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[redacted] OPERATIONAL EVALUATION
OF
RADIO SET AN/TRT-2B(XL-1) EMPLOYED AS A VT-FUZE JAMMER

(JOB 33-56-0013)

EW SYSTEMS TEST
USAEPG-3
PHASE II
EQUIPMENT TEST
AND EVALUATION (U)

FEBRUARY 1957

UNITED STATES
ARMY ELECTRONIC PROVING GROUND
FORT HUACHUCA, ARIZONA

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USAEPG-SIG 920-76, Job 33-56-0013, Final Report, Operational Evaluation of Radio Set AN/TRT-2B(XL-1) Employed as a VT-fuze Jammer (U), has been prepared by the Electronic Warfare Department for the information of all concerned. Suggestions or criticisms on the form, contents, or use thereof, are invited, and recommendations may be submitted to the Commanding General, United States Army Electronic Proving Ground, Fort Huachuca, Arizona, ATTN: SIGPG-DCGO.

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Errata Sheet USAEPG 920-76

Page 20 "AN/URC-17 Radio Set"(Upper right of Fig. 7) should read "AN/VRC-17 Radio Set"

FINAL REPORT
OPERATIONAL EVALUATION
of
RADIO SET AN/TRT-2B(XL-1)
EMPLOYED AS A VT-FUZE JAMMER (U)
(Job 33-56-0013)

February 1957

Electronic Warfare Department
UNITED STATES ARMY ELECTRONIC PROVING GROUND
Fort Huachuca, Arizona

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FOREWORD

This final report on the operational evaluation of Radio Set AN/TRT-2B(XL-1) employed as a VT-fuze jammer has been prepared by the Electronic Warfare Department (EWD) as a part of Job 33-56-0013 (USAEPG-3 EW Systems Test) of the United States Army Electronic Proving Ground Technical Program. The tests were conducted during the period from October through December 1956.

Artillery support was furnished by the following organizations: C Battery, 38th Field Artillery Battalion, Fort Lewis, Wash.; 155-mm Howitzer Section, C Battery, 12th Field Artillery Battalion, Fort Lewis, Wash.; 8-in. Howitzer Section, A Battery, 268th Field Artillery Battalion, Fort Bragg, N.C.; Flash Platoon and Survey Squad, A Battery, 285th Field Artillery Observation Battalion, Fort Bragg, N.C.; Company D, 22nd Infantry Regiment, Fort Lewis, Wash.

The Army Security Agency Operations Center, Fort Huachuca, Arizona, assisted in these tests. Personnel of the 1st Signal Group and EWD, USAEPG, Fort Huachuca, Arizona, operated and maintained the equipment.

H. McD. BROWN
Col SigC
Chief, Electronic Warfare Department

ABSTRACT

The results of an operational evaluation of Radio Set AN/TRT-2B (XL-1), a VT-fuze jammer, are set forth. The equipment, which operates over a frequency range of from 70 to 200 Mc/s, is a swept cw jammer of approximately 80 watts maximum output, capable of am. modulation with audio tones and random mcw keying. The AN/TRT-2B (XL-1) is a modification of the AN/TRT-2B that provides greater time-on-signal to make the set effective against VT fuzes with anti-jamming features. The results of an operational evaluation of Radio Set AN/TRT-2B were published in USAEPG-SIG 920-50, September 1956.

Under optimum conditions the set predetonated 90 percent of T-226E2/A and T-227/A VT fuzes at a range of 2,500 yards. However, when the jamming aspect was varied, that effective range was not consistently maintained. A total of nine firing tests was conducted under varying parameters including simultaneous friendly and enemy fire and NVT and CVT fuzes.

Other subjects investigated were certain technical characteristics, operational times, ruggedness and transportability, vulnerability to intercept and direction finding, interference with communications, maintenance, and man-machine relationships.

CONTENTS

CONTENTS (Cont)

LIST OF ILLUSTRATIONS

CONTENTS (Cont)

LIST OF ILLUSTRATIONS (Cont)

LIST OF TABLES

Section I. Summary

Radio Set AN/TRT-2B(XL-1) was operationally evaluated to determine its usefulness as a VT-fuze jammer. The set is a swept cw jammer of about 80 watts maximum output, capable of am. modulation and provided with an URA-T1 tone generator for producing audio tones, step-tones, audio noise, and random mcw keying.

The AN/TRT-2B(XL-1) is a modified version of the AN/TRT-2B, upon which was published an operational evaluation report, AEPG-SIG 920-50, September 1956. The XL-1 modification restricts the sweep range, providing greater time-on-signal and increasing the effectiveness of the set as a VT-fuze jammer. The modification also eliminates the necessity of using 6 sets of plug-in coils to cover the frequency range of 70 to 200 Mc/s by providing two bands selected by a switch on the front panel.

Tests were conducted using three types of VT-fuze. The T-226E2/A was used with 105-mm howitzer; the T-227/A was used with the 8-in. and 155-mm howitzers; and the T-178E3 was used with the 81-mm mortar.

The interference effect of the jammer on an air-to-ground am. communication system was investigated. With the jammer sweeping at 1 sweep/sec communications were maintained although the jammer was within 1,000 yards of the ground station; both the aircraft and the ground station were within the main beam of the jammer, and the jammer was sweeping across the communication frequency. The interference effect was further reduced when the ground station did not lie in the main beam of the jammer. Since a low sweep rate was found to be most effective against VT-fuzes, the jammer is normally operated at low rates.

The AN/TRT-2B(XL-1) signal was intercepted at 10,000 yards by the AN/TLR-9 search and intercept receiver when the intercept station was in the main beam of the jammer. At this range the azimuth of the jammer was determined within 6 degrees by an AN/TRD-10 direction-finding set when the jammer was not sweeping. When the jammer was sweeping, it was difficult to obtain an accurate bearing. Beyond 15,000 yards the jammer was not intercepted even when beamed at the intercept site.

To simulate differing tactical situations, tests were conducted under widely varied conditions. The jammer was placed on the gun-to-target line with targets placed both ahead of and behind the jammer to obtain 0-degree aspect jamming. The jammer was also placed to the side of the gun-to-target trajectory to perform 90-degree aspect jamming. In each of these situations rounds were fired

in both high- and low-angle trajectories. A further variation in test conditions was provided by varying the arming time of the fuzes. Fuzes that armed as soon after leaving the weapon as safety permitted as well as fuzes set to arm at the mid-point of the trajectory of the projectile were used. Finally, tests were conducted with simultaneous fires from friendly and enemy gun positions.

In many cases the jammer parameters, sweep rate, modulation frequency, antenna polarization, and antenna elevation angle were varied to ascertain the optimum settings for a given situation. A sweep rate of one sweep/sec and a modulation frequency of 200 cps generally provided maximum effectiveness against the VT fuzes used. Horizontal polarization for 90-degree aspect firing and vertical polarization for 0-degree aspect firing usually provided the maximum power transfer between the jammer and the fuze. The optimum antenna elevation angle was obtained when the main beam was aimed at the trajectory of the projectile in the area where jamming was desired.

Experiments were performed with three antennas: the AS-266/TRT-2, the AS-542/U, and the EDL folded dipole which is a component of the AN/MLQ-8(XL-2). Varying the antenna elevation angle showed that the effect of ground reflection on the space pattern is a major and often unknown factor in the effectiveness of the AN/TRT-2B(XL-1). It is evident that an antenna pattern which minimizes the effect of ground reflection is highly desirable. It is impractical to attempt to predict the effect of ground reflection over a large tactical area because terrain and soil variations have a marked effect upon such reflection.

Under optimum conditions a kill of 90 percent was obtained against T-226E2/A and T-227/A fuzed projectiles at 2,500 yards. These ranges were not consistently maintained, however, when the projectile trajectory and jamming aspect were varied. When both friendly and enemy fire were present, it was possible to orient the jammer antenna so that a kill of 70 percent was obtained on enemy rounds with only 10-percent kill on friendly rounds.

The jammer is soundly constructed and required little maintenance. It is simple to operate and may be left unattended except when it is necessary to refuel the generator or change the operating conditions of the jammer. The complete equipment can be transported in a jeep with a trailer.

With further modification of the jammer and with the development of an antenna more suited to fuze jamming, the AN/TRT-2B(XL-1) is expected to be consistently effective against VT-fuzed fire at ranges of 1,000 to 2,500 yards.

Section II. Introduction

1. BACKGROUND

In its original form the AN/TRT-2 was a cw transmitter with a power supply and antenna covering from 66 - 200 Mc/s in six separate bands. The frequency of the transmitter was swept over the entire band of interest.

A modified version, the AN/TRT-2B, incorporated a modulator and amplifier into the original design and thus provided amplitude modulation of several types. This modification of the AN/TRT-2B was tested at AEPG to determine its capability in jamming VT fuzes. The results obtained were far from satisfactory, but none the less encouraging.*

The Electronic Defense Laboratories, a division of Sylvania Electric Co., performed the necessary modifications indicated by early tests and built the AN/TRT-2B(XL-1). The set covers a frequency range of 70 - 200 Mc/s in two bands. The frequency can be swept over a band of 2 to 7 percent of the carrier frequency. When used to jam VT fuzes, the smaller sweep band provides a greater time-on-signal and greatly increases the effectiveness of the jammer.

2. PURPOSE OF TESTS

The purpose of the tests was to evaluate the operating characteristics and limitations of the AN/TRT-2B(XL-1) when used to jam VT fuzes.

3. SCOPE OF TESTS

The tests were conducted to determine range and effectiveness against T-226E2/A fuzes used with the 105-mm howitzer, T-227/A fuzes used with the 8-in. howitzer and the 155-mm howitzer, and T-178E3 fuzes used with the 81-mm mortar.

*Results published in AEPG-SIG 920-50, September 1956.

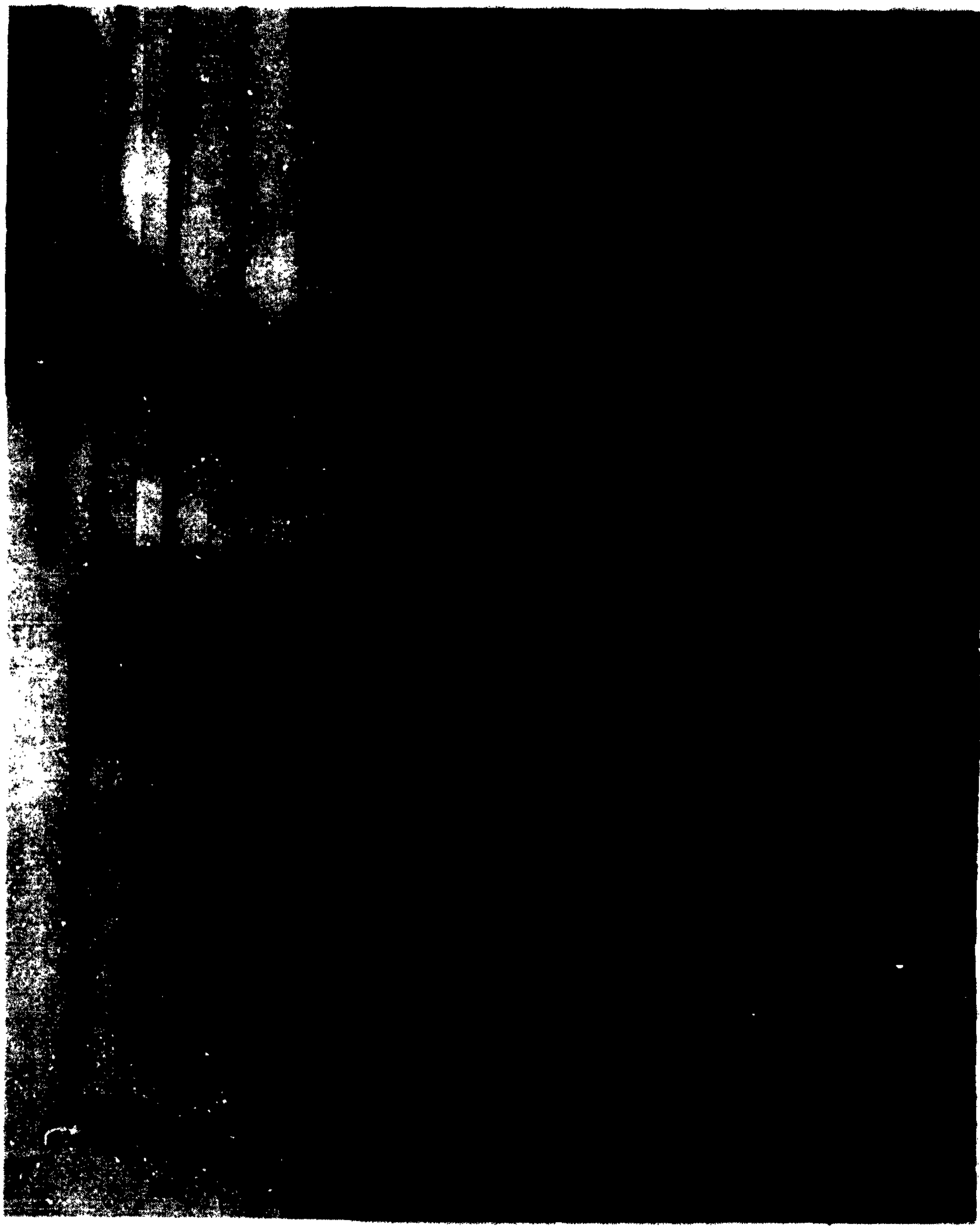


Fig. 1. Radio Set AN/TRC-29(XE-1) mounted in truck with Antenna AS-264/TRC-2

Section III. Description of the AN/TRT-2B(XL-1)

