CHANGE

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6740.4 CHG 1

7/24/81

Cancellation
Date: Retain

SUBJ: NONDIRECTIONAL BEACON (NDB) INSTALLATION STANDARDS HANDBOOK

1. PURPOSE. This change provides information for commissioning of facilities after the installation of NDB equipment.

2. CHANGE. Paragraph 8 of chapter 1 has been changed to correct the procedure for commissioning a facility after the installation of NDB equipment.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
3 and 4	2/23/81	3	2/23/81
		4	7/24/81

for GERALD L. THOMPSON
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Distribution: Selected Airway Facilities Field Offices; A-X(AF)-3; ZAF-602

Initiated By: AAF-410

FOREWORD

Civil NDB facilities are operated and maintained by the FAA to provide aircraft bearing information. This service is to be expanded and upgraded by the installation of solid-state nondirectional beacon (NDB) units at terminal navigation aids. This order provides installation guidance, installation drawings, and appropriate electrical wiring diagrams, for this multiyear effort of installing the 400 watt and 50 watt NDB transmitters and associated antenna tuning unit (atu) at air navigation facilities. The Installation Procedure (Chapter 4) and Installation Standards (Chapter 5) are also generally applicable to higher wattage NDB and atu units. Site Engineering (chapter 6) provides information needed for selecting sites and suitable antennas.

The Chief, Navaids/Communications Engineering Division, AAF-400, is authorized to issue changes to this order except that authority to approve changes in policy is reserved for the Director, Airway Facilities Service, AAF-1.

GERALD L. THOMPSON
Director, Airway Facilities Service

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Washington, D.C. 20402

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CHAPTER 1. GENERAL INFORMATION

1. PURPOSE. This order is a guide for planning and installing the nondirectional beacon (NDB) transmitter type FA-9781 (400 watt) NDB, the FA-9782 (50 watt) NDB, and the FA-9782/1 (50 watt) atu at air navigation facilities.

2. DISTRIBUTION. This order is distributed to selected offices and services in Washington headquarters, FAA Technical Center, and the Aeronautical Center; to branch level within regional Airway Facilities division.

3. BACKGROUND. The NDB provides aircraft bearing information during transition from en route to airport precision approach facilities and as a nonprecision approach at many smaller airports. The FA-9781 and FA-9782 NDBs are completely solid-state units which will be used to replace the obsolete vacuum tube NDB units currently installed at air navigation facilities. Cost studies have shown that replacing obsolete vacuum tube equipment with solid-state equipment will pay for itself in savings on operating costs and maintenance costs. The FAA has planned an NDB replacement program starting in fiscal year 1980 and extending for about five years. This order will provide NDB installation directions to cognizant FAA and assigned contractor personnel.

4. SCOPE. This order provides direction for installing the FA-9781 and FA-9782 NDBs and the FA-9782/1 atu at existing air navigation facilities. The text provides a brief description of the equipment's functional and physical characteristics, presents floor plan arrangement drawings for locating the NDB units and the atu in the facility enclosures, defines a step-by-step procedure for installing the equipment, provides installation standards, and presents applicable interface and interconnection wiring diagrams.

a. A 400 watt atu is available from the NDB equipment manufacturer (Nautel Maine, Inc.) and is listed on the Federal Supply Schedule (Contract No. GS-00S-92095, SIC No. 225-217, Model No. NX2000TUB). The 400 watt NDB can be adjusted to suit a 50 or 72 ohm terminal impedance. If unique site conditions require a 400 watt atu, the unit is a regional procurement option, which does not require a request for a waiver.

b. The order describes the NDB equipment (chapter 2), presents applicable installation drawings and wiring diagrams (chapter 3), delineates a step-by-step installation procedure (chapter 4) and provides installation standards (chapter 5).

c. <u>The order provides</u> only NDB and associated equipment installation guidance and direction for existing or future air navigation facilities. Once the NDB equipment is installed, the applicable manufacturer-furnished instruction books, referenced in text or appropriate references, shall be referred to for any equipment operation, calibration, or initial checkout procedures.

5. <u>SAFETY</u>. Personnel shall, at all times, exercise care while working on equipment where dangerously high voltages are employed. This is especially true when inspection plates and dust covers are removed or access doors are opened, exposing internal wiring. Contact with ac, dc, or rf potentials can result in severe shock, burns, or loss of life. Maintenance personnel should familiarize themselves with the technique for resuscitation found in the manual of first aid instructions. All individuals should be thoroughly familiar with general safety practices prior to working on equipment so as not to endanger themselves or others. Operating and maintenance personnel should refer to FAA Orders 6000.15A, General Maintenance Handbook for Airway Facilities, for safety precautions to be observed and 3900.6A, Occupational Safety Program for Airway Facilities Personnel. Ignorance and carelessness are predominant factors in most accidents. Particular attention shall be given to proper use of the grounding cable prior to working on high voltage circuits with power controls in the "off" position due to charges retained in capacitors. To avoid casualties, always remove power, then discharge and ground by use of a grounding rod, prior to touching any parts.

6. <u>DIRECTIVE VERBS</u>. This order contains policy statements and/or other guidance material wherein directive verbs such as SHALL, WILL, and MAY are used. The following rules of usage apply:

a. <u>Shall</u> is used to denote compulsory or mandatory action which the person directed is obliged to take. Example: The equipment SHALL be adjusted to operate in accordance with Handbook tolerances.

b. <u>Should</u> is used to denote an action which is strongly recommended, but left to the discretion of the person being directed. Example: The equipment SHOULD be shut down if, in the opinion of the technician, catastrophic failure is imminent.

c. <u>Will</u> is used to denote action in the future tense. Example: Obsolete equipment WILL be replaced as soon as funds can be made available.

d. <u>May</u> is used to denote permission. Example: At navigation aid facilities, certain maintenance activities MAY be performed without recourse to flight inspection.

7. <u>FAA DRAWINGS</u>. The drawings included in this order as standard references are listed in figure 1-1.

Drawing Number	Description	Page
D-6186-001	FA 9782 NDB Installation Marker/Comlo Bldg Layout 50 watt NDB	25
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D-6186-012	FA 9781 and FA 9782 NDB Installation Ground Plane, FM-MH Facility or H or MH Facility	47
D-6186-013	9782/1 NDB Installation External Mounting of ATU	49
D-6186-014	FA-9782 NDB Installation "T" Antenna 2-wire	51

FIGURE 1-1. NDB INSTALLATION DRAWINGS

* 8. COMMISSIONING DATA. The facility shall be commissioned only after satisfactory completion of a joint acceptance inspection (JAI) by the installation personnel and the Field Office Chief or his representative. This shall include preparation of FAA Form 198 for the NDB. A sample of this form is presented in appendix 1 herein. *

9. ABBREVIATIONS. The following abbreviations are used in this order.

ATU	-	antenna tuning unit
ICAO	-	International Civil Aviation Organization
lf	-	low frequency
mf	-	medium frequency
ATC	-	Federal Aviation Administration Technical Center
NDB	-	nondirectional beacon
NEC	-	National Electrical Code
rf	-	radio frequency
vswr	-	voltage standing wave ratio

10. WAIVERS. Facility configuration must be standardized to allow for future standard enhancements to the facility. The instructions, descriptions, standards, drawings, and procedures contained in this directive represent the FAAs baseline and standard criteria concerning NDB equipment. Some facilities under the purview of this directive have been commissioned prior to the effective date of this order using equipment which has been procured without the benefit of FAA approved specification. Existing NDB facilities on the effective date of this order which are not in compliance with this order shall be considered nonstandard facilities.

a. Regional procurement of equipment and devices to be used for air traffic control or navigation for which specifications have not received prior FAA approval is prohibited by the latest edition of Order 1100.5, FAA Organization Field, paragraph 222.j(2). The inclusion of such nonstandard equipments in this directive is for installation purposes only and, as such, will not be used as justification for procurement, installation, or commissioning of additional or similar equipment. Those facilities having a need to use nonstandard procedures for NDB installation will request waivers to applicable paragraphs of this directive in order to continue to operate with justifiable variances. For explicit instructions pertaining to commissioning, operating, and maintaining nonstandard facilities see the latest edition of Order 6000.20 Waiver of Criteria for Establishment and Maintenance of Airway Facilities. Requests for waivers submitted by facilities management personnel will be accompanied by all pertinent technical data necessary to define the problem and to justify the nonstandard equipment or operation requested. They will also include recommended solutions to the problem. Waivers already approved are still valid and do not require resubmission.

b. <u>At existing facilities</u> that are operationally acceptable, no wiring changes are to be made solely as a result of receiving this handbook. Existing waivers shall remain in effect as long as these facilities are considered operationally acceptable; however, whenever a facility undergoes modification such as modernization, conversion, relocation, or equipment addition and removal, the standards set forth herein shall be followed.

c. <u>Action to be taken</u> to budget for facility improvements which eliminate the need for waivers. Nonstandard facilities shall be upgraded to standard facilities within 3 years of the effective date of this order. The 3-year time frame allows for the normal budget process. The regions have the responsibility to submit budget estimates to effect the upgrading of nonstandard facilities.

11. <u>RESERVED</u>.

CHAPTER 2. NDB EQUIPMENT DESCRIPTION

12. INTRODUCTION. The following paragraphs provide a general functional and physical description of the 50 and 400 watt NDB units and the 50 watt atu. Figure 2-1 presents the interrelationship of the 50 watt NDB and its associated atu. Figure 2-2 shows the 400 watt NDB.

13. NDB FUNCTION. The NDB is a completely solid-state system that provides all the requirements of a NDB ground station transmitter for electronic aeronautical navigation.

a. The NDB is designed to operate in the low frequency (lf) and medium frequency (mf) bands to provide ground wave signals to a receiver. A radio direction finder is used to measure the relative bearing of the transmitter with respect to the heading of the airplane. The NDB is used primarily for transition of aircraft from en route to airport approach facilities.

14. NDB PHYSICAL DESCRIPTION.

a. The 50 watt NDB cabinet dimensions are presented in figure 2-3. Figure 2-4 depicts the 50 watt NDB with the cover opened to show the control panel and internal electrical components. The unit is wall- mounted at the mounting brackets and will extend out from the wall approximately 10 inches. The electrical component installations were performed at the factory prior to shipment. The regulator/charger (A1A1) must be removed to expose the terminal boards TB1 and TB2 as part of performing external wiring connections.

(1) External Connections. The 50 watt NDB transmitter is provided with external inputs for voice (600 ohm balanced) and a dc battery emergency supply (48 V dc). Remote status indication is available from a set of "C" contacts, closed to indicate normal operation, and a choice of ac or dc supply (0.5 to 5.0 V ac into 600 ohms or 24 V dc). The external connections are accomplished through the use of terminal boards TB1 and TB2 mounted in back of the regulator/charger A1A1. The cabling is installed using the conduit feed through located at the base of the cabinet. The NDB power requirement is a single phase nominal 115 V ac (102-138 V), 60 Hz at 160 volt-ampere maximum.

(2) Internal Wiring Connections. All internal wiring connections were performed at the factory prior to shipment.

b. The 400 watt NDB cabinet dimensions are presented in figure 2-5. A rear view of the unit is shown in figure 2-6. Vents at the top of the cabinet must be unobstructed to permit forced air from the fan to escape and provide cooling. The cabinet must be secured to the floor by

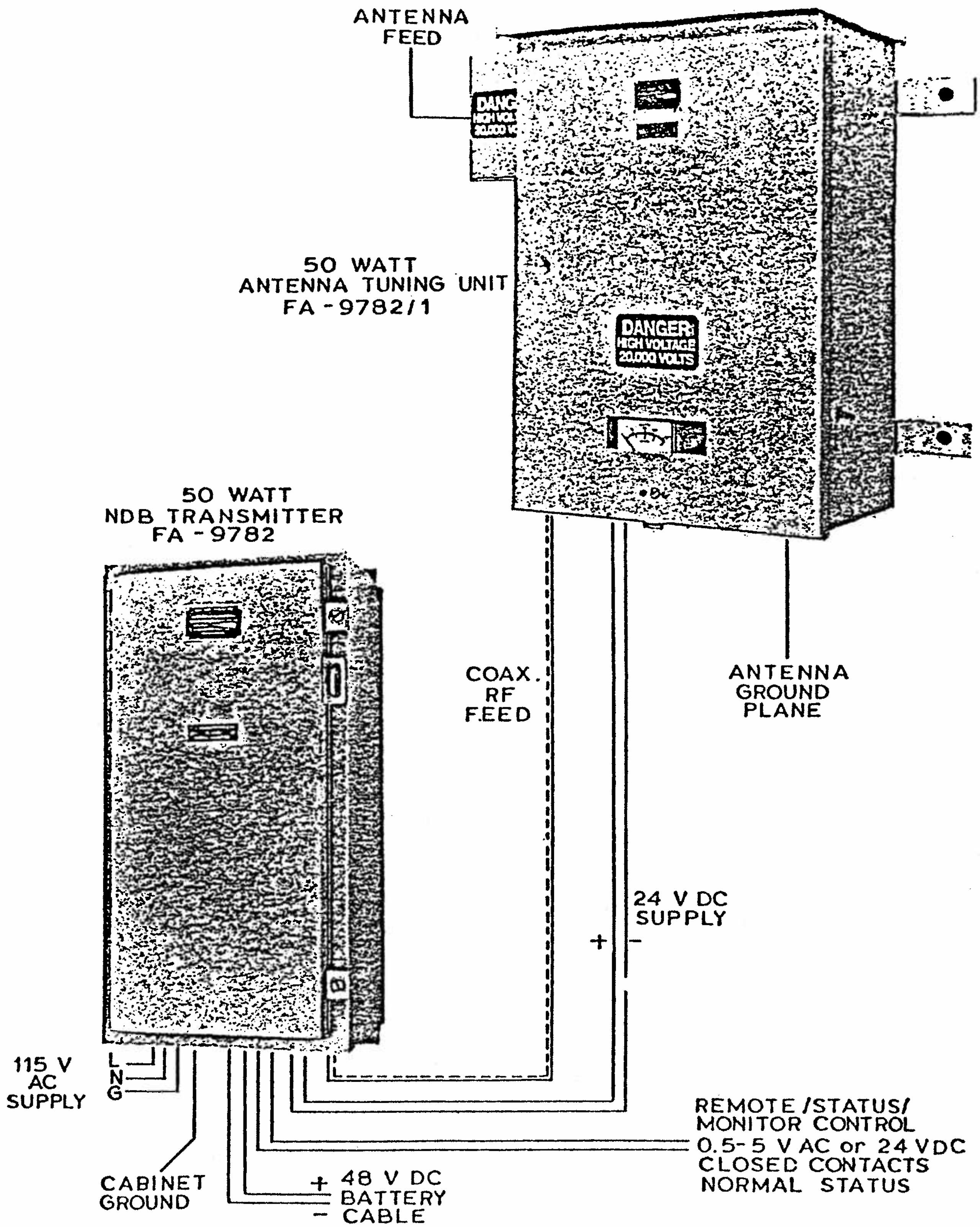


FIGURE 2-1. INTERRELATIONSHIP OF TRANSMITTER

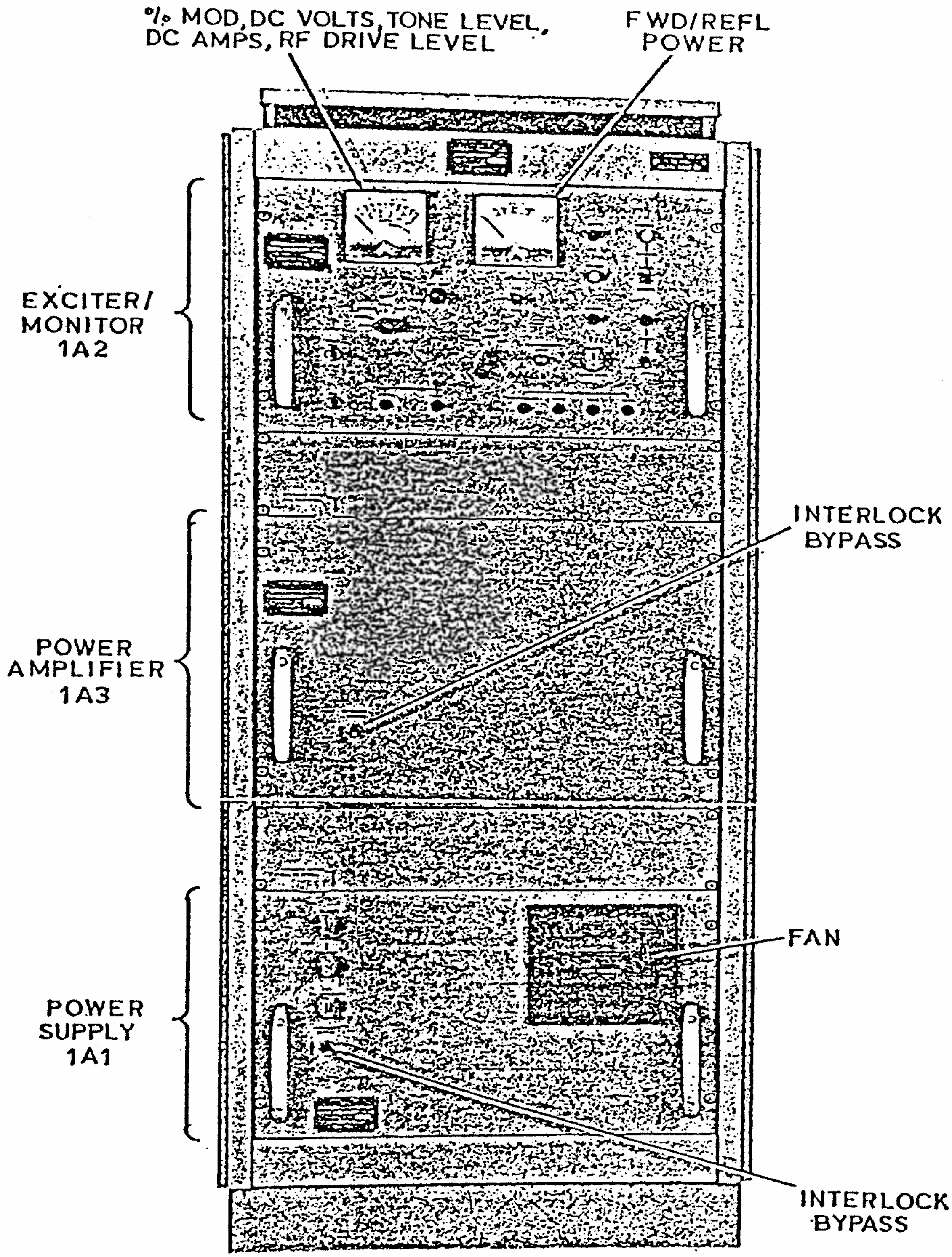


FIGURE 2-2. TRANSMITTER FRONT VIEW

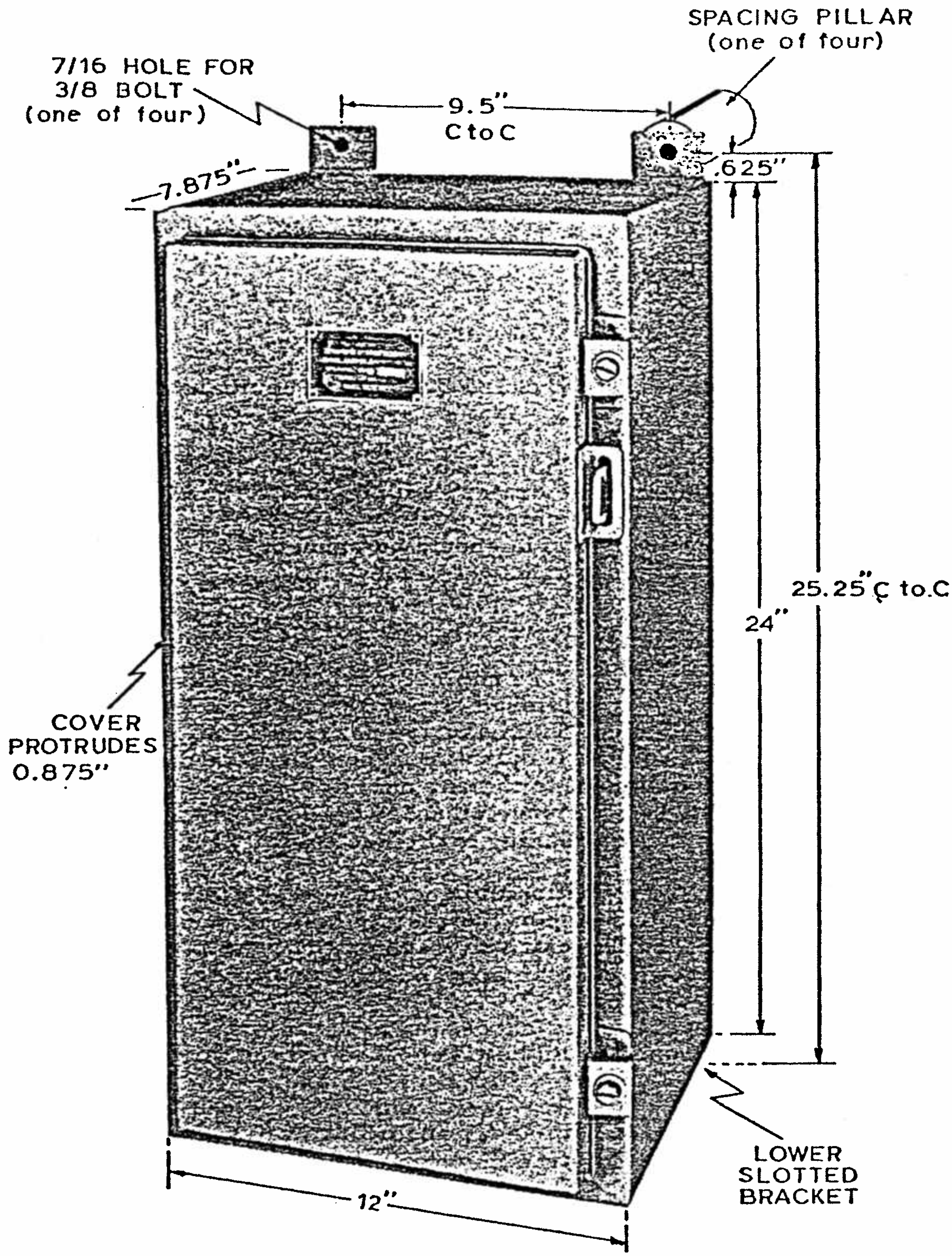


FIGURE 2-3. MOUNTING DIMENSIONS

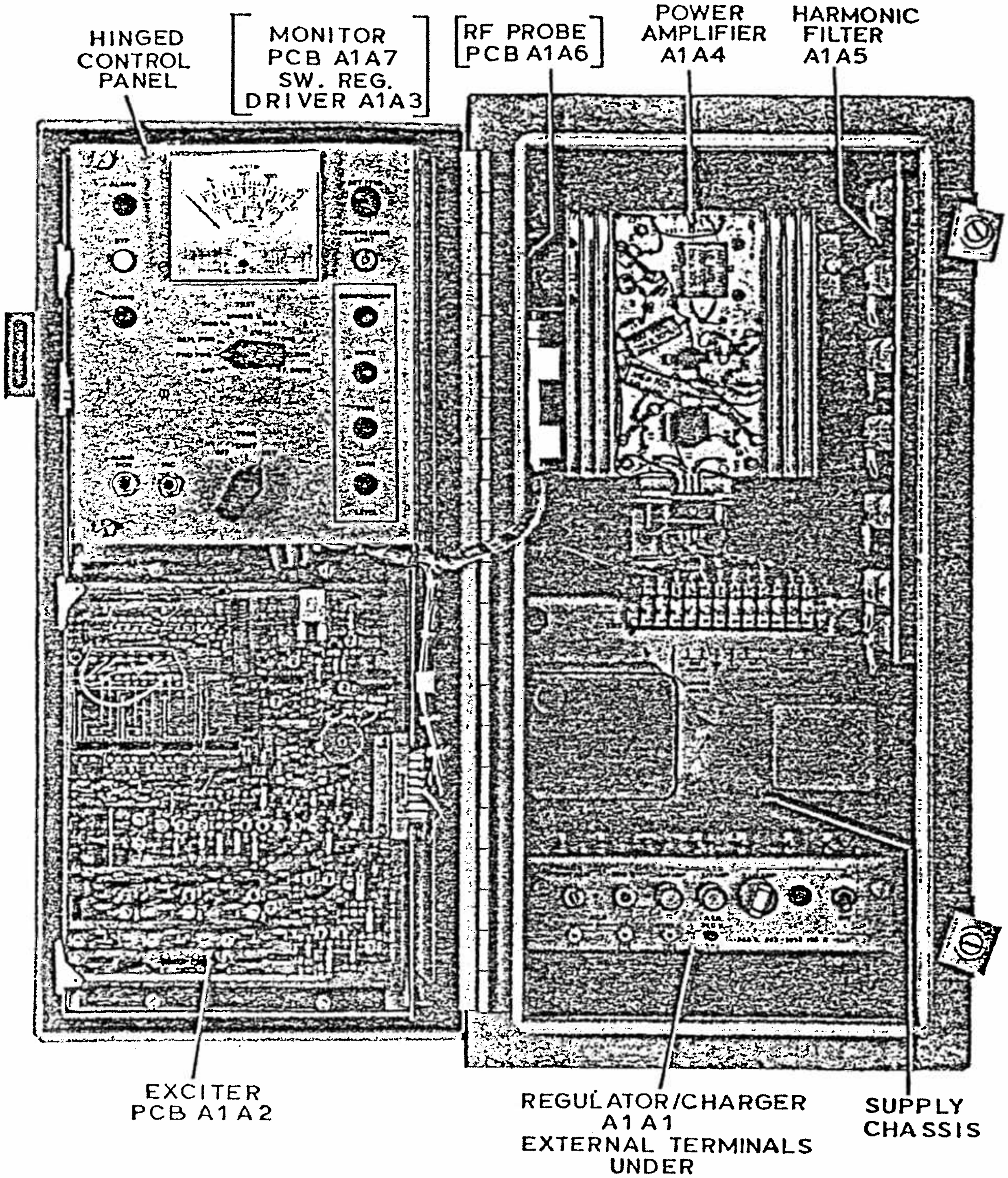


FIGURE 2-4. TRANSMITTER FA9782 - ACCESS DOOR OPEN

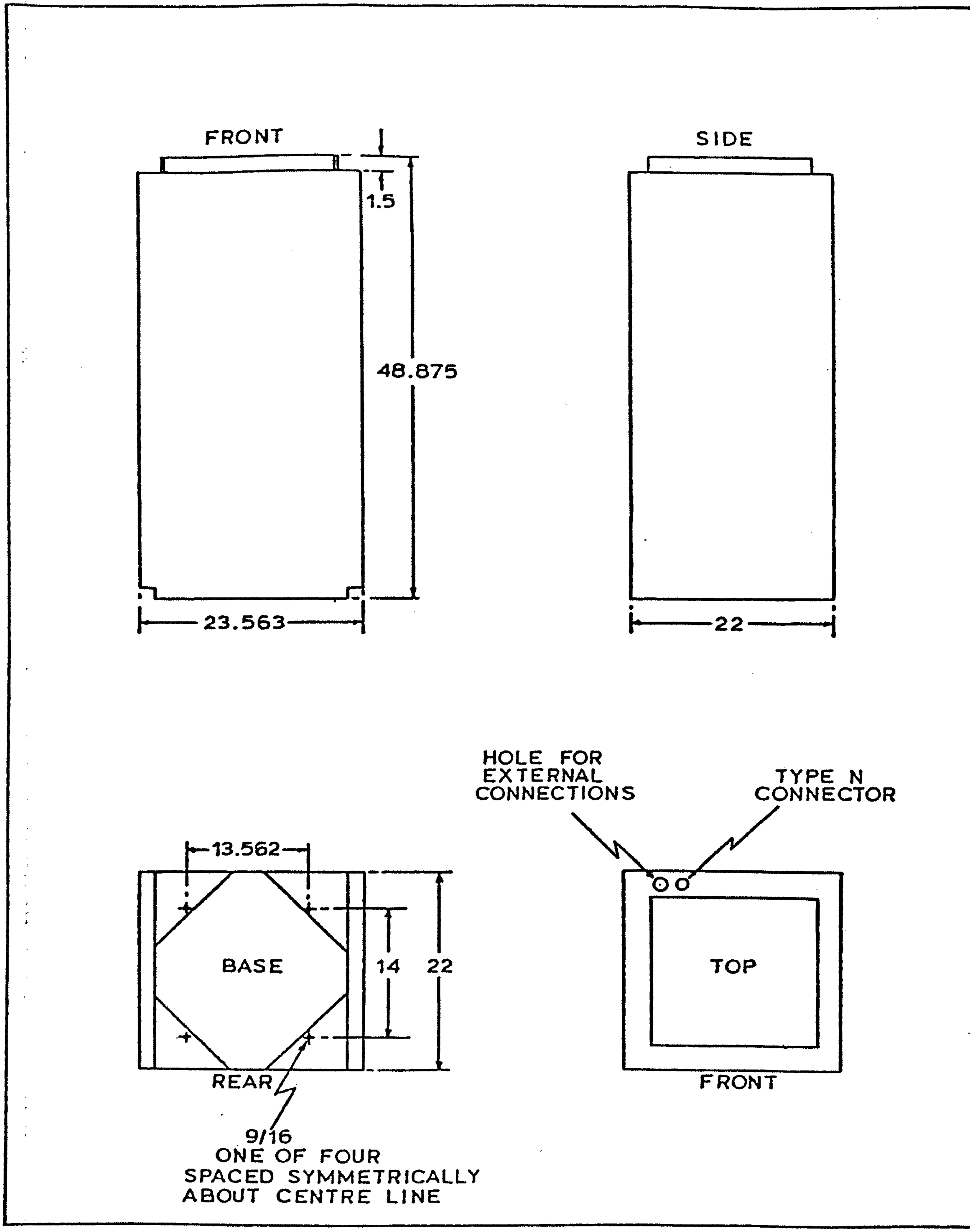


FIGURE 2-5. CABINET DIMENSIONS

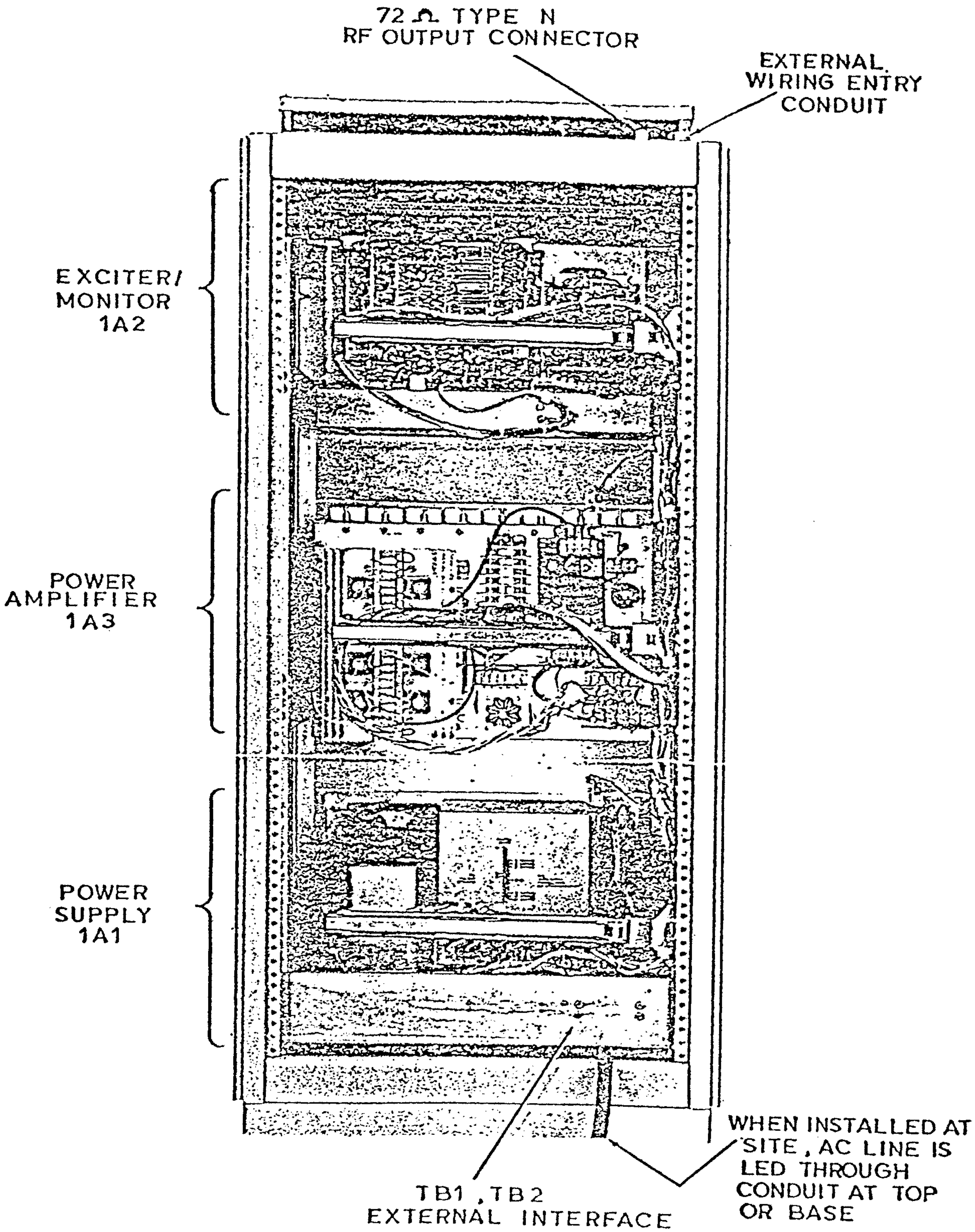


FIGURE 2-6. TRANSMITTER REAR VIEW

half-inch bolts located as shown in figure 2-5. All internal components of the cabinet are accessible from the front. Therefore, the cabinet back may be installed close to a wall. A clearance space of 2 inches between the cabinet and the wall should be allowed to permit entry of cooling air through the perforated panels.

(1) External Connnections. The external terminal connections at the transmitter are completed at terminal boards 1TB1 and 1TB2 mounted behind the power supply drawer 1A1. The terminal boards, as presented in figure 2-7, are easily accessible when the drawer is removed. Connections are most readily made before the drawer is mounted. Cabling may enter the cabinet through the top cover beside the rf output type N connector or through the aperture in the base of the cabinet.

15. 50 WATT atu FUNCTION. The FA-9782/1 50 watt atu matches the impedance of the antenna, within the range from 2 to 24 ohms resistance and from 166 to 1500 picofarads capacity, to the 50 ohm impedance of the transmitter output. It automatically compensates for the variations in antenna reactance caused by environmental changes while the system is operating. The maximum vswr of the rf feed into the antenna is 1.25 : 1, when TONE is off. Metering of forward and reflected power and rf current is provided.

a. The resistive and inductive components of the antenna impedance are matched by adjustable tappings on the transformer and loading coil assembly, respectively. The coil assembly is fined-tuned by a servo system which, through a motorized drive, positions ferrite tuning slugs in two coils. The electronics are totally solid-state. Three sets of coils, NAUTEL 133-9023, have been produced to cover the frequency range from 190 kHz to 535 kHz. All three match to the total specified range of antenna capacities over the following ranges.

(1) 133 - 9023 - 1 and 2 from 190 - 285 kHz)
1, 3, 5 - right-hand
(2) 133 - 9023 - 3 and 4 from 286 - 405 kHz)
2, 4, 6 - left-hand
(3) 133 - 9023 - 5 and 6 from 406 - 535 kHz)

b. 50 WATT antenna tuning measurement of output power and antenna current on the panel meter is required. Because of the impedance matching transformer the current metering circuit sees 50 ohms resistive. To determine the current flowing in the antenna the reading of the meter must be multiplied by a factor which depends upon the tapping. These are presented in Table 2-1.

c. A method of reestablishing output power, so that a confirming flight inspection is not required, regions may use ammeter method

TABLE 2-1. Correction Factor for FA-9782/1 Antenna Current

Input Tap	Output Tap	Load Resistance Ohms	Multiplying Factor
3	4	34.7	1.2
2	4	28.1	1.33
1	4	23.2	1.47
3	5	18.7	1.64
2	5	15.1	1.82
1	5	12.5	2
3	6	9.9	2.25
2	6	8.0	2.5
1	6	6.6	2.75
3	7	5.6	3
2	7	4.5	3.33
1	7	3.7	3.67
The actual antenna current is obtained by multiplying the meter reading by the multiplying factor.			

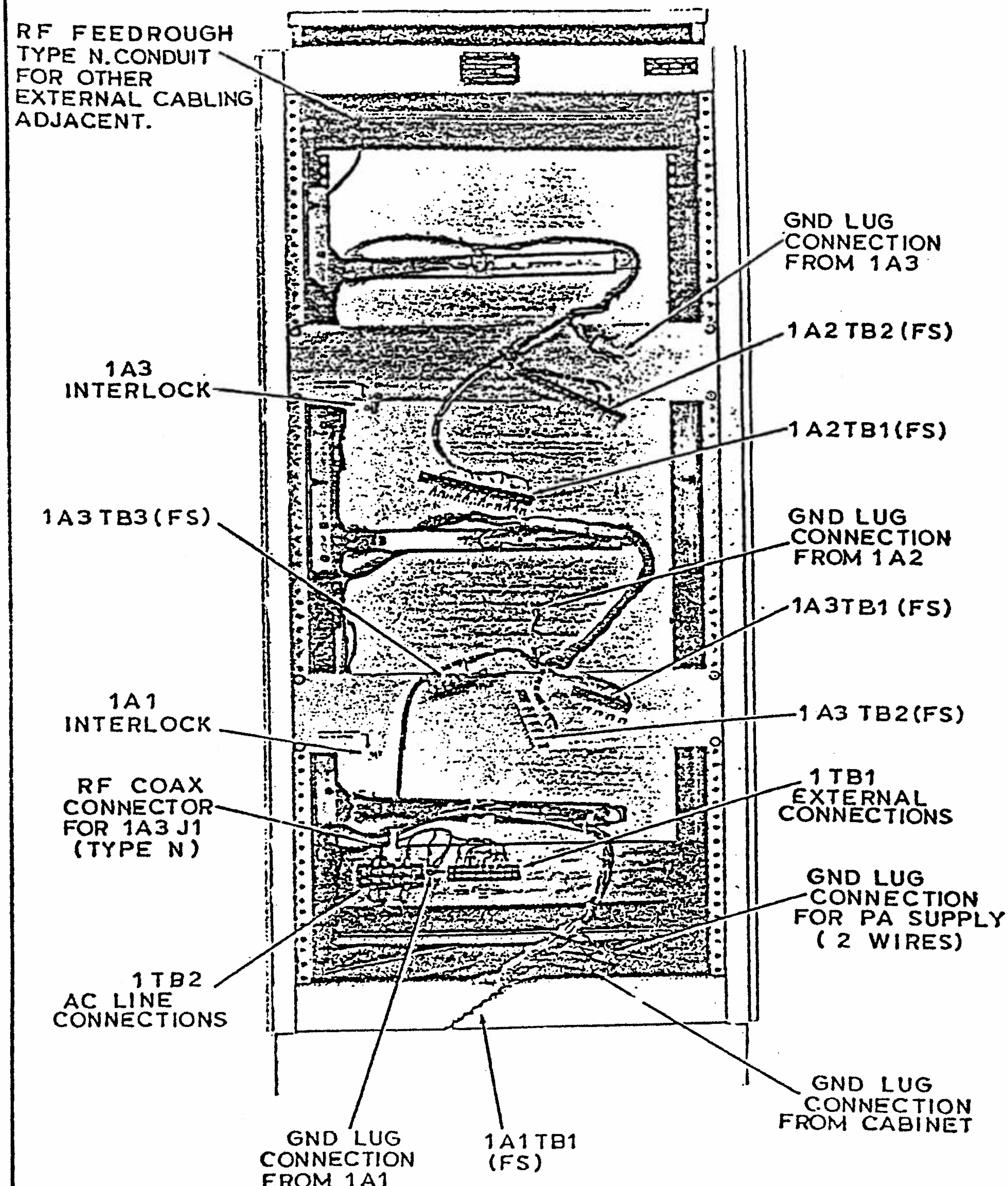


FIGURE 2-7. INTERNAL TERMINALS

to verify same power during replacement. The FA9782 has Ia current antenna meter built into the unit. Regions may also use a signal strength meter which is available from the Frequency Management staff in the region.

16. 50 WATT ATU PHYSICAL DESCRIPTION.

a. The 50 watt atu cabinet dimensions are presented in figure 2-8 and the atu with the cover removed in figure 2-9. The atu unit is housed in a single, all-weather cabinet fitted with rear brackets for mounting on a vertical surface adjacent to the antenna feed through opening. The top-hinged front cover is secured at the bottom when closed, and is supported in the open position by a bar and lug arrangement. The top cover is flanged to provide weather protection for the top ventilating ports on three sides of the cabinet. A ventillation air intake, which must not be obstructed when the unit is installed, is located in the atu base plate. In areas of severe weather, such as blowing snow, an additional length of pipe and baffle should be added to the air intake pipe.

b. The two loading coils and a drive motor are mounted on a bracket bolted to the rear panel. The vertical threaded motor drive shaft controls the positioning of the ferrite tuning slugs in the coils via a threaded horizontal traveller attached to the two spindles. Limit switches interrupt the electrical drive to the motor at both ends of travel. The coils are wound on vertically mounted forms supported by pillars on the bracket.

c. The electronic chassis mounts on the front of the same bracket by captive fixing screws and contains all the component electronic subassemblies in the unit.

(1) External Connections. The two external electrical connections, for the signal and power supply cables, are made at the base of the unit. A heavy ground lug for connections to the antenna ground plane is fitted at the lower left corner of the rear panel. A window in the front cover allows observation of the test meter without raising the cover. An externally mounted switch shorts the meter when not in use.

(2) Internal Wiring Connections. All internal wiring connections were made at the factory prior to shipment.

