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Final Technical Report
April 1970

AN/PRC-66, AN/PRC-75 UHF TRANSCEIVER DEVELOPMENT PROGRAM

Collins Radio Company of Canada Limited

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, New York

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AN/PRC-66, AN/PRC-75 UHF TRANSCEIVER DEVELOPMENT PROGRAM

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FOREWORD

This report was prepared by Collins Radio Company of Canada Limited, Toronto, Ontario, on Air Force contract AF 30(602)-3378, Project 5592, Task 559201, for Rome Air Development Center, Griffiss Air Force Base, New York, and under Canadian Commercial Corporation contract 7PG4-1. Carmen J. Luvera (EMCTN) was the RADC Project Engineer on the contract.

The scope of the contracts encompasses the development of two types of UHF radio receiver-transmitter, namely, the AN/PRC-66 for the United States Air Force and the AN/PRC-75 (XN-1) for the United States Marine Corps and a subsequent development program which produced the AN/PRC-66 radio set having wideband and guard channel capability.

Distribution of this report is restricted under the provisions of the U.S. Mutual Security Acts of 1949.

This technical report has been reviewed and is approved.

Approved: CARMEN J. LUVERA
Project Engineer

Approved: for RICHARD M. COSEL, Colonel, USAF
Chief, Communications & Navigation Division

FOR THE COMMANDER: IRVING J. GABELMAN
Chief, Plans Office

ABSTRACT

This report summarizes the results of the design and development of Radio Set AN/PRC-66 for the United States Air Force and Radio Set AN/PRC-75 for the United States Marine Corps. Both radio transceivers are completely solid state and utilize the latest micro-miniature techniques and most recent advances in modular construction. The AN/PRC-66 represents a major breakthrough in portable manpack equipment and the AN/PRC-75 represents, likewise, a major breakthrough in handheld UHF equipment.

The results of the design and development indicate that major advances have been accomplished in the areas of reliability, weight and size. Both transceiver units have a predicted MTBF in excess of 2000 hours and weigh no more than 5.5 pounds (AN/PRC-66) and 3.9 pounds (AN/PRC-75), excluding battery. Also, the size of these radio sets is at least 80% smaller than similar equipment in production and use today.

EVALUATION

The subject effort has successfully provided to the USAF and US Marine Corp. and their tactical commands a long needed capability in tactical UHF Radio communications. The contractor has delivered two fully militarized lightweight, highly reliable, completely solid-state, all channel UHF Manpack transceivers, the AN/PRC-66 (USAF) and the AN/PRC-75 (USMC). The addition of these transceivers provides an increase in use flexibility by providing increased channel capability to 3500 channels, increase in reliability to 2000 hours, and significant reductions in size and weight over existing comparable equipments.

These equipments have successfully undergone operational feasibility testing in a tactical environment to verify operational suitability. Production specifications have been prepared incorporating results of various testing and production quantities are being procured.

Carmen J. Luvera

CARMEN J. LUVERA
Project Engineer

T A B L E   O F   C O N T E N T S

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1.0 INTRODUCTION

This report presents the results of the design effort conducted between April 1964 and May 1969 on the United States Air Force Contract No. AF 30 (602)-3378 (EMKC) and Canadian Commercial Corporation Contract No. 7PG4-1.

The final equipments consisted of two each developmental models of radio set AN/PRC-75 in accordance with Purchase Description USMC PD CYS-FY 64-12, four each prototype models of radio set AN/PRC-66 (without squelch-transceiver unit RT 865/PRC-66) two each prototype models of radio set AN/PRC-66 (with squelch-transceiver unit RT-865A AN/PRC-66) in accordance with RADC-5137, and two each prototype models of radio set AN/PRC-66 (with squelch, wideband and guard channel capability - transceiver unit RT 865B/PRC-66 . Both radio sets include a UHF transmitter-receiver, batteries and miscellaneous auxiliary equipments.

Extensive tests have been carried out to show: performance under standard and environmental conditions; reliability, maintainability and the spectrum signature of the equipment.

As reflected in the equipment specifications, size and weight are factors of major importance in man-carried radio sets such as the AN/PRC-66 and AN/PRC-75. Furthermore, in the design and development of these equipments considerable emphasis has also been placed on producibility, reliability and maintainability. In considering the various factors it is, therefore, felt that the present design approach and degree of modularization represents the best construction of these equipments.

2.0 SYSTEM DESCRIPTIONS

2.1 AN/PRC-66 SYSTEM DESCRIPTION

2.1.1 General

The AN/PRC-66 system is a lightweight portable UHF system providing AM communication over the frequency range of 225.00 to 399.95 megahertz. This frequency range is covered in 3500 channels spaced 50 kHz and operator selectable by means of controls on the control panel of the transceiver. A photograph of the AN/PRC-66 system together with accessory items is shown in figure 2-1, and a table of specifications is provided in table 2.1. Table 2-1 includes characteristics of the AN/PRC-66B (Wideband with guard receiver capability) described in section 6 of this report.