4. PHYSICAL DESCRIPTION

Radio Set AN/TRT-2B(XL-1) is a compact, transportable transmitting set. A photograph of the equipment is shown in fig. 1. Its main components are a transmitter, modulation and amplifier unit, antenna, power unit, and set of spare parts. The physical characteristics of the set are as follows:

Component	Required (nr)	Dimensions (in.)	Weight (lbs)
Transmitter Chest CY-17/TRC-1 containing: 1 Transmitter T-131B/TRT-2B (XL-1) 1 Cable CX-1911/U 1 Cable CX-1890/U 1 Cable CG-874/U	1	16 x 17 3/4 x 22½	95
Modulator/Amplifier Chest CY-1093/TRT-2B containing: 1 Modulator MD-156( )/TRT-2B 1 Amplifier AM-583( )/TRT-2B(XL-1)	1	16 x 17 3/4 x 22½	90
Antenna Chest CY-16/TRA-1 containing: 1 Antenna AS-266/TRT-2 1 Junction Box J-152/TRT-2 1 Cable CX-1889/U	1	13½ x 16 x 46	80
Power Unit PU-6/TPS-1	1	23½ x 22½ x 40	235
Spare Parts Chest CY-1420/TRT-2B containing: 1 set of spare parts 1 Junction Box JB-451/TRT-2B (XL-1)	1	16 x 17 3/4 x 22½	60

Antenna AS-266/TRT-2 consists of a large sleeved dipole reflector and matching transformer. It is nondirectional without reflector and approximately 180 degrees in beamwidth with reflector. It can be polarized either horizontally or vertically.

5. TECHNICAL CHARACTERISTICS

The transmitter of the AN/TRT-2B(XL-1) is a self-excited oscillator and power supply contained in one package. The frequency of 70 to 200 Mc/s is divided into two bands which are selected by means of a switch on the front panel. The carrier frequency can be swept over a frequency band of 2 to 7 percent of center frequency, depending on the particular center frequency, by a motor-driven sweep mechanism. This carrier can be modulated by use of the amplifier AM-583( )/TRT-2B(XL-1).

A block diagram of the equipment is shown in fig. 2, and the technical characteristics are listed in the following table:

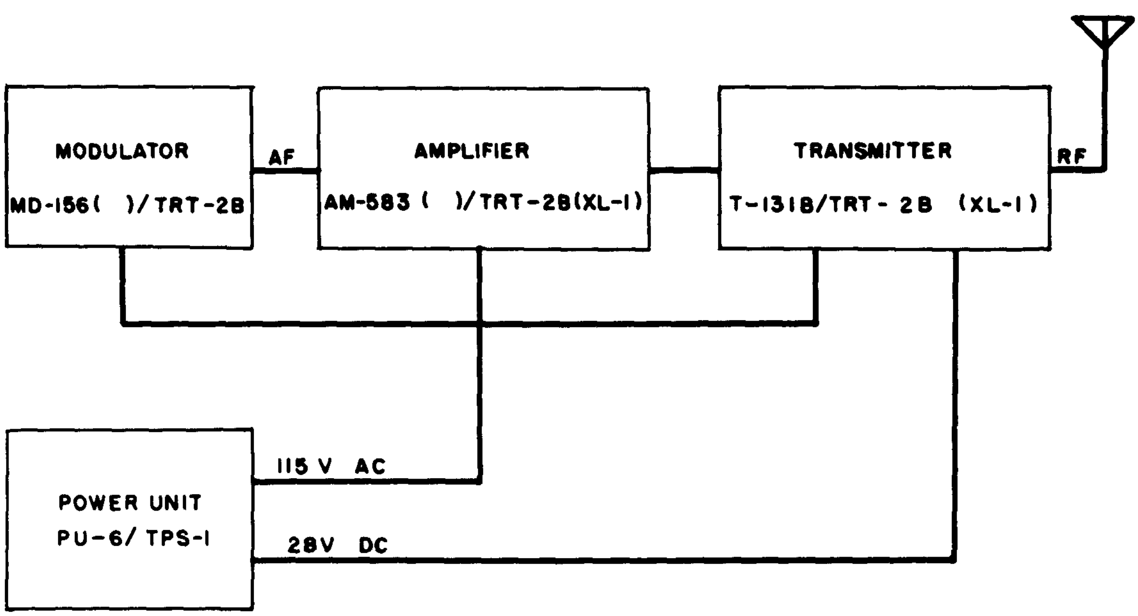


Fig. 2. Block diagram of AN/TRT-2B(XL-1)

Frequency Range:	Band A, 70-120 Mc/s Band B, 110-200 Mc/s
Transmitter type:	Self excited, parallel line, push-pull oscillator feeding the antenna directly
Type of signal transmitted:	Unmodulated cw or am., either of which may be swept over a frequency range of 2 to 7 percent of the center frequency depending on transmitting frequency
Types of modulation available:	Random noise, steptones, audio sine wave tones, cw and mcw random keying
Rate of sweep:	1 to 8 sweeps/sec
Power output:	75 to 100 watts, depending upon transmitter frequency
Power input: 115 v 400 cps input 28 v dc input	 2.5 amperes 1 ampere

Section IV. Operational Tests

6. TEST 1. SWEEP RATE AND SWEEP DEVIATION

The purpose of this test was to determine the sweep rate at different positions of the sweep rate control and to determine the sweep frequency deviation at 20-Mc/s intervals over the frequency range of the AN/TRT-2B(XL-1).

The modified AN/TRT-2B(XL-1) has a sweep rate control calibrated in sweeps/sec. This is not to be confused with the revolutions of the sweep index indicator. One complete revolution of the sweep index equals 4 sweeps as defined by EDL. This is because the motor-controlled variable capacitor used to sweep a narrow band is of the butterfly type. It causes a complete sweep of frequencies every quarter turn (90^{o}), thus producing 4 sweeps per revolution.

The sweep rate control is calibrated from 1 to 8 sweeps/sec. The sweep rate was checked at each of the positions against a stop watch. Results are as follows:

Indicated sweeps/sec	Actual sweeps/sec
1	0.9
2	1.9
3	2.8
4	4.0
5	4.8
6	5.6
7	6.4
8	7.2

The sweep deviation was measured by observing the output of the AN/TRT-2B(XL-1) on an AN/TLR-9 receiver. The results are shown in the following table:

Band	Frequency			Frequency deviation	
	Low (Mc/s)	Center (Mc/s)	High (Mc/s)	(Mc/s)	(percentage)
A	69.7	70.0	74.0	4.3	6
	86.9	90.0	92.5	5.6	6
	106.5	110.0	113.4	6.9	6.4
B	105.5	110.0	114.0	7.5	6.5
	125.0	130.0	135.0	10.0	7.6
	143.9	150.0	157.0	13.1	8.6
	163.0	170.0	178.0	15.0	8.9
	181.9	190.0	199.1	17.2	9.1

The power unit used was a PU-20 C/B, which operates from 110 v ac at 60 cps and produces 110 v ac at 400 cps and 28 v dc for the sweep motor and blower. Any variation in the dc voltage causes a variation in sweep rate.

7. TEST 2. POWER OUTPUT AS A FUNCTION OF FREQUENCY; NOISE MODULATION BANDWIDTH

The purpose of this test was to measure the power output of the AN/TRT-2B(XL-1) as a function of frequency and to measure the noise modulation bandwidth. A bench test was arranged as shown in fig. 3. The power output was measured every 5 Mc/s from 100 to 200 Mc/s. At each frequency the output control was adjusted for maximum power output as read on the wattmeter. The results of this test are presented in figs. 4 and 5. No modulation was applied to the transmitter. Input voltages for the AN/TRT-2B(XL-1) supplied by the PU-6 power unit remained constant during the test.

With noise modulation applied to the transmitter the noise modulation bandwidth was 3 Mc/s with the noise filter in the circuit. The noise bandwidth without the filter was not measured because the filter could not be removed from the circuit.

8. TEST 3. RUGGEDNESS AND TRANSPORTABILITY

The purpose of the test was to examine the AN/TRT-2B(XL-1) for

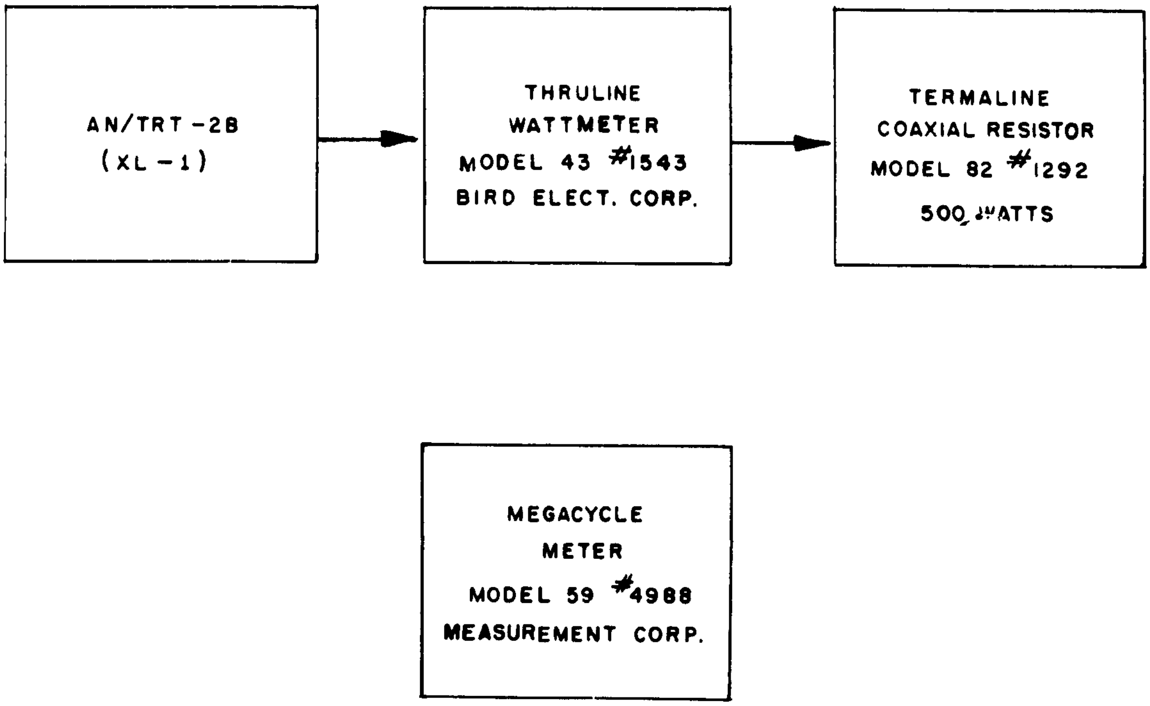


Fig. 3. Arrangements for test of power output and noise modulation

ruggedness and transportability. The equipment was placed in a 3/4-ton truck which had no protective covering and driven at ten miles per hour over the 10-mile cross-country course shown in fig. 6. No malfunctions of the equipment resulted from this movement.

