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31 January 1962

TECHNICAL REPORT

FORESTPORT ANTENNA STUDY

DECO Electronics, Inc.
Leesburg, Va.

Report Nr 42-F

Contract Nr AF 30(602) - 2588

Prepared
for
Rome Air Development Center
Air Research and Development Command
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ABSTRACT

This report presents the results of a study to determine the feasibility of modifying the U. S. Air Force Forestport vlf antenna to increase its power radiating capability to 500 watts.

Ten possible top-hat configurations are investigated by scale-model techniques. The model ranges and antennas, instrumentation, and methods of measurements are described in detail. The results of the model study (electrical parameters and power-radiating characteristics) are presented quantitatively for each of the configurations studied. Radiated power measurements of the present full-scale Forestport antenna show some disagreement with the model results. This is believed due to a calibration error in the antenna current measurement circuit of the Forestport antenna.

The maximum antenna voltage of 109 kv is established as one of the design criteria for the increased power of 500 watts. (At this point, flash-overs of the guy insulators occur during dry weather.) Several of the configurations meet or exceed this power vs antenna voltage requirement. The most economical configuration is recommended. It is further recommended that additional insulation be provided to increase the safety factor of the modified antenna.

CONTENTS

ILLUSTRATIONS

TABLES

1. INTRODUCTION

The U. S. Air Force transmitting station at Forestport, New York, is currently being evaluated as part of a three-station, vlf, navigational system known as Project Omega. At present, the Forestport station is capable of radiating a maximum power of approximately 300 watts. To increase the effectiveness of the station, the Service desired to modify the Forestport antenna system to increase the radiated power capability to 500 watts.

The antenna system of the Forestport station consists of a triangular, 1205-foot, base-insulated tower, with the upper 805 feet of each of the six top guys providing capacitive top loading. Resonant at approximately 100 kc, the antenna operates at 10.2 kc. Because of the high capacitive reactance of the tower at this frequency, the antenna develops very high voltages at modest amounts of radiated power; under average weather conditions, flash-overs have been observed at approximately 280 watts radiated power.

In August 1961, DECO Electronics, Inc., proposed a model study program to investigate the necessary modifications which would enable the tower to radiate greater power without a corresponding increase in antenna voltage. This study is now complete, and this report presents the results of the model study.

2. MEASUREMENT PROGRAM AND RESULTS

The measurement equipment and techniques used in the model study of the Forestport Tower modification were similar to those used in the design and development of the TRIDECO antenna for the Navy's vlf facility at Cutler, Maine. For many years, DECO has used the model-range approach to the design and development of large, complex antenna systems with considerable success. The use of scale models allows many configurations of the antenna to be investigated, simplifies the measurement program, and greatly reduces the cost of such a feasibility study. The justification of the model range approach may be seen in the very close agreement of the full scale measurements made on the TRIDECO antenna with the performance predicted by the model studies.

2.1 Model Range

Ideally, in the performance study of antennas operating against the ground, the ground plane should be a perfectly conducting, smooth, flat area of finite extent. Practically, however, the ground plane will be of infinite conductivity and restricted in area. Fortunately, a range of practical size and finite conductivity will yield results well within the accuracy required for most antenna systems.

The model range used in the studies of the Forestport antenna was designed and constructed at the Leesburg laboratories of DECO Electronics for the purpose of investigating vlf antennas. The ground plane of this range is large enough to control the environment affecting the impedance and effective height of the Forestport model antenna. The highly conducting portion of the ground plane extends far enough from the base of the radiator to insure that the vast majority of flux lines in the stored energy region terminate on the ground screen, a distance approximately equal to the height of the tower plus the height of the top hat formed by the upper guy cables. To avoid an abrupt discontinuity at the edge of the highly conducting ground screen, radials extend outward across the earth from the edge of the ground screen. Figure 1 shows the pertinent details of the vlf range.

Instrumentation for the range is housed in a 6-by-12-foot building under the center of the screen. A hole in the copper sheet over the building permits direct access to the antenna base. Instruments are mounted on a shelf directly under the access hole to minimize the lead lengths in the measurement circuits.

The instrumentation required for the various types of measurements made on the Forestport antenna is described in Section 2.3.

2.2 Antenna Models

In the vlf portion of the frequency spectrum, where waves are several miles in length, vertical-radiator heights of an appreciable portion of a wavelength cannot be achieved practically. Ordinary tower-type vertical radiators, so common in the medium and high frequency regions, cannot be made tall enough, either to radiate the amount of power involved in vlf systems (within the limits imposed by corona and voltage breakdown) or to accommodate the necessary frequency bandwidth. Radiators at the very low frequencies require the "top loading" of vertical elements as high as feasible. However, there is an economic compromise between the height of a radiation system and the area of the top hat which can be supported.

During recent vlf antenna model studies conducted by DECO, it was determined that the optimum electrical contribution of the top guy cables (in terms of radiated power versus antenna voltage) occurred

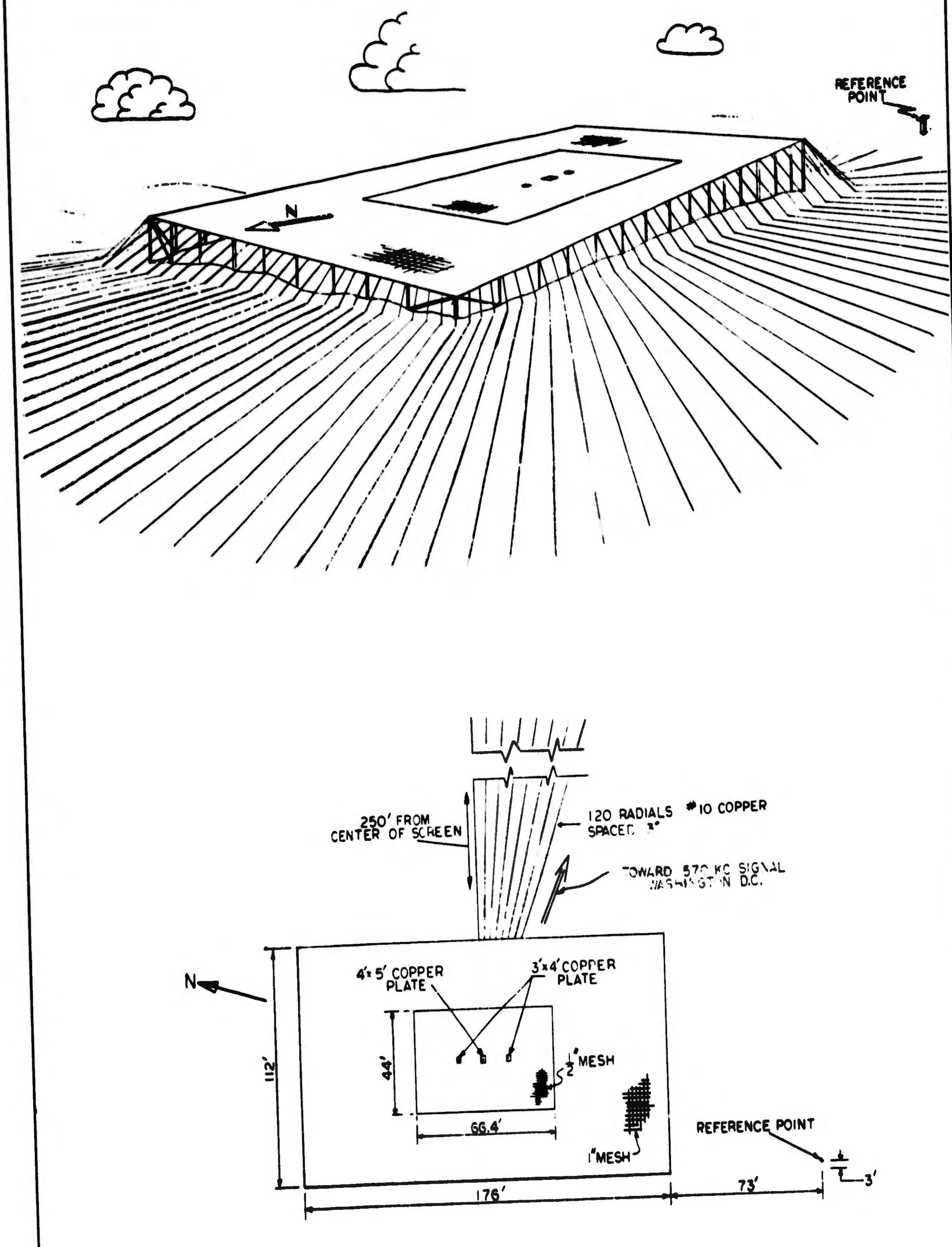

Figure 1 GROUND PLANE VLF MODEL RANGE

when the cables were made active down to a point representing approximately 0.8 of their chord length. For the purposes of these studies, this length if referred to as the K factor, where K is the active length divided by the chord length. Figure 2 shows the manner in which the power radiating capabilities of a top-loaded antenna varies with K for a given antenna voltage. Note that the power radiating capabilities of the tower increases as the active guy length up to the K = 0.8 point.

A K factor of 0.8 was initially chosen for the Forestport model antenna. In addition to various top hat configurations using the 0.8 K factor, several configurations employing the K factor (0.55) of the full-scale Forestport Antenna were also modeled. The ten conditions under which the model was studied are shown in Table I.

Table I Physical Parameters of Modeled Antennas

Configuration Nr.	Nr. of Active Guys in Top Hat	K	Nr. of Skirts
1 (as built)	6	0.55	0
2	6	0.55	1
3	12	0.55	1
4	18	0.55	1
5	6	0.8	0
6	6	0.8	1
7	12	0.8	1
8	18	0.8	1
9	6	0.8	2
10	6	0.8	3

The skirts used in certain of the configurations were added to further increase the capacity of the top hat and to support the lower

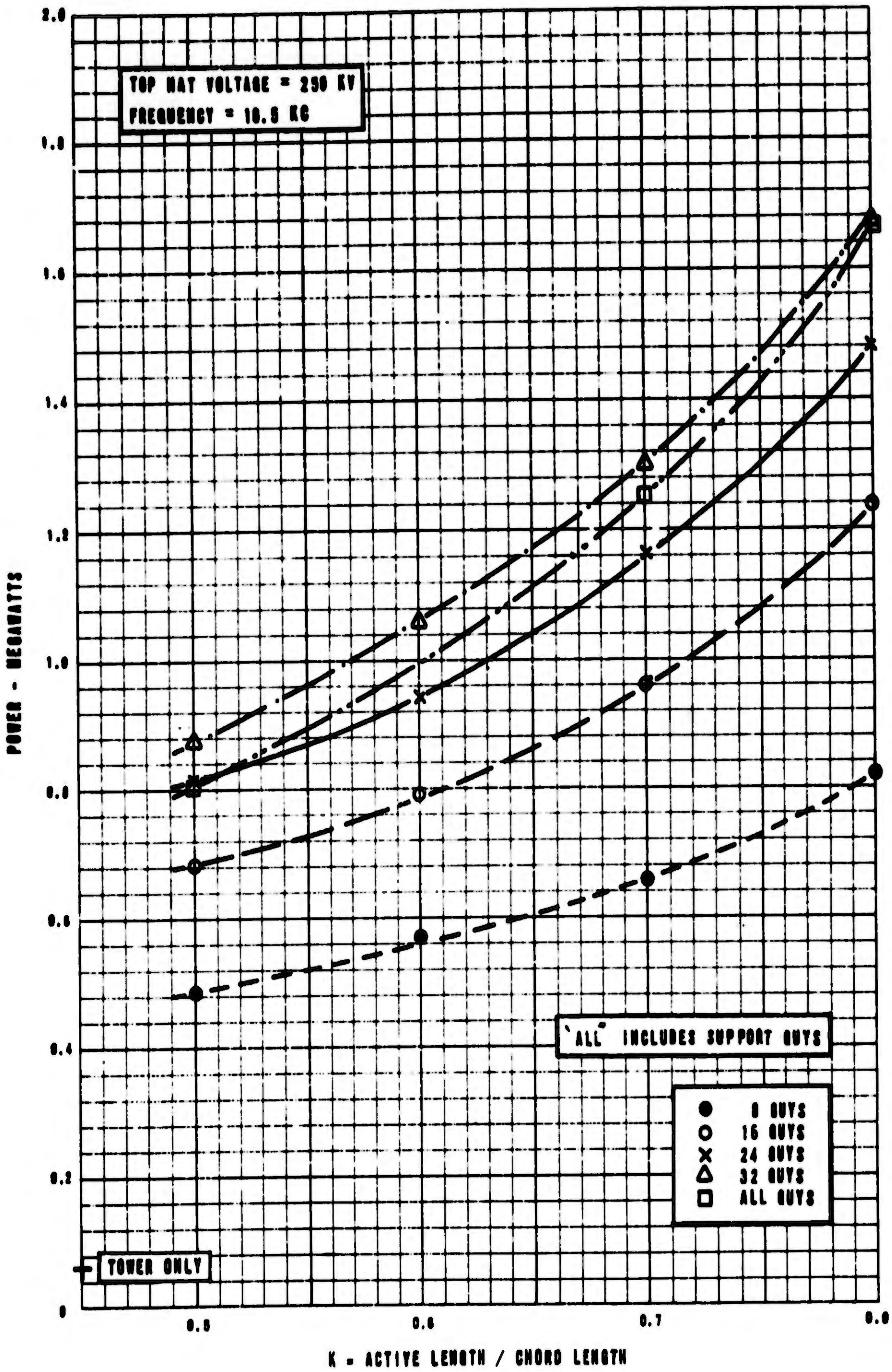

Figure 2 3000 FT. RADIATOR - POWER RADIATION CAPACITY AS A FUNCTION OF ACTIVE GUY LENGTH ends of the additional top hat radial conductors. Full-scale sketches of the configurations modeled are shown in Figures 3 through 12. For clarity, the intermediate and lower guys are omitted from these sketches, although they were in place during the measurements.

One of the principal parameters of a vlf radiator is its effective height. In the measurement of this characteristic of the model antenna, it is convenient to use the model as a receiving device with signals from local broadcasting stations normally used as signal sources. For the study of the Forestport model, station WGMS operating on 570 kc was selected. The ratio of this frequency to that of the Forestport station is 570/10.2 or approximately 56:1. The physical dimensions of the model were scaled by this factor, resulting in a radiator height of 21.4 feet. The dimensions of the guy cables and insulators were also scaled by the same factor. The tower itself was simulated by a length of 1-1/2" copper pipe.

2.3 Instrumentation and Methods of Measurements

The instrumentation used in the model study and the measurement methods for determining static capacitance, base impedance, and effective height are described in the following sections.

2.3.1 Static Capacitance

To determine the static capacitance of an antenna, a sufficiently low frequency is used so that the effect of any inductance in the vertical section or the top hat is substantially eliminated. The instrumentation arrangement for measuring this characteristic is shown in block diagram form in Figure 13.

With the standard capacitor paralleling the Q-meter output, the circuit was tuned to resonance at approximately 50 kc. After adding

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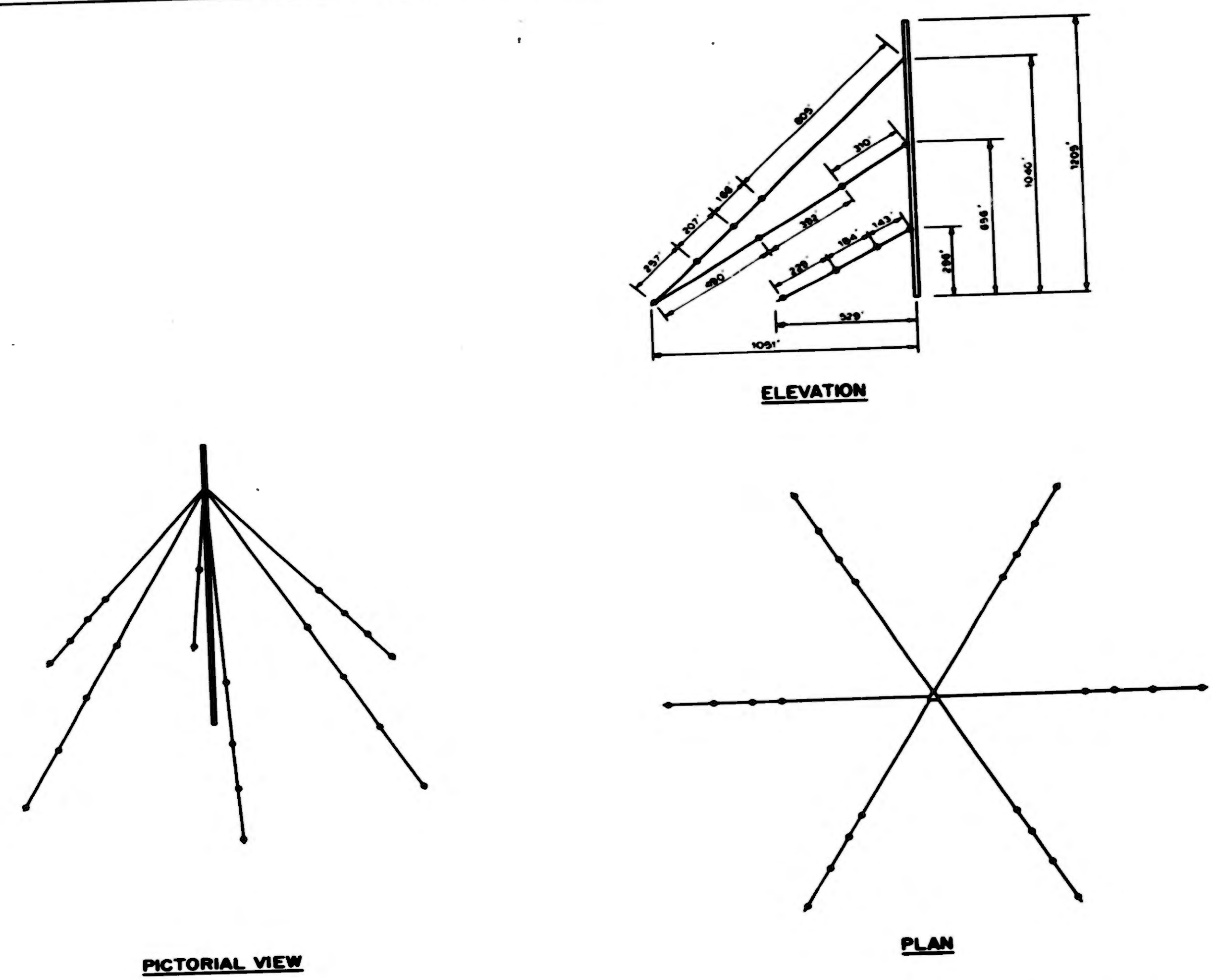

