RI-24-56 April 3, 1956

To: N. S. Parks 10-1

From: V. J. Mancino 10-6

Subject: Radiation Tests on the General Electric Transmitter, Type ET-1C #G4682

Distribution:

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File:
Test Report File (2)
Equipment File (1)

INTRODUCTION:

In accordance with the request of Mr. N. S. Parks of Mobile Communications Engineering open field radiation measurements were made on a General Electric Type ET-1C Transmitter. The purpose of these measurements was to:

(1) See how closely our open field measurements can be duplicated by the FCC and other interested companies. These measurements will be made by the FCC and other interested companies and will be discussed at a future meeting of the RETMA Subcommittee on Transmitters, TR8.1. From these discussions it is hoped that a method of measurement can be formulated so that good correlation of open field measurements can be obtained between Field Sites.

(2) See how closely our own results can be duplicated over a period of time. Previous measurements were made on this same transmitter in July 1955 and again in October 1955.

DESCRIPTION OF UNIT:

The ET-1C transmitter consists of two chassis mounted in an uncovered rack. These two chassis contained all the transmitter circuitry including the power supply. The transmitter has a power output of 50 watts at its fundamental frequency of 155.43 mc. The transmit frequency of 155.43 mc is derived from a 6.47625 mc crystal.

TEST EQUIPMENT:

The following test equipment was used in this evaluation:

Designation	Type	Serial No.	Range
NM-30A	Receiver	165-42	20-400 mc
NM-50A	Receiver	137-7	370-1,000 mc
HP-608C	Signal Generator	195	10-480 mc
HP-612A	Signal Generator	312	450-1200 mc
Stoddart Turret Attenuator			0-100 db

TEST PROCEDURE:

A. Transmitter Harmonic and Sourious Measurements

The radiation measurements were made at the Moorestown Incidental Radiation Field Site at a distance of 100 feet from the transmitter. For the antenna radiation measurements the transmitter output was fed to the antenna supplied with the unit. For the case radiation measurements the transmitter output was fed into a 51.5 ohm Bird wattmeter load. For both cases the procedure followed is as follows:

(1) Based upon the knowledge previously obtained concerning the relative strength of the spurious and harmonic frequencies (See Report #RI-22-55), only the following frequencies were measured: 38.9, 77.8, 155.4, 311, 466, 622 and 777 mc. These frequencies correspond to fo/4, fo/2, fo , 2fo, 3fo, 4fo, and 5fo respectively, where fo is the fundamental frequency.

(2) Each time the transmitter was fed into either the antenna or the dummy load the transmitter was tuned for peak output.

(3) When a frequency signal from the transmitter was found, the turntable upon which the transmitter rested was rotated to give maximum radiation.