17. RESERVED.

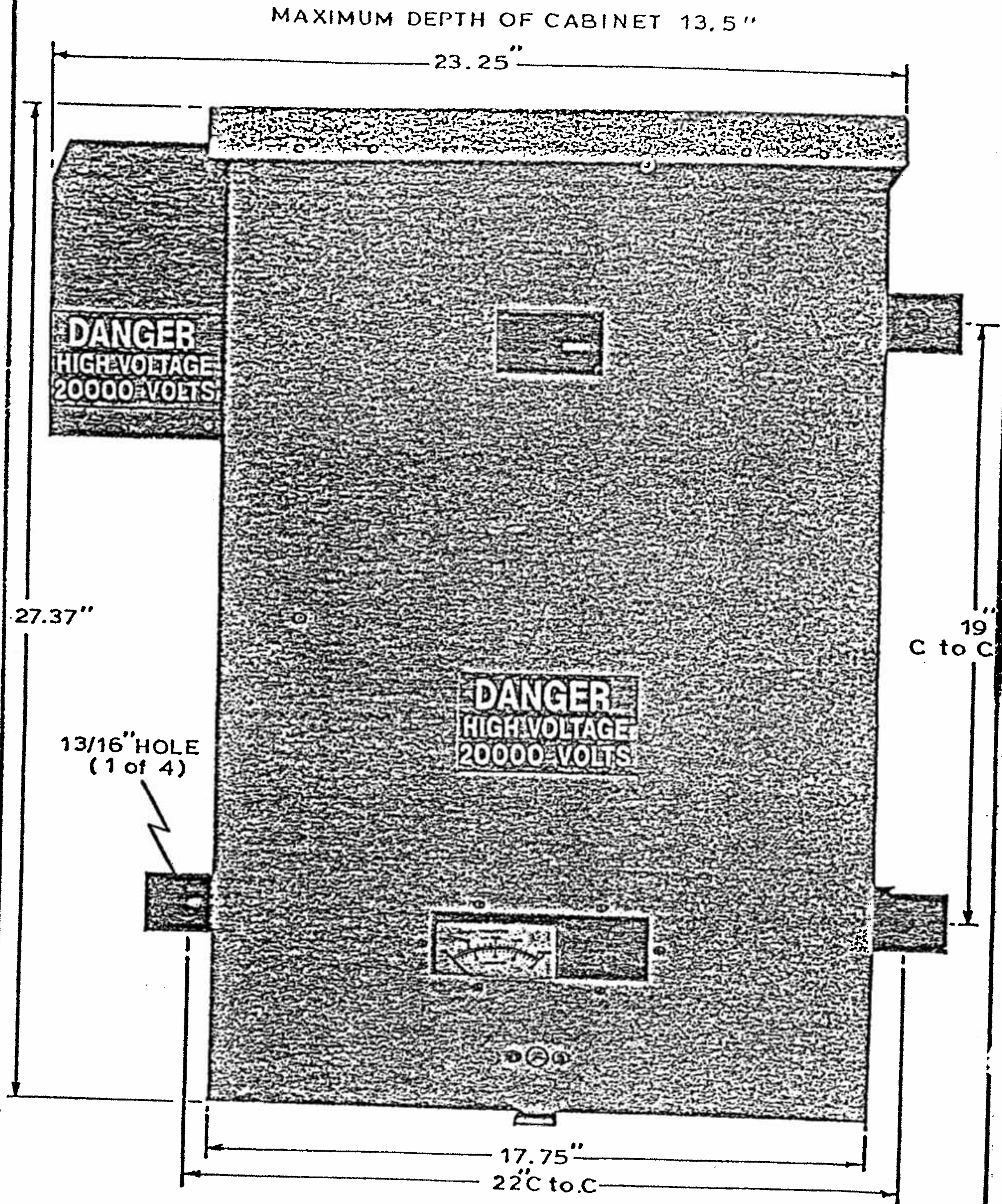


FIGURE 2-8 CABINET MOUNTING DIMENSIONS

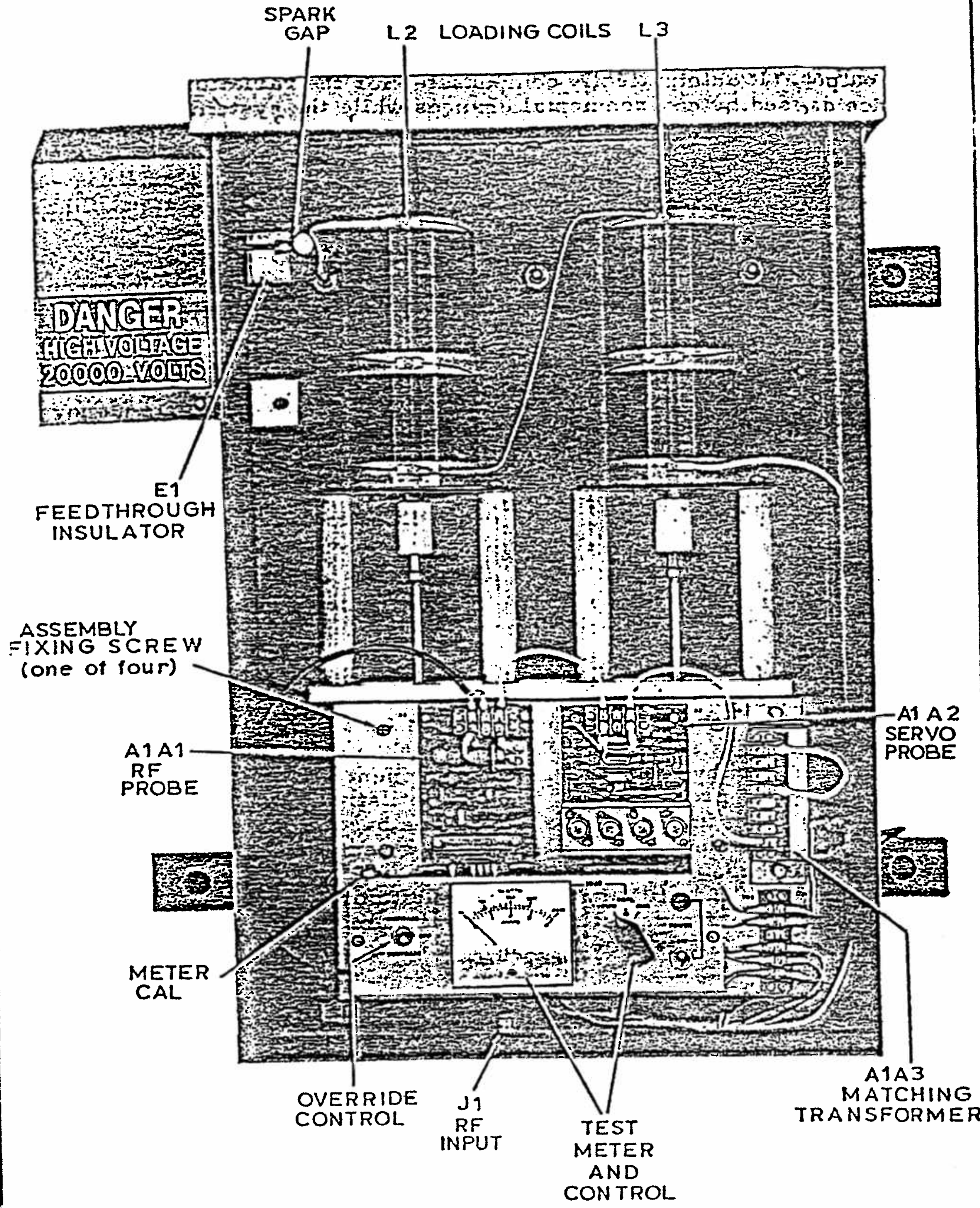


FIGURE 2-9. ANTENNA TUNING UNIT - COVER REMOVED

CHAPTER 3. NDB INSTALLATION DRAWING PACKAGE

18. INTRODUCTION. The installation drawings, tabulated in figure 3-1 and presented herein, shall be adhered to when locating the 50 and 400 watt NDB units, the 50 watt atu, completing applicable interface wiring connections, routing cable or conduit, and completing the antenna feed through and spark gap installations. The drawings also present typical NDB facility antenna installation drawings for routing antenna cables from the antenna feed through to the antenna mast.

19. DRAWING SYNOPSIS:

a. Drawing D-6186-001 presents the floor plan arrangement for a 50 watt NDB and atu in a marker compass locator building. The 50 watt NDB and its associated atu are wall mounted to unistrut channels. Overhead thin wall conduit and ducting will be employed for routing the appropriate 50 watt NDB and atu cabling.

b. Drawing D-6186-002 presents the floor plan arrangement for the 400 watt NDB in a marker compass locator building. The NDB rack is floor mounted. Appropriate envelope space is also shown for a 400 watt atu. Thin wall conduit will be installed for cable routing.

c. Drawing D-6186-003 presents the applicable 50 watt NDB and its associated atu wiring and interconnection diagram.

d. Drawing D-6186-004 presents the applicable 400 watt NDB wiring and interconnection diagram.

e. Drawings D-6186-005 through D-6186-009 present various NDB facility type antenna installation details. The rf cable is routed from the 50 watt atu or the 400 watt NDB to the antenna via the antenna feed through the spark gap, and antenna down wire.

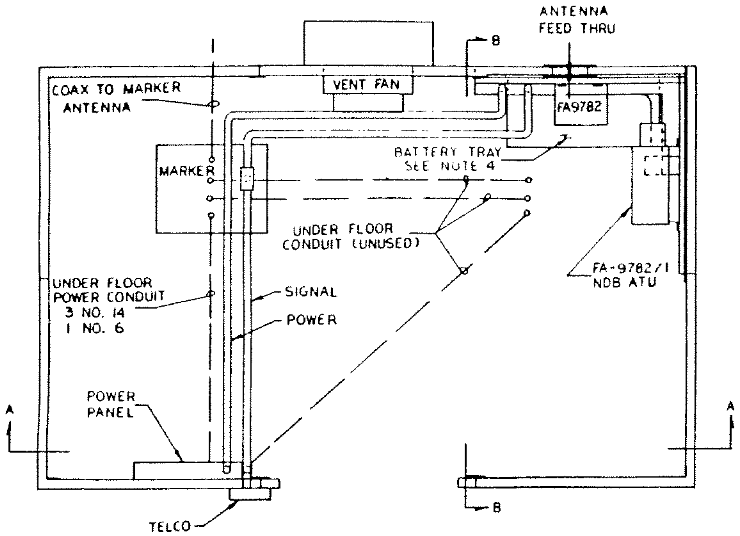
f. Drawing D-6186-010 presents the spark gap and antenna down wire installation details.

g. Drawings D-6186-011 and D-6186-012 present ground plane installations at various facility types.

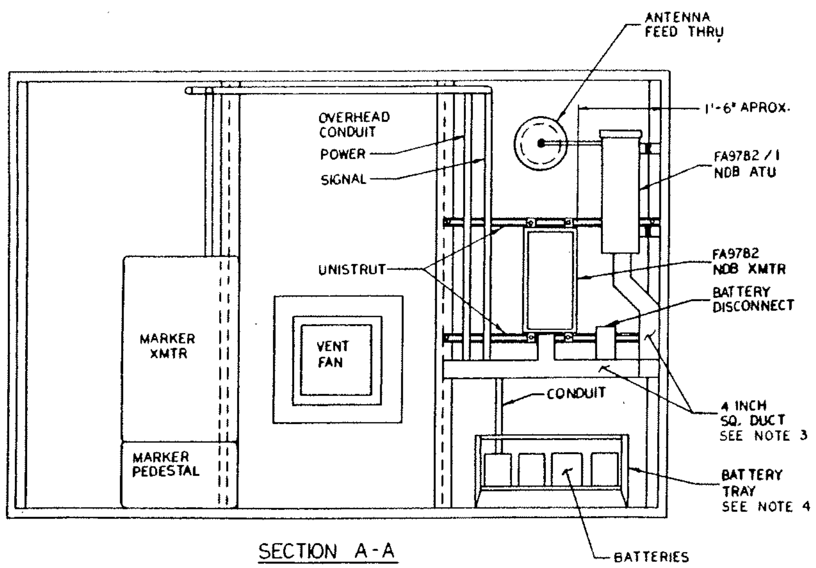
20. RESERVED.

Drawing Number	Description	Page
D-6186-001	FA 9782 NDB Installation Marker/Comlo Bldg Layout 50 watt NDB	25
D-6186-002	FA 9781 NDB Installation Marker/Comlo Bldg Layout 400 watt NDB	27
D6186-003	FA 9782 NDB Installation Power and Signal Wiring Diagram with Tube Marker 50 watt NDB and atu	29
D-6186-004	FA 9781 NDB Installation Power and Signal Wiring Diagram 400 watt NDB	31
D-6186-005	FA 9781 and FA 9782 NDB Installation Antenna Details ILS Marker and Compass Locator	33
D-6186-006	FA 9781 and FA 9782 NDB Installation Antenna Details, Type "T" ILS Marker and Compass Locator	35
D-6186-007	FA 9781 and FA 9782 NDB Installation Antenna Details, MH Facility	37
D-6186-008	FA 9781 and FA 9782 NDB Installation Antenna Details, Hexagonal Top Hat 500 Ft. Radials	39
D-6186-009	FA 9781 and FA 9782 NDB Installation Antenna Details, Hexagonal Top Hat 165 Ft. Radials	41
D-6186-010	FA 9781 and FA 9782 NDB Installation Spark Gap and Antenna down Wire	43
D-6186-011	FA 9781 and FA 9782 NDB Installation Ground Plane, Middle and Outer Compass Locator Markers	45
D-6186-012	FA 9781 and FA 9782 NDB Installation Ground Plane, FM-MH Facility or H or MH Facility	47
D-6186-013	9782/1 NDB Installation External Mounting of ATU	59
D-6186-014	FA-9782 NDB Installation "T" Antenna 2-wire	51

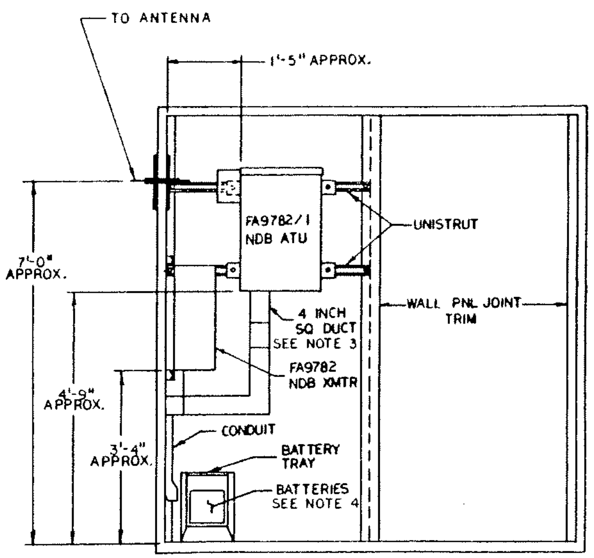
FIGURE 3-1. NDB INSTALLATION DRAWINGS



FLOOR PLAN



SECTION A-A



SECTION B-B

NOTES

1 MAXIMUM DISTANCE IS λ/8 FOR RG331 OR RG214 (FA-9782 INSTRUCTION BOOK)

2 - THE ATU CAN BE INSTALLED AT THE ANTENNA BASE IF DESIRED

3 - THE USE OF THIN WALLED CONDUIT IS OPTIONAL

4 - INSTALLATION OF THE BATTERY AND BATTERY TRAY ARE OPTIONAL

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

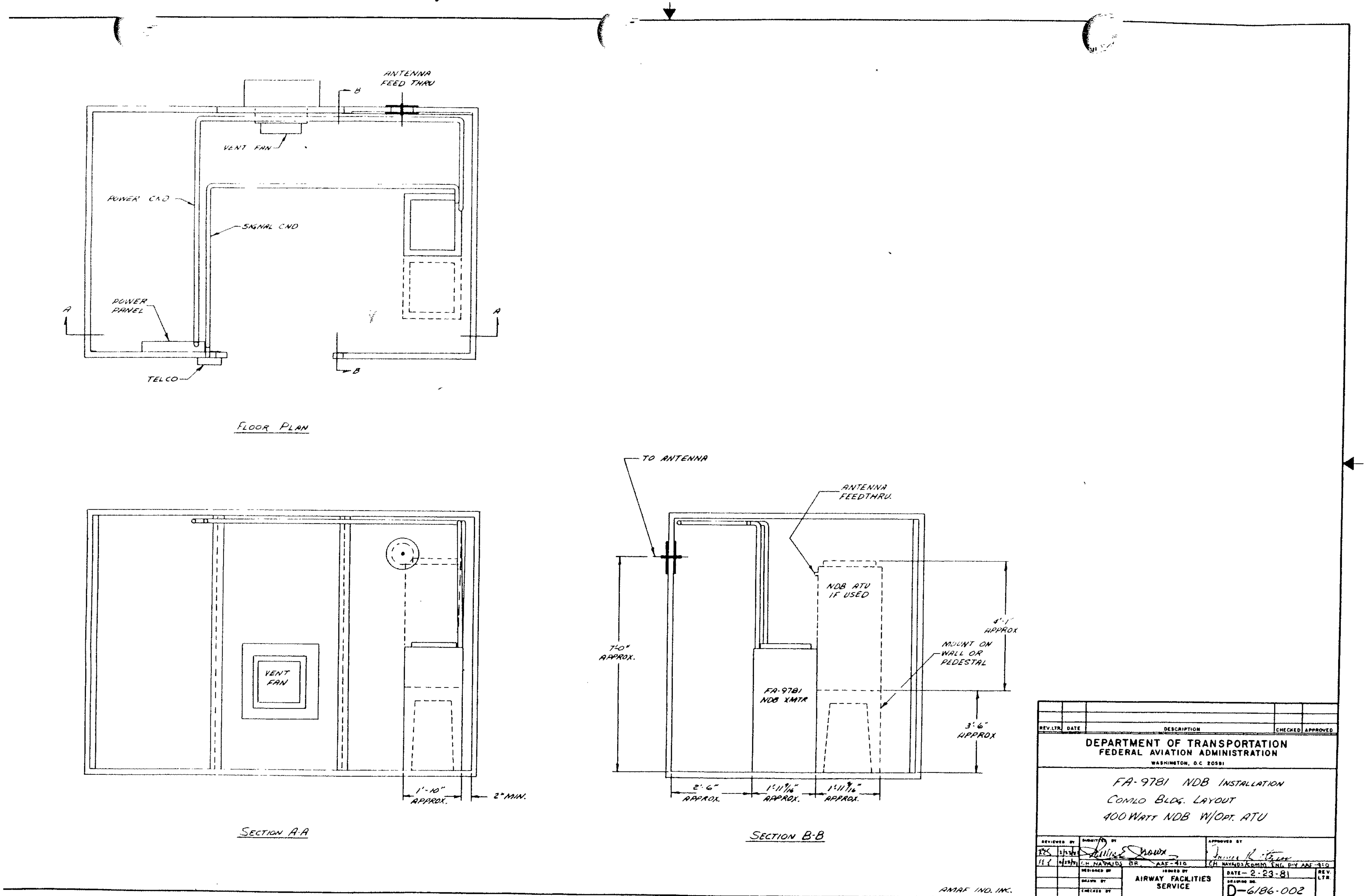
FA-9782 NDB INSTALLATION
MARKER / COMLO BLDG LAYOUT
50 WATT NDB

AIRWAY FACILITIES SERVICE

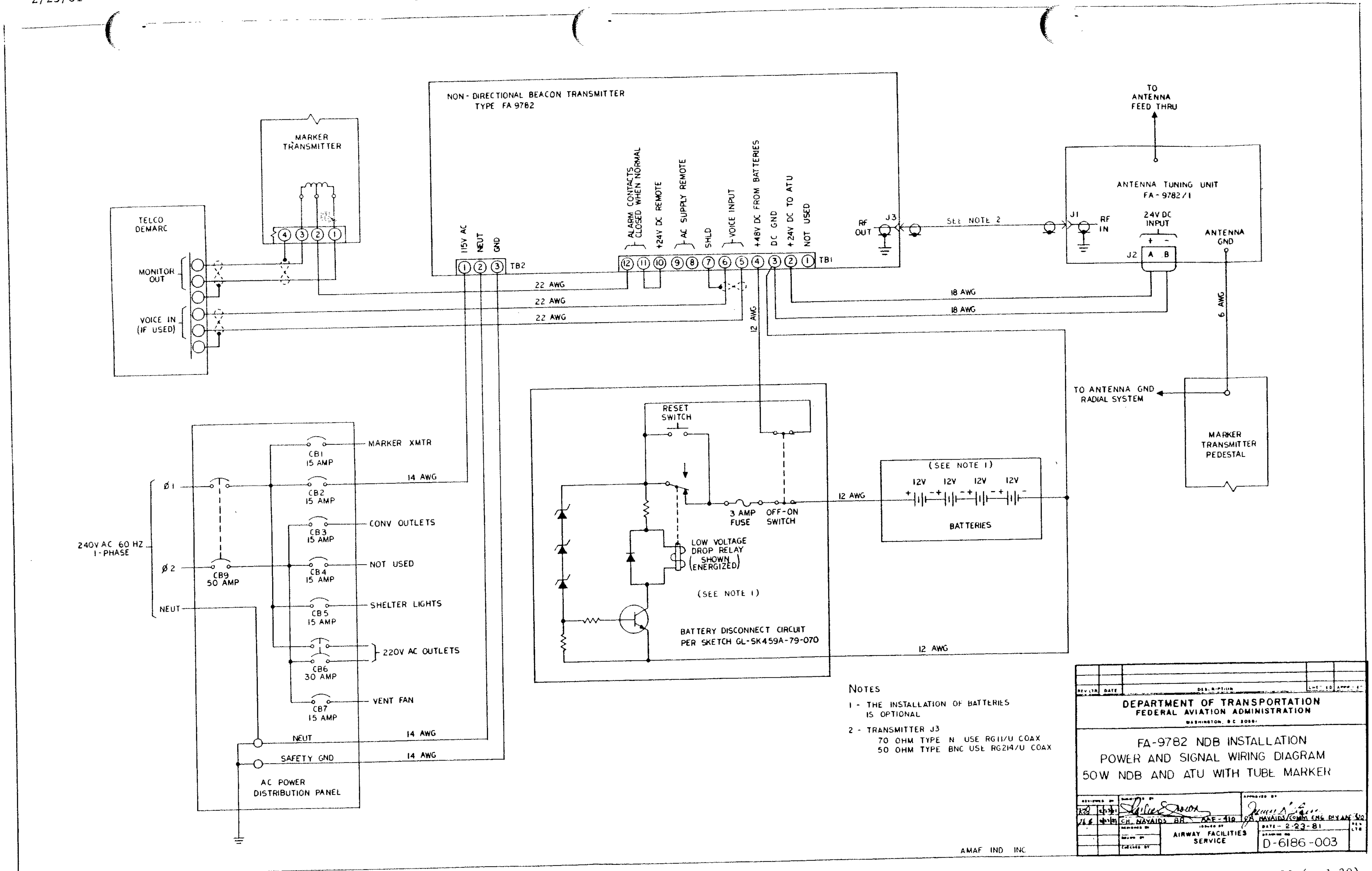
DATE 2-23-81

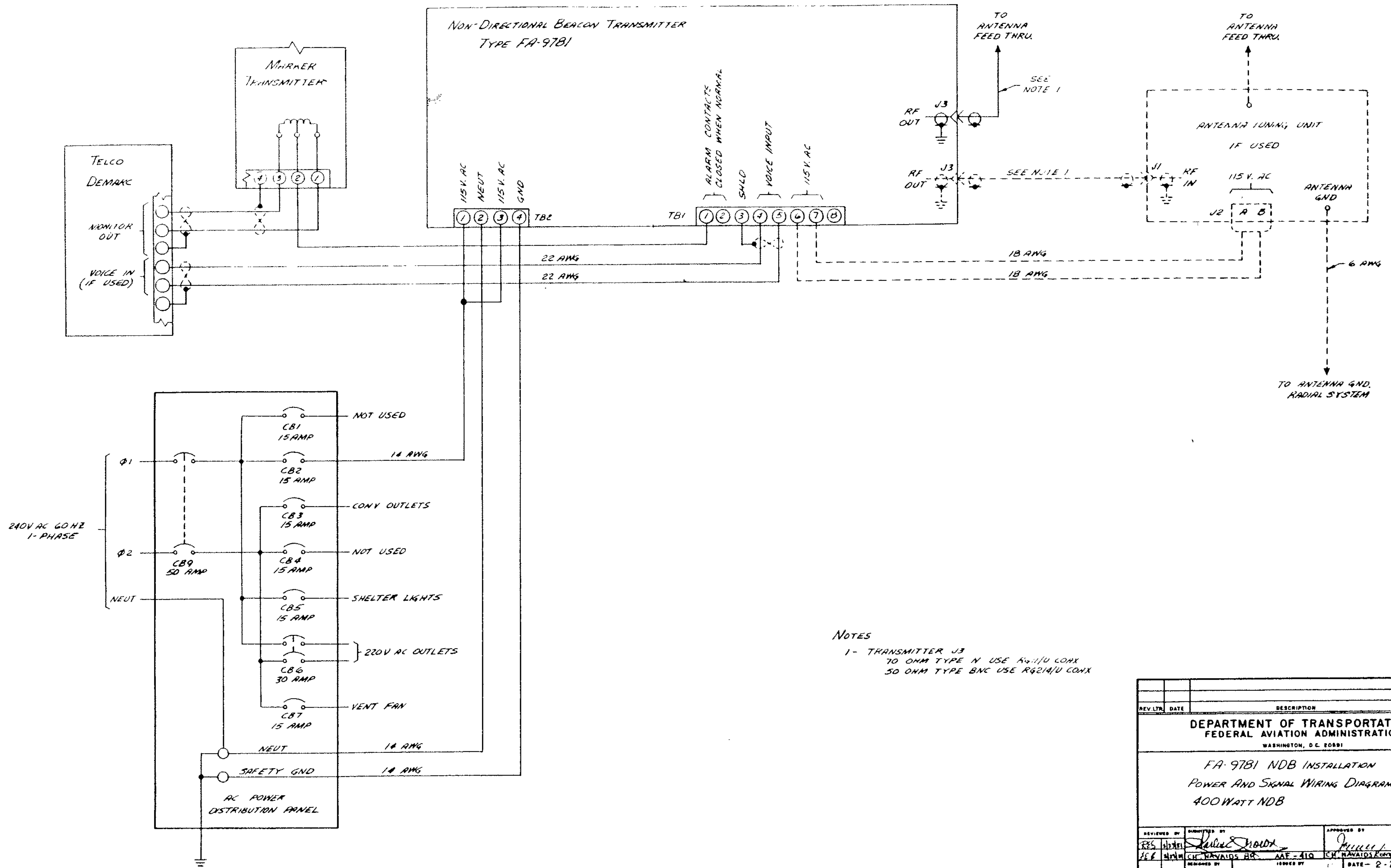
D-6186-001

AMAF IND INC



ANTENNA FEED THRU
B
VENT FAN
POWER CND
SIGNAL CND
POWER PANEL
A
A
TELCO
B
FLOOR PLAN
TO ANTENNA
ANTENNA FEEDTHRU.
NDB ATU IF USED
4'-1" APPROX
MOUNT ON WALL OR PEDESTAL
7'-0" APPROX.
FA-9781 NDB XMTR
3'-6" APPROX
VENT FAN
1'-10" APPROX.
2" MIN.
2'-6" APPROX.
1'-11 9/16" APPROX.
1'-11 9/16" APPROX.
SECTION A-A
SECTION B-B
AMAF IND. INC.
REV. LTR.
DATE
DESCRIPTION
CHECKED
APPROVED
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591
FA-9781 NDB INSTALLATION
COMLO BLDG. LAYOUT
400 WATT NDB W/OPT. ATU
REVIEWED BY
SUBMITTED BY
APPROVED BY
CH NAVAIDS BR. AAF-410
CH NAVAIDS COMM. ENG. DIV AAF-400
DESIGNED BY
DRAWN BY
CHECKED BY
ISSUED BY
AIRWAY FACILITIES SERVICE
DATE- 2-23-81
DRAWING NO.
D-6186-002
REV. LTR.


NON-DIRECTIONAL BEACON TRANSMITTER
TYPE FA 9782
MARKER TRANSMITTER
TELCO DEMARC
MONITOR OUT
VOICE IN (IF USED)
115V AC
NEUT
GND
TB2
ALARM CONTACTS CLOSED WHEN NORMAL
+24V DC REMOTE
AC SUPPLY REMOTE
SHLD
VOICE INPUT
+48V DC FROM BATTERIES
DC GND
+24V DC TO ATU
NOT USED
TB1
RF OUT
J3
SEE NOTE 2
J1
RF IN
22 AWG
22 AWG
22 AWG
12 AWG
18 AWG
18 AWG
TO ANTENNA FEED THRU
ANTENNA TUNING UNIT
FA-9782/1
24V DC INPUT
J2
A B
ANTENNA GND
6 AWG
TO ANTENNA GND RADIAL SYSTEM
MARKER TRANSMITTER PEDESTAL
RESET SWITCH
LOW VOLTAGE DROP RELAY (SHOWN ENERGIZED)
(SEE NOTE 1)
BATTERY DISCONNECT CIRCUIT
PER SKETCH GL-SK459A-79-070
3 AMP FUSE
OFF-ON SWITCH
12 AWG
(SEE NOTE 1)
12V 12V 12V 12V
BATTERIES
12 AWG
MARKER XMTR
CB1 15 AMP
14 AWG
CB2 15 AMP
CONV OUTLETS
CB3 15 AMP
NOT USED
CB4 15 AMP
SHELTER LIGHTS
CB5 15 AMP
220V AC OUTLETS
CB6 30 AMP
VENT FAN
CB7 15 AMP
Ø 1
Ø 2
CB9 50 AMP
240V AC 60 HZ 1-PHASE
NEUT
NEUT
14 AWG
SAFETY GND
14 AWG
AC POWER DISTRIBUTION PANEL
NOTES
1 - THE INSTALLATION OF BATTERIES IS OPTIONAL
2 - TRANSMITTER J3
70 OHM TYPE N USE RG11/U COAX
50 OHM TYPE BNC USE RG214/U COAX
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C.
FA-9782 NDB INSTALLATION
POWER AND SIGNAL WIRING DIAGRAM
50W NDB AND ATU WITH TUBE MARKER
CH. NAVAIDS BR.
AAF-410
AIRWAY FACILITIES SERVICE
DATE - 2-23-81
D-6186-003
AMAF IND INC



NOTES

1- TRANSMITTER J3
70 OHM TYPE N USE RG-11/U COAX
50 OHM TYPE BNC USE RG214/U COAX

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 NDB INSTALLATION
POWER AND SIGNAL WIRING DIAGRAM
400 WATT NDB

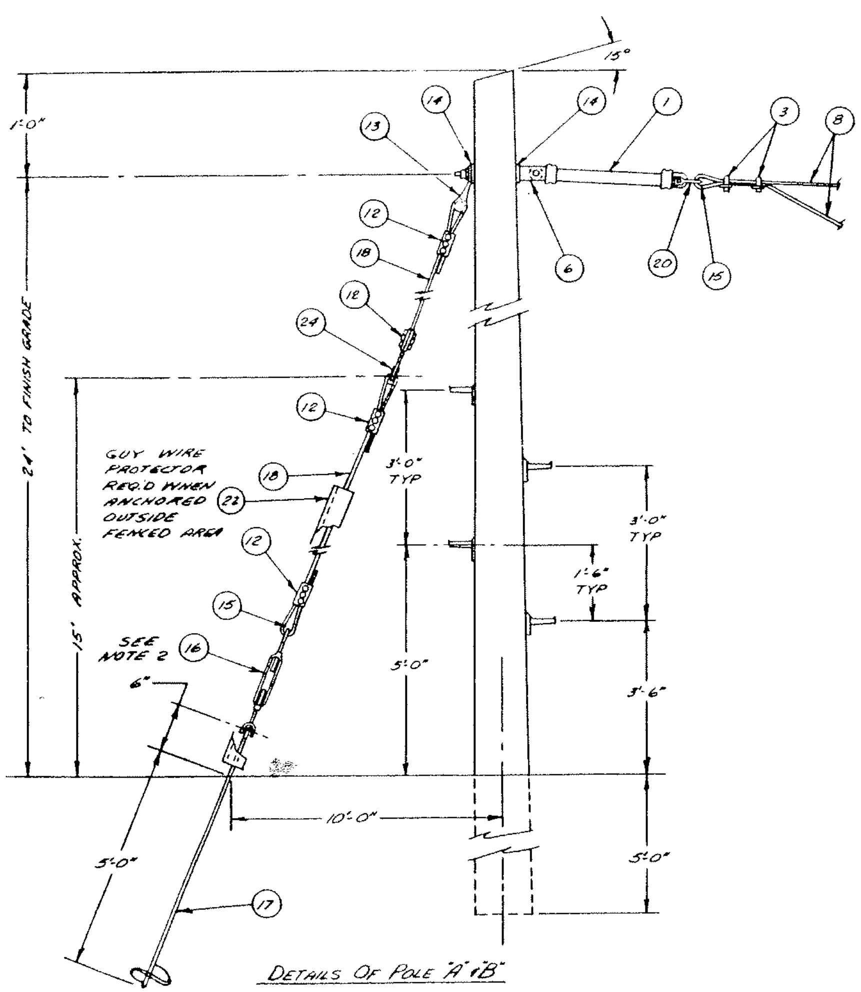
REVIEWED BY: ESS 3/23/81; JSG 3/23/81
SUBMITTED BY: CH. NAVAIDS BR. AAF-410
APPROVED BY: CH. NAVAIDS COMM ENG DIV AAF-400
ISSUED BY: AIRWAY FACILITIES SERVICE
DATE- 2-23-81
DRAWING NO. D-6186-004

AMAF IND. INC.

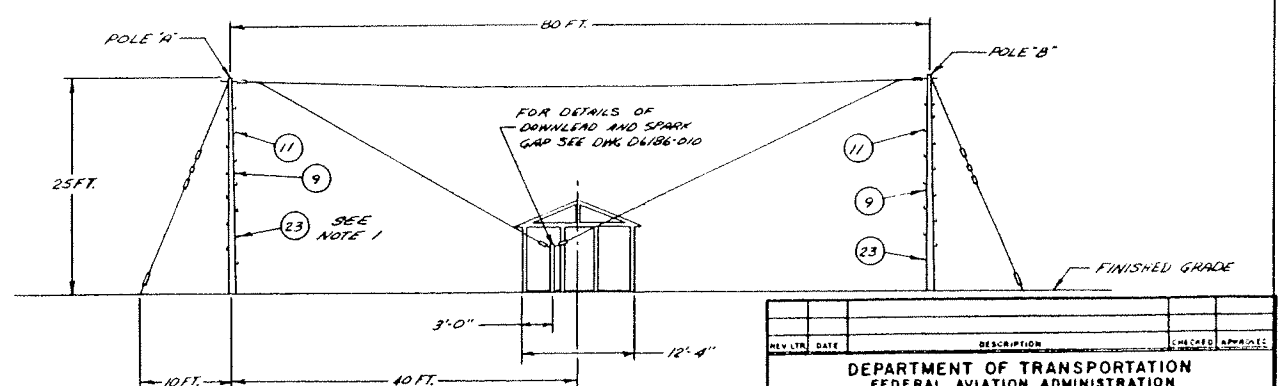
NOTES:-

1. THE FIVE BOTTOM POLE STEPS (ITEM 23) ON EACH POLE SHALL BE THE DETACHABLE TYPE. ALL OTHERS SHALL BE THE FIXED TYPE (ITEM 11).
2. AFTER TENSION ADJUSTMENT, ALL TURNBUCKLES SHALL BE LACED 3 TIMES WITH NO. 14 AWG COPPER WIRE AND TIED.
3. SIMILAR AND EQUAL PARTS MANUFACTURED BY OTHERS MAY BE SUBSTITUTED FOR THOSES CALLED FOR IN THE MATERIAL LIST.

ITEM		MATERIAL LIST
1		SULATOR, ANTENNA LAPP NO. 43808P12
2		
3	4	CONNECTOR, COPPER, KEARNEY NO. 840-2R
4		
5		
6	2	BOLT, CLEVIS, 5/8" x 14" GALV. HUBBARD NO. 6814
7		
8	200'	WIRE, COPPER, HARD DRAWN NO. 4-STRANDED, SILICON BRONZE OR EQUAL
9	2	POLE, WOOD, CLASS-5, 30 FT. TYPE I OR II IN ACCORDANCE WITH SPECIFICATION CAA-746
10		
11	16	STEP, POLE 5/8" x 9" HOOK HEAD, GALV. HUBBARD NO. 7124
12	8	CLAMP, GUY, 3-BOLT, GALV. FOR 3/8" GUY WIRE HUBBARD NO. 7449
13	2	ANGLE THIMBLEYE, FOR 5/8" BOLT, GALV. HUBBARD NO. 1100
14	4	WASHER, CURVED 2½" x 2½" GALV. HUBBARD NO. 7822
15	6	THIMBLE, FOR 3/8" WIRE, GALV. HUBBARD NO. 7593
16	2	TURNBUCKLE ½" x 12" EYE-CLEVIS, GALV. HUBBARD NO. 8644
17	2	ANCHOR, GUY STEELWING, OVAL EYE, 3/4" x 5½ FT. LONG GALV. HUBBARD NO. 7526-A
18	100'	WIRE, GUY, 3/8 SIMENS MARTIN GRADE CLASS-A COATING OR BETTER
19		
20	4	SHACKLES, DROP FORGED, STEEL 1-1/4" x 7/16" WITH 1/2" DIA. PIN, GALV. THOMAS LAUGHLIN CO. FIG. NO. G-213
21		
22	2	GUY WIRE PROTECTOR WITH 2 "U" BOLTS HUBBARD NO. 7558
23	10	STEPS, POLE, DETACHABLE, LAG AND PLATE HUBBARD NO. 7235 AND STEP NO. 7236 GALV.
24	2	INSULATOR, GUY, PORCELAIN 13/16" HOLES, HUBBARD NO. 506



DETAILS OF POLE "A" & "B"



REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 AND 9782 NDB INSTALLATION
ANTENNA DETAILS, TRIANGULAR
ILS MARKER AND COMPASS LOCATOR

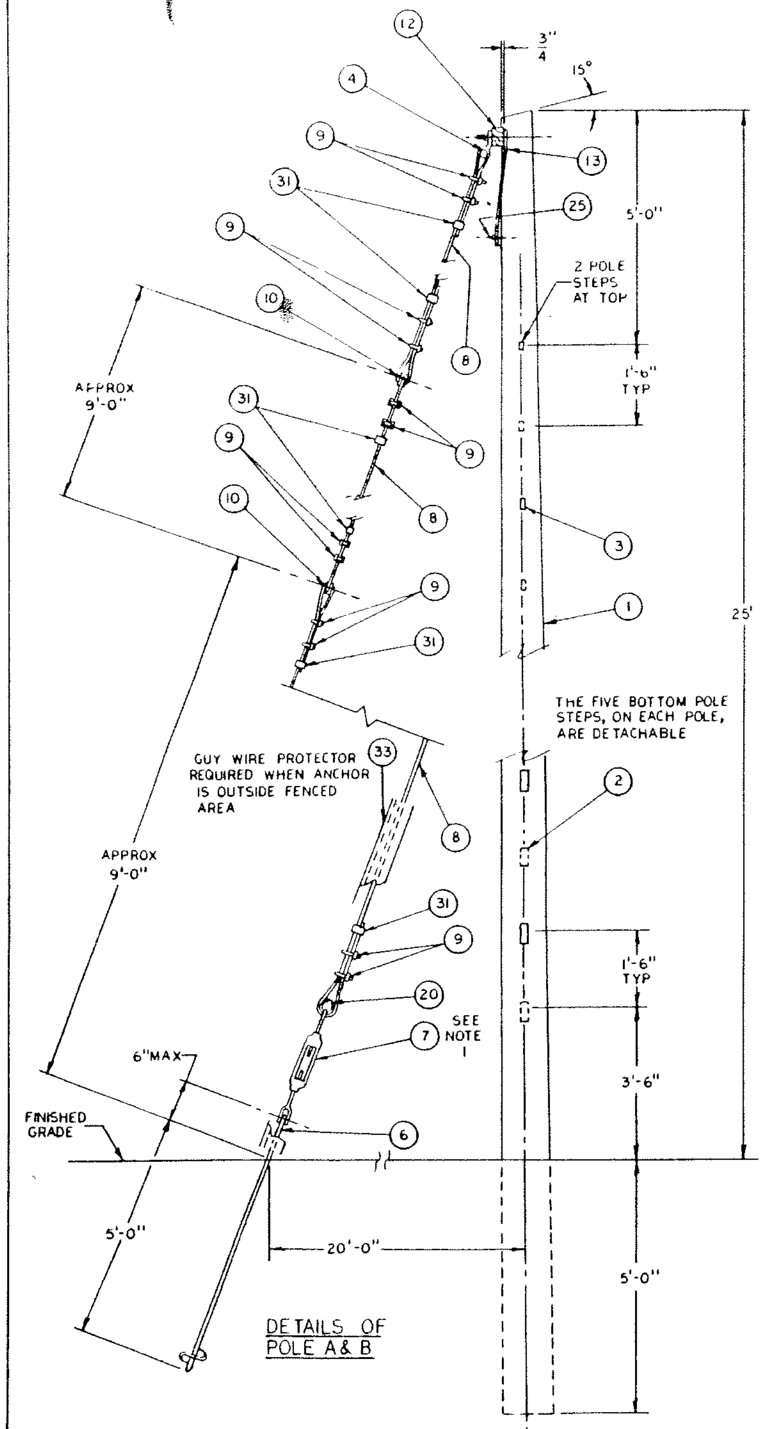
CH. NAVAIDS BR. AAF-410 — CH. NAVAIDS ENG. DIV. AAF-400

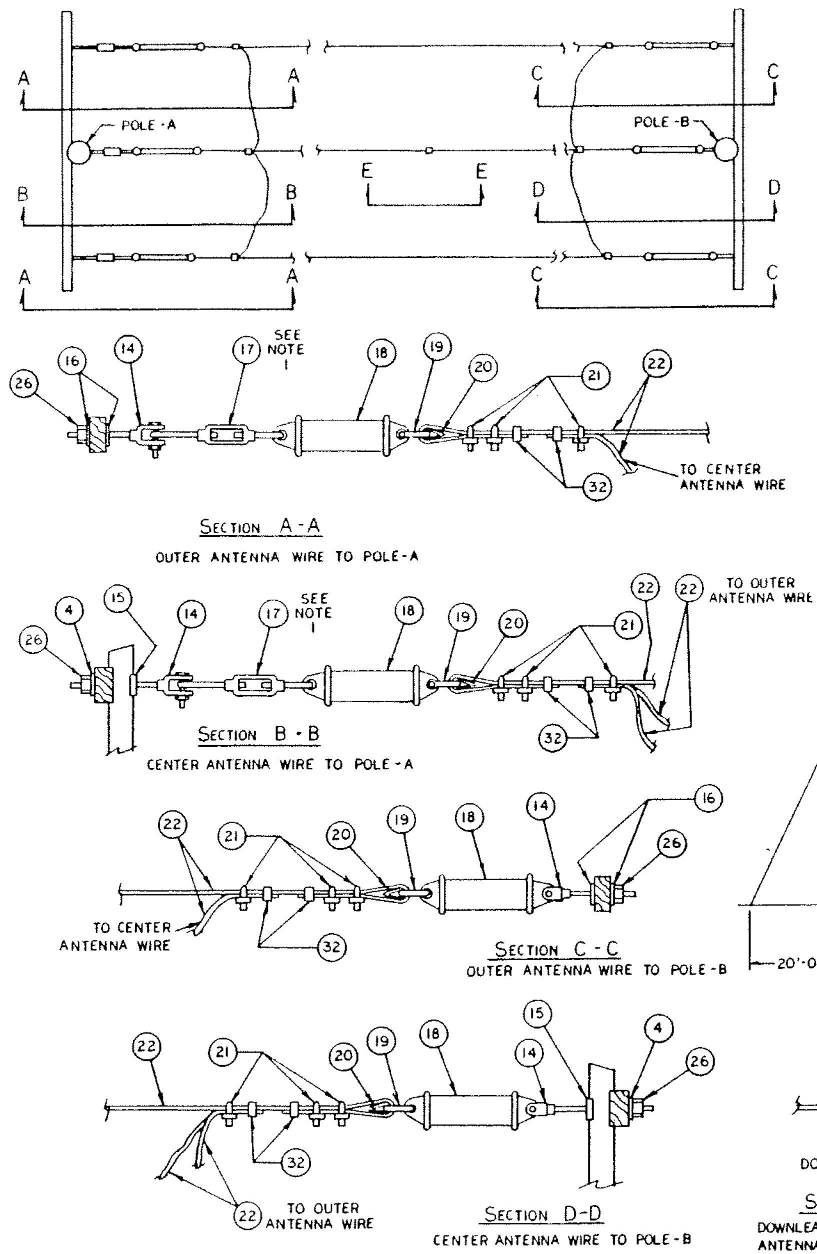
AIRWAY FACILITIES SERVICE

DATE - 2-23-81

D6186-005

AMAF IND. INC.