Figure 3 FORESTPORT† ANTENNA, TOP HAT CONFIGURATION NUMBER 1 (AS BUILT)

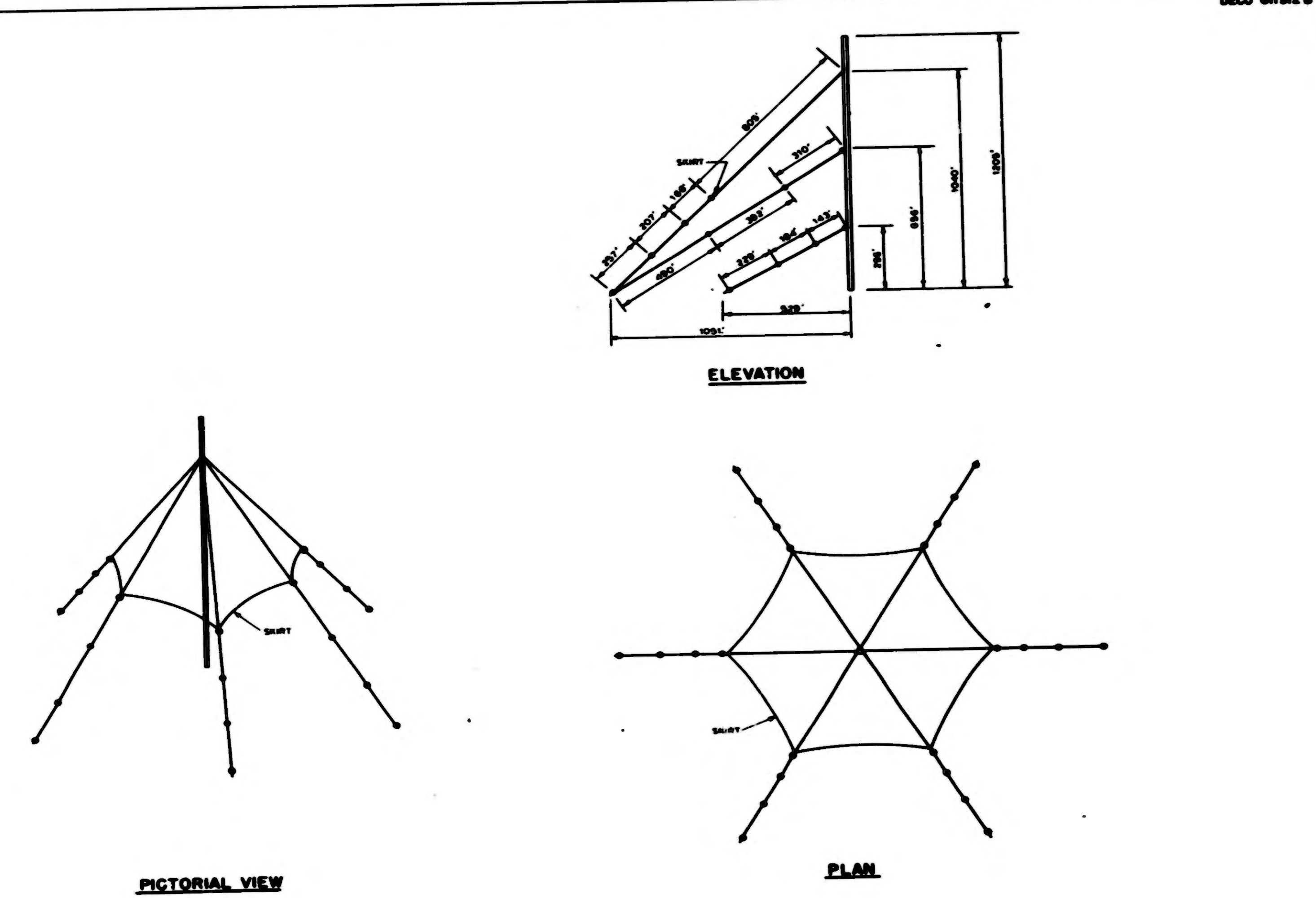

Figure 4 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 2

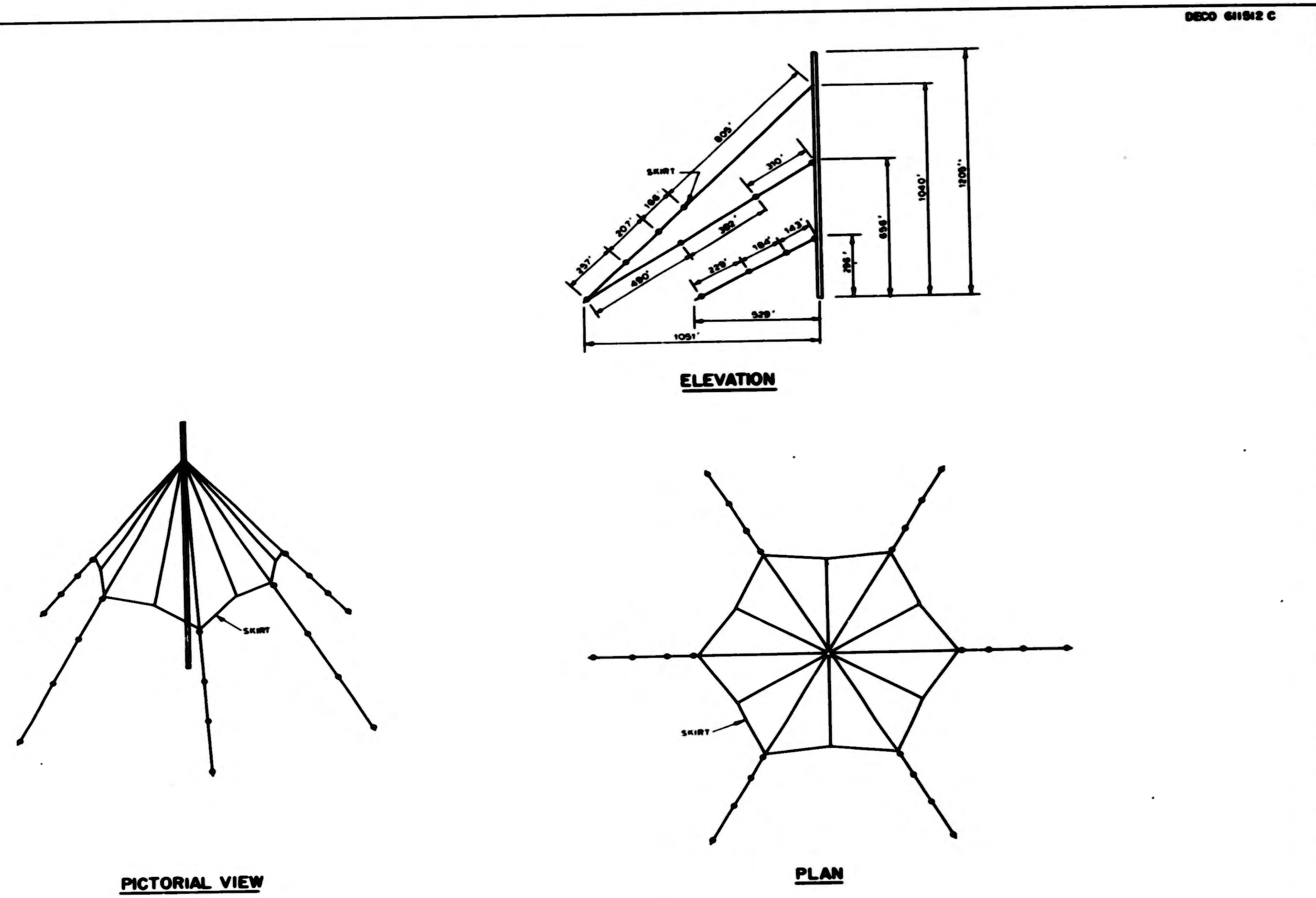

Figure 5 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 3

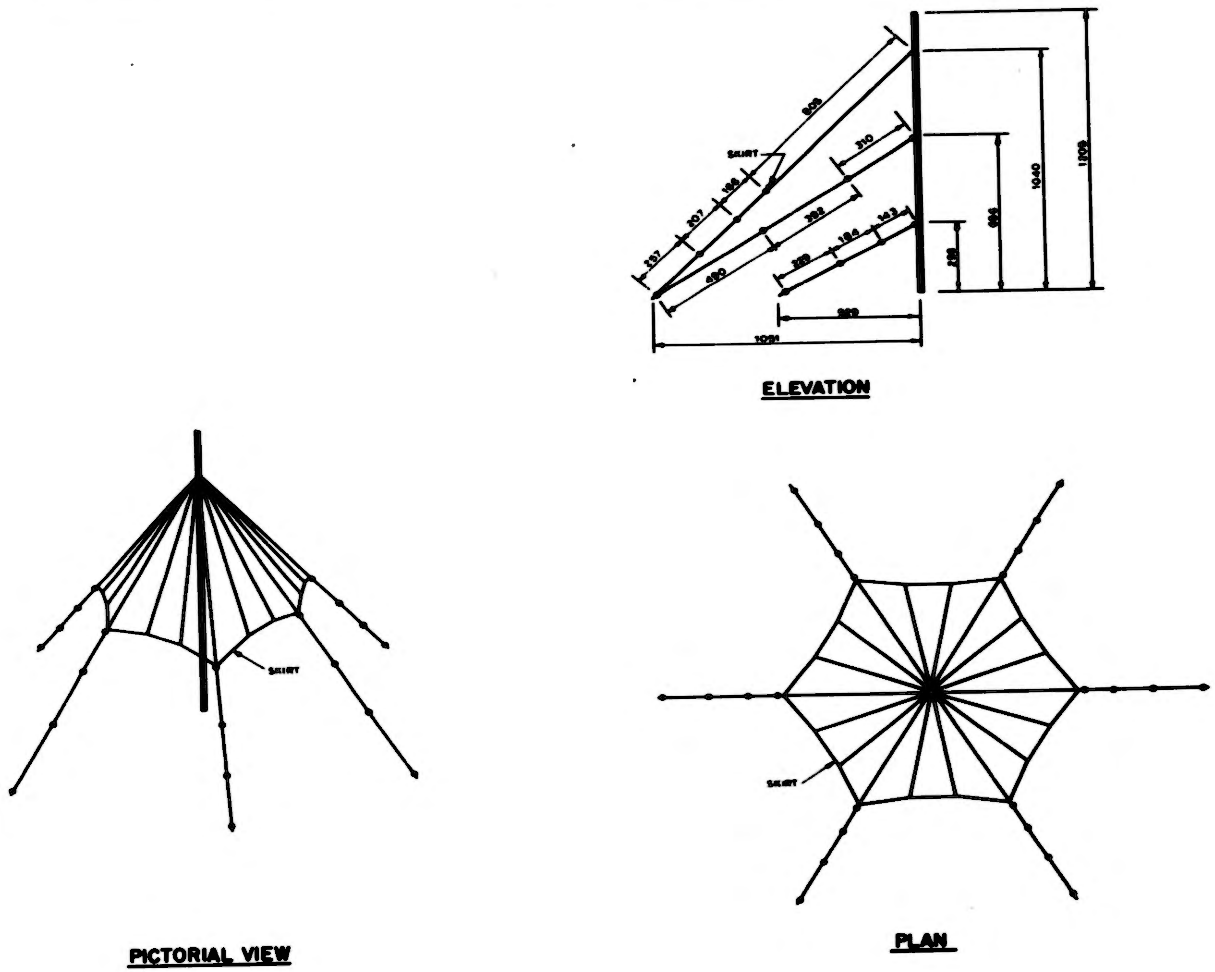

Figure 6 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 4

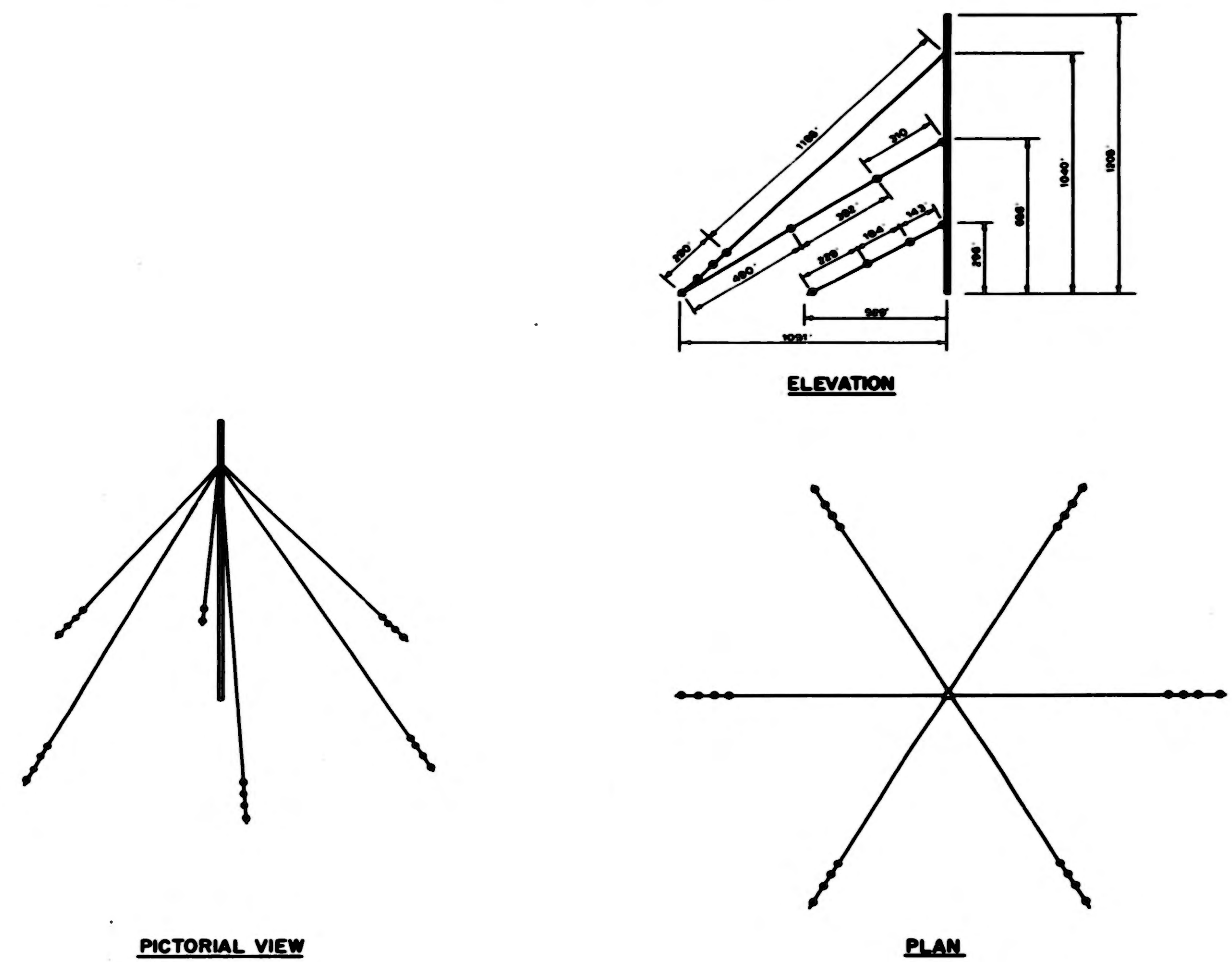

Figure 7 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 5

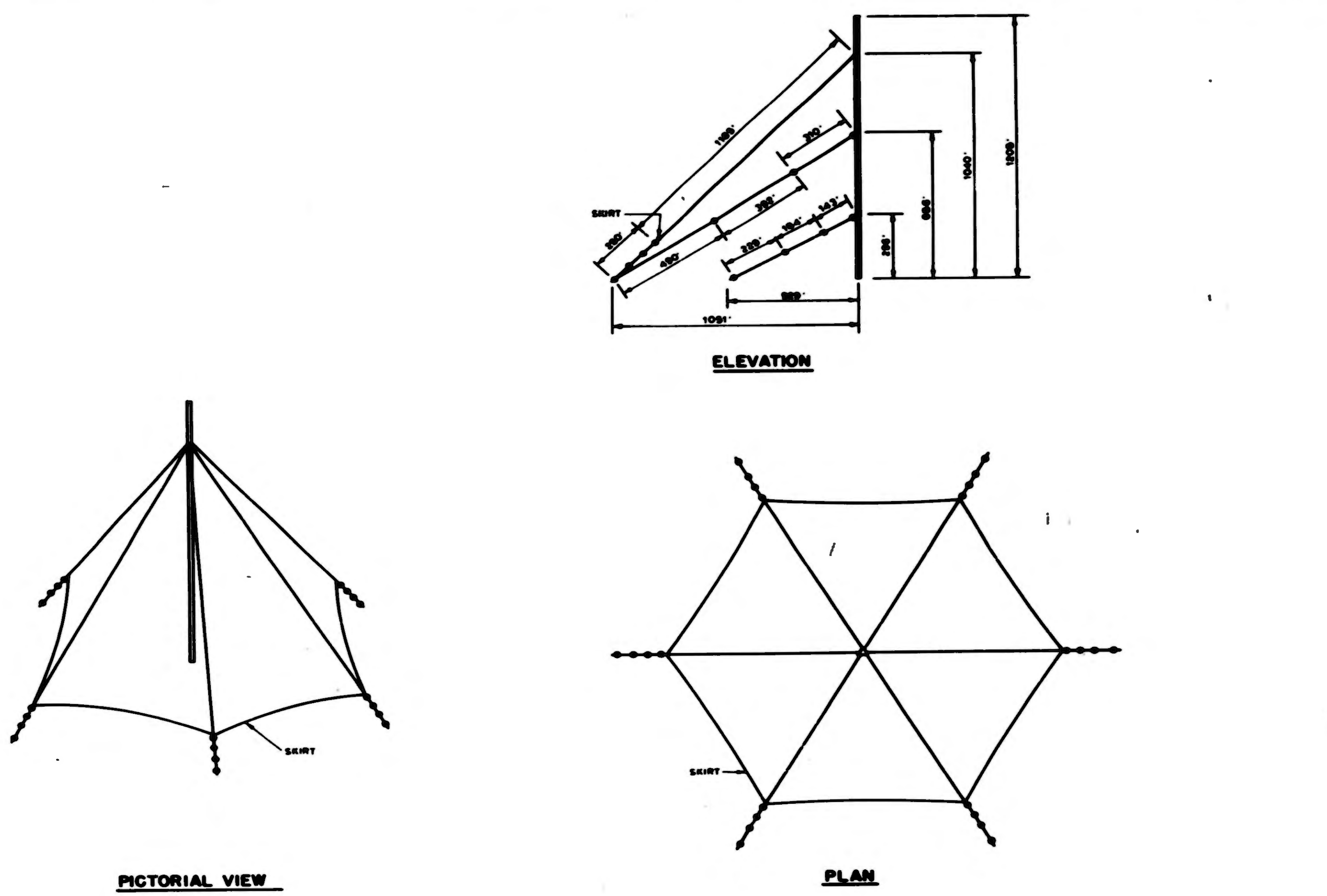

Figure 8 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 6

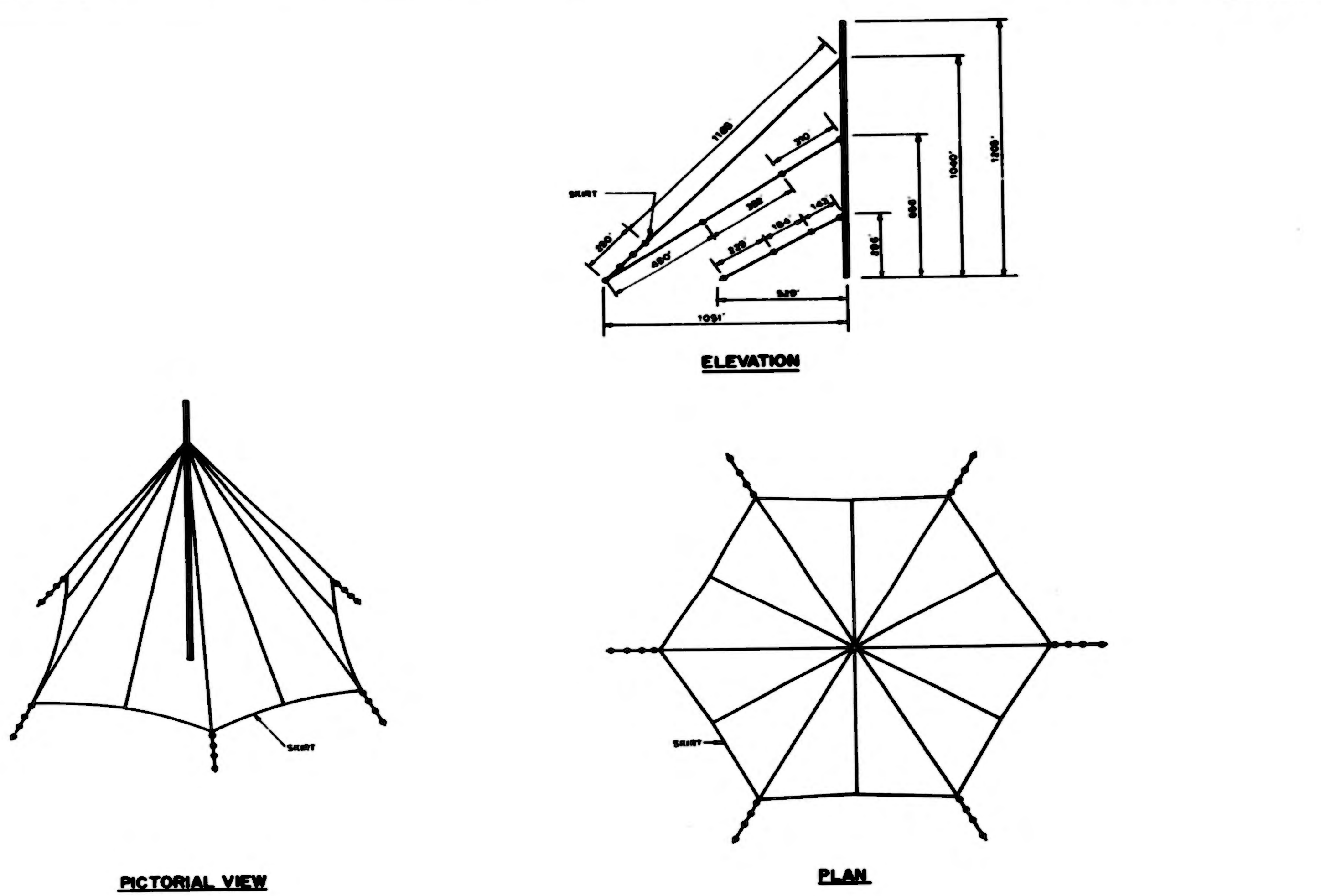

Figure 9 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 7

