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REMOTE-RETRANSMISSION SYSTEM C-7772/GRC

by

Stanley D. Peirce
Communications and Electronics Branch

March 1974

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Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report covers the development and test of Retransmission Units, C-7772/GRC. These units, when used with the tactical radios such as the PRC-77 and VRC-12, permit a commander to maintain radio communications while at a position remote from the radios so as to minimize his situation as a potential target. The units can also be used in a field-artillery telephone net with GRA-39's to allow the field-artillery commander use of this telephone net from a remote location.		

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BLOCK 20. ABSTRACT CON'T

Although the two-frequency techniques employed proved feasible, its implementation with existing military radios resulted in less than good performance for tactical application. Standardization of this approach by the Army is not recommended.

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INTRODUCTION

Under normal operating conditions, a unit commander must remain in close proximity to his radio operator, who is equipped with a Radio Set AN/PRC-77, or to his command vehicle which has a Radio Set AN/VRC-12. This situation is undesirable because both the commander and the radio operator are extremely venerable targets, and, in addition, the commander's domain of operation is limited by the length of his handset cord.

The Remote-Retransmission Unit C-7772/GRC is an electronic assembly which permits a commander to communicate via his tactical radio set or telephone and, at the same time, be free to move about within a half-mile radius. This flexibility is accomplished by providing the commander with a Squad Radio Transmitter AN/PRT-4A and a Squad Radio Receiver AN/PRR-9 which he uses to communicate with a similar pair which is connected and contained within the retransmission device. This assembly provides automatic switching to relay communications between the commander and the tactical net.

Voice transmissions from the commander are received at the retransmission site where electronic circuitry actuates the tactical radio or telephone device, which in turn relays the audio information to all net stations. Information received from the tactical net actuates automatic control circuitry which turns on the integral transmitter and relays the information to the commander.

Remote-Retransmission Unit C-7772/GRC is designed specifically for use with Radio Set AN/PRC-77, Radio Set AN/VRC-12, or Control AN/GRA-39 when used in a telephone net. However, with proper adaptation of connections, it may be used with a number of other sets.

In an earlier task, LWL developed retransmission units to meet a combat requirement from Southeast Asia. Four of these early models were sent to Vietnam for test and evaluation. The evaluation was favorable but pointed up the necessity for some redesign to harden the equipment for field use. This report covers the development and test of the improved Remote-Retransmission Unit C-7772/GRC.

DESCRIPTION OF EQUIPMENT

The retransmission unit (Figure 1) is contained in a waterproof, seam welded, aluminum case which provides the environmental protection necessary for reliable tactical operation. Connectors, mode switch and antennas are mounted on top.

The interior electronics of the retransmission unit consists of a Squad Transmitter AN/PRT-4A (less case), a Squad Receiver AN/PRR-9 (less case), control electronics and associated cabling and wiring.

Two BA-399/U batteries are housed in a separate, waterproof compartment on the bottom of the case. This configuration permits rapid replacement of batteries in operational situations without jeopardizing the reliability of the electronic circuitry through exposure to degrading environments. These batteries may be used as an optional power source when the retransmission unit is connected to the AN/GRA-39. However, longer operating life will be obtained from an externally connected BA-386/PRC-25 battery. When the retransmission unit is used with the AN/PRC-77 or the AN/VRC-12, power is supplied from the radio set, so auxiliary batteries are not required.

Equipment Specifications

The specifications for the retransmission unit and major assemblies are presented below:

Transmitter electronics

Frequency coverage	- 47 to 57 MHz
Type of modulation	- FM
Power output	- 450 mw @ 12 vdc
Range	- 1/2 to 1 mile

Receiver electronics

Frequency coverage	- 47 to 57 MHz
Tuning	- single channel, crystal controlled
Range	- 1/2 to 1 mile

Batteries - internal (two required)

Type	- BA-399/U
Voltage taps	- 0, +15V
Size	- 1-3/8 x 1-7/8 x 3"
Connector	- 4-pin, special
Life expectancy	- 16 hours
Weight	- 4 ounces each

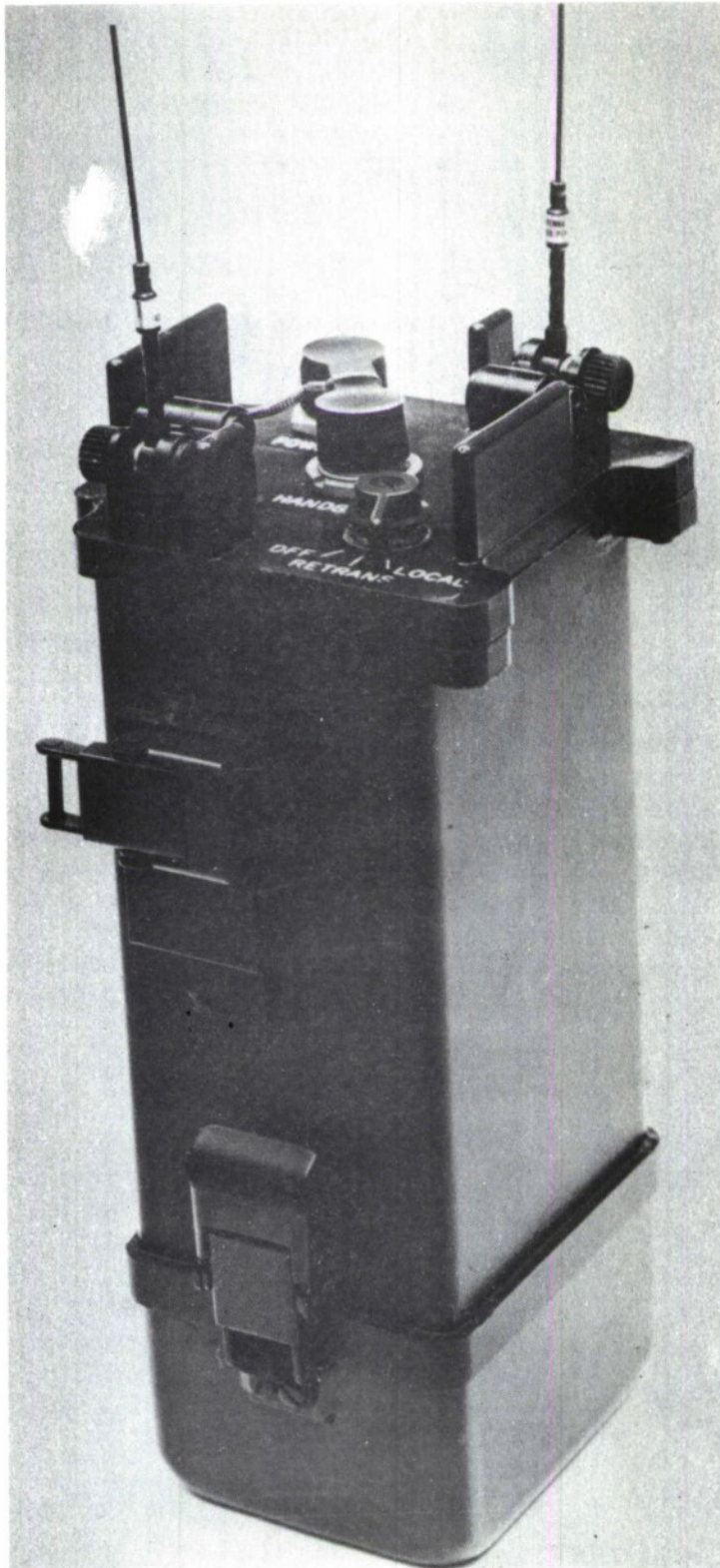


Figure 1. Control, Remote-Retransmission Unit C-7772/GRC

Batteries - external (one required)

Type	- BA-386/PRC-25
Voltage taps	- 0, +3V, +15V
Size	- 9-1/2 x 3-1/2 x 2"
Weight	- 4 pounds
Life expectancy	- 100 hours

Mechanical

Size	- 3-1/2 x 4 x 10-1/2"
Weight	- 4 pounds (without batteries)

Connectors and mode switch

Power connector	- Used to connect retransmission unit to companion radio set or external power supply
Handset connector	- Used to allow handset connection for retransmission site operator with all configurations except AN/GRA-39
Mode switch	- Used to select retransmission, local operation or off mode

The retransmission unit is used to control a Squad Radio Set and primary communications sets such as the AN/PRC-77, AN/VRC-12, and AN/GRA-39. The retransmission unit assembled with an AN/PRC-77 tactical radio set is shown in Figure 2. A typical application of this equipment is illustrated in Figure 3. The retransmission unit assembled with an AN/VRC-12 vehicular radio set is shown in Figure 4. A typical application of this equipment configuration is illustrated in Figure 5. The retransmission unit assembled with the AN/GRA-39 (comprised of the C-2328B/GRA-39 and the C-2329B/GRA-39) is shown in Figure 6. Typical applications of this equipment are illustrated in Figures 7 and 8.

A description of the theory of operation and circuitry is given in Appendix A.

