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Special Technical Report 8

FIELD TESTS OF VHF MAN-PACK RADIOS

By: N. K. SHRAUGER

Prepared for:

U.S. ARMY ELECTRONICS LABORATORIES
FORT MONMOUTH, NEW JERSEY

CONTRACT DA-36-039-AMC-00040(E)
ORDER NO. 5384-PM-63-91
PR&C NO. 64 ELN/D-6034
ARPA ORDER NO. 371

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

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SRI Project 4240

Approved: W. R. VINCENT, MANAGER
COMMUNICATION LABORATORY

D. R. SCHEUCH, DIRECTOR
ELECTRONICS AND RADIO SCIENCES

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PREFACE

The work described in this report was performed with the support of the Military Research and Development Center at Bangkok, Thailand, a joint United States-Thailand organization. The cooperation of staff members of the Thailand Ministry of Defense, the United States Advanced Research Projects Agency, and the United States Army Electronics Laboratories made possible the work described.

Computation for the report was performed by Vichit Lorchirachoonkul. Test team members were:

Kenneth Taylor, Test Team Leader

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Manit Downkhanon, Chief Petty Officer, RTN

Sathorn Meudorn, Master Sergeant, RTAF.

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ILLUSTRATIONS

TABLES

I INTRODUCTION

At the request of the Advanced Research Projects Agency and the United States Army Electronics Laboratories, a field test program was conducted in Thailand to determine the performance capability of selected VHF man-pack radio sets. The principal objective of the test program was to determine the effective range of the sets in flat, open terrain, with standard whip antennas, and under controlled conditions simulating potential operational situations. Secondary objectives were to compare variations in performance between day and night, variations with changes in frequency, and variations with changes in antenna position and height. The tests were conducted over the delta region near Bangkok. The following sets were tested:

AN/PRC-35 (XC-3) radio set
AN/PRC-25 radio set
AN/PRC-25 with 15-watt amplifier
AN/PRC-25 with 35-watt amplifier
Motorola Handie-Talkie FM Radiophone, Model H21DCN-1000.

Figure 1 is a photograph of these sets.

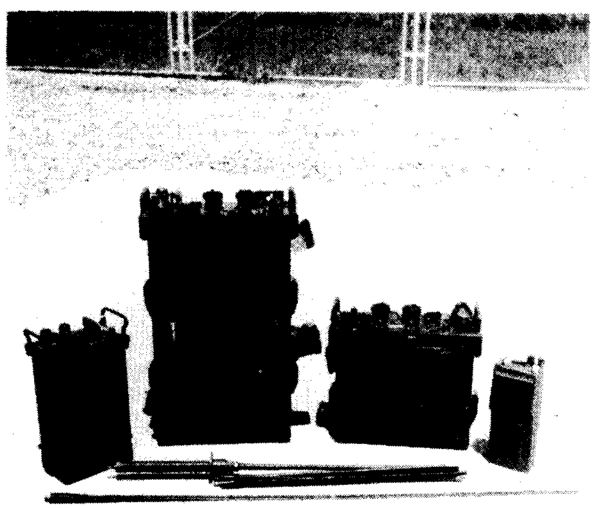

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FIG. 1 PHOTOGRAPH SHOWING SETS TESTED

II DESCRIPTION OF SETS TESTED

The laboratory was supplied with three units of each set to be tested and three units of the power amplifier for use with the AN/PRC-25. The descriptions given are from manuals supplied with the sets. In some cases, the only available manual was for an earlier experimental model of the set tested. Thus the specifications given may not be exact for the sets actually tested.

A. AN/PRC-35 (XC-3) RADIO SET

The AN/PRC-35 radio set is a compact, man-portable, FM transceiver designed for short-range voice communication.[1*] It is completely transistorized and battery powered. A tuning mechanism permits pre-setting of four frequency channels, any one of which can then be selected instantly by turning a single front-panel selector switch. For portable use, the 3-foot whip antenna is mounted on the front panel. The front panel also provides a 50-ohm connection for auxiliary antennas. Table I gives some characteristics of this set.

B. AN/PRC-25 RADIO SET

The AN/PRC-25 radio set is a short-range, man-pack FM receiver transmitter used for two-way voice communication in the frequency range of 30 to 75.95 Mc, with continuous tuning over the frequency range.[2] The transceiver uses transistors in all stages except the transmitter power-output stage. Table II gives the characteristics of this set.

C. POWER AMPLIFIER

The power amplifier approximately doubles the operating distance of the AN/PRC-25. When assembled with the AN/PRC-25, the amplifier provides a selection of 15 or 35 watts of RF power in the 30-to-53-Mc band.[3] Batteries are used for power. The battery pack and amplifier weigh 14 pounds; together with the AN/PRC-25, they weigh 31.7 pounds.

---

*References are given at the end of the report.

Table I

CHARACTERISTICS OF THE AN/PRC-35 RADIO SET

Frequency range	30 to 69.95 Mc in 50-kc intervals
Type of modulation	Narrow-band FM with ±10-kc nominal peak deviation
Type of transmission	Voice
Power source	20-cell dry battery, tapped at 9 cells to give voltages of 11.7v and 26v at 1.3 v/cell
Total weight	10.5 lb
Antenna	3-ft whip (also provision for 50-ohm auxiliary antenna connection)
Power output	300 mw into 50 ohms at any frequency in the 30-to-69.95-Mc range
Range	Approximately 2 miles under favorable terrain conditions
Receiver sensitivity	1 μv
Selectivity	35 kc minimum (6 db down); 60/6-db shape factor, 2.5 maximum

Table II

CHARACTERISTICS OF THE AN/PRC-25 RADIO SET

Frequency range	30 to 75.95 Mc
Type of modulation	FM
Type of transmission	Voice
Power source	3v, 15v, and 150v required--available from either low-voltage battery or vehicular power supply and converter
Total weight	17 lb with converter and low-voltage battery
Antennas	3-ft whip and 10-ft whip
Power output	1.5w
Receiver sensitivity	0.7 μv RF to give 10-db S/N
Limiting	Less than 3-db change in audio for RF variation of 3 to 10,000 μv

D. MOTOROLA HANDIE-TALKIE FM RADIOPHONE

The completely transistorized Motorola Handie-Talkie FM radiophone (Model H21DCN-1000) is a portable, hand-held, communication unit.[4] It is a battery-powered radio capable of two-way communication with any FM radio set within range and operating on the same frequency. The unit is weatherproofed and is small enough to be carried in a pocket. Its characteristics are given in Table III.

Table III

CHARACTERISTICS OF THE HANDIE-TALKIE FM RADIOPHONE

Modulation	FM
Total weight	2.25 lb
Power output	1.4w
Receiver sensitivity	Less than 0.35 μv for 20-db quieting
Frequency	25 to 54 Mc crystal controlled
Range	Not given by manufacturers

III DESCRIPTION OF THE TESTS

A. GENERAL

The tests were conducted in a flat, open area typical of much of Southeast Asia, in a delta region a few kilometers northeast of Bangkok. The land between test locations was free of villages or other man-made construction. This land is used for rice growing and contains the occasional low dykes and waterways found in such areas; no significant changes in elevation exist. At the time the tests were conducted, 9-20 April 1964, the rice paddies were dry, and the water table was low (a few feet below the earth's surface). No rain or thunderstorms occurred in this area during the test period.

After a fixed transmitting site had been located in this region, a series of tests were made at temporary receiver sites at various distances from the transmitter. Auxiliary HF communications were maintained between the fixed and mobile sites. Figure 2 shows a map of the area used for testing. Figures 3 through 8 are photographs illustrating the terrain near typical test sites.

B. FIELD STRENGTH TESTS

At each site, signal strength and noise readings were obtained from a dc recorder which monitored a rectified output of an IF stage prior to the receiver limiting stages of a set being tested. The recorder was calibrated by applying a signal from a Hewlett Packard Model 606A signal generator to the input of the set. This measurement also conveniently insured that the set was operating properly throughout the tests. The power output of the sets was fixed except when a power amplifier was used. This power amplifier has variable loading and was adjusted to either 15 or 35 watts. Before each transmission, the RF power output of the transmitter was measured by using a Bird Electronics Inc. Model 611 absorption RF wattmeter. Power was measured at the 50-ohm antenna output jack of each set to insure a proper impedance match into the

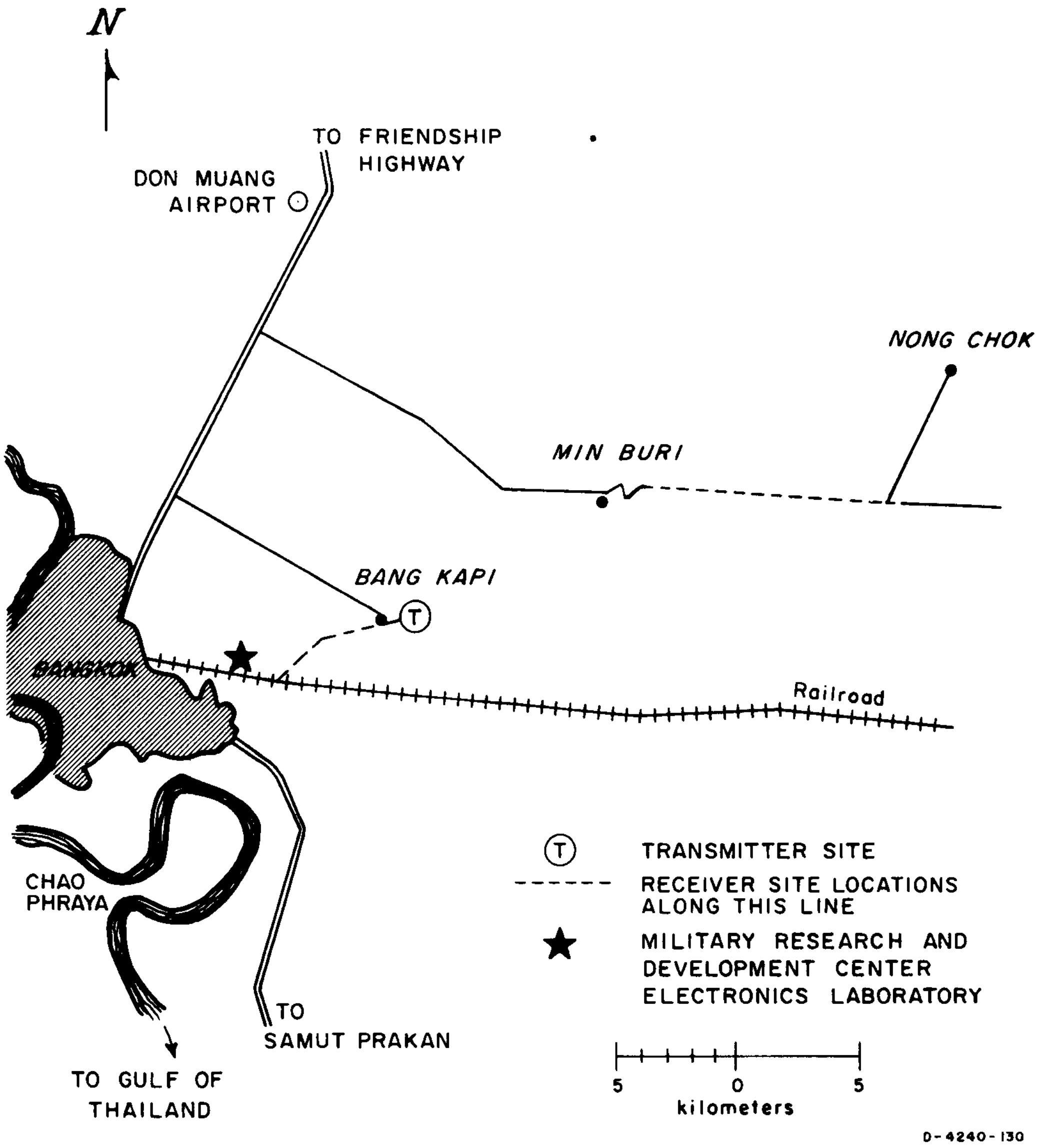


FIG. 2 MAP SHOWING LOCATION OF DELTA AREA TEST SITES

wattmeter. These measurements also served as a means of monitoring the transmitter to insure proper and consistent operation throughout the tests.

Other procedures were followed to insure consistent operation of the sets. Before and after each field test, all sets were checked to insure that they met the manufacturer's specifications as given in the available references. (These measurements are given in Appendix A.)

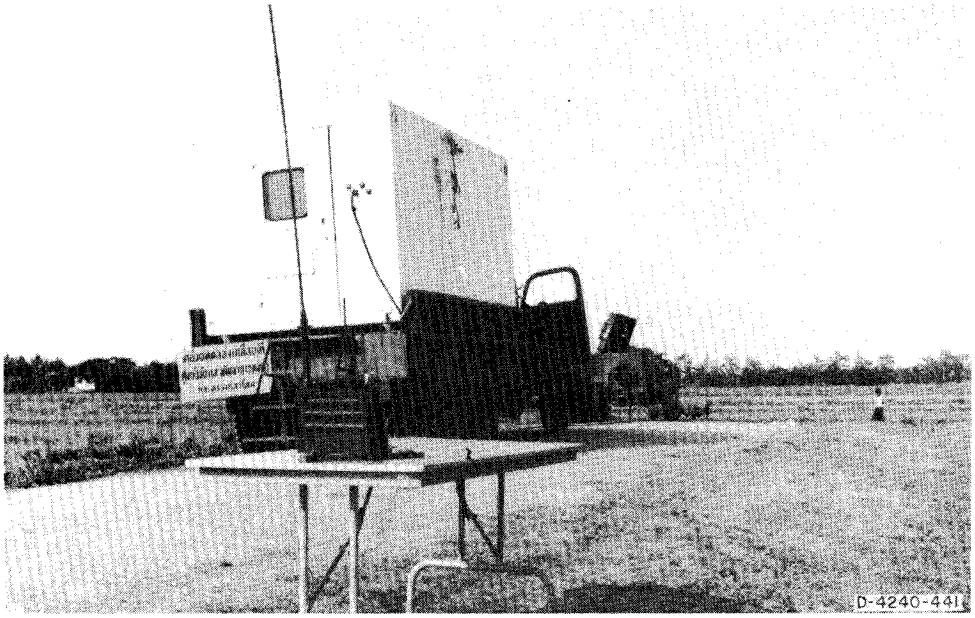


FIG. 3 TRANSMITTER SITE SHOWING AN AN/PRC-25

FIG. 4 A TYPICAL DRY RICE FIELD IN THE TEST AREA

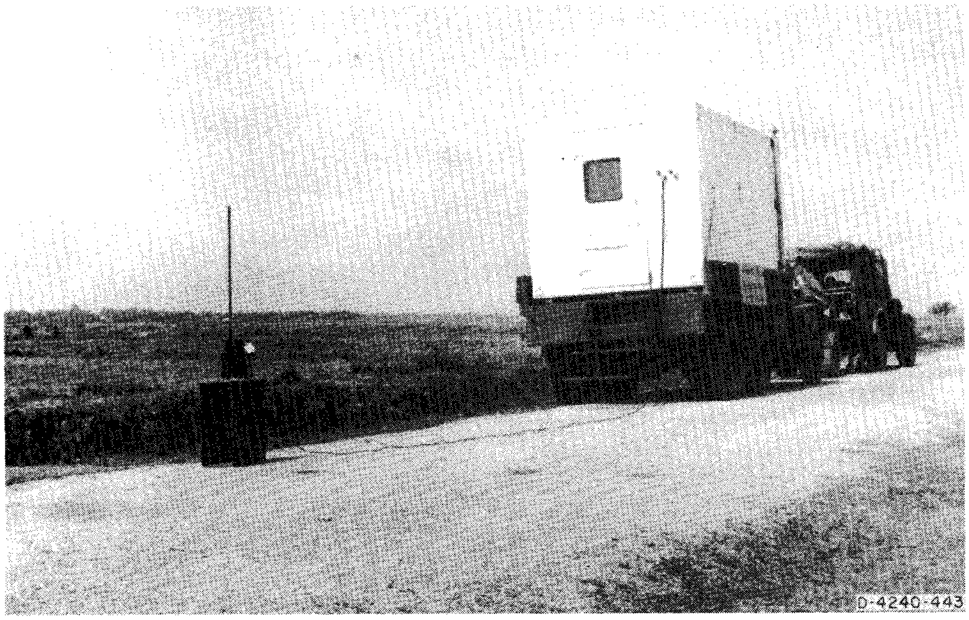


FIG. 5 A TEMPORARY RECEIVER SITE NEAR BANG KAPI SHOWING AN AN/PRC-35 (XC-3)