With the equipment mounted in a 3/4-ton truck as shown in fig. 7, the truck was crowded, and inadequate space remained for safe operation while the vehicle was in motion.

9. TEST 4. SET-UP AND TAKE-DOWN TIME

The purpose of these tests was to determine the set-up and take-down time for the AN/TRT-2B(XL-1). The set-up and take-down tests were conducted with a two-man crew. It was difficult for two men to handle and install Antenna Assembly AS-266/TRT-2 because of its bulkiness. Under windy conditions erection is very difficult. The average set-up time was 19 minutes with an additional

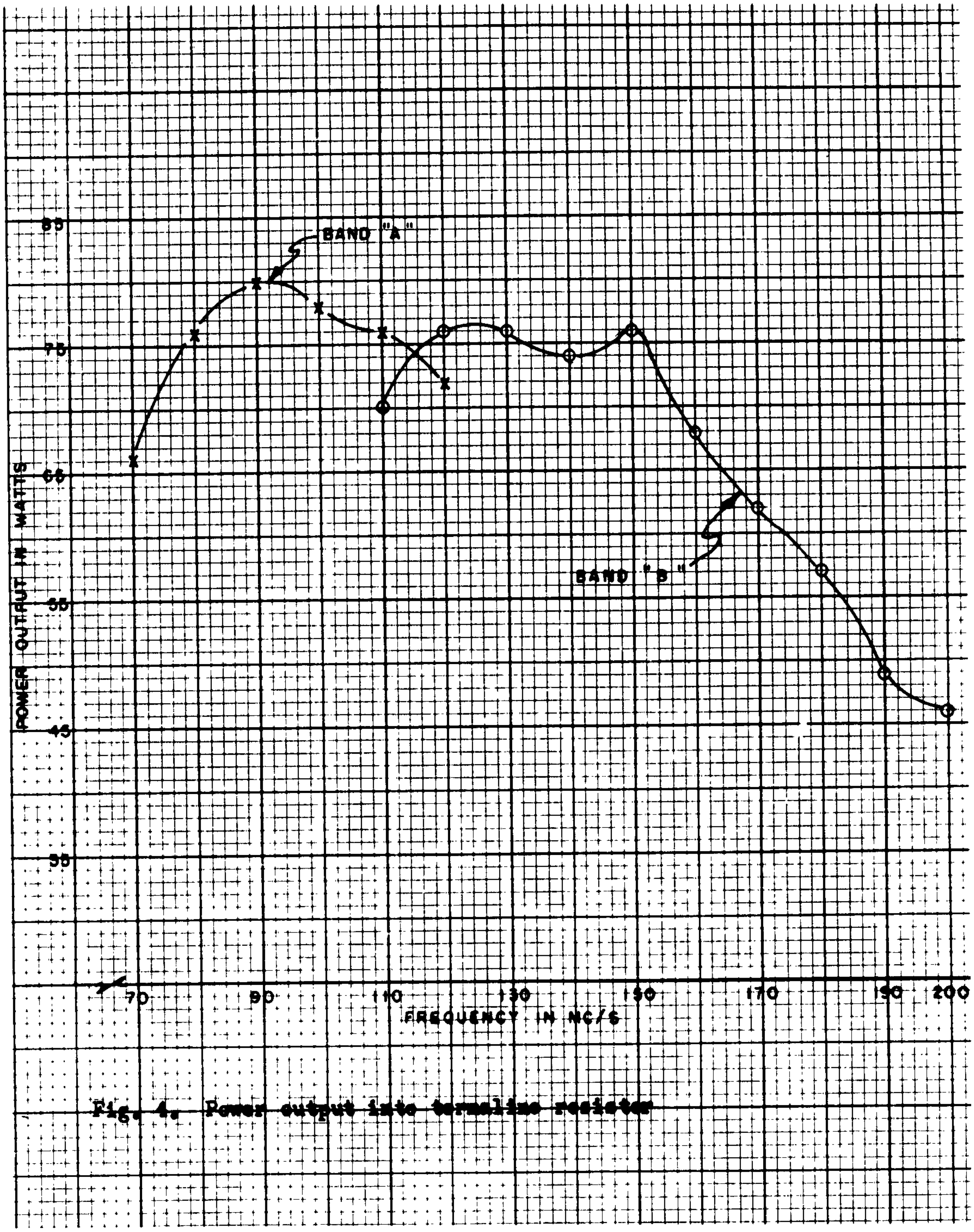


Fig. 4. Power output into termaline resistor

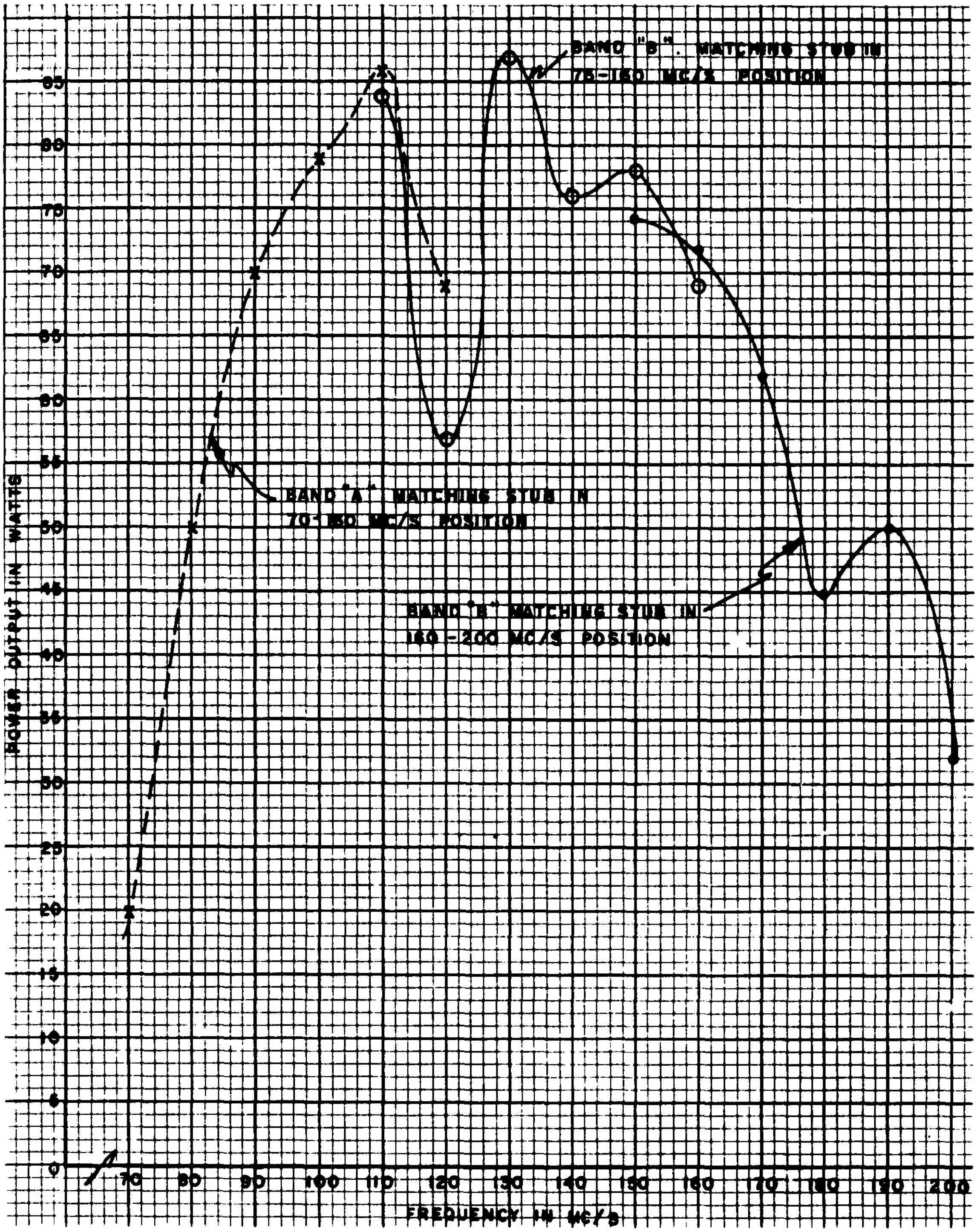


Fig. 5. Power output into AS-266/TRT-2

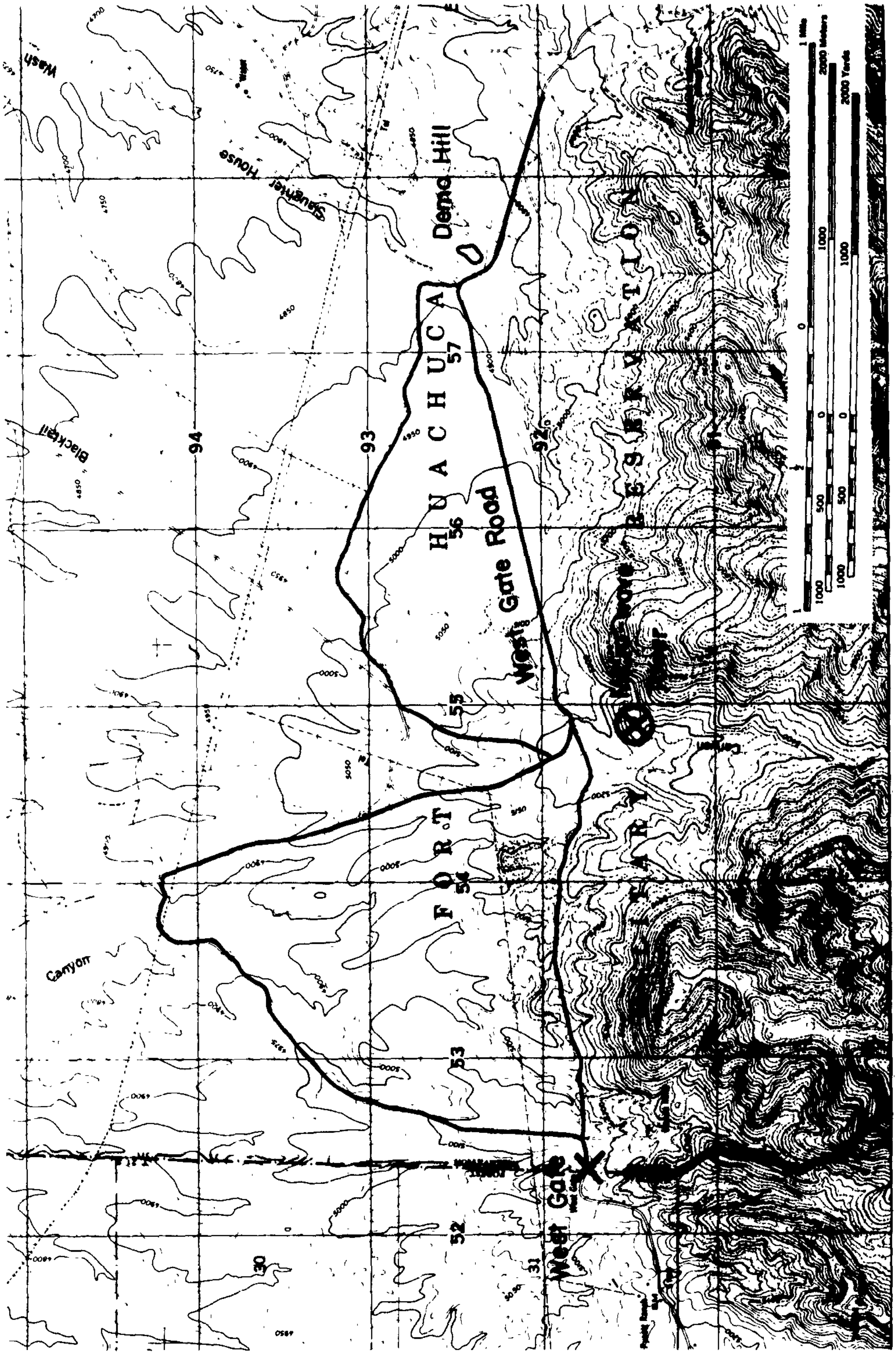
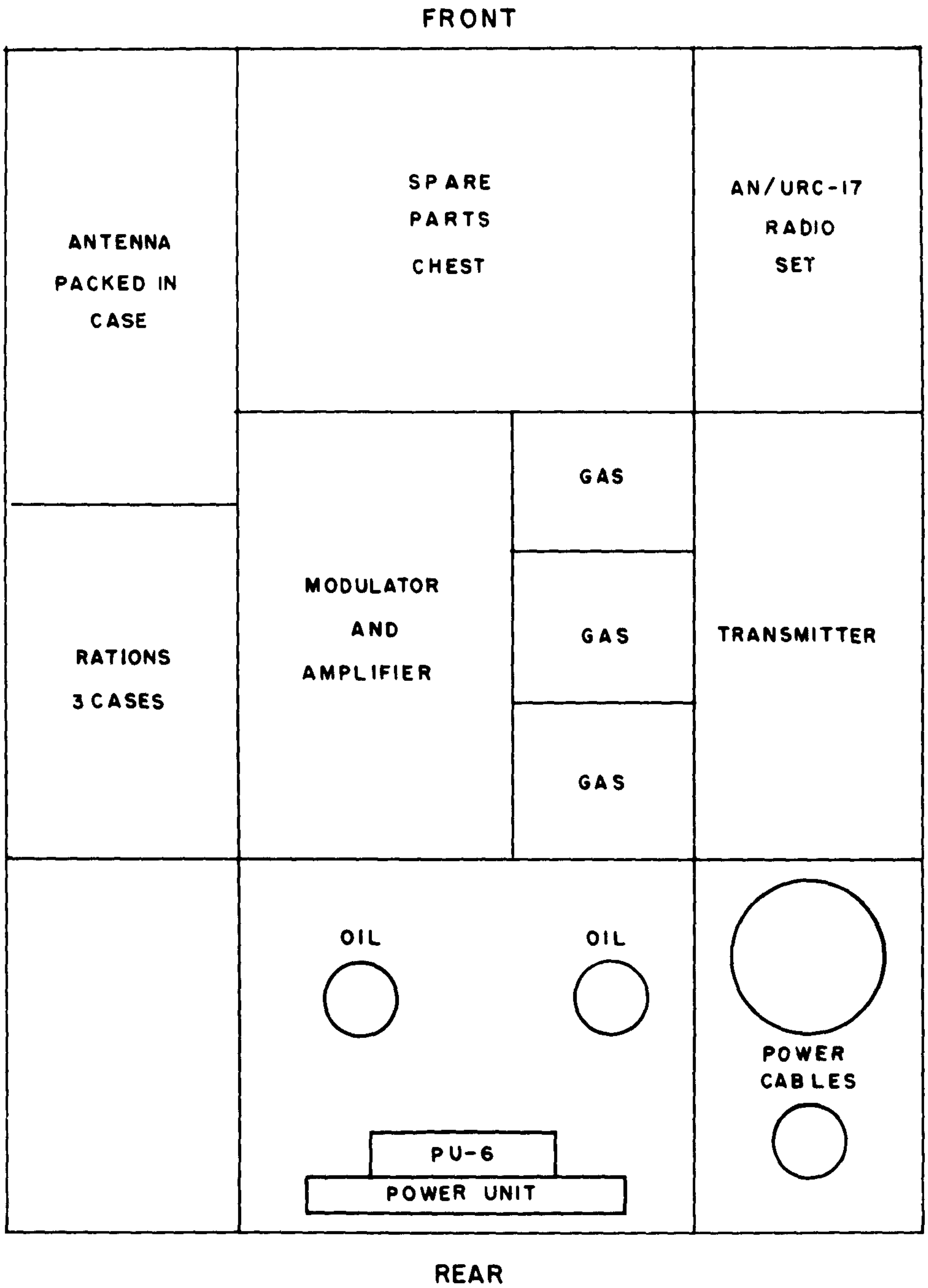


Fig. 6. Route for test of ruggedness and transportability



NOTE: TWO MEN WITH WEAPONS CARRIED IN CAB OF TRUCK

Fig. 7. Arrangement of equipment in truck for test of ruggedness and transportability

warm-up time of 3 to 5 minutes required before operation. The average take-down time was 15 minutes.

10. TEST 5. TIME REQUIRED TO CHANGE FREQUENCY

The purpose of this test was to determine the frequency change time of the AN/TRT-2B(XL-1). Two frequency bands are selected by a switch on the front panel. The time required to change from one transmitting frequency to a second specified frequency was measured. The operator used the following procedure:

a. Switch PLATE VOLTAGE to OFF
b. Set frequency tuning control to the desired frequency
c. Set BAND SWITCH to desired band
d. Switch PLATE VOLTAGE to ON
e. Adjust coupling control for maximum output.

Tuning the entire range of band A (70-110 Mc/s) required 32 seconds. Tuning the entire range of band B (110-200 Mc/s) required 38 seconds. Tuning the entire range of band A and then switching to band B required 46 seconds.

11. TEST 6. SIGNAL RADIATION

The purpose of this test was to measure the signals radiated by the AN/TRT-2B(XL-1) in the frequency range of 20 to 400 Mc/s with the set tuned to 100 Mc/s. The signal strength was measured with a field strength meter placed 1,000 yards from the set. Step-tone modulation was applied to the set, which was supplying 80 watts to Antenna AS-266/TRT-2. At 100 Mc/s a field strength of 1,600 uv/m was measured in the main beam of the antenna and 400 uv/m in the reverse direction. One undesired signal was observed at 78.7 Mc/s with a strength of 5.5 uv/m in the main beam and 2.5 uv/m in the reverse direction.

12. TEST 7. VULNERABILITY TO INTERCEPT

This test was conducted to determine the vulnerability of the AN/TRT-2B(XL-1) to intercept and direction finding.

An AN/TLR-9 search receiver and AN/TRD-10 direction-finding set were used. The AN/TRT-2B(XL-1) was operated at 100 Mc/s with 70 watts output and was beamed at the intercept and direction-finding equipment.

The following indications were obtained on an AN/TRD-10 placed 10,000 yards from the AN/TRT-2B(XL-1):

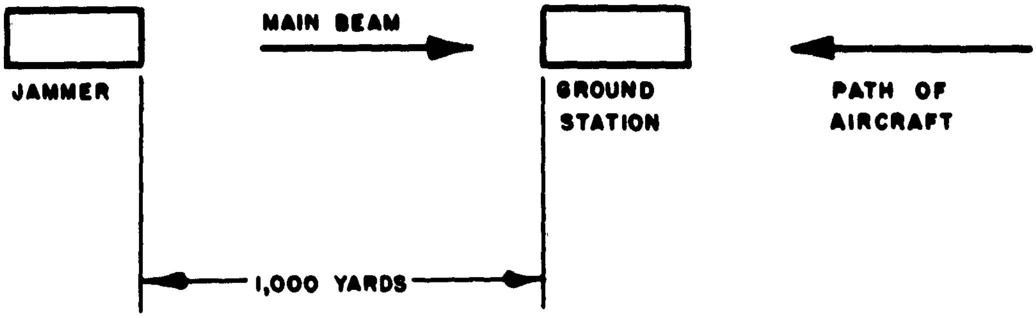