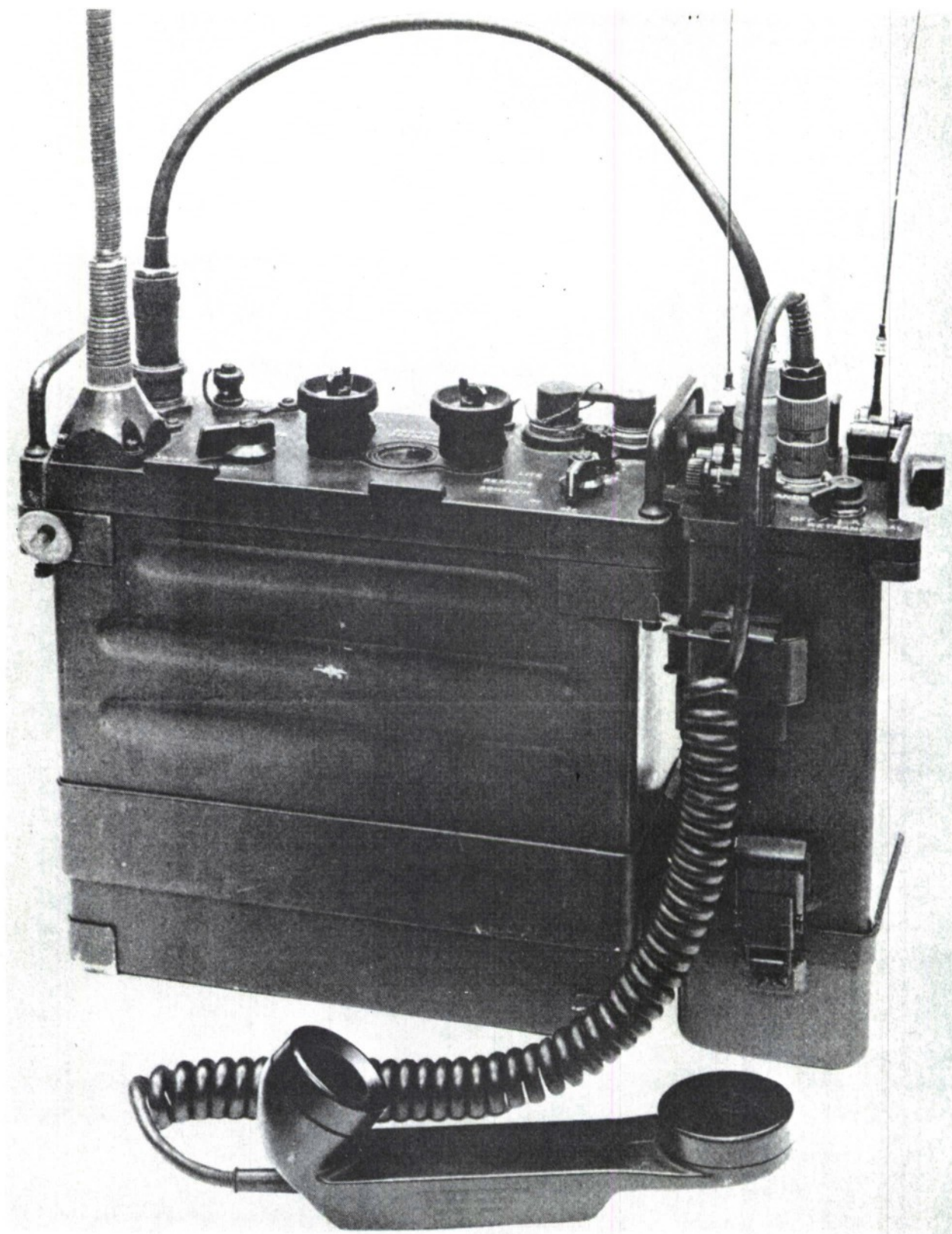


Figure 2. Retransmission Unit Assembled With AN/PRC-77

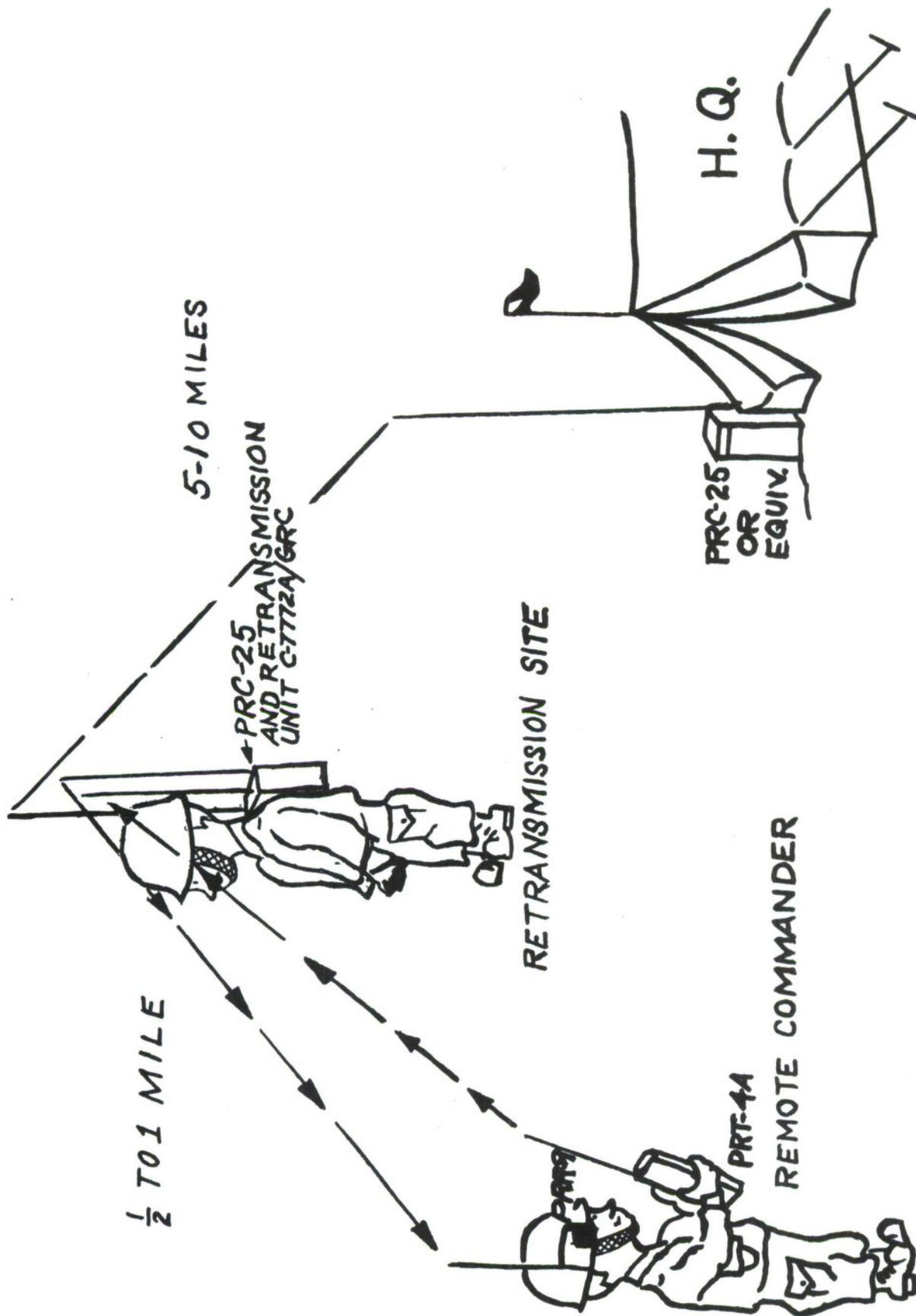


Figure 3. Retransmission Unit Used With AN/PRC-77

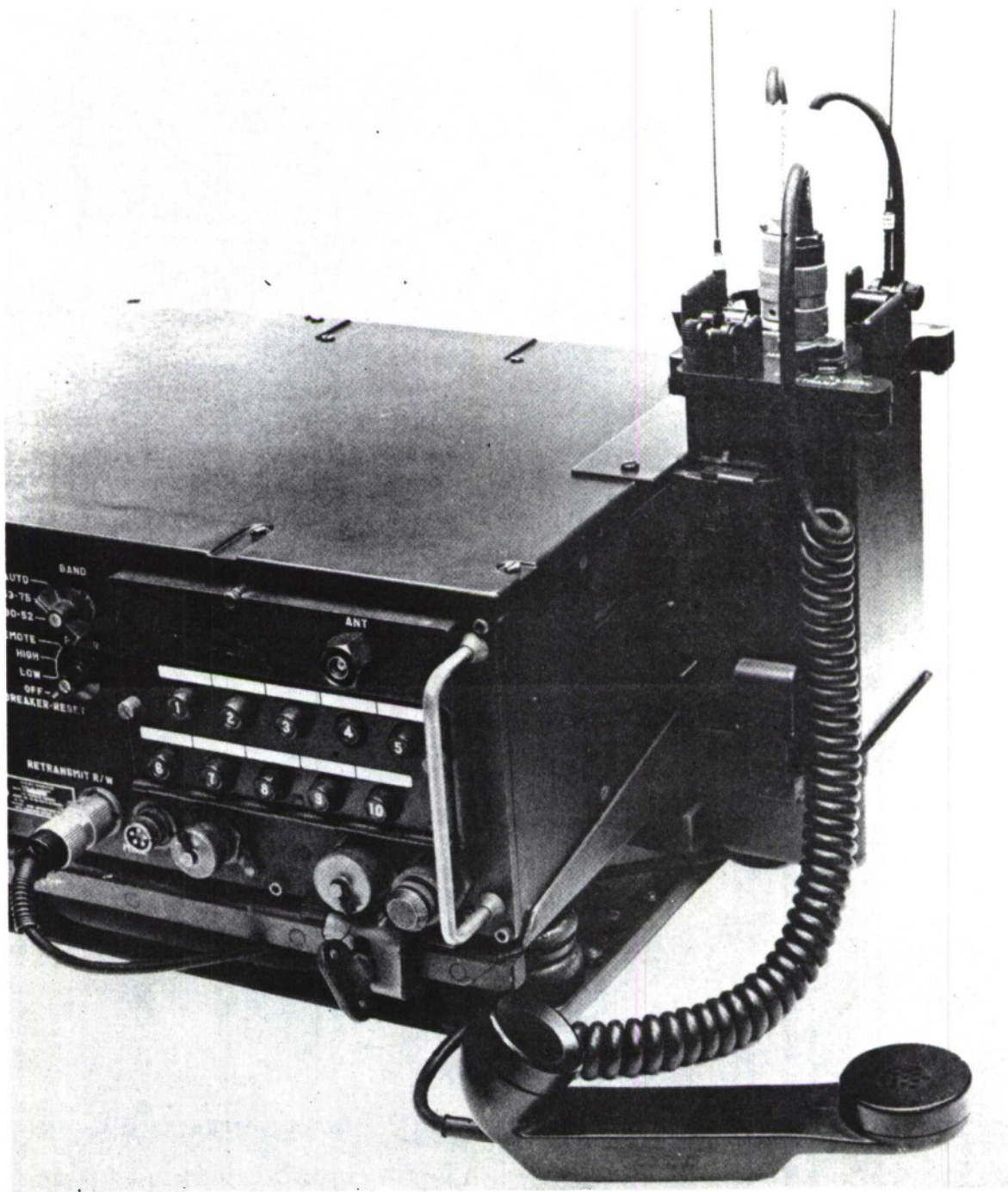


Figure 4. Retransmission Unit Assembled With AN/VRC-12

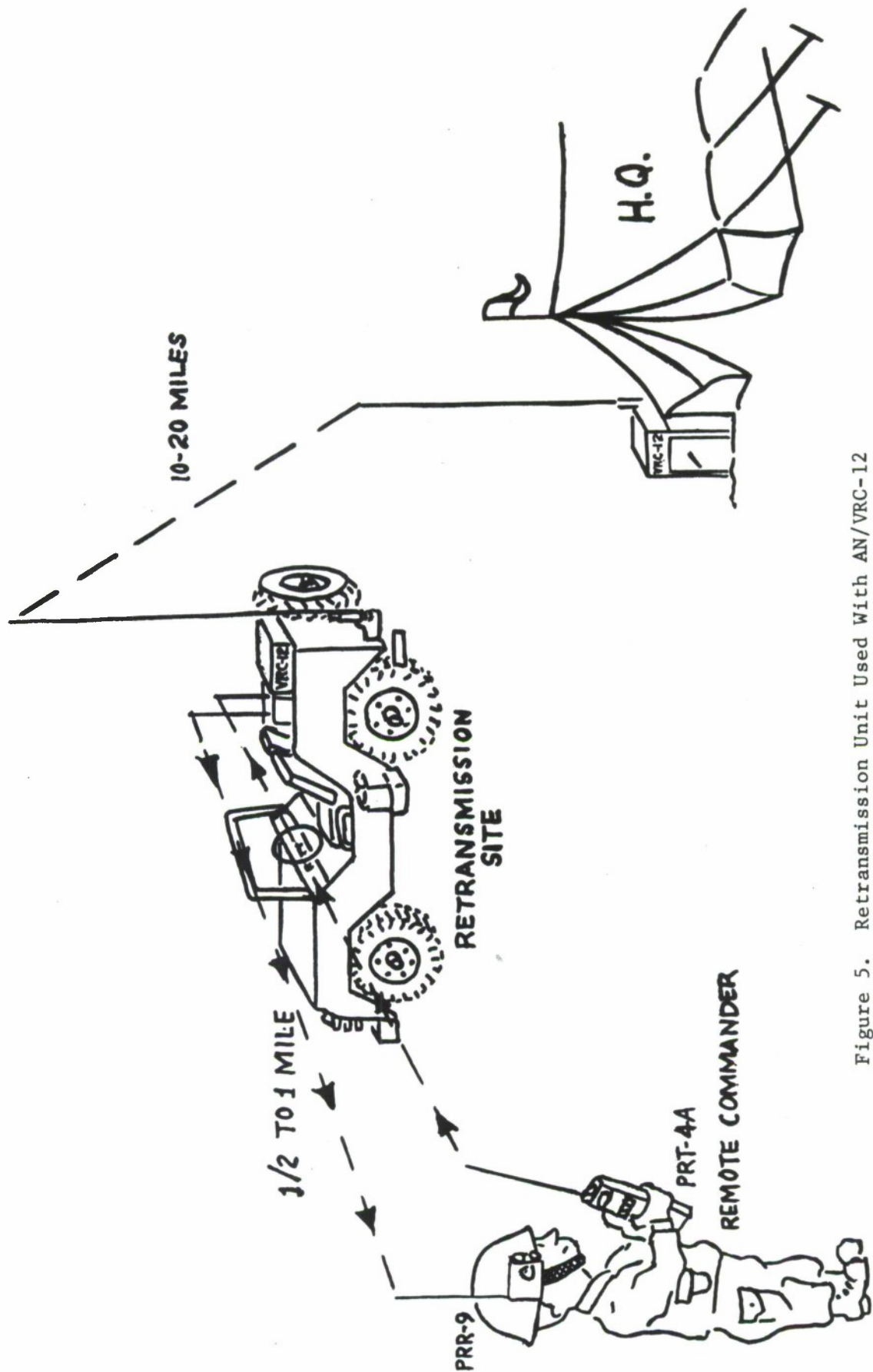


Figure 5. Retransmission Unit Used With AN/VRG-12

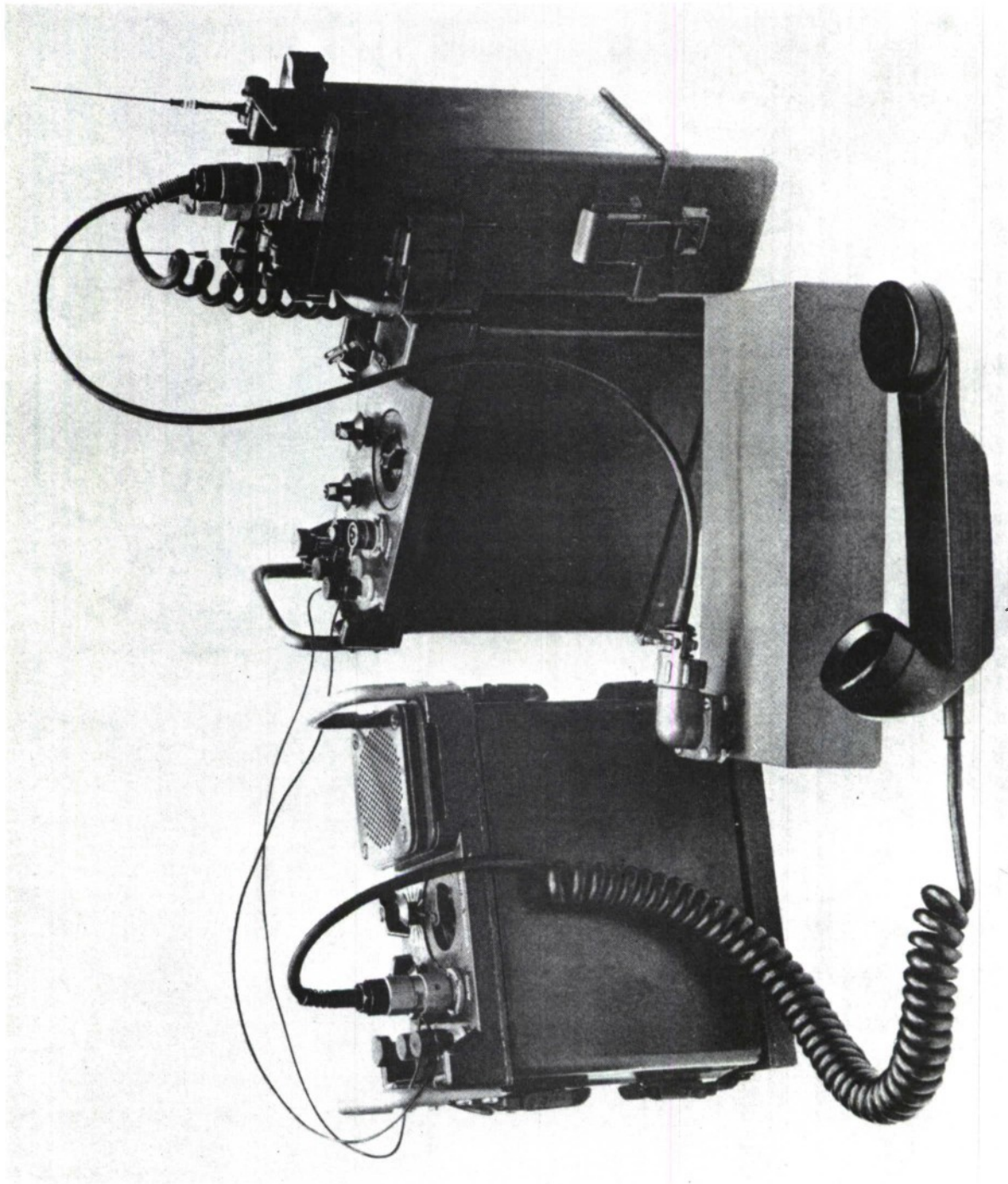


Figure 6. Retransmission Unit Assembled With AN/GRA-39

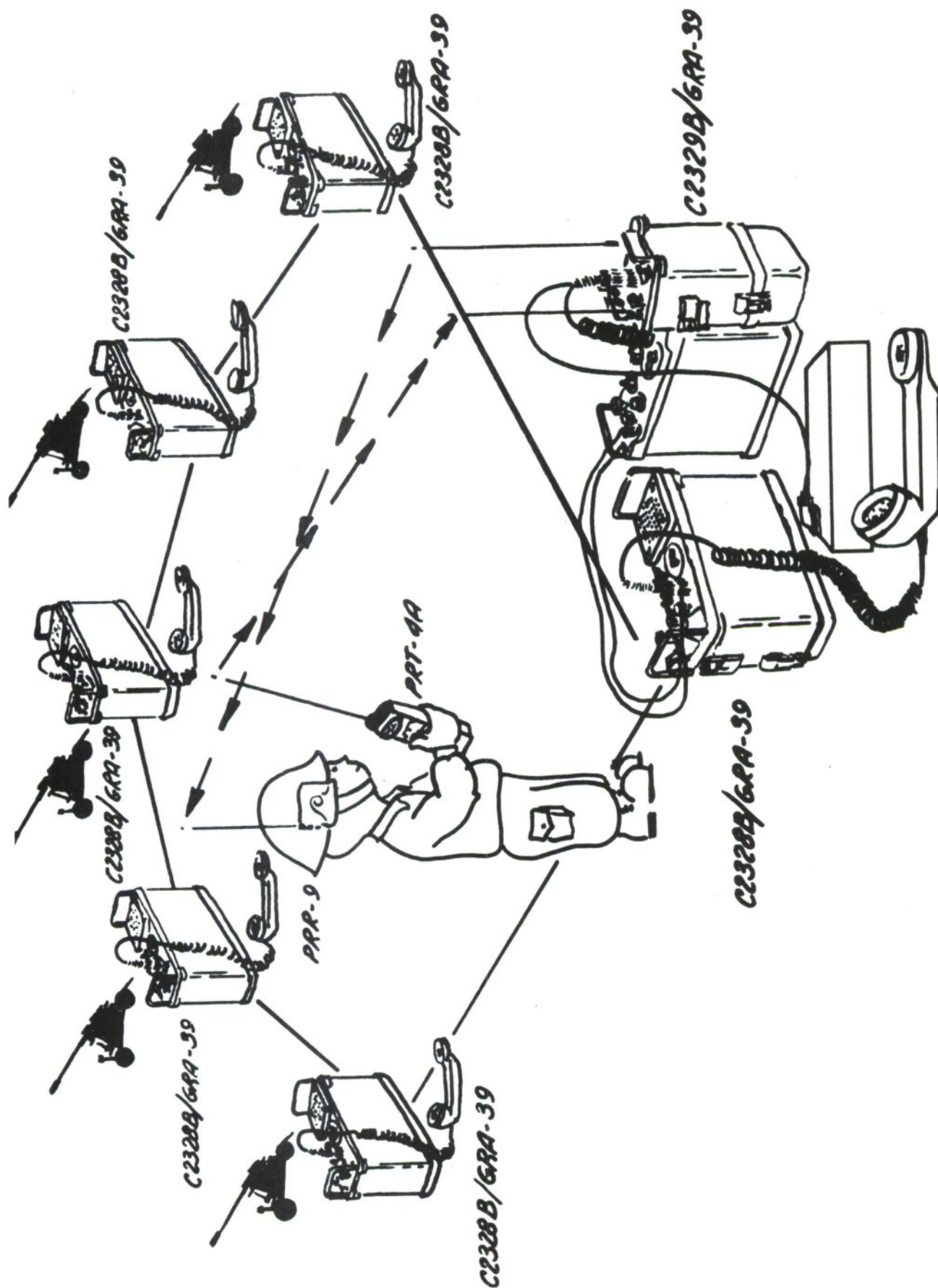


Figure 7. Retransmission Unit Used With AN/GRA-39

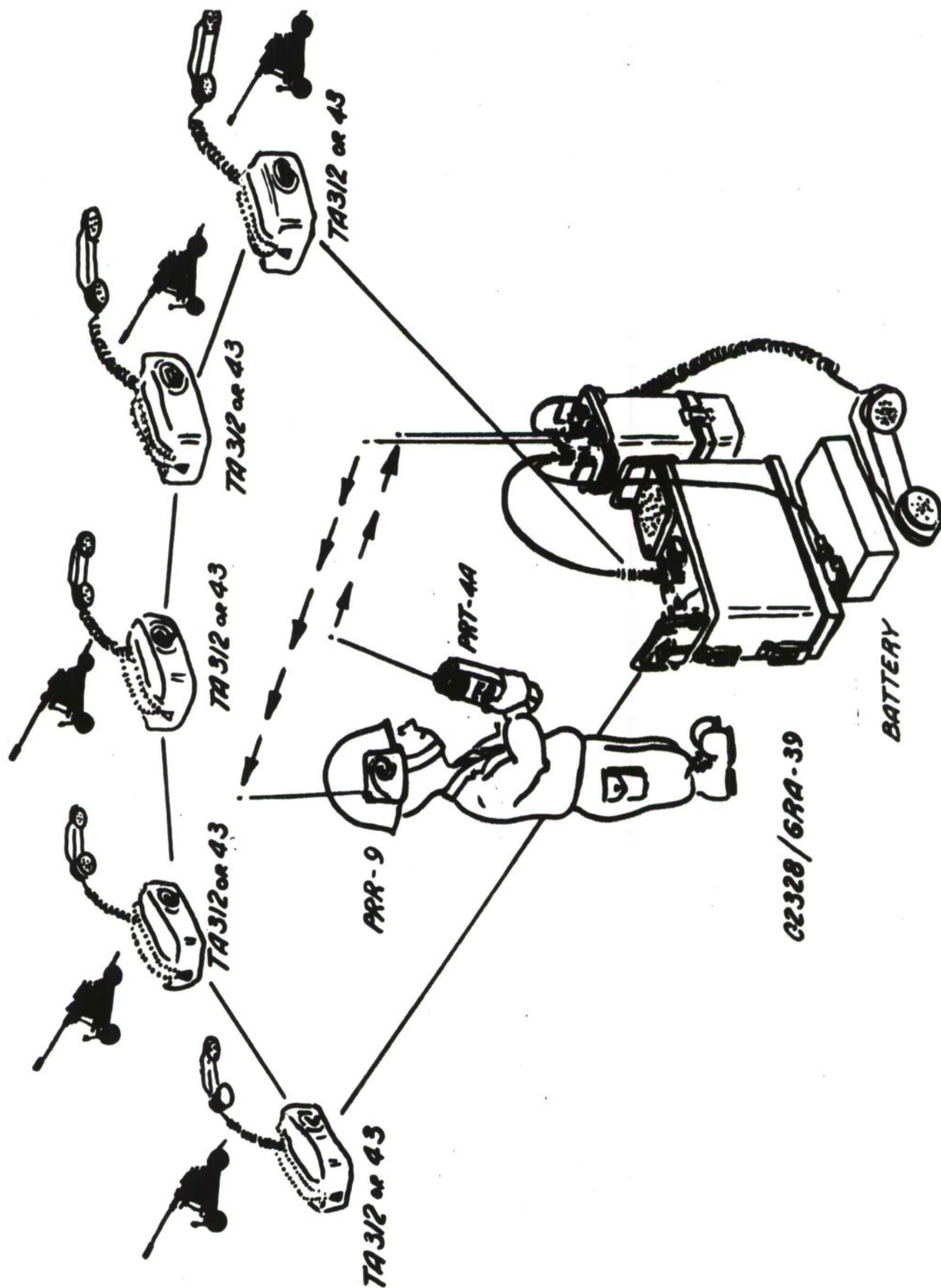


Figure 8. Retransmission Unit Used With AN/GRA-39 (Alternate)

TEST PROCEDURES AND RESULTS

Engineering Tests

Initially, a sample of the improved retransmission devices were subject to a broad spectrum of engineering tests for conformance with the procurement specifications. These included fully instrumented functional tests of the circuitry and a variety of environmental tests. Functional testing consisted of:

1. Operational Test - performance of the retransmission unit as part of a complete communications system.
2. DC Power Drain - to determine the power drain of the retransmission unit over the useful life of the BA-399 battery in various modes of operation.
3. VOC response - to determine the sensitivity and hysteresis characteristics of the automatic switching circuits which control the operating mode.
4. Attack and Delay Time of Control Circuit - to measure the time required for the automatic switching circuits to respond to the presence and disappearance of audio signals.
5. Amplifier Volume Compression - to determine the ability of the retransmission unit to compensate for varying output level of the radios with which it is associated.
6. Response and Distortion - to determine the frequency response and distortion of the audio amplifiers both above and below the level of compression (see 5 above).