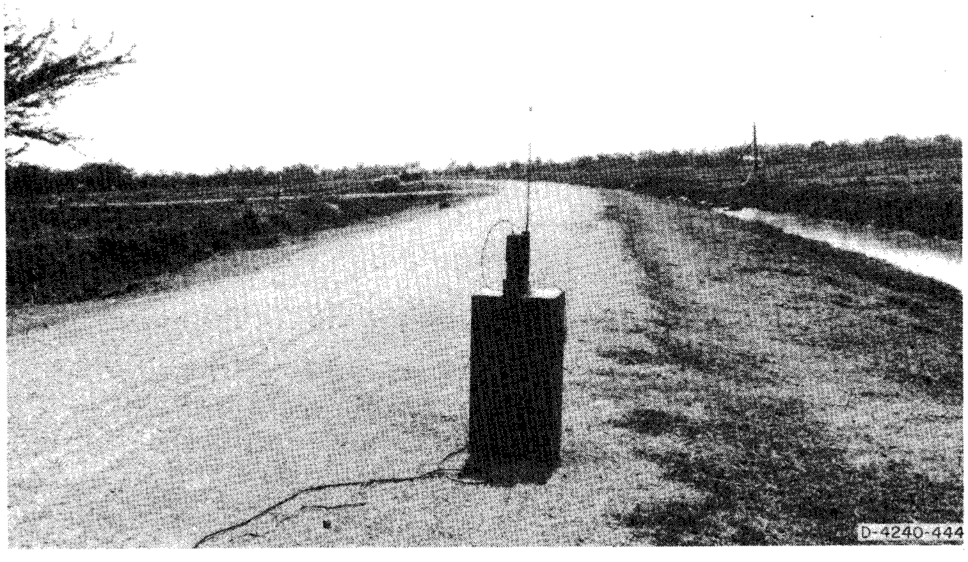
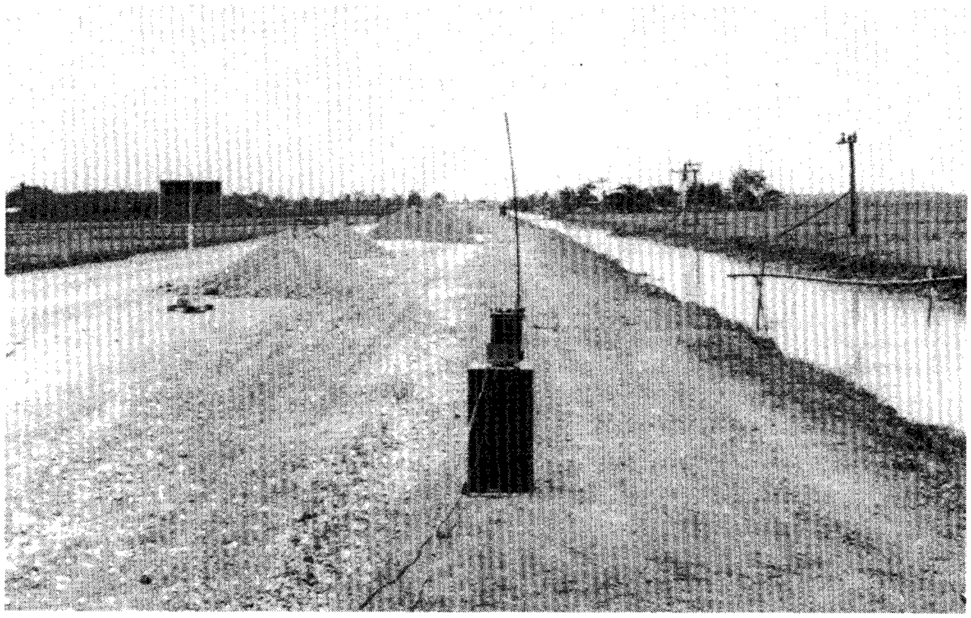


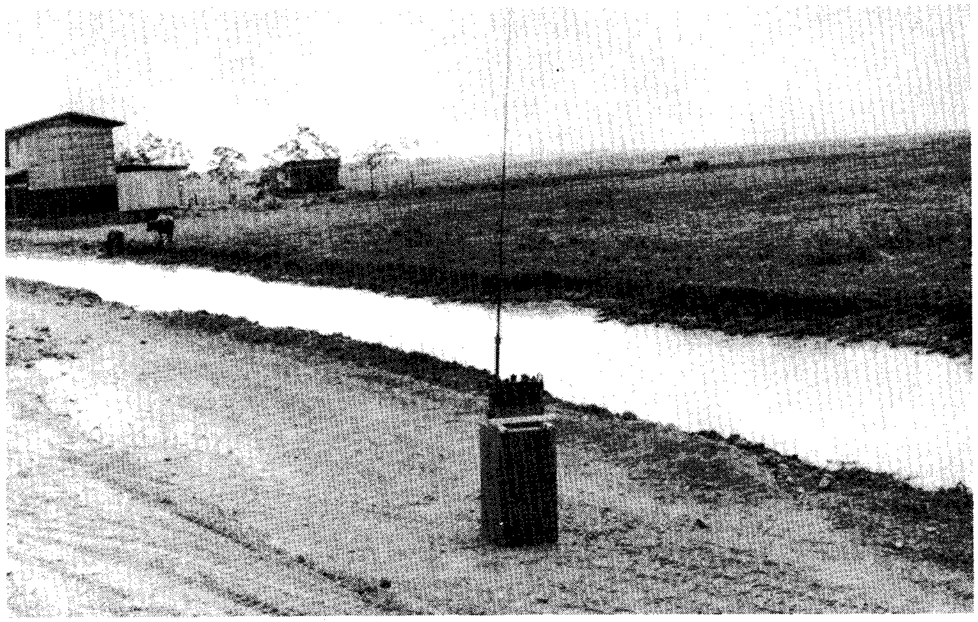
FIG. 6 A TEMPORARY RECEIVER SITE NEAR BANG KAPI SHOWING A MOTOROLA HANDIE-TALKIE



a

b

FIG. 7 TEMPORARY RECEIVER SITES NEAR BANG KAPI



c

d

FIG. 7 Continued

e

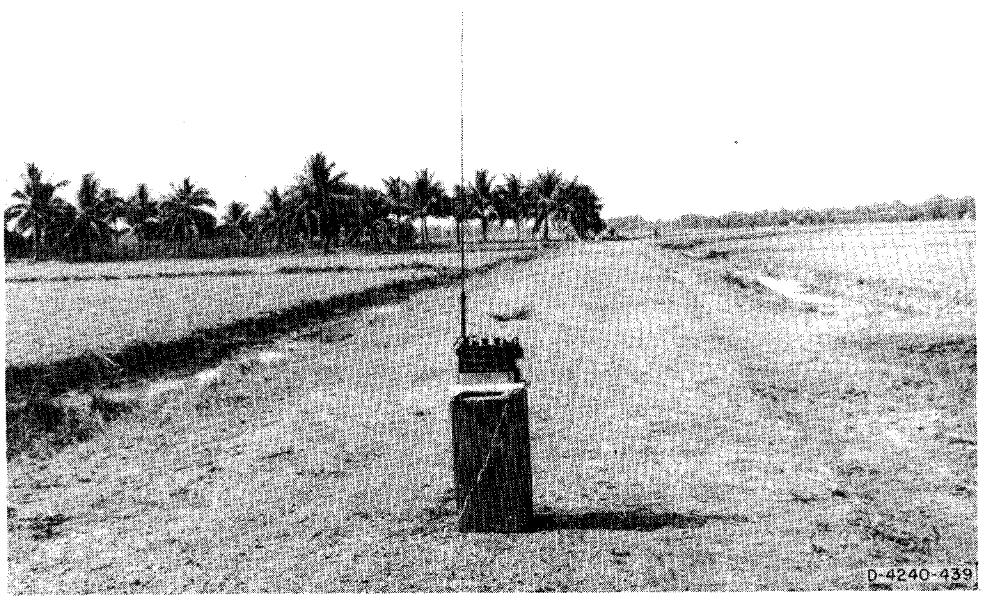


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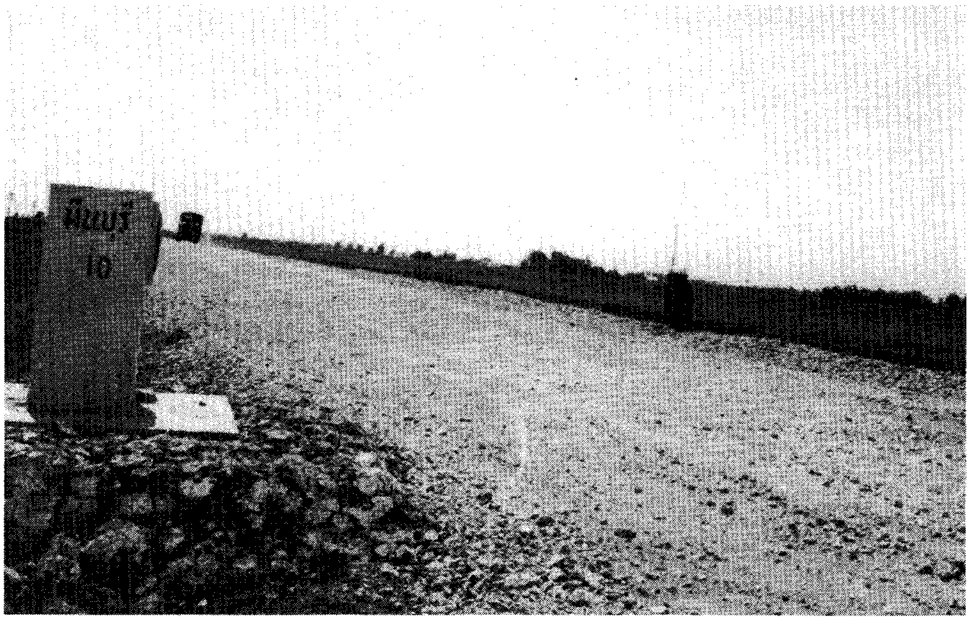
FIG. 7 Concluded



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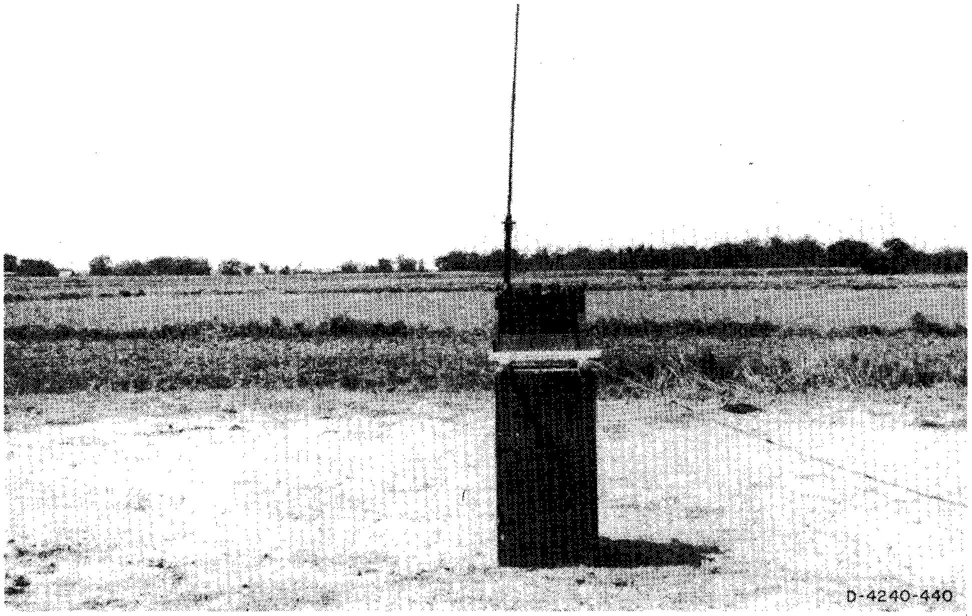
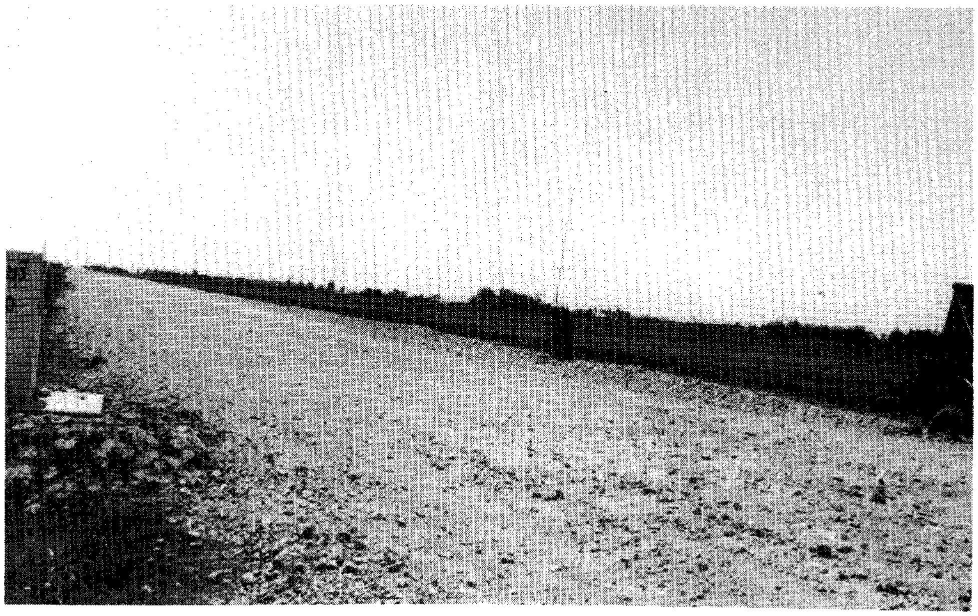