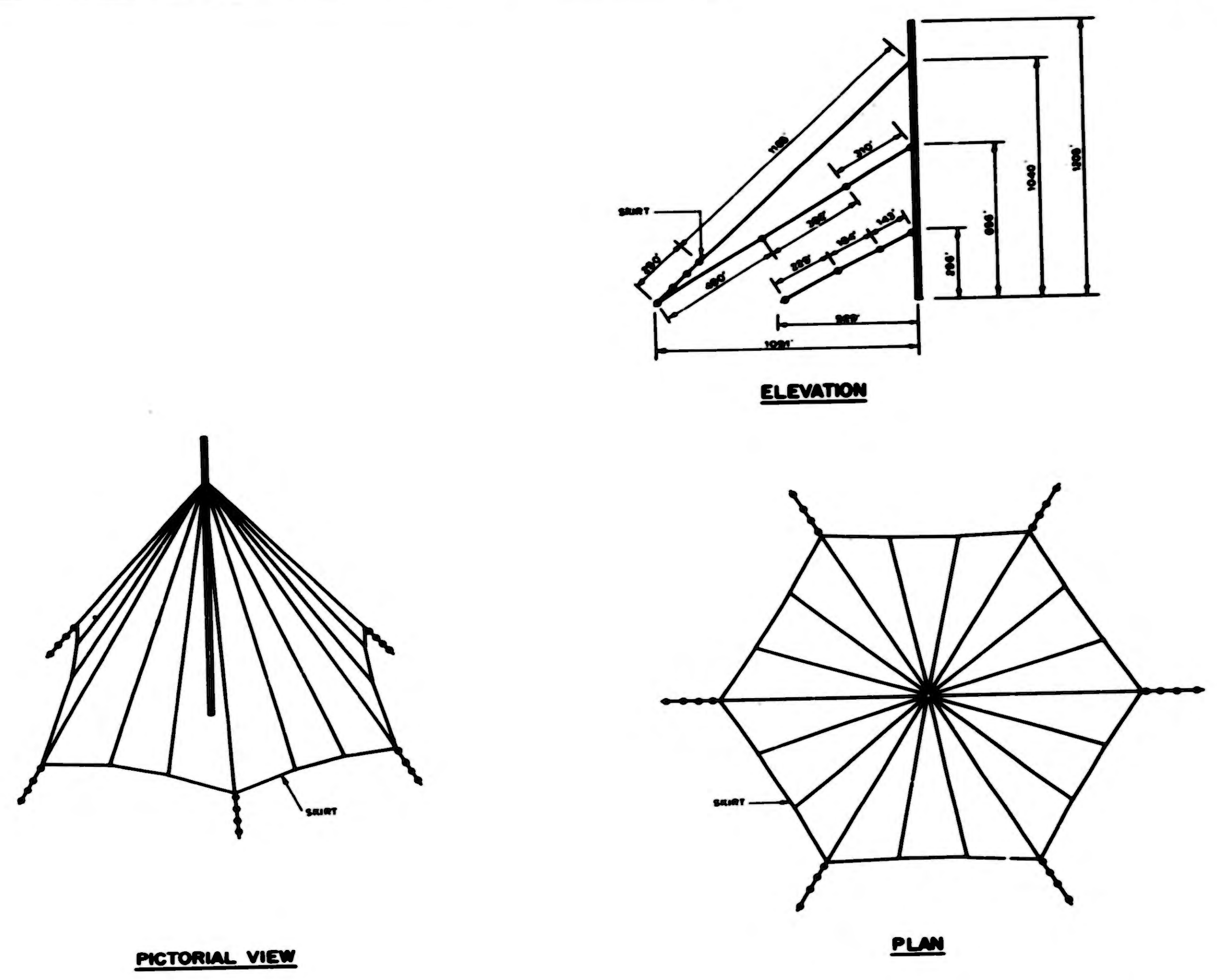

Figure 10 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 8

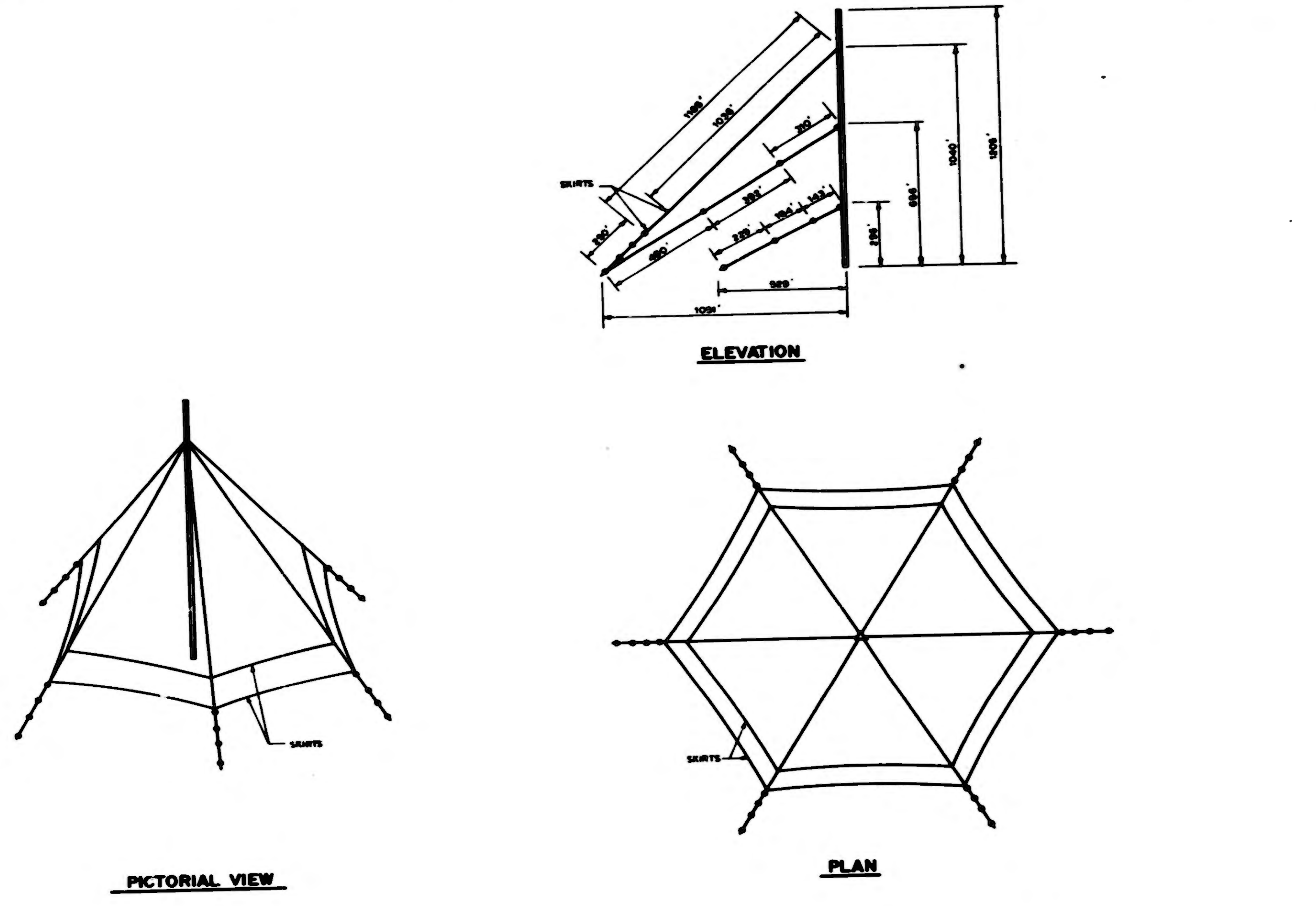

Figure 11 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 9

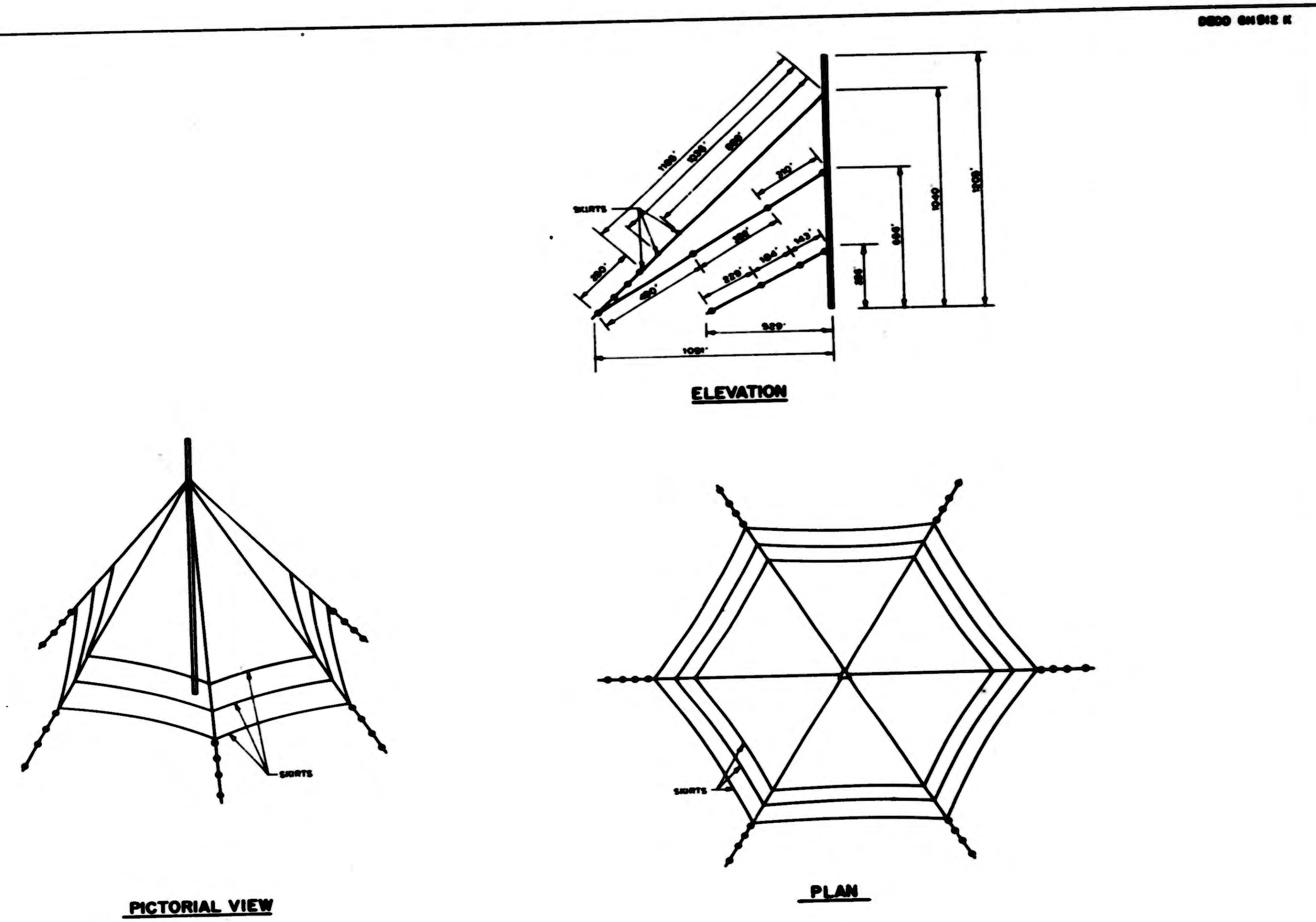

Figure 12 FORESTPORT ANTENNA, TOP HAT CONFIGURATION NUMBER 10

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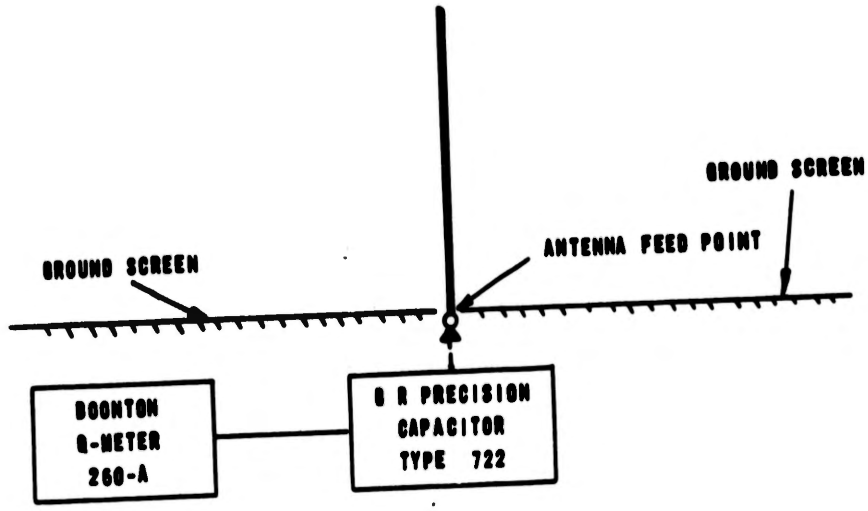

Figure 13 EQUIPMENT BLOCK DIAGRAM
STATIC CAPACITANCE MEASUREMENTS

the antenna in parallel with the standard capacitor, the circuit was re-resonated by varying the standard capacitor. The resulting difference in capacitance is the static capacitance of the antenna.