Fig. 8. First siting arrangement to test communications interference

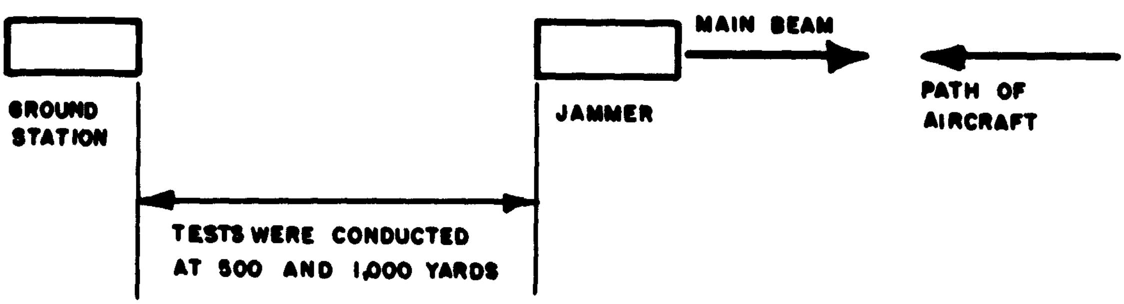


Fig. 9. Second siting arrangement to test communications interference

Signal frequency		Signal modulation		Azimuth	
True (Mc/s)	Indicated (Mc/s)	True (as shown)	Indicated (as shown)	True (deg)	Indicated (deg)
100	100.35	Step-tones only	Step-tones	9	3
100	104.15	Sweeping at 2 sweeps/sec plus step-tones	Not detectable	9	265

The intercept operators were told only that the frequency of the jammer was between 95 and 150 Mc/s. On the average the operators required two minutes to determine the frequency and azimuth of the jammer signal received at the intercept site.

At 15,000 yards the intercept and direction-finding equipment was not able to intercept or locate the AN/TRT-2B(XL-1) although the jammer was beamed at the intercept site.

13. TEST 8. INTERFERENCE WITH COMMUNICATIONS

The purpose of the test was to determine the interference effect of the AN/TRT-2B(XL-1) on an air-to-ground am. communications system. An ARC-12 operating at 121.7 Mc/s was used for the ground station, and the AN/TRT-2B(XL-1) was also tuned to 121.7 Mc/s.

Using the test layout shown in fig. 8 the aircraft made three runs at altitudes of 500, 1,000, and 2,000 feet. The same effects were noted for all altitudes. When the jammer was sweeping at 1 sweep/sec, slight interference was observed, but communications were not affected. With the jammer sweeping at its maximum sweep rate, severe interference was observed although communication could still be maintained. With the jammer set on 121.7 Mc/s and not sweeping, communication was not possible.

Using the test layout shown in fig. 9 the aircraft made three runs at 500, 1,000, and 2,000 feet. The same effects were noted for all altitudes. Although, when the jammer swept at its maximum rate, severe interference was observed, communications could still be maintained. With the jammer set on 121.7 Mc/s and not sweeping severe interference was observed, but communication was possible provided that the aircraft was within 5 miles ground distance of the ground station.

Section V. Tests of Range and Effectiveness

14. GENERAL INFORMATION

The tests of effectiveness were conducted using the 105-mm howitzer, 155-mm howitzer, 8-in. howitzer, and 81-mm mortar. Throughout the firing tests "aspect" is defined as the horizontal projection of the angle between the axis of the main lobe of the jammer antenna and the trajectory of the projectile in the direction from target to weapon. High-angle fire is defined as fire with the weapon at an elevation angle greater than 800 mils, and low-angle fire conversely employs a weapon elevation of less than 800 mils.

The jamming range at 90-deg aspect is defined as the distance along the ground between the jammer and the point on the ground directly beneath the intersection of the axis of the main beam of the jammer and the trajectory of the projectile. The jamming range at 0-deg aspect is defined as the distance between the jammer and the ground target.