2.1.2 Physical Description

The system is composed of the following units:-

Item	Quantity	Description
1	1 each	Transceiver RT 865/PRC-66 (without squelch)
		OR
		Transceiver RT 865A/PRC-66 (with squelch)
2	1 each	Antenna (Flexible) AS-2117/PRC-66
3	1 each	Antenna (Dipole) AS-1404/PRC-41
4	1 each	Handset
5	1 each	Battery, Dry BA 3515/PRC-66
6	1 each	Battery, Storage BB 636/PRC-66 (8 hour)
		OR
		Battery, Storage BB /PRC-66 (12 hour)
7	1 each	Battery Case
8	1 each	Carrying Harness
9	1 each	Battery Extension Cable

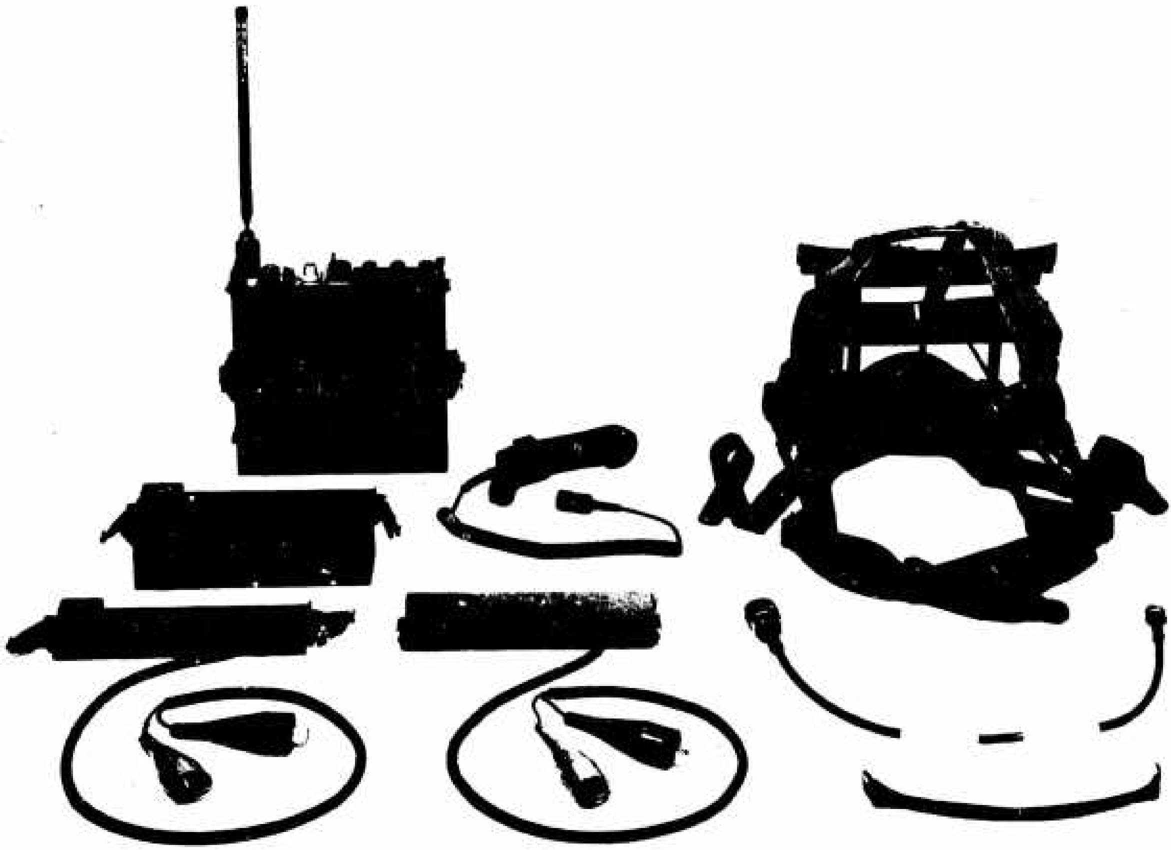


FIG. 2-1 AN/PRC-66 SYSTEM

Table 2-1 Performance Characteristics

CHARACTERISTIC	DESCRIPTION
	A. GENERAL
Frequency Range	225.00 to 399.95 MHz.
Number of channels	3500 spaced at 50 kHz intervals
Frequency selection	Knob-operated dials with direct readout
Resetability	Upon rechanneling the set will be within 4 kHz of the original frequency.
Frequency accuracy	±4 kHz on any channel within the operating frequency range.
Frequency stability	Within 10 parts per million (10 Hz per 1 MHz) per day.
Transmitter duty cycle	30 minutes continuous transmission.
Standard Duty Cycle	9 minutes receive : 1 minute transmit
Primary input voltage	24-vdc nominal from dry cell battery supply. Will operate from 18 to 30 vdc.
Battery Life:	For 9 min receive/1 min transmit duty cycle.
Alkaline non-rechargeable:	
Normal mode*	At least 12 hours (without Guard Receiver). At least 10 hours (with Guard Receiver)*
Wideband mode	At least 8 hours (with Guard Receiver)
Nickel-cadmium rechargeable:	
Normal mode	At least 8 hours.
Wideband mode*	At least 5 hours
	B. TRANSMITTER
RF power output	Not less than 2 watts on any individual channel (90% modulated with 1000 Hz tone) into antenna or 50 ohm load.
Modulation	AM and MCW
Modulation capability	At least 90%
Modulating audio input:	
Normal mode	Accepts output of H-250/U handset.
Wideband mode*	Accepts ±0.6 volt audio input signals into 125 ohm nominal input impedance
Spurious output	Harmonic output at least 40 db below transmitter fundamental output
	Spurious radiation at least 60 db below transmitter fundamental output.