2.3.2 Base Impedance

Figure 14 shows in a block diagram of the equipment used to measure the base impedance of the model. Standard bridge techniques were used in the antenna impedance measurements.

One of the difficulties of measuring an electrically short antenna is that the resistance value is extremely low. Therefore, care was required to obtain even an approximate value of the resistive components of the base impedance. However, by exercising extreme care, values could be repeated reasonably well. The resistance component, as measured, included not only the radiation resistance of the antenna, but also the loss resistance of the antenna and ground system. While these loss components are very low, they are probably a measurable part of the total resistance at the lower end of the frequency range of interest, since the radiation resistance itself is very low.

2.3.3 Effective Height

The effective height of an antenna may be determined by both receiving and transmitting techniques. The receiving technique is much simpler and faster, and was employed for all effective height measurements in this study.

The measurement of effective height, using the antenna under test as a receiving device, is made by determining the open circuit voltage developed at the base of the antenna as it relates to the field intensity in which the antenna is immersed. Figure 15 shows block

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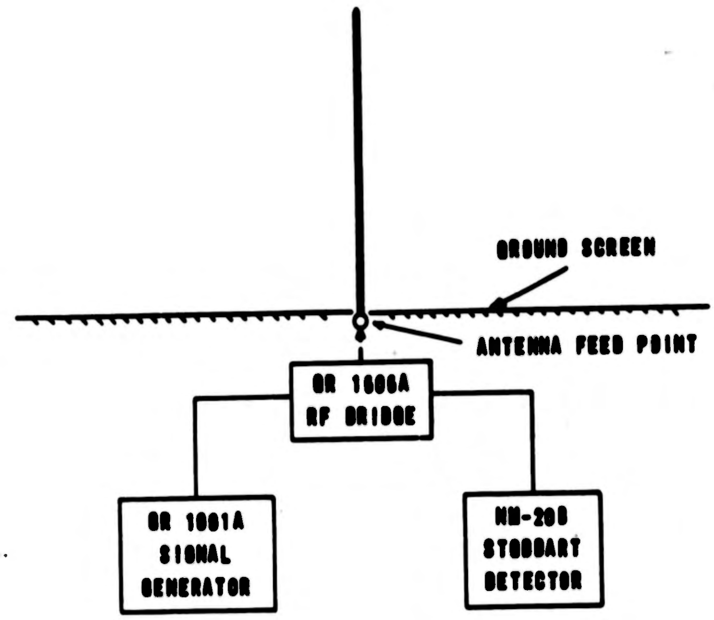

Figure 14 EQUIPMENT BLOCK DIAGRAM
BASE IMPEDANCE MEASUREMENTS

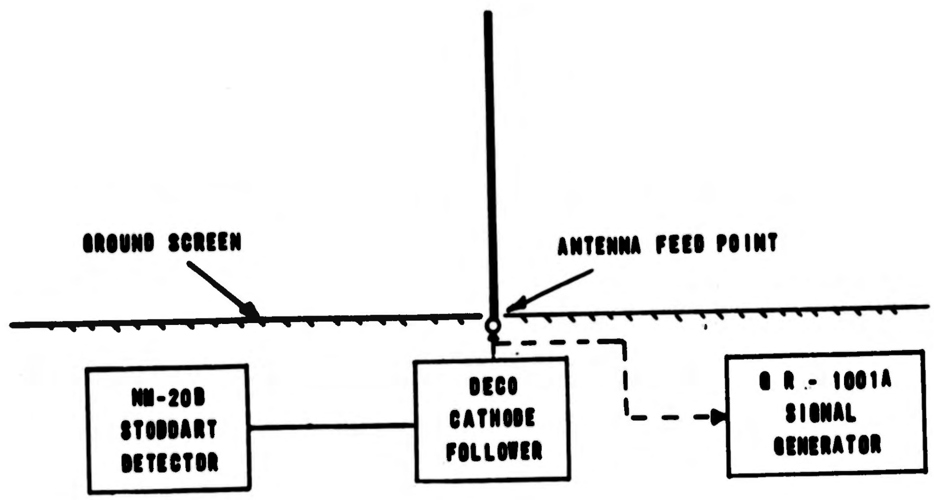

Figure 15 EQUIPMENT BLOCK DIAGRAM
EFFECTIVE HEIGHT MEASUREMENTS

diagrams of the equipment arrangements used to determine the effective height of the model. Radio station WGMS operating on 570 kc was used as a signal source. Any variation of signal levels in the area was determined by continual monitoring at a reference point near the range. (See Figure 1.)

In determining the open circuit voltage generated in the antenna by the receiving signal, a very-high-impedance-measuring device was required at the antenna base. A cathode follower was used, and the output was fed into a tuned voltmeter, used merely as a stable reference indicator.

With the field set tuned to the desired station and the cathode follower connected to the antenna, the output voltage on the tuned voltage indicator was noted. Simultaneously, the field intensity of the received station was checked at the reference point. The cathode follower was then shifted from the antenna to the standard generator, and its output voltage necessary to obtain the reference voltage on the tuned voltmeter was determined. Since this value represented the voltage generated in the antenna by a signal of known intensity, the effective height of the antenna could be easily calculated.

2.3.4 Calibration

The basic equipment used in the antenna measurement program was calibrated before, during, or just after the series of tests. The RCA Type WX-2C field intensity meter, used as the reference in establishing the absolute field intensity over the model range, was calibrated prior to the measurement program by Vitro Electronics; the accuracy of this meter was found to be within its rated 3 per cent. The Hewlett Packard Model 400 H vacuum tube voltmeter used as the voltage reference was calibrated by the Standards Laboratory of the U. S. Naval Weapons Plant; its readings were within plus one per cent of absolute over the ranges of interest. The standard signal-generator readings of voltage developed at the antenna base were referenced to this standardized vacuum tube voltmeter.

In addition to the conversion (as indicated by reference-meter) used in determining the absolute field in the vicinity of the antenna, certain factors also had to be considered in determining the absolute voltage developed in the antenna. A correction factor was applied to the signal-generator readings to convert them to voltages in terms of the standardized vacuum tube voltmeter. It was also necessary to consider the effect of the input impedance of the cathode follower on the open circuit antenna voltage. The cathode follower used in the measurements has an input capacitance of 6.6 $\mu\mu f$. This capacitance represents a shunt impedance low enough to require correction of the indicated voltages to obtain absolute values.

2.4 Results

2.4.1 Static Capacitance

The static capacitance of each of the ten configurations of the Forestport antenna is presented in Table II. The values shown are for the full-scale antennas, i.e., the static capacity of the models multiplied by 56, the scale factor.

2.4.2 Base Impedance

The base resistance and reactance as a function of frequency for the ten configurations modeled is shown in Figures 16 through 21. These curves show the base impedance over a band of frequencies extending from the operating frequency through resonance. (Resonance

Table II Principal Parameters of Forestport Tower for Various Top-Hat Configurations (from model measurements)

Nr	Nr of Top Hat Radial Conductors	K Factor	Nr of Skirts	Effective Height (ft)	Capacity	Radiation Resistance (ohms)	Resonant Frequency (kc)	Radiated Power (watts 100 kv)
1	6	0.55	0	648	0.00957	0.0710	100.0	279
2	6	0.55	1	582	0.01289	0.0556	83.5	394
3	12	0.55	1	612	0.01360	0.0638	79.0	488
4	18	0.55	1	603	0.01472	0.0635	81.0	553
5	6	0.8	0	538	0.01344	0.0638	80.0	367
6	6	0.8	1	405	0.02106	0.0275	63.0	505
7	12	0.8	1	419	0.02302	0.0298	61.0	654
8	18	0.8	1	449	0.02414	0.0342	61.0	824
9	6	0.8	2	367	0.02531	0.0228	56.0	605
10	6	0.8	3	356	0.02772	0.0217	53.5	687

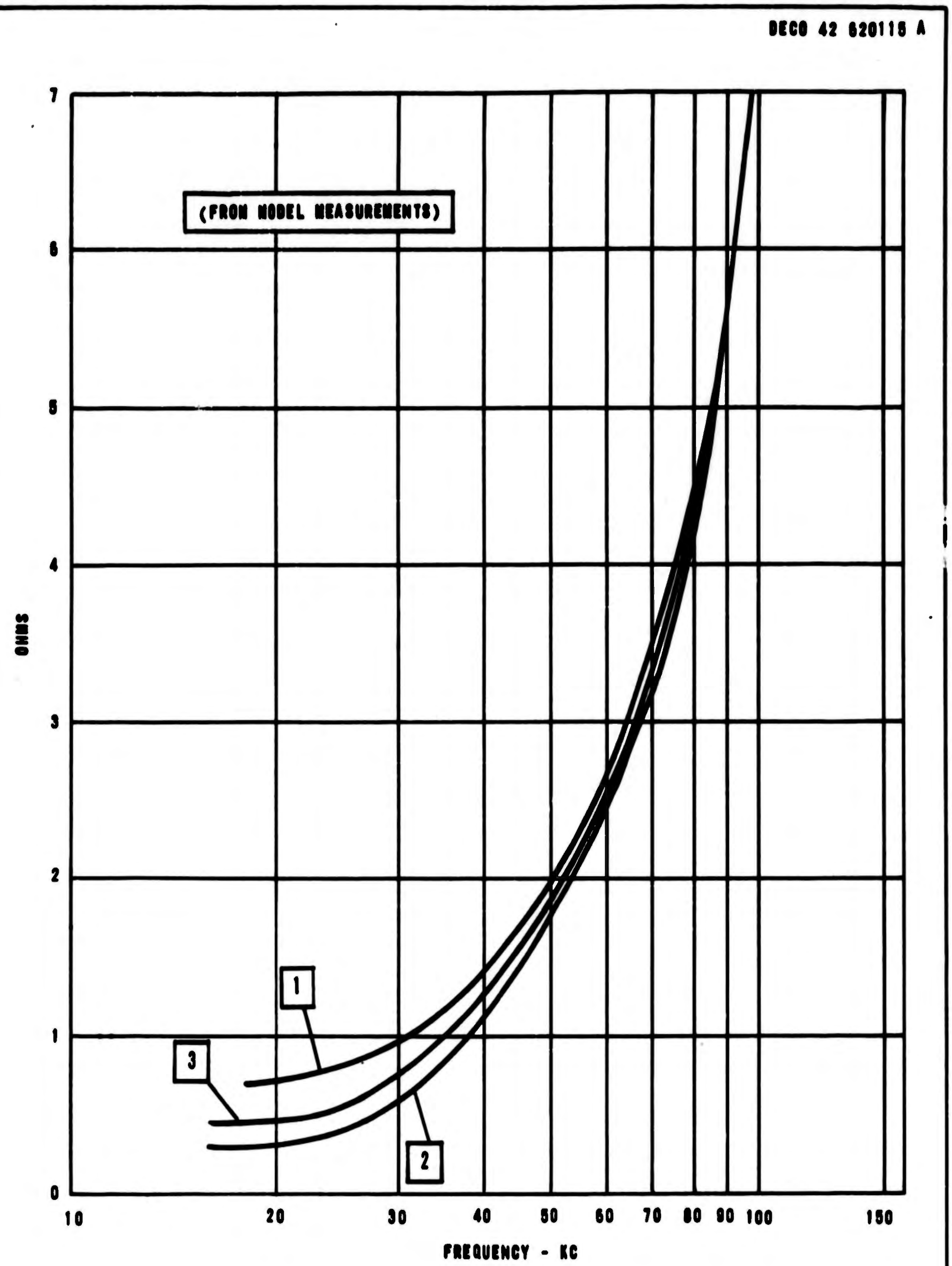

Figure 16 BASE RESISTANCE OF FORESTPORT TOWER OVER PERFECT GROUND PLANE FOR TOP HAT CONFIGURATIONS NUMBERS 1, 2 AND 3

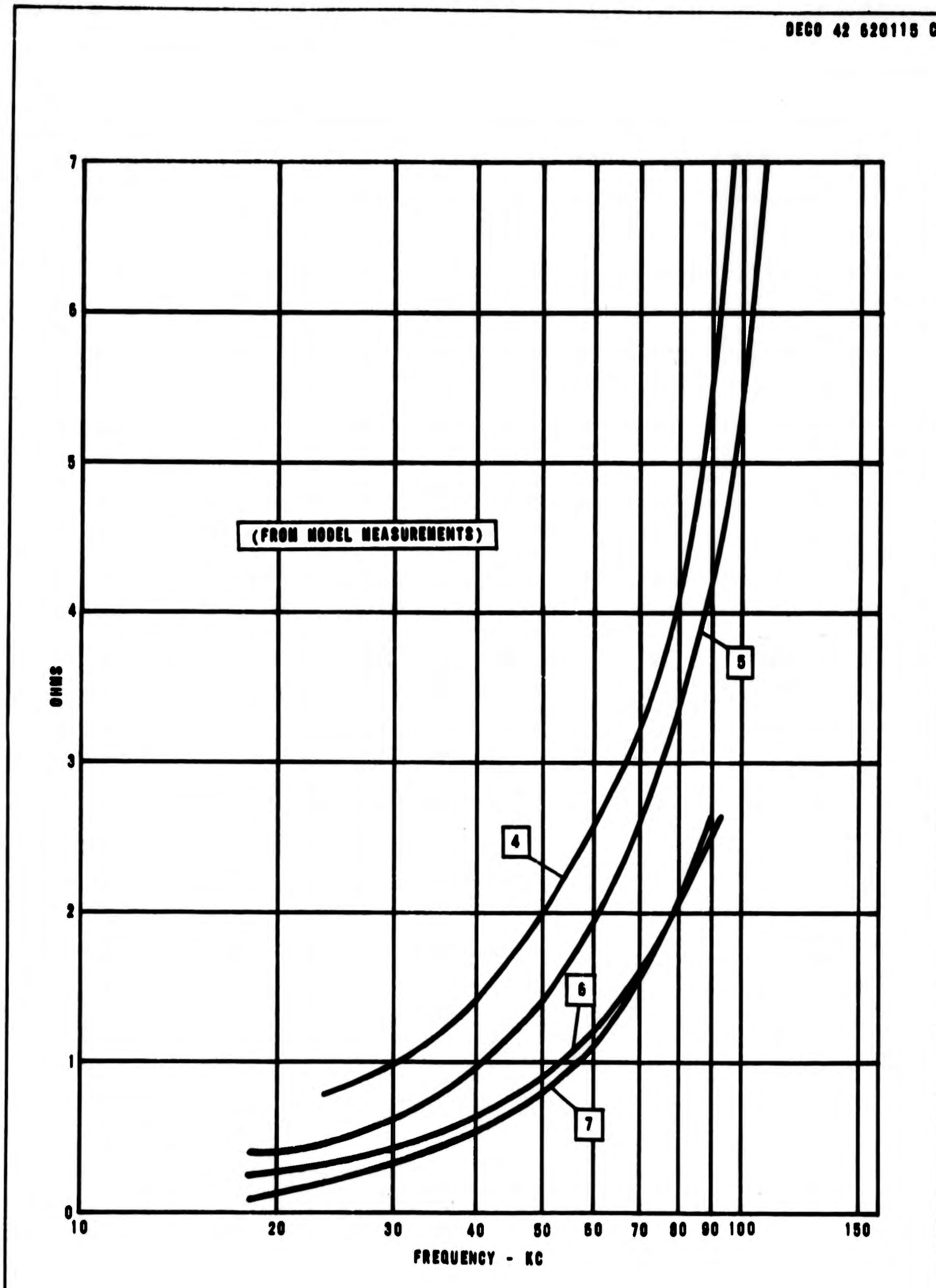

Figure 17 BASE RESISTANCE OF FORESTPORT TOWER OVER PERFECT GROUND PLANE FOR CONFIGURATIONS 4, 5, 6, AND 7.