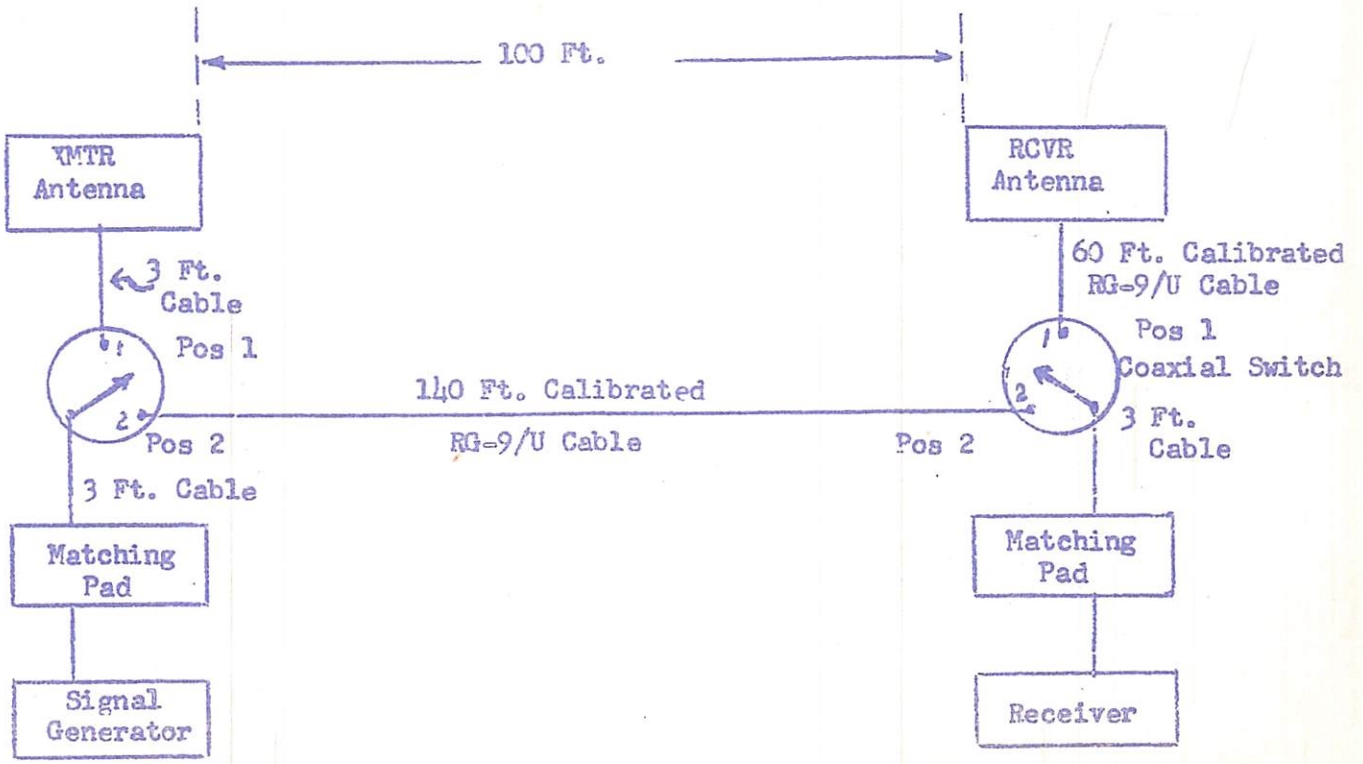
(4) The measuring antenna was then varied over a height of 7 to 20 feet above the ground plane and fixed at the height at which it incurred a maximum signal.

(5) Since there was no means to automatically rotate the receiving antenna 360 degrees, measurements were made only with the receiving antenna vertical and horizontal. Of these two readings the maximum reading was selected for comparison with the fundamental maximum received signal and a db ratio was obtained.

The receivers were used solely as detectors, the signal generators were used to determine the absolute levels.

B. Calibration of Field Site:

The path loss of the field site was measured using two identical dipole antennas set up as shown in the following diagram.



The following procedure was used to obtain the path loss:

(1) The transmitting antenna was set on the turntable platform at a height of five feet above the ground plane. (This is the same height that the ET-1C Transmitter antenna was set at.)

(2) With both coaxial switches in Position 1 both the signal generator and the receivers were tuned to a frequency of interest. The lengths of both antennas were previously adjusted for this frequency.

(3) The elevation of the receiving antenna was varied from 7 to 20 feet to obtain a maximum deflection on the receiver.

(4) The coaxial switches were both switched to Position 2, and the signal generator output was adjusted to give the same deflection on the receiver as obtained in (3).

(5) The difference of the db readings obtained in (4) and (3) when corrected for the cable losses is the field path loss of the site in db.

C. Application of the Field Site Path Loss:

The field path loss in db was used in the following manner:

(1) In part A(5) of the Test Procedure the relative strength of all the harmonic and spurious frequencies was calculated in db below the fundamental transmitter frequency.

(2) In part B(5) of the Test Procedure a curve of the field path loss in db versus frequency was obtained.

(3) At each harmonic and spurious frequency obtained the difference in db between the path loss at the fundamental and the path loss at the frequency of interest was:

a. Added to the relative db strength of the frequency of interest if the path loss at the frequency of interest was lower than the path loss at the fundamental frequency.

b. Subtracted from the relative db strength of the frequency of interest if the path loss at the frequency of interest was higher then the path loss at the fundamental frequency.

TEST RESULTS and CONCLUSIONS:

The test results and calculations are tabulated in data sheets attached to this report. A summary of these results is tabulated below. Also included are the db levels found by Motorola, General Electric, and the FCC.

(a) Levels of Harmonic Frequencies with the RCS Results Not Corrected for Field Path Loss.