b

FIG. 8 TEMPORARY RECEIVER SITES NEAR MIN BURI



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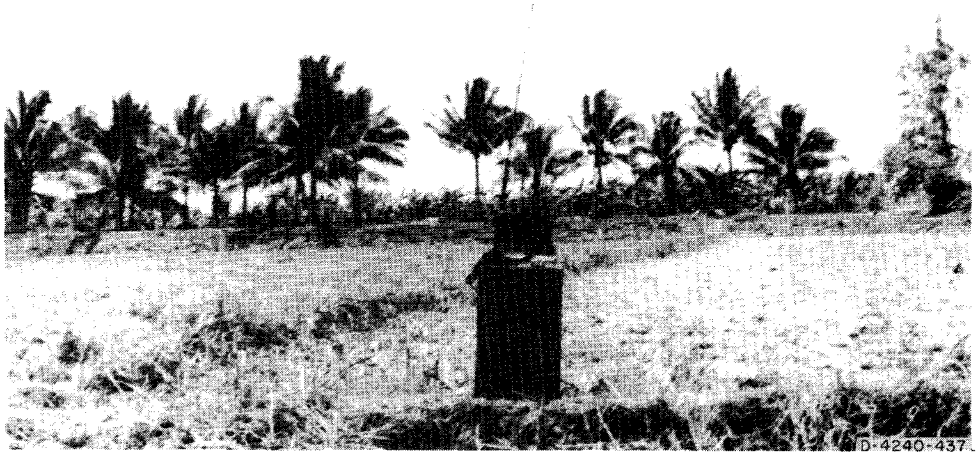

d

FIG. 8 Continued

For each transmission during the test series, the received noise was monitored by recording the received signal for a period before the transmitter was turned on and after it was turned off. Auxiliary power supplies were used to eliminate the effects of battery drain on set performance. During the measurements the antennas were maintained at a fixed height above the ground. At selected sites near the range limitation of a set, however, several other antenna heights were used to give some idea of the height required to establish voice contact. Four frequencies were used for the tests: 35, 51, and 64 Mc for the AN/PRC-25 and AN/PRC-35 (XC-3) and 50.7 Mc for the Motorola Handie-Talkie.

The day-versus-night performance of the AN/PRC-35 (XC-3) was investigated by transmitting hourly over a 24-hour period. For this investigation, a receiver site was chosen at a distance near the range limit of the set, to provide a more sensitive check of set performance.

C. INTELLIGIBILITY TESTS

Simultaneously with the field strength tests, intelligibility tests were performed on the AN/PRC-35 (XC-3). Since duplicate equipment was not available for conducting intelligibility tests on all the sets at once and time was not available for repeating the tests, only sample tests were conducted. Prerecorded word lists were transmitted and received by the AN/PRC-35 (XC-3) under the conditions described for the field strength tests.

The word lists used, developed by Fairbanks and known as Rhyme Tests,[5] were chosen to provide a critical and sensitive intelligibility test. No recorded lists to accurately simulate military messages were known to be available. An example of a Rhyme Test is given in Table IV; it consists of 50 word stems, each of which could become several different words, depending upon the consonant preceding it. The test is designed to make the listener differentiate between several phonemes.*

*A phoneme is the smallest unit of speech that, in any given language, distinguishes one utterance from another, as the p in pin and the f in fin.

Table IV

A RHYME TEST

1.	hot	11.	tire	21.	men	31.	sin	41.	tail
2.	pay	12.	male	22.	park	32.	bust	42.	fight
3.	top	13.	sent	23.	coil	33.	fine	43.	torn
4.	feel	14.	moon	24.	big	34.	mink	44.	rod
5.	wake	15.	kick	25.	rage	35.	sold	45.	dock
6.	law	16.	same	26.	cast	36.	hit	46.	bump
7.	vile	17.	wide	27.	gain	37.	led	47.	date
8.	neat	18.	rip	28.	west	38.	tend	48.	well
9.	look	19.	sore	29.	gun	39.	rid	49.	set
10.	fill	20.	bang	30.	heal	40.	back	50.	luck

Six Rhyme Tests pronounced by one speaker were recorded under carefully controlled conditions prior to the field tests.

The tape recorders used in the field tests were operated in air-conditioned vans. The test setup is shown in Fig. 9 and a photograph of a van interior in Fig. 10. Prior to field testing, the recorders were calibrated by using a standard Ampex test tape. Immediately before each test, the recorder was adjusted by the receiving site operator to the correct recording level.

The tests consisted of transmitting two word lists on three frequencies at each site. Transmission time for a word list was about 1.5 minutes. Subsequently, the tapes on which the lists were recorded were sent to the Speech Research Group at Stanford Research Institute, Menlo Park, California, for scoring. The scoring was done by two groups of ten listeners each and consisted of 500 word evaluations (fifty words per test and ten listeners). The intelligibility scores were given as the percentage of correct words for a particular word list used for a particular distance.

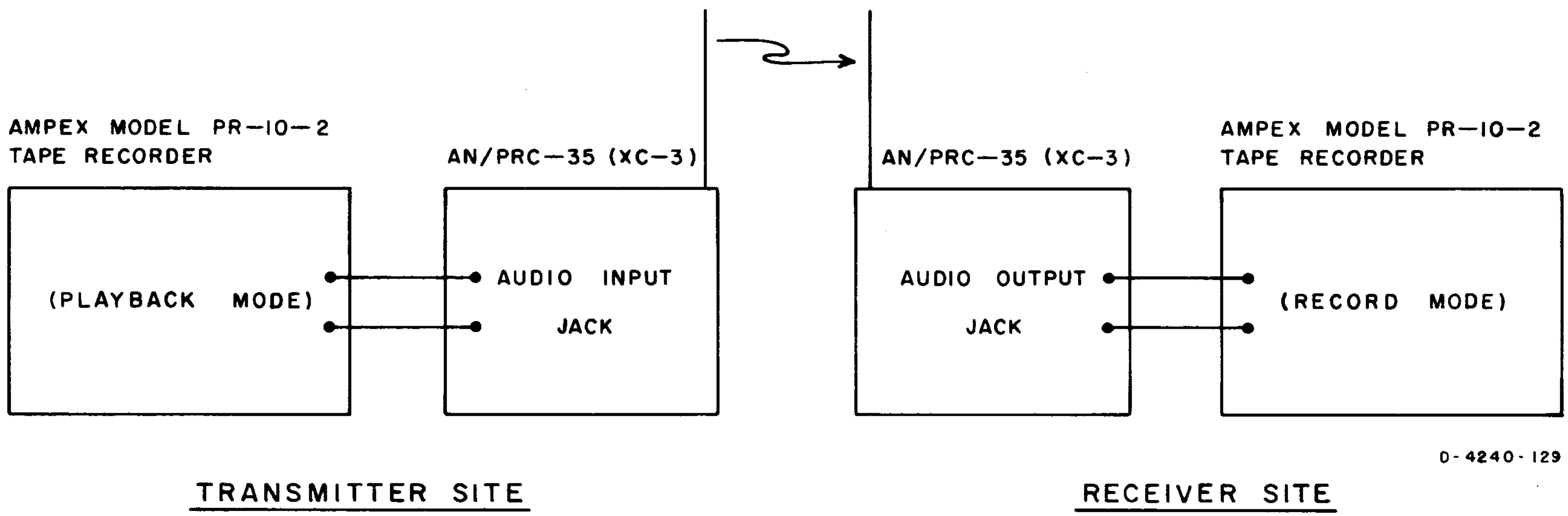

FIG. 9 INTELLIGIBILITY TEST SETUP

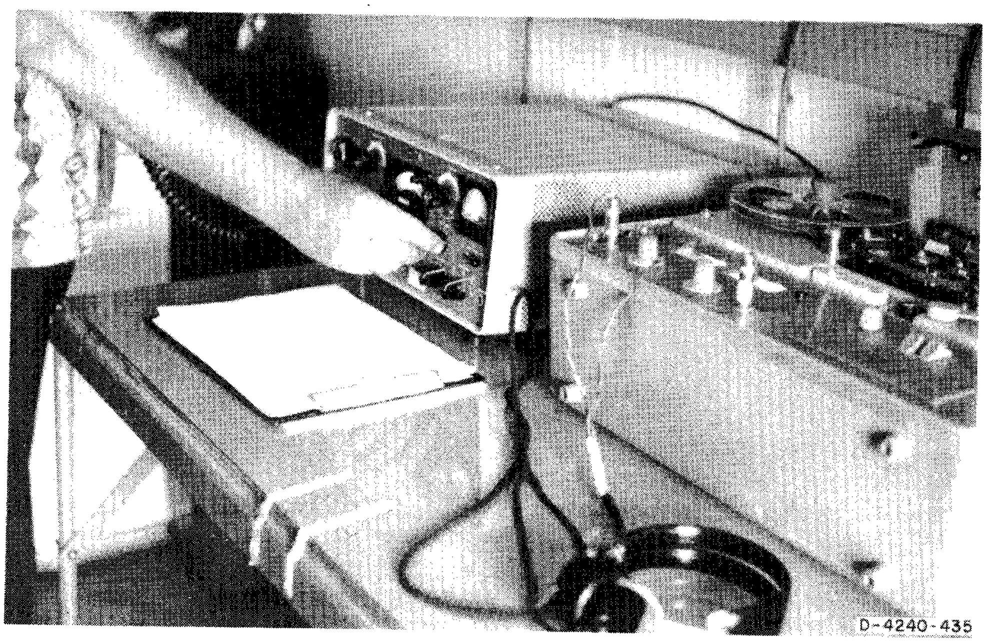

FIG. 10 INTERIOR OF TRANSMITTER VAN

IV RESULTS OF THE TESTS

A. FIELD STRENGTH TESTS

The relationship between the voltage, V, at the receiver antenna terminals and the field strength, E, were developed for each antenna used during the test. These relationships were used in determining received field strengths for the test distance and conditions. (See Appendix B for the development of these relationships and for convenient conversion curves.)

Theoretical received signal strengths were then calculated for each test. Two received signal strength curves were calculated to illustrate the expected difference between types of transmitting antennas, namely a half-wave horizontal dipole above ground and a short vertical antenna. The calculations were based on assumed values for ground conductivity of 15×10^{-14} emu and relative ground dielectric constant of 25. Unity distance free-space field (E_0) values of 137.6 mv/m and 93.2 mv/m (at 1 mile) were used for the dipole and the vertical antenna, respectively. In addition, the theoretical calculation includes the assumed radiated powers of each set.

The results of these computations of signal strength are shown in Figs. 11 through 21, along with the measured results. Antenna efficiencies and patterns, which are not included in the computation of received signal strength, are factors accounting for the difference between calculated and measured signal strengths.

Measured received antenna-terminal voltages converted to equivalent values of signal strength, E, in millivolts per meter have also been plotted in Figs. 11 through 21. A best-fitting curve has been plotted through the measured value by using the least-squares method.

For these tests, effective range is defined as the longest distance that yielded a usable received signal under the given conditions. The usable signal was arbitrarily taken to be 10 db above the average noise

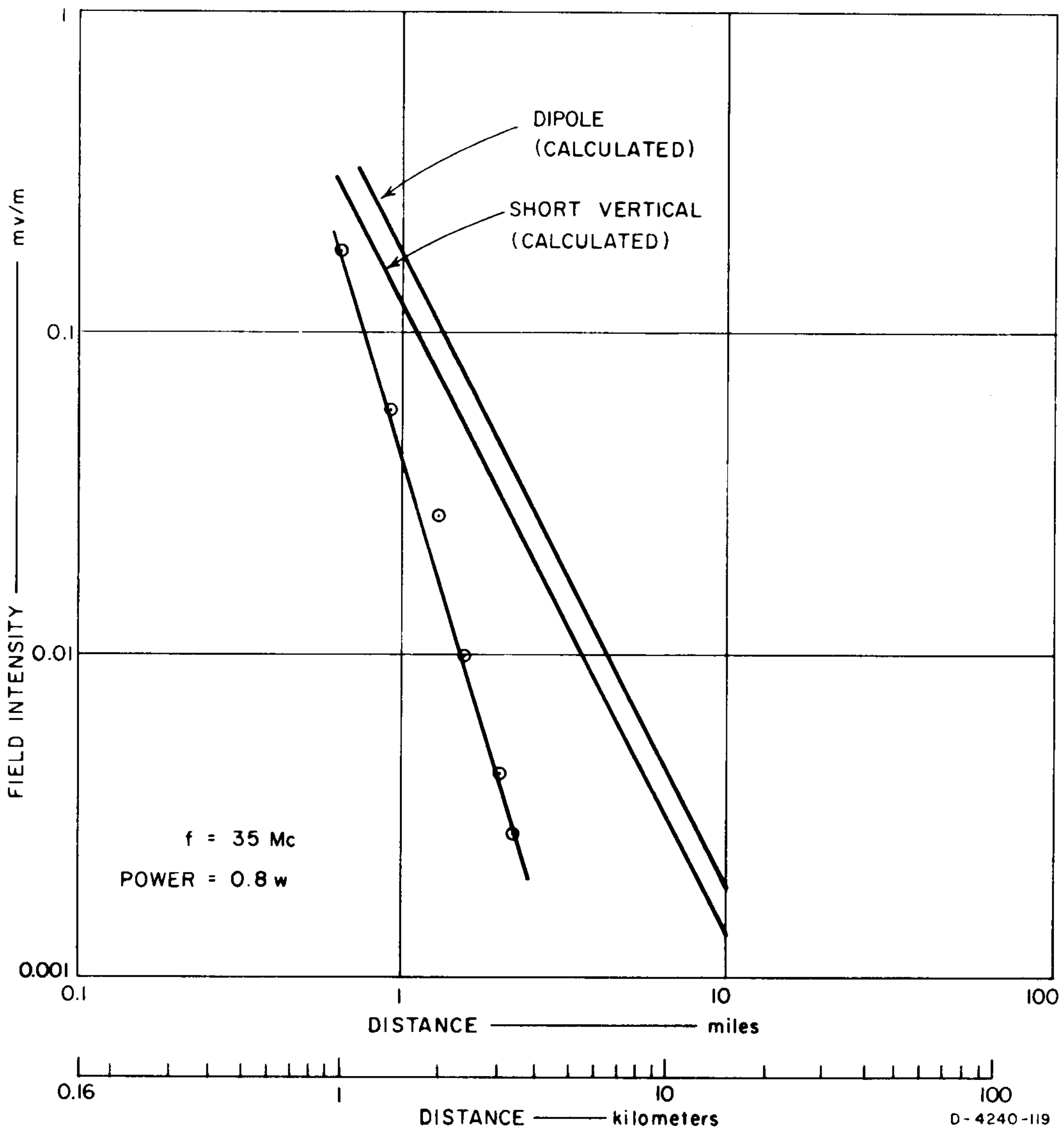

FIG. 11 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-35 (XC-3) — 35 Mc, 0.8 watt

level measured during a particular test.[6] The average noise measured was 0.2 microvolt for the AN/PRC-35 (XC-3), 0.3 microvolt for the AN/PRC-25, and 0.08 microvolt for the Motorola, for the frequencies used. The noise level was measured when no signal was being transmitted; it was calibrated with an HP 606A signal generator connected to the auxiliary antenna terminal. The noise output level did not change when the antenna was removed and the set was connected to the