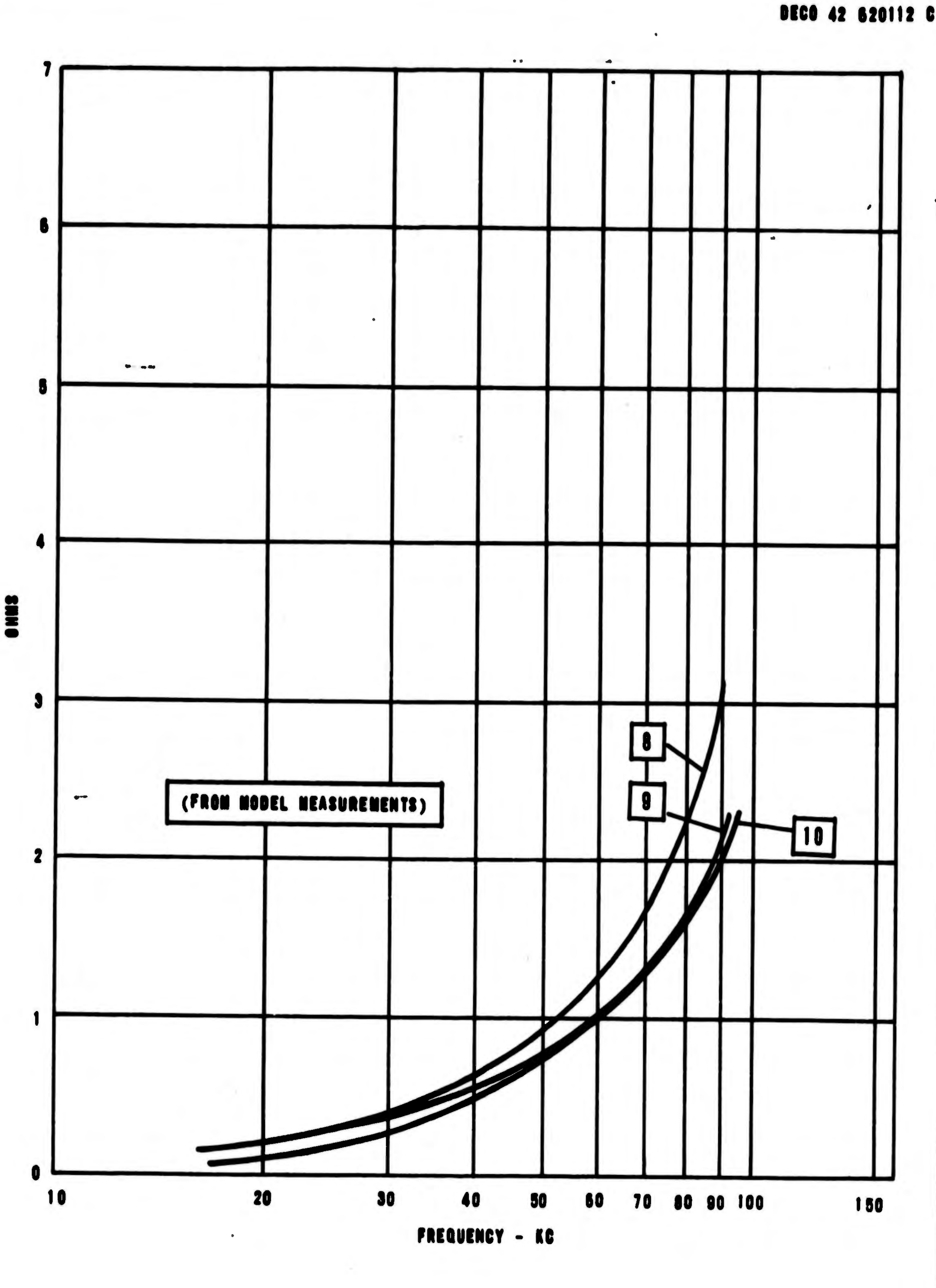

Figure 18 BASE RESISTANCE OF FORESTPORT TOWER OVER PERFECT GROUND PLANE FOR TOP HAT CONFIGURATIONS NUMBERS 8, 9 AND 10

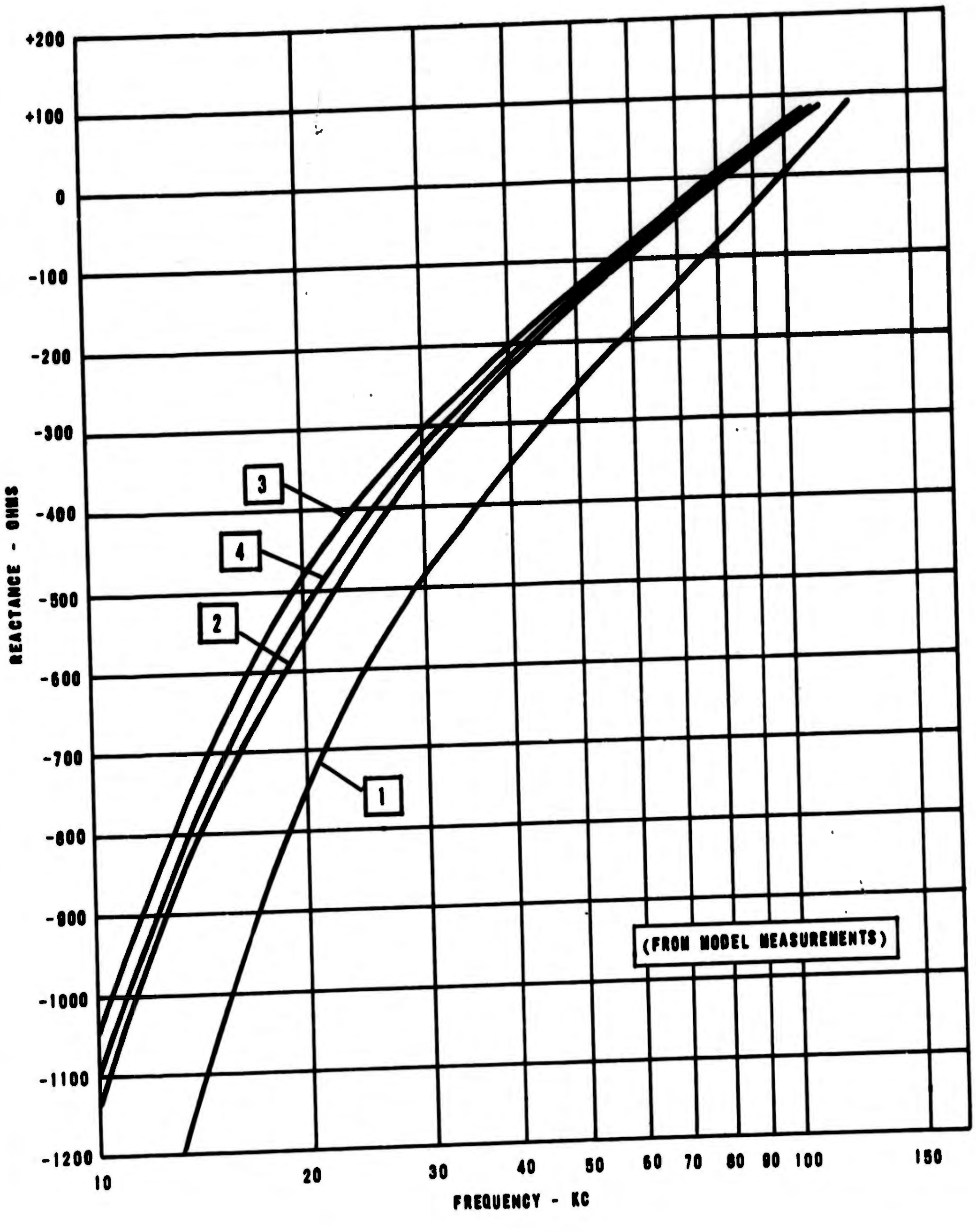

Figure 19 FORESTPORT TOWER BASE REACTANCE FOR TOP HAT CONFIGURATIONS NUMBERS 1, 2, 3 AND 4

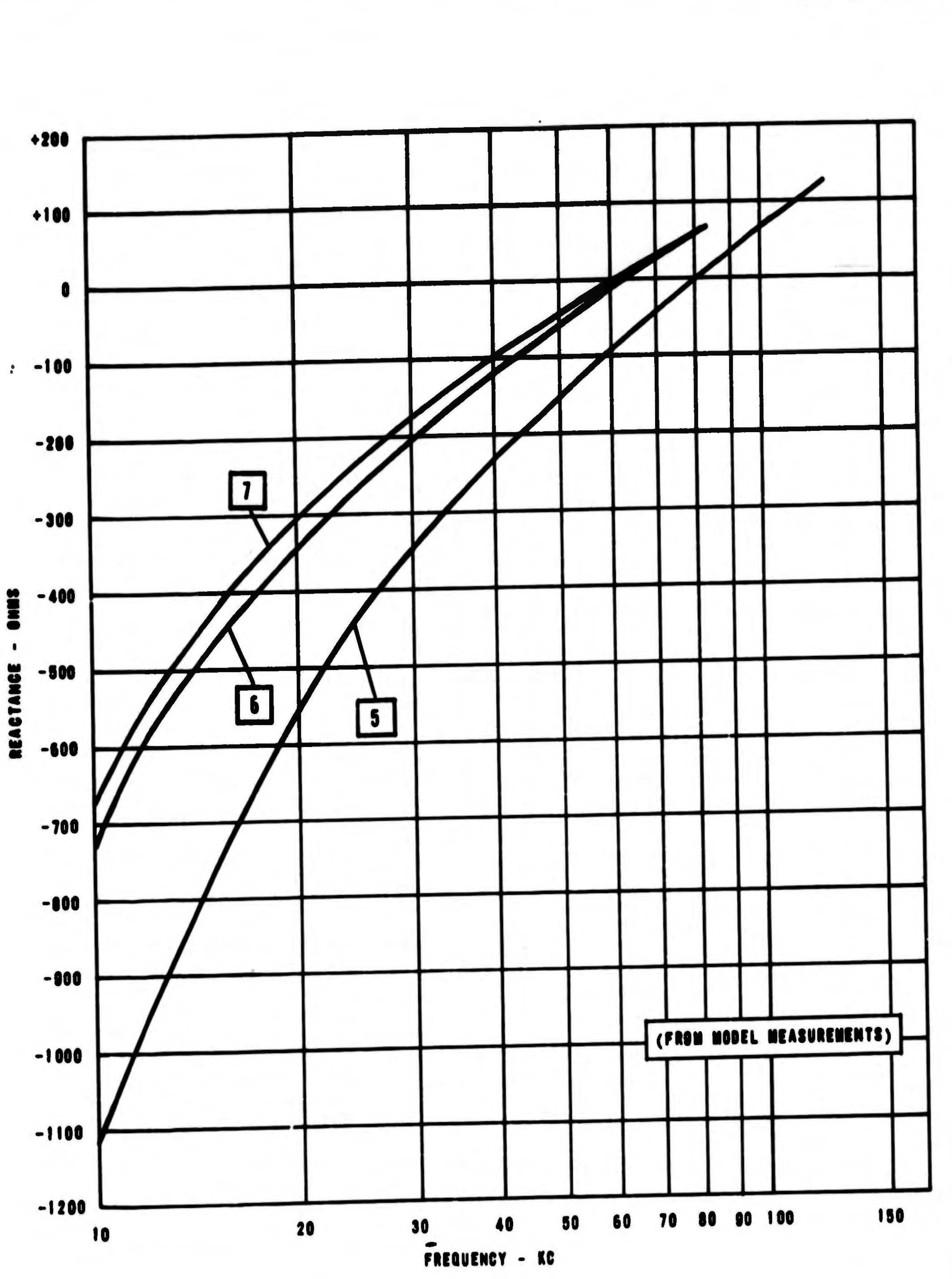

Figure 20 FORESTPORT TOWER BASE REACTANCE FOR TOP HAT CONFIGURATIONS NUMBERS 5, 6 AND 7

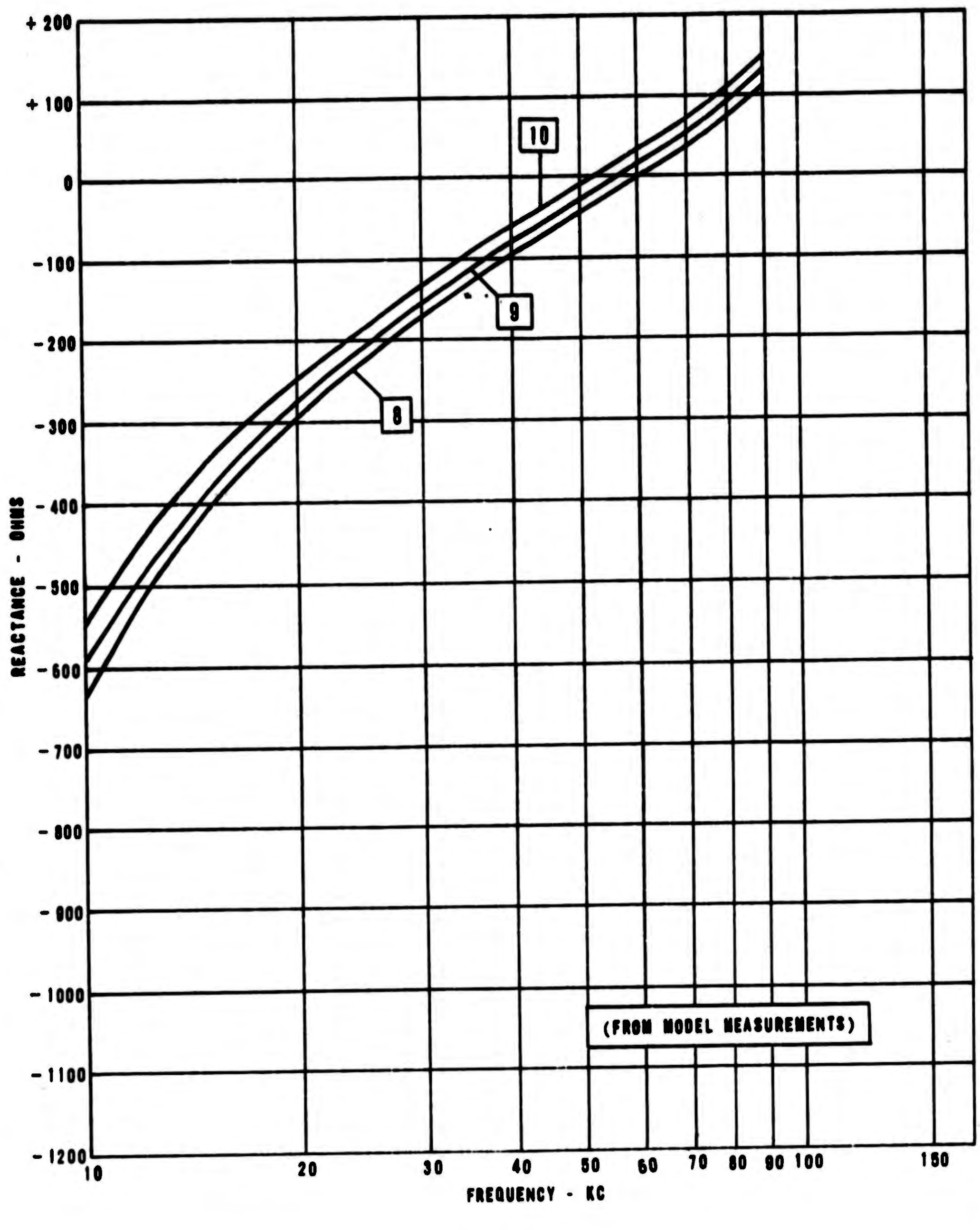

Figure 21 FORESTPORT TOWER BASE REACTANCE FOR TOP HAT CONFIGURATIONS NUMBERS 8, 9, AND 10.

is indicated at the zero reactance point on the curves.) As noted in Section 2.3.2, the value of the base resistance is considered as only approximate for the extremely low values at the lower frequencies. However, the radiation resistance can be accurately computed from the effective height of the models. (See Section 2.4.4.)

2.4.3 Effective Height

For the configurations modeled, the effective height of the Forestport antenna was computed from the model measurement data. The results are presented in Table II. Since the models were constructed to a scale factor of 56, the effective height figures shown in Table II were obtained by multiplying the measured values by this scale factor.

2.4.4 Radiation Resistance

Radiation resistance is related to the effective height and operating frequency as:

$$R_r = 160\pi^2 \left(\frac{h_e}{\lambda}\right)^2$$

Where: R_r = Radiation resistance in ohms

h_e = effective height in meters

λ = operating wavelength in meters

The radiation resistance of the Forestport antenna at 10.2 kc for each of the configurations studied is shown in Table II.

2.4.5 Radiated Power

The power radiating capability of a vlf antenna may be determined from the relation

$$P_o = 6.95 \times 10^{-7} V^2 C^2 h_e^2 f^4$$

Where: P_o = radiated power in watts

V = top-hat voltage in kv

C = top-hat capacity in microfarads

h_e = effective height in meters

f = operating frequency in kilocycles

Table II shows the power radiating capability (normalized to 100 kv) of the Forestport antenna for each of the configurations.

2.4.6 Antenna Voltage

The voltage appearing on the top hat of a vlf antenna is equal to the antenna current multiplied by the capacitive reactance of the top hat as determined from its static capacity. The voltage at the base of the tower is related to the top-hat voltage by the expression:

$$V_b = V_t \left[1 - \left(\frac{f_o}{f_r}\right)^2\right]$$

Where: V_b = base voltage

V_t = top-hat voltage

f_o = operating frequency

f_r = resonant frequency

From antennas operating far below resonance, the base voltage is essentially the same as the top-hat voltage. In the case of the Forestport antenna, the difference would be negligible for any of the configurations modeled.

The electrical parameters of the full-scale Forestport antenna were determined by the model (Configuration Nr. 1) measurements, from which the operating voltage was computed. The relationship between antenna voltage and antenna current is shown in Figure 22.

2.5 Radiated Power Measurements at Forestport

To confirm the results of the model study program, the radiated power of the full-scale Forestport antenna in its present configuration was measured and compared to the measurements obtained on the same configuration of the model. The full-scale antenna measurements were obtained by measuring the field intensity of the station at three widely separated points and computing the radiated power required to produce the fields observed for the distances involved. The three measurements points and the location of the tower are shown on the map in Figure 23. Directions for reaching each of the sites are given in Section 2.5.1.