Freq. (mc)	Order	Termination	FCC	General Electric	Motorola	RCA July '55	RCA Oct. '55	RCA Mar. '56	Maximum Deviation of RCA Results	Maximum Deviation between all Results
			db	db	db	db	db	db	db	db
38.9	f/4	Ant.	82	--	70	93	89	66	27	27
		Watt.	82	71	75	79	--	80	1	11
78.8	f/2	Ant.	75	--	66	77	53	54	24	24
		Watt.	73	54	59	61	--	54	7	19
311	2f	Ant.	41	--	51	35	35	33	2	18
		Watt.	56	46	48	48	--	40	8	16
466	3f	Ant.	57	--	74	59	50	66	16	24
		Watt.	61	56	77	58	--	69	11	21
622	4f	Ant.	66	--	--	59	69	73	14	14
		Watt.	65	60	--	57	--	59	2	8
777	5f	Ant.	53	--	72	61	63	64	3	19
		Watt.	54	53	70	63	--	74	11	21

(b) Levels of Harmonic Frequencies with the RCA Results Corrected for Field Path Loss.

38.9	f/4	Ant.	82	--	70	82	78	56	16	26
		Watt.	82	71	75	72	--	74	3	11
78.8	f/2	Ant.	75	--	56	71	42	48	29	33
		Watt.	73	54	59	53	--	48	5	25
311	2f	Ant.	41	--	51	32	34	30	4	21
		Watt.	56	46	48	42	--	34	8	22
466	3f	Ant.	57	--	74	52	43	59	16	31
		Watt.	61	56	77	50	--	61	11	27
622	4f	Ant.	66	--	--	49	62	63	14	14
		Watt.	65	60	--	47	--	47	0	18
777	5f	Ant.	53	--	72	52	63	51	12	20
		Watt.	54	53	--	54	--	61	7	8

4/3/56

Conclusions which might be derived from an examination of the above results are:

(1) Correlation of results between field sites is difficult to obtain. With the transmitter terminated into its antenna the minimum deviation between field sites was 14 db and the maximum deviation was 33 db. When the transmitter was terminated into a dummy load the minimum and maximum deviation was 8 db and 27 db respectively. (See Table b - results corrected for path loss.)

(2) Correlation of results on the same field site taken over a long period of time are likewise difficult to obtain. With the transmitter terminated into its antenna the minimum and maximum deviation was 4 db and 29 db respectively. When the transmitter was terminated into a dummy load the minimum and maximum deviation was 0 db and 11 db respectively. (See Table b - results corrected for path loss.)

(3) Better correlation of results are obtained when the transmitter is terminated into a dummy load.

(4) Correcting the results for path loss does not increase the degree of correlation as shown in the table below:

Antenna Termination	Minimum Deviation (db)	Maximum Deviation (db)	
Dummy Load	1	11	Path loss neglected
Antenna	2	27	
Dummy Load	0	11	Path loss taken into account
Antenna	4	29	

(5) The path loss has not changed significantly between results taken August 1955 and March 1956.

(6) In view of the above it is suggested that with regards to open field measurements:

(a) All measurements of harmonic and spurious frequencies be made with the transmitter terminated into a dummy load. These measurements then be compared to the fundamental frequency with the transmitter terminated into its antenna.

(b) Path loss be neglected. However, the field site should be calibrated periodically to make sure the actual path loss compares reasonalby well with the theoretical path loss.

4/3/56

LABORATORY TEST SHEET

Table #1

LABORATORY

Moorestown Field Site

TEST OF General Electric Transmitter, Type ET-1C #G-4682

TEST ENGINEER	OBSERVERS	DATE
V. J. Mancino	M. Spiro	April 16, 1956

TEST EQUIPMENT NM-30A #165-42, HP 608C #195
NM-50A #137-7, HP 612A #312

All data shown below taken March 27, 1956

Freq.	Antenna Termination	Max Sig Received	Antenna Factor	Max Signal Received	Voltage Ratio	DB	Cable Loss	DB Down	Path Loss	DB Down
mc		Received		Received			DB	from	DB	Corrected for Path Loss
		μV*		μV/m				fo		
38.9	Antenna	280 H	2.05	574	2440	68	0.5	66	50.5	56
	Wattmeter	56 V		115	12.2K	82		80	V —	74
77.8	Ant.	700 V	3.88	2710	571	55	1.0	54	V 50	48
	Watt.	700 V		2710	571	55		54	V 50	48
155.4	Ant.	325,000 V	4.3	1400 K	1	0	2	—	V 44	
								—	H 40	
311	Ant.	3800 V	9	34.2K	41	32	2.5	33	V 47	30
	Watt.	1700 H		15.3K	91.5	39		40	H 45.5	34
466	Ant.	58 V	13.5	782	1790	65	3	66	V 51	59
	Watt.	45 H		607	2310	67		69	H 48	61
622	Ant.	20 V	18.8	3760	3730	71	4	73	V 53.5	63
	Watt.	10 H		1880	745	57		59	H 51.5	47
777	Ant.	45 H	24	1080	1300	62	4	64	H 53	51
	Watt.	15 H		360	3890	72		74	H 53	61
932	Ant.	—								
	Watt.	—								