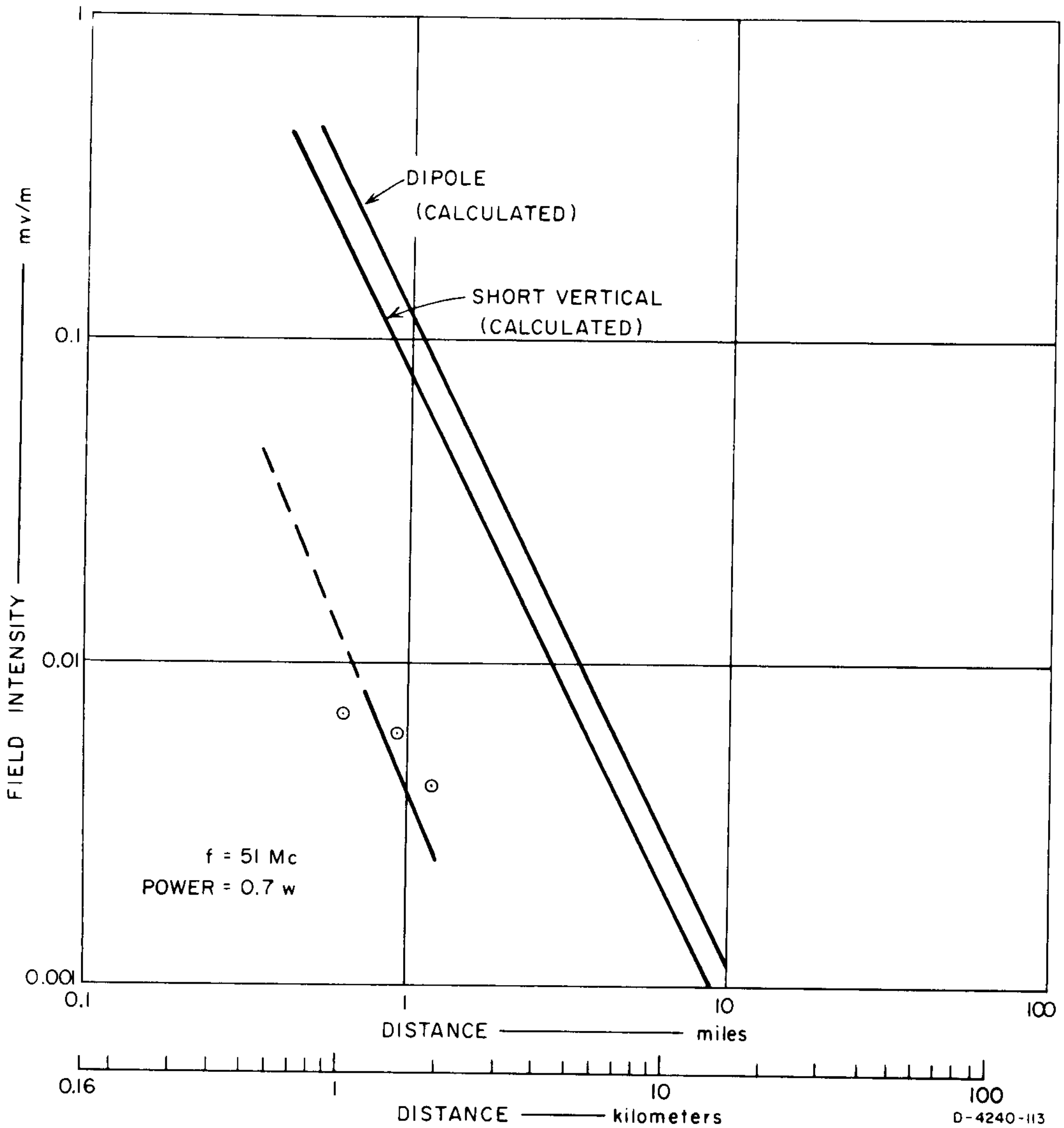

FIG. 12 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-35 (XC-3) — 51 Mc, 0.7 watt

signal generator unless an interfering signal was present. During the long-range power amplifier tests, high interference was encountered on 35 Mc. This noise was riding on the carrier signal and was limited by the receiver with no noticeable effect on intelligibility. The results of the range tests are summarized in Table V. It was observed during pre-test checkouts of the sets that the receiver sensitivity of the AN/PRC-25 sets was considerably higher than that of the AN/PRC-35 (XC-3) sets.

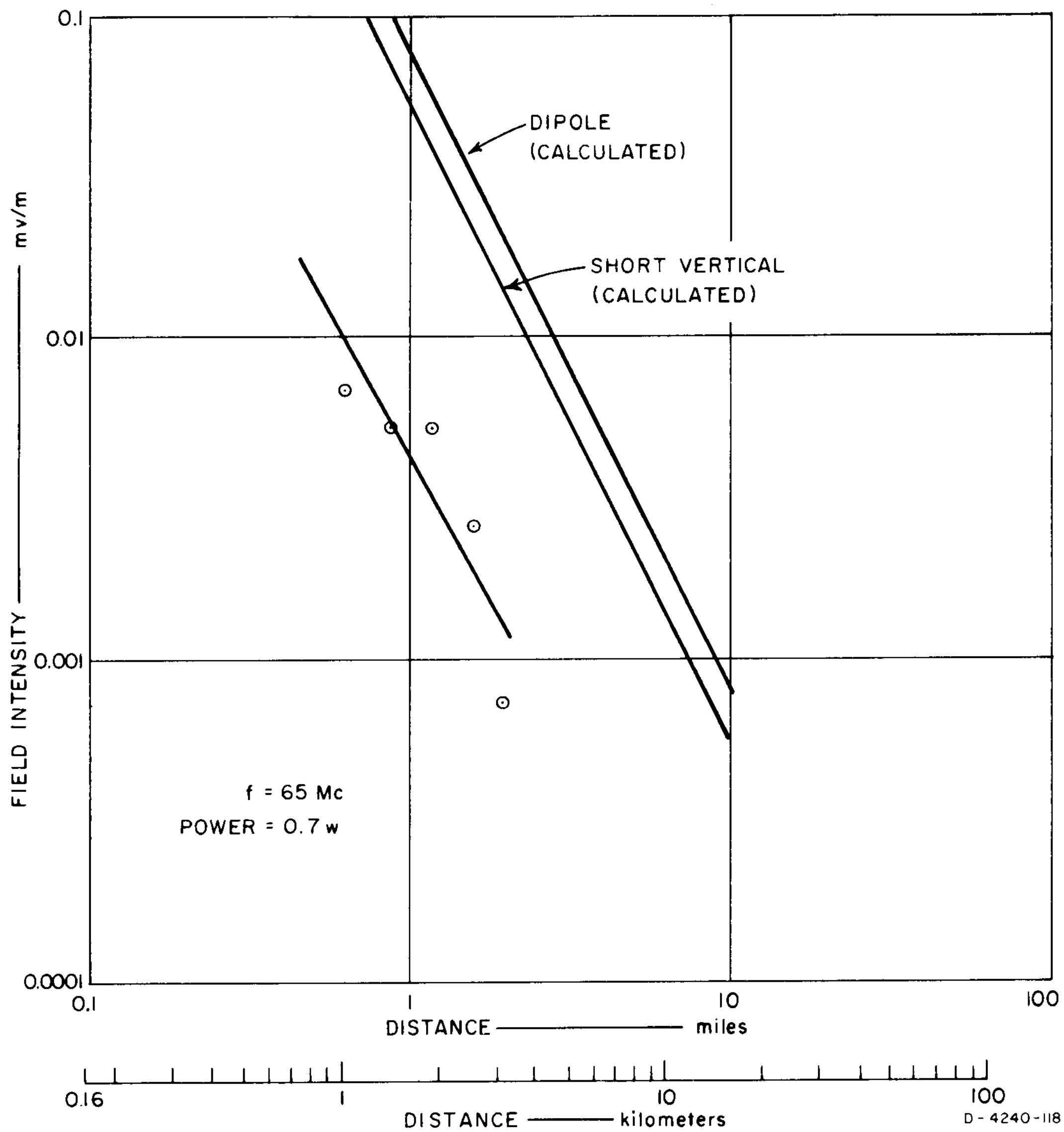

FIG. 13 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-35 (XC-3) — 65 Mc, 0.7 watt

Results shown in Table V indicate that increased performance is obtained from the AN/PRC-25 with power amplifier on 51 Mc when compared to 35 Mc. No accurate explanation can be given on the basis of these tests; however, antenna patterns may favor the higher frequency. Pattern data for the specific antenna used in these tests at the particular height above ground are not available to aid in data evaluation.

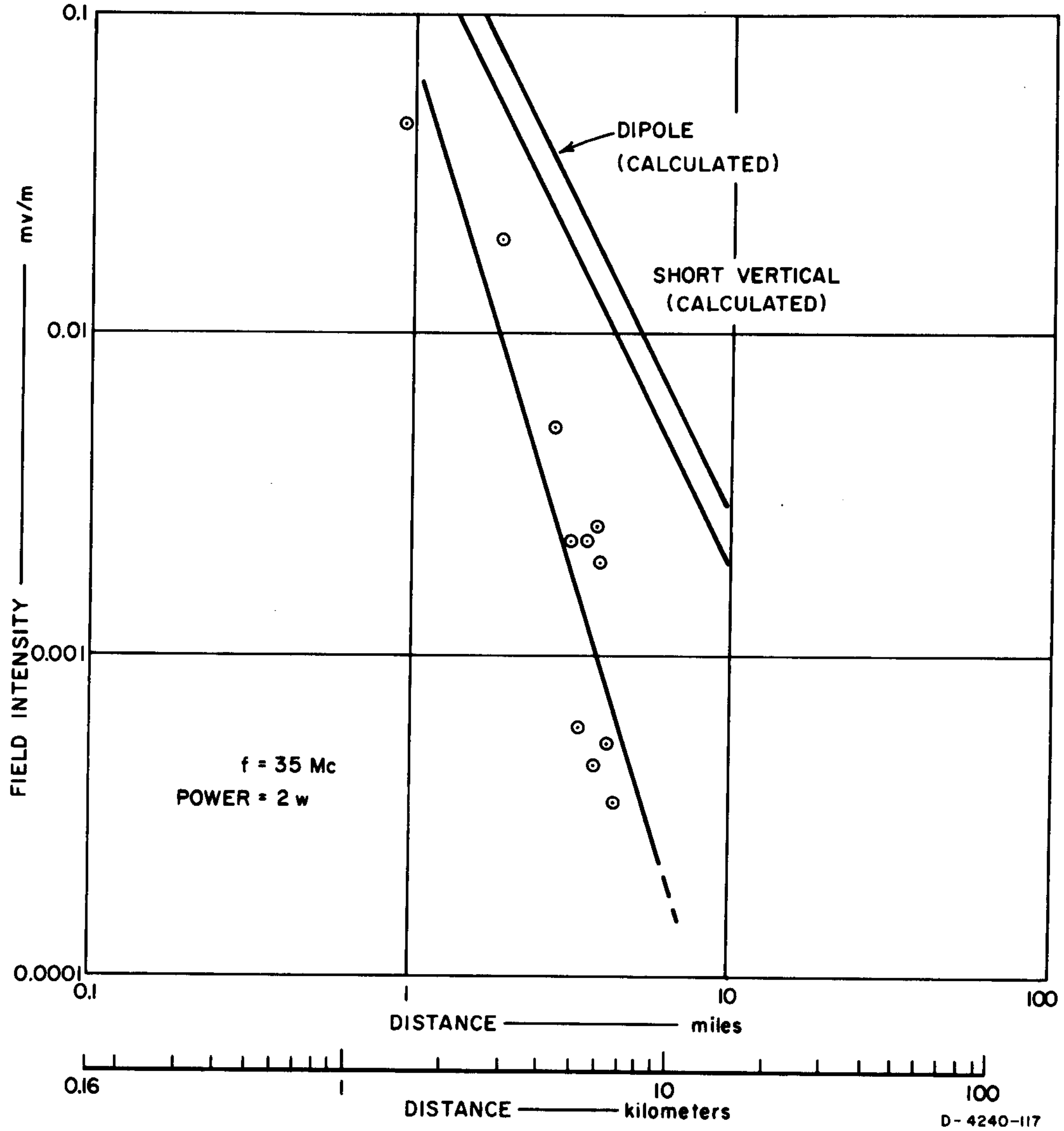

FIG. 14 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 — 35 Mc, 2 watts

The AN/PRC-35 (XC-3) was operated through one 24-hour period during the program to determine whether any day-night variations occurred. No variations in performance were found on the three frequencies used.