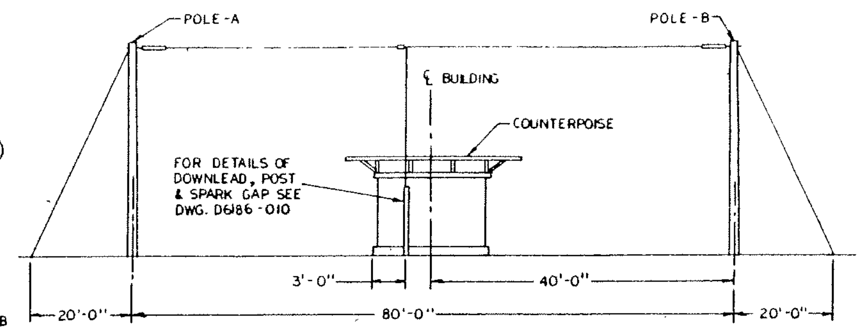
ITEM NO	QTY REQ	MATERIAL LIST
* 1	2	POLE[illegible] 30 FT LONG, CLASS 3, FULL LENGTH, PRESSURE TREATED, PAIN[illegible]
2	10	STEP[illegible] TACHABLE, GALV. HUBBARD NO.7235 (LAG [illegible] PLATE) AND NO.7236 STEP GALV.
3	16	STEP, POLE, HOOKHEAD 5/8 IN. x 9 IN. GALV. HUBBARD NO.7124
4	2	ANGLE THIMBLEYE, HUBBARD NO.1100 FOR 5/8 IN. BOLT GALV.
5		
6	2	ANCHORS, GUY, STEEL WING, OVAL EYE 3/4 IN. x 5-1/2 FT. GALV. HUBBARD NO 7526-A
7	2	TURNBUCKLE, EYE & CLEVIS 1/2 IN. x 12 IN. HUBBARD NO. 8713 GALV.
8	110 FT.	STRANDED, STEEL, 5/16 IN. GUY, SIEMENS-MARTIN GALV. CLASS "A" COATING OR BETTER
9	24	CLIPS FOR 5/16 IN. WIRE ROPE, HUBBARD NO.7481 GALV.
10	4	INSULATORS, GUY, PORCELAIN, 13/16 IN. HOLES, HUBBARD NO.506
11		
* 12	2	CROSSARMS WOOD 8 FT.-0 IN. STANDARD 3-1/4 IN. x 4-1/4 IN. CREOSOTED
13	4	BRACES, CROSSARM, FLAT, 7/32 IN. x 1-7/32 IN. x 32 IN. GALV. HUBBARD NO.8032
14	6	BOLTS, CLEVIS 5/8 IN. x 14 IN. HUBBARD NO.6814 GALV. WITH NUT
15	2	WASHERS, CURVED 2-1/2 IN. x 2-1/2 IN. HUBBARD NO.7822 GALV
16	8	WASHERS, SQUARE 2 IN. x 2 IN. HUBBARD NO.7812 GALV
17	3	TURNBUCKLE, EYE & CLEVIS 1/2 IN. x 9 IN. HUBBARD NO.8645 GALV
18	6	INSULATOR, ANTENNA LAPP INSULATOR CO. NO.4380BB12-12 IN. LONG
19	6	SHACKLE, DROP FORGED, STEEL 2 IN. x 11/16 IN. WITH 5/8 IN. DIA. PIN GALV. HUBBARD NO.6793
20	8	THIMBLE FOR 3/8 IN. WIRE ROPE GALV. HUBBARD NO.7593
21	16	CONNECTOR, COPPER KEARNEY NO.840-2
22	300 FT.	WIRE, ANTENNA NO.4 STRANDED SILICON BRONZE OR EQUAL.
23		
24		
25	2	LAG SCREW 1/2 IN. x 5 IN. LONG GALV.
26	3	NUT, HEX 5/8 IN. GALV.
27		
28		
29		
30	4	CARRIAGE BOLT, 3/8 IN. x 4 IN. GALV.
31	12	SERVISLEEVS HUBBARD NO.7453 GALV.
32	15	SERVISLEEVS HUBBARD NO.7452 GALV.
* 33	2	GUYWIRE PROTECTOR WITH 2-"U" BOLTS, HUBBARD NO.7558

NOTES

1 AFTER TENSION ADJUSTMENT ALL TURNBUCKLES SHALL BE SAFETIED WITH 3-TURNS OF NO.9 WIRE WHICH SHALL BE COPPER AND SIMILAR TO METAL USED IN GUY WIRES AND TURNBUCKLES TO PREVENT ELECTROLYSIS

2 SIMILAR AND EQUAL PARTS MANUFACTURED BY OTHERS MAY BE SUBSTITUTED FOR THOSE CALLED FOR IN MATERIAL LIST

3 * ITEM NOT FURNISHED BY THE GOVERNMENT



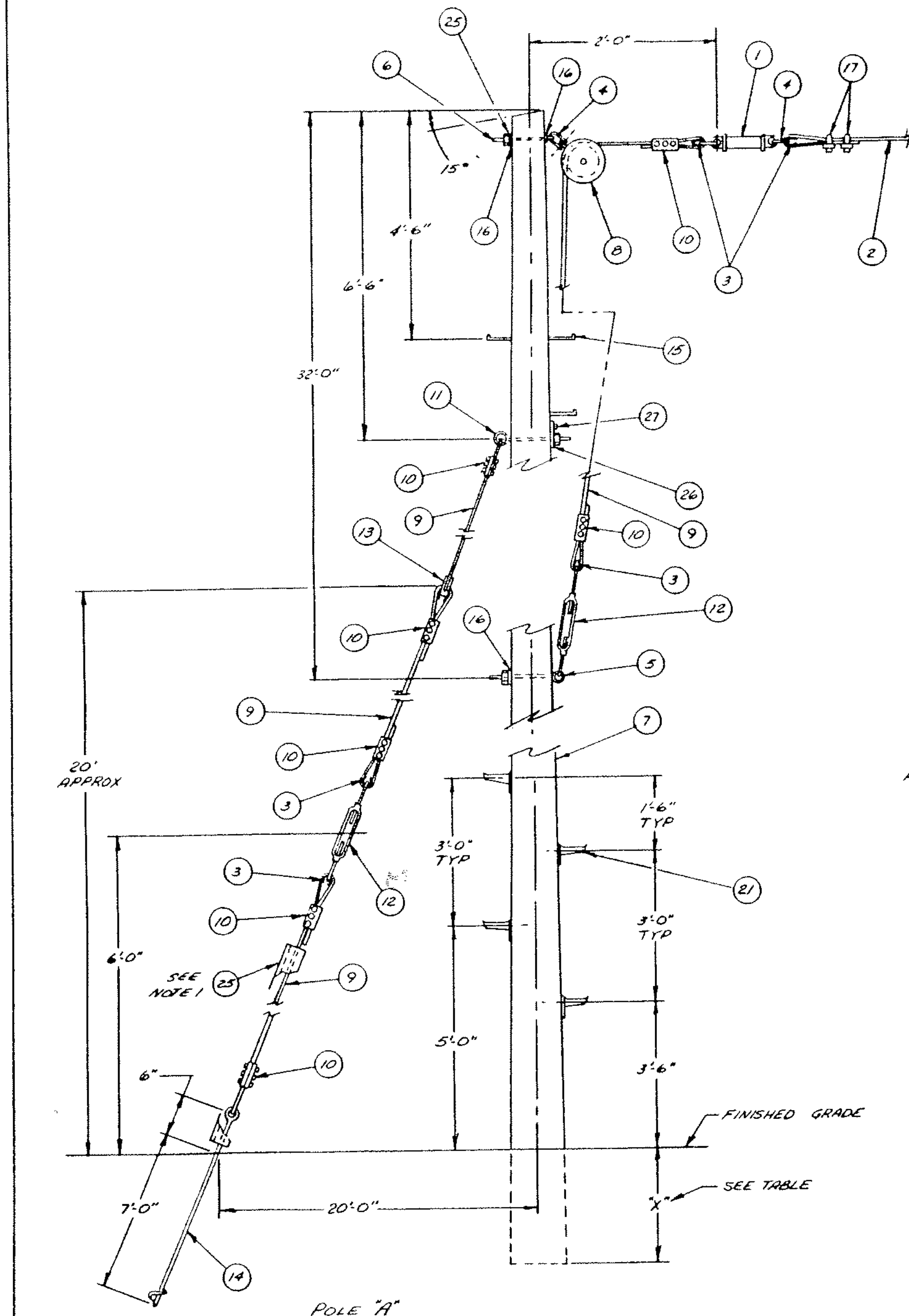
AMAF IND. INC.

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

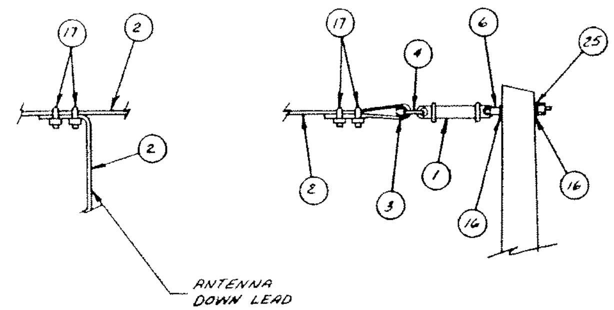
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 AND 9782 NDB INSTALLATION
ANTENNA DETAILS, TYPE "T"
ILS MARKER AND COMPASS LOCATOR

SUBMITTED BY: CH. NAVAIDS BR., AAF-410
APPROVED BY: CH. NAVAIDS/COMM ENG. DIV AAF-400
ISSUED BY: AIRWAY FACILITIES SERVICE
DATE - 2-23-81
DRAWING NO. D-6186-006



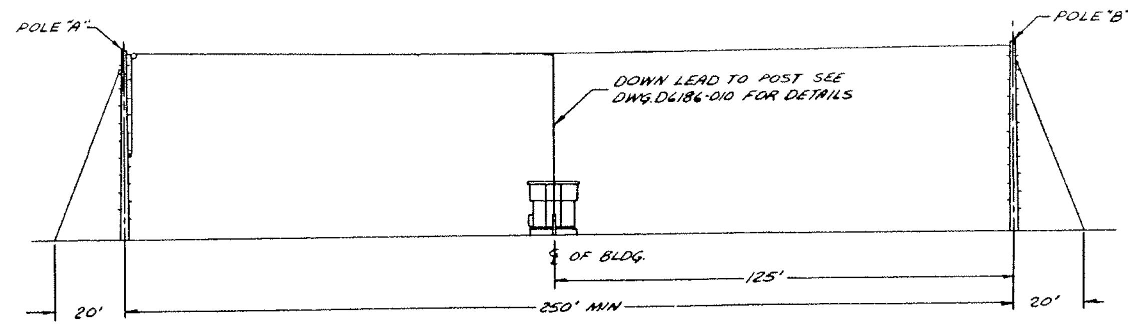
POLE "A"



POLE "B"

POLE "B" IS THE SAME AS POLE "A" EXCEPT AS SHOWN

ITEM	QTY	MATERIAL LIST
1	2	INSUL ANTENNA. LAPP INSULATOR CO. NO. 5993 12"
2	310'	WIRE, ANTENNA NO. 4 AWG STRANDED, SILKON BRONZE OR EQUAL
3	8	THIMBLE, GALV. FOR 3/8" WIRE ROPE HUBBARD NO. 7593
4	3	SHACKLE, ANCHOR, GALV. 5/8" PIN HUBBARD NO. 6793
5	1	EYEBOLT GALV. 5/8" × 18" WITH NUTS & WASHERS HUBBARD NO. 9068
6	2	BOLT, CLEVIS, 5/8" × 14" GALV. HUBBARD NO. 6814
7	2	POLE, WOOD ASA CLASS III TREATED FULL LENGTH
8	1	PULLEY, GALV. 6" SINGLE BLOCK, SWIVEL EYE 3/8" CABLE
9	150'	CABLE, GUY, 7STRANDS, GALV. 3/8" 6500 LB MIN.
10	12	CLAMP, GUY, GALV. 3-BOLT 3/8" CABLE HUBBARD NO. 7449
11	2	BOLT, THIMBLE EYE ANGLE 5/8" × 12" GALV. WITH NUT HUBBARD NO. 9152
12	3	TURNBUCKLE GALV. 5/8" × 12", EYE AND CLEVIS
13	2	INSULATOR, GUY, PORCELAIN 5/8 HOLES, HUBBARD NO. 521
14	2	ANCHOR, GUY, STEELWING, E Z EYE 1-1/4" × 8' GALV. HUBBARD NO. 7550
15	50	STEP, POLE, HOOK HEAD, GALV. 5/8" × 9" HUBBARD NO. 7124
16	4	WASHER, CURVED, GALV. 2-1/2" × 2-1/2" HUBBARD NO. 7822
17	6	CONNECTOR, COPPER, KEARNEY NO. 840-2
18		
19		
20		
21	10	STEP, POLE, DETACHABLE, GALV. HUBBARD NO. 7235 LAG AND PLATE HUBBARD NO. 7236
22		
23		
24		
25	2	GUY WIRE PROTECTOR WITH 2-"U" BOLTS HUBBARD NO. 7558
26	4	GUY, PLATE, CURVED, GALV. HUBBARD NO. 8887
27	4	LAG SCREW, 1/2" × 2"
28	16	GUY WIRE SLEEVING HUBBARD NO. 7454



POLE SETTING		
POLE HEIGHT ABOVE GROUND	SET IN EARTH "X"	SET IN ROCK "X"
50'-0"	7'-0"	5'-0"
55'-0"	8'-0"	5'-0"
60'-0"	8'-6"	5'-0"

NOTES:-

1 - GUY WIRE PROTECTOR REQUIRED WHEN ANCHORED OUTSIDE FENCED AREA

AMAF IND. INC.

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 AND 9782 NDB INSTALLATION
ANTENNA DETAILS
MH FACILITY

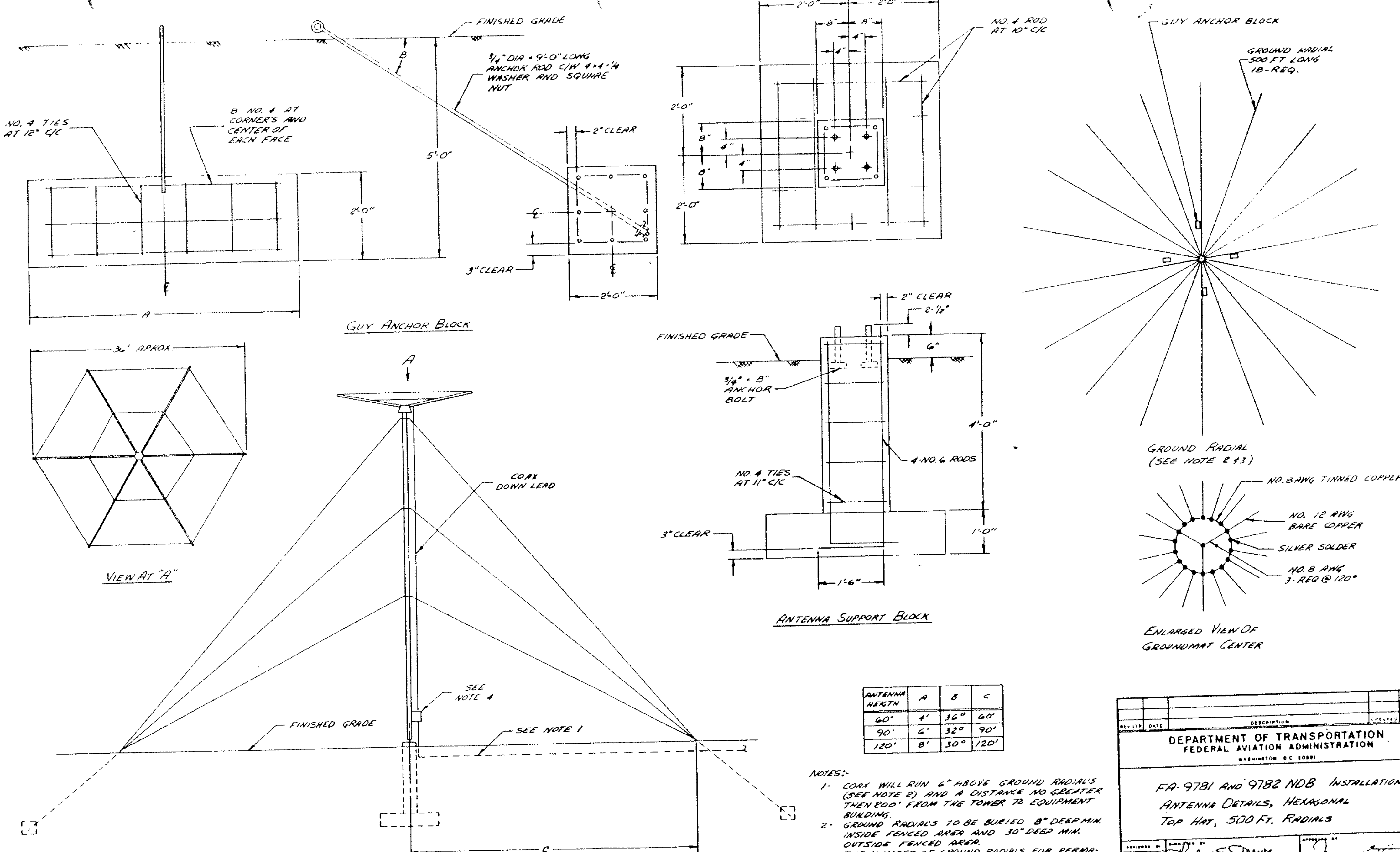
REVIEWED BY		SUBMITTED BY	APPROVED BY
RZS		CH. NAVAIDS BR. AAF-410	CH. NAVAIDS/COMM ENG DIV AAF-400
JLG			

ISSUED BY AIRWAY FACILITIES SERVICE

DATE - 2-23-81

DRAWING NO. D-6186-007

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED



ANTENNA HEIGTH	A	B	C
60'	4'	36°	60'
90'	6'	32°	90'
120'	8'	30°	120'

NOTES:-

1- COAX WILL RUN 6" ABOVE GROUND RADIAL'S (SEE NOTE 2) AND A DISTANCE NO GREATER THEN 200' FROM THE TOWER TO EQUIPMENT BUILDING.
2- GROUND RADIAL'S TO BE BURIED 8" DEEP MIN. INSIDE FENCED AREA AND 30" DEEP MIN. OUTSIDE FENCED AREA.
3- THE NUMBER OF GROUND RADIALS FOR PERMA-FROST LOCATIONS SHOULD BE 30 AND 500 FT. LONG.
4- THE CONNECTOR BOX OR ATU IS LOCATED AT THE BASE OF THE ANTENNA

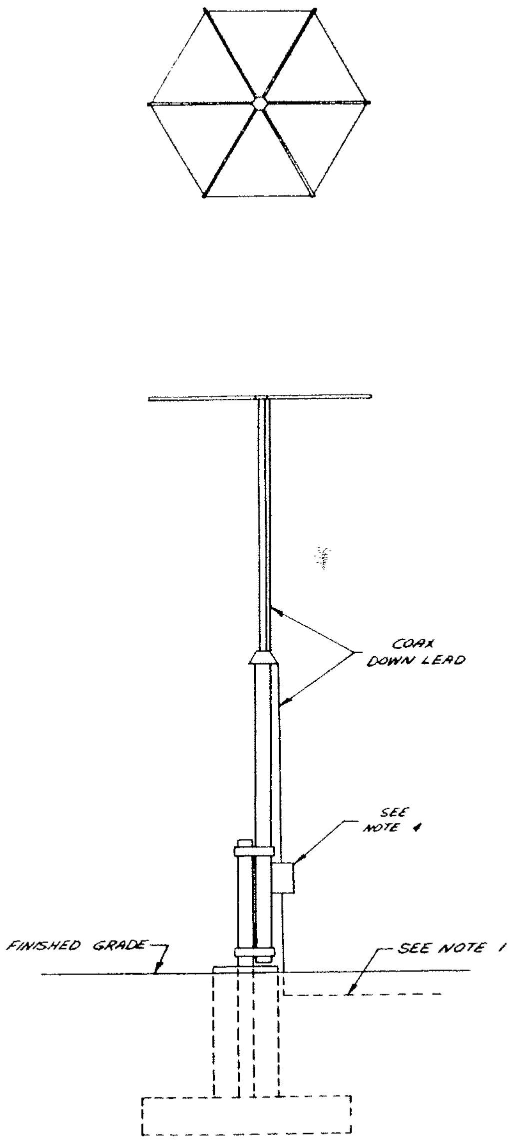
REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

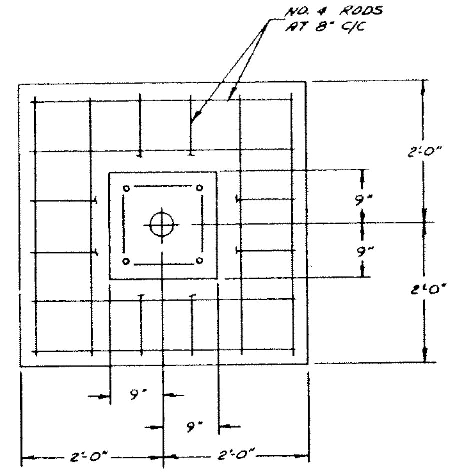
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

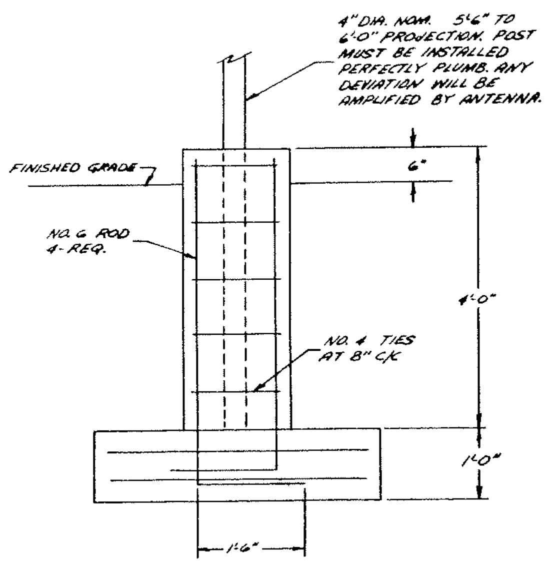
FA-9781 AND 9782 NDB INSTALLATION
ANTENNA DETAILS, HEXAGONAL
TOP HAT, 500 FT. RADIALS

SUBMITTED BY: CH. NAVAIDS BR. AAF-410
APPROVED BY: CH. NAVAIDS/COMM. ENGR. DIV. AAF-400
ISSUED BY: AIRWAY FACILITIES SERVICE
DATE - 2-23-81
DRAWING NO. D-6186-008

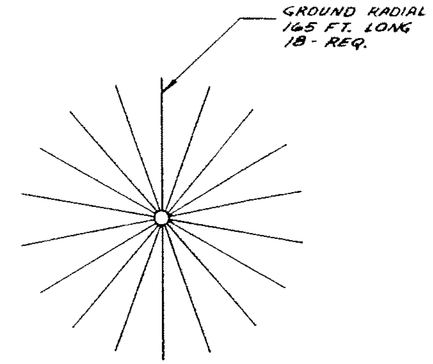
AMAF IND INC



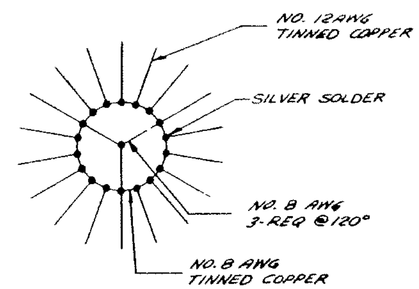




CONCRETE ANTENNA BASE



GROUND RADIAL
(SEE NOTE 2 & 3)



ENLARGED VIEW OF GROUNDMAT CENTER

NOTES:-

1 - COAX WILL RUN 6" ABOVE GROUND RADIAL'S (SEE NOTE 2) AND A DISTANCE NO GREATER THEN 200' FROM THE TOWER TO EQUIPMENT BUILDING.
2 - GROUND RADIAL'S TO BE BURIED 8" DEEP MIN. INSIDE FENCED AREA AND 30" DEEP MIN OUTSIDE FENCED AREA.
3 - THE NUMBER OF GROUND RADIALS FOR PERMA-FROST LOCATIONS SHOULD BE 30 AND 500 FT. LONG.
4 - THE CONNECTOR BOX OR ATU IS LOCATED AT THE BASE OF THE ANTENNA

ANTENNA HEIGHT
35 FT.
40 FT.

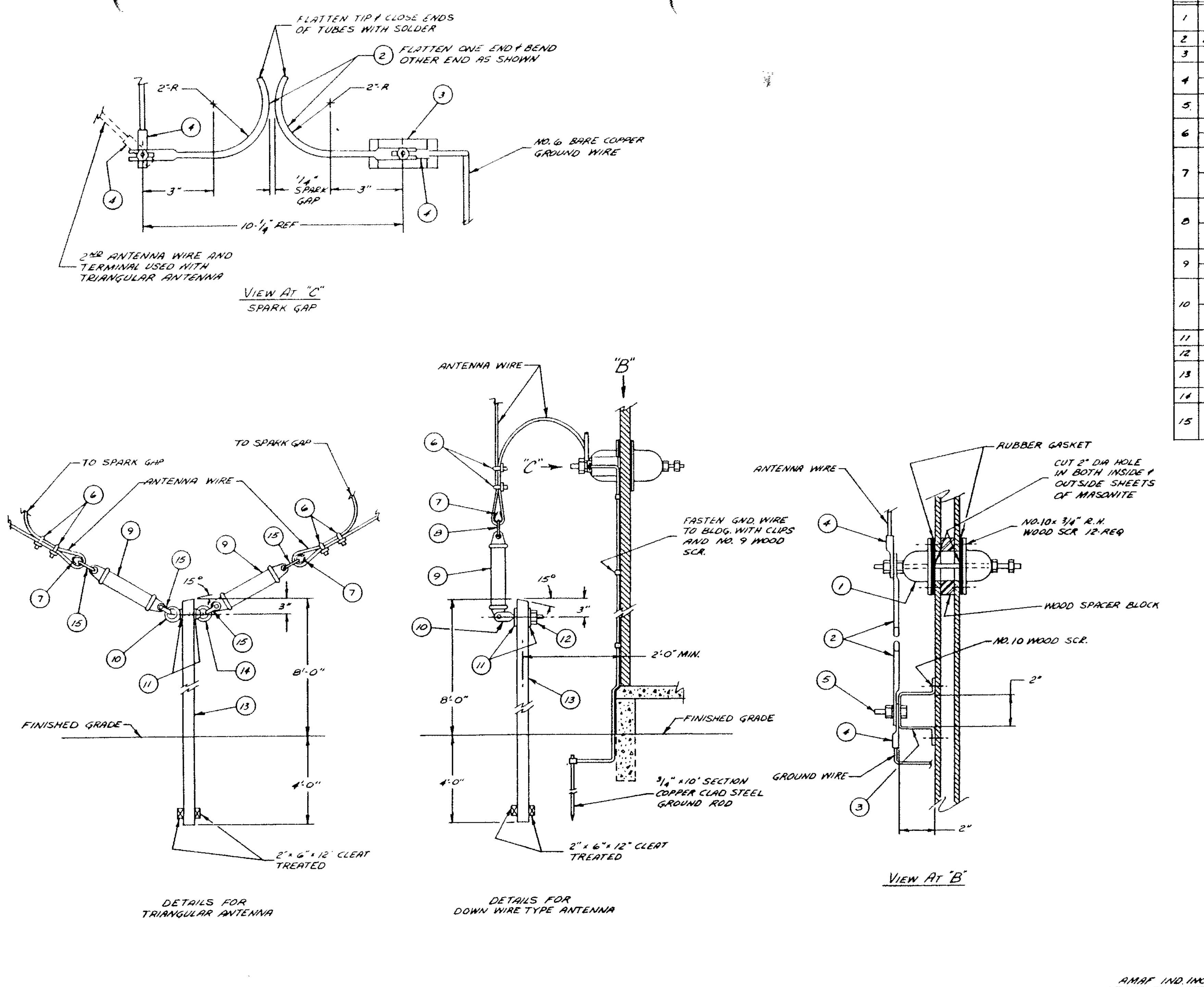
AMAF IND. INC.

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 AND 9782 NDB INSTALLATION
ANTENNA DETAILS, HEXAGONAL TOP
HAT 165 FT. RADIALS

SUBMITTED BY: Charles E. Doux — CH. NAVAIDS BR. AAF-410
APPROVED BY: CH. NAVAIDS/COMM. ENG. DIV. AAF-400
DATE - 2-23-81
AIRWAY FACILITIES SERVICE
DRAWING NO. D6186-009



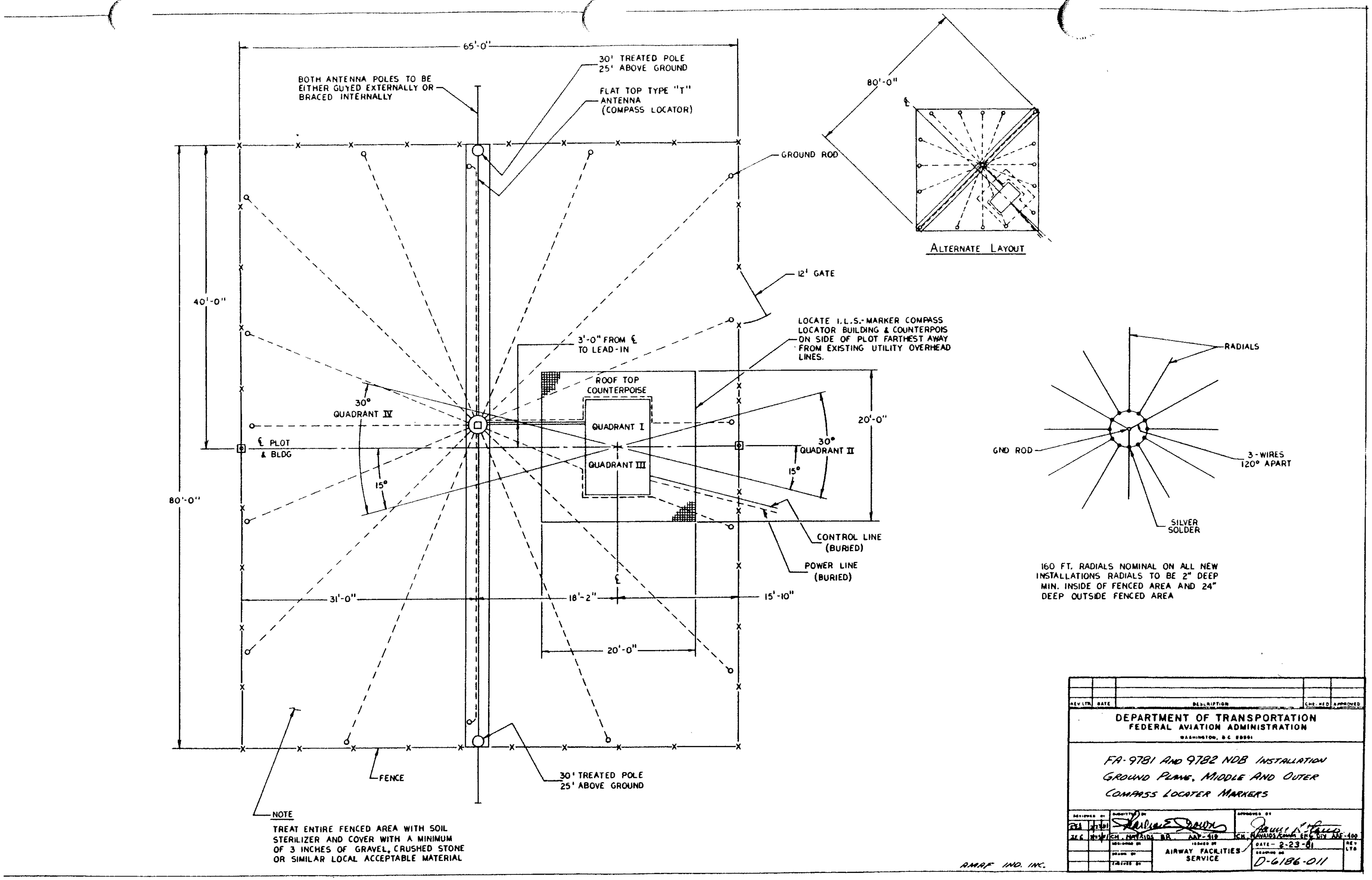
ITEM	QTY	MATERIAL LIST
1	2	INSULATOR, LOCKE NO. 24107, WITH 1/4" DIA x 8 1/2" LONG STUD BOLT
2	24"	3/4" O.D. COPPER TUBING
3		BRACKET #10GA. x 1 1/2" STEEL, FLAT, GALV. (AS SHOWN)
4	2	TERMINAL LUG (DOWN WIRE TYPE)
	3	TERMINAL LUG (TRIANGULAR TYPE)
5	1	BOLT 1/4" DIA. x 1 1/4" LONG WITH NUT, LOCKWASHER, 2-PLAIN WASHERS, ALL BRASS
6	2	CONNECTOR, COPPER, KEARNEY NO. 840-2 (DOWN WIRE TYPE)
	4	CONNECTOR, COPPER, KEARNEY NO. 840-2 (TRIANGULAR TYPE)
7	1	THIMBLES, FOR 3/8" WIRE ROPE, GALV. HUBBARD NO. 7593 (DOWN WIRE TYPE)
	2	THIMBLES FOR 3/8" WIRE ROPE, GALV. HUBBARD NO. 7593 (TRIANGULAR TYPE)
8	1	SHACKLES, DROP FORGED STEEL 2" x 11/16 WITH 5/8 DIA. PIN, GALV. HUBBARD NO. 6793 (DOWN WIRE TYPE)
	2	SHACKLES, DROP FORGED STEEL 2" x 11/16" WITH 5/8 DIA. PIN, GALV. HUBBARD NO. 6793 (TRIANGULAR TYPE)
9	1	INSULATOR, ANTENNA, LAPP INSULATOR CO. (DOWN WIRE TYPE)
	2	INSULATOR, ANTENNA, LAPP INSULATOR CO. (TRIANGULAR TYPE)
10	1	BOLT, CLEVIS 5/8" x 5" GALV. WITH NUT HUBBARD NO. 6805 (DOWN WIRE TYPE)
	1	SHOULDER EYEBOLT 5/8" x 6" GALV. HUBBARD NO. 4956 (TRIANGULAR TYPE)
11	2	WASHER SQUARE 2" x 2" GALV. HUBBARD NO. 7812
12	1	NUT, HEX 5/8" GALV. (DOWN WIRE TYPE ONLY)
13	1	POST, WOODEN 4" x 4" x 12' DOUGLAS FIR OR EQUAL PRESSURE TREATED
14	1	EYE NUT 5/8 GALV. HUBBARD NO. 7502 (TRIANGULAR TYPE ONLY)
15	4	SHACKLE, DROP FORGED STEEL 1 3/4 x 11/16 WITH 1/2" DIA PIN GALV. THOMAS LAUGHLIN CO. FIG. NO. G-213 (TRIANGULAR TYPE ONLY)

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

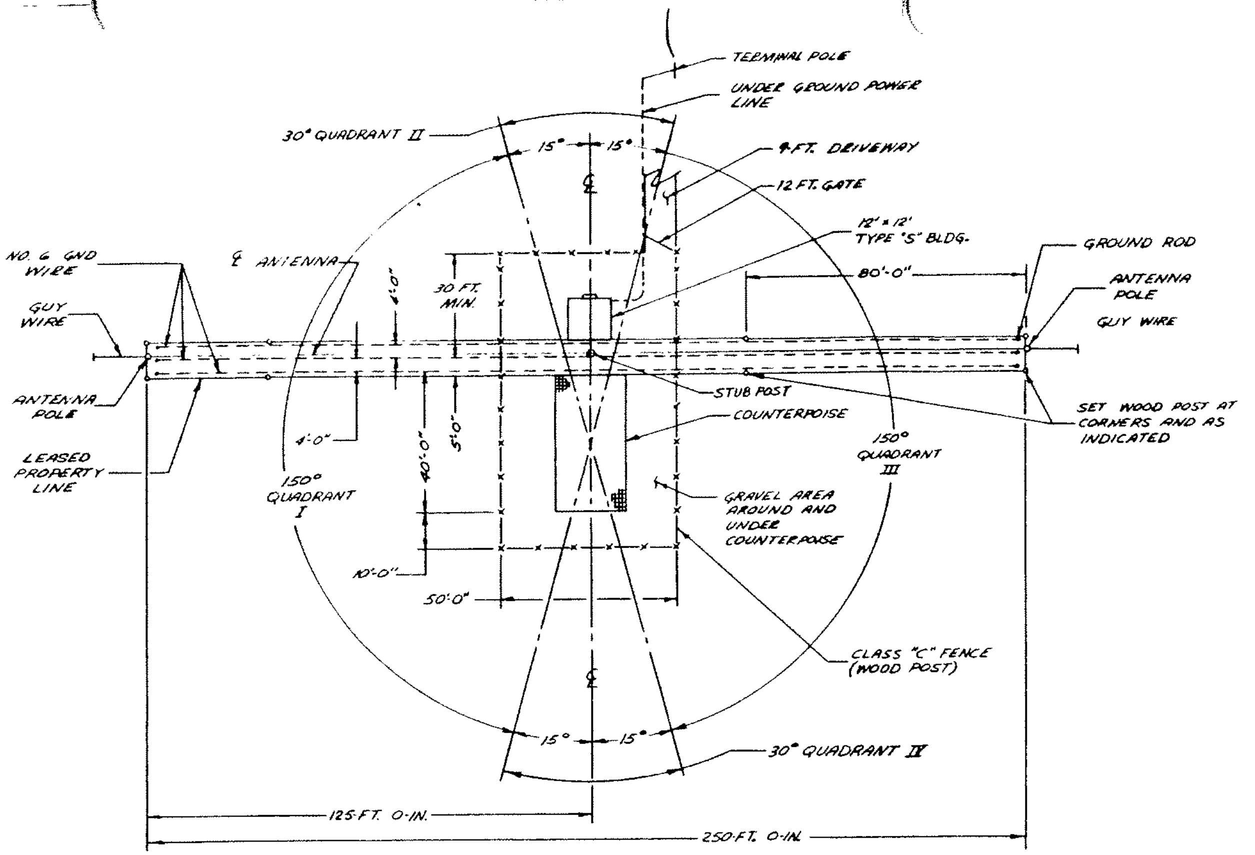
FA-9781 AND 9782 NDB INSTALLATION SPARK GAP AND ANTENNA DOWN WIRE SUPPORT

REVISIONS BY: RJS; AA
SUBMITTED BY: CH. NAVAIDS BR. AAF-410
APPROVED BY: CH. NAVAIDS & COMM. ENG. DIV. AAF-400
ISSUED BY: AIRWAY FACILITIES SERVICE
DATE – 2-23-81
DRAWING NO. D-6186-010

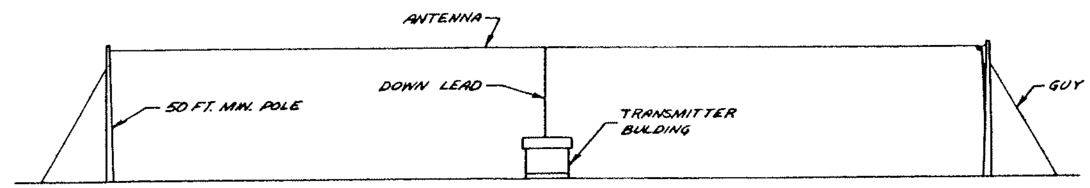

65'-0"
BOTH ANTENNA POLES TO BE EITHER GUYED EXTERNALLY OR BRACED INTERNALLY
30' TREATED POLE 25' ABOVE GROUND
FLAT TOP TYPE "T" ANTENNA (COMPASS LOCATOR)
GROUND ROD
12' GATE
40'-0"
80'-0"
LOCATE I.L.S.-MARKER COMPASS LOCATOR BUILDING & COUNTERPOIS ON SIDE OF PLOT FARTHEST AWAY FROM EXISTING UTILITY OVERHEAD LINES.
3'-0" FROM ℄ TO LEAD-IN
ROOF TOP COUNTERPOISE
30°
QUADRANT IV
QUADRANT I
QUADRANT III
30°
QUADRANT II
15°
15°
20'-0"
℄ PLOT & BLDG
CONTROL LINE (BURIED)
POWER LINE (BURIED)
31'-0"
18'-2"
15'-10"
20'-0"
FENCE
30' TREATED POLE 25' ABOVE GROUND
NOTE
TREAT ENTIRE FENCED AREA WITH SOIL STERILIZER AND COVER WITH A MINIMUM OF 3 INCHES OF GRAVEL, CRUSHED STONE OR SIMILAR LOCAL ACCEPTABLE MATERIAL
80'-0"
ALTERNATE LAYOUT
RADIALS
GND ROD
3-WIRES 120° APART
SILVER SOLDER
160 FT. RADIALS NOMINAL ON ALL NEW INSTALLATIONS RADIALS TO BE 2" DEEP MIN. INSIDE OF FENCED AREA AND 24" DEEP OUTSIDE FENCED AREA
AMAF IND. INC.
REV LTR DATE DESCRIPTION CHECKED APPROVED
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591
FA-9781 AND 9782 NDB INSTALLATION
GROUND PLANE, MIDDLE AND OUTER
COMPASS LOCATER MARKERS
CH. NAVAIDS BR. AAF-410
CH. NAVAIDS/COMM. ENG. DIV. AAF-400
AIRWAY FACILITIES SERVICE
DATE 2-23-81
D-6186-011

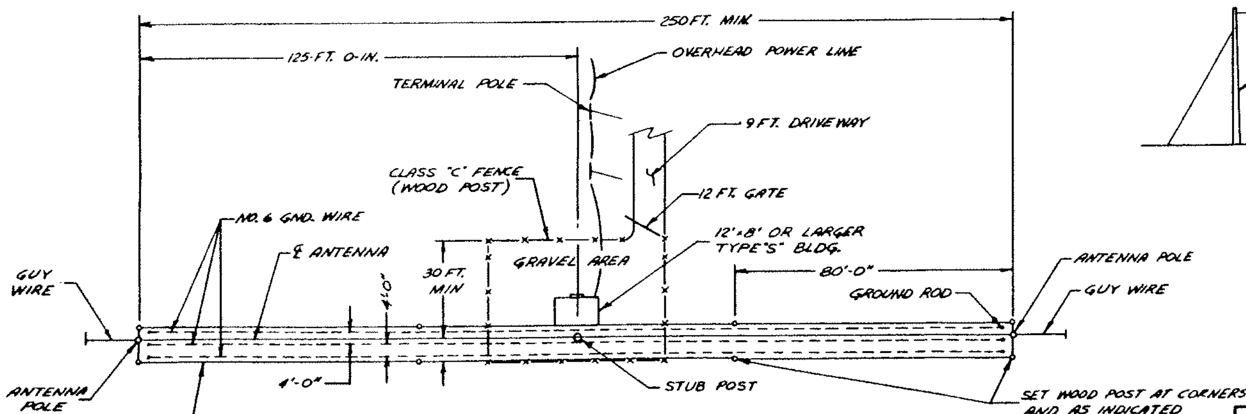
NOTES:-

1- USE THIS GROUND CONFIGURATION ONLY WHERE AVAILABLE LAND AREA DOES NOT PERMIT THE USE OF RADIAL'S. FOR STANDARD GROUND RADIAL LAYOUT SEE DRAWING D6186-011
2- GROUND WIRES TO BE BURIED 2" DEEP MIN. INSIDE OF FENCED AREA AND 24" DEEP MIN. OUTSIDE OF FENCED AREA



FM-MH PLOT PLAN





H OR MH PLOT PLAN

AMAF MD. INC

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9781 AND 9782 NDB INSTALLATION
GROUND PLANE, FM-MH FACILITY
OR H OR MH FACILITY