The environmental tests consisted of:

1. Thermal stress - storage between -65 and +155 degrees F and operation between 25 and 143 degrees F.
2. Altitude - storage to 40,000 ft. and operation to 10,000 ft.
3. Water Vapor - operation at 95% RH (105 degrees F) through 85% RH (82°F).
4. Precipitation - simulated rainfall of 5 ± 1 inches per hour with wind of 40 MPH.
5. Blowing Sand and Dust - MIL STD 810B (Method 510).
6. Salt Fog - MIL STD 810B (Method 509).
7. Drop Test - 4 ft. drop onto 2" wood plank; 4 drops: 1 corner, bottom, side and end.
8. Immersion - 3 ft. of water at 60°F.

9. Vibration - 0.05 inches in three planes for one hour each with frequency swept from 10 to 55 Hz.

The improved retransmission units passed all of these tests.

Field Tests

Operational testing in the field was performed with AN/PRC-77 radios in Puerto Rico to simulate the hot-wet jungle conditions of Southeast Asia. Additional testing was performed at Ft. Belvoir, VA to check compatibility of the unit with a vehicular mounted AN/VRC-12 radio.

Puerto Rico Tests

A description of the test procedures and sites is given in Appendices B and C. Detailed test results are given in Appendix C.

The results may be summarized as follows:

1. For the most part the retransmission units appeared to operate satisfactorily; however, there was a wide variation in ranges of operation from 200 to 600 meters. This appeared to be due to variability in performance of the squad radios (PRT-4 and PRR-9).
2. Voice distortion occurred with some of the retransmission units. This apparently resulted from maladjustment of circuits.
3. "Lockup" of the system in one or another mode of operation occurred occasionally. This seems to result from the presence of many spurious frequencies at the transmitter output of the AN/PRC-77 tactical radios. This could be resolved only by locating operating frequencies for the various radios at which interference did not occur.

Ft. Belvoir Tests

These tests were performed primarily to confirm that the retransmission units would operate satisfactorily with vehicular radio AN/VRC-12 under representative field operational conditions. A description of the test procedure and test sites is given in Appendices D and E. Detailed test results are given in Appendix E. The results may be summarized as follows:

1. For the most part, the retransmission units operated satisfactorily at all distances used (400 meters max.); however, some of the units were defective and failed one or more of the tests.
2. Under one mode of operation, interference occurred as a result of a 900 Hz tone which is inherent in the audio modulation of the AN/VRC-12 radio.

CONCLUSIONS

1. This development and test effort confirmed the validity of the two frequency ($F_1 - F_2$) retransmission technique. However, the usefulness of the Retransmission System was severely limited by the presence of numerous interference frequencies radiated by Army radios with which it was tested. These caused the units to "lockup" in one mode of operation and prevented two-way communications at many of the tactical frequencies.

2. The main source of unreliability in the system was the Squad Radio Set (AN/PRT-4 and AN/PRR-9).

RECOMMENDATIONS

1. It is recommended that the Retransmission Unit C-7772/GRC not be considered for incorporation into Army inventory.

2. It is recommended that future development efforts be concentrated on the use of single frequency ($F_1 - F_1$) relay techniques with its many tactical advantages. Recent developments in this area have finally succeeded in giving promise to this approach.

APPENDIX A: Retransmission Unit C-7772/GRC Theory of Operation

SYSTEM OPERATION

The Retransmission unit contains and controls the electronics of a Squad Radio pair AN/PRR-9 and AN/PRT-4A, and also controls an external tactical radio set or a field telephone.

1.1 Retransmission unit used with Radio Set AN/VRC-12 or AN/PRC-77

When a signal is received on the AN/VRC-12 or the AN/PRC-77, the audio energy activates an electronic switch, turning on the AN/PRT-4A Transmitter electronics, which relays the information to the commander via his AN/PRR-9 Receiver.

To allow for normal speech pauses, the electronic switch holds the AN/PRT-4A on for approximately one-half second after the end of transmission. Then, the electronic switch cuts the power to the AN/PRT-4A and retransmission ceases.

When the commander talks via his AN/PRT-4A, the AN/PRR-9 in the retransmission unit produces an audio signal which is processed to turn on the AN/VRC-12 or AN/PRC-77 Transmitter, which retransmits the received signal. A half-second after termination of the audio signal, the electronic switch of the retransmission unit turns the AN/PRC-77 or AN/VRC-12 Transmitter off, and the receiver becomes operative.

An operator located at the retransmission site can monitor all signals with his handset. A signal originating at the retransmission site is sent to the remote commander as well as transmitted on the AN/PRC-77 or AN/VRC-12.

1.2 Retransmission unit used with AN/GRA-39 in a telephone net (preferred method)

If all interconnected stations use the AN/GRA-39, the following method of connection is preferred, because it permits loudspeaker operation at the retransmission site. The audio plug of C-2329/GRA-39 is connected to the handset socket of the retransmission device, which is operated in the LOCAL mode. A field wire pair connects C-2329/GRA-39 to C-2328/GRA-39 at the retransmission site and to the net line. Audio signals from the internal AN/PRR-9 Receiver of the retransmission unit are applied to the input of C-2329/GRA-39, amplified, and applied to the line for reception at all C-2328/GRA-39 units of the net, including the one at the retransmission site, permitting loudspeaker monitoring at that point.

When an operator in the net depresses his handset switch, a 3900 Hz tone is applied to the line. Upon receipt of this tone, electronic circuits in the C-2329/GRA-39 at the retransmission site ground the push-to-talk terminal at the connector of the retransmission unit, turning on the internal AN/PRT-4A. Audio signals applied to the line are superimposed upon the 3900 Hz control signal, and the two are separated in C-2329/GRA-39. Modulation is applied to the AN/PRT-4A Transmitter and received at the remote AN/PRR-9. When the push-to-talk switch is released, the 3900 Hz tone ceases and the system reverts to a standby condition.

1.3 Retransmission ~~unit~~ used with AN/GRA-39 and other types
 in a telephone net

If any of the stations in a telephone net use equipment of any type other than AN/GRA-29, the following alternate method of connection is required. Loudspeaker operation is not possible at the retransmission site unless two C-2328/GRA-39 units are used there. C-2329/GRA-39 is not used in this configuration. C-2328/GRA-39 is connected to telephone line. A special cable is used to connect the retransmission ~~unit~~ to C-2328/GRA-39 and to a BA-386/U battery.

Audio signals from the internal AN/PRR-9 Receiver actuate the automatic switching circuit of the retransmission unit. The push-to-talk circuit of C-2328/GRA-39 is grounded. Audio signals applied to the input terminals of this unit are amplified and applied to the telephone line. Transmission ceases a half-second after termination of the audio signal.

When another operator in the net transmits, audio signals from the line are amplified by C-2328/GRA-39 and applied to the switching circuit of the retransmission unit, causing it to turn on the internal AN/PRT-4A transmitter. Audio information from the line modulates the transmitter, which relays the information to the remote AN/PRR-9. Transmission ceases a half-second after termination of the audio signal.

Three modes of operation are provided by a function switch. In the "off" mode no power is supplied to the retransmission unit, including the Squad Radio electronic units. Normal operation of the AN/PRC-77, AN/VRC-12 or GRA-39 is available at the handset connector. The "retrans" mode is described in (A), (B), and

(C) above. With the function switch set to "LOCAL", a communication link is established with the handset and the Squad Radio at the retransmission site, and the remote commander using a Squad Radio pair. Signals received on the AN/PRC-77, AN/VRC-12 or GRA-39 are monitored with the handset but not retransmitted to the remote commander. In the AN/PRC-77 or AN/VRC-12 application, normal operation of these units is available at the second audio connector on the front panel.

2. CIRCUIT DESCRIPTIONS

2.1 General

The circuit description of the retransmission unit is limited to a discussion of the control electronics circuit board and the power supply. Circuit descriptions of the Squad Transmitter AN/PRT-4A and Squad Receiver AN/PRR-9 are contained in existing technical manuals for these units. The term "companion radio set" contained in the discussion refers to any of the three primary communications units which are used in conjunction with the retransmission unit.

2.2 Control Electronics

The control electronics circuitry consists of two nearly identical channels - one channel for operating the AN/PRT-4A transmitter and one channel for controlling the companion radio set. Each channel consists of a compressor/VOX stage, a bistable switch and circuits which switch transmitters on and off. When either channel is in operation, a muting circuit in the non-operating channel prevents simultaneous operation of both transmitters. When no signals are being received, both channels are open for traffic.

The output of each compressor is combined in the audio amplifiers. This signal is increased in the earphone amplifier to the level required by the handset.

All circuitry except the AN/PRT-4A transmitter is powered from the 6 volt dissipative regulator.

The detailed circuit description of the control electronics is presented in the three basic modes of operation associated with the retransmission device. Refer to block diagram, Figure 1A and schematic diagrams, Figures 2A and 3A, for additional clarification of circuit discussion.