Using set heights listed in Table V the range was increased to a point where received signal disappeared. It was found that a set evaluation of about 10 feet was then required to regain communications.

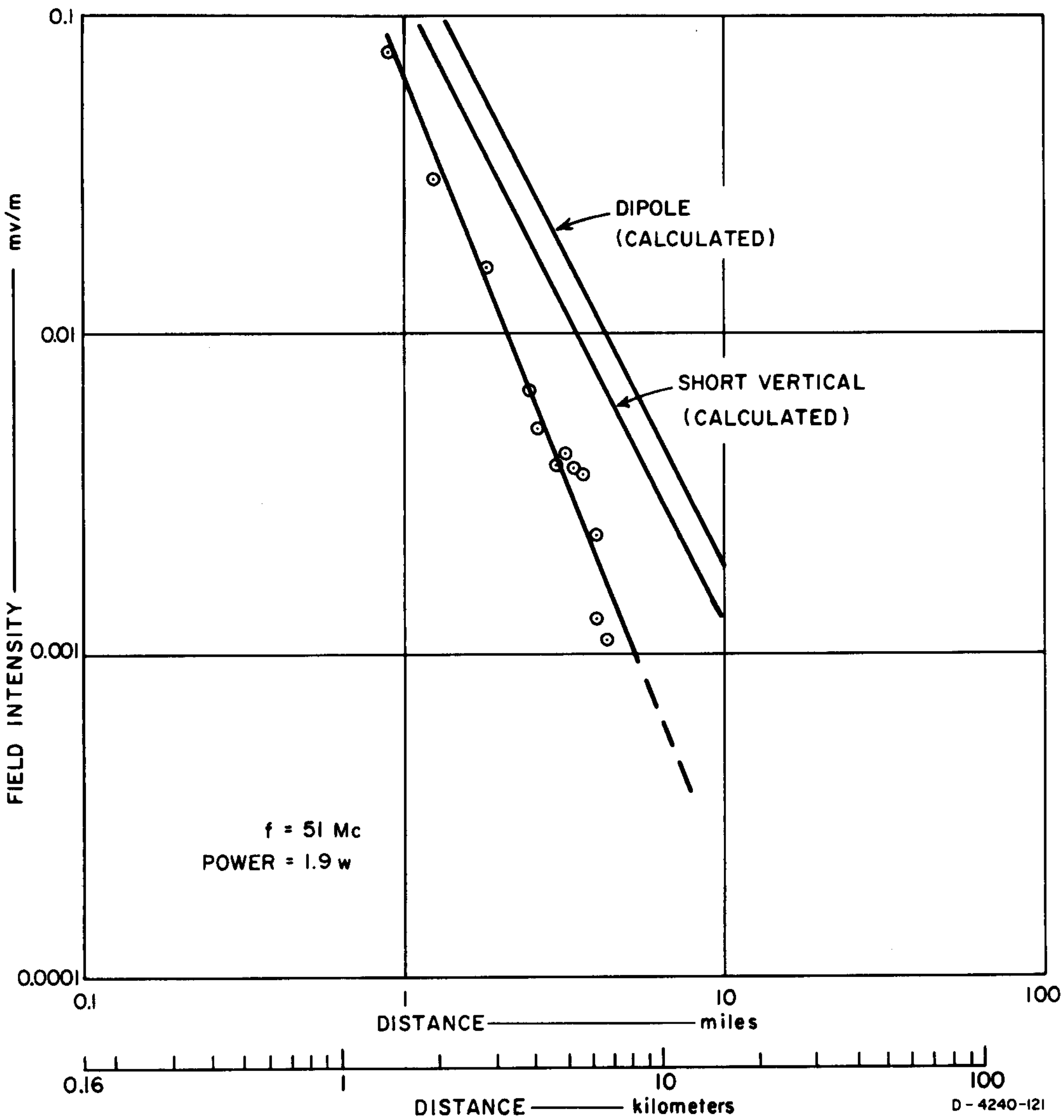

FIG. 15 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 — 51 Mc, 1.9 watts

B. INTELLIGIBILITY TESTS

Results from listener tests of speech intelligibility on the AN/PRC-35 (XC-3) sets are shown by the curves in Figs. 22 through 24. Results are shown for frequencies of 35, 51, and 65 Mc. Mean values of intelligibility score are plotted, and the range of standard deviation is shown. Some unexplained variations appear, such as small dips in intelligibility near mid-range capability. Extensive testing would be required to determine the extent and importance of these dips.

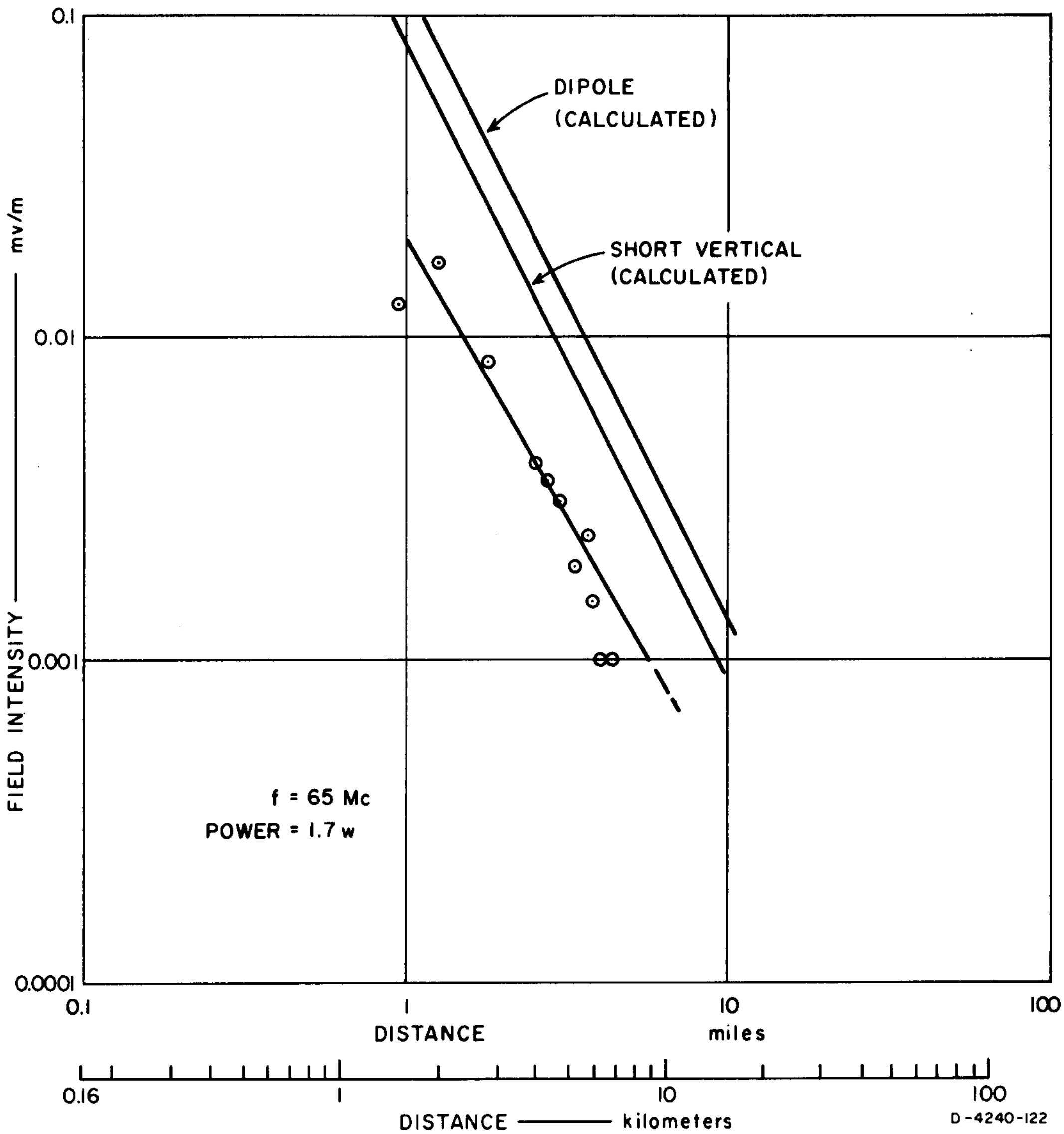

FIG. 16 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 — 65 Mc, 1.7 watts

The range at which a 10-db signal-plus-noise-to-noise ratio was obtained is also shown in Figs. 22 through 24, so that the intelligibility score near the maximum effective range of the set can be obtained. Intelligibility fell sharply as range was increased beyond the distance giving a 10-db signal-plus-noise-to-noise ratio and soon became zero beyond the ranges where data points are shown in Figs. 22 through 24. The maximum intelligibility values obtained, approximately 85 percent,

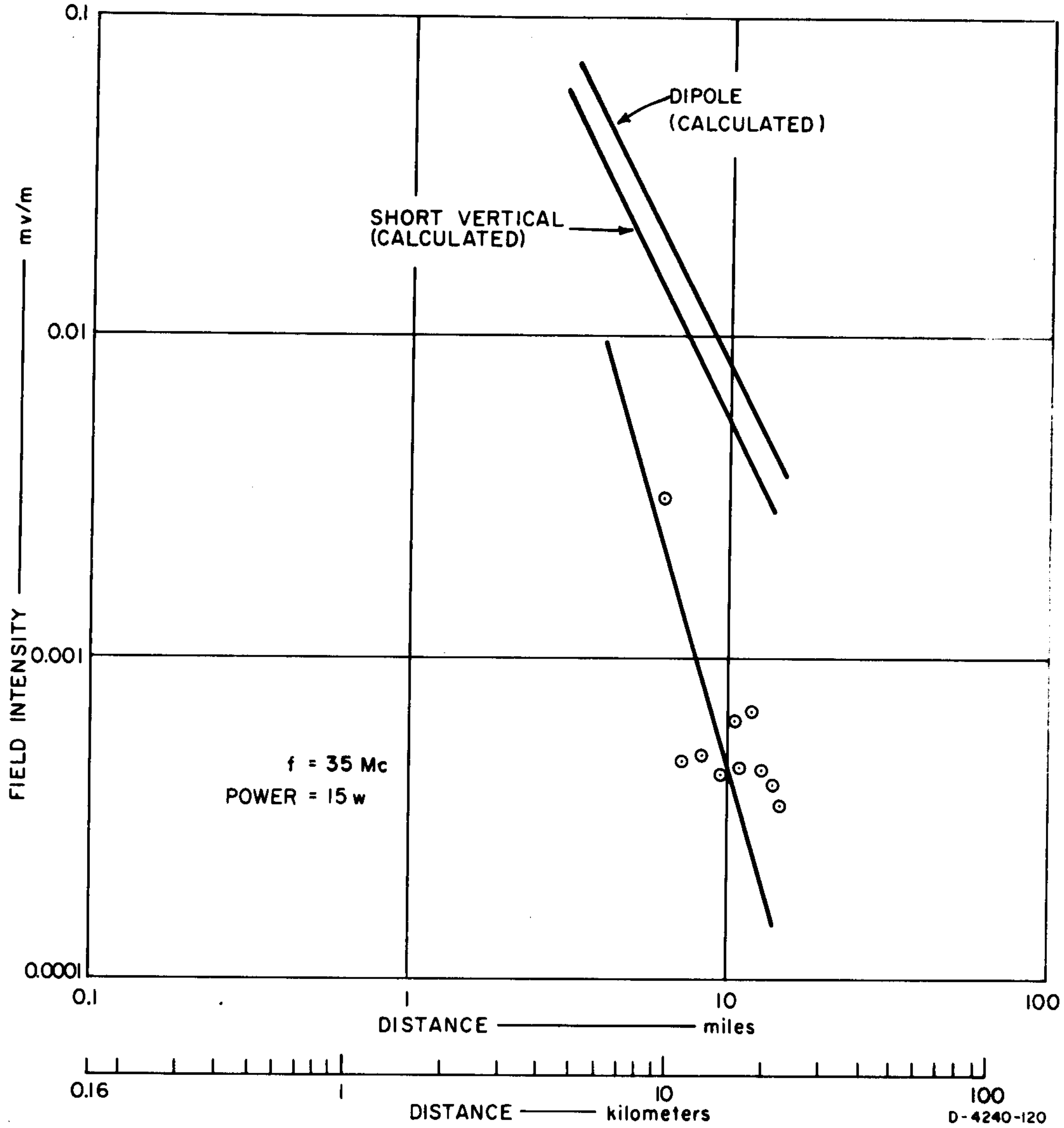

FIG. 17 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 WITH POWER AMPLIFIER — 35 Mc, 15 watts

are consistent with results expected with Rhyme Tests between two telephones.