Optimum antenna parameters are those for which the antenna is beamed at the trajectory and the polarization is parallel to the trajectory at the point of interest. This generally results in vertical polarization for 0-deg aspect fire and horizontal polarization for 90-deg aspect fire.

The term "normal variable time" (NVT) describes fuzes which are set to arm as soon after the projectile leaves the weapon as safety will permit. The term "controlled variable time" (CVT) describes fuzes which are set to arm three seconds before impact.

Three antennas were used during these tests. The AS-266/TRT-2 is the component antenna of the AN/TRT-2B(XL-1) and consists of a dipole with reflector. The antenna of the AN/MLQ-8(XL-2) is a dipole with corner reflector. The AS-542/U antenna is a component part of the AN/MRT-4 and consists of a discone with a large corner reflector.

The results of all firing tests are tabulated in Annex A, table I.

15. TEST 9. EFFECTIVENESS AGAINST NVT FIRE, ASPECT 90 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-226E2/A fuze when used with the 105-mm howitzer at 90-deg aspect and to compare the AS-266/TRT-2 antenna with the AN/MLQ-8(XL-2) antenna.

The constants of the test were:

Power output	maximum
Sweep range	157-177 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	NVT, type T-226E2/A
Antenna parameters	optimum
Weapon	105-mm howitzer
Aspect	90 deg

The results indicate that the jammer is more effective against low-angle fire than high-angle fire under these conditions, and the AN/MLQ-8(XL-2) antenna is more effective against high- and low-angle fire than the AS-266/TRT-2.

At 2,500 yards a kill of 66 percent was obtained on low-angle fire with the AS-266/TRT-2 although lobing effects reduced the low-angle effectiveness at shorter ranges. At 2,500 yards the AN/MLQ-8 (XL-2) antenna produced 88 percent kill against low-angle fire. At 2,500 yards 20-percent kill was obtained against high-angle fire with the AN/MLQ-8(XL-2) antenna. When the AS-266/TRT-2 was used against high-angle fire, the range had to be reduced to 1,000 yards in order to predetonate 30 percent of the fire. The results are shown graphically in fig. 10.

16. TEST 10, EFFECTIVENESS AGAINST CVT FIRE, ASPECT 90 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-226E2/A fuze (CVT) when used with the 105-mm howitzer at 90-deg aspect.

The constants of the test were:

Power output	maximum
Sweep range	151-165 Mc/s
Sweep rate	½ sweep/sec (a rate of 1 sweep/sec was found ineffective)
Modulation	200 cps
Antenna	AS-266/TRT-2
Fuze	CVT type T-226E2/A
Antenna parameters	optimum
Weapon	105-mm howitzer
Aspect	90 deg

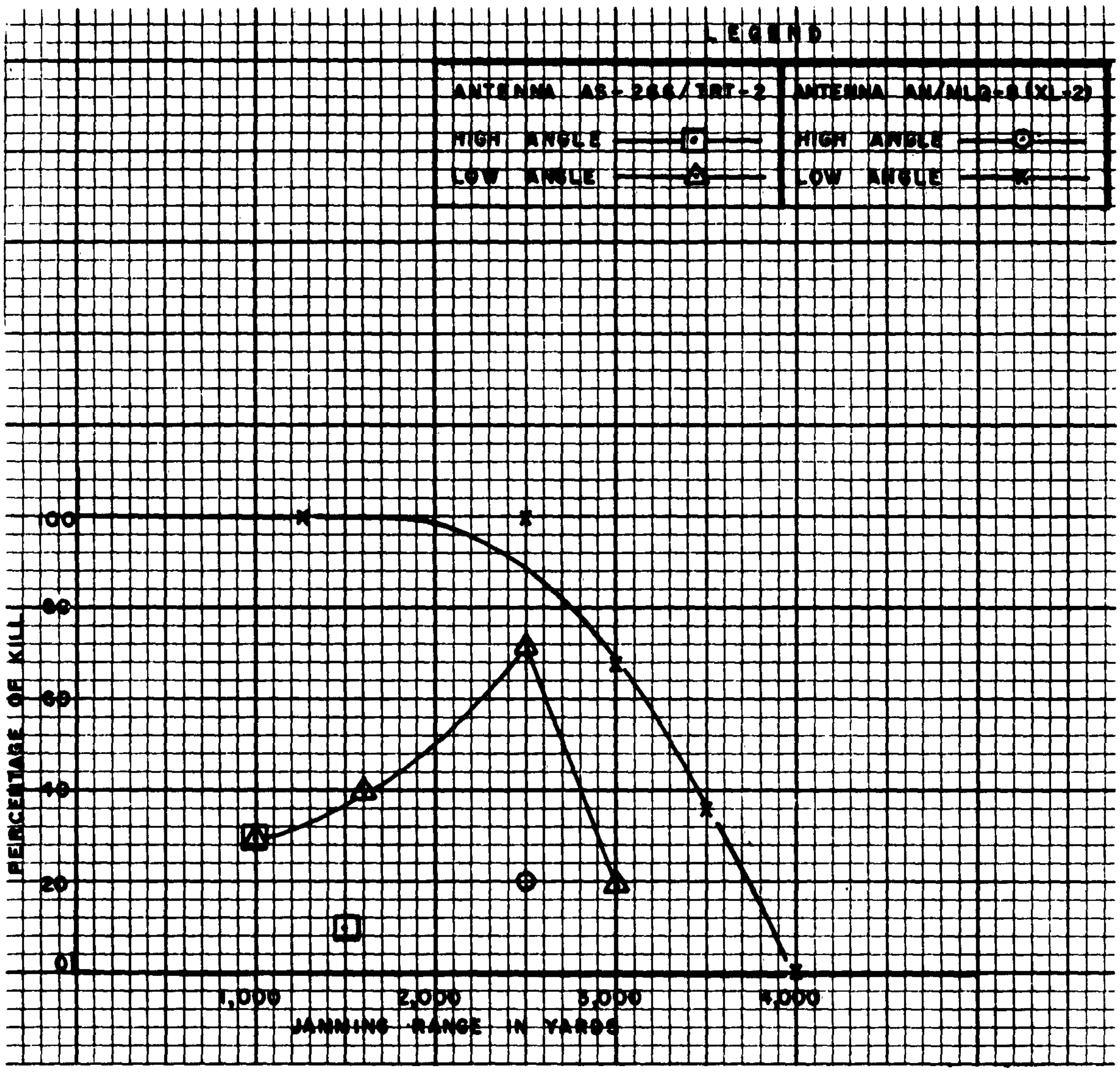


Fig. 10. Effectiveness against 105-mm howitzer fire at 90-degree aspect

At 1,600 yards a kill of 10 percent was obtained on low-angle fire and 40 percent kill on high-angle fire, in contrast to test 9, where NVT fuzes were used and greater effectiveness was obtained against low-angle fire.

When jamming NVT fuzes, the jammer is beamed horizontally at the midpoint of the trajectory, and high-angle fire probably passes above the effective beam of the jammer. When jamming CVT fuzes, the jammer must be beamed at the target end of the trajectory, where the projectile becomes armed and low-angle fire probably passes below the effective beam of the jammer.

This may explain why the jammer is more effective against low-angle NVT fire and high-angle CVT fire and less effective against high-angle NVT fire and low-angle CVT fire. Unquestionably the difference in effectiveness is for the major part chargeable to the shift in the antenna pattern caused by the difference in antenna aiming and ground reflection, relative to the projectile trajectory.

17. TEST 11. EFFECTIVENESS AGAINST CVT FIRE, ASPECT 0 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-226E2/A fuze (CVT) when used with the 105-mm howitzer at 0-deg aspect with target areas both before and behind the jammer.

The constants of this test were:

Power output	maximum
Sweep range	155-171 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	CVT, type T-226E2/A
Antenna parameters	optimum
Weapon	105-mm howitzer
Aspect	0 deg

The results shown in fig. 11 indicate that the jammer is more effective against high-angle than low-angle fire. Use of the AS-542/U antenna increases the effective range over that obtained with the AS-266/TRT-2 antenna.

The maximum effective range (90-percent kill) ag inst high-angle fire using the AS-266/TRT-2 antenna is 750 yards with the target either before or behind the jammer. At 550 yards a kill of 10 percent was obtained in low-angle fire.

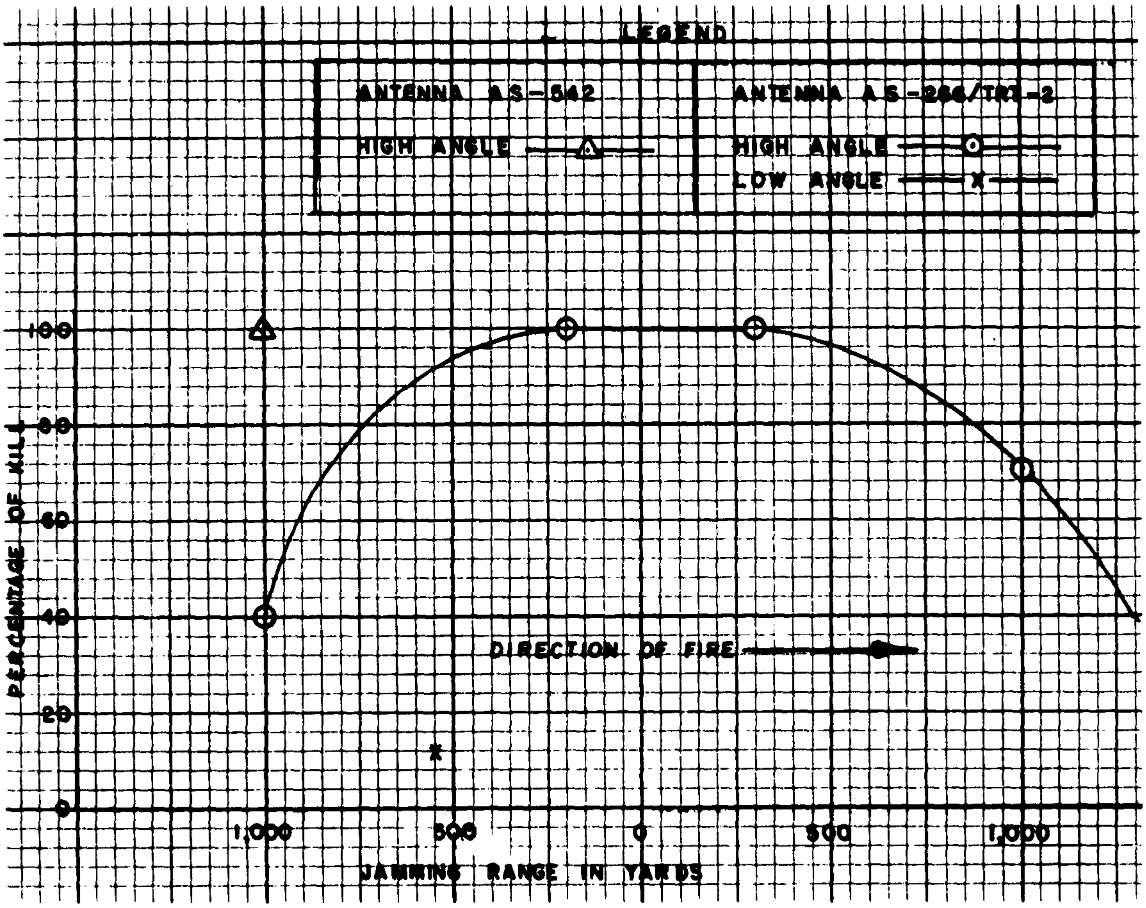


Fig. 11. Effectiveness against 105-mm howitzer fire at 0-degree aspect

18. TEST 12. EFFECTIVENESS AGAINST T-227/A FUZE, ASPECT 90 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-227/A fuze (NVT) when used with the 8-in. howitzer and 155-mm howitzer at 90-deg aspect.