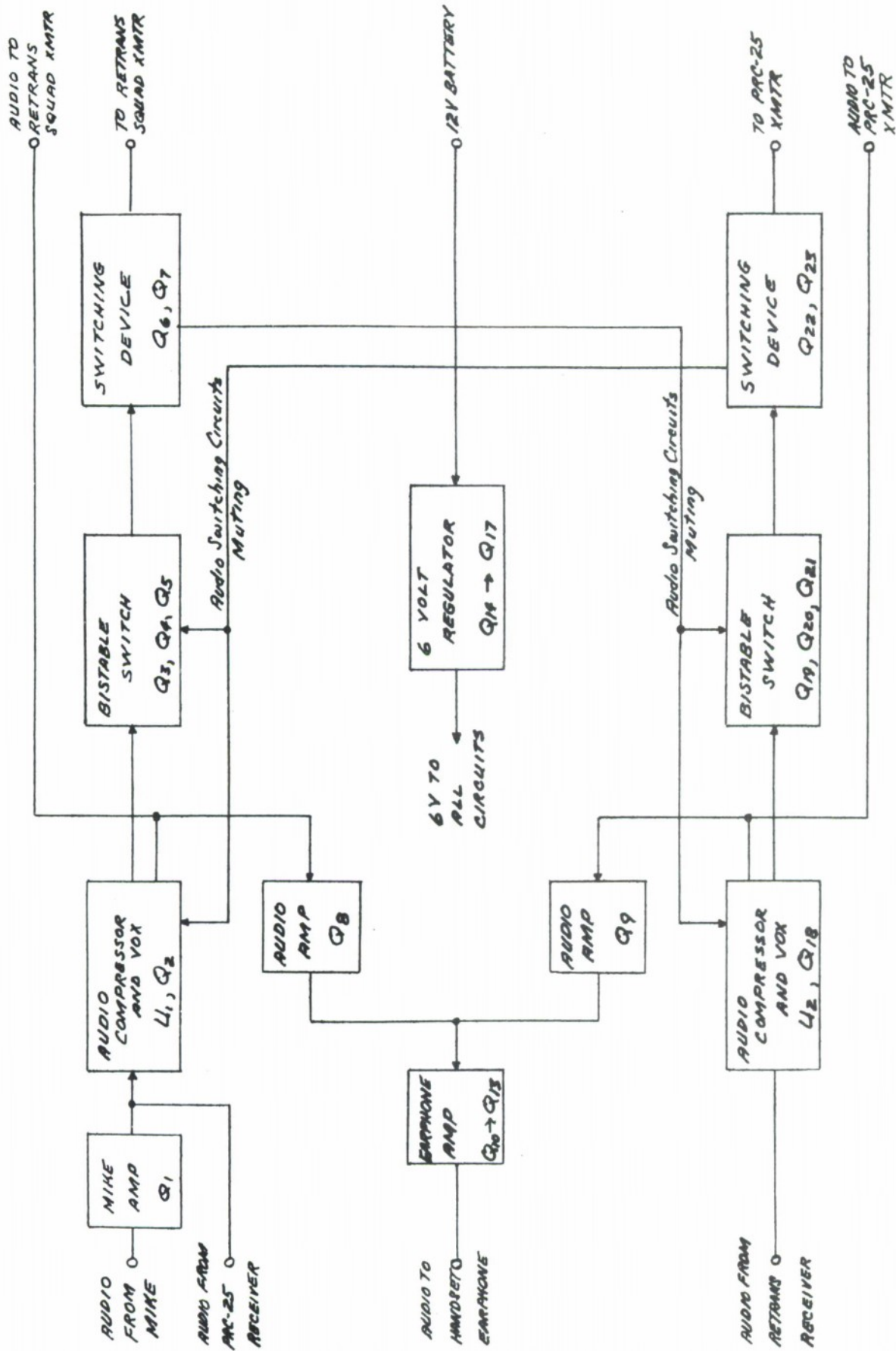


Figure 1A
Block Diagram - Control Electronics

2.2.1 Retransmission Mode.

Audio from the companion radio set is applied to U₁, the audio amplifier-compressor-VOX integrated circuit. The signal is amplified in the IC and applied to Q₂, the peak detector, through pin 8. The audio peaks are rectified and fed back to the IC, pin 4. This feedback signal controls the gain of the IC and the audio level at the output of the IC, pin 8. The output level is controlled by the gain of the peak detector set by control R₁₇. The output, pin 8, is supplied through attenuator R₇ and R₉ to the AN/PRT-4A transmitter. IC U₁ also provides a VOX signal at pin 6. The audio level required to produce this signal is set by control R₁₄. This signal is a negative going signal at pin 6 and is changed to a positive going signal by Q₃. The time required for the signal at the collector of Q₃ to disappear after the VOX signal is removed (or the audio from the companion radio set ceases) is called the decay time and is controlled by the time constant of R₂₃ and C₁₈.

Bistable switch Q₄ and Q₅ produces an output which has two distinct states with no intermediate levels.

The output of the bistable switch is amplified in Q₆ and used to switch Q₇. With Q₇ on, B+ is applied to the AN/PRT-4A, turning it on. Q₇ also supplies a muting voltage through R₃₄ to 8 volt Zener CR₅. The time the muting voltage remains is determined by R₃₅ and C₁₉. This voltage is applied to the base of Q₁₉ which raises its potential above the emitter, inhibits the device and effectively mutes the opposite channel's bistable switch circuitry. CR₃, R₂₉ and R₃₀ also produce a voltage which is applied to pin 3 of U₂ to suppress its output.

To provide an earphone output for monitoring the conversation on this channel, the audio output of U₁ is amplified in transistor Q₈ and applied to the earphone amplifier Q₁₀ through Q₁₃. This amplifier is a typical complementary symmetry power amplifier chosen to minimize power drain.

Operation of the other channel is nearly identical with the channel just discussed. A signal from the AN/PRR-9 receiver is applied to IC U₂ which amplifies and compresses the signal for modulation of the companion radio set.

The audio signal is also amplified in audio amplifier Q₉ to drive the earphone amplifier, enabling the operator to monitor signals on this channel.

The VOX signal from U₂ is applied to the bistable switch Q₂₀ and Q₂₁. Q₂₂ turns on the companion radio set. These circuits function in the same manner as the comparable stages of the opposite channel. CR₁₁ is a Zener diode which protects Q₂₂ from transients on the PTT line of the companion radio set.

A muting voltage is developed when Q₂₃ is turned on by Q₂₂. This muting voltage is set at 8 volts by Zener CR₁₄ and R₆₈ and applied to Q₃. The potential of Q₃ is lifted above its emitter inhibiting device. The time this voltage remains after Q₂₃ is turned off is determined by R₆₉ and C₃₁. Another voltage derived through CR₁₀, R₆₄ and R₆₅ is applied to pin 3 of U₁, thereby muting this channel's output.

2.2.2 Local Mode.

In the local mode of operation, the AN/PRT-4A transmitter is turned on by grounding the collector of Q₆ with the handset PTT switch. The input of the bistable switch at Q₃ is opened by the function switch. U₁ is still active and allows signals received on the companion radio set to be monitored at the handset.

Audio from the microphone is amplified in the microphone amplifier, Q₁, and applied to U₁. The operation of the amplifier-compressor-VOX integrated circuit in the local mode is identical to the operation in the retransmission mode.

Signals received on the AN/PRR-9 receiver are processed by U₂ as before and are amplified in Q₂ and the earphone amplifier. The audio output of U₂ is broken by the function switch before it reaches the companion radio set. The bistable switch and switching device operates as before except that the PTT line of the companion set is broken by the function switch. In this manner, the companion radio set is neither modulated nor keyed.

2.2.3 OFF Mode.

Power to the retransmission device is removed and all handset connections are placed in parallel with those on the companion radio set. The companion radio set functions as though the handset were connected directly to the radio set.

2.3 Power Supply

The power supply is a simple dissipative regulator with a large amount of gain to assure low output impedance at minimum battery voltage. The supply's output level, 6 volts, provides bias for the 5.2 volt Zener diode CR9. This level is amplified by transistors Q17, Q16 and Q15. The output of Q15 controls the pass transistor Q14. C28 suppresses any possibility that the power supply will oscillate at high audio frequencies. Capacitor C29 provides a final assurance that the B+ line is at a low impedance.

All of the circuitry in the retransmission device is operated at 6 volts from this supply except the AN/PRT-4A transmitter which operates directly from the battery.

When an external battery supply is connected to the retransmission device, diode CR18 prevents the internal batteries in the retransmission unit from charging the external power source.

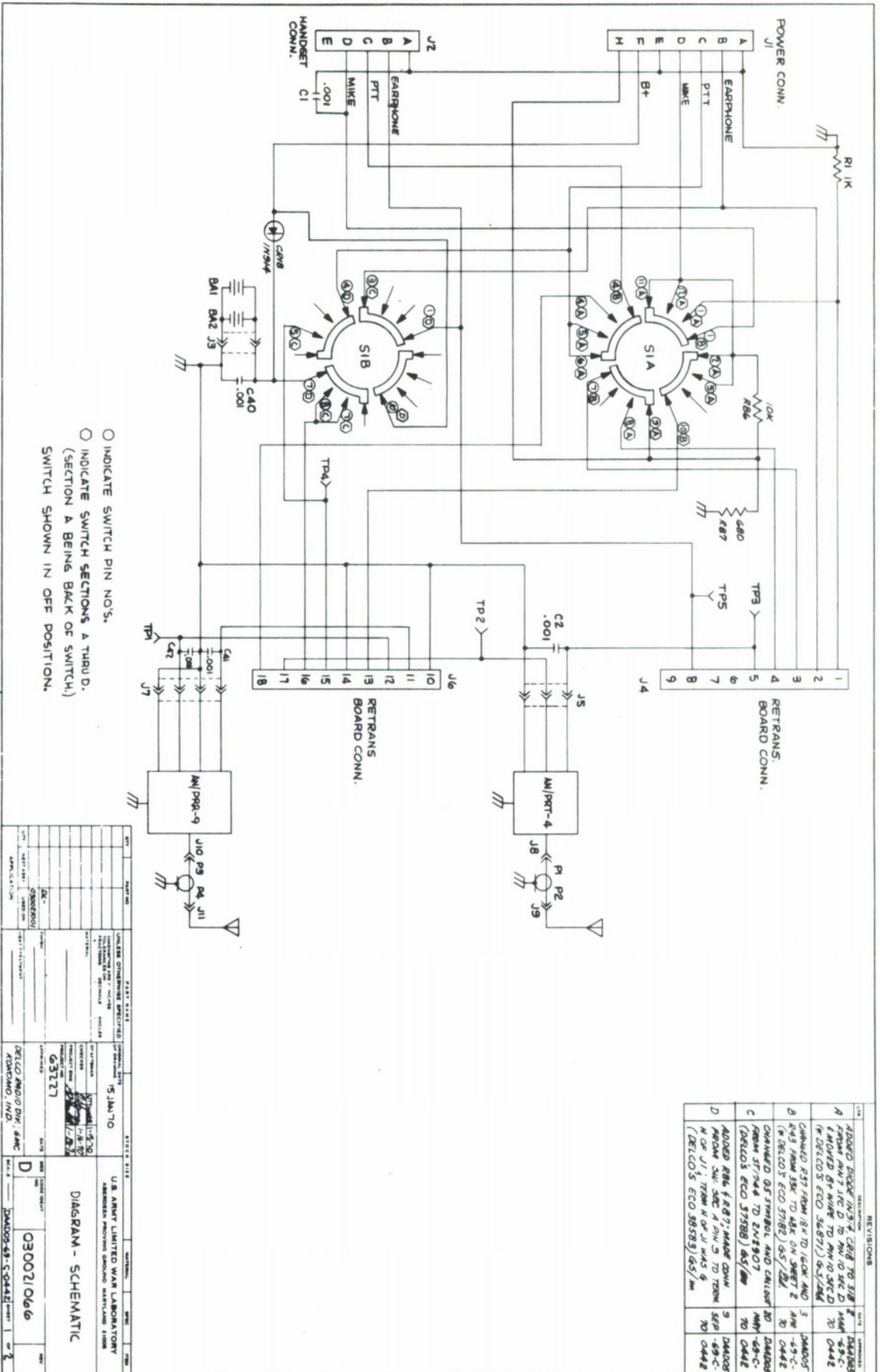
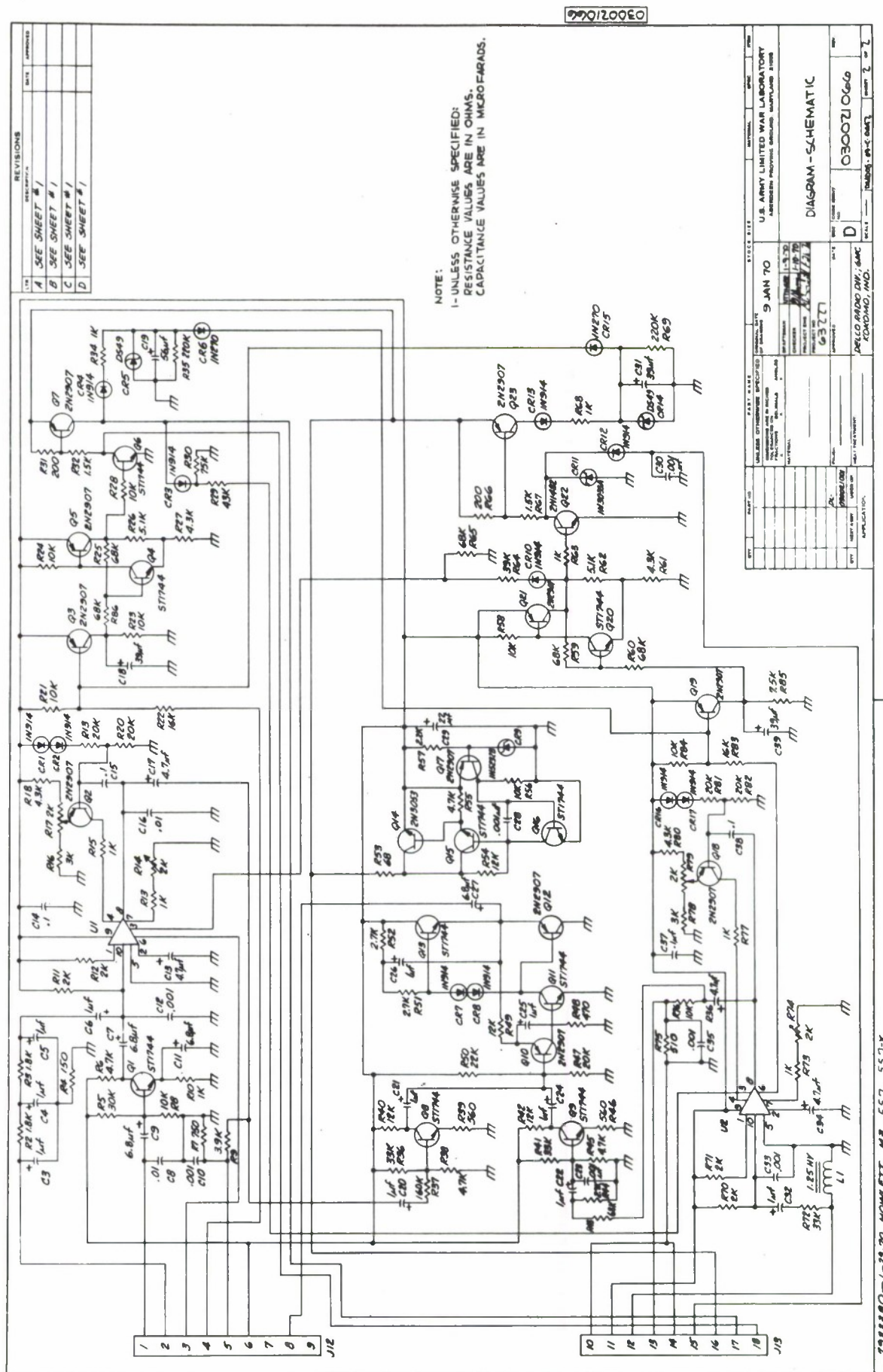
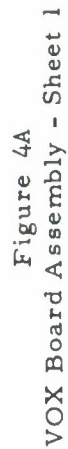