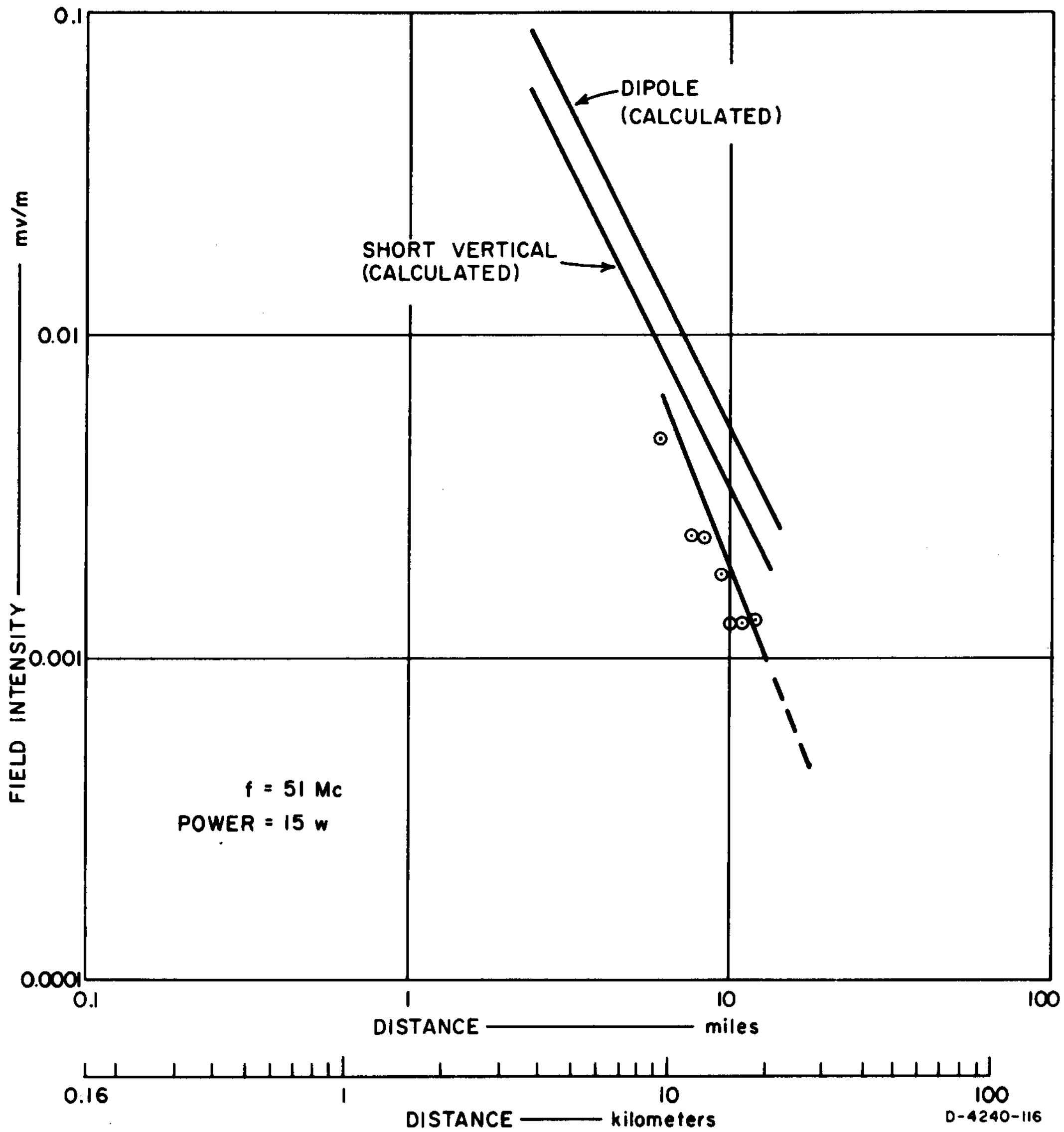

FIG. 18 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 WITH POWER AMPLIFIER — 51 Mc, 15 watts

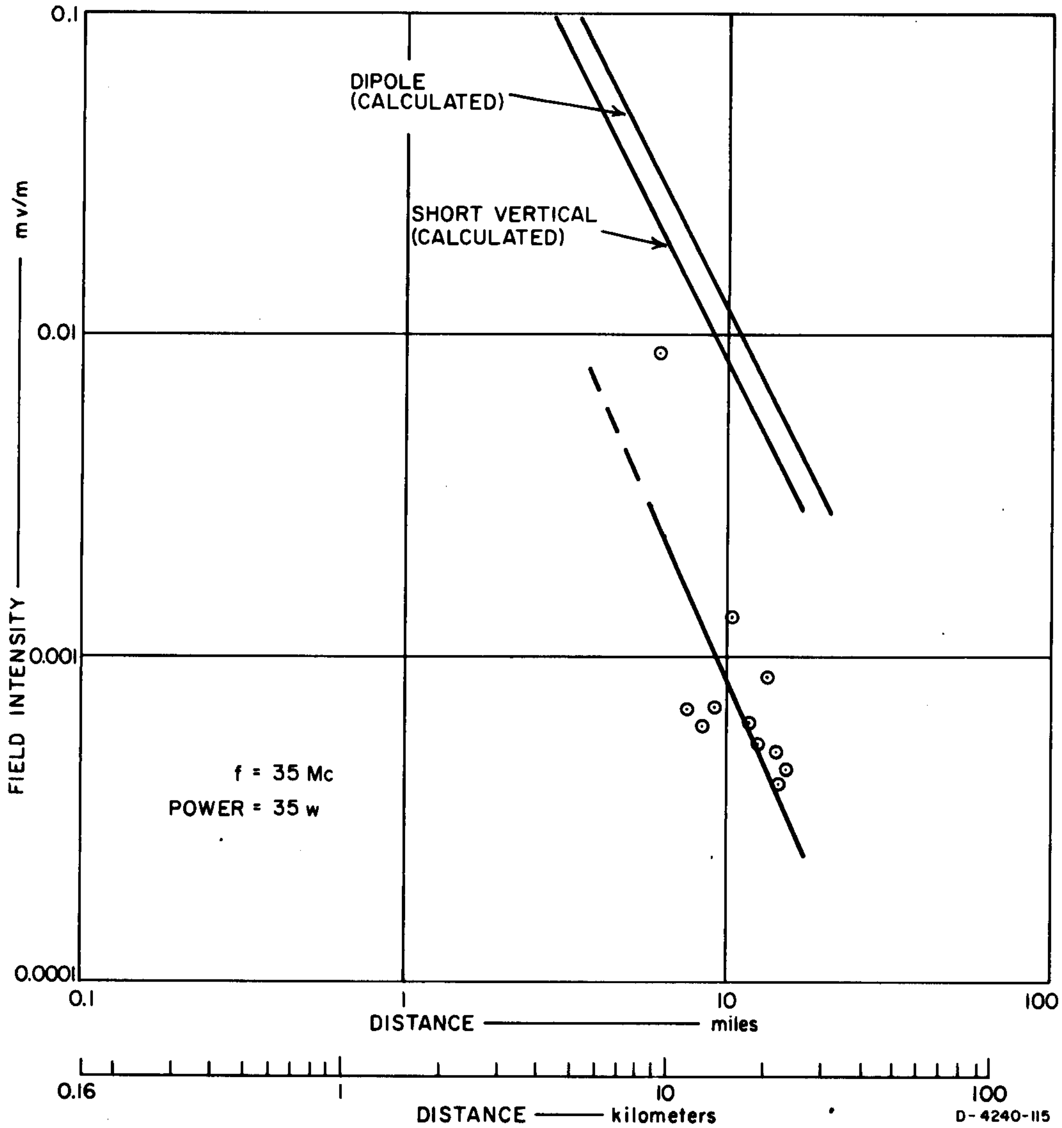

FIG. 19 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 WITH POWER AMPLIFIER — 35 Mc, 35 watts

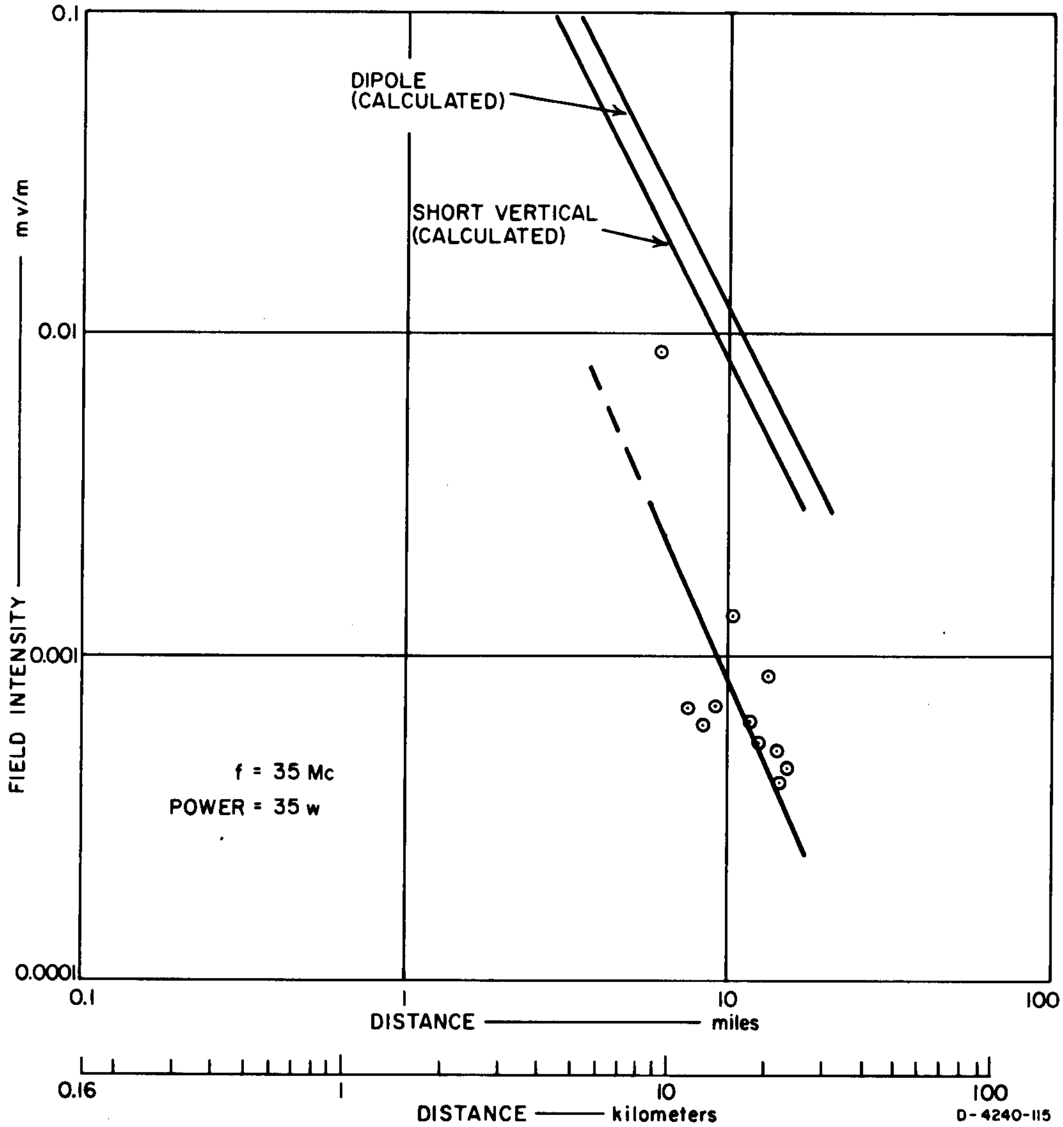

FIG. 19 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR AN/PRC-25 WITH POWER AMPLIFIER — 35 Mc, 35 watts

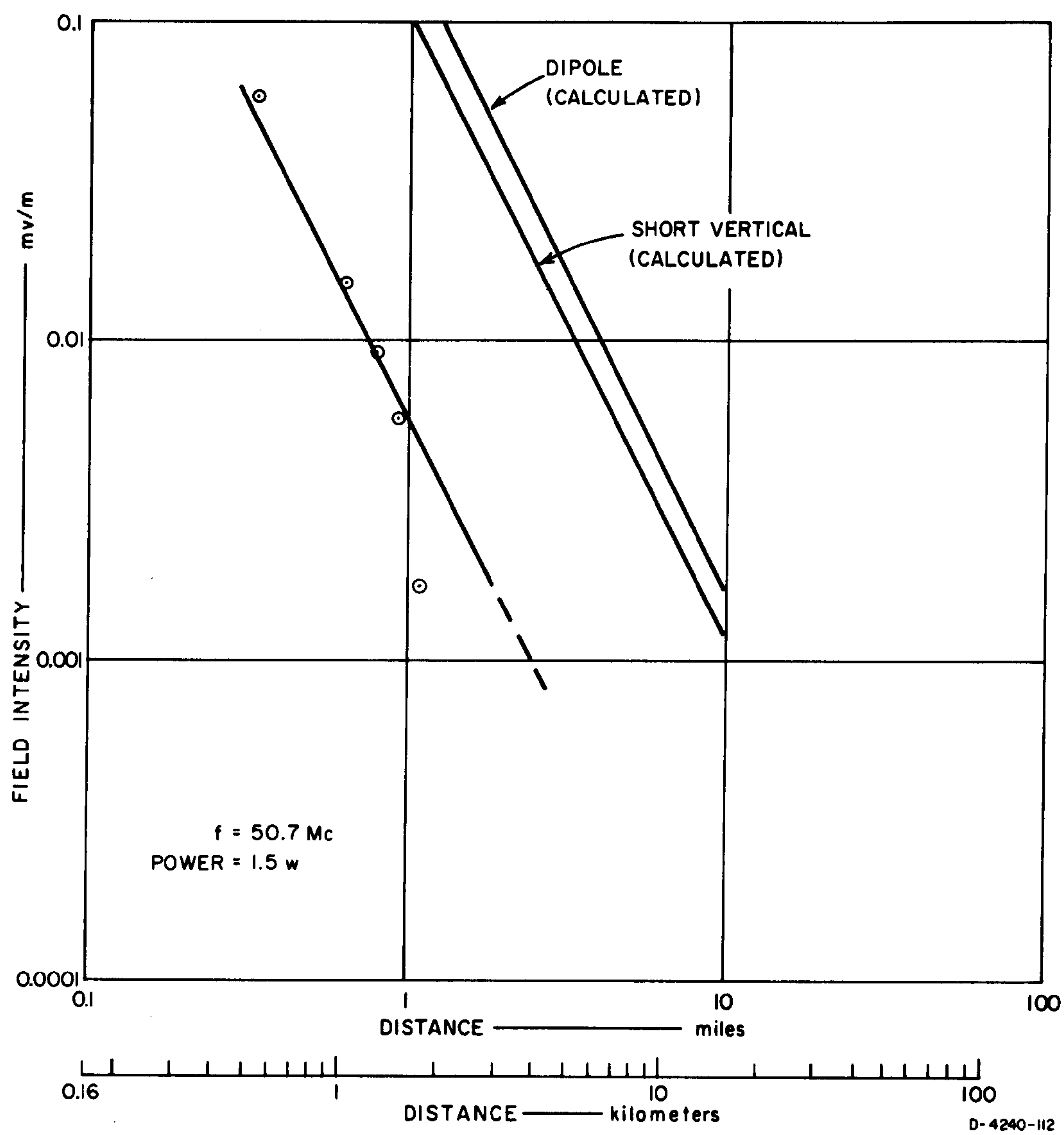

FIG. 21 CALCULATED AND MEASURED FIELD STRENGTH CURVES vs. DISTANCE FOR MOTOROLA HANDIE-TALKIE — 50.7 Mc, 1.5 watts

Table V

EFFECTIVE RANGES FOR RADIO SETS TESTED

	Frequency (Mc)	Power Output (watts)	Effective Range (miles)
AN/PRC-35 (XC-3)	35	0.8	2.0
	51	0.7	1.2
	65	0.7	1.4
AN/PRC-25	35	2.0	4.2
	51	1.9	5.4
	65	1.7	3.4
AN/PRC-25	35	15.0	8.0
With power amplifier, 15w	51	15.0	12.0
AN/PRC-25	35	35.0	9.0
With power amplifier, 35w	51	35.0	13.2
Motorola Handie-Talkie	50.7	1.5	1.2

Height of sets: Base 2.5 ft above ground for both transmitter and receiver.