* H denotes receiving antenna polarized horizontally
V denotes receiving antenna polarized vertically

All values referenced to the maximum transmitted signal frequency

LABORATORY TEST SHEET

LABORATORY Moorestown Field Site

4/3/56

Table #2

TEST OF General Electric Transmitter, Type ET-1C # G-4682

TEST ENGINEER	OBSERVERS	DATE
A. Rende	M. Spiro	April 16, 1956

TEST EQUIPMENT NM-30A #165-42 HP 608C #195
NM-50A #137-7 HP 612A #312

All data shown here taken Oct. 27, 1955

Freq	Antenna Terminated	Max Signal Received	Antenna Factor	Max Signal Received	Voltage Ratio	DB Ratio	Cable Loss DB	DB Down from f_o	Path Loss DB	DB Down from f_o corrected for Path loss
mc		uV		uV/m						
38.9	Antenna	25 V	2.05	51	28.7K	89	0.5	88	V 52	78
77.8	Antenna	800 V	3.9	3160	463	53	1.0	52	V 52	42
155.4	Antenna	340K V	4.3	1460K	1	0	2		V 42 H 42	
311	Antenna	2700 H	9	24.6K	59.4	35	2.5	36	H 44	34
466	Antenna	400 H	13.5	5400	271	49	3	50	H 49	43
622	Antenna	36 V	18.8	677	2160	67	4	69	V 49	62
777	Antenna	60 V	24	1440	1010	61	4	63	V 42	63

H3/56

LABORATORY TEST SHEET

Table # 3

LABORATORY

Moorestown Field Site

TEST OF General Electric Transmitter, Type ET-1C # C-4682

TEST ENGINEER: V J Marcano

OBSERVERS: M Spiro

DATE: April 17, 1956

TEST EQUIPMENT: NM-30A # 165-42; NM-50A # 137-7; HP 608C # 195; HP 612A # 312

All data shown below taken July 12, 1955

Freq mc	Antenna Termin.	Max Signal Received μv	Antenna Factor	Max Signal Received μv/m	Voltage Ratio	DB	Cable Loss DB	DB down from f_0	Path Loss DB	DB Down Corrected for Path Loss
38.9 H	Antenna	14	2.05	28.7	54K	95	0.5	93	51	82
V	Watt.	65		134	11.5K	81		79	-	72
77.8 V	Ant.	50	3.9	195	7.94K	78	1	77	50	71
H	Watt	200		1170	1.32K	62		61	48	53
155.4 V	Ant.	360K	4.3	1548K	1	0	2	-	44	
H								-	40	
311 V	Ant	3600	9	32.4K	47.8	33.6	2.5	35	47	32
H	Watt	750		6750	229	47		48	46	42
466 V	Ant.	150	13.5	2020	765	58	3	59	51	52
H	Watt.	160		2160	716	57		58	48	50
622 V	Ant.	110	18.8	2070	746	57	4	59	54	49
V	Watt.	150		2820	548	55		57		47
777 V	Ant.	75	24	1800	860	59	4	61	53	52
V	Watt	55	24	1320	1170	61		63		54
932 H	Ant.	40	29	1160	1330	62	5	65	56	49
	Watt.	-	29	-						

LABORATORY TEST SHEET #4

LABORATORY

4/3/56

TEST OF: Field Site Path Loss Calculation - Theoretical for 100 F (Neglecting Antenna Mismatch)