The constants of the test were:

Power output	maximum
Sweep range	96-108 Mc/s
Sweep rate	2 sweeps/sec
Modulation	200 cps
Antenna	AS-266/TRT-2
Fuze	NVT type T-227/A
Antenna parameters	optimum
Aspect	90 deg

The results shown in figs. 12 and 13 indicate that the jammer is more effective against low-angle fire than against high-angle fire. The maximum effective ranges with 90-percent kill are shown below:

155-mm Howitzer		8-inch Howitzer	
High angle	Low angle	High angle	Low angle
1,000 yds	1,500 yds	90 percent kill not obtained	2,500 yds

19. TEST 13. EFFECTIVENESS AGAINST T-227/A FUZE, ASPECT 0 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-227/A fuze (CVT) when used with the 155-mm howitzer at 0-deg aspect.

Constants of the test were:

Power output	maximum
Sweep range	96-108 Mc/s
Modulation	200 cps
Antenna	AS-266/TRT-2
Fuze	CVT type T-227/A
Weapon	155-mm howitzer
Antenna parameters	optimum
Aspect	0 deg

With low-angle fire and a sweep rate of 2 sweeps/sec, no predetonations were obtained at 300 yards. Changing the rate to 1 sweep/sec produced a 20-percent kill. With low-angle fire and a rate of 2 sweeps/sec, no predetonations were obtained at 1,000 yards. Changing the rate to 1 sweep/sec resulted in a 50-percent kill.

With high-angle fire and a sweep rate of 2 sweeps/sec,a 30-percent kill was obtained at 1,000 yards. Using 1 sweep/sec a kill of 30-percent was also obtained at this range. With high-angle fire and a rate of 1 sweep/sec, a kill of 20 percent was obtained at 300 yards.

20. TEST 14. EFFECTIVENESS AGAINST T-178E3 FUZE, ASPECT 90 DEGREES

The purpose of this test was to determine the effectiveness of

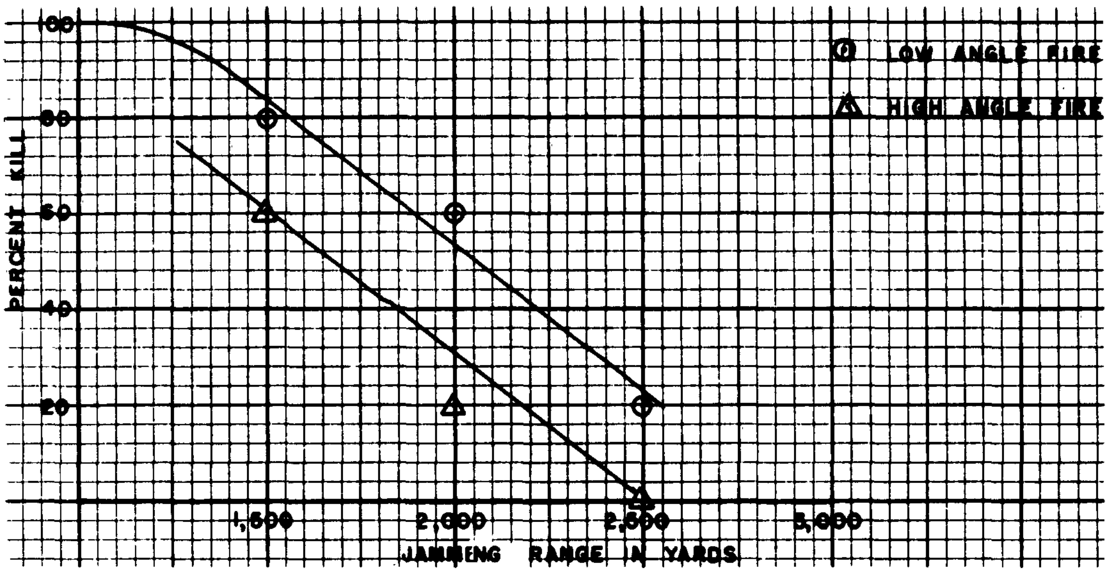


Fig. 12. Effectiveness against 155-mm howitzer fire

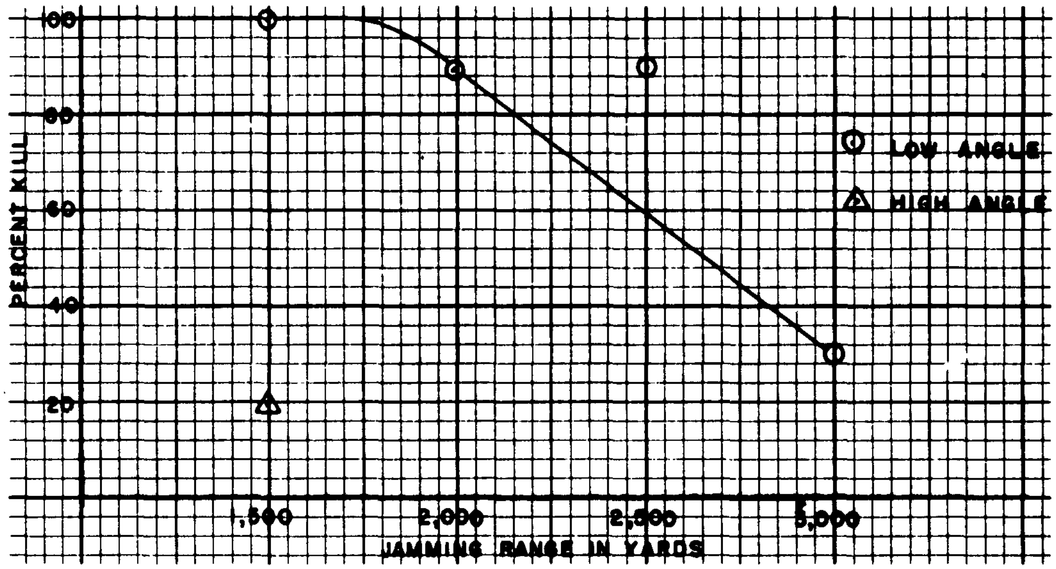


Fig. 13. Effectiveness against 8-in. howitzer fire

the AN/TRT-2B(XL-1) against the T-178E3 fuze (NVT) when used with the 81-mm mortar at 90-deg aspect.

The constants of the test were:

Power output	maximum
Sweep range	134-146 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	NVT, type T-178E3
Weapon	81-mm mortar
Antenna parameters	optimum
Aspect	90 deg

With high-angle fire at 1,000 yards, 30-percent kill was obtained using antenna AS-266/TRT-2. Under the same conditions 20-percent kill was obtained using the antenna of the AN/MLQ-8(XL-2). The antenna elevations were varied to determine optimum elevations. The best results were obtained with horizontal polarization using antenna AS-266/TRT-2 at 0-deg elevation and the AN/MLQ-8(XL-2) antenna at 45-deg elevation.

21. TEST 15. EFFECTIVENESS AGAINST THE T-178E3 FUZE, ASPECT 0 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-178E3 fuze (NVT) when used with the 81-mm mortar at 0-deg aspect.

The constants of the test were:

Power output	maximum
Sweep range	134-146 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	NVT, type T-178E3
Weapon	81-mm mortar
Antenna parameters	optimum
Aspect	0 deg

With high-angle fire a kill of 80 percent was obtained at 200 yards using the AS-266/TRT-2 antenna. Under the same conditions 100-percent kill was obtained with the AS-542/U antenna, which has higher gain and is therefore expected to provide greater effectiveness than the AS-266/TRT-2.

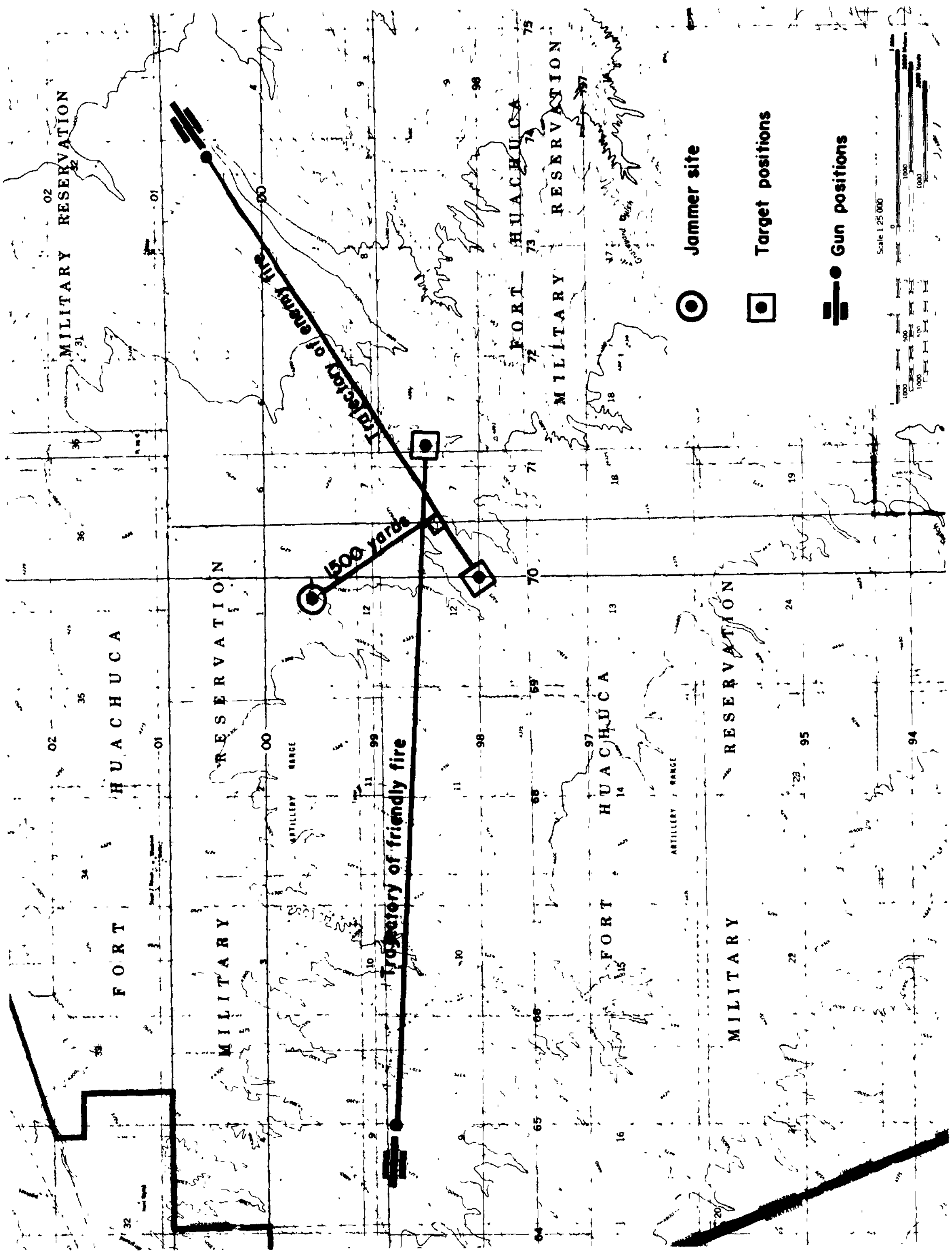


Fig. 14. Siting arrangement for Test 16

22. TEST 16. SIMULTANEOUS FRIENDLY AND ENEMY FIRE, ASPECT 90 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-226E2/A fuze with simultaneous friendly and enemy fire at 90-deg aspect. The 105-mm howitzer and the NVT type T-226E2/A fuze were used by both friendly and enemy artillery. The siting arrangements are shown in fig. 14.

The constants of the test were:

Power output	maximum
Sweep range	155-171 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	NVT, T-226E2/A
Weapon	105-mm howitzer
Antenna parameters	optimum
Aspect	90 deg

A kill of 10 percent of enemy rounds and no kill of friendly rounds resulted when using the AS-266/TRT-2 antenna (horizontal polarization, 0-deg elevation) at a range of 1,500 yards from the jammer to the enemy trajectory. Under similar conditions 50-percent kill of enemy rounds and no kill of friendly rounds resulted when using the AN/MLQ-8(XL-2) antenna (45-deg polarization, 20-deg elevation).