Antenna lengths: AN/PRC-35 (XC-3) 3 ft

AN/PRC-25 10 ft

Motorola 1.5 ft

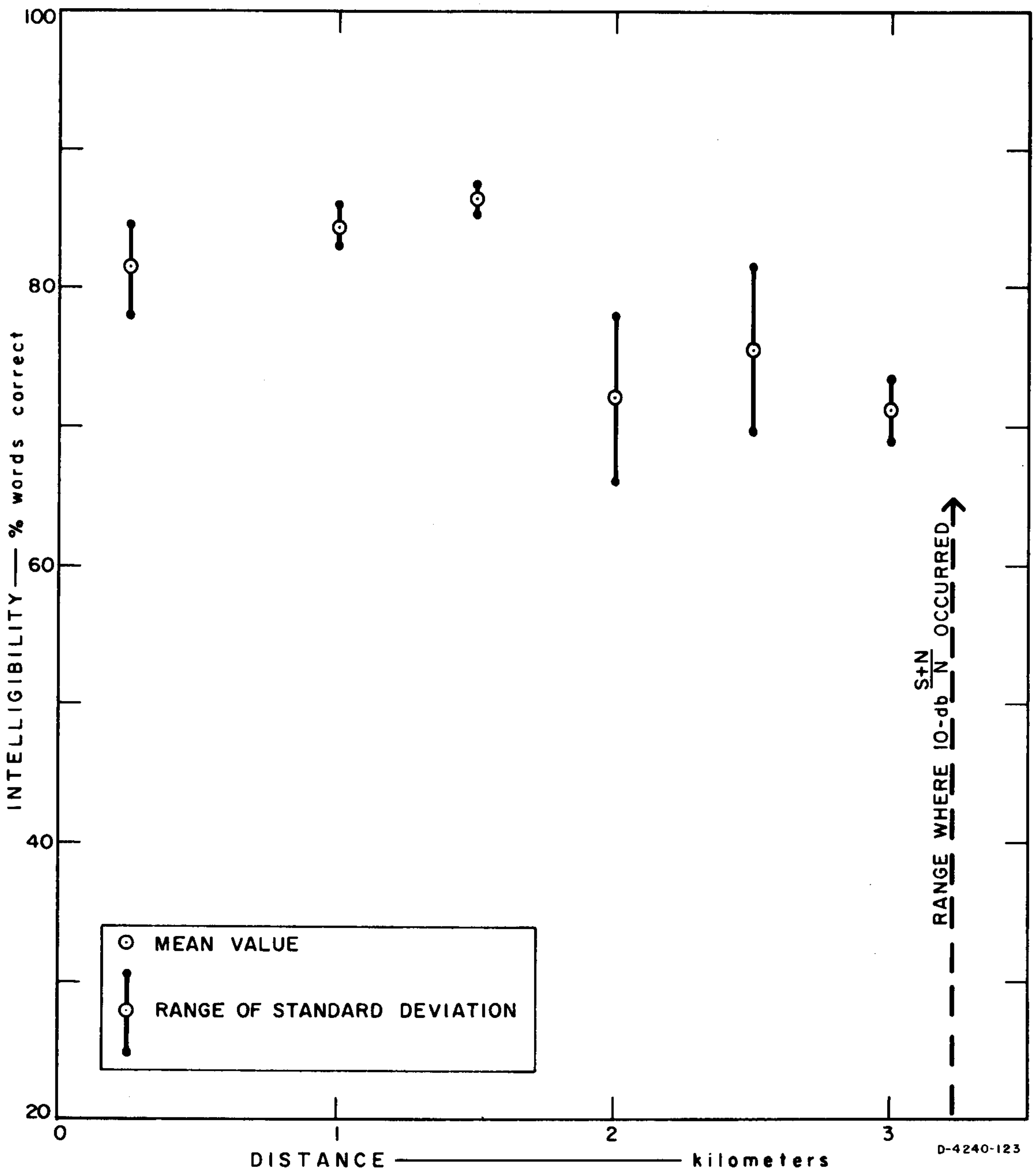

FIG. 22 INTELLIGIBILITY vs. DISTANCE FOR AN/PRC-35 (XC-3) — 35 Mc

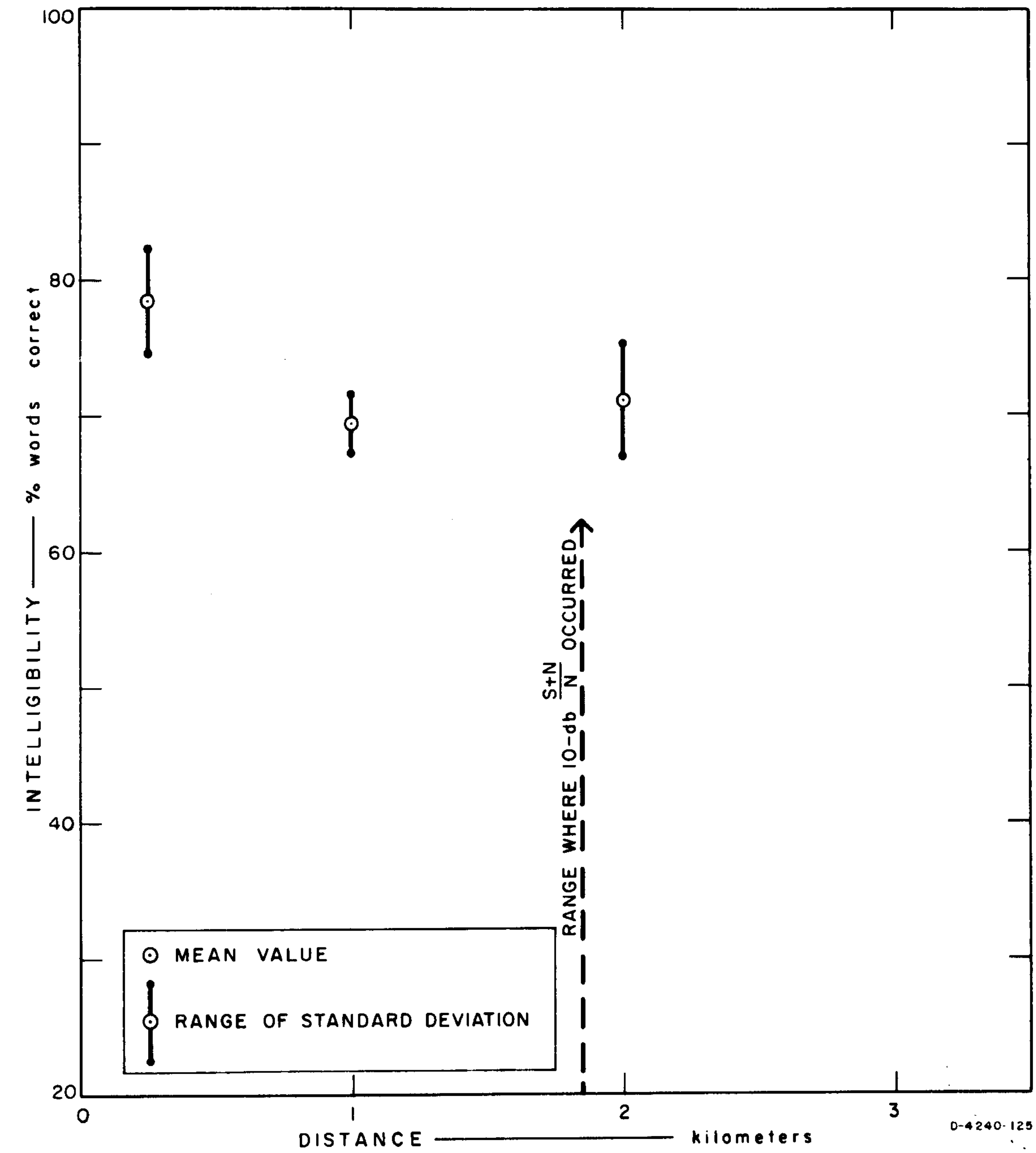

FIG. 23 INTELLIGIBILITY vs. DISTANCE FOR AN/PRC-35 (XC-3) — 51 Mc

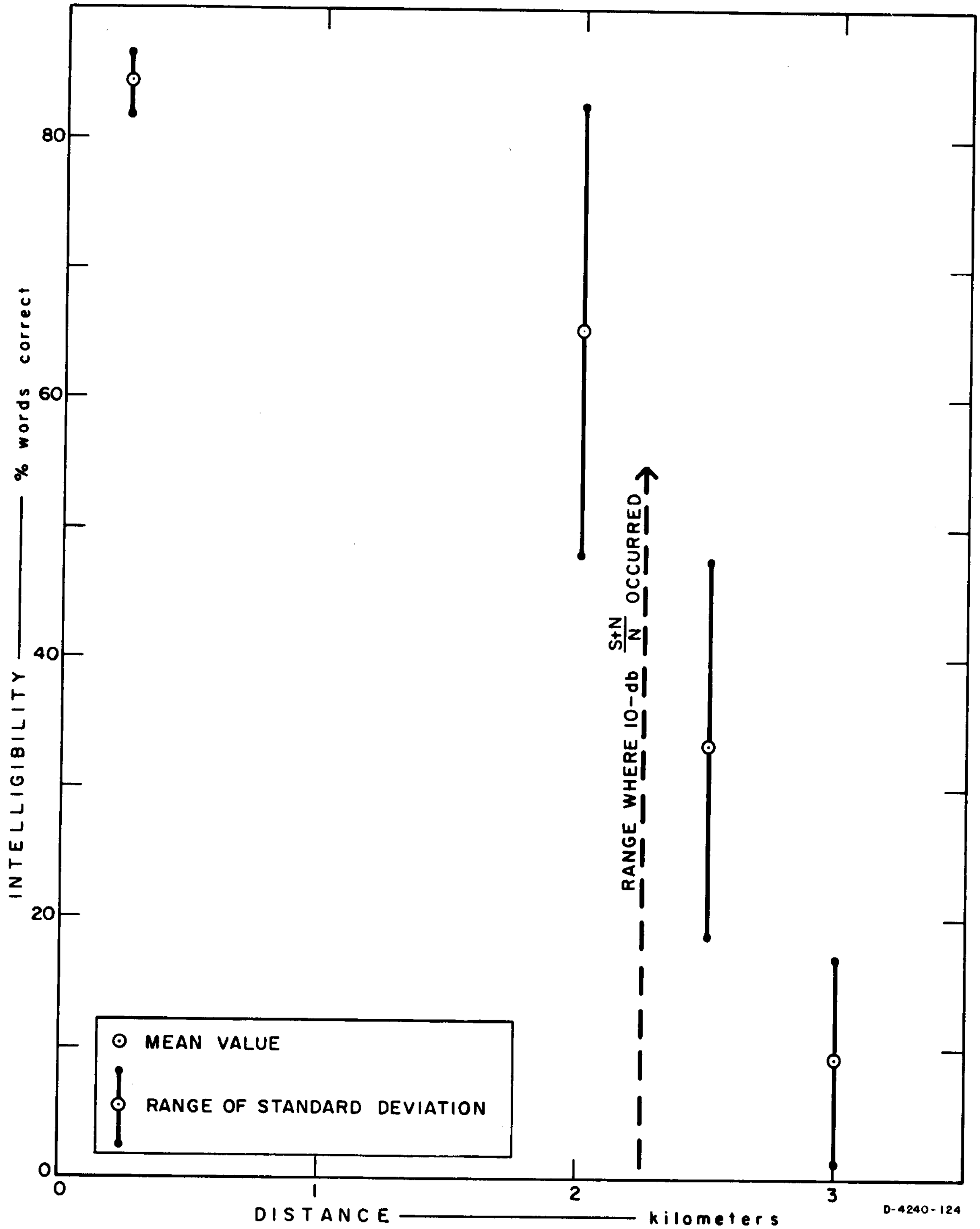

FIG. 24 INTELLIGIBILITY vs. DISTANCE FOR AN/PRC-35 (XC-3) — 65 Mc

V CONCLUSIONS

The tests described in this report provided an opportunity to observe and measure the performance of various VHF man-pack radio sets. The data accumulated during these tests give a basis for evaluating the performance of the sets over typical rice paddy land during the dry season.

The following conclusions have been reached:

(1) Received signal strengths generally varied with range in accordance with calculations.

(2) Increases in transmitter power gave significant increases in useful range (see Table V).

(3) No significant difference was observed between day and night operation.

(4) Variations in range capability were found as frequency was changed. No explanation is offered in this report since data regarding antenna pattern variation with frequency are not available, and this can be a significant factor.

(5) For the sets tested, effective ranges during the dry season over flat, open, delta regions have been determined (see Table V).

(6) At the range where received signals disappeared, a set elevation of about 10 feet was required to regain communications.

APPENDIX A

TESTS OF CONFORMANCE OF SETS TO SPECIFICATIONS

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TESTS OF CONFORMANCE OF SETS TO SPECIFICATIONS

All radio sets were checked to insure that the manufacturer's specifications were met. The tests given in the respective operating manuals were performed before and after the series of tests and no significant changes were noted. According to set type, these were:

AN/PRC-35 (XC-3)

(1) Operating sensitivity with normal, low, and high B+ voltage

(2) Limiting

(3) Tone squelch operation

(4) Audio power output

(5) Noise level

(6) Resetability

(7) Audio fidelity

(8) Sidetone fidelity

(9) Transmitter power output

(10) Transmitter frequency output

AN/PRC-25

(1) Sensitivity

(2) Limiting

(3) Audio response

(4) Audio output

(5) IF frequency

(6) IF bandwidth

(7) Transmitter power output

Power Amplifier

Power output

Motorola Handie-Talkie

(1) Power output

(2) 20-db quieting sensitivity check

(3) Squelch check

(4) Audio check

APPENDIX B

ANTENNA TERMINAL-VOLTAGE/FIELD-STRENGTH RELATIONSHIP

APPENDIX B

ANTENNA TERMINAL-VOLTAGE/FIELD-STRENGTH RELATIONSHIP

The receiver antenna was not standard and for this reason, the relationship between the antenna terminal voltage and field strength was determined, by the method used by Kraus,[7] as follows.