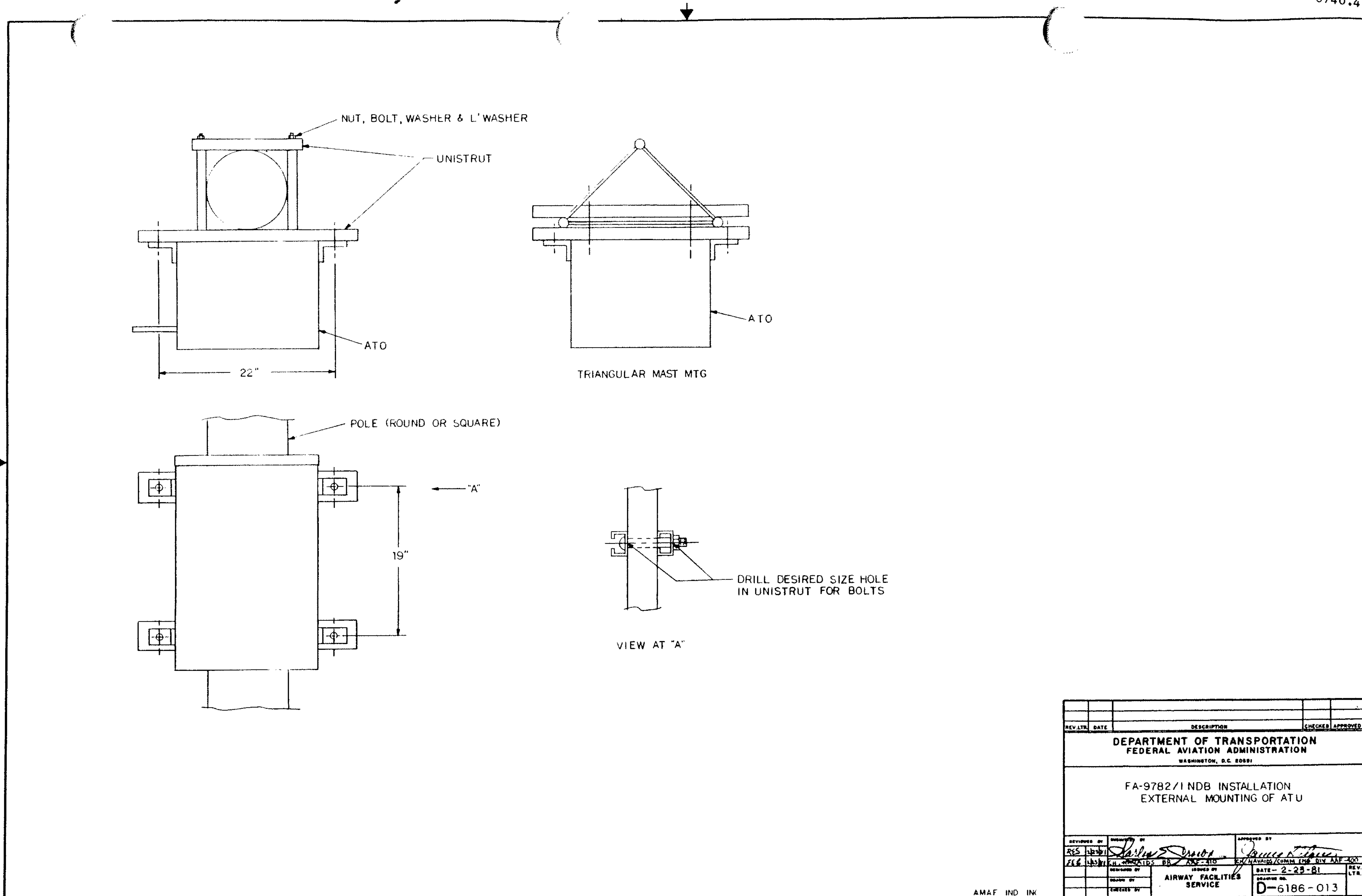
AIRWAY FACILITIES SERVICE

DATE - 2-23-81

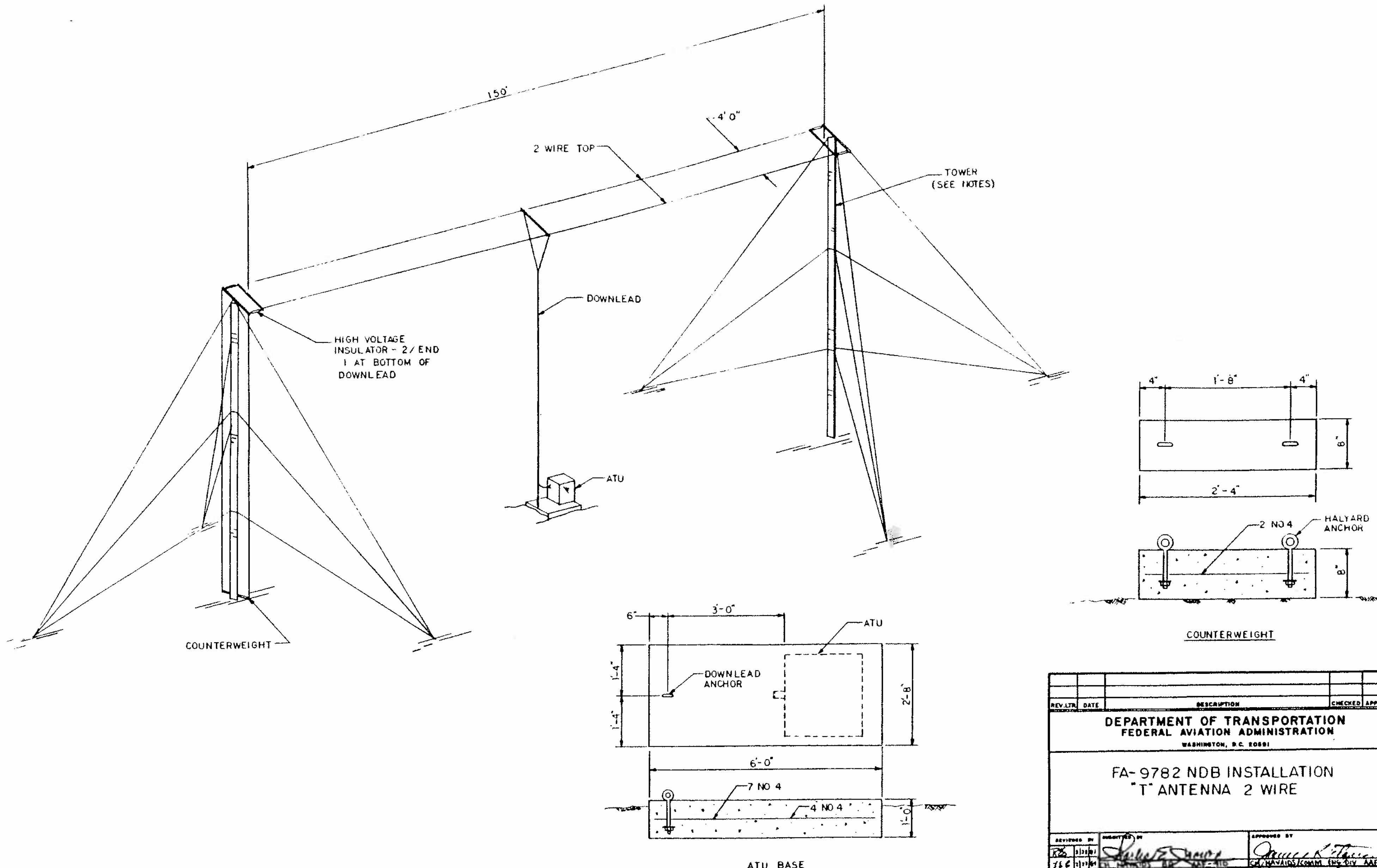
D-6186-012

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED

13


NUT, BOLT, WASHER & L'WASHER
UNISTRUT
ATO
22"
ATO
TRIANGULAR MAST MTG
POLE (ROUND OR SQUARE)
"A"
19"
DRILL DESIRED SIZE HOLE
IN UNISTRUT FOR BOLTS
VIEW AT "A"
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591
FA-9782/I NDB INSTALLATION
EXTERNAL MOUNTING OF ATU
AIRWAY FACILITIES SERVICE
DATE - 2-23-81
D-6186-013
AMAF IND INK

NOTES:
1. ANTENNA, POLE OR TOWER, AND ACCESSORIES ARE A LOCAL REGINAL PROCUREMENT OPTION DEPENDING UPON SITE CONDITIONS.
2. RECOMMENDED TOWER HEIGHTS 60 FT.(18 M) TO 100 FT.(30 M)



REV. LTR	DATE	DESCRIPTION	CHECKED	APPROVED

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D.C. 20591

FA-9782 NDB INSTALLATION
"T" ANTENNA 2 WIRE

SUBMITTED BY: CH, NAVAIDS BR AAF-410
APPROVED BY: CH, NAVAIDS/COMM ENG DIV AAF-400
ISSUED BY: AIRWAY FACILITIES SERVICE
DATE - 2-23-81
DRAWING NO. D-6186-014

CHAPTER 4. NDB AND ATU INSTALLATION GUIDANCE

21. INTRODUCTION. This chapter documents a step-by-step procedure for installing the 400 and 50 watt NDB units and the 50 watt atu. The installation steps are tabulated in table 4-1 with references to detailed text presented in chapter 5 (Installation Standards) and chapter 3 (NDB Installation Drawings Package).

a. Prior to implementing the table 4-1 installation steps, the cognizant FAA field activity or installation contractor should thoroughly review chapters 2 and 3 of this order to understand the installation equipment's physical characteristics, where it will be located, cable routing paths, and necessary wiring connections.

22. INSTALLATION SUMMARY. Briefly, the assigned NDB installation personnel shall perform the following:

a. Unpack and inspect the NDB units and the atu.

b. Install the 400 watt NDB equipment rack frame, locate it as shown in the applicable chapter 3 drawing, D-6186-002, and anchor it to the facility floor.

c. At 50 watt NDB and atu installation, install unistrut, for wall mounting the equipment, as shown in chapter 3 drawing, D-6186-001. Mount the NDB and atu cabinets to the unistruts.

d. Install conduit or ducting and route power and signal cables in accordance with drawings D-6186-001 and D-6186-002.

e. At 50 watt NDB and atu installation, install battery box, four 12 volt batteries, battery disconnect switch, and associated conduit cabling. (Optional item, regional decision and funding.)

f. Complete external wiring connections in accordance with drawings D-6186-003 and D-6186-004.

g. Install 400 watt NDB rack components.

h. Route antenna cable from the 50 watt atu or 400 watt NDB to the antenna feed through opening to the spark gap.

i. Install spark gap and antenna down wire support in accordance with drawing D-6186-010 and check antenna and antenna ground plane installation drawings. This spark gap is optional.

j. Antenna installation details are presented in drawings D-6186-005 through D-6186-009.

TABLE 4-1 NDB INSTALLATION PROCEDURE

Task	Definition	Chapter 5, Installation Standards	Comments/Notes
1	Unpack and inspect the NDB units and the 50 watt atu • Unpacking and repacking • Check equipment supplied and required • Visual inspection • Damaged equipment	Para. 25, General	• Equipment supplied/required - Table 5-1 400 watt NDB - Table 5-2 50 watt NDB - Table 5-3 50 watt atu - Table 5-4 equipment required but not supplied.
2	At 400 watt NDB installations • Locate NDB rack • Anchor rack	Para. 26, 400 watt NDB rack installation	• Refer drawing D-6186-002 • A two inch minimum air space gap required between rack and facility wall
3	At 50 watt NDB installations • Install unistruts • Wall mount NDB and associated atu	Para. 27, 50 watt NDB cabinet installation details Para. 28, 50 watt atu cabinet installation details	• Refer drawing D-6186-001 • Two inch ventilation air gap required on both units. • Allow one foot clearance from equipment
4	• Install ducting and thin wall conduit • Route power cable, signal cable, and AC protective ground wire.	Section 2, Wiring and Cabling Section 3, Grounding, Shielding, and Bonding	• Refer drawing D-6186-001 thru, D-6186-004 for ducting or conduit and cable routing • Power cables shall be routed in 3/4 inch thin wall conduit. • Signal cables shall be routed in 1½ inch thin wall conduit • Route the ac protective ground wire in the power cable conduit. • Once the power cables have been wired to the ac power distribution panel, appropriate safety precautions shall be taken to prevent energizing the NDB

Task	Definition	Chapter 5, Installation Standards	Comments/Notes
5	• Locate antenna feed through opening point • Install antenna feed through equipment • Install spark gap equipment	Para. 29, Antenna feed through and antenna spark gap installation	Refer drawing D-6186-010 for installation direction and applicable materials list
6 1/	At 50 watt NDB installations, install • Battery Box • Four 12 volt batteries • Battery Switch • Battery Cables Conduit	Para. 30, Emergency power supply	• Refer drawings D-6186-001 and D-6186-003 • The box must be vented to atmosphere outside facility.
7	Route antenna cable from antenna feed through to the 50 watt atu or 400 watt NDB		Refer drawings D-6186-001 and D-6186-002 • Provide sufficient length for drip loop at antenna feed through
8	Perform external cabling interconnections	Para. 31, External cabling interconnections Section 2, Wiring and Cabling Section 3, Grounding, Shielding, and Bonding	
1/	Optional item, regional decision and funding		

Task	Definition	Chapter 5, Installation Standards	Comments/Notes
9	NDB grounding summary • AC protective ground • AC safety ground • Equipment external ground	Section 3 Grounding, Shielding, and Bonding Para. 34, Inside cable ducts	Ground Connections • Power cable-green wire, power panel to NDB terminal board • No. 6 insulated wire transmitter external ground to power panel. Ducting bare No. 6 copper wire. No. 6 insulating wire atu External ground-to marker transmitter pedestal-to antenna ground

k. Antenna ground plane installation details are presented in drawings D-6186-011 and D-6186-012.

l. Prior to energizing any NDB equipment, review applicable manufacturer furnished equipment manuals.

23. INSTALLATION PROCEDURE. Table 4-1 is the step-by-step procedure for installing the NDB units and the 50 watt atu. The procedure is applicable to all NDB system installations. Table 4-1 identifies each task, provides references to the applicable chapter 3 drawings or detailed text in the Installation Standards (chapter 5), and provides appropriate comments. The installation standards of chapter 5 are an integral part of the procedure and shall be adhered to during the installation.

a. Prior to implementing the procedure, the assigned NDB installation personnel shall review table 4-1, the referenced text, and drawings. Depending upon the facility and the size of the installation staff, some of the tasks can be performed in parallel to expedite the installation.

b. Installation Test Equipment Required:

(1) See Appendix 1, page 4. Frequency counter and oscilloscope.

(2) See Appendix 1, page 5, paragraph (2)d, Insulation Tester.

(3) See Appendix 1, page 5, paragraphs e and f, Impedance Measuring Unit CZ 546 or equal.

(4) See Order 6740.2A, page 43, paragraph 162.a. Field Intensity Meter.

24. RESERVED.

CHAPTER 5. INSTALLATION STANDARDS

SECTION 1. EQUIPMENT INSTALLATION

25. GENERAL, NDB UNITS AND 50 WATT ATU.

a. Unpacking. The 400 watt NDB unit is shipped in three packing crates. The 50 watt NDB and its associated atu are each shipped in single crates. The contents of the respective packing crates are listed on the packing slips. The construction of the crate clearly indicates which side should be opened. After opening the packing crates, the installation crew should conduct a thorough examination for shipment damage. Remove all packing material.

b. Check Equipment Supplied. Check contents of each shipping container (tables 5-1 through 5-3) to ensure that the NDB units and the 50 watt atu are complete.

c. Damaged Equipment. Examine the contents of the containers for signs of shipping damage. Particularly check to see if the containers show signs of mishandling. If any equipment is found to be damaged, no attempt should be made to remove, install or operate it. Inform the carrier as to the nature of the damage before repacking and returning the equipment to the factory.

d. Visual Inspection. After opening all the containers, removing all packing materials or interior restraints, and checking that no shipping damage has occurred; the NDB and atu are ready to be moved into a flat, clear surface for a thorough inspection.

(1) Remove the NDB and the atu with associated hardware from the containers, and place on clean, flat surface or work bench.

(2) Inspect electrical components for shipping damage.

e. Check Equipment Not Supplied. Table 5-4 lists those items required to complete the NDB unit or atu installation which are not furnished.

f. Repacking. If it is necessary to repack either NDB unit or the 50 watt atu, it is recommended that packing for reshipment be accomplished by using the same containers and cushioning fillers with which the equipment was originally packed. If these materials are not available, care should be taken to provide adequate cushioning and sturdy shipping containers, as required by specification MIL-E-17555. The following precautions should be taken when packing either the NDB unit or the 50 watt atu:

(1) Internal Studs. Overlay internal studs with shock absorbing material for equipment support. Ensure that protruding connectors do not bear on any part of the crate.

TABLE 5-1. EQUIPMENT SUPPLIED IN 400 WATT NDB CRATES

Packing Crate Number	Size	Weight	Contents
1.	25.5 cu. ft	276 lbs	cabinet with power supply and power amplifier modules unshipped.
2.	4.22 cu. ft	132 lbs	power supply
3.	6.12 cu. ft	72 lbs	8xpower amplifier modules, spare parts listed in 1, 2

1. Spare sub-assemblies and relay

Item	Part	Desig
Power amplifier module	133-1022	1A3A2-A9
exciter	133-1018	1A2A1
monitor	133-1026	1A2A2
rf probe	133-9046	1A3A11
24 V dc power supply	133-2022	1A2A3
contactor relay	2160B23AA-66	1A2K1

2. Harmonic filter spare components 1A3A10

Item	Value	Part	Desig
Inductors	17 uH 27.4 uH 24.1 uH 15 uH 24.5 uH 39.7 uH	133-3048 133-3048/1 133-3048/2 133-3048/3 133-3048/4 133-3048/5	L1/L3/L4 L2/L5/L6 L7 L8 L9 L10
Capacitors	390 pF 9100 pF 5600 pF 1200 pF 750 pF 8600 pF 4300 pF	DM20FF391G04CR 27115B912G00 27120B562G00 DM20FF122G04CR DM20FF751G04CR 27120B682G00 27120B432G00	C1 C2/C4 C3/C5 C6 C7 C8 C9
Resistors	50 ohm 70 W	NHL-70 flat	R1/R2

TABLE 5 - 2

EQUIPMENT SUPPLIED IN 50 WATT NDB PACKING CRATE 1/

ITEM	QTY	DESCRIPTION	REMARKS
1	1	50 WATT NDB (30x17x16 INCHES) TRANSMITTER	WT - 98 lbs
2	2	BATTERY CABLE, AWG 14	LENGTH - 12 FT
3	2	CONDUIT CONNECTORS, 2H42	
4	4	CABINET SPACERS FOR REAR MOUNTING BRACKETS	

1/ The exciter pcb A1A2, monitor pcb A1A7 and all transmitter spares are crated with the atu.

TABLE 5-3. EQUIPMENT SUPPLIED IN 50 WATT ATU PACKING CRATE

Nomenclature	Dimensions	Weight
50 Watt Antenna Tuning Unit	31.5 x 38 x 18 inches 80 x 96.5 x 45.7 centimeters	88 lbs 41.4 kg.

1. System spares.

Name	Circuit Description	Part
Servo probe	FA-9782/1-A1A2	133-9041
Matching transformer	FA-9782/1-A1A3	133-9055
RF probe	FA-9782-A1A6. FA9782/1-A1A1	133-9046
Regulator charger	FA-9782-A1A1	133-1052
Exciter	FA-9782-A1A2	133-1018
PA module	FA-9782-A1A4	133-1022
Monitor	FA-9782-A1A7	133-1026
RF transformer	FA-9782-A1A5T1	133-1072
Inductor 27.4 uH	FA-9782-A1A5 L1,L3,L4,L7	133-1043
Inductor 17 uH	FA-9782-A1A5 L2, L5,L6,L8	133-1043/1
Inductor 39.7 uH	FA-9782-A1A5 L9	133-1043/2
Inductor 24.5 uH	FA-9782-A1A5 110	133-1043/3
Capacitor 390 pF	FA-9782-A1A5 C1	CMR05F291GODM
Capacitor 9100 pF	FA-9782-A1A5 C2,C4	CMR07F912GODM
Capacitor 5600 pF	FA-9782-A1A5 C3,C5	CMR07F562GODM
Capacitor 6800 pF	FA-9782-A1A5 C6	CMR07F432GODM
Capacitor 4300 pF	FA-9782-A1A5 C7	CMR06F432GODM
Resistor 100 ohm 2 W	FA-9782-A1A5 R1,R2,R3,R4	RL42S101G

2. Mating connector for 24 V dc supply at J2 MS3106E14575.

3. Loading coil assembly (right and left hand coils) with rf jumper cables for the specified frequency. Packed separately.

4. Tuning ferrite slug assembly (right and left hand slugs). Packed separately.

5. Two lock nut and washer sets for tuning slugs (plastic bag).

TABLE 5-4. EQUIPMENT REQUIRED BUT NOT SUPPLIED

50 WATT NDB

1. Cabinet securing bolts. (4) 3/8 inch bolts or similar arrangements long enough to take 2 inch spacers.

2. Solid sheath coaxial cable type RG331 or similar, not longer than λ /8 at the operating carrier frequency, fitted with weatherproof Type N connectors at each end. RG-214 would be acceptable as a similar type cable.

3. ATU dc supply wiring. 2 wire total resistance less than 5 ohms. (See Table 5-4 for mating connector).

4. Battery on/off switch, 2 amp fuse and battery enclosure. (optional)

5. Four 12 Volt lead acid batteries rated at 40 AH min. (optional)

6. External ground cabling and rod.

7. Remote monitor status control lines: 2 wires. See paragraph 29 and table 5-5.

50 WATT ATU

1. Antenna ground cabling to the ground plane. AWG6 or larger.

2. Antenna feeder from the feedthrough insulator E1.

400 WATT NDB

1. Four, one-half inch cabinet securing bolts or threaded studs to brace the transmitter to the floor.

2. Antenna feeder cable suitable for outdoor use at the 400 watt power level, with a characteristic impedance of 72 or 50 ohms, dependent upon the matching terminal impedance level at the antenna.

3. If the transmitter is to feed into 50 ohms, the connector, J1, fitted in the cover must be exchanged for the appropriate component.

4. The cable must be fitted with suitable outdoor mating connectors.

5. External ground cabling and rod.

6. Remote monitor status control lines; 2 wires.

50 AND 400 WATT NDBs

1. Antenna feed through hardware, drawing D-6186-010.

2. Spark gap hardware, drawing D-6186-010.

(2) Loose Ancillary Equipment. Insure that any loose ancillary equipment packed with the shipment is supported by packing material and the chassis components are tightly secured.

(3) Short Out Meter Terminals. On the 50 watt NDB, short out the test meter terminals. On the 400 watt NDB, short out the two meters on the exciter/monitor control panel.

(4) Power Supply Drawer/Power Amplifier Modules. When packing the 400 watt NDB shipping crates, make certain the power supply and power amplifier modules are not mounted in the cabinet.

26. 400 WATT NDB RACK INSTALLATION.

a. 400 Watt NDB Rack Dimensions. The 400 watt NDB rack dimensions, as presented in figure 2-5, are nominally 48 inches high, 24 inches deep, and 22 inches wide.

b. 400 Watt NDB Rack Installation Details. The 400 watt NDB rack shall be installed in existing air navigation facilities as a free standing unit (drawing D-6186-002). The following general guidelines should be followed when installing the 400 watt NDB rack:

(1) The rack should be installed plumb, level, and square. Metal washers may be used as shims to compensate for floor irregularities.

(2) After proper leveling and alignment, the rack should be anchored to the floor, as described in subparagraph c.

(3) Grounding the rack to floor reinforcing steel should be avoided.

c. Anchoring of 400 Watt NDB Rack.

(1) The 400 watt NDB rack shall be anchored to the floor at all four corners at the 9/16-inch diameter holes located on the inside of the cabinet.

(2) Several methods of anchoring the racks to the floor are available. The preferred method is to use lead caulking anchors set in concrete floors. When using lead anchors, it is necessary to drill an appropriate size hole of sufficient depth to accept the anchor. The anchor is then firmly seated in the holes, and a screw or bolt is used to attach the rack to the anchor. Different floor constructions, of course, necessitate different anchoring techniques. In the case of wood floors, it would only be necessary to use lag bolts. Toggle or molley bolts can sometimes be used on certain type floors. The method of anchoring shall not present protrusions or sharp surfaces which may be hazardous to personnel.

27. 50 WATT NDB CABINET INSTALLATION DETAILS.

a. 50 Watt NDB Cabinet Dimensions. The 50 watt NDB cabinet dimensions, as presented in figure 2-3 are nominally 25 inches high, 9 inches deep, and 11 inches wide.

b. 50 Watt NDB Cabinet Location. The 50 watt NDB shall be located in existing air navigation facilities as presented in drawing D-6186-001. Brackets are fitted to the rear panel for wall mounting. The distance of the site from the antenna tuning unit (adjacent to the antenna) is significant. The length of the feeder cable should be no longer than /8. (70 meters at 535 kHz is the shortest critical length, increasing to 197 meters at 190 kHz). The mounting location shall be free from obstruction with a one foot clearance from other equipment.

c. Mounting. The 50 watt NDB shall be mounted to unistrut channels (or equivalent). The unistrut channels are bolted to enclosure wall studs as shown in drawing D-6186-001.

(1) The cabinet shall be installed plumb, level, and square.

(2) Vents in the base and at the top of the cabinet must not be obstructed to permit convection cooling. The exit vents are on the rear panel. Four spacer pillars are supplied to provide an appropriate air space.

(3) The cabinet shall be bolted to the unistruts at each corner mounting bracket with 3/8 inch bolts and lock washers. The spacing pillars shall be installed between the mounting brackets and the wall to insure adequate ventilation.

(4) The method of mounting shall not present protrusions or sharp surfaces which may be hazardous to personnel.

28. 50 WATT ATU CABINET INSTALLATION DETAILS.

a. 50 Watt atu Cabinet Dimensions. The 50 watt atu cabinet dimensions, as presented in figure 2-8, are nominally 27 inches high, 14 inches deep, and 18 inches wide.

b. 50 Watt atu Cabinet Location. The 50 watt atu shall be located in the air navigation facility as presented in drawing D-6186--001.. The atu is located within a specified distance from the 50 watt NDB (refer paragraph 27.b., FA-9782 Instruction book.).

c. Mounting. The 50 watt atu shall be mounted to unistrut channels (or equivalent). The unistrut channels are bolted to enclosure wall studs as shown in drawing D-6186-001.

(1) The vents in the base and sides of the atu must be unobstructed to permit convection cooling.

(2) The cabinet shall be installed plumb, level, and square.

(3) The cabinet shall be bolted to the unistruts at each corner.

29. ANTENNA FEED THROUGH AND SPARK GAP INSTALLATION. Drawing D-6186-010 presents the NDB facility antenna feed through and spark gap installation and delineates required hardware. This spark gap is optional depending upon the type unit.

a. Installation Procedure.

(1) At the antenna feed through location point, drill a 2 inch diameter hole.

(2) Wall mount insulator bowls to each side of masonite wall.

(3) Wall mount spark gap galvanized steel bracket.

(4) Fabricate and install copper gap spark tubes as specified in drawing D-6186-010.

(5) Install terminal lugs at antenna feed through and spark gap galvanized steel bracket.

(6) Route No. 6 bare copper wire from spark gap to ground as shown in drawing D-6186-010.

(7) Connect outside antenna cables to antenna feed through ground lug.

(8) Attach ring terminal to inside antenna rf cable for antenna feed through attachment.

30. EMERGENCY POWER SUPPLY INSTALLATION. The emergency 48 volt power supply system is an optional installation at 50 watt NDB facilities. It is a regional facility decision and will be procured with regional funds.

a. Installation Procedure.

(1) Install associated conduit as shown in drawing D-6186-001.

(2) Install battery switch and route battery cables. (Refer to drawing D-6186-003 for wiring and interconnection diagrams).

(3) Locate and install battery box as shown on drawing D-6186-001.

(4) If the facility does or does not have a vent fan, vent the battery box to atmosphere, outside the building, to exhaust hydrogen gas.

31. EXTERNAL CABLING INTERCONNECTION. Drawing D-6186-003 and D-6186-004 present wiring diagrams and cable interconnections for the 50 and 400 watt NDB units respectively. Paragraphs a through c provide interconnection guidance, and paragraph d provides specific direction on connector attachment.

a. 50 Watt NDB Installation.

(1) Figure 2-1 shows the general layout of the external cabling at the 50 watt NDB and atu. The terminal connections at the transmitter are shown in figures 5-1 and 5-2. The regulator charger assembly (A1A1) shown in figure 2-4, must be removed from its socket XA1, supported by two pillars, to expose TB1 and TB2. The rf antenna feed is taken from the type N connector J3, and all other cabling is brought up through the conduit feedthrough, located in the base of the cabinet.

(a) The feeder cable to the atu should not be longer than /8 using half-inch solid sheath coaxial cable or similar (50 ohm characteristic impedance). The mating connectors required are type N, suitable for outdoor conditions at the atu. Careful dressing is required and bends of less than 10 inches in diameter are to be avoided.

(2) A two-wire (line and neutral), with separate ground connection is required at TB1 as shown in figure 5-2. The power requirement is a single phase nominal 115 V ac (102-138 V), 60 Hz at 160 volt-ampere maximum. It is highly recommended that an external breaker be wired into the supply to expedite removal of ac from the cabinet for power-off maintenance procedures.

(3) The NDB cabinet shall be grounded from its external ground lug (figure 5-1) back to the power panel NDB circuit breaker with bare No. 6 copper wire routed in the 3/4 inch thin wall conduit with the power cable.

WARNING: Do not apply power at this time.

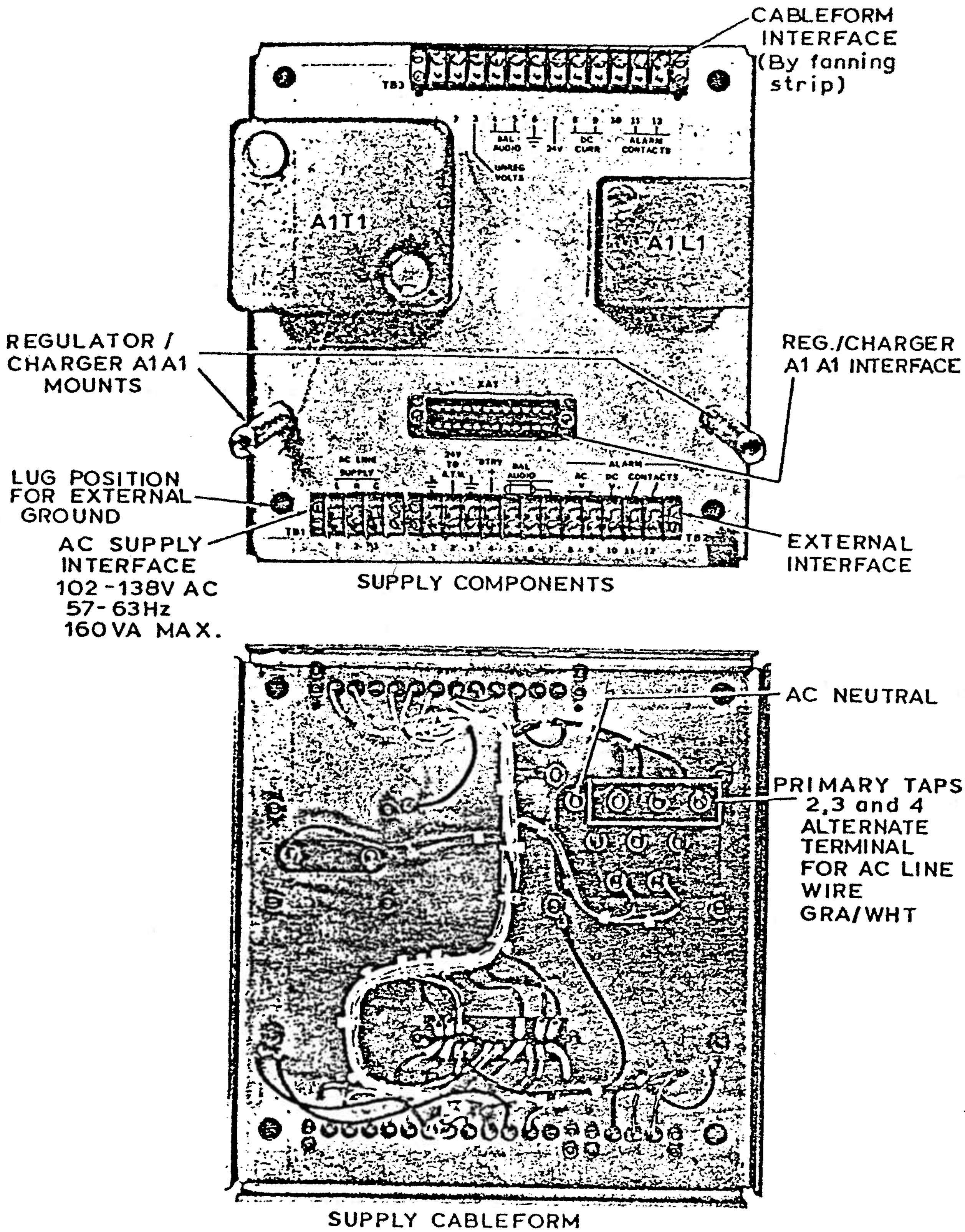


FIGURE 5-1 SUPPLY CHASSIS TOP AND BOTTOM

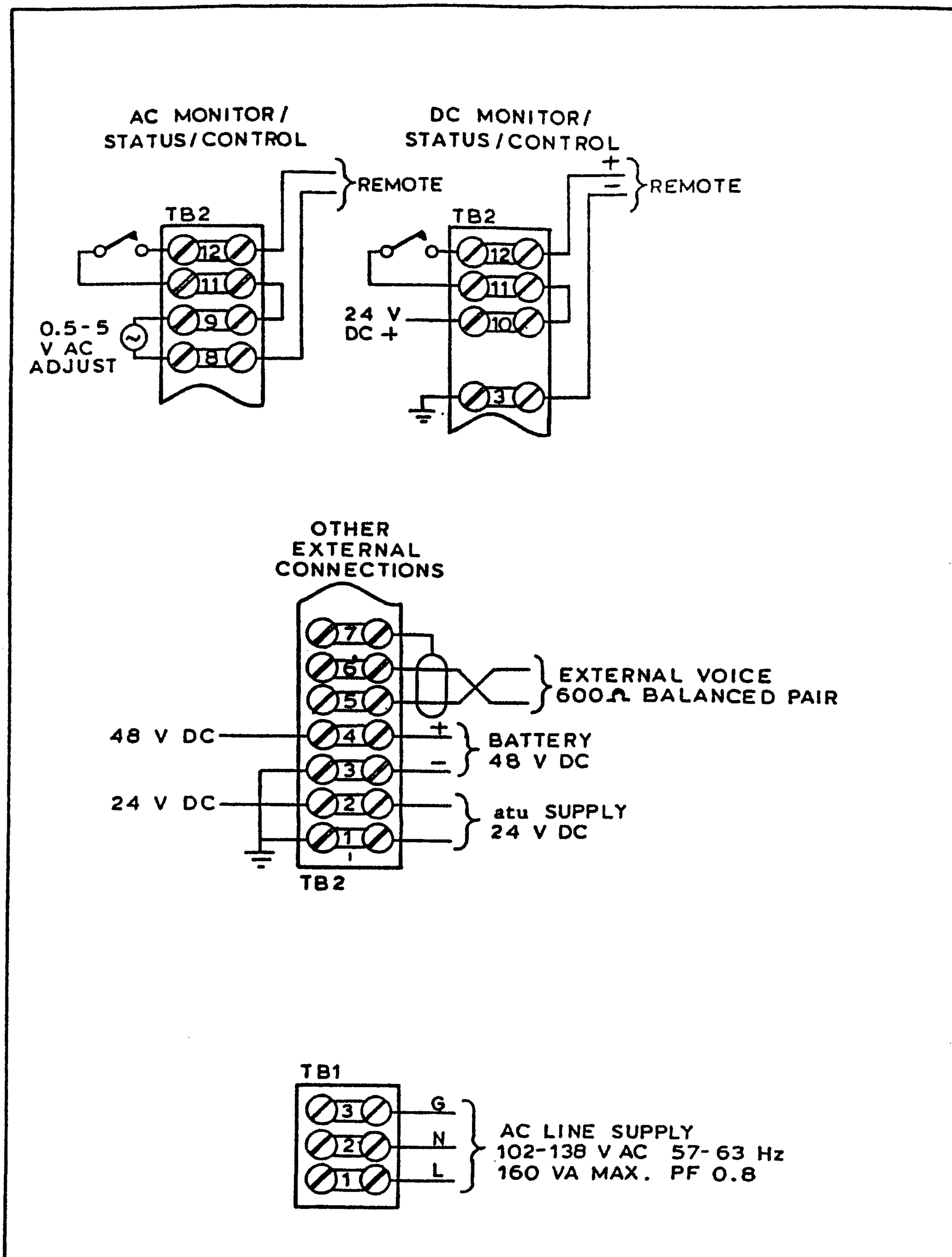


FIGURE 5-2. EXTERNAL CONNECTORS

(4) The atu interface and remote connections at TB2 are shown in figure 5-2. The external voice input should be a stranded shielded telephone pair having the shield well grounded as shown. The emergency battery (if installed) should be located as shown in drawing D-6186-001 and should be connected at A1TB2-4 via an external on/off switch and 3 amp fuse installed as closely as possible to the battery. These battery circuit items are not supplied. Leave switch off at this time.

(a) The remote monitor status control is provided for alternative ac/dc supplies, and a closed set of contacts from the transmitter to indicate normal status (open indicates alarm). The ac supply provides an adjustable voltage into 600 ohms from 0.5 to 5.0 V ac. The 24 V supply will not provide a current in excess of 133 mA.

(5) Table 5-5 summarizes 50 watt NDB input/output connections. Additional items to be checked include the following:

(a) No loose or detached wiring at XA1, XA2, XA3, XA4, XA6, and TB1, TB2, TB3, A3TB1, and A6TB1. All terminal boards mated with fanning strips on the wraparound cableform.

(b) Ground jumpers connected as follows:

1 Across control panel upper hinges (one wire).
2 At exciter XP2 lower lug (three wires).
3 At pa module lower bracket lug (three wires).
4 At harmonic filter fixing screw (one wire).
5 At monitor XA7 lower lug (three wires).
6 At rf probe XA6 left-hand (one wire).

(c) Rf jumpers connected at rf filter A1A5 at J1 and J2 from A3 and A6 (BNC's P1 and P2).

(d) M1 shortening strap removed from across positive/-negative terminals.

b. 50 Watt atu Installation

(1) The two-wire, 24 V dc power supply from the transmitter is connected at J2 using mating connector provided; +term A - term B. The tuning motor draws less than 0.15 amps under full load. The mating type N connector for the rf feed (not provided) is connected at J1 (UG1095A/U). The antenna connection at the feed through insulator should be arranged without sharp bends and should contain a drip loop at the insulator end. The wire should be of sufficient diameter to prevent corona discharge. The antenna ground connection is taken from the external lug on the rear panel to the antenna ground plane. Heavy cable or braid AWG 6 or larger should be used.

TABLE 5-5 NDB INPUT/OUTPUT CONNECTIONS

INPUT SUMMARY

FUNCTION	CABLING	TERMINAL
External Voice	Stranded shielded pair, AWG-22 600 ohm balanced	TB2-5 and 6
Battery (+)	AWG 12 x 12 foot cables are supplied. If longer cabling is required, the total loop resistance should not be greater than 0.1 ohm	TB2-4
Battery (-)	0.1 ohm	TB2-3
External Ground	No. 6 bare copper wire	External Ground lug

OUTPUT SUMMARY

FUNCTION	CABLING	TERMINAL
atu supply (24 V dc)	Two-wire - total resistance less than 5 ohms (AWG-18)	TB2-2 (+) TB2-3 ground
Remote monitor status control ac and dc supplies	Alternative connections are shown in figure 5-2	TB2

(2) All wiring to the electronic assembly is connected at the terminal strips A1TB1, A1A1TB1, A1A2TB1, and A1A3TB1. The external side at A1TB1, A1A1TB1 and A1A3TB1 must be disconnected to remove the assembly when access is required to the tuning motor drives in the rear of the cabinet. The connections at the two pcb's A1 and A2 are via fixed chassis sockets. The rf jumpers are connected at terminal strips.

(3) The loading coils and ferrite tuning slugs (figure 5-3) are disassembled prior to shipment and packed separately in the atu crate. To assemble the coils in the atu, proceed as follows.

(a) Having made all interconnections between the transmitter and the atu, remove exciter pcb from transmitter to ensure that its rf output is zero, then switch on the transmitter. The 24 volt supply will then be fed to the atu. Switch on the atu power at S1.

(b) Operate the decrease switch to drive the tuning slug to its lower limit switch.

(c) Switch off the atu and the transmitter, then remove the electronic assembly from the atu by disconnecting the external interconnections at A1TB1, A1A1TB1 and A1A3TB1 and backing off on the four captive fixing screws shown in figure 5-4.

(4) At the top of each tuning spindle, place a nut and lockwasher (shipped in plastic bag), then screw on the ferrite slug assembly, bearing on the lower female standoff only, until the thread bottoms. Tighten nut to lock in place. See figure 5-5. Do not bear on the ferrite or ceramic pillar.

(5) Install loading coils on coil support ceramic pillars using the screw and lockwashers provided. Part numbers for the operating frequency range for right- and left-hand coils (viewed from front) are listed below.

