard which will not allow moisture to trap between it and the guy wire and which is easily removable for inspection is desirable. "Plastic Wire Guard" is one such product.
		Grease, Wire Rope-Exposed Gear MIL-G-18458A		
	Electrical Conduits	Johns-Manville Duxseal		Sealing compound for RG-85A/U cable.
	Electrical Connections	Dow Corning Corp. No. 19 Compound		Use to prevent corrosion of electrical connections subjected to corrosive atmospheres or galvanic coupling.

APPENDIX I

LIST OF MANUFACTURERS

Hardware Items:

Graybar Electric Co.
420 Lexington Ave, New York, New York 10017

McMaster-Carr Supply Co.
P.O. Box 4355
Chicago, Illinois 60680

A. B. Chance Co.
210 North Allen St., Centralia, Missouri

Ohio Brass Co.
380 North Main St., Mansfield, Ohio

Hubbard Co.
Division of Kearney - National Inc.
1250 - 45th Street, Emeryville, Calif. 94608

Burndy Corp.
Richard Ave., Norwalk, Conn. 06852

Crosby - Laughlin
Division of American Hoist and Derrick Co.
2511 Taylor St., Fort Wayne, Inc.

Thomas and Butts Corp.
Elizabeth, New Jersey 07207

Joslyn Manufacture and Supply Co.
155 North Wacker Drive, Chicago, Ill.

Preformed Line Products Co.
5349 St. Clair Ave., Cleveland, Ohio

Reliable Electric Co.
11333 Addison St., Franklin Park, Ill. 60131

Insulators:

Victor Insulator Division
I. T. E. Circuit Breaker Co. Inc.
Victor, New York

Lapp Insulator Co. Inc.
Leroy, New York 14482

Fiberglass Rods:

Nupla Corporation
11912 Sheldon St., Sun Valley, Calif. 91352

Exothermic Welding:

Erico Products Inc.
Cadweld Division
2070 E. 61st Place, Cleveland, Ohio 44103

Wires and Cables:

Copperweld Steel Company
Wire and Cable Division
P.O. Box 1000, Glassport, Pa.

Anaconda American Brass Co.
Waterbury, Connecticut 06720

Concrete Products:

Sika Chemical Corp.
P.O. Box 899, Passaic, New Jersey 07052

Wood Pole Preservatives:

Chapman Chemical Co.
P.O. Box 9158, Memphis, Tennessee 38109

Cobra Wood Treatment Co.
235 5th Ave., New York, N.Y. 10016

Osmose Wood Preserving Co.
980 Ellicott St., Buffalo, N.Y. 14209

Greenlee Tool Co.
2136 12th St., Rockford, Ill. 61101

Tension Meters:

Tensitron Inc.
Harvard Depot Road
Harvard, Massachusetts 01451

Protective Coatings & Sealing Compounds:

Johns-Manville Co. Inc.
22 East 40th St., New York, N. Y.

Dow Corning Corporation
Midland, Michigan 48640

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