Figure 2A
Schematic Diagram - Sheet 1





APPENDIX B

TEST PLAN FOR Field Tests of Retransmission Units C-7772/GRC in Puerto Rico

OBJECTIVE: To determine the combat capability of the Control, Remote Retransmission Unit, C-7772/GRC while used in simulated operations in a hot-wet environment.

PLACE: Tropical Rain Forest, Puerto Rico.

PERSONNEL: 3 - 1 from C&E Br
2 from MOD

EQUIPMENT: 5 ea C-7772/GRC Units
5 ea PRT-4 and PRR-9 radio sets
3 ea AN/PRC-25/77
Spare BA-399's and BA-386's
2 ea Tape Recorders, spare tapes, batteries
2 ea Speakers
2 ea TS-318/PRC-25 Back-Packs
Misc. hand tools
1 ea Weather Instrument Kit

TEST PROCEDURE:

1. A base station utilizing a PRC-25/77 with long whip will be established near K13.3, Rt. 191 in rain forest. This station will simulate a company or battalion Hq. and be manned by 1 man. It will monitor and record all traffic and originate test transmissions when required.
2. One man and a second AN/PRC-25/77 with short whip and a retransmission device attached will be designated patrol communicator. He will back-pack the equipment over rough jungle terrain in a simulated patrol mission. Transmissions will be relayed and the equipment operated as per Para. 4, upon request of patrol leader.

He will subject the equipment to rain, sunlight, and high humidity whenever possible. (These times to be recorded.) This station will also monitor and record all traffic. He will be separated from the base station by not more than 3 miles. These tests will be repeated on all five (5) C-7772/GRC Retransmission Devices. Performance of each device will be recorded referring to Serial Number assigned by LWL to each device. The retransmission device will be operated on the PRC-25/77 internal battery for this test.

3. A third man will be designated as patrol leader and operate a PRR-9/PRT-4 squad radio set. This set will not record. The operator will originate numbered transmissions as required. He will be separated from the patrol communicator by at least 300 meters to 1/2 mile maximum.

4. The three (3) stations established above will try to simulate as near as possible a combat patrol situation. They will utilize the C-7772 Retransmission Unit in all of its modes of operation.

- a. The "off" position - operate PRC-25 to base.
- b. The "Local" position - operate "patrol communicator" to "patrol leader"
- c. The "Retrans" position - operate "patrol leader" to "base".

5. Frequencies will be utilized as per those set into the Retransmission Units. The ease of finding interference free frequencies on the PRC-25/77 associated with the retransmission will be established if possible.

6. The utilization of 2 or 3 different jungle trail location is recommended whenever possible. The equipment will be subject to rain whenever possible and operated under these conditions.

7. Sun loading of the retransmission units will be tested in the open area near the junction of Rts. 983 and 991. They will be exposed to the sun between the hours of 1200 and 1500 and checked for operation frequently during these times. The ambient temperature will be recorded.

8. Range: A direct comparison of the Retransmission Device to the squad radio will be made. Utilizing the retransmission device in the "Local" mode and used as a receiver/transmitter it will be compared to the squad radio for maximum range. The retransmission device will operate on its internal batteries for this test.

APPENDIX C

TEST RESULTS

OBJECTIVE: Field Test of Remote Retransmission Device C-7772/GRC in a

Hot-Wet Environment: Puerto Rico

PERSONNEL: Mr. J. S. Hemler, Comm/Elec Br
Mr. Ken Vogt, Delco Radio
LTC D. L. Romig, MOD
SFC E. Dickens, MOD

METHOD: See Test Plan attached.

SUMMARY OF ALL TESTS:

1. The field test of the Retransmission Device shows a need for better quality control by the contractor of the transmitters and receivers in the squad radio system and in the retransmission device.
2. The operation of the VOX circuits appears to be satisfactory except for some slight readjustment in VOX hold-on-time on Units No. 2.
3. Item #7 of Test Plan (Sun Loading) was not accomplished due to bad weather in the test site between 1200 and 1500 hours.
4. All transmissions monitored by the base station were recorded on tape.

RESULTS: Test No. 1

Locations: Retrans & Sq. Radio K13.3 - Old Mess Hall

Base Station - LWL House (see strip maps inclosed)

Weather: Partly cloudy, Temp. 76, RH 67%, Wind 2 MPH.

Foliage: Medium - Heavy

RETRANS ON PRC-77 W/LONG ANTENNA

Retrans No.	Retrans Freq.	Base Freq.	Mode Sw.	Retrans to Base - Sq. Set		Base to Retr - Sq. Set		Sq. Radio Set Base	Retr
No. 1	51.0	38.5	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	100%	Ok	N/A	N/A	N/A	100%
			Retrans	Broken	Dis- torted & Bro- ken	100%	Broken	Broken	Broken
No. 2	55.0	39.0	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	100%	N/A	N/A	N/A	Weak
			Retrans	No	No	No	No	No	No
No. 3	47.0	39.0	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	50%	N/A	N/A	N/A	50%
			Retrans	100%	50%	100%	30%	30%	30%
No. 4	49.0	39.0	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	50%	N/A	N/A	N/A	50%
			Retrans	100%	100%	100%	100%	100%	100%
No. 5	53.0	39.0	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	Ok	N/A	N/A	N/A	Ok
			Retrans	100%	100%	100%	100%	100%	100%

N/A - Not Applicable

% - Readability

CONCLUSIONS, TEST NO. 1

1. RT #1 developed problems in the Retrans mode. They were diagnosed by Delco Rep., Mr. Vogt, to be confined to the Transmitter in the Retrans Device and the VOX circuit internal adjustments.
2. Repairs were made and it was decided this unit would be rerun over the same course at a later time.
3. RT #2 developed trouble in the Retrans and Local mode. These were diagnosed by Mr. Vogt to be due to an improperly aligned transmitter PRT-4 in the Sq. Radio System. This item was replaced and would also be rerun on the same course at a later date.
4. RT #3 operated properly in all modes with the exception of some shorter than expected ranges with the Sq. System.
5. RT #4 operated properly in all modes.
6. RT #5 operated properly in all modes except for shorter ranges from the Sq. Radio to the Retrans.

TEST NO. 2

LOCATIONS: Retrans & Sq. Radio K13.3 - Old Mess Hall

Base Station - LWL House (see strip maps inclosed)

WEATHER: Heavy rain, Temp. 65-70, Wind 5 to 10 MPH.

FOLIAGE: Medium - Heavy

RETRANS ON PRC-77 W/LONG WHIP

Retrans No.	Retrans Freq.	Base Freq.	Mode Sw.	Retrans to		Base to		Sq. Radio Set	
				Base	Sq. Set	Retr	Sq. Set	Base	Retr
No. 1	51.0	38.50	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	100%	N/A	N/A	N/A	100 %
			Retrans	100%	100%	100%	100%	100%	100%
No. 2	55.0	38.50	Off	100%	N/A	100%	N/A	N/A	N/A
			Local	N/A	50%	N/A	N/A	N/A	50%
			Retrans	100%	50%	100%	75%	75%	50%
No. 3	47.0	38.50	Lock-up	- Changed Base Freq.					
No-Tone	47.0	39.00	Off	100%	N/A	100%	N/A	N/A	N/A
Sq. in Retrans- mitter			Local	N/A	50%	N/A	N/A	N/A	50%
			Retrans	100%	50%	100%	50%	50%	50%

N/A - Not Applicable

% - Readability

CONCLUSIONS, TEST NO. 2

1. RT #1 - Ranges in excess of 500 meters were experienced between the Sq. Radio System to the Retrans in this system. The repairs and adjustments incorporated by Mr. Vogt appeared to solve the problems encountered in this unit in Test No. 1.
2. RT #2 - Ranges to 300 meters were experienced between the Sq. Radio and Retrans. There is still evidence of some clipping of phrases and some distortion from the Sq. Radio Set through the Retrans. Checked through, the stand-by set (PRC-25) indicated the retrans time constant hold-in is slightly off. The distortion is from the PRT-4 in the Sq. Radio. Some loss of communications with the Retrans due to antenna hitting wet foliage.
3. RT #3 - Ranges to 200 meters between the Sq. Set and Retrans were experienced. Slight lock-up problems were experienced, freq. at the base station was changed, lock-up resolved. Short range of the Sq. System checked with the stand-by PRC-25, Retrans working properly. The short range of this Sq. System is approximately the same as experienced in Test No. 1. There was some evidence of short phrase clipping, however, most transmissions were readable.
4. RT #4 and RT #5 were not rechecked at this time. Their operation in Test No. 1 was deemed sufficient for this test, and the trails being used were becoming very treacherous due to the heavy rain.