(a)	190-285 kHz	133-9023-1 (right-hand)
		133-9023-2 (left-hand)
(b)	286-405 kHz	133-9023-3 (right-hand)
		133-9023-4 (left-hand)
(c)	406-535 kHz	133-9023-5 (right-hand)
		133-9023-6 (left-hand)

(6) The slugs are now positioned such that when driven to the upper limit switch, the ferrite sections are centered vertically in the loading coils. This produces the maximum available inductance value for the loading coil in use which is reduced as the slugs are withdrawn by the tuning motor. It may subsequently be determined that a lesser value of maximum inductance is required. Where this

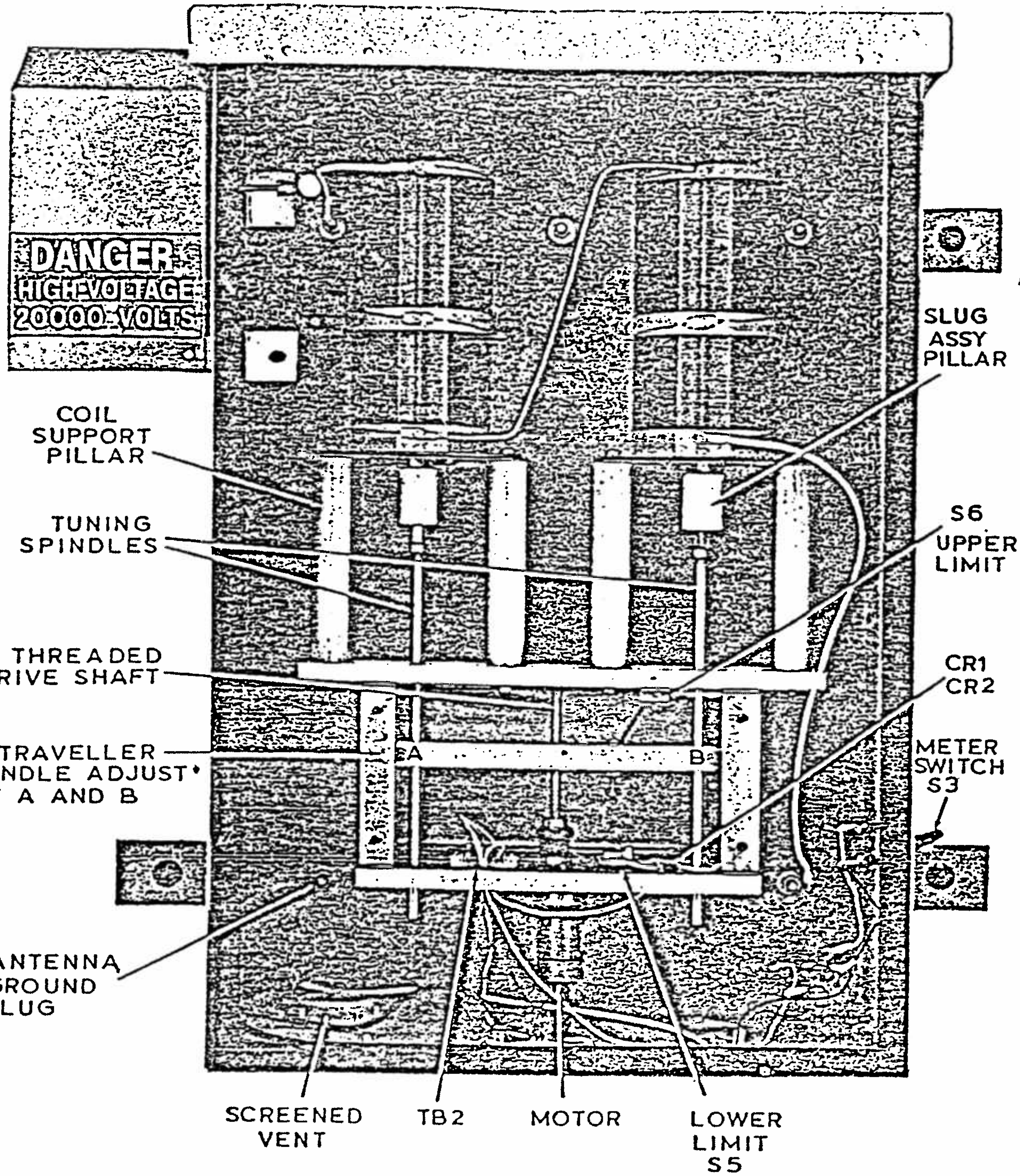


FIGURE 5-3. CABINET WITH ELECTRONIC CHASSIS REMOVED

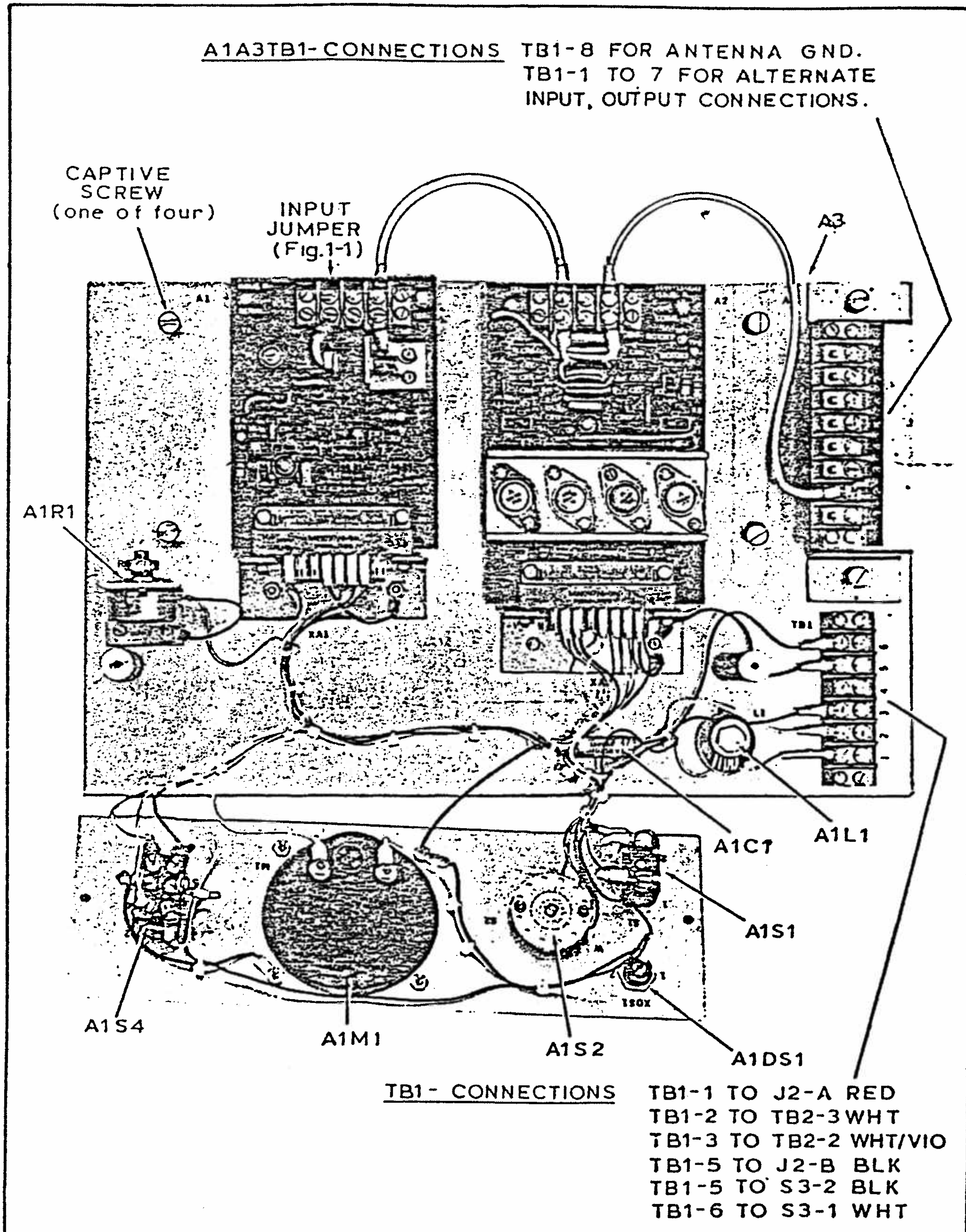


FIGURE 5-4 ELECTRONIC CHASSIS

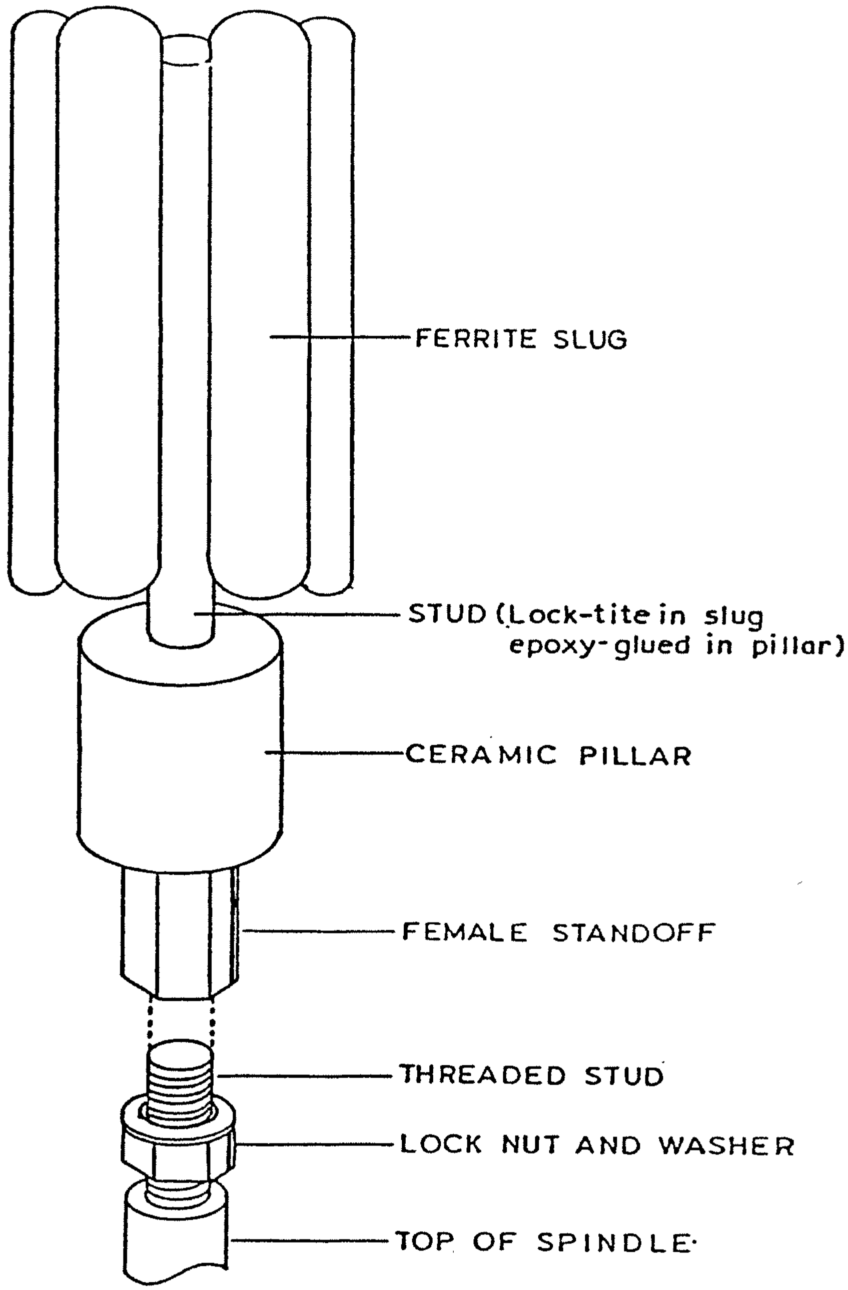


FIGURE 5-5 MOUNTING OF TUNING SLUGS

is the case, the position of the tuning spindles may require later readjustment.

First ensure that the motor drive is in its lower limit of travel as in paragraph 31.b.(3)(b), above. Loosen the spindle adjusting screws A and B (figure 5-3) and the two locking collars immediately above them. Lower the spindles until just clear of the cabinet base. Then tighten motor fixing screws.

(7) Replace the electronic assembly and reconnect all interconnecting wires (figure 5-4).

c. 400 Watt NDB Installation.

(1) The external terminal connections at the transmitter terminal boards are shown in figure 5-6 and in drawing D-6186-004. The 1TB1 and 1TB2 are mounted behind the power supply drawer 1A1, and therefore are easily accessible only when the drawer is removed. Connections are most readily made before the drawer is mounted. Cabling may enter the cabinet through the top cover beside the rf output type N connector or through the aperture in the base of the cabinet.

(2) The transmitter is fitted with 72 ohm type N receptacle on the top cover. The cable (not supplied) must be suitable for outdoor conditions with weatherproof connectors and have the appropriate power rating and attenuation characteristics for the 400 watt power level. Careful dressing is requried, and bends of less than 10 inches in diameter should be avoided. If a 50 ohm terminal impedance is required, the type N receptacle must be exchanged (not supplied). Because of its short electrical length, the coaxial cabling from the power amplifier (1A3J1) to the receptacle serves for either terminal impedance, but the matching transformer at the amplifier output (1A3T2) must be adjusted by connecting the output lead at 1A3TB3 as shown in Table 5-6. A second transformer must be set up to the intended operating power level at 1A3TB4 as shown.

(3) Ground the transmitter cabinet back to the power panel, from the external ground lug (figure 5-7), with bare No. 6 copper wire.

(4) A two-wire connection with separate ground is required at TB2 as shown in figure 5-6. The power requirement is a single phase, either nominal 114 V ac (102-138 V) or 230 V ac (204-276 V) as shown in figure 5-6, 60 Hz at 1.2 kilovolt ampere max. An external breaker shall be wired into the supply to expedite removal of ac from the cabinet during maintenance.

WARNING: Do not apply power at this time.

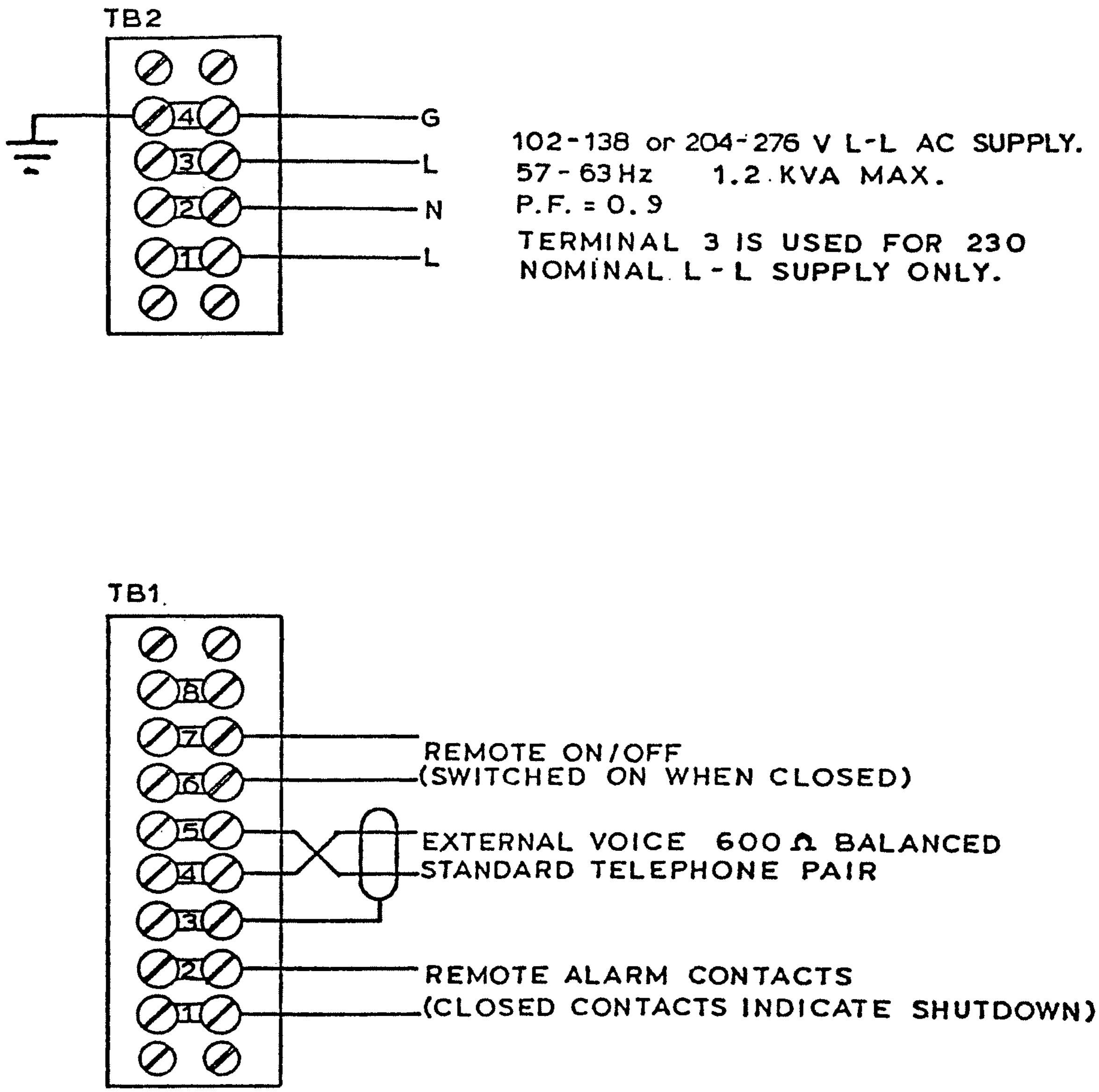


FIGURE 5-6 EXTERNAL CONNECTIONS

TABLE 5-6 POWER AMPLIFIER TRANSFORMER SETTINGS

Terminal	Setting
TB5-1	50 ohms
TB5-2	72 ohms
TB4-3	50 - 100 watts
TB4-4	100 - 200 watts
TB4-5	200 - 400 watts

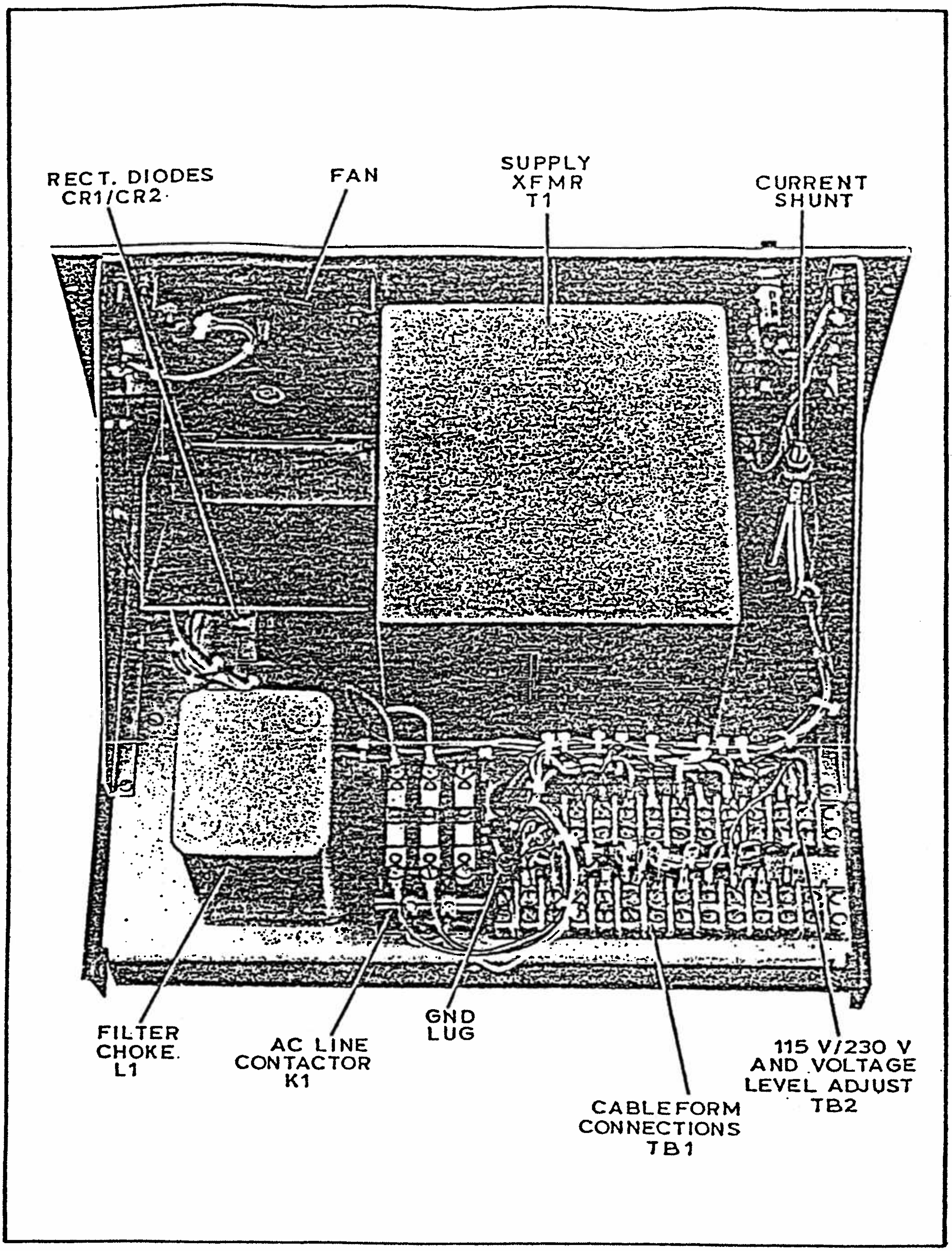


FIGURE 5-7. POWER SUPPLY ASSEMBLY - TOP VIEW

(5) The remote connections at TB1 are shown in figure 5-6. The external voice input should be a stranded shielded pair having the shield grounded as shown. The remote alarm contacts are closed for normal operation and open for alarm. The remote on/off switching terminals TB1-6 and 7 must be externally connected to switch transmitter on. Table 5-7 presents an input and output summary.

(6) After making the external connections at 1TB1 and 1TB2, the power supply assembly is to be inserted into the bottom drawer by depressing the spring-loaded catches on the slides. The fanning strip on the cableform is to be connected to 1A1TB1. The ground cabling, consisting of three wires - AWG 12 - two black and one black and white, is to be connected at the ground lug (figure 5-7). The eight power amplifier modules are then to be inserted into the power amplifier rack and the captive retaining screws secured (figure 5-8).

(7) Complete the following wiring checklist:

(a) External wiring is complete at 1TB1 and 1TB2.

(b) External ground wire connected from ground lug to power panel.

(c) Cableform fanning strips are securely connected at assembly terminal blocks.

(d) Rf jumper is connected from 1J1 (rf output receptacle) to 1A3J1 (power amplifier output).

(e) Meter shorting straps are removed from across positive/negative terminals at the exciter/monitor control panel.

d. Assemble Power and Signal Connectors.

(1) Assemble spade lugs (to fit No. 6 screws) for attaching power and signal cables to the 400 and 50 watt NDB transmitters, the marker transmitter, and the Telco demarc box.

(2) Assemble type N connectors to both ends of the rf feed cable between the 50 watt NDB and its associated 50 watt atu at J1 and J3.

(3) Assemble multipin connector for 50 watt atu 24 V dc power supply at J2.

(4) Assemble type N conntors for attaching the 400 watt NDB rf output and the antenna cable at J3 and at J1.

TABLE 5-7 INPUT AND OUTPUT SUMMARY

FUNCTION	CABLING	TERMINAL
External Voice	Stranded shielded pair, AWG-22 600 ohm balanced	1TB1-4 and 5 shield at 3
Remote Alarm	Two-wire - closed contacts for normal status	TB1-2 TB1-1
Remote ON/OFF	Two-wire 115 V ac	1TB1-6 and 7
External Ground	Bare No. 6 copper wire	Ground lug AWG power panel

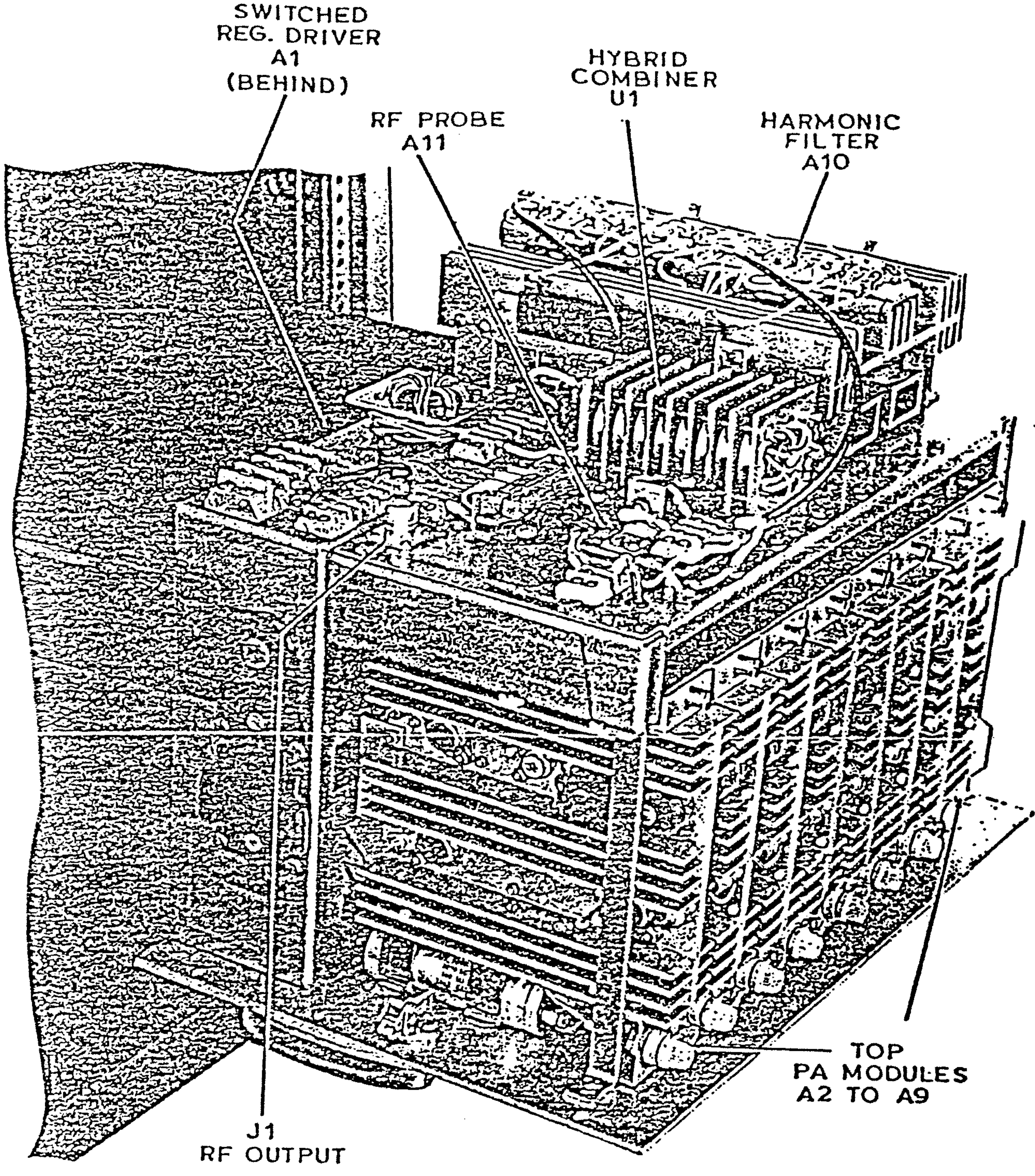


FIGURE 5-8 POWER AMPLIFIER ASSEMBLY, DRAWER EXTENDED

(5) Procedures for attaching Type N connectors are presented in figure 5-9.

SECTION 2. WIRING AND CABLING

32. ELECTRICAL WIRING. Power wiring in the NDB facility shall conform to the National Electrical code (NEC). All receptacles and equipment conductors shall be a 3-wire grounding type. Other general requirements are:

a. Ducts and Conduits. All electrical wires from circuit breaker panel to equipment cabinets shall be protected in approved ducts or conduits. At junction points of conduit-to-duct or conduit-to-elecrical outlet boxes, bushings shall be installed to protect wires from physical damage. On cable tray systems, dividers shall be provided if power and radio signaling conductors share the cable tray. Outside electrical installations shall use moistureproof conduits and fittings.

b. Electrical Conductors.

(1) Single conductor wiring protected in ducts or conduits shall be thermoplastic covered wire, type THW or THWN. The wire size is determined by the current flow of the circuit. Most branch circuits are protected with 20 amp breakers which, in accordance with NEC, requires use of No. 12 wire or larger diameter.

(2) Any wire splices shall be made with approved splicing connectors and be in accessible areas such as junction boxes and square ducts with covers.

c. Color of Wires.

(1) AC electrical wires, either single conductor or 3-wire cord types, shall be color coded as follows:

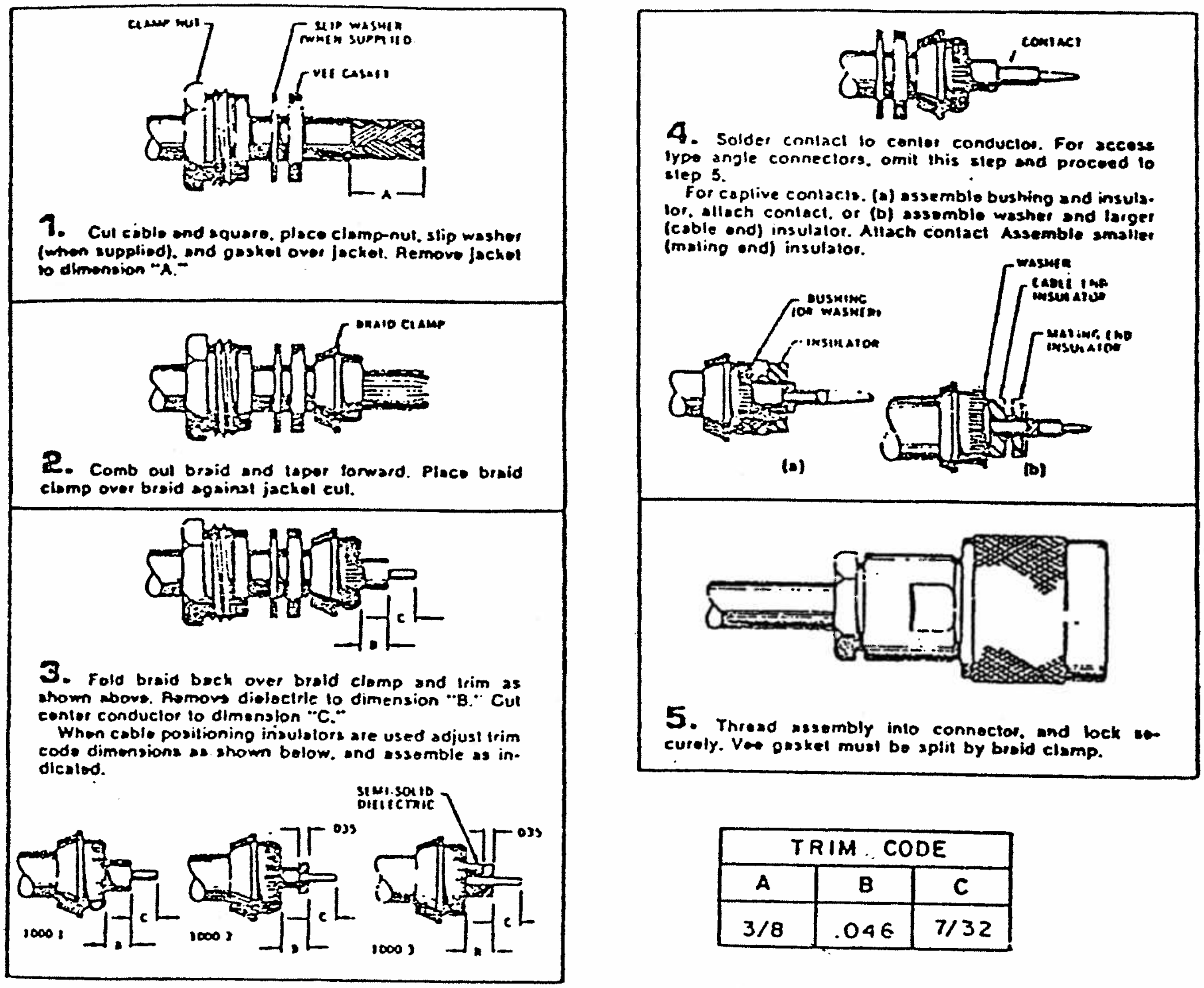
(a) White - Neutral.

(b) Green - Ground.

(c) Black - 115 volt ac.

(d) Every other voltage will use separate color wire.

(2) Wires may be wrapped with colored tape at the exposed areas to conform to the color code above.



TRIM CODE		
A	B	C
3/8	.046	7/32

FIGURE 5-9. PROCEDURE FOR ATTACHING TYPE N CONNECTORS M39012/1-0005, TO CABLE

33. SYSTEM WIRING.

a. Wiring and cabling between the ac power distribution panel in the facility building or shelter and the NDB equipment shall be installed to meet the present circuit demands.

b. Cable Installation. In the ducting, between the 50 watt NDB and its associated atu, cables shall be installed in the duct in a systematic order, with as few crossovers as possible. Where the number of cables requires stacking, the cables traveling the furthest shall be on the bottom of the stack. The first run of cables shall be secured to the tray at regular intervals using plastic tie-wraps (such as PAN-TY cable ties). Second, third, and succeeding stacks of cables are tied to those below. If signal/control cable runs share a common duct with power cables, signal/control cables shall be isolated from power cables by a metal barrier or separate duct. At NDB installations, 3/4 inch thin wall conduit shall be installed for routing the power cable with external ground cable and 1 1/2 inch thin wall conduct shall be installed for routing the signal cables.

c. Dressing of Cables. Dressing of cables includes arranging them in a systematic order, removing the outer covering and inner insulation on individual pairs, and otherwise preparing them for termination to blocks or equipment connectors. It is very important that the cable dressing be carried out in a uniform manner throughout the installation, and that the general appearance is pleasing to the eye. Cables extending into racks shall be arranged in the order of their use, with those terminating into the lowest part of the rack installed first and secured to the side wall of the rack. Other cables will lie on top and be tied to those below. The cover of the cables and their inner insulation are to be removed at the point which allows ample room for splitting the wires before they enter the terminal block or connector. The foil around shielded pairs is removed at the cable opening point and the drain wires either removed or continued to the connector point.

d. Terminating Wires. Cable connections should be made only at terminal strips or in junction boxes. Cable lengths up to 1,000 feet should be continuous in length (no splices). After dressing of the cables is completed to the intended terminating point, the individual cable pairs are separated. Actual terminating techniques depend upon the type of connector or block being wired. However, on all installations some slack shall be left in the terminal wire. It is apparent that termination of the facility wiring is probably the most important operation of the installation and should be carried out professionally. The care and attention exercised on this phase will pay off when the equipment is placed in operation and when the facility is inspected periodically.

e. Insulation. When removing insulation from wires, insulation stripping devices which nick, mar, or damage the conductor in any way should not be used. Good quality cable strippers should be used. The correct setting (size) of the stripping tool should be based on the size of the wire. Proper use of the cable strippers will ensure that the wire is not nicked, a condition which could later cause breaks. Strip only the insulation necessary to make the connection.

f. Solderless Lugs. When using solderless lugs, the size and type of wire must be considered so that the proper lug can be used. Lugs are color coded for wire size. Red lugs are No. 22 through No. 16 size wire, blue lugs are for No. 16 through No. 14 size wire, and yellow lugs are for No. 12 through No. 10 size wire. Also, lugs must be selected based on the size of the screw. The lugs used most often are spade lugs that accept No. 22 through No. 16 wire and fit a No. 6 screw, and the ones that accept No. 16 through No. 14 wire and fit a No. 6 screw. All lugs used are insulated; therefore, no insulation needs to be installed. Special crimping tools are provided for installation of lugs. Proper use of these tools is imperative for a good electrical connection. All stranded wire requires the use of lugs. Stranded wire shall not be installed under a binding post without the use of a lug.

g. Plastic Tubing. When soldering wires to cable plugs, lengths of spaghetti (plastic tubing) shall be used over each wire and connection point. This will ensure to the maximum extent possible that shorts are prevented. A cable clamp is to be used on all plugs to avoid strain on the cable connections and to avoid twisting.

h. Equipment-to-Equipment Connections. In a number of cases, direct equipment-to-equipment connections have to be made. They are generally of two types. In one type, a fixed length of cable with suitable connectors at either end are factory made and supplied complete with grounding connections. It is desirable to use them as supplied unless the length is insufficient. In the other type, only the equipment connectors are provided and the cable must be provided and the cable must be fabricated at site using the required length of appropriate type of cable with proper shielding and grounding drain connections where necessary.

i. Handling of Shields. Cables having shielded pairs shall have their shield grounded at the equipment end only. Shielded pairs normally have an aluminum foil wrapping with a bare wire (drain wire) under the foil. In such cases, only the drain wire is terminated to the ground. The best installation is achieved by removing the foil from all the cable pairs at the same point and then twisting their drain wires together to form a braid. All the drain wires can then be lugged together and attached to the insulated grounding bus.

j. Marking Cables. All cables should be tagged at each end for easy identification. Positioning of markers or labels should permit easy access without disturbing adjacent wiring and cabling. The markers used for this purpose should be of a type that is both durable and easy to install (such as PAN-TY markers). In all cases, markers should be installed in accordance with manufacturer's recommendations.

k. Clamping Cables. Cables should be supported adjacent to connectors by a cable clamp of appropriate size to prevent pulling on the connector. The distance between the cable clamp and connector should be such that the connector can be easily removed and reattached to its mating unit while minimizing loading on the connector.

l. Wiring Check-Out. Every connection made during an installation shall be verified both for unintended grounding and circuit continuity before energizing the system. Unintended grounding shall be tested with a low voltage megger or a multimeter set to a high resistance scale. The resistance between ground and the wire shall be nominally infinite. Continuity testing shall be accomplished by setting the multimeter on a low resistance scale. One end of the wire is connected to a common wire (ground wire). The resistance between the other end of test wire and common wire is measured. Continuity is established when this resistance is nominally zero. When testing small equipment plug wiring, the adjacent terminals to the connection being checked shall be tested for possible shorts caused by the cramped wiring in the connector housing.

34. INSIDE CABLE DUCTS.

a. General.

(1) A wide variety of methods for distributing interconnect cables and wiring are presently in use throughout the FAA. These methods include the following:

(a) Cabinet top open-type racks.

(b) Cabinet top enclosed ducts/trays (commercial and fabricated).

(c) Raised computer floor.

(2) In NDB installations the cable distribution method for the facilities shall be via the square duct or thin wall conduit as presented in drawings D-6186-001 and D-6186-002.

b. NDB Cable Ducts. The following guidelines shall be used in modifying or installing sections of the ducts.

(1) Ducts procured from commercial sources should not have knockouts.

(2) Ducts procured from commercial sources should be assembled and installed using matching hardware.

(3) Fabricated ducts should be assembled and installed using properly selected hardware.

(4) Where cutting is required, the workmanship should be such that all edges will be smooth, fit well, and are aligned.

(5) Surfaces of duct work should be level, plumb and square.

(6) Duct work will be grounded throughout their length using bare copper No. 6 AWG wire. The ground wire shall be attached to each section of the duct work (exlcusive of couplings) and mechanically fastened to clean metal with copper or bronze Blackburn LB-70 or equal type connectors. The ground wire should be continuous to its termination at the building ground but need not necessarily be a single piece.

(7) Ducts shall be insulated from equipment racks, consoles, etc., with phenolic spacers and nylon attaching screws. This practice is recommended for prevention of ground loops which could result in additional circuit noise.

c. NDB Thin Wall Conduit. The following guidelines shall be used in installing thin wall conduit:

(1) Conduit procured from commercial sources should be assembled and installed using matching hardware.

(2) Where cutting is required, the workmanship should be that all edges will be smooth, fit well, and are aligned.

SECTION 3. GROUNDING, SHIELDING, AND BONDING

35. GENERAL. Optimum performance of electronic equipment with adequate protection against power system faults and lightning strikes requires proper operation of signal and equipment grounding systems, a lightning protection system, and a power distribution ground system. These systems provide proper grounding of the building and its contents, proper bonding of all system components, and proper shielding of equipment for personnel safety and equipment interference control. This section provides a brief overview of procedures for checkout of grounding, shielding, and bonding at existing FAA facilities and procedures for installing nondirectional beacon equipment into operational grounding systems. Additional information is available in FAA-STD-019, Lightning Protection, Grounding, Bonding, and Shielding Requirements

for Facilities; FAA-STD-020, Transient Protection, Grounding, Bonding, and Shielding Requirements for Equipment; and the latest edition of Order 6950.19, Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation; Order 6950.20, Fundamental Considerations of Lightning Protection, Grounding, Bonding, and Shielding; and Order 6950.21, Structure Lightning Protection at FAA Facilities.

36. REQUIREMENTS FOR EXISTING FACILITIES. Before nondirectional beacon equipment is installed at existing FAA facilities the existing grounding, shielding, and bonding should be inspected for compliance with Order 6950.19, chapter 3. Any deficiencies should be corrected before the equipment is installed.

a. Earth Electrode System. The procedure for determining the components, configuration, and effectiveness of this system is presented in Order 6950.19, chapter 3, paragraph 97. The earth electrode system is the electrical connection between the facility and the body of the earth. The system provides a low-resistance connection to the earth for lightning and power fault protection and minimizes noise between interconnected facilities.

b. Lightning Protection System. The procedure for verification of system conformance with the National Fire Protection Association, Lightning Protection Code (NFPA 78) and the Installation Requirements for Master Labeled Lightning Protection Systems (UL 96A) is presented in Order 6950.19, chapter 3, paragraph 98. The lightning protection system provides a low-resistance path to the earth so that lightning discharges will enter or leave the earth only through the conducting parts of a structure.

c. Signal and Equipment Grounding Networks. The procedure for determining the configuration and effectiveness of the signal reference network (signal ground) and multipoint ground system (equipment ground) and instructions for evaluating and correcting these systems are presented in Order 6950.19, chapter 3, paragraphs 99 and 100. The signal ground provides a single-path connection to the earth electrode system and the equipment ground for low-frequency (less than 100 kHz) equipment. The equipment grounding network provides multiple, low-resistance paths for high-frequency (greater than 100 kHz) signals between various parts of the facility, the equipment, and the earth electrode system. The equipment ground also supplements, but does not replace, the National Electric Code (NEC) required equipment grounding conductors. Except for an interconnection at the main ground plate, the equipment ground is electrically isolated from the signal ground.

d. Bond Evaluation and Resistance. The procedure for evaluating, and determining resistances in, facility bonds is presented in Order 6950.19, chapter 3, paragraph 101. High quality bonds between conducting elements of grounding and shielding networks ensure proper operation of these networks.

e. Shielding Evaluation. The procedure for evaluating the presence, purpose, and condition of equipment and facility shields is presented in Order 6950.19, chapter 3, paragraph 102. Shielding protects equipment from unwanted coupling and protects personnel from electromagnetic radiation and electric shock.

f. Transient Protection. The procedure for evaluation of systems protecting solid-state electronic equipment from lightning-generated transients is presented in Order 6950.19, chapter 3, paragraph 103. Because solid-state electronic equipment is extremely susceptible to damage from small transients, greater care must be taken to ensure that transients are suppressed.

g. NEC Compliance Evaluation. The procedure for inspection of NEC-required grounding, bonding, and shielding and correction of deficiencies is presented in Order 6950.19, chapter 3, paragraphs 104 through 106. NEC equipment grounding provides fault protection and protects personnel from electric shock.

37. REQUIREMENTS FOR GROUNDING, BONDING, AND PROTECTION. Grounding, bonding, and shielding for the nondirectional beacon must be properly installed to ensure optimum operation of the equipment. General procedures for connection with the signal and equipment grounding systems, the lightning protection system, and the power distribution ground system are included in the following paragraphs. For further guidance see Order 6950.19, chapters 2 and 4.

a. Signal Grounding Network. The voice input cable shield shall be connected to the signal ground from the equipment end of the shield. A single 6 AWG insulated copper wire color coded green with a bright yellow tracer shall be used to connect the shield with the nearest signal ground plate. This wire should be routed to minimize path length and parallel runs with primary power conductors, lightning grounding system conductors, and other conductors that carry high-amplitude currents.

b. Equipment Grounding System. All equipment chassis, cases, and housing and the ac ground (safety ground) shall be connected to the equipment grounding system. Where nondirectional beacon equipment is not properly grounded to other equipment, structural elements, racks, or other metallic objects properly connected to the equipment ground, a 14 AWG insulated copper wire shall be used to connect equipment with the nearest equipment ground plate. Equipment ground wires shall be color coded green with a bright orange tracer. In addition, nondirectional beacon equipment shall be connected with separate grounding conductors (color coded green) as required by the NEC.

c. Lightning Protection System. The two spark gaps on the RG 214/U RF cable at the nondirectional beacon transmitter and the antenna tuning unit shall be grounded to the lightning protection or earth electrode system. The spark gaps shall be connected to ground with 6 AWG bare copper ground wires (see drawing D-6186-010).

d. Power Distribution Ground System. NEC grounding requires 14 AWG insulated copper wire color coded green to be connected to the ac ground (safety ground) and all equipment chassis, cases, and housings. This system shall be separate from, and installed in addition to, the equipment grounding system.

38. RESERVED.

CHAPTER 6. SITE ENGINEERING

39. INTRODUCTION.

a. The purpose of this chapter is to provide engineering information for selecting NDB sites, selection of antennas and transmitter output power, and calculation of expected coverage range. Formulas are provided for calculating the various quantities along with typical propagation curves. A completed example is also included.

b. NDBs operate in the frequency range of 190 to 535 kHz. At these frequencies, an efficient antenna would require an effective height of 600 to 220 feet, respectively. Tower structures of this size are neither economical nor practical when sited close to airport runways. The effective heights of antennas in common use vary between 20 and 100 feet. These short antennas are inefficient and reduce bandwidth. As a result, there are trade-offs between effective antenna height, antenna costs, and coverage range. These trade-offs are explained in the following paragraphs.

40. PROPAGATION.

a. The use of many different variables in the lf and mf field strength prediction methods is indicative of the complexity and uncertainty regarding the physical properties that are involved in long-distance sky-wave propagation. The International Radio Consultative Committee (CCIR) method is the most commonly used propagation prediction method for North America.

b. At lf and mf propagation, the antenna field radiation is comprised of two components:

(1) Ground wave is the field in the vicinity of the earth.

(2) Sky wave is the field radiated at angles above the horizontal.

During the hours of darkness, the sky wave is reflected back to the earth by the ionosphere. The CCIR method assumes that the maximum sky-wave field strength occurs about six hours after sunset, or approximately local midnight at the path midpoint.

c. Important points concerning lf and mf propagation are:

(1) The ground wave field strength increases with decreasing frequency.

(2) Because of ionospheric disturbances, the sky wave reflected back to earth varies in magnitude and phase, which will cause fading when its amplitude is comparable to that of the ground wave.

(3) The attenuation of the ground wave by buildings and other installations within several wavelengths of the ground station transmitter is also a limiting factor. These objects will distort the coverage pattern and cause multiple reflected signals near the transmitter.

(4) Bearing errors can be caused by reflections, defraction, ducting, and shoreline effect. Bearing error is the most predominate limitation in mountainous terrain. Virtually nothing can be done to correct this problem.

d. Another limitation to coverage range is static noise. Atmospheric static noise is caused by lightning and other natural electrical disturbances and is propagated over the earth by the ionosphere. Static levels are stronger at night than during daytime periods. Warm tropical areas have higher static levels because storms are more frequent while the polar regions are far removed from the lightning storms and have lower static levels. The static noise also increases at the lower frequencies.

41. SITE SELECTION.

a. The desired coverage area will determine the type of antenna and transmitter power required to meet the minimum signal level at the coverage area boundaries. Another important parameter is ground conductivity within the desired coverage area.

b. When selecting a site, several potential sites should be surveyed for:

(1) Available area for installation of antenna.

(2) Available area for installation of radial ground plan.

(3) Known or predicted soil conductivity.

c. Consideration should be given to distortion of the radiation pattern because of the effect of buildings in close proximity to the antenna when operating at higher frequencies.

42. DETERMINATION OF EARTH GROUND.

a. The electrical characteristics of earth ground may be expressed by three constants:

(1) Relative permeability.

(2) Dielectric constant.

(3) Conductivity.

b. The complex dielectric constant can be expressed as follows:

$$\varepsilon' = \varepsilon - j\ 18000\ \sigma/f = \varepsilon - j\ 60\sigma\lambda$$

where:

σ = conductivity in mho/m
f = frequency in MHz
λ = free space wavelength in meters

The relative permeability can normally be regarded as unity, which leaves one concerned only with the dielectric constant and conductivity. These two constants jointly influence wave propagation. At a frequency of 3.6 MHz, the displacement and conduction current densities are equal. At frequencies below 1.2 MHz the displacement current, ε, is practically negligible.