Norton[1] and Wait and Howe[2] have shown that the ground wave field (neglecting ionospheric reflection fields) can be written as

$$E_v = \frac{30\sqrt{0.1 P_r}}{d} (W_g)$$

Where: E_v = vertical electric field in millivolts per meter

[1] K. A. Norton. "The Calculation of Ground-Wave Field Intensity Over a Finitely Conducting Spherical Earth." Proc. I.R.E. December 1941. Vol. 29. P 623-639.

[2] J. R. Wait and H. H. Howe. "Amplitude and Phase Curves for Ground-Wave Propagation in the Band 200 Cycles Per Second to 500 Kilocycles." NBS Circular 574. 21 May 1956.

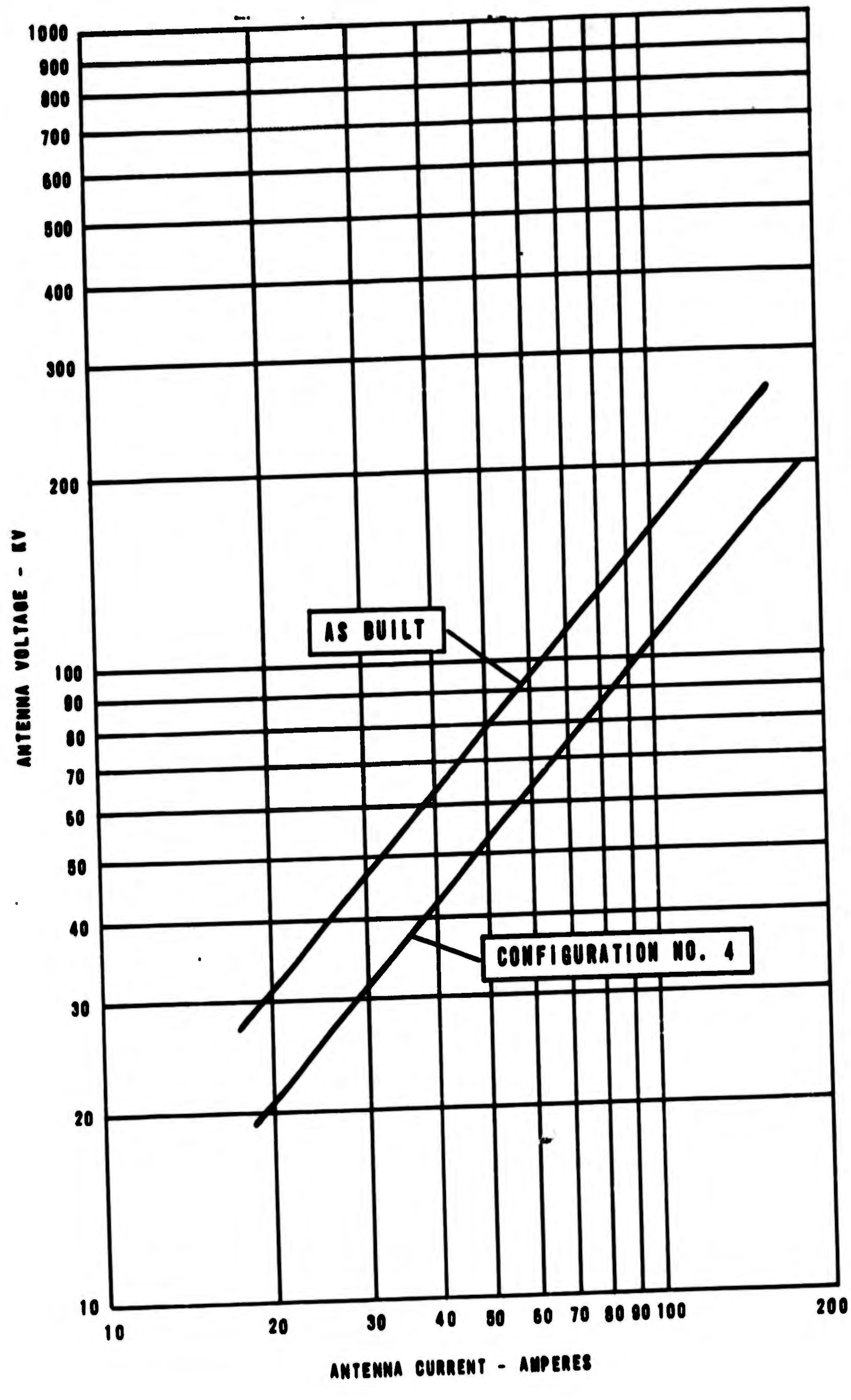

Figure 22 FORESTPORT ANTENNA VOLTAGE vs ANTENNA CURRENT

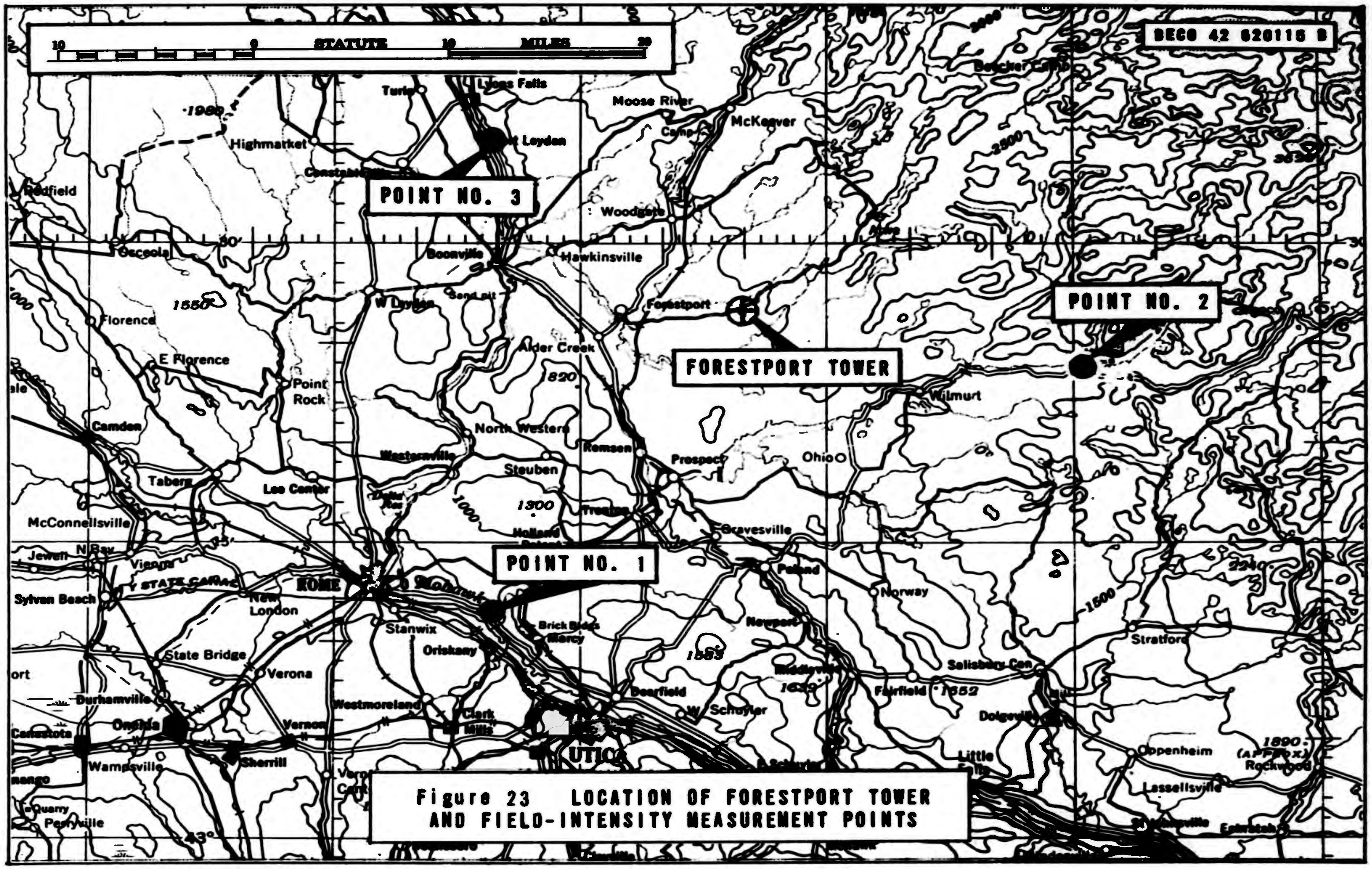

Figure 23 LOCATION OF FORESTPORT TOWER AND FIELD-INTENSITY MEASUREMENT POINTS

P_r = radiated power in watts

d = distance in kilometers

W_g = ratio of the ground wave to the inverse distant field

At short distances, the ground wave attenuation at 10.2 kc is very small and the W_g factor can be neglected. To facilitate the computation for radiated power, we can write, for d in statute miles,

$$P_r = 10\left(\frac{E_v d}{18.65}\right)^2$$

The measurements at Forestport were made with a Stoddart AN/URM-102 field intensity meter. This instrument was carefully calibrated prior to each measurement with the aid of SIEN-1 signal generator and a Ballantine Model 302 vacuum tube voltmeter. The voltmeter was calibrated by United Instrument Laboratories, Inc., just after the measurements were completed, and the measured voltages were corrected by a factor representing the voltmeter error. Figure 24 shows a block diagram of the measurement equipment.

The results of the measurements are shown in Table III.

Table III Forestport Radiated Power Measurements

Site	Date	Time EST	Distance statute miles	Antenna Current (amps)	Field Intensity (mv/m)	Radiated Power (w)
1	4 Jan '62	12:15	21.5	35	3.16	132
2	"	15:15	17.75	35	3.65	120
3	"	16:45	16.4	35	3.71	106
					Average Radiated Power =	119

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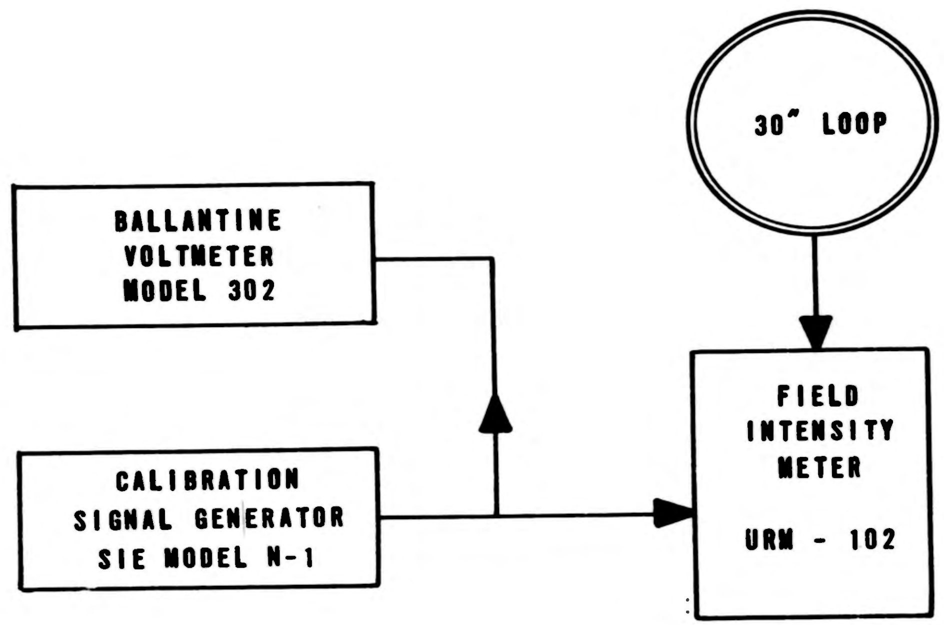


Figure 24 BLOCK DIAGRAM OF FIELD-INTENSITY MEASUREMENT EQUIPMENT

The radiated power of the present Forestport antenna vs antenna current, as computed from model measurements, is shown in Figure 25. Note that the measured value presented in Table III is somewhat greater than that indicated by the computed curve. Since the field measurement equipment was carefully calibrated, it is believed that the discrepancy is probably due to an error in the antenna current ammeter. This instrument is a remote, vacuum-tube device located in the transmitter room and energized by a current transformer coupled to the ground lead of the antenna matching transformer secondary, some 1000 feet away. Although the measuring circuit is of excellent design, it is quite conceivable that it could have developed an error since its last calibration. Considering the measured field intensity, the actual antenna current was probably near 40 amperes, rather than the indicated 35 amperes.

It is recommended that the radiated power of the Forestport antenna be measured again, immediately before and after the modifications. This will enable the relative capabilities to be determined under similar local conditions. At that time a recently calibrated antenna ammeter should also be employed to enable absolute values of radiated power to be determined.

2.5.1 <u>Locations of the Measurement Sites</u>

The directions for reaching the measurement sites are given below since it may be desirable in the future to obtain similar data from these same locations.

Point Nr. 1 - At Floyd Test Site. Enter site via main gate, and proceed straight ahead to large circular building on left. Turn left just beyond this structure and then right on next roadway. Measurement point is on this roadway 700 feet beyond circular building.

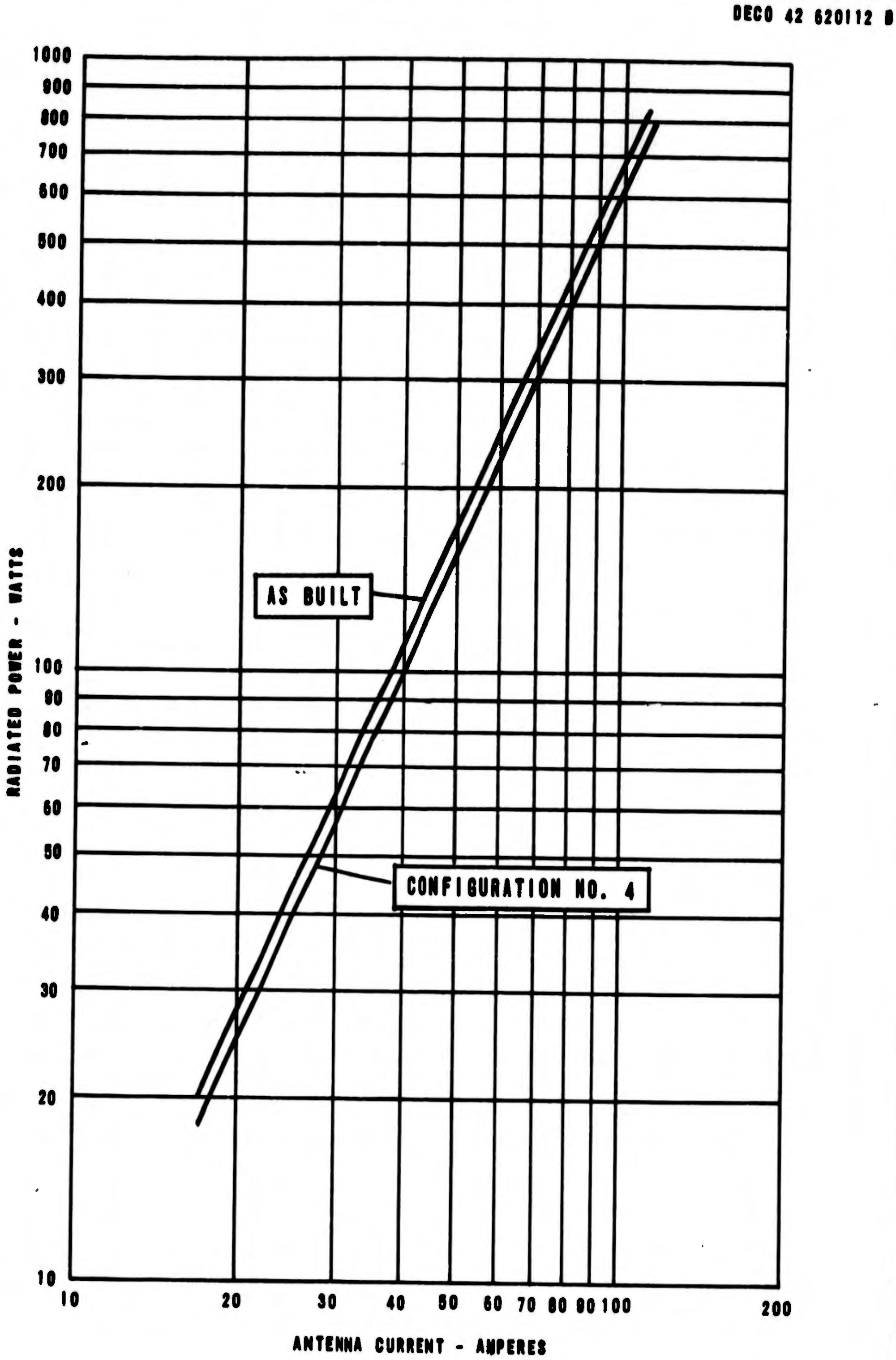


Figure 25 FORESTPORT ANTENNA RADIATED POWER vs ANTENNA CURRENT

Point Nr. 2 - Proceed east of Utica on New York Route 8 to a point 2 miles east of Morehouser. Turn left on secondary road and follow to creek crossing. Site is 150 feet south of bridge.

Point Nr. 3 - Proceed north on New York Route 12 to Port Leyden. Turn right at main intersection. Proceed 0.1 mile to road leading to school on left. Measurement point is on school yard drive, adjacent to NE corner of building.