5. Range Comparison Test:

Weather: Overcast and Some Rain, Wind 2 MPH from the South, RH 86% to 100%

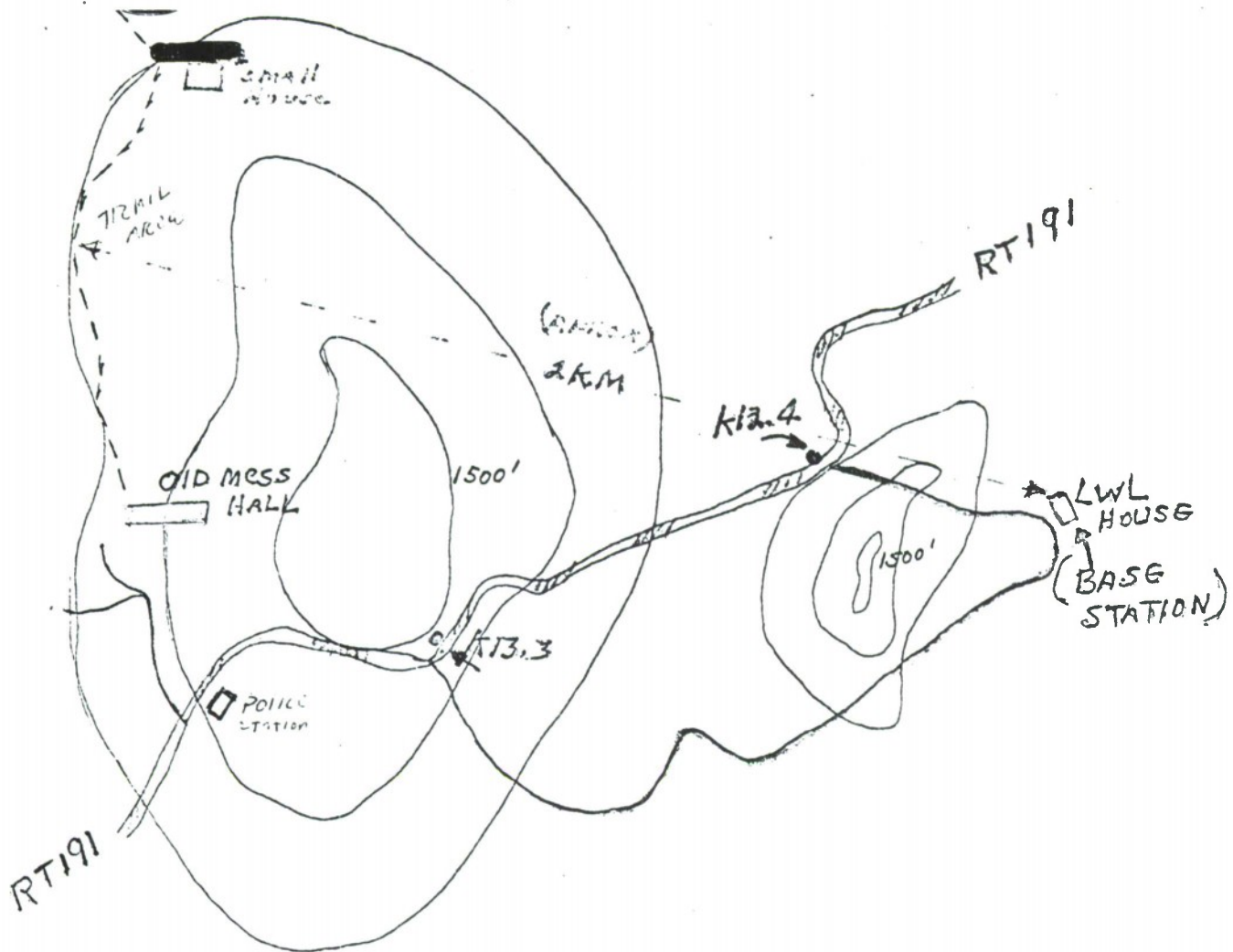
1. A Radio Set AN/PRC-77 was established at the maximum range of Sq. Radio Set #1 by walking out-range until reception and transmission became broken. The range was then shortened until reception and transmission was solid (loud and clear). All tests were conducted at this range unless otherwise stated in the following chart.

KO - H4 Location

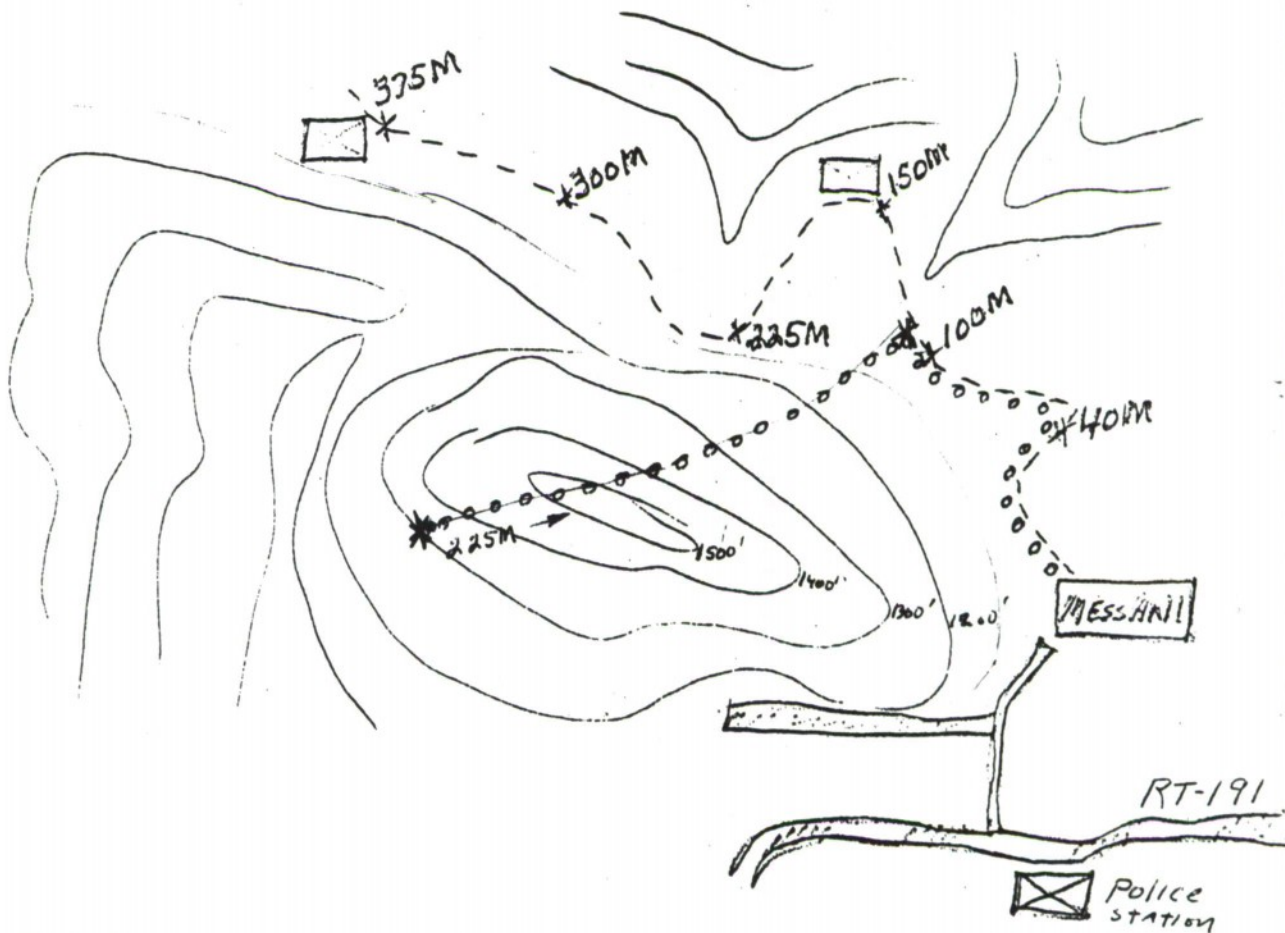
<u>Unit No.</u>	<u>Sq. Radio Set</u>	<u>Retrans</u>	<u>Range to PRC-77</u>	<u>Notes</u>
1	100%	100%	600 meters	Defective horn in PR9 - heavy foliage
2	100%	Tr. - Broken Rec - Readable	600 meters	
3	Broken - Read- able, Tr & Rec	No contact	600 meters	No tone sq.
3	100%	Tr - 100% Rec - N/C	525 meters	K-1, H-1
4	Weak Tr 100% Rec	Weak Tr Rec 100%	600 meters	
5	100%	Tr - 100% Rec - N/C	600 meters	
5	90%	Tr - 100% Rec - N/C	525 meters	K-1, H-1
5	100%	Tr - 100% Rec - N/C	500 meters	Walking into Base, K-1, H-0
5	100%	Tr - 100% Rec - N/C	300 meters	K-0, H-9
5	100%	Tr - 100% Rec - 80%	200 meters	K-0, H-8

CONCLUSIONS. RANGE COMPARISON TEST

These tests show a wide variation in communication ranges of the transmitters and receivers. It appears the quality control at both Sq. Radio Transmitters and Receivers and the Transmitters and Receivers used in the Retrans, could be improved.



OVER-ALL TEST SITE



INC 2

TRAIL TEST SITE

C-9

--- Re-TRANS

oo oo 59 Radio Set

APPENDIX D

TEST PLAN FOR CONTROL, REMOTE RETRANSMISSION UNIT C-7772/GRC

OBJECTIVE: To determine the compatibility and capability of the Control, Remote Retransmission Unit C-7772/GRC when used with a vehicular mounted AN/VRC-12 Radio Set.

PLACE: Fort Belvoir, Virginia.

PERSONNEL: 3 - 2 from C&E Br
1 from MOD

EQUIPMENT: 9 ea C-7772/GRC Unit
9 ea AN/PRT-4 Radio Transmitters w/spare batteries
9 ea AN/PRR-9 Radio Receivers w/spare batteries
2 ea AN/PRC-77 w/spare batteries
1 Jeep with AN/VRC-12 (supplied by Fort Belvoir)
1 spare Rec/Trans RT-246/VRC
1 Tape Recorder with tapes
Cables for Retransmission Unit including spares

TEST PROCEDURE:

- a. A base station utilizing a PRC-77 with long whip will be established to monitor and record all traffic. This station will be controlled by 1 man.
- b. One man will drive the vehicle and operate the AN/VRC-12 and the control unit C-7772/GRC.
- c. The third man will act as a roving patrol and will operate the PRT-4/PRR-9. He will be separated from the vehicle by various ranges up to 1/2 mile maximum. During these tests the vehicle shall be moving, standing with engine running and standing with engine stopped.
- d. All nine C-7772/GRC Units will be exercised and tested for operation and compatibility with the AN/VRC-12 for both local and retransmit modes of operation.
- e. Data will be collected on magnetic tape at the base station. The following information will be noted:
 - (1) C-7772/GRC serial number.
 - (2) Mode of operation, local or retrans.
 - (3) Vehicle moving or standing.
 - (4) Vehicle engine running or stopped.
 - (5) Distance and location of roving patrol in relation to vehicle.
 - (6) Readability of signal at base station.

APPENDIX E

TEST RESULTS

CONTROL, REMOTE RETRANSMISSION UNIT C-7772/GRC

OBJECTIVE: To determine the compatibility and capability of the Control, Remote Retransmission Unit C-7772/GRC when used with a vehicular mounted AN/VRC-12 series radio set.

PERSONNEL: Mr. S. Peirce, C&E Br

Mr. H. Offney, C&E Br

SFC E. Dickens, MOD

SP/4 E. Van Hoesen, Driver

PLACE: Armstead Woods, Fort Belvoir, Virginia

METHOD: See Test Plan attached.

SUMMARY OF ALL TESTS:

1. The field test of the retransmission units was conducted in light to medium foliage. The temperature during the test averaged approximately 90°F.
2. To speed the test, the patrol position was a fixed location, the base station was a fixed location and the jeep moved to four different locations as indicated by the Figure. For all four locations, the tests were conducted with the following conditions:
 - a. Jeep stopped, engine stopped.
 - b. Jeep stopped, engine running.
 - c. Jeep moving.