43. FACTORS DETERMINING THE EFFECTIVE GROUND CONDUCTIVITY. The effective values of the ground conductivity are determined by the following:

a. Nature of Soil. The conductivity varies with the nature of the soil, but this variation is caused not so much by the chemical composition of the soil as by its ability to absorb and retain moisture. Normally loam has a conductivity of 10^{-2} mho/m, but when dried, the conductivity may be as low as 10^{-4} mho/m, which is of the same order as that of granite.

b. Moisture Content. As the moisture content is increased from a low value, the conductivity increases rapidly, reaching its maximum as the moisture content approaches the value normally found in such soils on site. At depths of one meter or more, the wetness of the soil at a particular site seems to be substantially constant year round and although it may increase during rains, the drainage of the soil and surface evaporation soon reduces it to its normal value after the rain has stopped. The moisture content may vary considerably from one site to another because of differences in geological formation.

c. Temperature. The temperature coefficient of conductivity is of the order of 2 percent per degree centigrade, with a large rapid change at the freezing point. Although these changes are appreciable, it must be realized that the range of temperature variation during the year decreases rapidly with depth, so that the temperature effects are important only at high frequencies where the penetration of the radio waves is small or when the ground is frozen to a considerable depth.

d. Frequency. The variation of conductivity with frequency depends basically on the moisture content.

e. Geological Structure. The conductivity is based not only by the nature of the surface soils, but also by the underlying strata. These lower strata may form part of the medium through which the waves travel or they may have an indirect effect by determining the water level in the upper strata.

f. Wave Penetration. The depth of radio wave penetration, σ, is defined as the depth in which the wave has been attenuated to 1/e or 37 percent of its value at the surface. The depth of penetration of radio waves into the ground is show in table 6-1.

TABLE 6-1. RADIO WAVE GROUND PENETRATION

Frequency		Depth δ (m)		
	σ ε	4 mho/m 80	10^{-2} mho/m 10	10^{-3} mho/m 5
100 kHz 3 MHz		.80 .14	15 5	50 17

44. MEASURING GROUND CONDUCTIVITY.

a. The most common method of measuring ground conductivity is the probe method. Measurements are made on site of the resistance between probes driven into the ground. These measurements are usually made with direct current using a system of four probes, a current being passed between one pair. The depth to which the measurements are effective is determined by the spacing between the probes and the thickness of the surface layer of soil, or the height of the water table.

b. Another method is measurement of soil samples in a laboratory determined by measurements of the resistance and reactance of capacitor units containing the soil as the dielectric.

45. FIELD STRENGTH.

a. A minimum operating field strength at the boundary of the NDB's coverage is usually defined in order to assess performance.

This field strength must be great enough to give at least a 10 to 15 dB S/N ratio most of the time when compared with atmospheric noise in the area concerned. Atmospheric noise varies with season and time of day and is worse during the hours of darkness, and is much higher in low latitudes.

b. The International Civil Aviation Organization (ICAO) standard recommends that a minimum value of field strength in the rated coverage area shall be 70 μ volts/meter. The field strength of 70 μ volts/meter is used in the following range estimates which are considered suitable within most areas in North America.

c. The field strength of the ground wave at a given distance from the antenna depends on the radiated power and the ground conductivity between the transmitter site and the aircraft. Since this conductivity is related to physical ground characteristics, the following figures are assumed to be suitable:

Physical Nature of Land	Ground Conductivity in mhos/meter
Mountains, industrial cities, dry, sandy, flat coastal land	$\sigma = 10^{-3}$
Rocky, hilly land, residential cities, northern forest	$\sigma = 3 \times 10^{-3}$
Good soil, medium hills	$\sigma = 10^{-2}$
Rich soil, low hills	$\sigma = 3 \times 10^{-2}$
Sea water	$\sigma = 4$

d. A map showing ground conductivities for North America is shown in figure 6-1. This map is presently limited in application to the vlf part of the spectrum, i.e., up to 30 kHz. No known map has been established for the lf and mf bands. This map has been calculated from physiographical and geological data used to define the boundaries of the land areas of given conductivity together with actual conductivity data derived from measurements from many workers. No allowance has been made for seasonal variations.

e. The range for a number of system configurations for a field strength of 70μ V/m versus soil conductivity have been plotted on the attached graphs (figures 6-2 through 6-14). A typical system best suited to a specific purpose and area may then be determined.

f. Other propagation curves developed by the International Radio Consultative Committee (CCIR) are shown in figures 6-15 through 6-23. These curves apply at frequencies below 10 MHz under the following conditions:

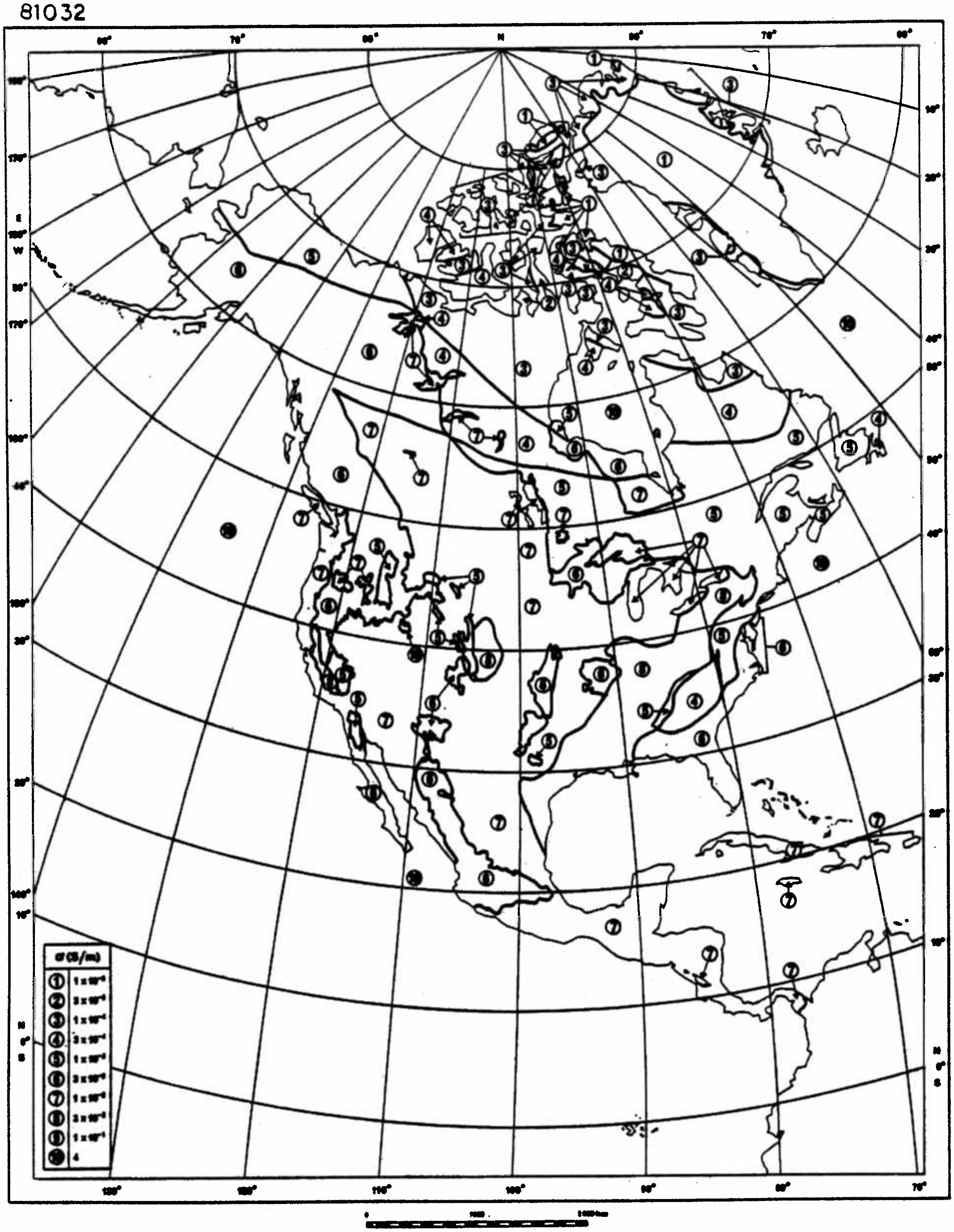


FIGURE 6-1. GROUND CONDUCTIVITY FOR NORTH AMERICA AT 30 KHZ [1]

[1] MORGAN, ROBERT R., WORLD-WIDE VLF EFFECTIVE CONDUCTIVITY MAP, NTIS REPORT AD675771, 1968

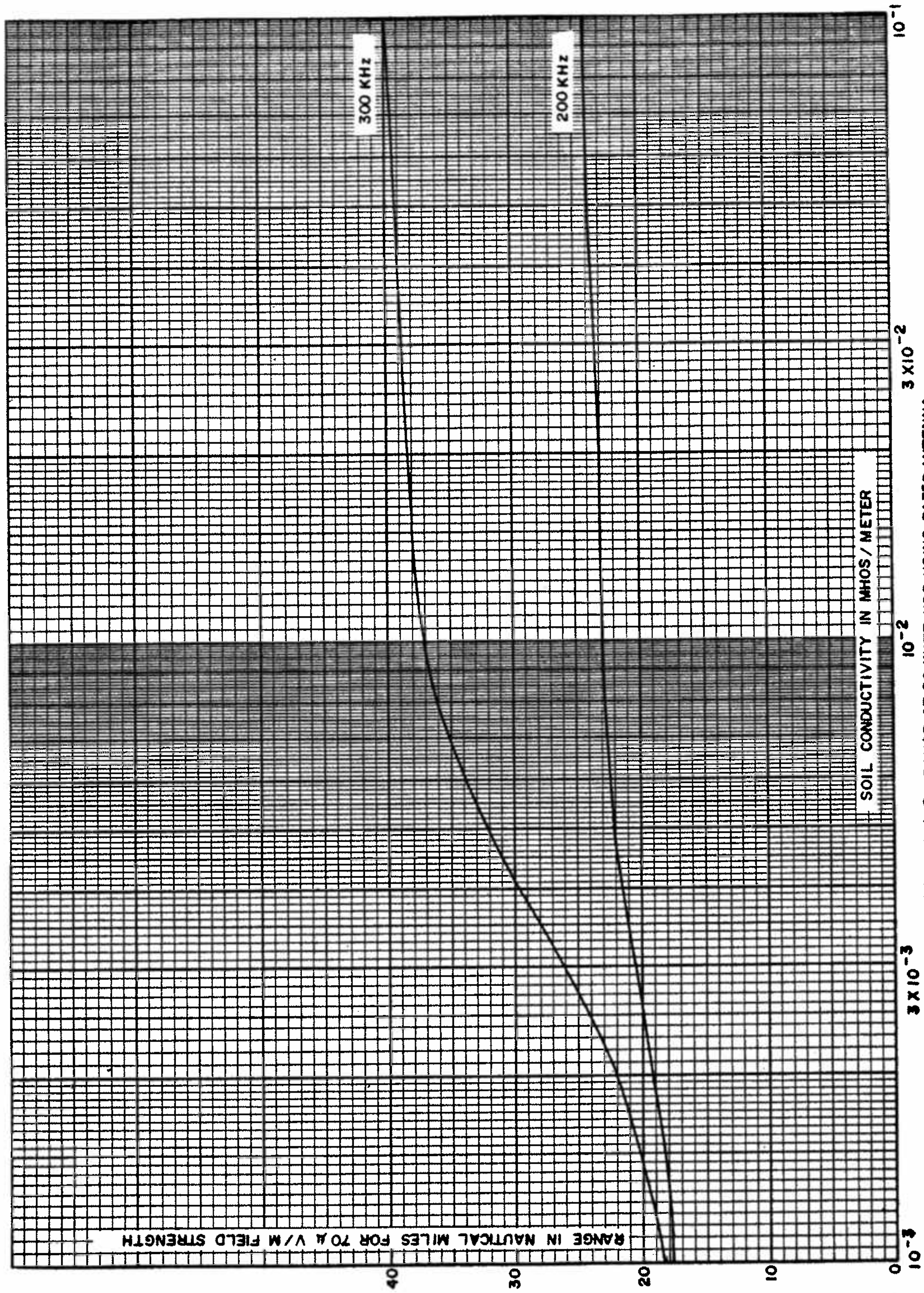


FIGURE 6-2. RANGE OF 50 WATT NDB USING PA35D ANTENNA

81033

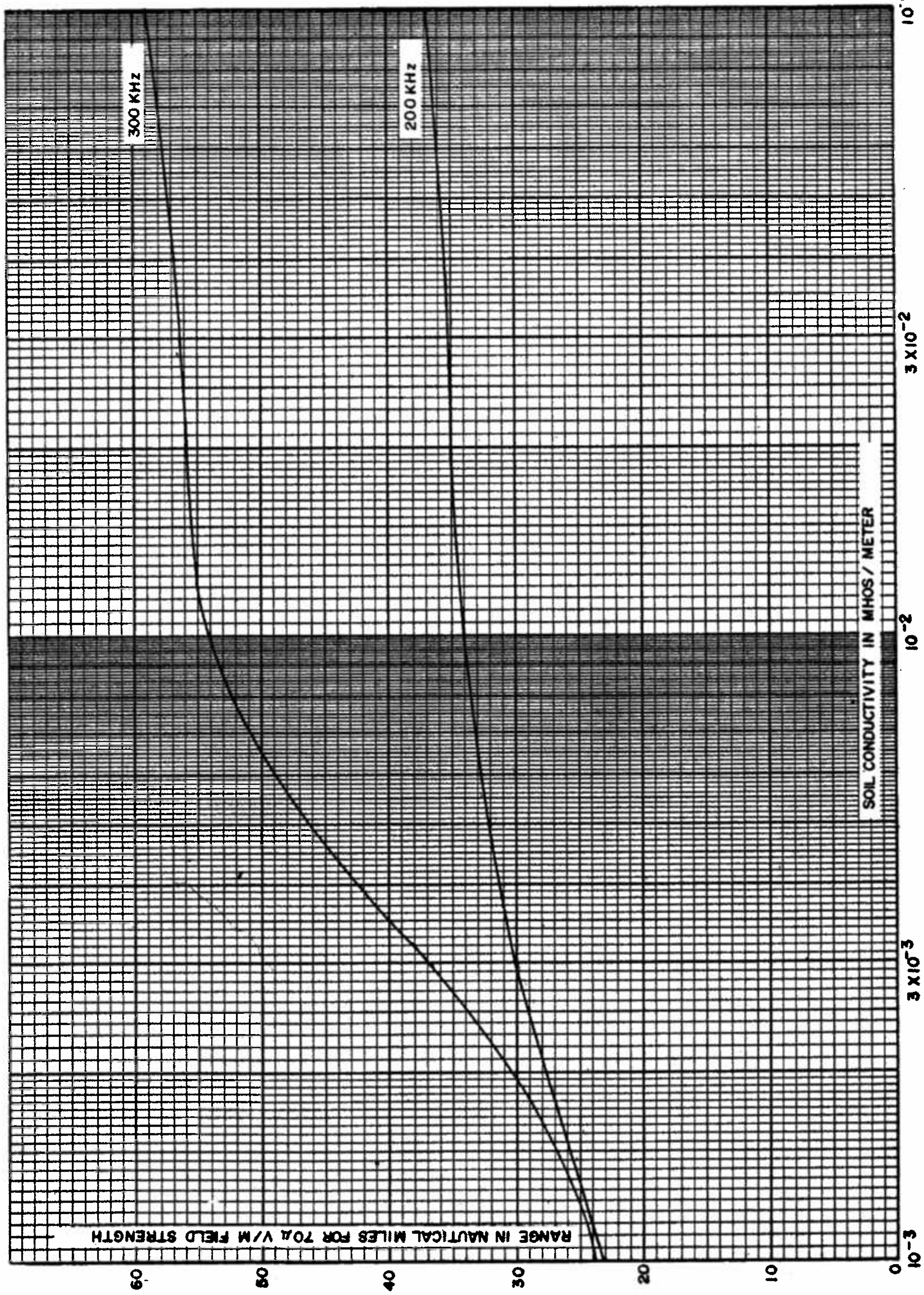


FIGURE 6-3. RANGE OF 100 WATT NDB USING PA35D ANTENNA

81034

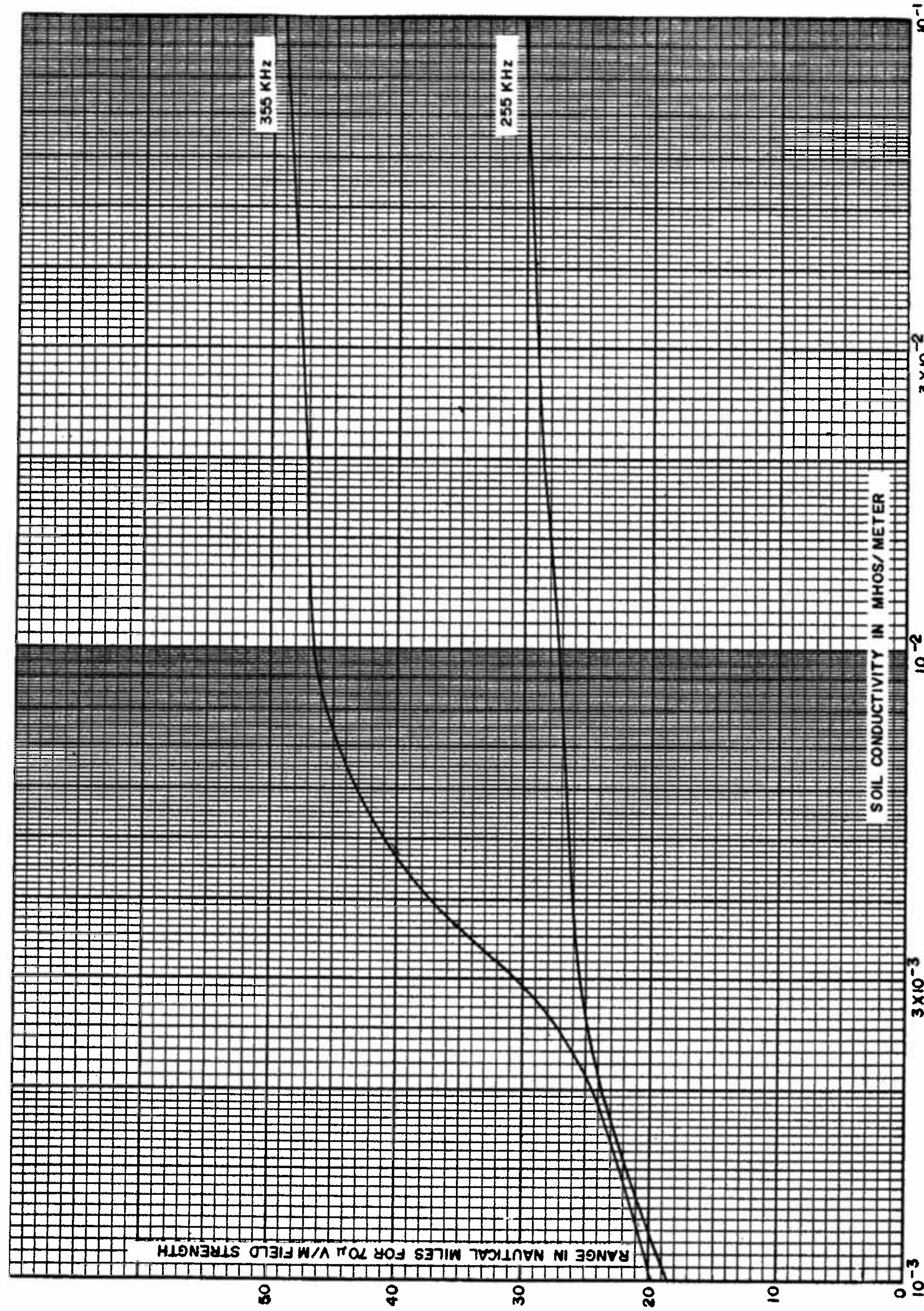


FIGURE 6-4. RANGE OF 50 WATT NDB WITH AATU AND PA35E ANTENNA (AATU-NX200TUB, FAA TYPE-FA9782/1)