The jammer was oriented to obtain 90-deg aspect with enemy fire and approximately 135-deg with friendly fire while the distance along the axis of the main beam of the jammer to the enemy trajectory was 1,500 yards and to the friendly trajectory, 1,300 yards. A greatly increased kill of enemy rounds resulted from the greater coupling of jammer to fuze obtained at 90-deg aspect.

23. TEST 17. SIMULTANEOUS FRIENDLY AND ENEMY FIRE, ASPECT 0 DEGREES

The purpose of this test was to determine the effectiveness of the AN/TRT-2B(XL-1) against the T-226E2/A fuze with simultaneous friendly and enemy fire at 0-deg aspect. The 105-mm howitzer and the early arming T-226E2/A fuze were used by both friendly and enemy artillery. The test siting is shown in figs. 15 and 16. The enemy weapons fired low-angle fire, and the friendly weapon fired high-angle fire.

The constants of this test were:

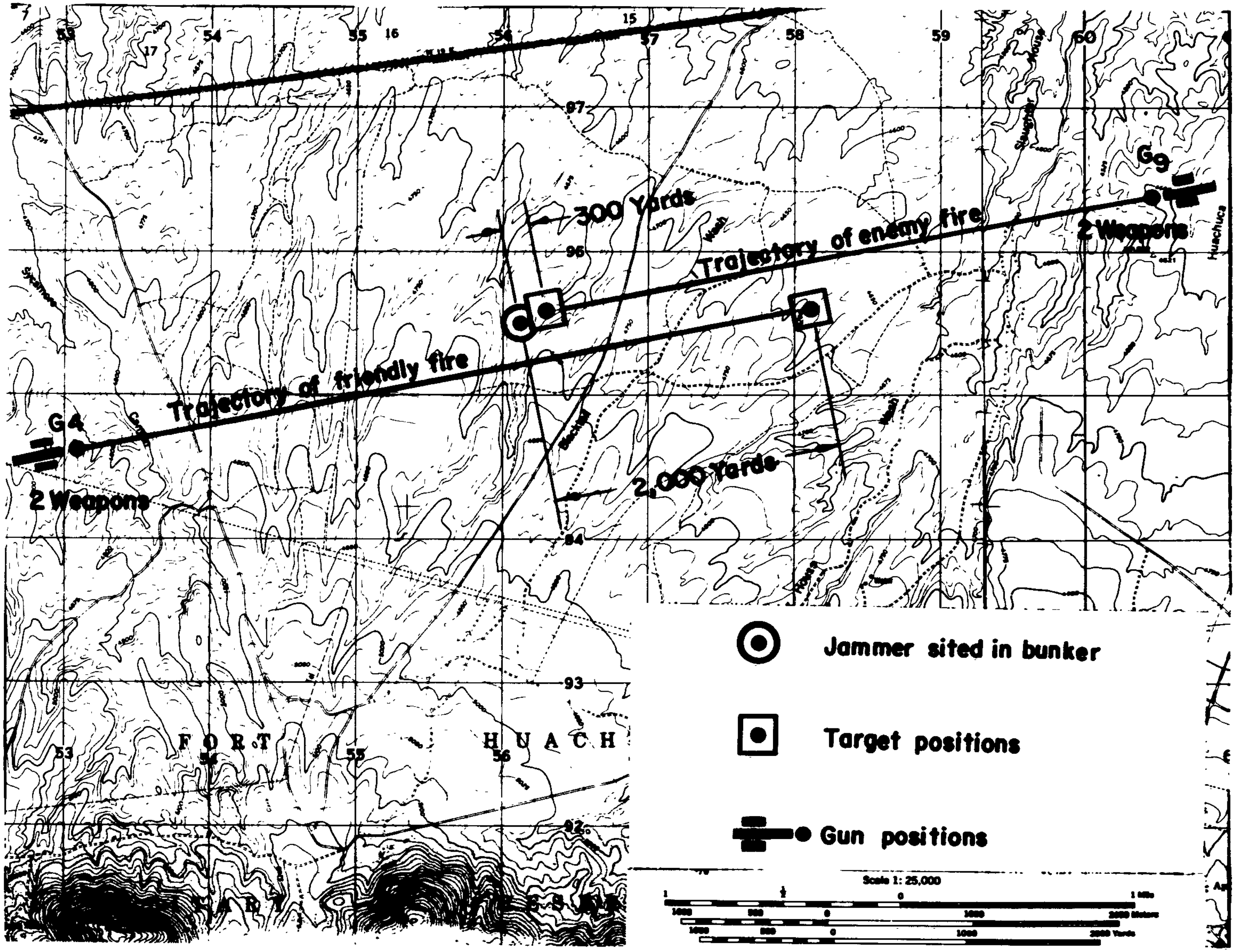


Fig. 15. Siting arrangement for Test 17 in plan

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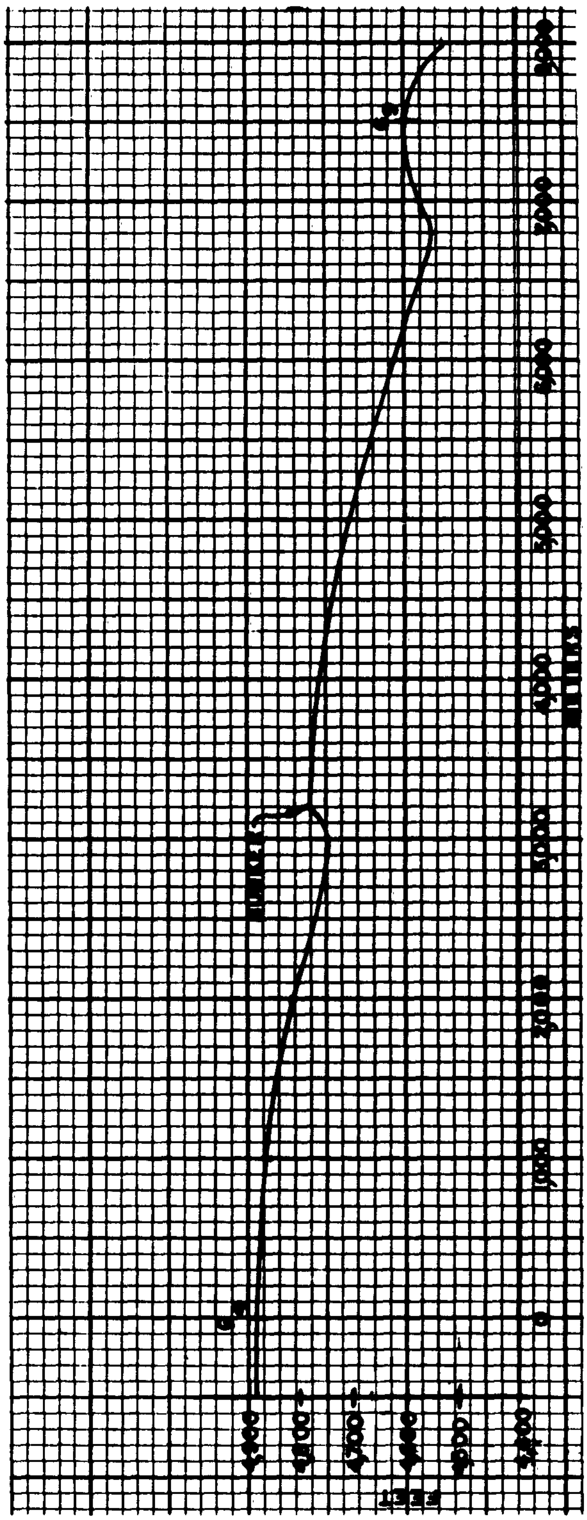

Fig. 16. Siting arrangement for Test 17, profile

Power output	maximum
Sweep range	115-171 Mc/s
Sweep rate	1 sweep/sec
Modulation	200 cps
Fuze	CVT, type T-226E2/A
Weapon	105-mm howitzer
Antenna parameters	0-deg elevation; vertical polarization
Aspect	0 deg

A kill of 70 percent of enemy fire and 10 percent of friendly fire was obtained.

The friendly artillery fired high-angle fire, allowing the friendly projectiles to pass over the jammer at a considerable height and preventing them from entering the beam of the jammer until they had passed a distance beyond the jammer. However, the low-angle enemy fire came within the main beam as it approached the jammer. The greatly increased kill on enemy rounds resulted from orienting the jammer antenna so as to provide maximum coupling to the low-angle enemy projectile.

Section VI. Maintenance Problems

The two AN/TRT-2B(XL-1) sets, serial nrs 1 and 2, were found to be generally rugged and reliable. Over a period of three months three repairs were performed at EWD. The breakdowns and corrective actions are listed below:

a. High voltage transformer T-1 in transmitter T-131B/TRT-2B (XL-1), serial nr 1, burned out and was replaced.

b. Tubes V-207 and V-208 (both are type 807W/5933) in amplifier AM-583( )/TRT-2B(XL-1) became faulty and were replaced in serial nr 1.

c. A short circuit developed in the RF output cable of transmitter T-131B/TRT-2B(XL-1), serial nr 2, and was repaired.

Capacitor C-9 has a tendency to arc over, but no damage to the equipment resulted from this deficiency. A capacitor of higher voltage rating will eliminate this difficulty.

Section VII. Human Engineering Evaluation

24. TEST 18. COMPATIBILITY OF OPERATORS AND EQUIPMENT

The purpose of this test was to evaluate the operating ease of the AN/TRT-2B(XL-1). Four trained AN/TRT-2B(XL-1) operators and four experienced radio communications operators were queried for suggestions on facilitating operation of the equipment.

The operators commented on the difficulty of setting up antenna assembly AS-266/TRT-2. The desirability of obtaining a metal mast which could be ground- or vehicular-mounted was suggested. The metal tripod provided with the AN/MLQ-8(XL-2) was found to be satisfactory for use with the AS-266/TRT-2 antenna.

All operators commented favorably on the ease of operation of the transmitter and modulator. The AN/TRT-2B(XL-1) has two frequency bands selected by a switch on the front panel instead of the six bands and six sets of coils used with the AN/TRT-2B. This modification greatly increased the ease of changing frequency bands. However, it is time-consuming to tune frequency with the present frequency tuning knob. A crank handle that would fold into the knob when not required would save tuning time.

Simulated user tests were given the operators under the following conditions: operator wearing gloves; operation in total darkness; and putting equipment into operation at maximum speed under time pressure.

Wearing of gloves had a negligible effect on operation efficiency. Total darkness markedly increased the time required to put the equipment into operation because no panel lights are provided on the equipment and the luminous markings provided were not legible.

No effect on efficiency was noted when the men were told to put the equipment into operation at maximum speed.

25. TEST 19. OPERATOR TRAINING AND CREW REQUIREMENTS

The purpose of the test was to evaluate the operator training and crew requirements of the AN/TRT-2B(XL-1).

If a more suitable antenna and mount are provided, the AN/TRT-2B(XL-1) can be operated by a two-man crew. A jeep-mounted antenna such as is furnished with the AN/MLQ-8(XL-2) would be suitable for use with the AN/TRT-2B(XL-1).

A lesson plan consisting of five 50-minute lessons and one 4-hour practical exercise has been developed by the 1st Signal Group for training AN/TRT-2B(XL-1) operators. This course is intended for an operator already familiar with conventional communication equipment. The AN/TRT-2B(XL-1) is easier to operate than the AN/TRT-2B because bandswitching in place of plug-in-coils is provided.

Section VIII. Conclusions

1. The results of the firing tests are summarized in tabular form in Annex A. Although the AN/TRT-2B(XL-1) is seen to have obtained an occasional kill of 90 percent, its effectiveness was erratic. Changing antennas and varying the elevation of a given antenna caused changes in the effectiveness of the set. These results indicate that variations in the antenna pattern caused by ground reflections were at least partially and probably in the main responsible for the erratic results.