TEST ENGINEER: V. J. Mancino

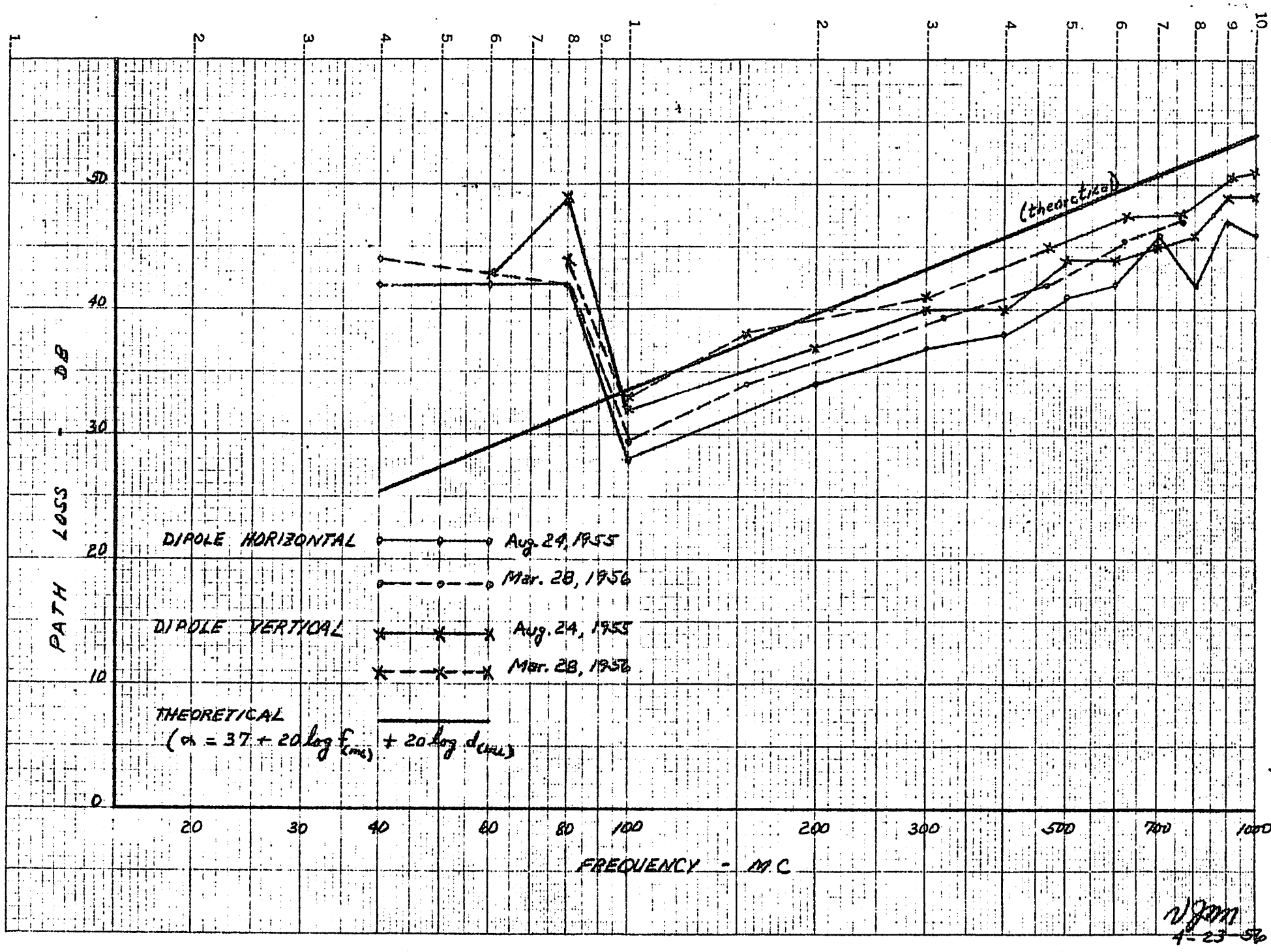
OBSERVERS

DATE: April 23, 1956

TEST EQUIPMENT

$$\alpha = 37 + 20 \log f_{(mc)} + 20 \log d_{(miles)}$$

Freq. mc.	Free Space Atten. d.b.	Distance Factor $20 \log d_{(miles)}$ d.b.	Freq Factor $20 \log f_{mc}$ db	Ground Reflection db	Gain of Dipole db	α db
38.9	37	-34.4	31.8	-4.7	-4.3	25.4
79.8	37	-34.4	37.9	-4.7	-4.3	31.5
155.4	37	-34.4	43.8	-4.7	-4.3	37.4
311	37	-34.4	49.9	-4.7	-4.3	43.5
466	37	-34.4	53.4	-4.7	-4.3	47
622	37	-34.4	55.9	-4.7	-4.3	49.5
777	37	-34.4	57.8	-4.7	-4.3	51.4


SEMI-LOGARITHMIC 359-61
KEUFFEL & ESSER CO.
2 CYCLES X 70 DIVISIONS
PATH LOSS - DB
FREQUENCY - MC
(theoretical)
DIPOLE HORIZONTAL
Aug. 24, 1955
Mar. 28, 1956
DIPOLE VERTICAL
Aug. 24, 1955
Mar. 28, 1956
THEORETICAL
(α = 37 + 20 log f(mc) + 20 log d(mi)
4/3/56
4-23-56