3. CONCLUSIONS AND RECOMMENDATIONS

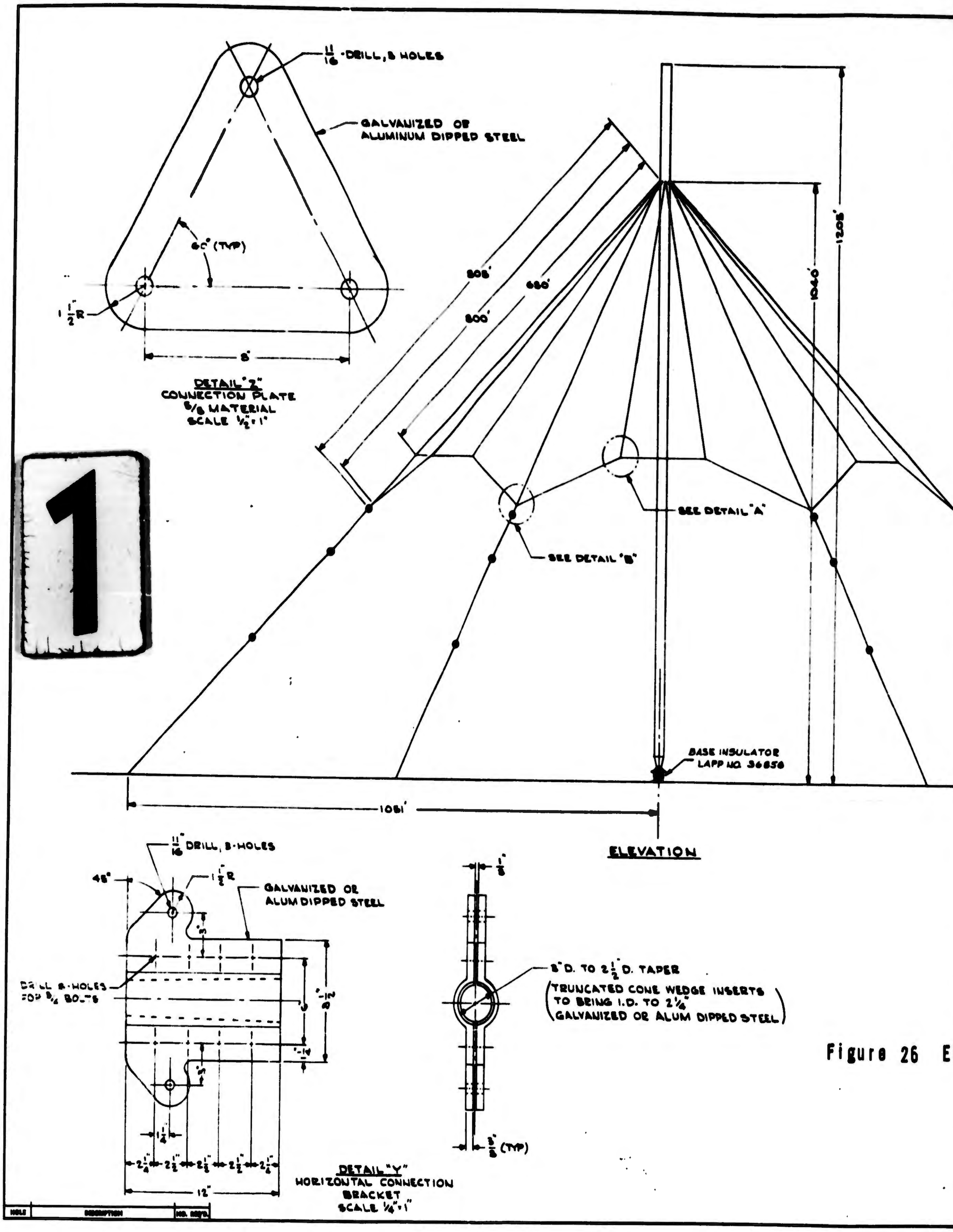
The objective of this study was, in general, to determine the electrical effects of increasing the top-hat capacity of the Forestport antenna and, in particular, to develop an electrical design that would increase the power radiating capability of the antenna to 500 watts at 10.2 kc within the present voltage limitations of the antenna.

Operating experience at Forestport has shown that, under dry weather conditions, flash-overs of the guy insulators occur at about 68 amperes antenna current. Figure 22 indicates that the antenna voltage is about 109 kv for this condition. Thus, if the objective is to be met, the top-hat configuration chosen must provide a radiation capability of 500 watts at an antenna voltage of not more than 109 kv.

Table II shows that although several of the configurations meet or exceed the power vs voltage requirement, the design represented by Configuration Nr. 4 is the more economical. The present active guy-cable lengths would not have to be altered, and a smaller amount of new material would be required. Also, since the radiation resistance of this configuration is higher than that of the other designs meeting the requirement, it is more efficient than the others and, therefore, would require less input power to achieve the required radiated power. The radiated power vs antenna current of the present Forestport antenna and of Configuration Nr. 4 are shown in Figure 25.

For the reasons given above, it is recommended that Configuration Nr. 4 be chosen as the basis for the Forestport antenna modification design. Engineering drawings of the antenna so modified are shown in Figures 26 through 29. A list of materials for this configuration is presented in Appendix I.

It should be pointed out that the insulators presently isolating the Forestport antenna provide voltage breakdown protection for about 100 kv during periods of dry weather only. This would mean, of course, that radiation of 500 watts for the modified antenna could only be achieved under these conditions. On wet days, radiation would be voltage limited to a much lower value. For this reason, it is strongly recommended that additional insulation be included in the modification design. Accordingly, an alternate list of materials to increase the safety factor of the modified antenna is also presented in Appendix I. This additional insulation would increase the voltage handling ability of the antenna by a factor of two.



11/16 DRILL, 3 HOLES
GALVANIZED OR ALUMINUM DIPPED STEEL
60° (TYP)
1 1/2" R
8"
DETAIL "Z"
CONNECTION PLATE
5/8 MATERIAL
SCALE 1/2"=1"
808'
680'
800'
1208'
1040'
SEE DETAIL "A"
SEE DETAIL "B"
BASE INSULATOR
LAPP NO. 36856
1051'
ELEVATION
11/16" DRILL, 3-HOLES
45°
1 1/2" R
GALVANIZED OR ALUM DIPPED STEEL
DRILL 8-HOLES FOR 3/4 BOLTS
1/8"
3" D. TO 2 1/2" D. TAPER
(TRUNCATED CONE WEDGE INSERTS TO BRING I.D. TO 2 1/4" GALVANIZED OR ALUM DIPPED STEEL)
3/8" (TYP)
1 1/4"
2 1/4" 2 1/2" 2 1/2" 2 1/2" 2 1/4"
12"
DETAIL "Y"
HORIZONTAL CONNECTION BRACKET
SCALE 1/4"=1"

Figure 26 E

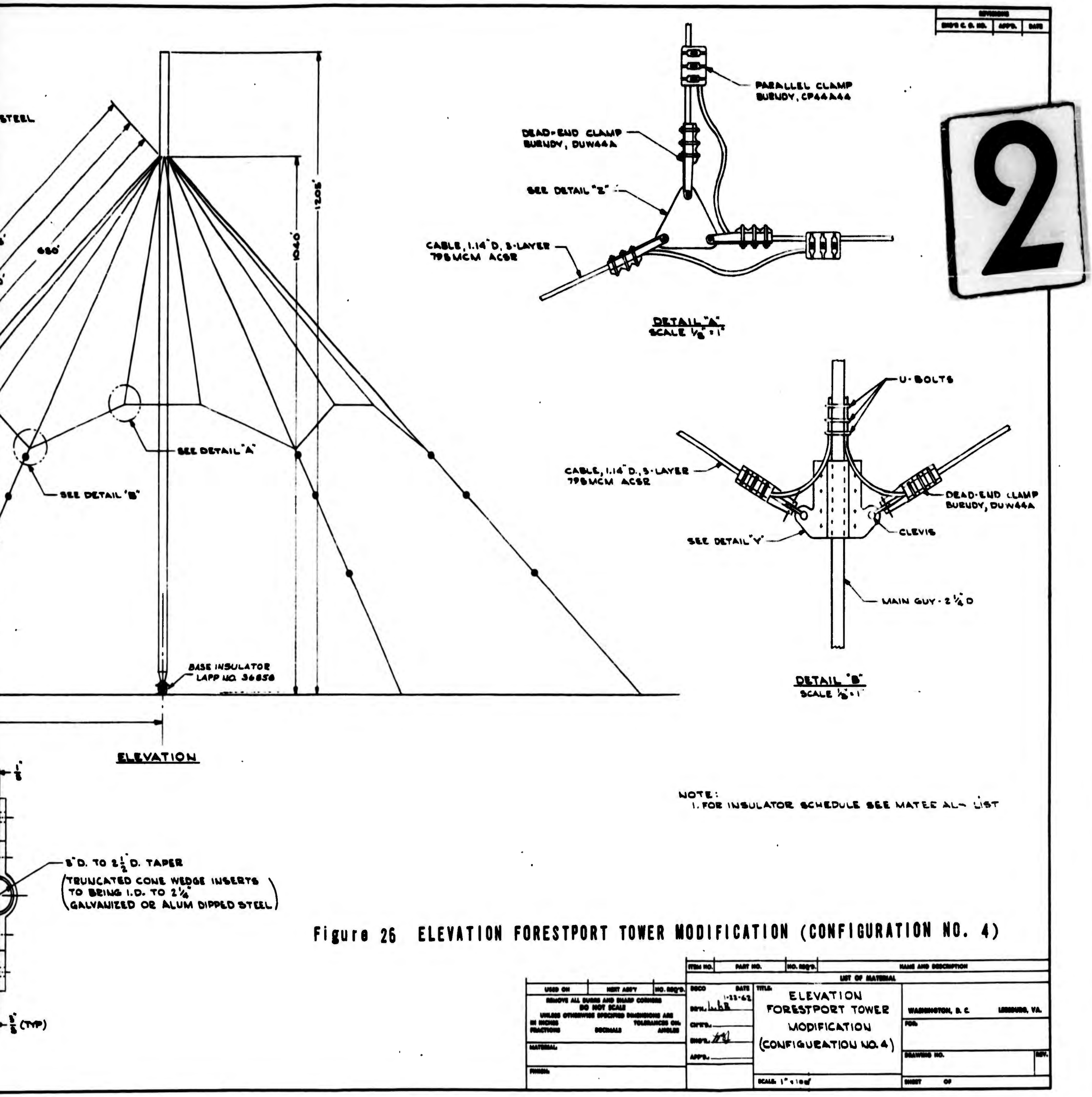


Figure 26 ELEVATION FORESTPORT TOWER MODIFICATION (CONFIGURATION NO. 4)

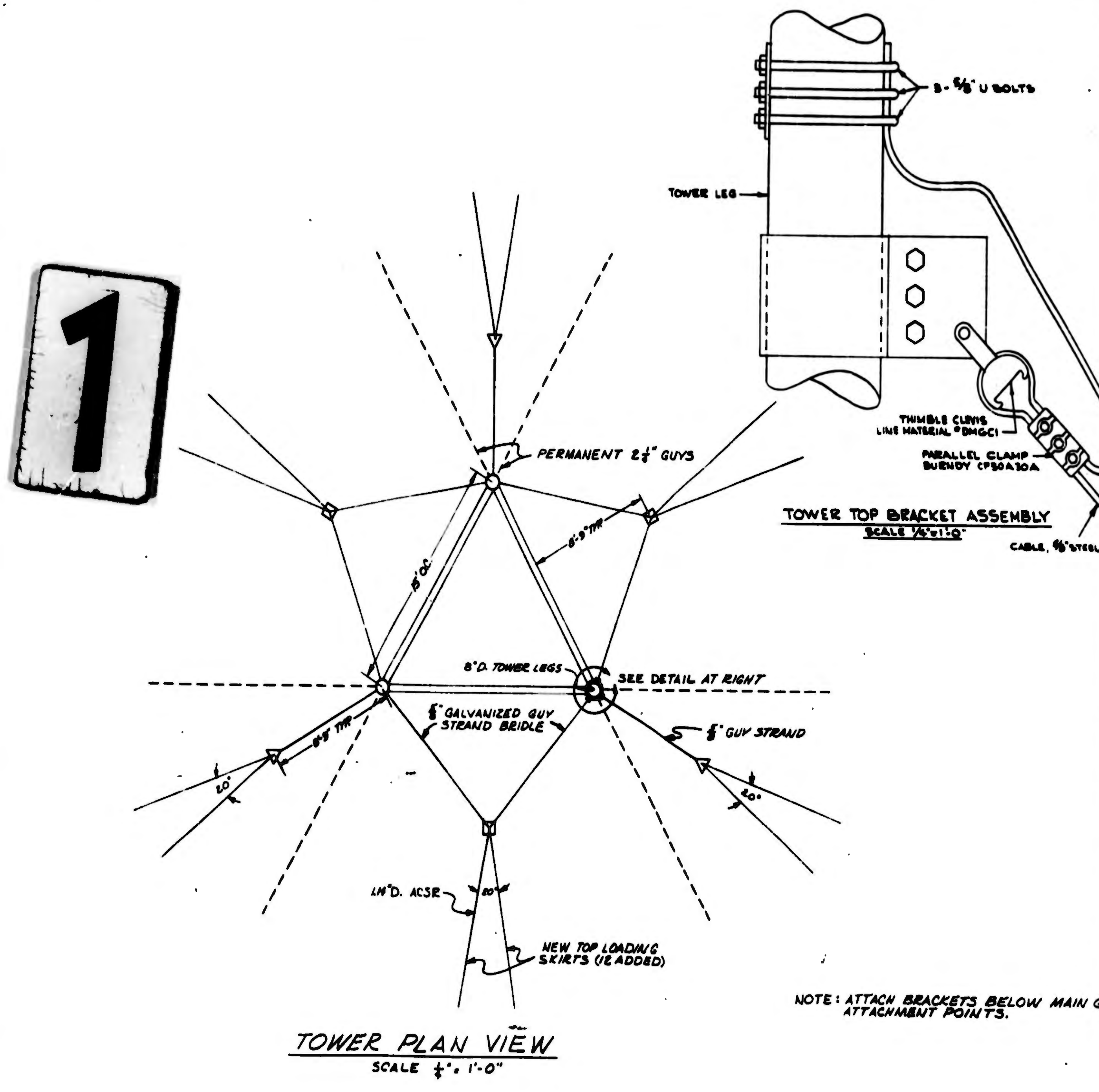
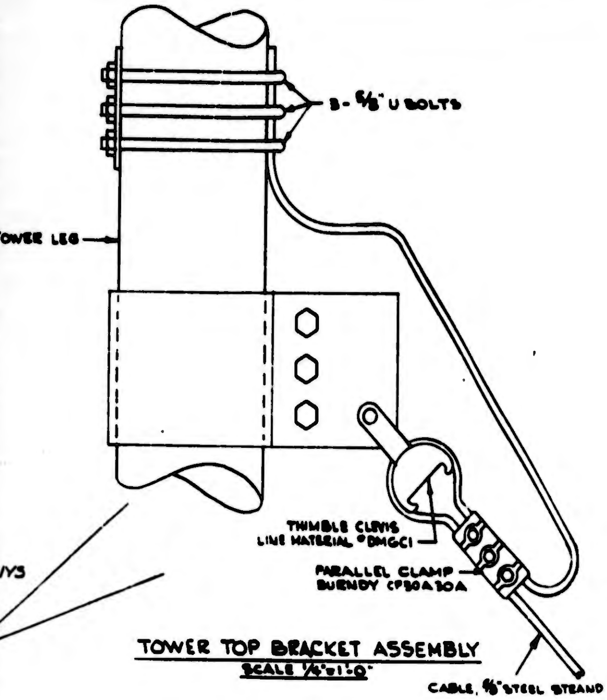
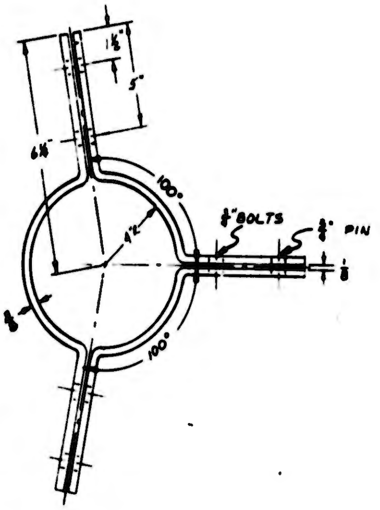


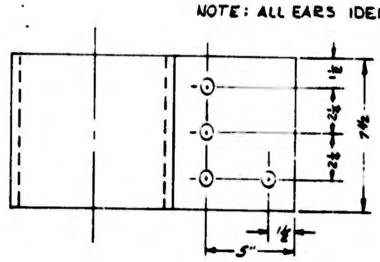
Figure 27 PLAN VIEW FORESTPORT TOWER MODIFICATION (CONFIGURATION NO. 4)



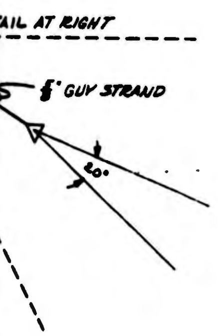
TOWER TOP BRACKET ASSEMBLY
SCALE 1/4"=1'-0"



NOTE: ALL EARS IDENTICAL



TOWER TOP BRACKET
MATERIAL: 3/8" x 7½" STRAP
SCALE ½"= 1"



NOTE: ATTACH BRACKETS BELOW MAIN GUY ATTACHMENT POINTS.

2

ION (CONFIGURATION NO. 4)

REVISIONS

LIST OF MATERIAL

PLAN VIEW
FORESTPORT TOWER
MODIFICATION
(CONFIGURATION NO.4)

WASHINGTON, D.C. LEESBURG, VA.