2. When the transmitter was sweeping, the power output varied widely over the sweep band. The variations were much smaller when the transmitter was connected to a resistive load than when connected to the AS-266/TRT-2 antenna. This result indicates that the load presented to the transmitter by the AS-266/TRT-2 antenna varies with frequency, causing the power output to vary accordingly. The variation in power output will reduce the effectiveness of the jammer against fuzes that operate in those parts of the sweep band where the power output is low. A more even power output will insure uniform effectiveness over the entire sweep range.

3. The combination of ground reflection and nonuniform power output resulted in the erratic and unpredictable effectiveness of the AN/TRT-2B(XL-1) as a VT-fuze jammer. Correcting these deficiencies by the selection or development of an antenna whose pattern is less affected by ground reflection and by improving the internal circuitry to provide uniform power output over the sweep band will enable the jammer to perform reliable and effective VT-fuze jamming.

4. The jammer can be used effectively in situations where both friendly and enemy projectiles are passing through the same area. By properly orienting the jammer with respect to the friendly and enemy fire and properly beaming its antenna, a large kill can be obtained on enemy rounds with a much smaller effect on friendly rounds.

5. An air-to-ground am. communication system using a ground radio station such as the ARC-12 can operate within 1,000 yards of the jammer under normal operating conditions. With the jammer sweeping at 1 sweep/sec, communications were maintained although the jammer was beamed at the ground station and was sweeping across its frequency. The interference effect is lessened when the ground station is placed out of the main beam of the jammer.

The interference increases when the sweep rate is increased. However, since a low sweep rate was found to be most effective against VT-fuzes, the jammer is normally operated at its lower rates.

6. The jammer signal can be intercepted at 10,000 yards when the intercept station lies in the main beam of the jammer, but it is difficult to obtain an accurate azimuth on the jammer when it is sweeping; fairly accurate bearings may be obtained when the jammer is not sweeping. Beyond 15,000 yards it was not possible to intercept or locate the ground-based AN/TRT-2B(XL-1) from a ground site even though it was beamed at the intercept site.

7. No receiver is provided for monitoring and search purposes. A good rapid-scan type of intercept receiver such as the AN/TLR-9 is needed to furnish the jammer adequate monitoring and search capability.

8. The AN/TRT-2B(XL-1) is generally rugged and well constructed, but the present antenna assembly AS-266/TRT-2 is awkward to handle. The use of a jeep- or truck-mounted antenna such as the dipole antenna and corner reflector supplied with the AN/MLQ-8(XL-2) would simplify the antenna handling. A team of two men can operate and maintain the AN/TRT-2B(XL-1) if an antenna more suitable for two-man installation is furnished. All equipment and personnel can be transported in a 3/4-ton truck or in a jeep with trailer.

9. Before modification the AN/TRT-2B proved to be useless as a VT-fuze jammer against such modern fuzes as the T-226E2/A and T-227/A. The modifications which produced the AN/TRT-2B(XL-1) have brought about a limited capability against VT-fuzes and more reliable operation and have greatly reduced the time and difficulty of changing frequency. With a more even power output not influenced by frequency and with the development of better antennas, the jammer is expected to provide reliable operation against VT-fuzed fire at ranges of 1,000 to 2,500 yards.

ANNEX A

Table I. Results of firing tests

Test (nr)	Arming	Fuze	Aspect (deg)	Weapon	Angle of fire	Jammer (yds)	Kill (percent)
9	NVT	T-226E 2/A	90	105-mm howitzer	High	1,000	30
						2,500	20*
					Low	2,500	66
						2,500	88*
10	CVT	T-226E 2/A	90	105-mm howitzer	High	1,600	40
					Low	1,600	10
11	CVT	T-226E 2/A	0	105-mm howitzer	High	750	90
					Low	550	10
12	NVT	T-227/A	90	155-mm howitzer	High	1,000	90
					Low	1,500	90
				8-in. howitzer	High	1,500	60
					Low	2,500	90
13	CVT	T-227/A	0	155-mm howitzer	High	300	20
						1,000	30
					Low	300	20
						1,000	50
14	NVT	T-178E3	90	81-mm mortar	High	1,000	30
15	CVT	T-178E3	0	81-mm mortar	High	200	80
						200	100*

* The antenna provided with the AN/MLQ-8(XL-2) was used in these two tests; Antenna AS-266/TRT-2 was used in all others. In addition, the AS-542/U was used in Test 11 and in Test 15.

ANNEX B

Modification of the AN/TRT-2B to produce the AN/TRT-2B (XL-1)

1. The transmitter T-131B/TRT-2 was completely redesigned. Major modifications were as follows:

a. Oscillator plate voltage was lowered from 2,000 to 1,000 volts.

b. Oscillator tubes were changed from type HK-54 to type 4X150A.

c. Oscillator tuning was accomplished by shorted parallel lines, as shown in fig. 17, and adjusted by calibrated front-panel dial. The unmodified transmitter T-131B/TRT-2 had used plug-in type coils as shown in fig. 18 and had no front-panel dial to indicate frequency.

d. RF output was taken off through a bifilar link.

e. Frequency range was divided into two bands selectable by a band switch on the front panel.

f. Frequency sweep deviation was limited to a maximum of 7 percent of center frequency.

2. The Amplifier AM-583 ( )/TRT-2B(XL-1) was only slightly modified. The changes were as follows:

a. The grid bias supply circuit was redesigned so that when BIAS control R-202 is turned fully counterclockwise, there is still some bias voltage on the amplifier tubes, thus protecting the tubes from excessive plate currents.

b. Ruggedized type 807W/5933 tubes were substituted for the 807 tubes.

c. Amplifier plate voltage was reduced.

d. Amplifier power output was reduced to that required for 60- to 70-percent modulation of the transmitter.

3. The Junction Box JB-451 was modified to include the ac line voltmeter and the ac voltage control formerly in the transmitter front panel.

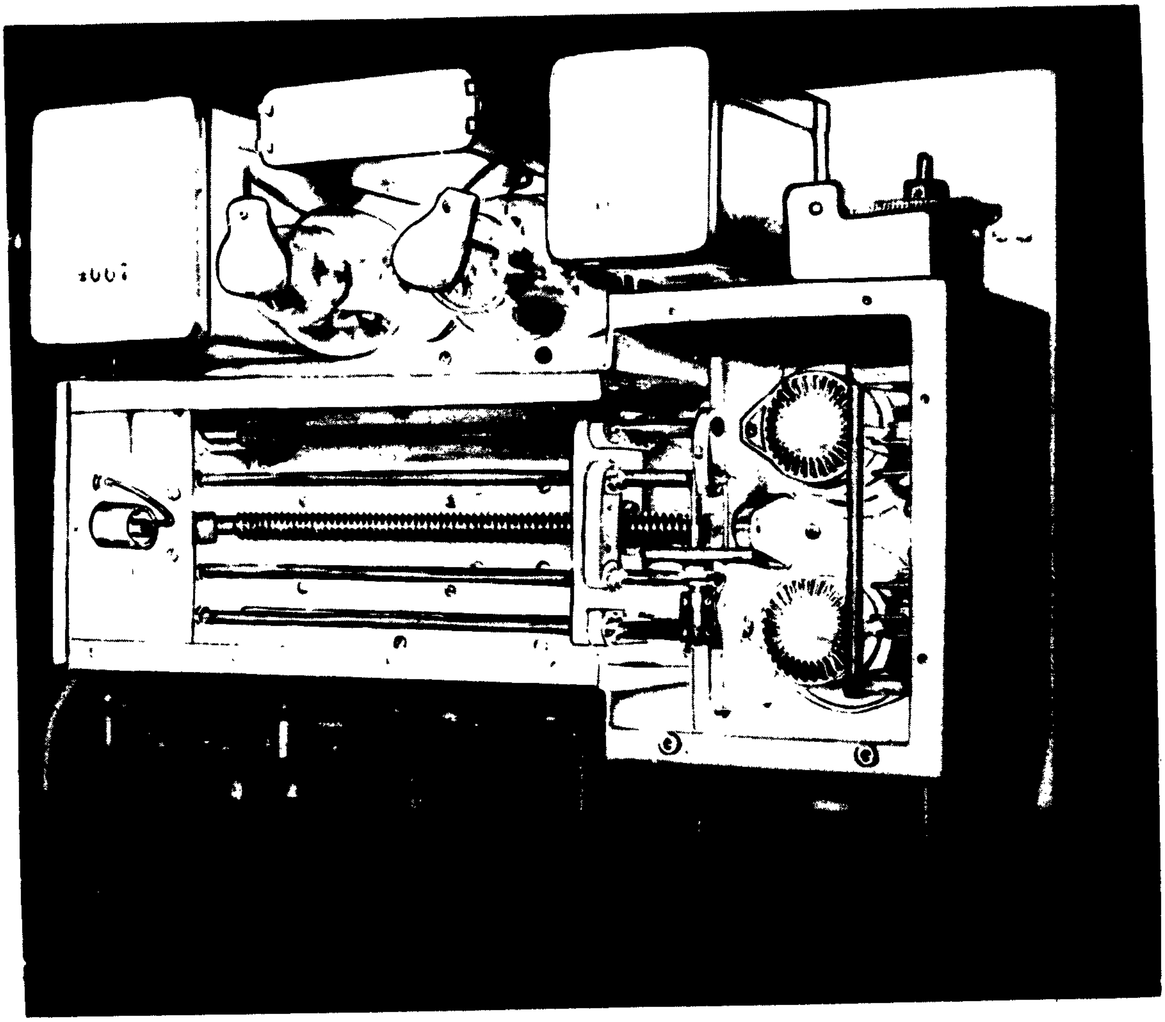

Fig. 17. Top view of AN/TRT-2B(XL-1) showing tuned parallel lines

ANNEX B. (cont)

4. The Antenna AS-266/TRT-2 was altered to eliminate the necessity of installing or removing the shorting bar as described in paragraph 14-B (3) of TM-11-270. A slot was cut in the case of the matching transformer, through which a sliding shorting bar can be moved to the feed end of the transformer for operation below 160 Mc/s, or to a point 5 inches from the feed end for operation above 160 Mc/s. A knurled screw permits locking the slider in the desired position.

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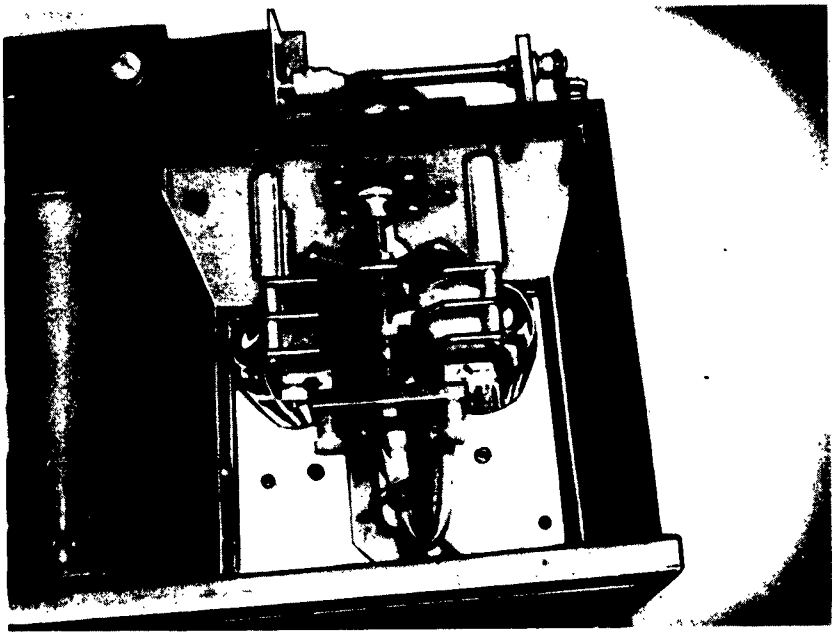

Fig. 18. Top view of AN/TRT-2B after first field modification at AEPG showing plug-in coil assembly