81035

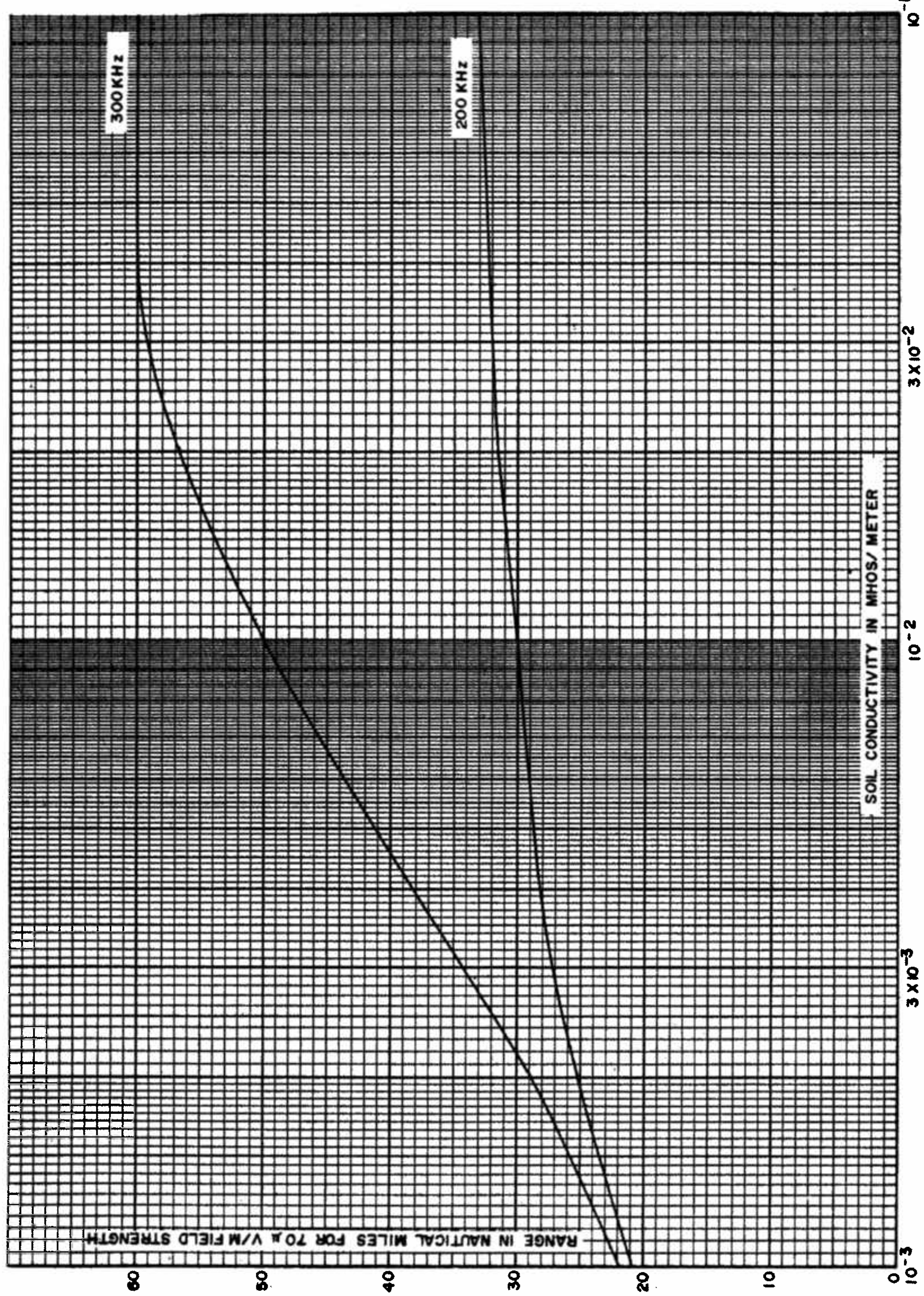


FIGURE 6-5. RANGE 50 WATT NDB (ND200) USING PA40A ANTENNA

81036

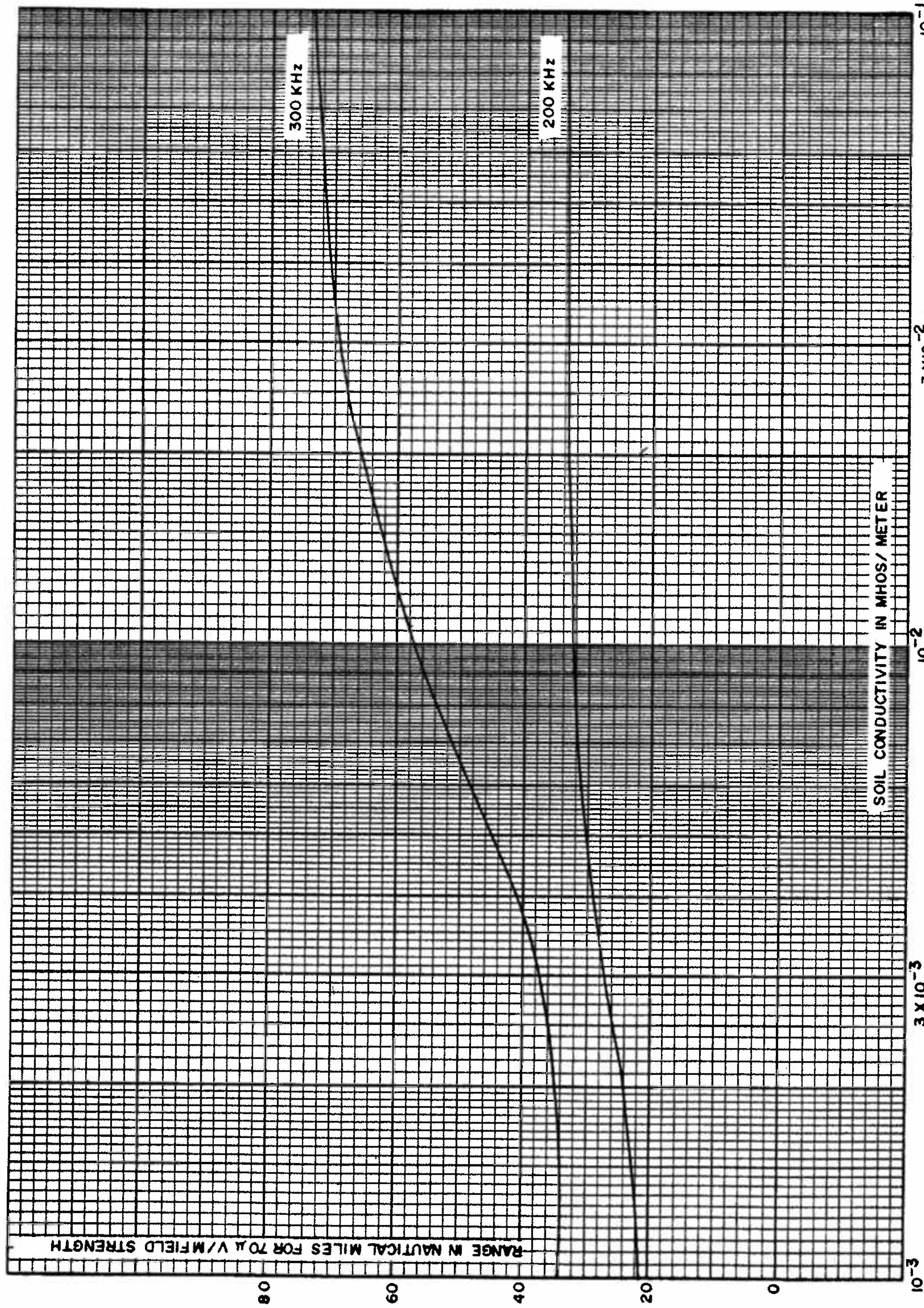


FIGURE 6-6. RANGE OF 25 WATT NDB USING PA60A ANTENNA

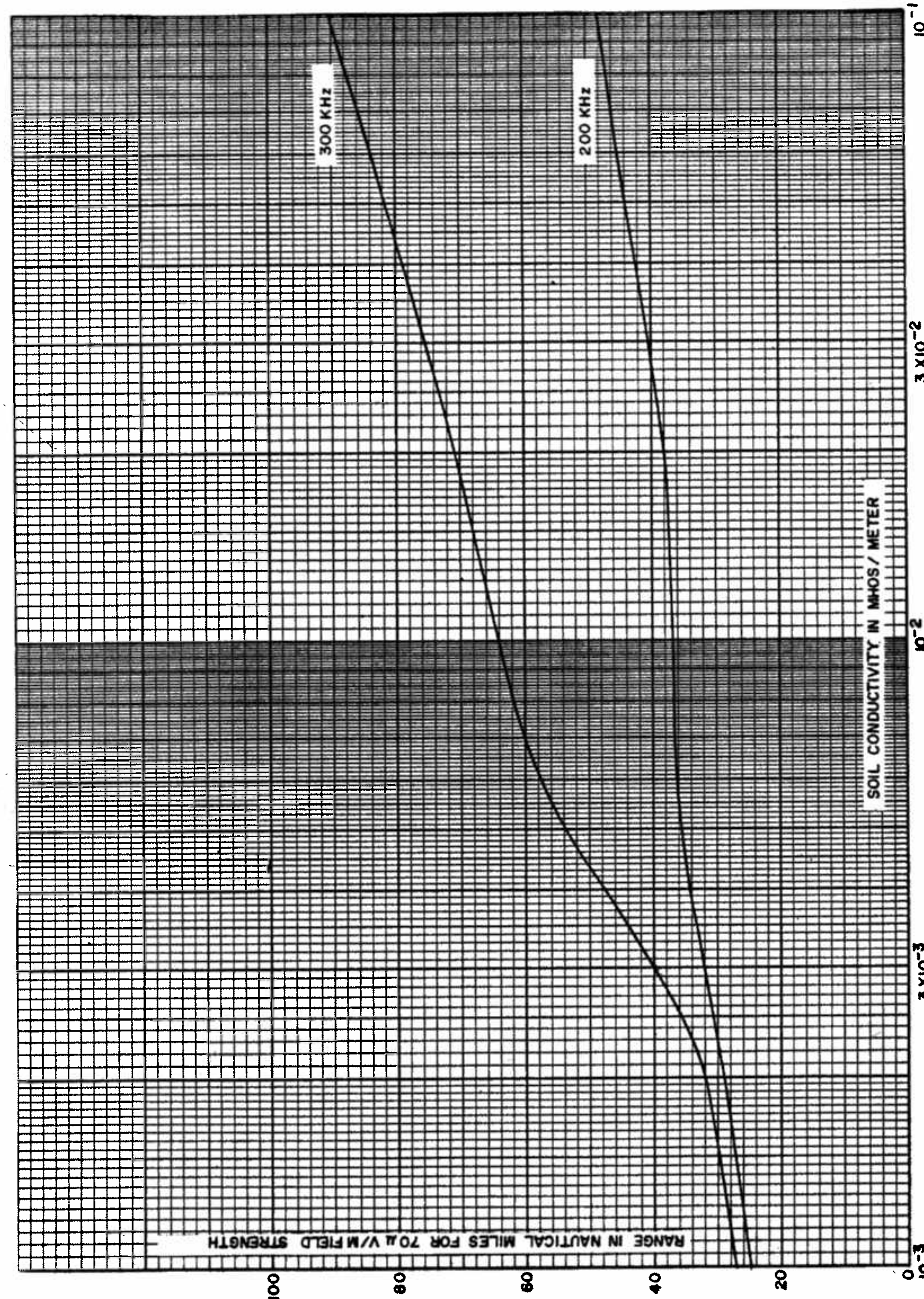


FIGURE 6-7. RANGE OF 50 WATT NDB USING PA60A ANTENNA AND 100 WATT NDB USING PA40A ANTENNA

81038

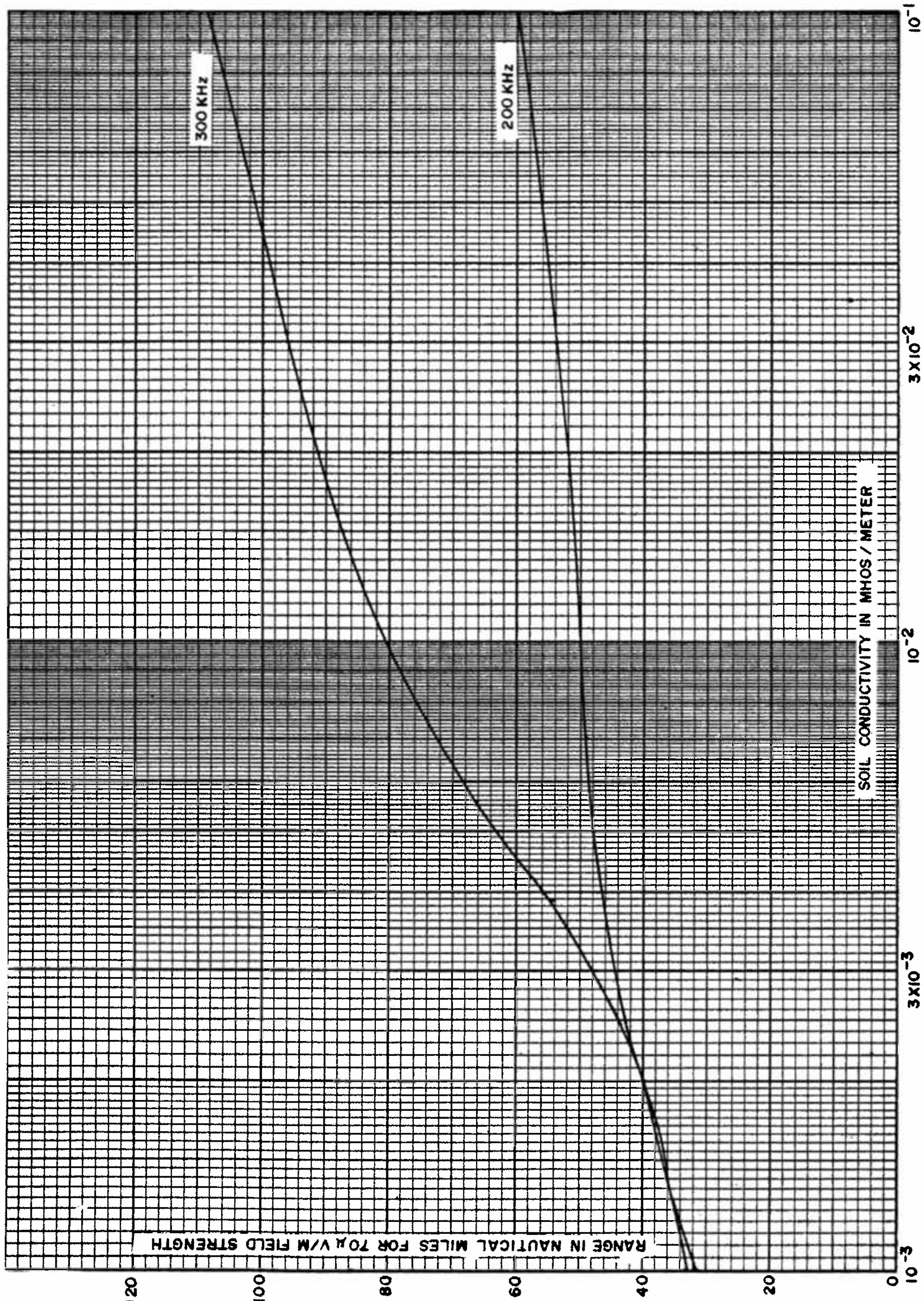


FIGURE 6-8. RANGE OF 100 WATT NDB USING PA60A ANTENNA

81039

810310

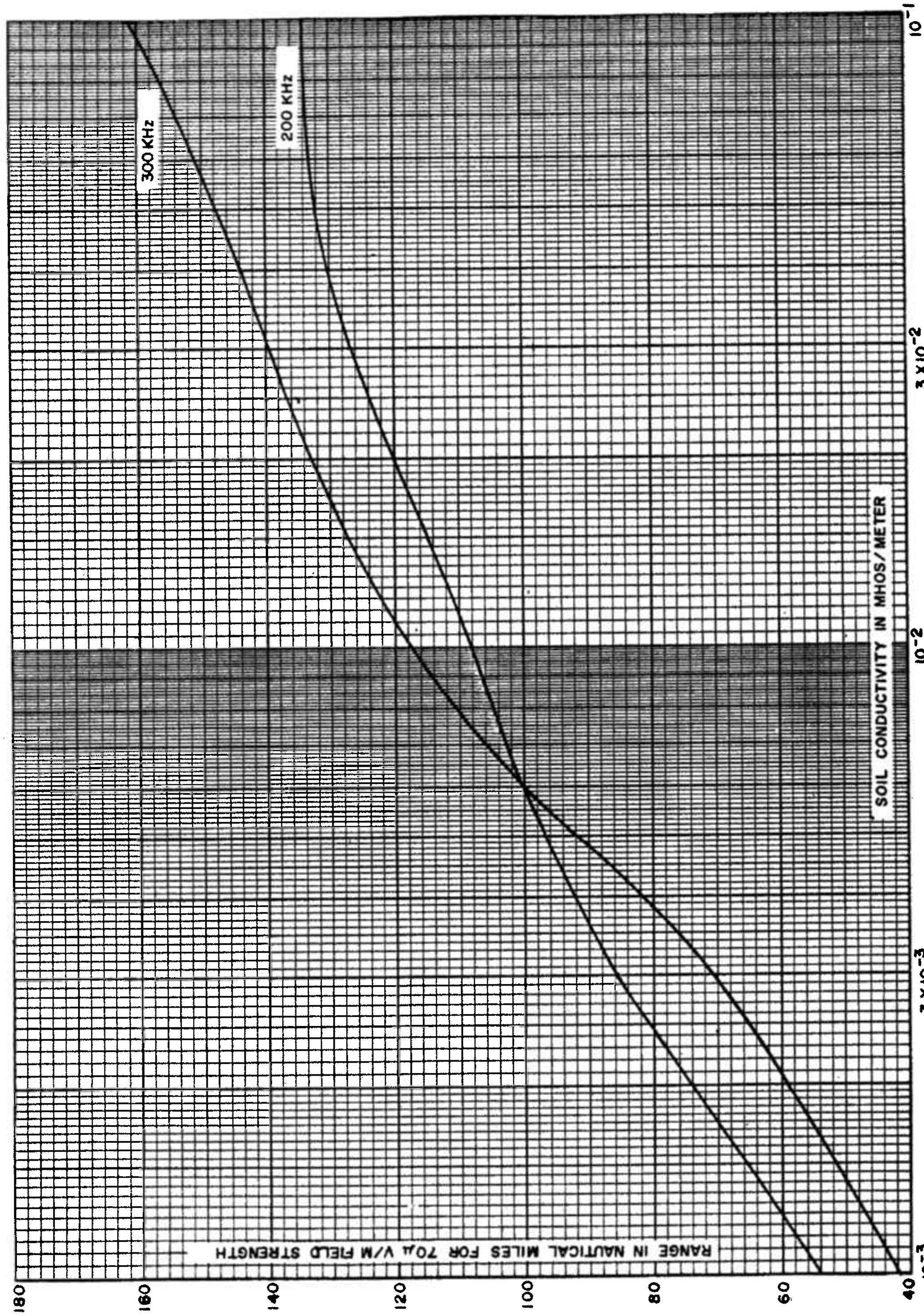


FIGURE 6-9. RANGE OF 250 WATT NDB USING PAGOB ANTENNA

810311

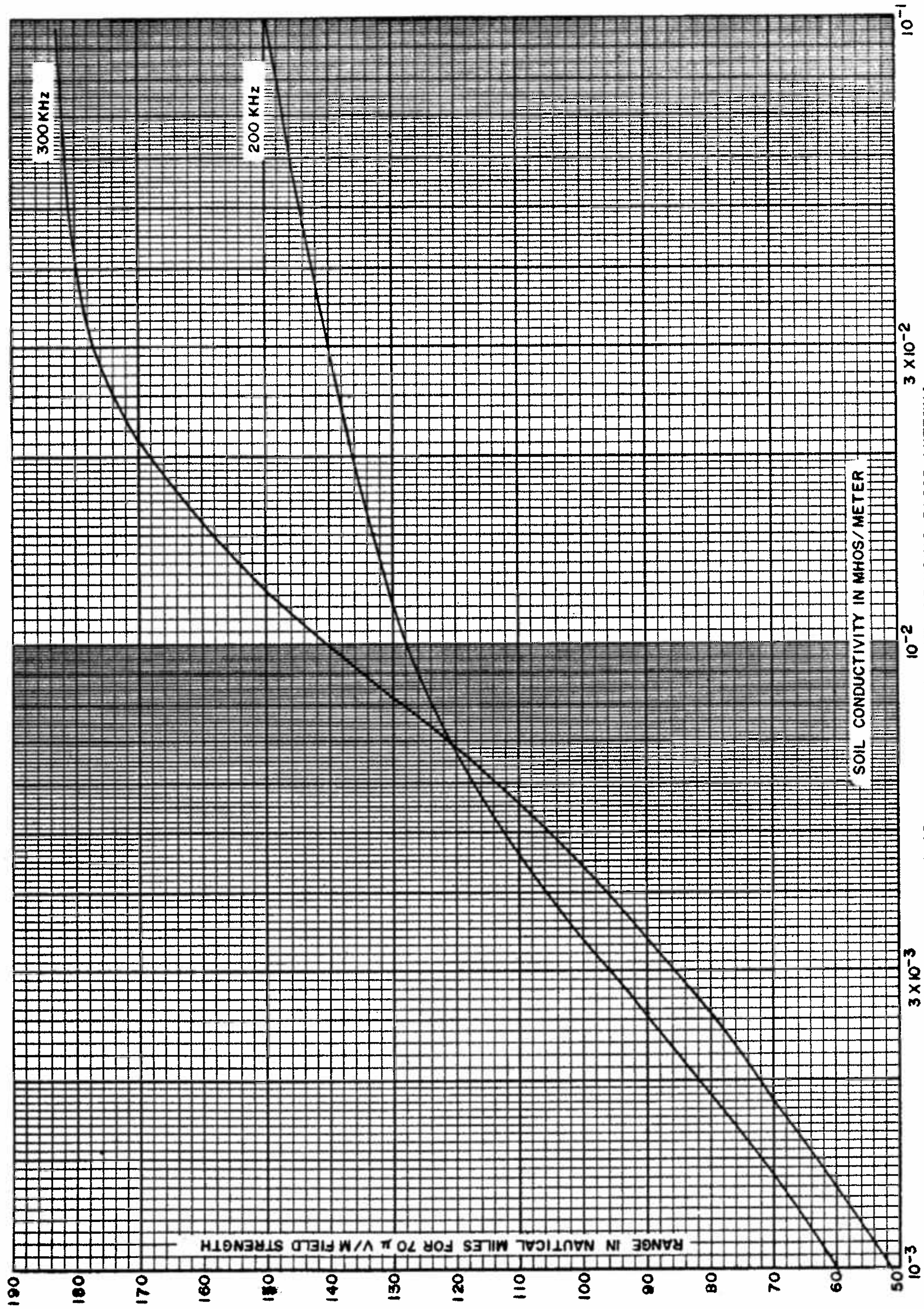


FIGURE 6-10. RANGE OF 400 WATT NDB USING PA60B ANTENNA

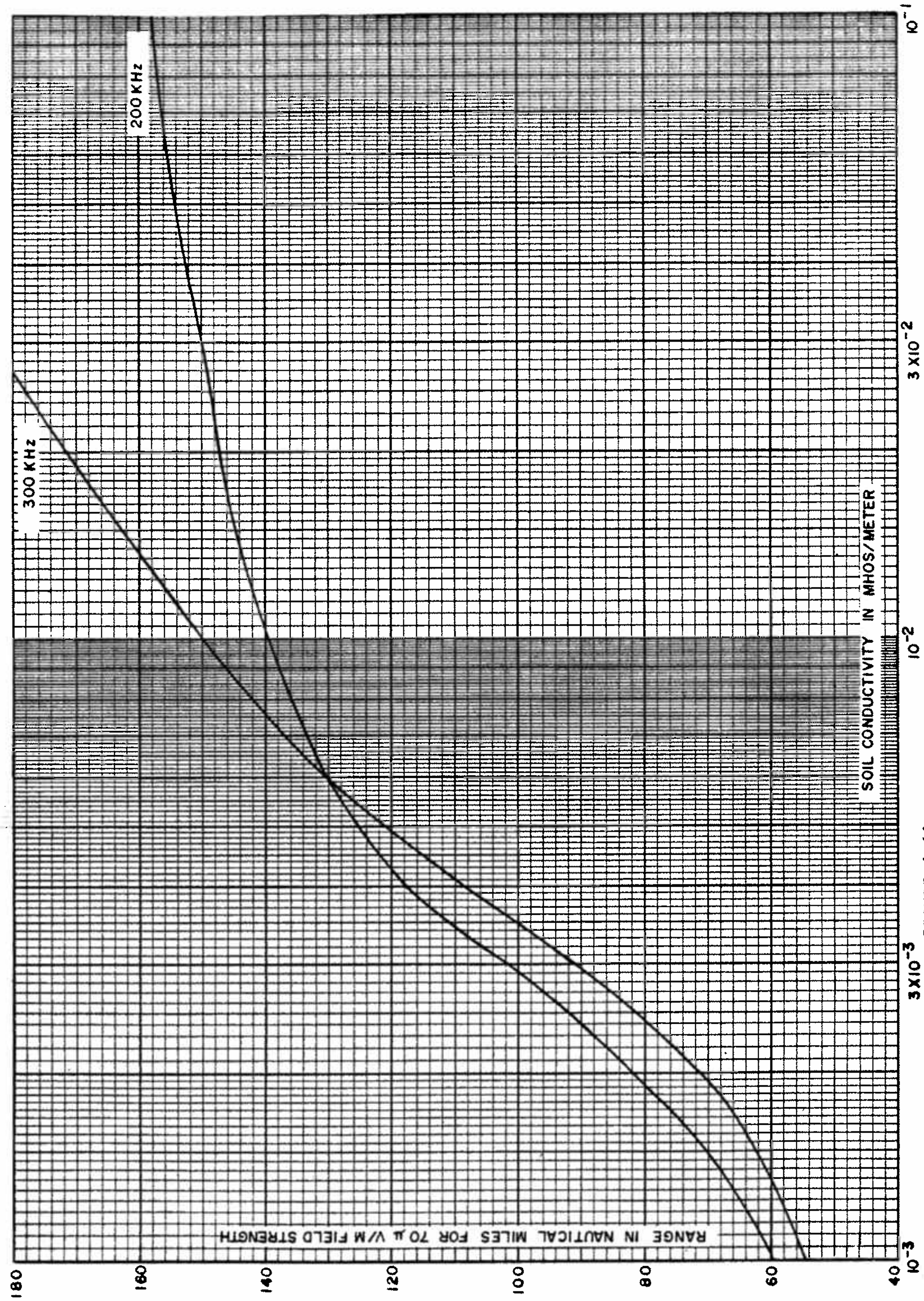


FIGURE 6-11. RANGE OF 250 WATT NDB USING PA90B ANTENNA

810312

810313

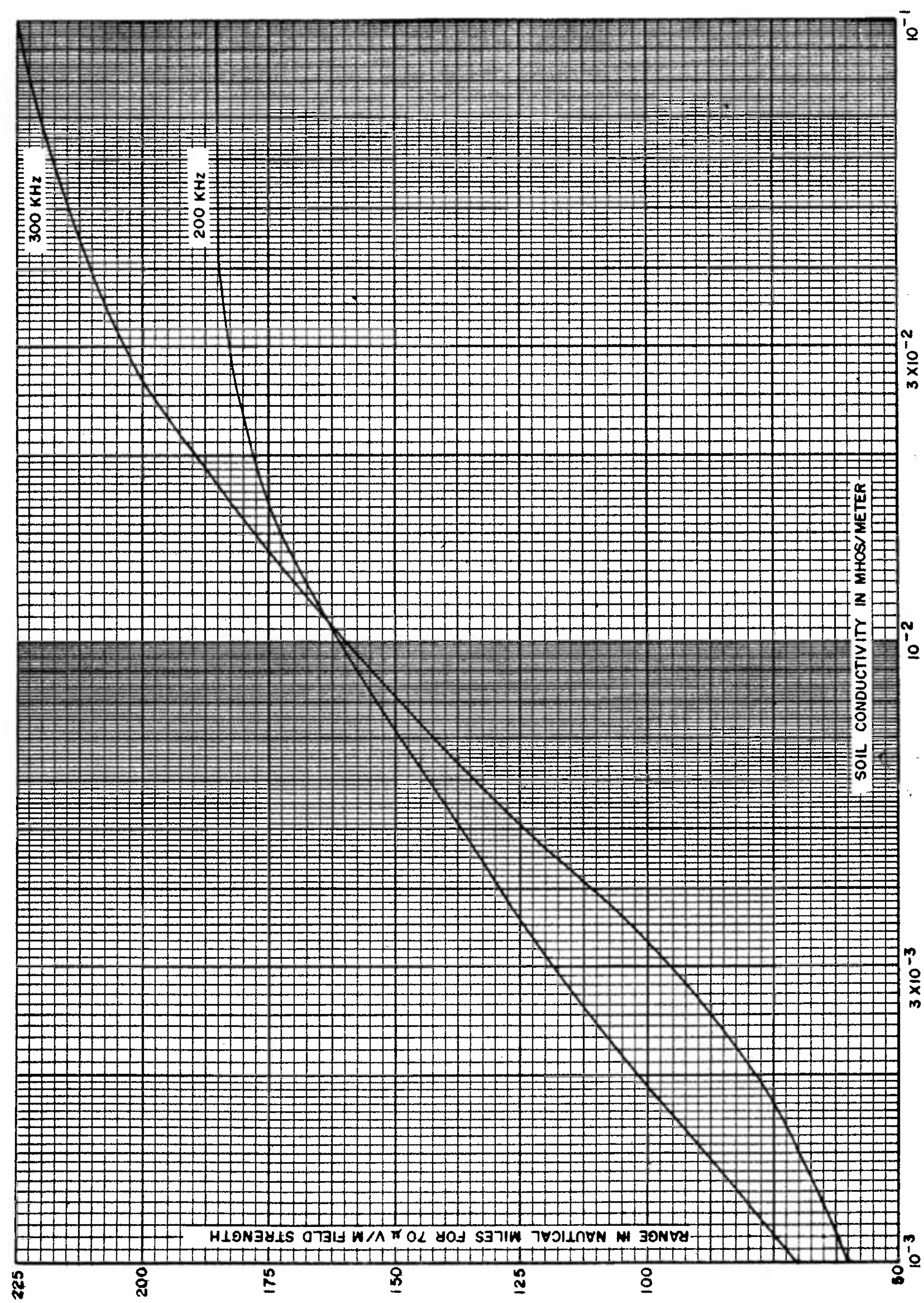


FIGURE 6-12. RANGE OF 400 WATT NDB USING PA908 ANTENNA

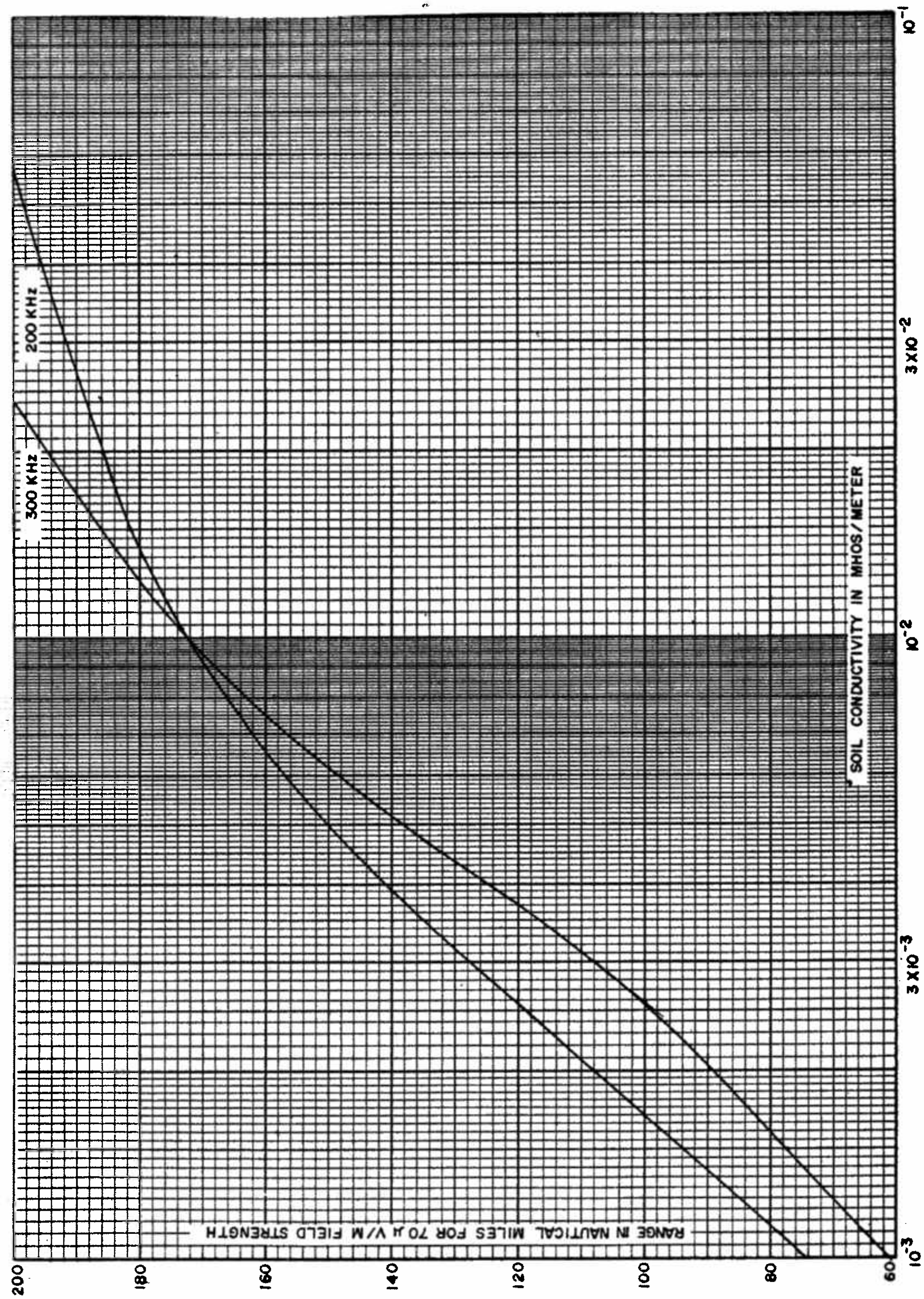


FIGURE 6-13. RANGE OF 250 WATT NDB USING PA1208 ANTENNA

810314

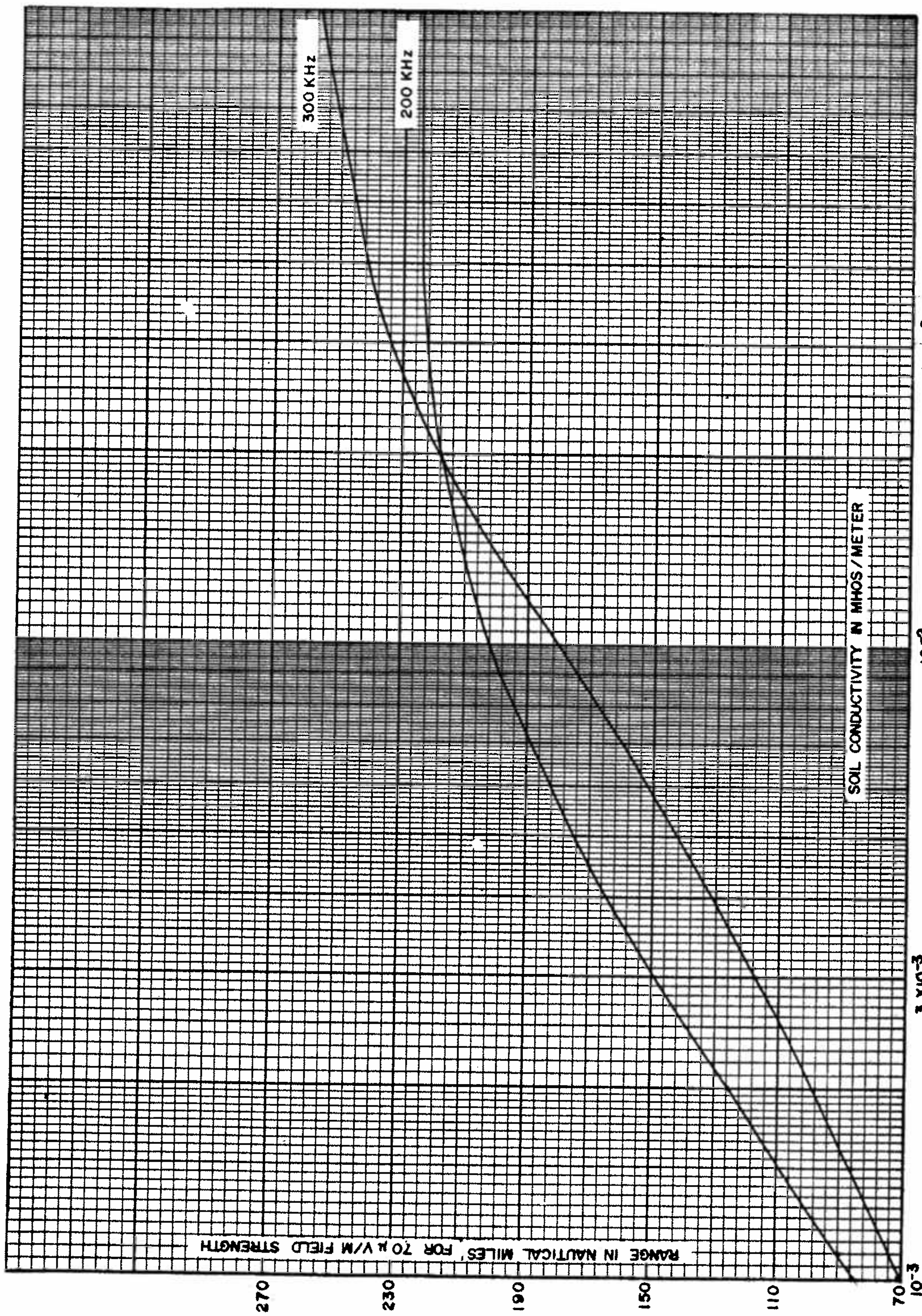


FIGURE 6-14. RANGE OF 500 WATT NDB USING PA1208 ANTENNA

810315

810316

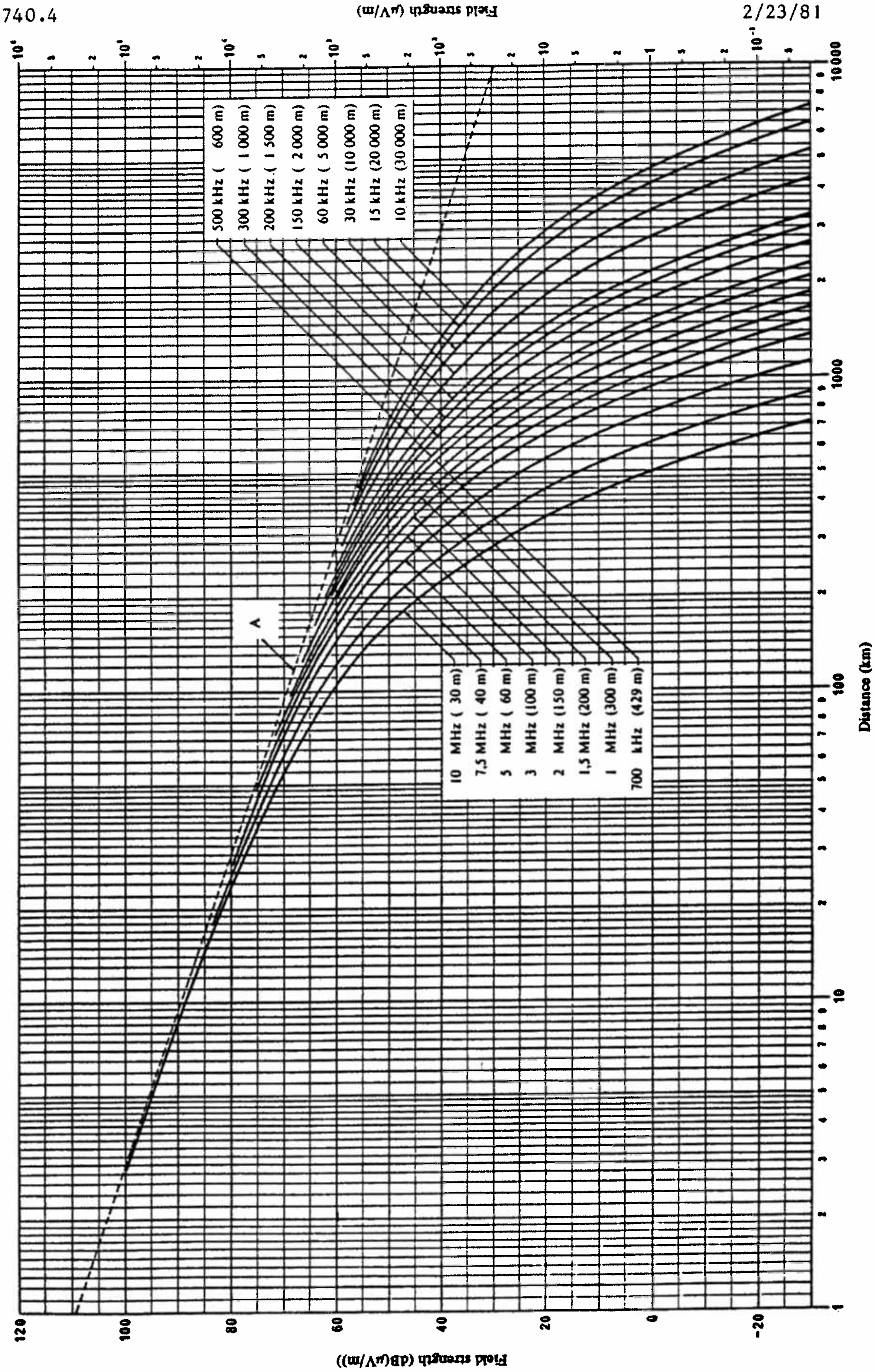


FIGURE 6-15. *–Ground-wave propagation curves; Sea, σ = 4 S/m, ε = 80*

A: Inverse distance curve

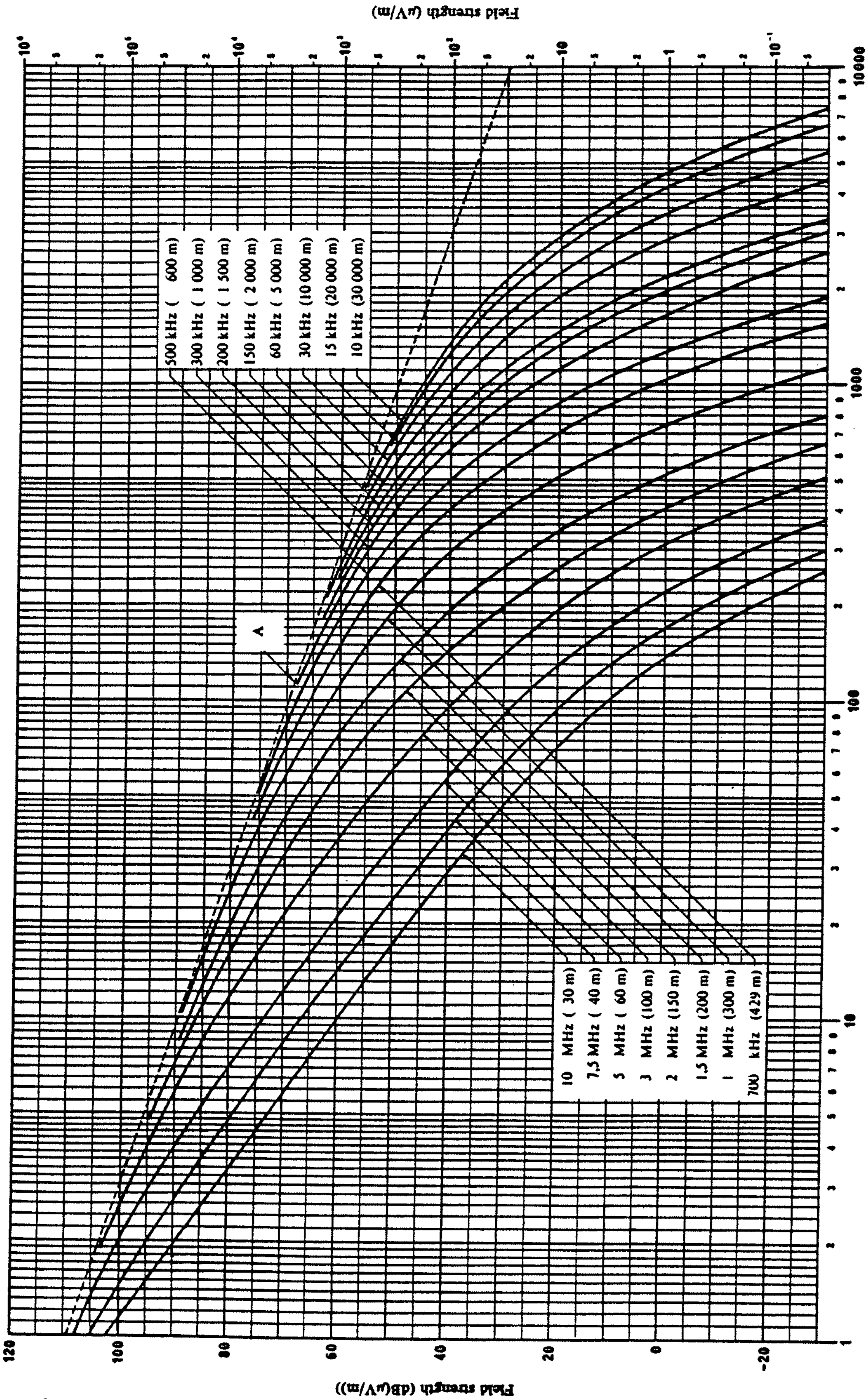


FIGURE 6-16. – *Ground-wave propagation curves; Earth, $\sigma = 3 \times 10^{-3}$ S/m, $\epsilon = 4$*

A: Inverse distance curve

810317

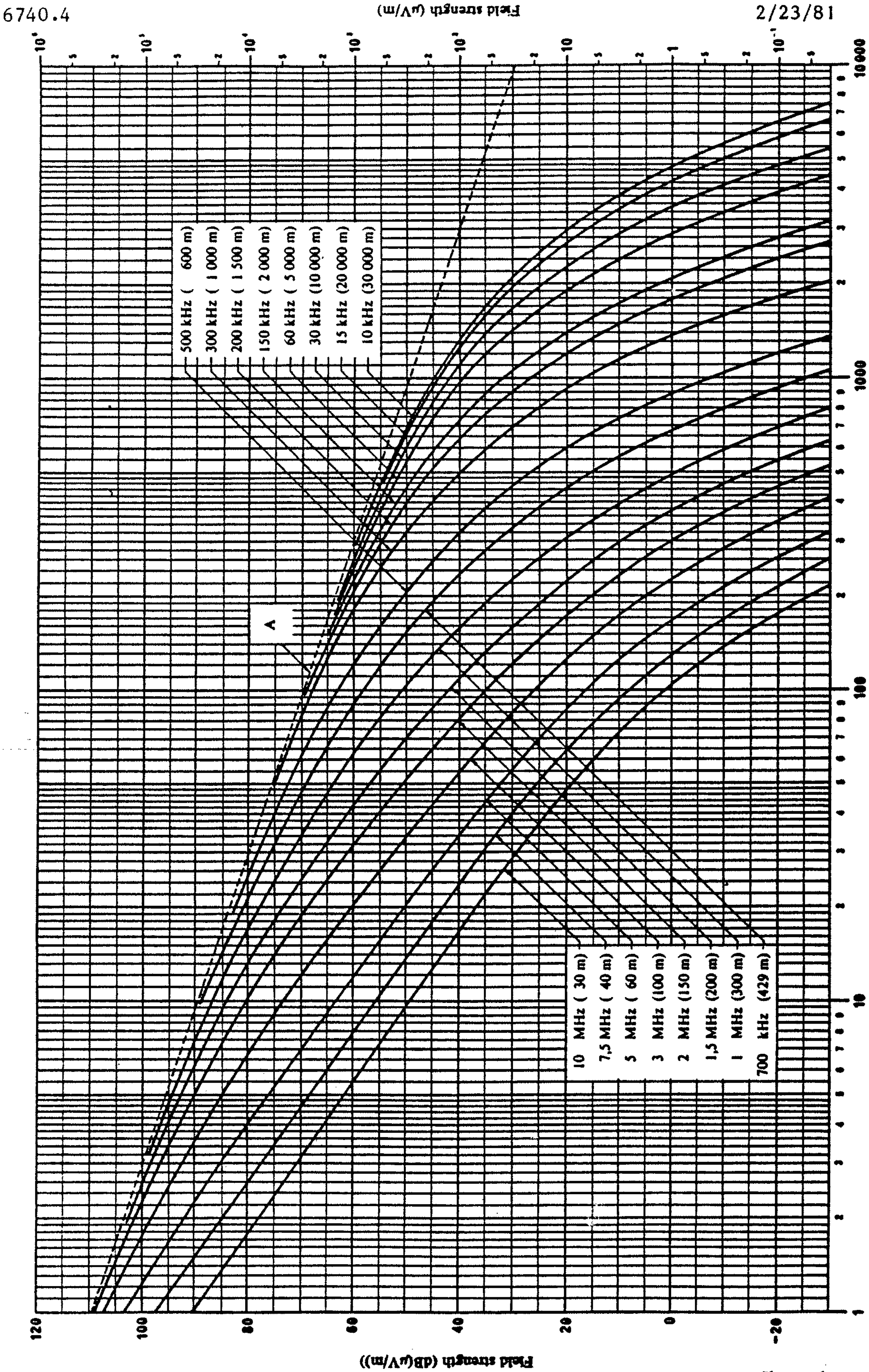


FIGURE 6-17. —*Ground-wave propagation curves; Earth, σ = 10⁻³ S/m, ε = 4*

A: Inverse distance curve

810318

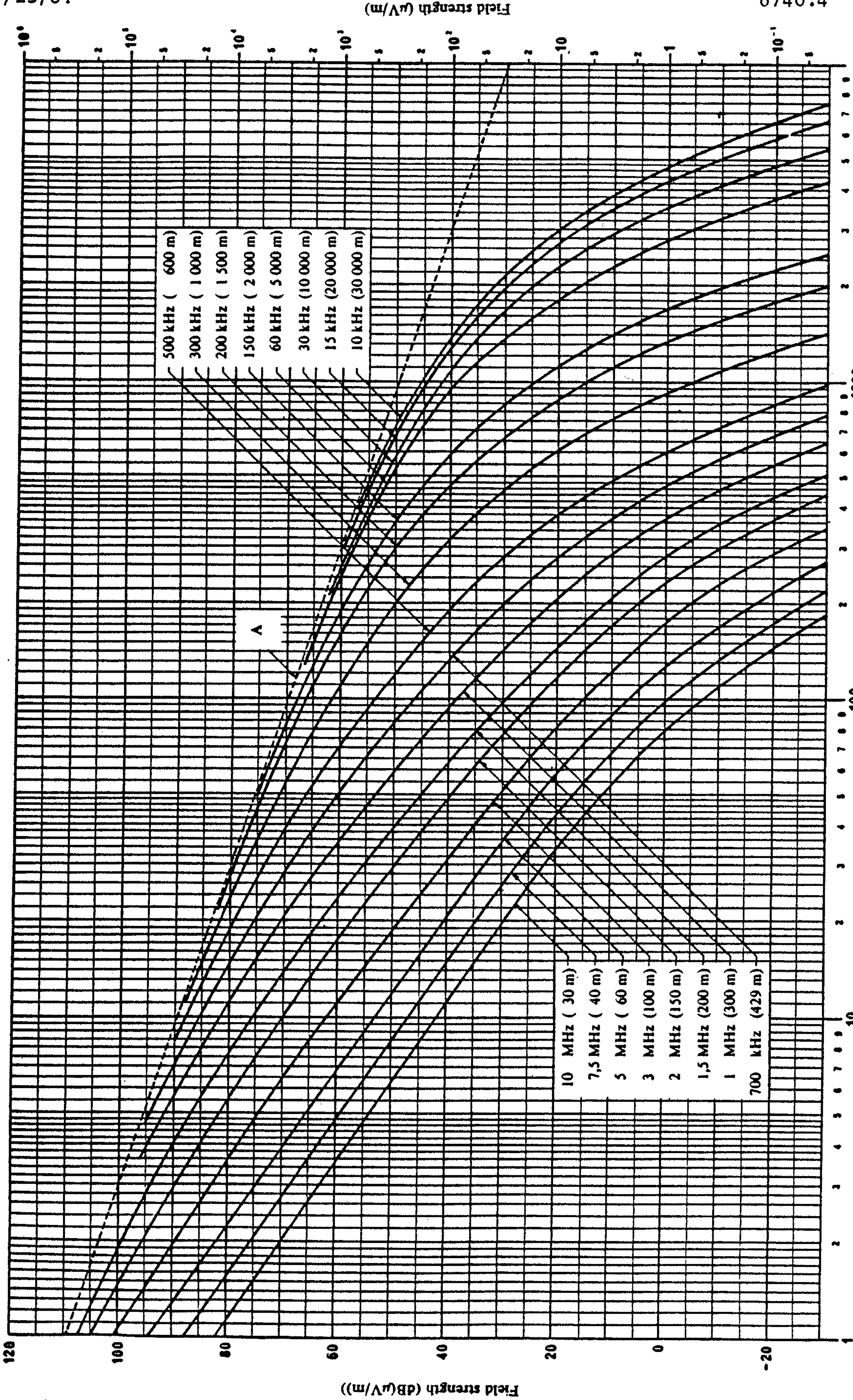


FIGURE 6-18. —*Ground-wave propagation curves; Earth, σ = 3 × 10⁻³ S/m, ε = 4*

A: Inverse distance curve

810319

810320

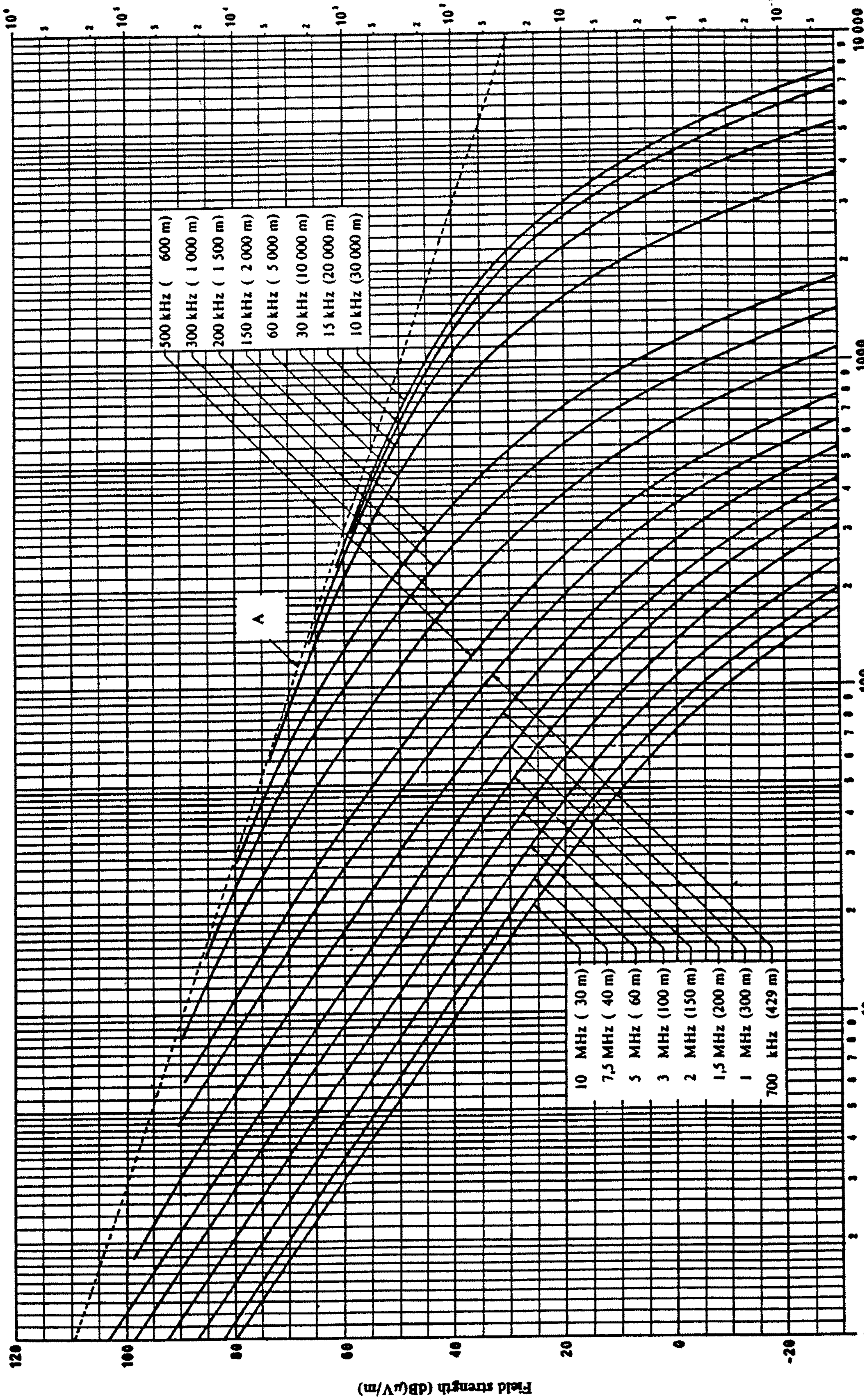


FIGURE 6-19. —*Ground-wave propagation curves; Earth, $\sigma = 10^{-3}$ S/m, $\epsilon = 4$*

A: Inverse distance curve

810321

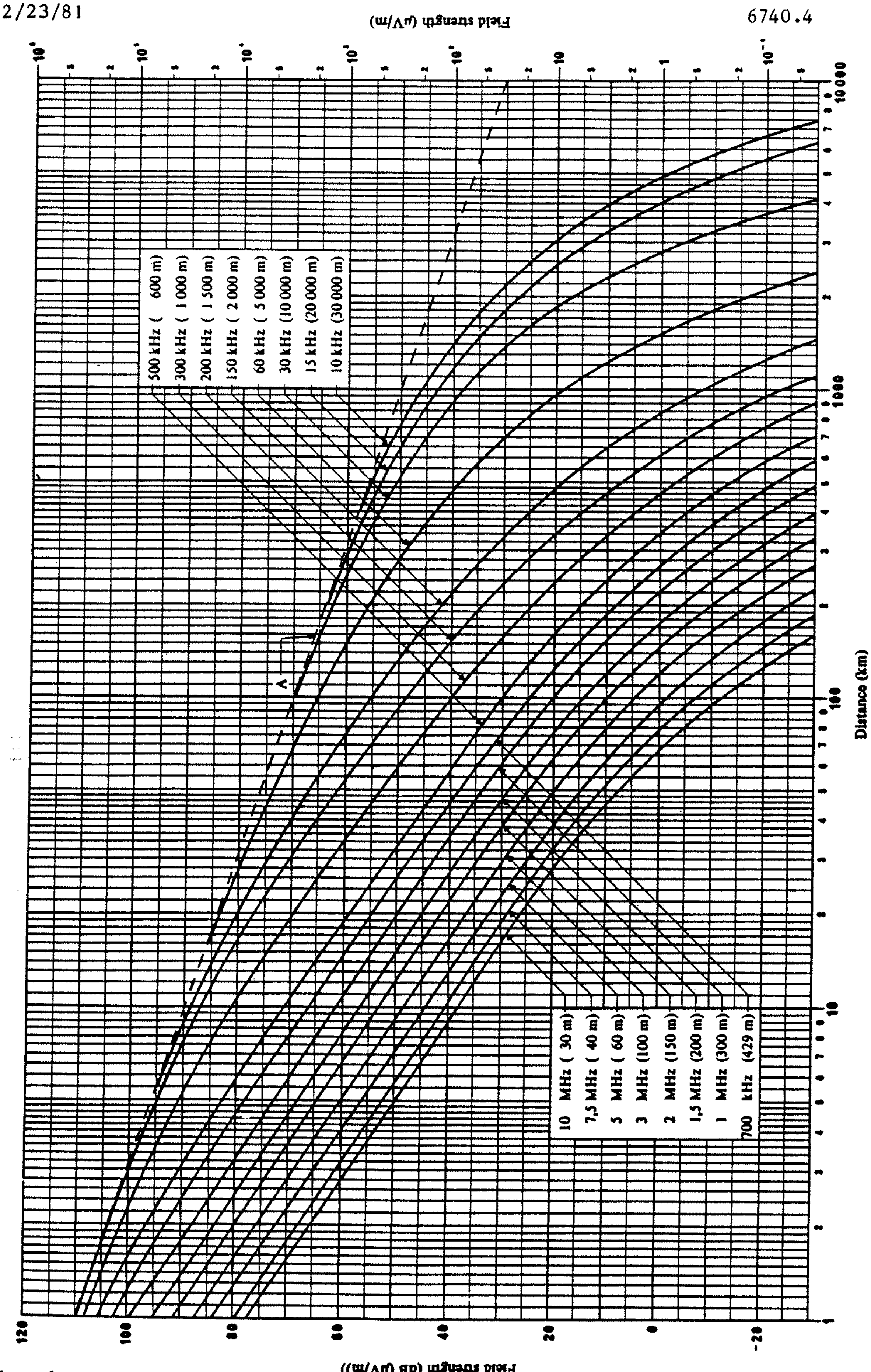


FIGURE 6-20. —*Ground-wave propagation curves; Earth, σ = 3 × 10^{-4} S/m, ε = 4*

A: Inverse distance curve

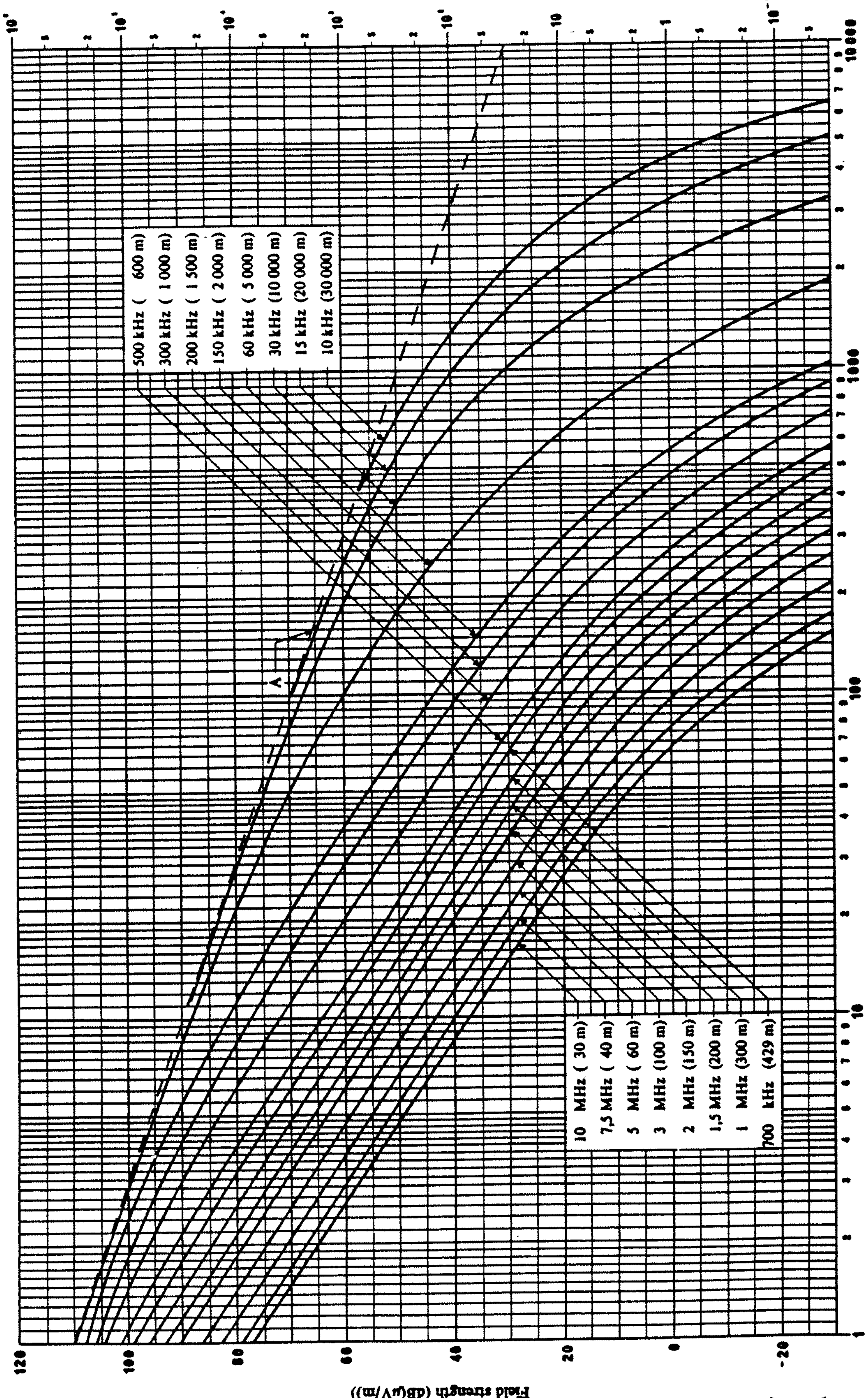


FIGURE 6-21. —*Ground-wave propagation curves; Earth, $\sigma = 10^{-4}$ S/m, $\epsilon = 4$*

A: Inverse distance curve

810323

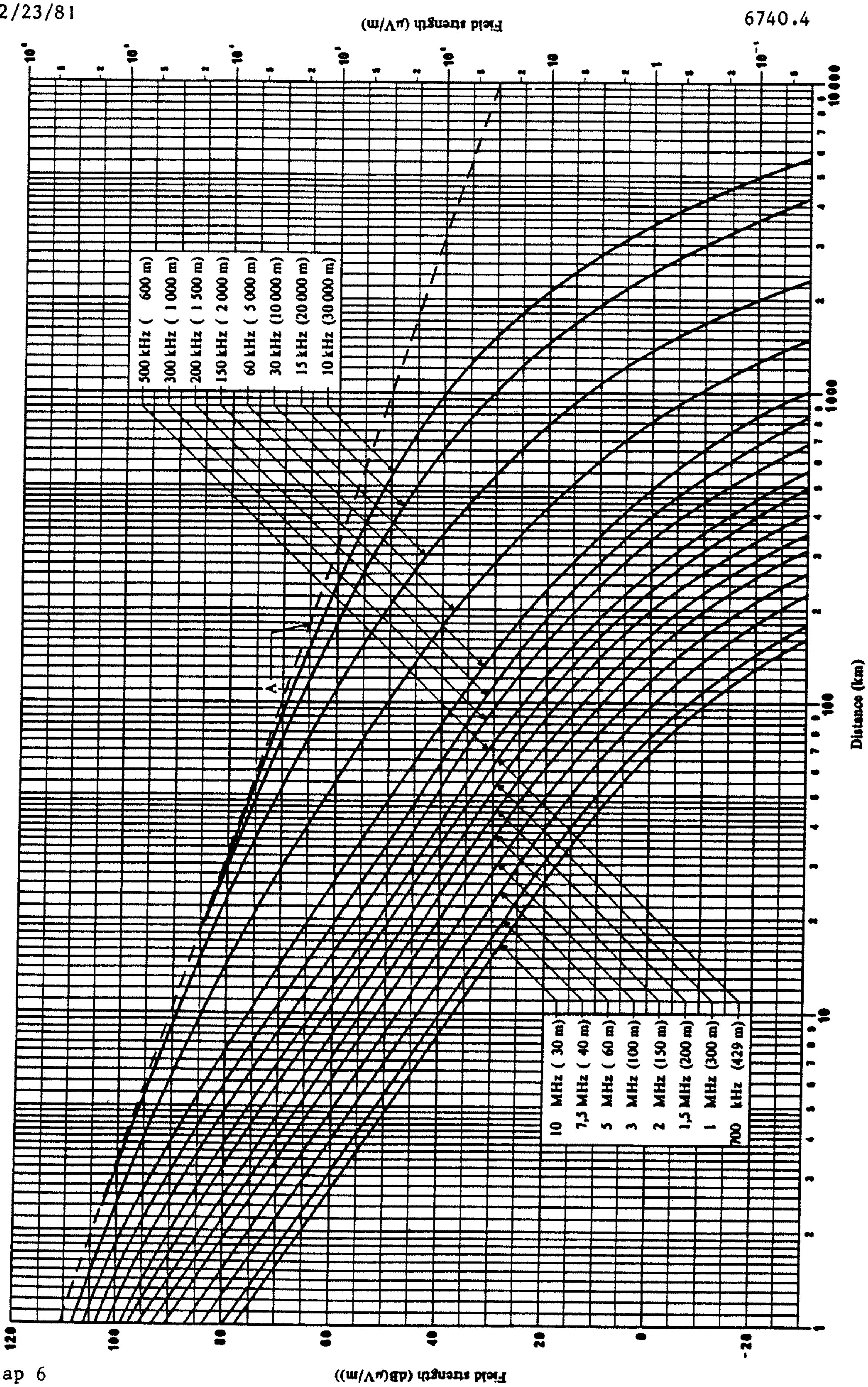


FIGURE 6-22. —*Ground-wave propagation curves; Earth, $\sigma = 3 \times 10^{-3}$ S/m, $\epsilon = 4$*

A: Inverse distance curve

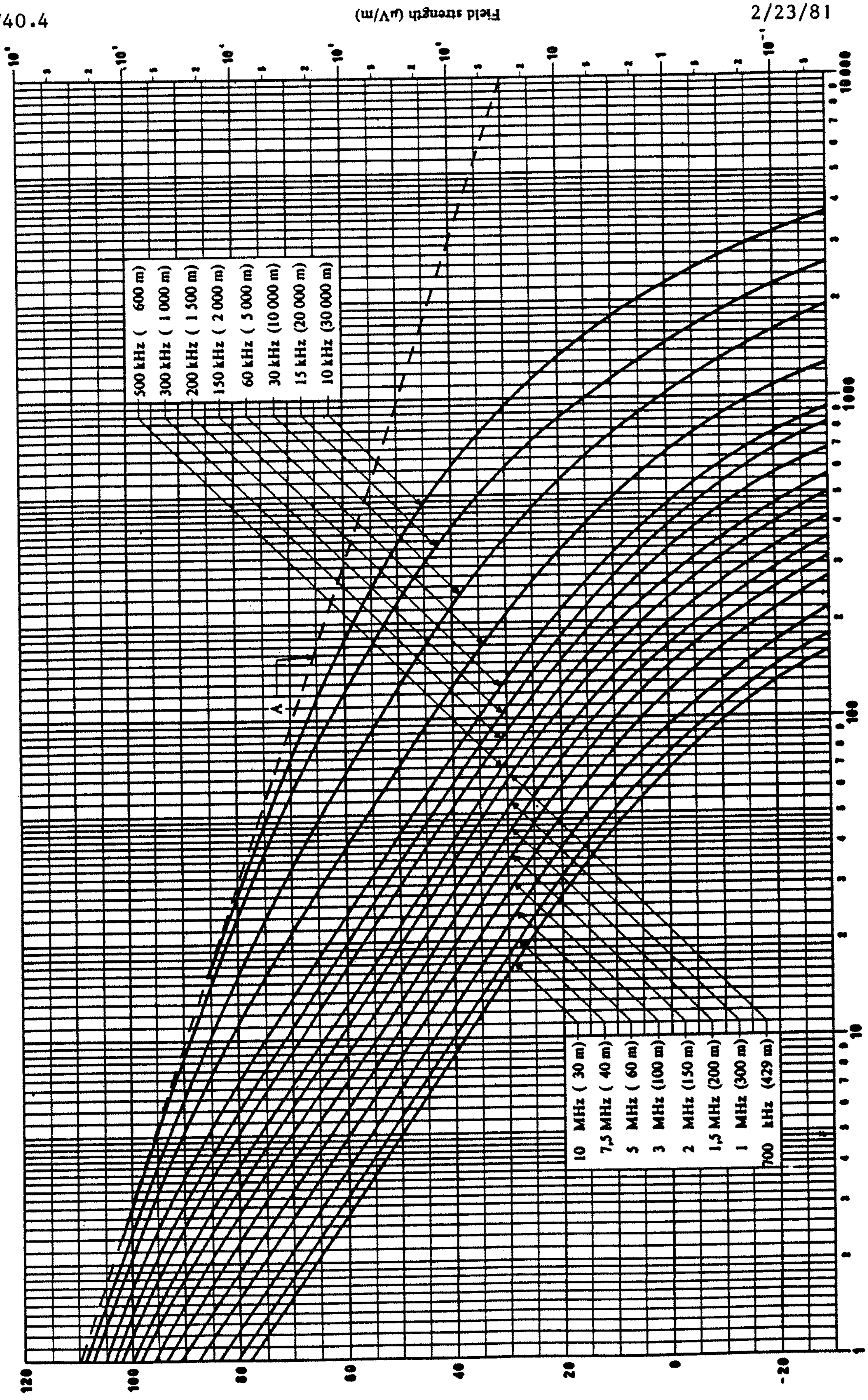


FIGURE 6-23. —*Ground-wave propagation curves; Earth, $\sigma = 10^{-5}$ S/m, $\epsilon = 4$*

A: Inverse distance curve

810324

(1) The curves refer to a smooth homogeneous earth.