MATERIAL: NOTED

SCALE: NOTED

SHEET 1 OF 1

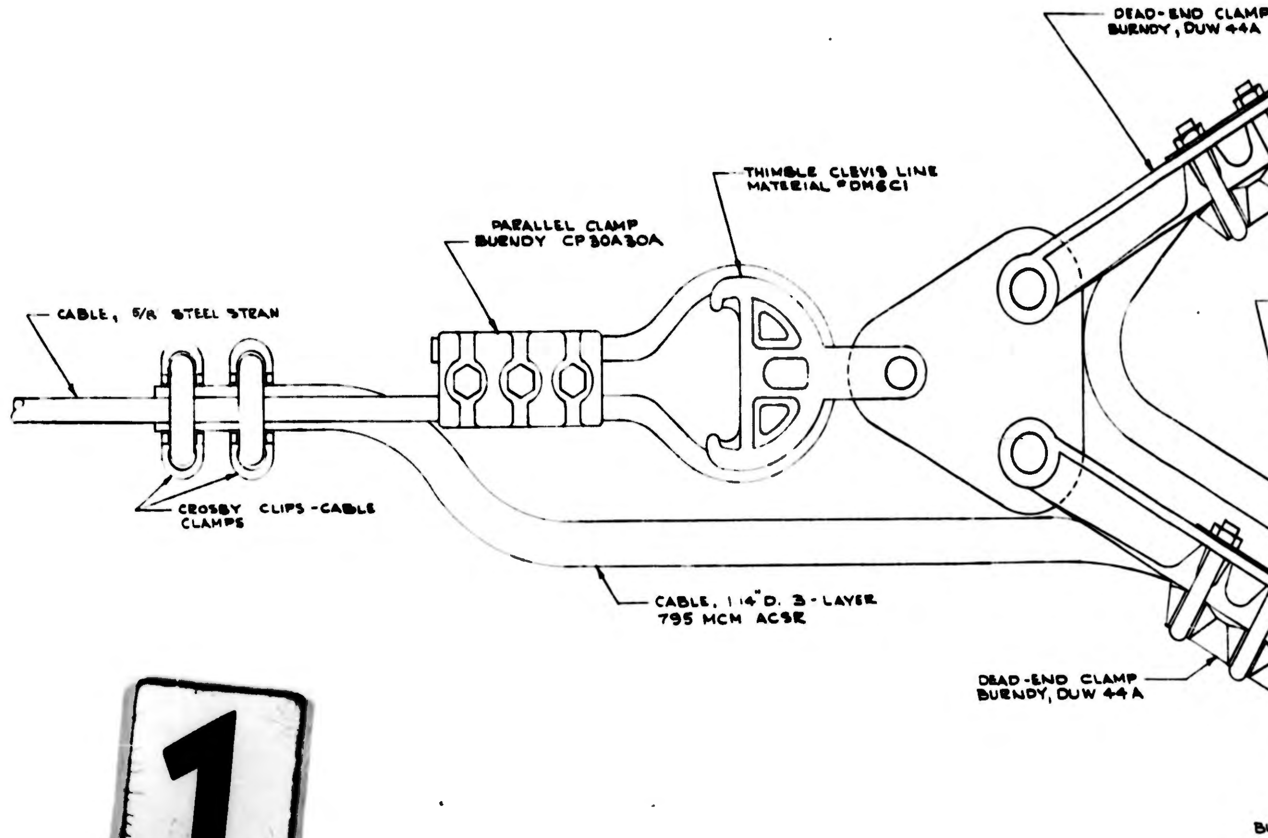
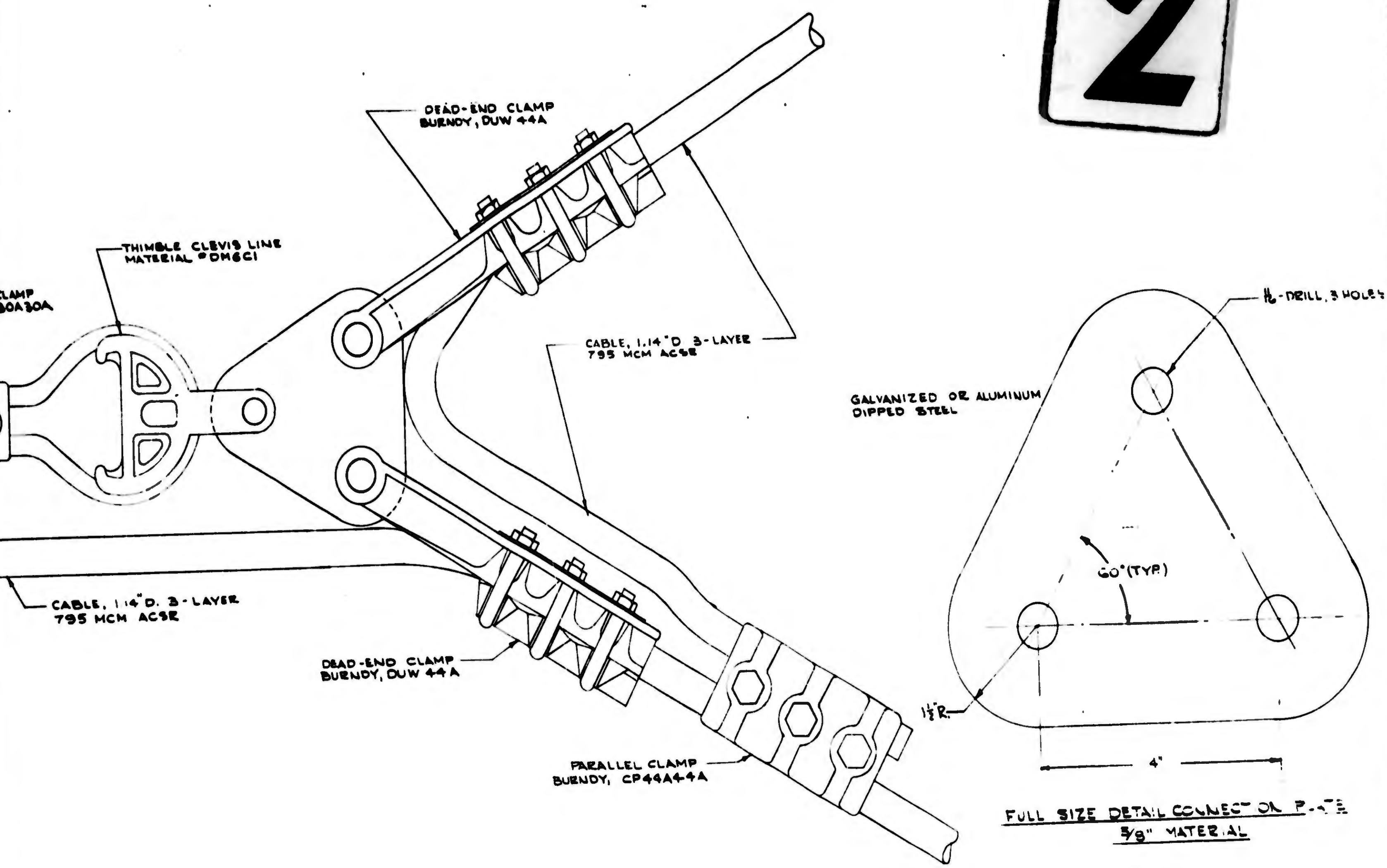


Figure 28 TOP LOAD TOWER LEG CONNECTOR FORESTPORT TOWER MODIFICATION (CONFIGURATIO

2



OR FORESTPORT TOWER MODIFICATION (CONFIGURATION NO. 4)

USED ON	NEXT ASS'Y	NO. REQ'D.

REMOVE ALL BURRS AND SHARP CORNERS
DO NOT SCALE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: FRACTIONS — DECIMALS — ANGLES —

MATERIAL:

FINISH:

ITEM NO.	PART NO.	NO. REQ'D.	NAME AND DESCRIPTION

LIST OF MATERIAL

DSGD — DATE 1-24-63
DRN. — CHK'D. — ENG'D. — APP'D.

TITLE: TOP LOAD TOWER LEG CONNECTOR FORESTPORT TOWER MODIFICATION (CONFIGURATION NO.4)

WASHINGTON, D. C. — LEESBURG, VA.

FOR:

DRAWING NO. — REV.

SCALE: AS NOTED

SHEET 1 OF 1

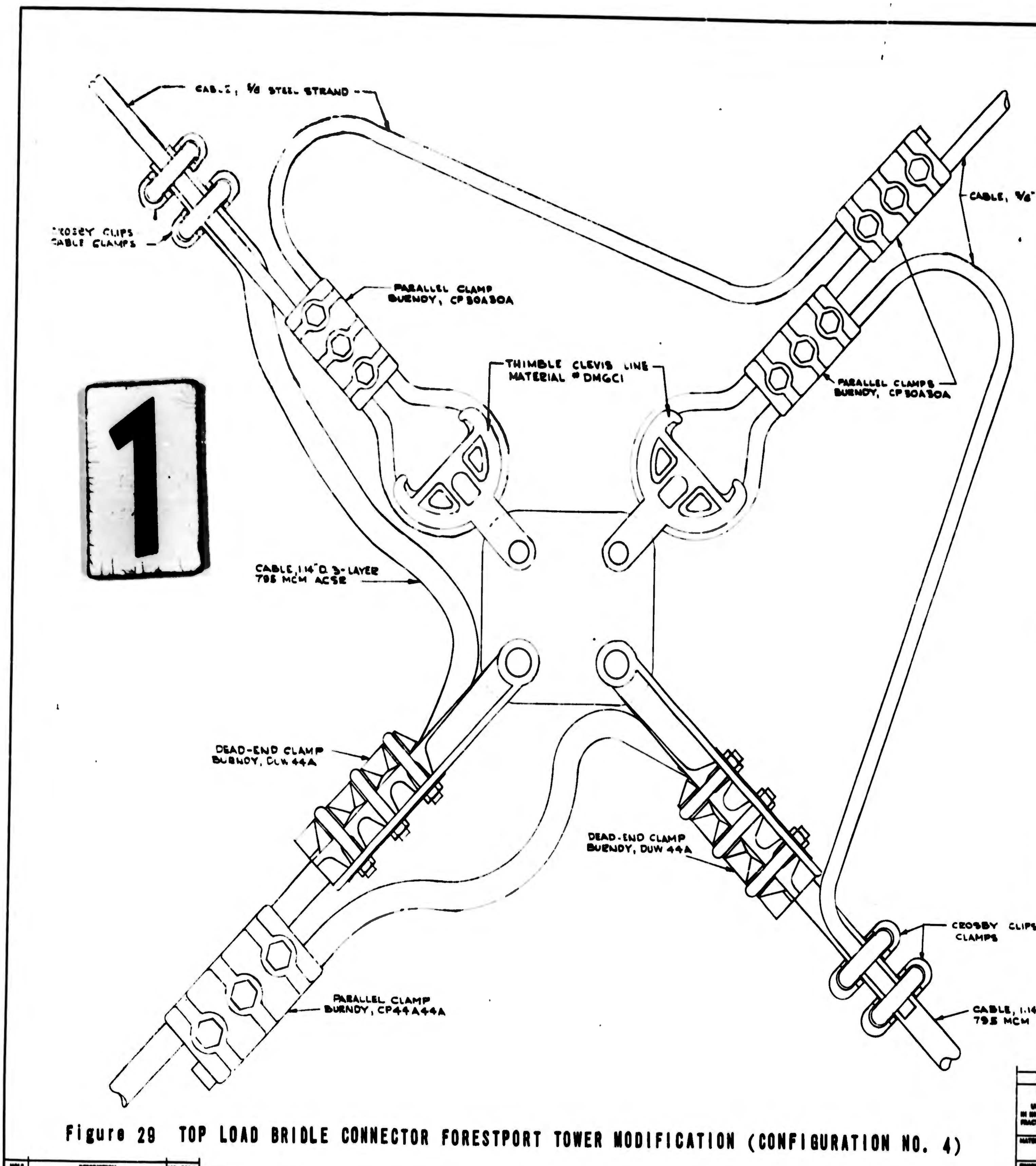
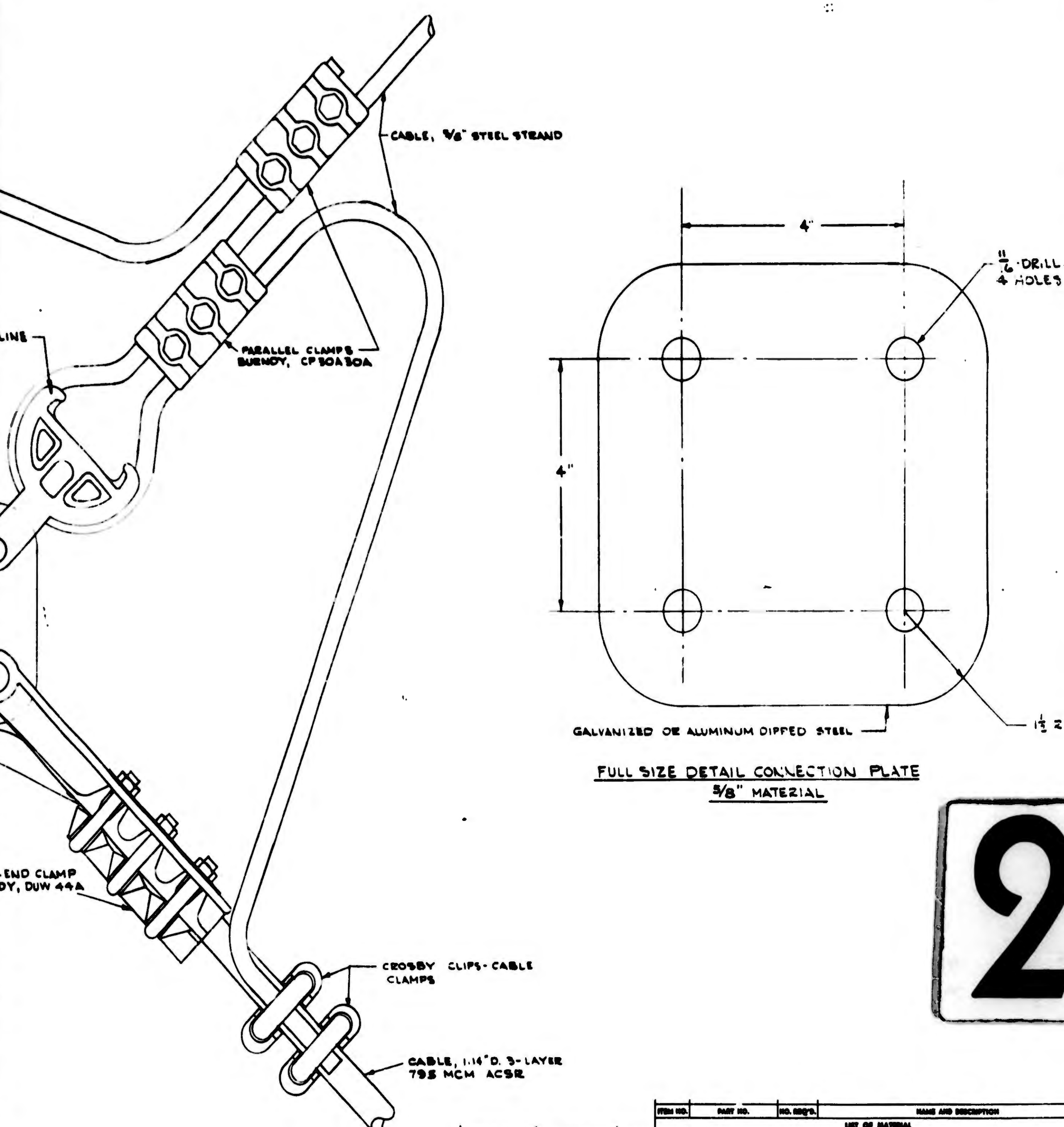


Figure 29 TOP LOAD BRIDLE CONNECTOR FORESTPORT TOWER MODIFICATION (CONFIGURATION NO. 4)



FULL SIZE DETAIL CONNECTION PLATE
5/8" MATERIAL

2

MODIFICATION (CONFIGURATION NO. 4)

ITEM NO.	PART NO.	NO. REQ'D.	NAME AND DESCRIPTION

LIST OF MATERIAL

USED ON	NEXT ASS'Y	NO. REQ'D.

REMOVE ALL BURRS AND SHARP CORNERS
DO NOT SCALE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: FRACTIONS DECIMALS ANGLES

MATERIAL: NOTED

FINISH:

DSGD 1-24 DATE 62
DR'N. Nf P
CH'K'D.
ENG'R. [illegible]
APP'D.

TITLE: TOP LOAD BRIDLE CONNECTOR FORESTPORT TOWER MODIFICATION (CONFIGURATION NO.4)

SCALE: NOTED

WASHINGTON, D. C. LEESBURG, VA.

FOR:

DRAWING NO.

REV.

SHEET 1 OF 1

REVISIONS		
ENG'G C. O. NO.	APP'D.	DATE

Appendix I: LIST OF MATERIAL FOR RECOMMENDED FORESTPORT ANTENNA MODIFICATION (CONFIGURATION NR 4)

Item	Quantity
Horizontal Connection Bracket	6 each
8" x 8" x 8" Triangular Connection Plate	12 each
Dead-End Clamp - Burndy DUW44A	60 each
Parallel Clamp - Burndy CP44A44	48 each
Clevis & Pin	21 each
Top Tower Bracket	3 each
5/8" Galv. Guy Strand	225 feet
Aluminum Cable - ACSR 795MCM	15,000 feet
4" x 4" Rectangular Connection Plate	3 each
4" x 4" x 4" Triangular Connection Plate	3 each
2-1/4" U-Bolt & Strap	18 each
8" U-Bolt & Strap	9 each
3-Bolt Clamps, 5/8" Guy Strand	18 each
5/8" Cable Clips	9 each
1-1/4" Cable Clips	6 each
Thimble Dead End - DM6C1	18 each

For increased voltage handling ability, add:

LAPP Nr 43710 Insulators	24 each (2 each in top and intermediate guys)
LAPP Nr 43709 Insulators	12 each (2 each in lower group)
LAPP Nr 36858 Base Insulator Assembly*	1

* To be inserted between present base insulator and tower.

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Contract AF 30(602) - 2588

Unclassified report

This report presents the results of a study to determine the feasibility of modifying the U. S. Air Force Forestport vlf antenna to increase its power radiating capability to 500 watts. Ten possible top-hat configurations are investigated by scale-model techniques. The model ranges and antennas, instrumentation, and methods of measurements are described in detail. The (over)

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