Since there was no discernible difference between the three conditions of the jeep, the data presented will be for one condition at each location.

3. The jeep with VRC-46 radio set was supplied by the 91st Engr Battalion, Fort Belvoir, Va. All nine C-7772/GRC units were tested using the receiver/transmitter RT 524/VRC. Four of the nine units were also tested using the receiver/transmitter RT-246/VRC. No differences in operation were noted between the two units.

4.
 - a. Retransmission Unit No. 1 has too short VOX stay on time.
 - b. Retransmission Unit No. 6 was very noisy when received by the base station.
 - c. Retransmission Unit No. 9 would not operate beyond 50 meters. Tests indicate a faulty receiver.
 - d. Retransmission Unit No. 10 would not operate beyond 50 meters. Tests indicate faulty transmitter.
 - e. The patrol position PRR-9 receiver experienced a loud background noise when receiving transmission from the jeep position with the retransmission unit in the retrans mode. Investigation shows that the VRC-12 audio has a 900 Hz tone which is amplified by the retrans unit and it appears as a loud background sound at the squad receiver.
5. Some difficulty was encountered in securing the retransmission mount to the VRC-46 Radio Set. The screws supplied with the retransmission mount were too short, because of the contour of the receiver-transmitter unit RT-524/VRC. No problems were encountered with the retransmission unit when used with the VRC-12 radio set using the receiver-transmitter unit RT-246/VRC.
6. Attached is a copy of the collected data and a reproduction of the map area used during the tests.



Scale 1:12,500



CONTOUR INTERVAL 10 FEET

VERTICAL DATUM: MEAN SEA LEVEL

TRANSVERSE MERCATOR PROJECTION

HORIZONTAL DATUM: 1927 NORTH AMERICA

FIGURE - Test Sites - Armstead Woods, Ft. Belvoir, VA.

11 June 1970

JEEP LOCATION #1

APPROXIMATE DISTANCE IN METERS

VRC 46 FREQ 41.3 MHz

Patrol to jeep 200

RETRANS UNIT IN LOCAL MODE

TRANSMISSION READABILITY

<u>RETRANS</u>		<u>PATROL</u> <u>TO JEEP</u>	<u>JEEP TO</u> <u>PATROL</u>
<u>UNIT</u> <u>NO.</u>	<u>FREQ</u> <u>(MHz)</u>		
1	51.0	Loud and clear	Loud and clear
2	55.0	Loud and clear	Loud and clear
3	47.0	Loud and clear	Loud and clear
5	53.0	Loud and clear	Loud and clear
6	47.0	Loud and clear	Loud and clear
7	51.0	Loud and clear	Loud and clear
8	49.0	Loud and clear	Loud and clear
9	53.0	Units would not operate beyond 50 meters	
10	55.0	Units would not operate beyond 50 meters	

11 June 1970

JEEP LOCATION # 1

APPROXIMATE DISTANCE IN METERS

VRC 46 FREQ 38.5 MHz

1. Patrol to jeep 200
2. Patrol to base 300
3. Base to jeep 500

Retrans Unit in Retrans Mode

TRANSMISSION READABILITY

RETRANS		PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT NO.	FREQ (mHz)						
1	51.0	5 X 5	Loud and clear	Loud with clipping	Loud with clipping	5 X 5	Loud and Clear
2	55.0	Loud and clear	Loud and clear	Loud and clear	5 X 5	Loud and clear	Loud and clear
3	47.0	5 X 5	Loud and clear	5 X 5	Loud and clear	Loud and clear	Loud and clear
5	53.0	Loud and clear	5 X 5	Loud and clear	5 X 5	5 X 5	5 X 5
6	47.0	5 X 5	Loud with noise	Loud and clear	Loud and clear	5 X 5	5 X 5
7	51.0	Loud and clear	Nasal sounding	Loud with noise	Loud and clear	Loud and clear	Loud and clear
8	49.0	Loud and clear	Loud and clear	Loud and noisy	Loud and clear	Loud and clear	Loud and clear
9	53.0	Retransmission Unit defective.					
10	55.0	Retransmission Unit defective.					

11 June 1970

JEEP LOCATION # 2

VRC 46 FREQ 38.5 MHz

Retrans Unit in retrans mode

APPROXIMATE DISTANCE IN METERS

1. Patrol to jeep 400
2. Patrol to base 300
3. Base to jeep 500

TRANSMISSION READABILITY

RETRANS	PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT FREQ NO. (MHz)						
1 51.0	5 X 5	Loud and clear	Loud and clear	Loud and clear	5 X 5	Loud and clear
2 55.0	Loud and clear	5 X 5	Loud and clear	Loud and clear	Loud and clear	5 X 5
3 47.0	Loud and clear	Loud and clear	Loud and clear	5 X 5	Loud and clear	5 X 5
5 53.0	5 X 5	5 X 5	5 X 5	5 X 5	Loud and clear	5 X 5
6 47.0	Loud and clear	Loud background noise	Loud with noise	Loud and clear	Loud and clear	Loud and clear
7 51.0	Loud and clear	5 X 5	Loud with noise	Loud and clear	Loud and clear	Loud somewhat nasal
8 49.0	Loud and clear	5 X 5	Loud with noise	Loud and clear	Loud and clear	5 X 5
9 53.0	Retransmission Unit defective.					
10 55.0	Retransmission Unit defective.					

11 June 1970

JEEP LOCATION # 3

VRC 46 FREQ 38.5 MHz

Retrans Unit in retrans mode

APPROXIMATE DISTANCE IN METERS

1. Patrol to jeep 250
2. Patrol to base 300
3. Base to jeep 200

TRANSMISSION READABILITY

RETRANS		PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT NO.	FREQ (mHz)						
1	51.0	Loud and clear	Loud and clear	Loud and clear	5 X 5	5 X 5	Loud and clear
2	55.0	5 X 5	Loud and clear	5 X 5	Loud and clear	Loud and clear	5 X 5
3	47.0	Loud and clear	5 X 5	Loud and clear	Loud and clear	Loud and clear	5 X 5
5	53.0	Loud and clear	Loud and clear	Loud and clear	5 X 5	5 X 5	Loud and clear
6	47.0	Loud and clear	Very noisy	Very noisy	Loud and clear	Loud and clear	Loud and clear
7	51.0	Loud and clear	5 X 5	noisy	Loud and clear	Loud and clear	Loud Nasal
8	49.0	Loud and clear	Loud and clear	5 X 5	Loud and clear	Loud and clear	Loud and clear
9	53.0	Retransmission Unit defective.					
10	55.0	Retransmission Unit defective.					

11 June 1970

JEEP LOCATION # 4

APPROXIMATE DISTANCE IN METERS

VRC 46 FREQ 38.5 mHz

1. Patrol to jeep 300
2. Patrol to base 300
3. Base to jeep 10

Retrans Unit in retrans mode

TRANSMISSION READABILITY

RETRANS		PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT FREQ NO. (mHz)							
1 51.0	Loud and clear	5 X 5	Loud and clear	Loud and clear	5 X 5	5 X 5	
2 55.0	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	
3 47.0	5 X 5	Loud and clear	*Weak signals at patrol	5 X 5	5 X 5	*Weak signals at patrol	
5 53.0	5 X 5	Loud and clear	5 X 5	5 X 5	5 X 5	Loud and clear	
6 47.0	Loud and clear	Loud with noise	Noisy	Loud and clear	Loud and clear	Loud and clear	
7 51.0	Loud and clear	Loud with noise	Noisy	Loud and clear	Loud and clear	Loud and clear	
8 49.0	Loud and clear	Loud and clear	Noisy	Loud and clear	Loud and clear	Loud and clear	
9 53.0	Retransmission Unit defective.						
10 55.0	Retransmission Unit defective.						

* Patrol had to replace battery in the squad receiver, PRR-9, Operation then normal

12 June 1970

JEEP LOCATION # 1

APPROXIMATE DISTANCE IN METERS

VRC 12 FREQ 38.5 mHz
RT 246/VRC

1. Patrol to jeep 200
2. Patrol to base 300
3. Base to jeep 500

Retrans Unit in retrans mode

TRANSMISSION READABILITY

RETRANS	PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
---------	-------------------	-------------------	-------------------	-----------------	-----------------	-------------------

UNIT FREQ
NO. (mHz)

* 1	51.0	Loud and clear	5 X 5	Loud with background noise	5 X 5	5 X 5	5 X 5
2	55.0						
* 3	47.0	Loud and clear	5 X 5	Loud and clear	5 X 5	5 X 5	5 X 5
5	53.0						
* 6	47.0	Loud and clear	5 X 5	Loud with back- ground noise	Loud and clear	Loud and clear	5 X 5
* 7	51.0	5 X 5	5 X 5	Background noise	5 X 5	5 X 5	5 X 5
8	49.0						
9	53.0						
10	55.0						

* Units tested with VRC-12 RT/246VRC

12 June 1970

JEEP LOCATION # 2

VRC 12 FREQ 38.5 MHz
RT-246/VRC

APPROXIMATE DISTANCE IN METERS

1. Patrol to jeep 400
2. Patrol to base 300
3. Base to jeep 500

Retrans Units in retrans mode

TRANSMISSION READABILITY

RETRANS	PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
---------	-------------------	-------------------	-------------------	-----------------	-----------------	-------------------

UNIT FREQ
NO. (MHz)

* 1	51.0	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	5 X 5
2	55.0						
* 3	47.0	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear
5	53.0						
* 6	47.0	Loud and clear	Loud with back- ground noise	Loud with back- ground noise	Loud and clear	Loud and clear	Loud and clear
* 7	51.0	Loud and clear	Loud and clear	5 X 5	Loud and clear	Loud and clear	Loud and clear
8	49.0						
9	53.0						
10	55.0						

* Units tested with VRC-12 RT-246/VRC

12 June 1970

JEEP LOCATION # 3

APPROXIMATE DISTANCE IN METERS

VRC 12 FREQ 38.5 MHz

1. Patrol to jeep 250
2. Patrol to base 300
3. Base to jeep 200

RT-246/VRC

TRANSMISSION READABILITY

RETRANS		PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT NO.	FREQ (MHz)						
* 1	51.0	Loud and clear	Loud and clear	Loud with noise	Loud and clear	Loud and clear	Loud and clear
2	55.0						
* 3	47.0	Loud and clear	Loud and clear	Loud and clear	5 X 5	5 X 5	Loud and clear
5	53.0						
* 6	47.0	Loud and clear	Loud with some noise	5 X 5	Loud and clear	Loud and clear	5 X 5
* 7	51.0	5 X 5	Loud and clear	5 X 5 w/noise	Loud and clear	5 X 5	5 X 5
8	49.0						
9	53.0						
10	55.0						

* Units tested with VRC-12 RT-246/VRC

12 June 1970

JEEP LOCATION # 4

VRC 12 FREQ 41.3 MHz
RT-246/VRC

APPROXIMATE DISTANCE IN METERS

1. Patrol to jeep 300
2. Patrol to base 300
3. Base to jeep 10

Retrans unit in retrans mode

TRANSMISSION READABILITY

RETRANS	PATROL TO JEEP	PATROL TO BASE	JEEP TO PATROL	JEEP TO BASE	BASE TO JEEP	BASE TO PATROL
UNIT FREQ NO. (MHz)						
* 1 51.0	Loud and clear	Loud and clear	5 X 5	5 X 5	Loud and clear	5 X 5
2 55.0						
* 3 47.0	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear
5 53.0						
* 6 47.0	Loud and clear	Loud with noise	Loud and clear	Loud and clear	Loud and clear	Loud and clear
* 7 51.0	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear	Loud and clear
8 49.0						
9 53.0						
10 55.0						

* Units tested with VRC-12 RT-246/VRC

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