The useful power of a receiving antenna is the product of the average Poynting vector and the effective area of the antenna:

$$W_r = A_e Pav \tag{1}$$

where

W_r = power in the terminating impedance

A_e = effective aperture = $\frac{\lambda^2}{4\pi} g$

Pav = power density of the incident wave = $\frac{E^2}{\eta}$

λ = wavelength in meters

g = directivity gain of receiving antenna

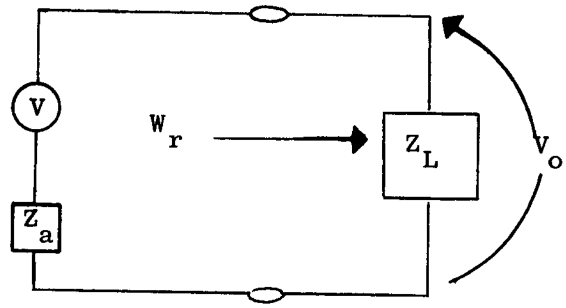
E = rms electric field intensity in volts per meter

η = the intrinsic impedance of free space equal to 120 π ohms

or

$$W_r = \frac{\lambda^2}{4\pi} g \frac{E^2}{\eta} \tag{2}$$

where the expressions of A_e and Pav are substituted in Eq. (1). It is assumed that the antenna has the same polarization as the incident wave and is orientated for maximum response. The equivalent circuit can be drawn as follows:



where

Z_a = the antenna impedance,

Z_L = the load impedance (the receiver),

V = induced antenna voltage.

Then, assuming a conjugate matched load,

$$W_r = \frac{V_o^2}{R_r} \qquad (3)$$

where

V_o = rms voltage across the terminating impedance

R_r = radiation resistance of antenna.

This assumes that $Re\{Z_L\} = R_r$ i.e., zero antenna loss.

Equating Eqs. (2) and (3) gives:

$$\frac{\lambda^2}{4\pi} g \frac{E^2}{\eta} = \frac{V_o^2}{R_r}$$

or

$$E = \frac{\pi}{\lambda} \left(\frac{480}{g R_r}\right)^{\frac{1}{2}} V_o \text{ volts/meter} \quad .$$

Equation (4) relates the incident field strength, E, to the antenna terminal voltage, V_o.

For this calculation, the antenna gain was taken as 1. The radiation resistance was calculated from[8]

$$R_r = 15[(2 + 2\cos b)S_1(b) - \cos bS_1(2b) - 2\sin bSi(b) + \sin bSi(2b)] \quad (5)$$

where

$b = \frac{4\pi H}{\lambda}$ and H = antenna height, in the same units as λ

$S_i(x)$ is the sine integral of x

$$S_1(x) = \int_0^x \left(\frac{1 - \cos v}{v}\right) dv = \frac{x^2}{2.2!} - \frac{x^4}{4.4!} + \frac{x^6}{6.6!} - \ldots + \ldots$$

Table B-I gives the calculated values of R_r.

Table B-I

CALCULATED VALUES OF R_r

Antenna	Frequency		
	35 Mc	51 Mc	65 Mc
3-ft whip	1.77Ω	7.65Ω	17.3Ω
10-ft whip	85.1Ω	94.1Ω	44.5Ω
1.5-ft whip	--	0.54Ω	--

The theoretical relationship between the field strength, E, and the measured terminal voltage, V_o, is plotted in Figs. 25 through 27 for each antenna used.

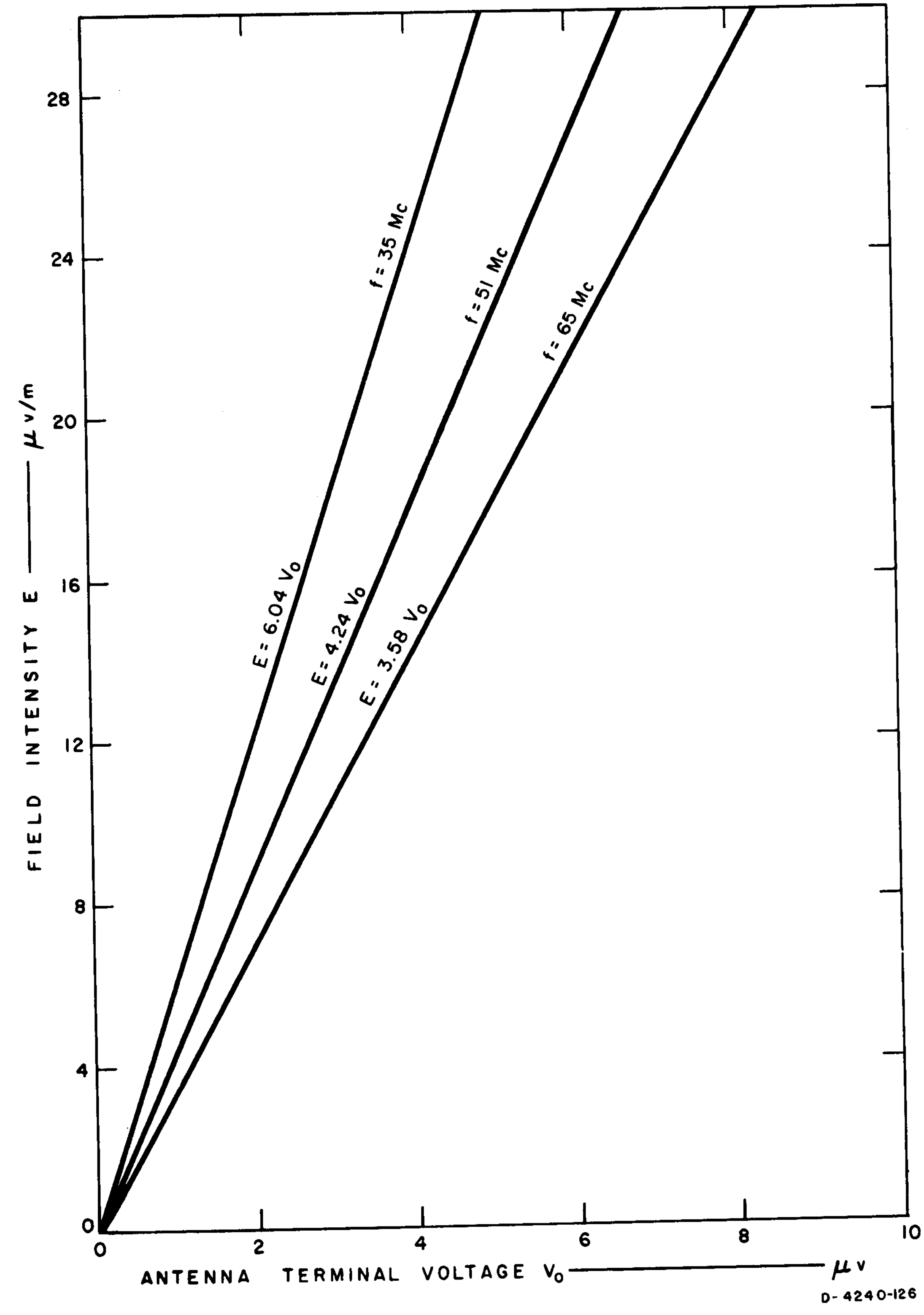


FIG. 25 RELATIONSHIP OF ANTENNA TERMINAL VOLTAGE TO FIELD STRENGTH FOR 3-ft VERTICAL WHIP ANTENNA

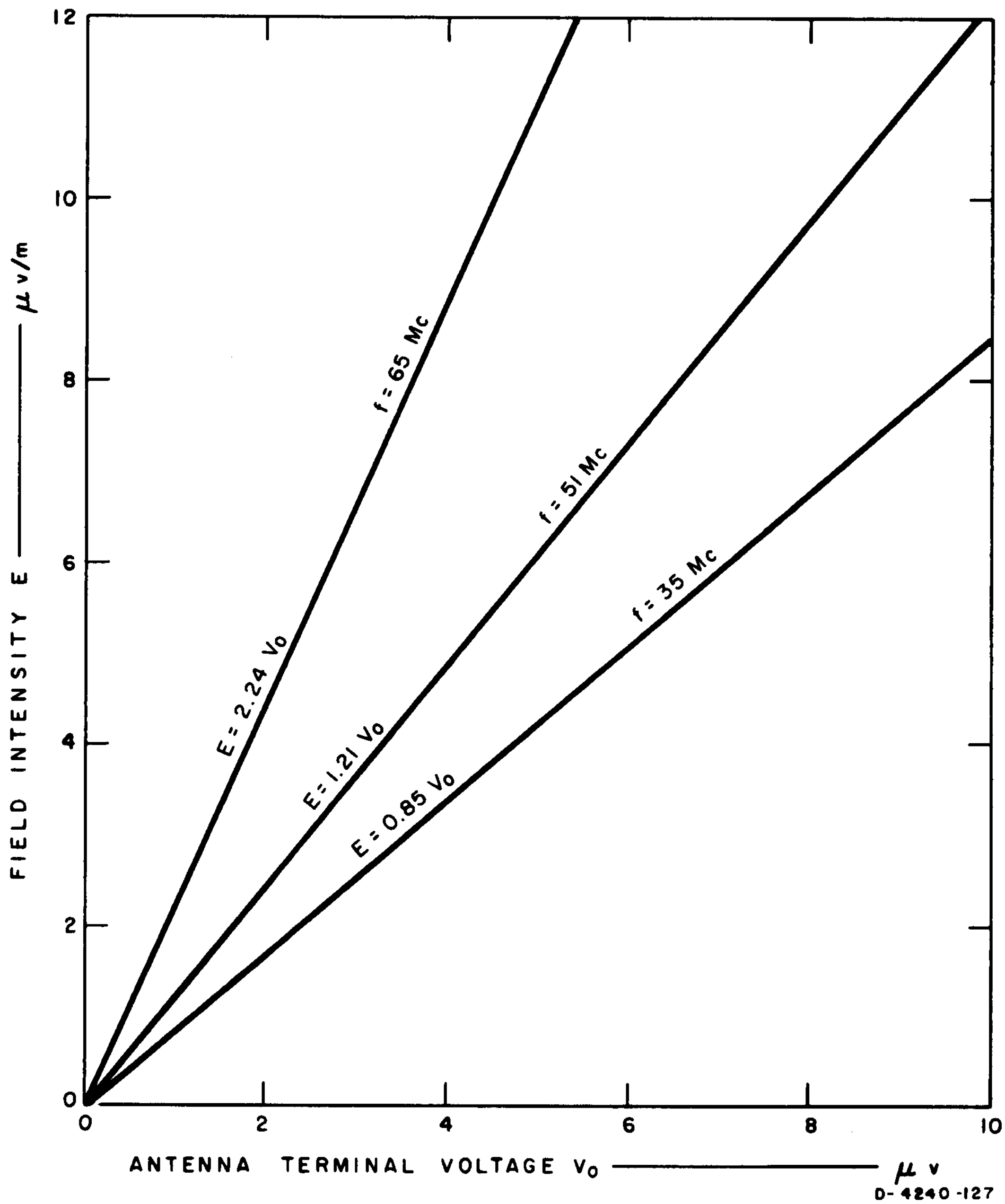


FIG. 26 RELATIONSHIP OF ANTENNA TERMINAL VOLTAGE TO FIELD STRENGTH FOR 10-ft VERTICAL WHIP ANTENNA

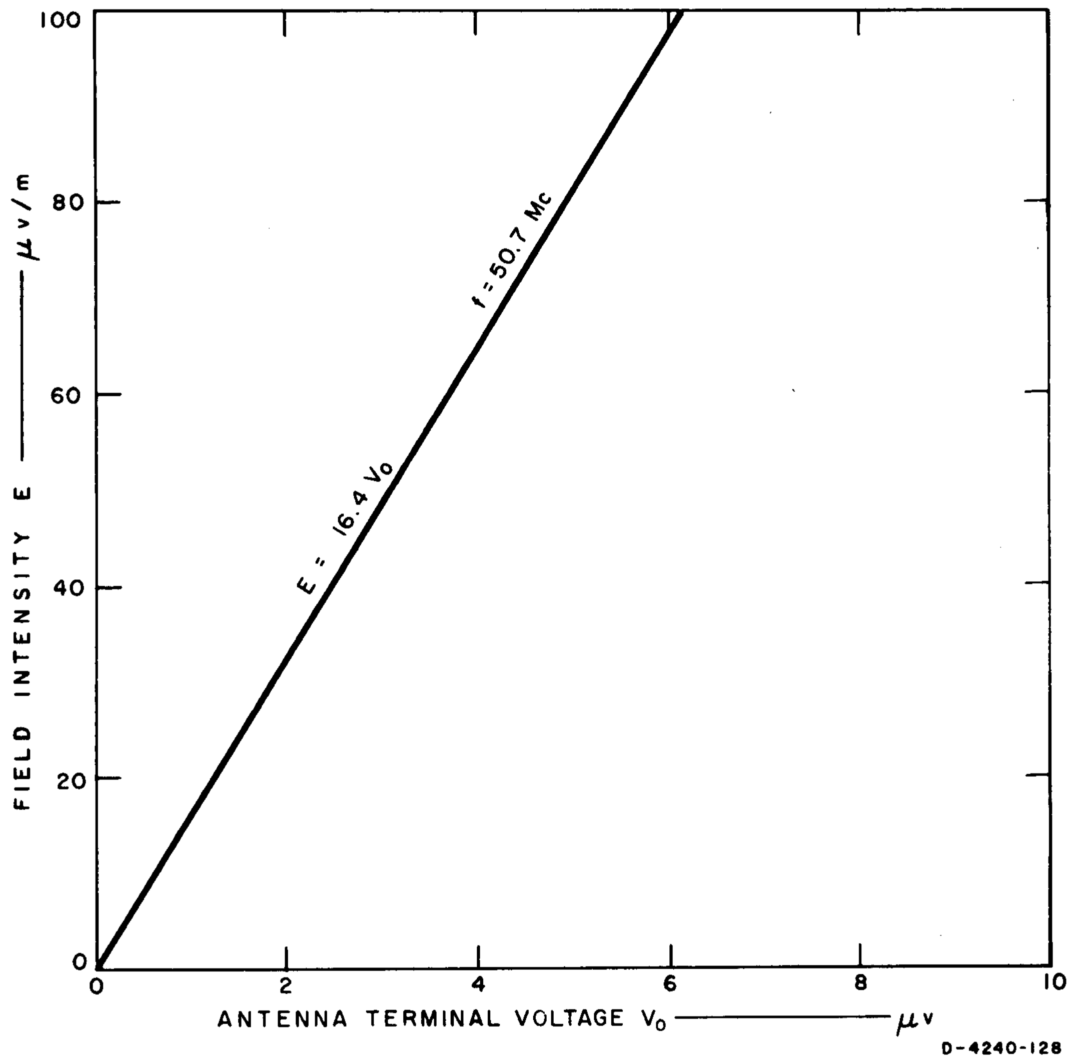


FIG. 27 RELATIONSHIP OF ANTENNA TERMINAL VOLTAGE TO FIELD STRENGTH FOR 1.5–ft VERTICAL WHIP ANTENNA

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