(2) The sky-wave produced by troposhperic effects at these frequencies is not considered.

(3) The transmitter and receiver are both assumed to be located on the ground, and height-gain effects are not included for aircraft.

(4) The curves shall be used to determine field strength only when it is known that ionospheric reflections at the frequency under consideration will be negligible in amplitude. For conditions when the sky-wave is comparable with or even greater than the ground-wave , the curves are still applicable when the effect of the ground-wave can be separated from that of the sky-wave by the use of pulse transmission as in some forms of direction-finding systems and navigational aids.

(5) The field strength is defined by a transmitter radiating 1 KW on the surface of a perfectly conducting plane earth.

g. The CCIR propagation curves may be used to predict the coverage range when the antenna efficiency, soil conductivity, and transmitter power output are known. These curves will give very close calculations for coverage range when compared to the Nautel transmitter/antenna coverage curves shown in figure 6-2 through 6-14.

h. The CCIR propagation loss curves shown in figures 6-15 through 6-23 are based on a transmitter with a 1 kw of effective radiated power (ERP) which is equal to a +30 dBw. Therefore, when using these curves for power outputs of more or less than 1 kw, the reference receive level will have to be adjusted accordingly.

i. An example is as follows:

The transmitter power output into the antenna is 50 watts, antenna efficiency is 4.1%, and minimum received signal required is 70 μ V/m.

P_{erp} = 50 x .041 = 2.05 watts = 3.1 dBw

Reduced transmitter power output = 30 dBw - 3.1 dBw = 26.1 dB

Minimum received signal level = 70 μ V/m = -100 dBw

0 reference level for 1 μ V/m = -137 dBw

Therefore, the reference level for 70 μ V/m (receive level) and P_{erp} of 2.05 watts is equal to:

Adjusted reference level = (137-100) + 26.1 = 63.1 dB

46. ANTENNA SELECTION. Two types of antennas used for lf and mf transmission are the top hat and flat top antennas.

a. The top hat antenna is used where mounting space is limited. The effective height of the top hat antenna is increased by using capacitive loading.

b. The flat top antenna is used for longer range navigation but requires sufficient real estate for installation of the antenna.

c. A selection of top hat and flat top antennas manufactured by Nautel is shown in table 6-2.

47. ANTENNA EFFICIENCY.

a. The equivalent circuit for an electrically short antenna is shown in figure 6-24 where:

R_A = series loss resistance of the antenna.

R_G = series loss resistance of the ground plane.

R_R = radiation resistance of the antenna which is the equivalent coupled component of the free space impedance

C = capacity of the antenna which is determined by the length and position of the radiating elements.

b. The power actually radiated from the antenna is equal to $I_A^2 \times R_R$ whereas, the dissipation in R_A and R_G represents wasted power. When the antenna is electrically short, R_R is usually very small compared to both R_G and the reactance X_C of capacitance C. The usual technique employed in matching the transmitter to the antenna system is to series resonate X_C using a tunable loading coil.

c. The overall equivalent circuit with a tuning coil is shown in figure 6-25 where:

X_L = inductive reactance of the loading coil.

R_L = loss resistance of loading coil in ohms.

F_o = operating carrier frequency in Hz.

Q_L = Q factor of the load coil.

d. The radiation resistance can be calculated from the expression:

TABLE 6-2. TYPICAL NAUTEL ANTENNA SPECIFICATIONS

	PA35D	PA40A/ PA60A	PA60B/PA90B/ PA120B	Low & Medium Power "T"	High Power "T"
Frequency Range (kHz)	200-535	200-1500	200-1500	LF & MF bands	LF & MF bands
Input Power (Average/Peak) (watts)	100/400	100/400	1000/4000	500/2000	4/16 KW
Tower Height (feet)	35	40/60	60/90/120	60 or 100	120 or 150
Tower Spacing (feet)				160, two elements 4 foot spacing	230, two elements 5'10" spacing
Ground Plane Radials (feet)	165	165	500	165	500
Capacity Top Section (pF)	180	200	350	600	1000
Loading Coil Q	250-350	250-350	300-500	250-350	300-500
Efficient (%)*					
200 kHz	.25	.36/.80	1.94/4.23/7.37	.80/3.7	7.37/12.4
300 kHz	.75	1.54/3.41	5.22/11.04/17.9	3.41/12.0	17.9/26.5
400 kHz	1.70	3.49/7.53	10.50/20.8/31.7	7.53/25.0	31.7/40.9
500 kHz	3.65	6.50/13.6	16.38/30.73/44.41	13.6/42.0	44.4/49.7
Wind Loading (MPH, no ice)	100	120	120	120	120

*Assumed basic ground (R_G) of 8 ohms and 4 ohms, respectively for 165 foot and 500 foot ground plane radials.

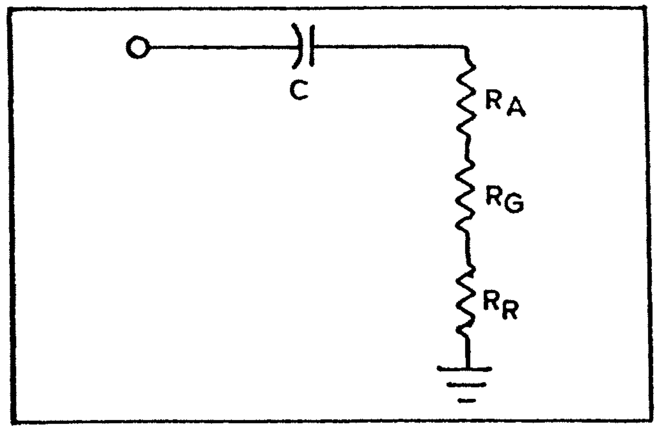


FIGURE 6-24. EQUIVALENT ANTENNA CIRCUIT

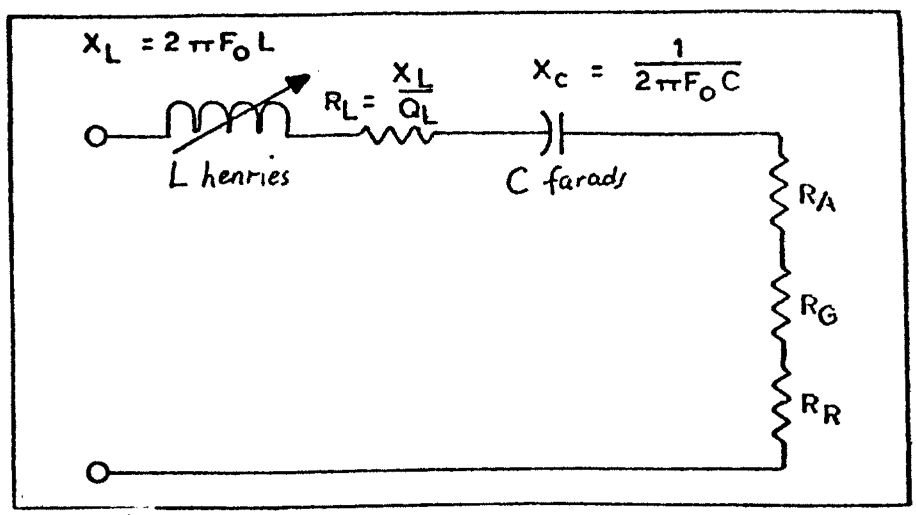


FIGURE 6-25. EQUIVALENT ANTENNA AND TUNING COIL CIRCUIT

$$R_R = 160\pi^2 \left(\frac{h_e}{\lambda}\right)^2 \quad (6\text{-}1)$$

where:

h_e = effective height of the antenna in feet (not physical height).

λ = wavelength of the operating frequency in feet.

e. The antenna radiation efficiency is given by the following expression:

$$\text{Efficiency } N = \frac{R_R}{R_R+R_L+R_A+R_G} \quad (6\text{-}2)$$

f. The radiated power P_R at the carrier frequency is equal to P_{in} x N where P_{in} is the carrier power output of the transmitter.

g. Therefore, the antenna current I_A is $\sqrt{\frac{P_R}{R_R}}$ and the peak antenna voltage for the carrier is:

$$V_A \text{ peak} = \sqrt{2} \cdot I_A \cdot X_C \text{ volts peak}$$

At 100-percent modulation, this voltage would be doubled if sideband attenuation is ignored.

h. The antenna efficiency can be improved by the following:

(1) Make the effective antenna height and hence R_R as large as possible.

(2) Make the antenna capacitance as high as possible to reduce the value of X_C and X_L which will reduce R_L and the rf voltage potential of the radiating elements.

(3) Keep the antenna loss resistance R_A as small as possible by minimizing the contact resistances and dielectric losses in the insulators.

(4) Select an operating frequency which is as high as possible in the 190 to 535 kHz band.

(5) Provide an adequate ground plane to minimize R_G.

48. ANTENNA BANDWIDTH.

a. Being a high Q resonant circuit, the antenna acts as a bandpass filter with a finite bandwidth which can significantly attenuate the sidebands of the radiated signal.

b. This bandwidth may be obtained from the expression:

$$BW = \frac{F_O}{Q_A} = \frac{F_O\,(R_L + R_A + R_R + R_G)}{X_C} \tag{6-3}$$

c. The sideband attenuation A_S is given by:

$$A_S\ (\mathrm{dB}) = 10 \log_{10} \frac{1}{1 + Q_A^2\left(\frac{2F_M}{F_O}\right)^2}\ \mathrm{dB} \tag{6-4}$$

where: F_M = modulation frequency in Hz and

$$Q_A = \frac{X_C}{R_L + R_A + R_R + R_G} \tag{6-5}$$

d. This sideband attenuation is an undersirable effect which reduces the modulation depth of the transmitted signal below the optimum level of 90 to 95 percent. Various methods of overcoming this problem are as follows:

(1) Selection of an antenna with a greater capacitance and effective height. This method is often uneconomical for low-power installations.

(2) Change the tone modulation frequency from 1020 Hz to 400 Hz. This method can significantly increase the radiated modulation depth, but under conditions of high atmospheric noise may provide a less easily readable signal.

(3) Broadband the antenna circuit (lower the Q) by increasing either its capacitance or resistance. Inserting additional resistance in an antenna wastes power, whereas additional capacitance does not.

e. It should be noted that when operating a conventional amplitude modulated signal, it is emphatically neither useful nor desirable to overmodulate the signal at the transmitter output, in an attempt to improve the radiated modulation depth. This reaction will simply result in excessive stress and signal distortion in the power amplifier of the transmitter and will actually reduce the mean level of the radiated carrier signal when the modulation is present.

f. In summary, a certain amount of sideband attenuation is unavoidable with a short antenna and, like antenna efficiency, must be considered as a trade-off against the cost of the installation. It should be realized that the modulation signal is for station identification purposes only. The directional accuracy of the radio compass is solely a function of the signal-to-noise ratio of the carrier signal and is not dependent upon the modulation.

g. Low power installations seldom radiate signals with high levels of modulation depth, but in most cases this does not significantly reduce the useful operating range of the installation. Low power NDB transmitters usually use short antennas which are inefficient. These short antennas constitute a narrow bandpass filter when associated with the antenna tuning unit. This bandpass filter can significantly attenuate the sidebands of the radiated signal, depending on several factors, including operating frequency and the antenna ground plane resistance. This effect is more pronounced at the lower frequencies.

h. Overmodulation has been a problem with low power NDB installations. It is internationally accepted that the optimum modulation depth of 95 percent is seldom obtained as detailed in the Annex C to Part 1, Volume I of ICAO Aeronautical Telecommunications Annex 10. Modulation of the carrier signal serves only to permit audible identification of the radiobeacon signal. It does not contribute in any way to the accuracy of the bearing. Overmodulated does, however, degrade the signal-to-noise ratio of the carrier signal and, hence, the bearing accuracy.

49. ANTENNA INPUT IMPEDANCE.

a. When the circuit of figure 6-25 is tuned to resonance, the input impedance of the antenna system at the carrier frequency is purely resistive and equal to;

$$Z_o = R_L + R_A + R_R + R_G \text{ ohms} \qquad (6\text{-}6)$$

This is usually transformed in a tapped matching transformer to a suitable terminating impedance for the transmitter of 50 or 72 ohms. However, because of the high Q of the antenna circuit, the input impedance Z_S at the sideband frequencies is higher than that at F_o and is given by the expression:

$$Z_S = Z_o \left(1 + 2_j Q_A \cdot \frac{F_M}{F_o}\right) \qquad (6\text{-}7)$$

b. It is important to recognize the effect of this impedance difference upon the transmitter output stage. The rf current supplied at the sideband frequencies, for a given voltage modulation depth setting, will be less than they would have been when working into a purely resistive 50-ohm load. This means that if the voltage and current waveforms at the transmitter output are examined using an oscilloscope, the voltage waveform will exhibit a greater modulation depth than the current waveform. The current waveform, on the other hand, will exhibit a modulation depth which is equal to that of the actual radiated signal. It is interesting to note that this situation may be reversed if the feeder cable connecting the transmitter to the antenna approaches an electrical quarter-wave length. This line then acts as a quarter-wave transformer terminated by its characteristic impedance at the carrier frequency F_o but mismatched at the sideband frequencies $F_o \pm F_M$. Thus, at the input end of this transmission line, the higher impedance at the sideband frequencies will be transformed to an impedance which is lower than the characteristic impedance of the cable. Where this is the case, the current waveform at the transmitter output would exhibit a greater modulation depth than the voltage waveform. When adjusting the transmitter circuits, care should be exercised to ensure that neither the voltage nor the current waveform is overmodulated at the transmitter output amplifier. Monitoring the current and voltage waveform when adjusting modulation is the proper approach.

c. It is also worth noting that when using a short feeder cable, the antenna input impedance goes higher if the system is detuned. It follows that the power fed to the system from a transmitter which acts as a voltage source will reduce when this occurs. The reverse is true if a quarter-wave length feeder cable is used when detuning would cause increased power to be delivered by the transmitter.

d. Some antenna tuning units utilize the loading coil to parallel resonate the antenna capacity. This technique produces decreased impedance at the sideband frequencies and at the carrier frequency when detuned. Often the loading coil forms part of the pi network used to achieve impedance matching without the use of a matching transformer. This technique further compounds the effect of lowering the input impedance at the sideband frequencies. The performance of the parallel resonant circuit is otherwise very similar to the series resonate type but it is not a common configuration because it is not recommended for use with some transmitters.

50. CALCULATION OF ANTENNA PARAMETERS. In the process of selecting an antenna for a particular installation, it is necessary to calculate its characteristics.

a. Effective Antenna Height.

(1) The effectiveness of an antenna is determined by the product of the antenna current and the vertical distance through which it flows. Considering the example of a base-insulated vertical mast radiator of height h without top loading, fed with a current I at the base as shown in figure 6-26(a), the current flowing in the mast will taper to zero at the top such that the average mast current is equal to I/2. Hence, its effectiveness as a current radiator is proportional to I/2 x h. Another way of expressing this product is $I \times h_e$ where h_e = the effective antenna height = h/2.

(2) Considering a second example, shown in figure 6-26(b), of a base-insulated, top-loaded vertical radiator, it can be seen that the current then tapers to zero at the extremities of the capacity top hat. The average current flowing the vertical section is clearly increased above that in the first example; hence, the effective height h_e is said to be increased.

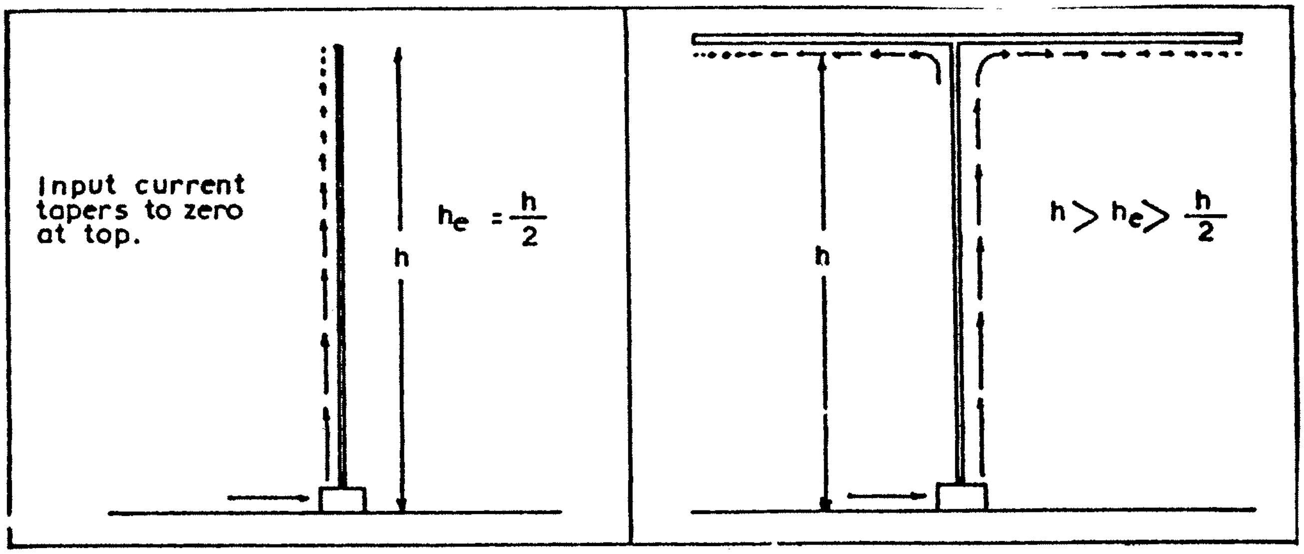


FIGURE 6-26(a) FIGURE 6-26(b)

EFFECTIVE ANTENNA HEIGHT

(3) <u>In quantitative terms</u>, the increase in h_e is dependent upon the relative values of the capacities of the mast and the top hat such that the effective height, h_e, is given by:

$$h_e = h \left[1 - \frac{1}{2} \left(\frac{C_M}{C_M + C_H} \right) \right] \tag{6-8}$$

where: h = actual height

C_M = capacity of vertical section

C_H = capacity of horizontal section

(4) <u>Top loading</u> is often achieved by the use of guys which are electrically connected to the top of the tower with insulators placed part way down their length. It is obvious that if these insulators are positioned close to the ground, the top capacity will be increased, but the average height of the top hat will be reduced. As a compromise, the insulatiors are usually placed at a vertical height above ground level equal to four-sevenths of the height of the tower.

(5) <u>A third example</u> may be considered in which the mast is grounded and an insulator is placed between the top of the mast and the capacity top hat. With this arrangement, the loading coil must also be positioned at the top of the mast. The total input

current I then flows through the full height of the mast; hence, $h_e = h$.

(6) As shown in equations 6-1 and 6-2, the radiation resistance R_R varies with h_e^2 and the efficiency, N, varies with R_R. Therefore, the efficiency, N, varies as a function of h_e^2. It is therefore, important to obtain as much effective height as possible which, in turn, is achieved by positioning the loading coil as high as possible on the antenna structure.

b. Antenna Capacity.

(1) Increasing the antenna capacity increases the system bandwidth and efficiency by reducing the necessary value of loading coil inductance together with its series loss resistance.

(2) Antenna capacities can be roughly estimated using the following data:

Antenna	Approximate Capacitance Allowance
Base-insulated vertical lattice tower	5-6 pF per foot
Whip or other than vertical radiator	4 pF per foot
Single horizontal or vertical wire	3 pF per foot

(3) Where more than a single wire is used, the effective capacity per foot is reduced by mutual coupling between the wires; hence, they should be positioned as far apart as possible. Considering the plan view of a top loading umbrella perpendicular to the mast, the following capacitance can be estimated for the toal length of the radiating elements as shown in figure 6-27.

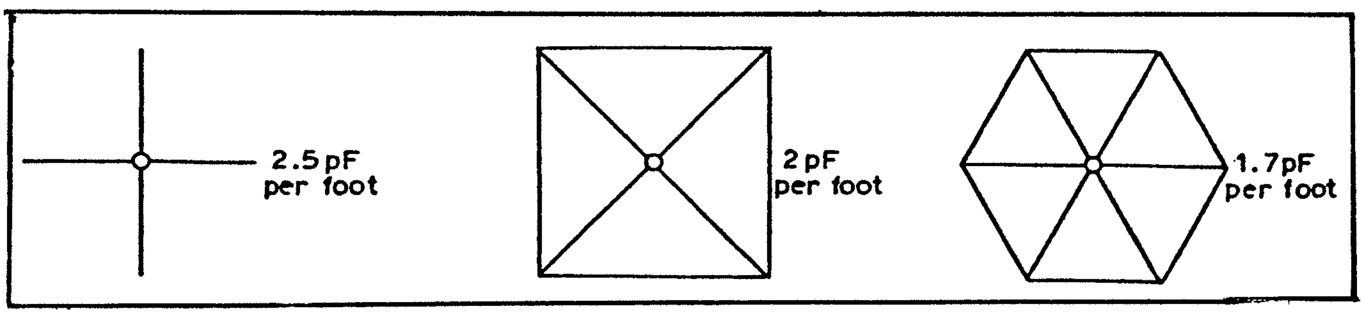


FIGURE 6-27. ANTENNA CAPACITANCE

(4) When top loading guys are used, the capacity per foot is reduced because they do not lie in a single plane; hence, the coupling between the guys and vertical radiator is increased. Where

four top loading guys at 45° to the mast are used, a capacity of 1.5 pF per foot may be estimated.

c. Ground Loss Resistance.

(1) Calculation of the effective series loss resistance of a particular ground mat configuration is rather complex. Examples of some commonly used arrangements using sets of radial conductors placed symmetrically around the antenna base are shown in table 6-3. These may be used as a guide to estimating the ground loss resistance for similar configurations. It should be emphasized that these values are very approximate, being somewhat dependent upon the effective height of the associated antenna and the ground conductivity in the vicinity of the ground mat.

(2) The 165 foot radials shown in table 6-3 use copper wire sized AWG #12 and #8, respectively for the radials and ring. The 500 foot radials use AWG #12 and #6, respectively for the radials and ring. In addition, the radial resistance for 1000 foot radials is shown to illustrate its impracticability due to the cost and real estate required for the decrease in radial resistance gained. It is more practical to increase the transmitter power.

(3) The length of the radials is more critical than the number of radials used. It is better to use ten radials 100 feet long than twenty radials 50 feet long.

(4) Proper grounding of the radial ground system to the equipment requires that a ground is connected to the ATU to provide a return path for the rf antenna current. This rf current flow should be limited to include only the secondary winding of matching transformer and the loading coil as shown in figure 6-28. To prevent ground loop currents and rf interference to the low level stages of the transmitter, the antenna ground plane should not be electrically connected to the ac ground line or the transmitter cabinet ground.

(5) In a correct installation the antenna ground plane is connected by a heavy conductor only to the ground terminal of the ATU. The ac power ground wire is connected to the transmitter cabinet ground which in turn should be grounded using a conventional copper ground rod located as close as possible to the transmitter location. Contact between the antenna ground plane and the ground rod should be avoided. Continuity between the transmitter cabinet and the antenna ground plane will exist via the shield of the coaxial feeder cable.

(6) The transmitter should be remotely located from the direct field of the antenna system or well screened by a cage connected only to the ground plane (not the transmitter cabinet) to discourage the transmitter and feeder cable shield from acting as another radial of the ground plane and providing a path for the antenna current.

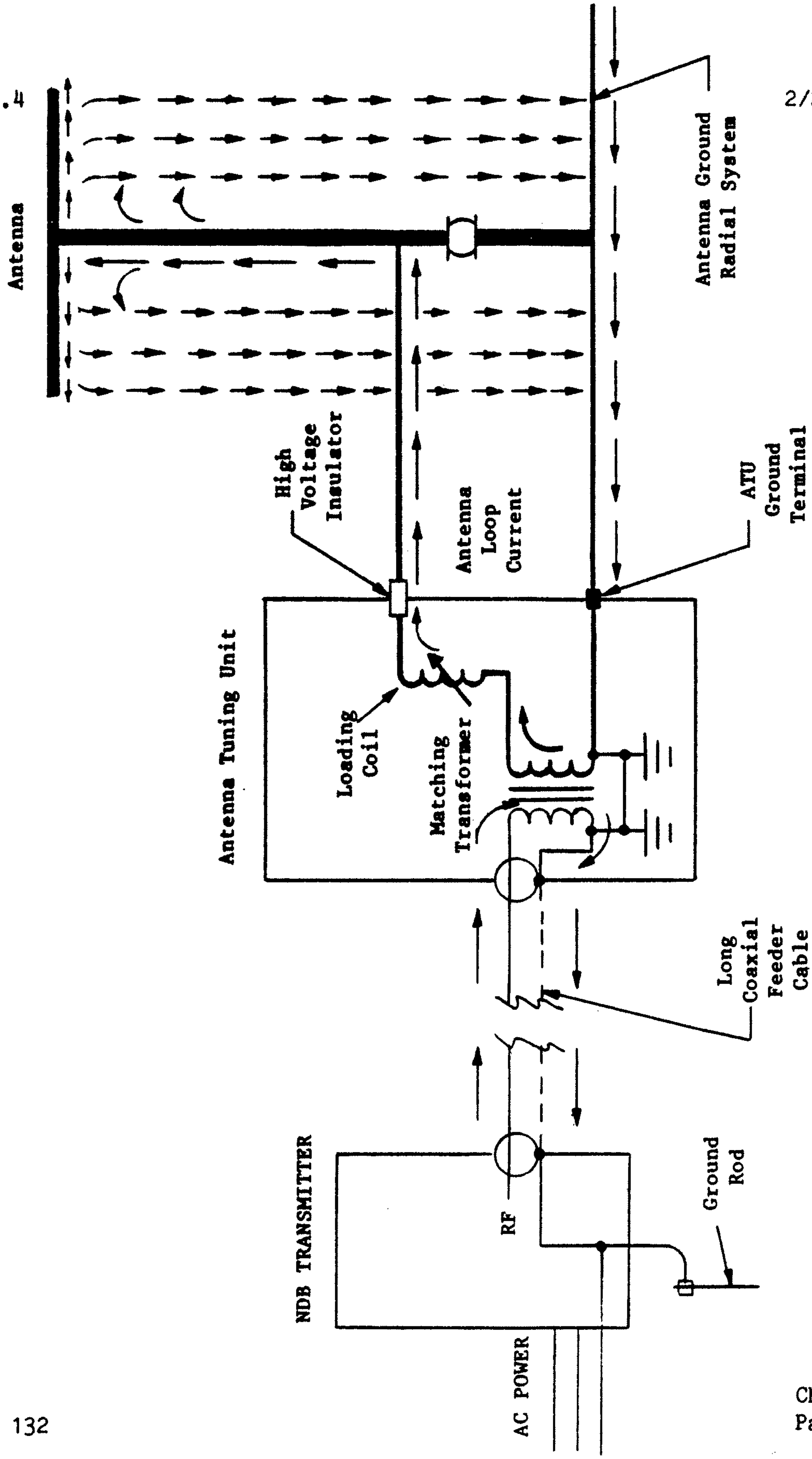


FIGURE 6-28. NDB RF CURRENTS

TABLE 6-3. ANTENNA RADIAL RESISTANCE

Number of Radials	Length of Radials	Operating Frequency F_o			
		200 kHz	300 kHz	400 kHz	500 kHz
6	165 ft	15 ohm	8 ohm	6 ohm	5 ohm
18	500 ft	4.5 ohm	4 ohm	3.5 ohm	3 ohm
120	1000 ft	2.5 ohm	2 ohm	1 ohm	0.5 ohm

d. Antenna Loss Resistance. This resistance is usually quite small and can be ignored in all but the most efficient antennas. A figure of $R_A = 0.1$ ohm could be used as a rough approximation.

51. SAMPLE CALCULATIONS. Consider a base-insulated 150-foot lattice tower with umbrella top loading consisting of four radials each 50 feet long. Its ground plane uses twenty-four 500-foot radials. The antenna is fed from a 1 kW transmitter at 300 kHz, modulated at 1020 Hz. Estimate the antenna reactance, efficiency, bandwidth, sideband attenuation, and peak voltage (assume a coil Q of 300) as follows:

a. Antenna Capacities.

Mast capacity C_M $= 6 \times 150 = 900$ pF

Top hat capacity C_H $= 4 \times 50 \times 1.5 = 300$ pF

Total Capacity $= 1200$ pF

$$\text{Antenna reactance } X_C = \frac{1}{2\pi F_o C} = \frac{1}{2\pi \cdot 300 \cdot 10^3 \cdot 1200 \cdot 10^{-12}}$$

$$X_C = -j\,442 \text{ ohms}$$

The loading coil reactance must be +j 442. Assuming a coil Q factor of 300, the coil loss resistance:

$$R_L = \frac{442}{300} = 1.47 \text{ ohm}$$

b. Radiation Resistance

From equation 6-8

$$\text{Effective height } h_e = h\left[1 - \frac{1}{2}\left(\frac{C_M}{C_M + C_H}\right)\right]$$

$$= 150\left[1 - \frac{1}{2}\left(\frac{900}{900+300}\right)\right]$$

$\underline{h_e = 93.75 \text{ feet.}}$

Wavelength at 300 kHz $= \dfrac{300 \times 10^6}{300 \times 10^3} \text{ m} = 1000 \text{ m} = 3280 \text{ feet}$

From equation 6-1

Radiation resistance $R_R = 160.\pi^2.\left(\dfrac{93.75}{3280}\right)^2$

$\underline{R_R} \quad \underline{= 1.29 \text{ ohm.}}$

c. Ground Loss Resistance

From table 6-3, the ground loss resistance will be less than 4 ohms or 3.9 ohms.

d. Antenna Efficiency

From equation 6-2

Antenna Efficiency $N = \dfrac{R_R}{R_R + R_L + R_A + R_G} \times 100\%$

$= \dfrac{1.29 \times 100\%}{1.29 + 1.47 + 0.1 + 3.9} = 19.1\%$

Hence, Radiated Carrier Power $= 1 \text{ kW} \times \dfrac{19.1}{100} = 191$ watts

The radiated power $= I_A^2 \times R_R = 191$ watts

Hence, antenna current $I_A = \dfrac{191}{1.29} = 12.16$ amps rms (carrier only)

e. Antenna Bandwidth

From equation 6-5

The Q of the antenna system $= \dfrac{X_C}{R_L + R_A + R_R + R_G}$

$Q_A = \dfrac{442}{1.47 + 0.1 + 1.29 + 3.9} = 65.38$

From equation 6-3

$$\text{Antenna BW} = \frac{F_o}{Q_A} = \frac{300 \text{ kHz}}{65.38} = 4.58 \text{ kHz}$$

From equation 6-4

$$A_S = 10 \log \frac{1}{1 + Q_A^2 \left(\frac{2F_M}{F_o}\right)^2} \text{ dB}$$

$$= 10 \log \frac{1}{1+(65.38)^2 \left(\frac{2040}{300 \times 10^3}\right)^2} \text{dB}$$

$$= 0.78 \text{ dB}$$

or modulation depth is reduced by 8.65 percent

i.e., if modulation depth was 95 percent at the input, the radiated modulation depth would be (95 -8.65) = 86.35 percent.

Hence, effective modulation component of antenna current $= I_A \times .8635$.

Therefore, peak antenna voltage

$$V_P = (I_A + .8635\ I_A) \sqrt{2}\ X_C$$

$$V_P = 1.8635 \times 12.16 \times \sqrt{2} \times 442 = 14{,}164 \text{ volts}$$
peak-to-peak.

52. <u>INFORMATION REFERENCES</u>.

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b. Documents of the XIV Plenary Assembly, Volume V, Propagation in Non-ionized Media, ITU, 1978.

c. Jasik, Henry, Antenna Engineering Handbook, McGraw-Hill, 1961.

d. Morgan, Robert R, World-Wide VLF Effective Conductivity Map, NTIS Report AD675771, 1968.

e. Norton, K.A., The Calculation of Ground-Wave Field Intensity Over A Finitely Conducting Spherical Earth, Proceedings I.R.E., pp. 623-639, December 1941.

f. Pinks, J.R., "Ground Connections at NDB Site Installations," Nautel Technical Note 112, Nautical Electronic Laboratories Limited, Nova Scotia, Canada.

g. Pinks, J. R., "NDB Antenna," Application Note, Nautical Electronic Laboratories Limited, Nova Scotia, Canada.

h. Po Kempner, Margo, Comparison of Available Methods for Predicting Medium Frequency Sky-Wave Field Strengths, NTIA Report-80-42, June 1980.

APPENDIX 1. FAA FORMS (NDB)

FAA FORM 198 (NDB)

STATION ____________________

DATE ____________________

REV. NO. ____________________

FLIGHT CHECK INFORMATION

Date of last flight check: ____________________

Comments by flight or technical personnel: ____________________

____

____

For Installation Title

For Facility Title

Copies:
Facility (original)
Sector Office
Regional Office

FEDERAL AVIATION ADMINISTRATION

FAA FORM 198 (NDB)

STATION________________________

DATE___________________________

REV. NO.________________________

RECORD OF METER READINGS AND ADJUSTMENTS

INSTRUCTIONS

When the facility is originally commissioned, a complete Form FAA-198 (NDB) will be prepared jointly by the installation personnel and the sector manager or his representative. Use of the word, "original" "rev. no." in the heading above will indicate that no previous record of adjustments has been prepared. When an entry is not applicable to a particular NDB system, "N/A" shall be entered in the appropriate space.

Following facility modification or a retuning of the facility which results in significant deviations from the data recorded herein, page 1 and other applicable pages will be revised in duplicate for the facility, and for the sector office.

The following sheets of Form FAA-198 (NDB) ________________________ Nondirectional Beacon, are being preapred as of the above original or revision date:______________________________. Changes have not been made affecting any of the data on pages not listed above.

Reason for making revisions:____

____

____

FAA FORM 198 (NDB)
STATION ____________
DATE ____________
REV. NO. ____________

COMMISSIONING DATA
NDB GROUND SYSTEM
TYPE FA-9781 (400w NDB)
TYPE FA-9782 (50w NDB)
TYPE FA-9782/1(50w atu)

Station Ident. ____________ Channel No. ____________

Transmitter Freq. ____________ Receiver Freq. ____________

Type Facility used with ____________ Monitoring Category ____________

Original Commissioning Date ____________

*Geographic Location of Facility ____________

____

Latitude ____________ Longitude ____________

Magnetic Declination ____________ Elevation ____________

Controlling Region ____________ Controlling FSS ____________

Monitoring Category ____________

*Geographic location at ground station building should be briefly described with reference to a prominent landmark such as a city or airport.

Example: 4.6 miles north of Eastern Airport

TABULATION OF STANDARDS, TOLERANCES, AND METER READINGS

Parameter	Standard	Tolerance	Data
a. Transmitter Carrier Frequency	Assigned Frequency per FAA Form 6050-1	±0.01%	____
b. Identification Oscillator Frequency	1020HZ	±50 Hz	____
Identification Oscillator Frequency	400Hz 1/	±20 Hz 2/	____
c. Modulation Levels			
(1) NDB Nonsimultaneous			
(a) HH Facilities			
Voice	40%	38%-42%	____
Tone	40%	38%-42%	____
(b) Converted L/MF Range (H Facility)			
Voice	60%	58%-62%	____
Tone	20%	17%-21%	____
(c) All Others (including LOM and LMM facilities)			
Voice	85%	80%-90%	____
Tone	85%	80%-90%	____
(2) NDB Simultaneous			
(a) Converted L/MF Range (H Facility)			
Voice	60%	58%-62%	____
Tone	20%	17%-21%	____

1/ To assist in overcoming antenna bandwidth problems (modulation). This is an alternative, see 6740.2A.

2/ Under conditions of high atmospheric noise may provide a less easily readable signal.

TABULATION OF STANDARDS, TOLERANCES, AND METER READINGS

Parameter	Standard	Tolerance	Data
(b) Compass Locators (LOM and LMM)			
Voice	70%	68-72%	____
Tone	20%	17%-21%	____
d. Monitoring RF Power Alarm at remote monitor location	40% reduction of power output level	Same as standard	____
e. Antenna, Tuning House and Transmission Line Leakage Resistance (separately)	Infinity	Greater than 50 megohms	____
f. Transmission Line Impedance	Characteristic impedance	Within $\pm 5\%$ of standard	____
g. Remote Antenna Tuning House Input Impedance			
(1) Resistive Component	Characteristic impedance	Within $\pm 8\%$ of standard	____
(2) Reactive Component	Zero	Less than 3% of Z_o	____
h. Antenna Safety Gap Settings			
(1) Class HH	1 to 2 inches	Same as standard	____
(2) Class H	½ to 1 inch	Same as standard	____
(3) Class MH	3/8 to 1/2 inch	Same as standard	____
(4) Compass Locators LOM, LMM	1/4 to 3/8 inch	Same as standard	____

TABULATION OF STANDARDS, TOLERANCES, AND METER READINGS

	Parameter	Standard	Tolerance	Data
i.	Output Power 1/	Assigned power as authorized on FAA Form 6050-1	Initial: as set Operating: ±1 dB (both are the same)	____
j.	Shutdown Time Delay	27 sec	18 sec	____
k.	Field Intensity Measurements 2/	Microvolts per meter ____ measured at ____ feet from antenna downlead. Instrument/receiver type ____ S/N ____	Within ±10%	____

NOTE: The above field intensity recording would eliminate need for flight inspection following transmitter, coaxial line, tuning house, or coupling unit replacements.

1/ Initial setting adjustment control is provided.

2/ See Order 6740.2A, page 43, paragraph 162.a., Field Intensity Meter.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981—343-944:8246

FACILITY EQUIPMENT PERFORMANCE AND ADJUSTMENT DATA COVER SHEET	CHECK AS APPLICABLE ☐ INITIAL ☐ REVISION	DATE
SYSTEM		
CATEGORY		
FACILITY DESIGNATOR	FACILITY TYPE CODE	
NAME OF PLACE	LOCATION IDENTIFICATION CODE	
LATITUDE	LONGITUDE	MSL
DATE OF MOST RECENT COMMISSIONING ACTION	DATE OF LAST FLIGHT CHECK:	
	RESTRICTIONS	
LIST OF REVISED PAGES		

REASON FOR ACTION *(Check as applicable)*

☐ NEW INSTALLATION ☐ RELOCATION ☐ MAJOR TUNE UP ☐ MAJOR OVERHAUL OR REPAIR

INSPECTION DATE CERTIFICATION

NO.	ORGANIZATION	SIGNATURE OF REPRESENTATIVE	DATE

The attached series of forms numbered ______________ has been reviewed, verified, and certified by authorized technical personnel listed above as meeting Agency standards of performance for a commissioned facility of its type, subject to the following waiver action:

DEFICIENCY	
REASON FOR WAIVER	
JUSTIFICATION	
AUTHORITY	DATE OF WAIVER ACTION

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

DATE:

WASHINGTON, D.C. 20591

IN REPLY REFER TO:

FEDERAL AVIATION ADMINISTRATION

SUBJECT: Suggested Improvements to Nondirectional Beacon Installation Standards Handbook

FROM:

TO: Chief, Navaids/Communications Engineering Division, AAF-400

Problems with present handbook.

Recommended improvements:

Signature

Facility Identifier and AF Address

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

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