Table 2-1 continued

CHARACTERISTIC	DESCRIPTION
	B. TRANSMITTER (CONT)
Sidetone Level	Adequate to drive H-250/U handset earphone.
Envelope distortion	Not more than 10% at any frequency between 300 Hz to 23 kHz modulated 64%
	C. RECEIVER
R-F input impedance	50 ohms, nominal
Sensitivity:	
Normal mode	3 microvolts with an r-f signal modulated 30% at 1000 Hz for a minimum S+N/N ratio of 10 db and an audio output of 10 milliwatts into a 500-ohm load.
Wideband mode*	10 microvolts with an r-f signal modulated 30% at 1000 Hz for a minimum S+N/N ratio of 10 db and an audio output of 0.25 volt across a 22,000 ohm external load.
I-F Selectivity *	3 db bandwidth: not less than 60 kHz 60 db bandwidth: not more than 120 kHz.
Response to spurious signals:	
I-F rejection	Attenuated at least 60 db below desired signal level.
Image rejection	Attenuated with other spurious responses to a level not greater than 60 db relative to the response of a 3 microvolt input signal
AGC characteristics	Output constant within 3 db, for a signal input variation of 5 microvolts to 100,000 microvolts.
Carrier squelch	Continuously adjustable for r-f input from 50 uV maximum to 3 uV minimum to open squelch.
Audio distortion	Not more than 15% using a 1000 microvolt r-f signal modulated 30%.
	D. OUTPUT AUDIO
Audio Output:	
Normal mode	Not less than 10 mW into 500 ohms for an r-f input of 3 microvolts, 30 percent modulated.

Table 2-1 continued

CHARACTERISTIC	DESCRIPTION
	D. OUTPUT AUDIO (CONT)
Wideband mode*	Not less than 0.25 volts across an external load of 22,000 ohms,
Overall audio response:	
Normal mode	Not more than ±6 db relative to 1000 Hz from 300 to 2700 Hz.
Wideband mode*	Not more than -3 db relative to 18.75 kHz from 300 Hz to 23 kHz.
Volume control	10 mW down to minimum discernible output.
	E. ENVIRONMENTAL CONDITIONS
Relative humidty	Up to 95%, sealed against 3 foot water depth immersion.
Operating temperature range	$-30^{\circ}C$ ($-22^{\circ}F$) to $+52^{\circ}C$ ($+125.5^{\circ}F$)
Non-operating temperature range	$-54^{\circ}C$ ($-65^{\circ}F$) to $+71^{\circ}C$ ($+160^{\circ}F$)

* AN/PRC-66 (B) - Wideband Radio with Guard Receiver Capability

The dimensions and weights of the major system components delivered per the development contract were as follows:-

__Transceiver RT 865(   )/PRC-66__

Height:	5 inches	
Width:	8 inches	(including antenna but
Depth:	1-5/8 inches	excluding handset)
Weight:	4.9 pounds	

__Battery (Rechargeable)__

	BB 636/PRC-66 (8 hour)	BB ( )/PRC-66 (12 hour)
Height:	3-1/4 inches	5 inches
Width:	8 inches	8 inches
Depth:	2-1/4 inches	2-1/16 inches
Weight:	4.9 pounds	6.2 pounds

__Non-Rechargeable Battery Pack__

Height:	4 inches
Width:	8 inches
Depth:	1-3/4 inches
Weight:	4.7 pounds

__Carrying Harness__

Weight:	2.7 pounds

In addition to the above system items, a battery charging cable and a radio bench test cable have been developed and are also shown in figure 2-1A.

2.1.3 OPERATIONAL DESCRIPTION

2.1.3.1 Transceiver RT 865( )/PRC-66

2.1.3.1.1 General

A photograph of the transceiver unit with battery and flexible antenna is shown in Figure 2-1A. All operating controls are contained on the single control panel of the transceiver unit. Selection of any one of the 3500 communication channels is accomplished by the rotation of one or more of the three frequency controls on the panel. The frequency to which the transceiver is tuned is automatically displayed. Also included on the control panel is a volume control, a function switch and, on the RT 865(A)/PRC-66 transceiver unit, a squelch control.

The transceiver is directly attachable to the supplied battery pack without the necessity of making electrical connections manually. The transceiver may be operated apart from the battery pack, if desired, by the use of a battery extension cable provided as part of the equipment.

The transceiver is constructed on a modular basis, consisting of a main chassis/control head (1A1) that accepts the following plug-in modules (refer to Figure 2-2):-

1. Frequency Synthesizer (1A3)
2. IF/Audio (1A4)
3. PA Modulator (1A5)

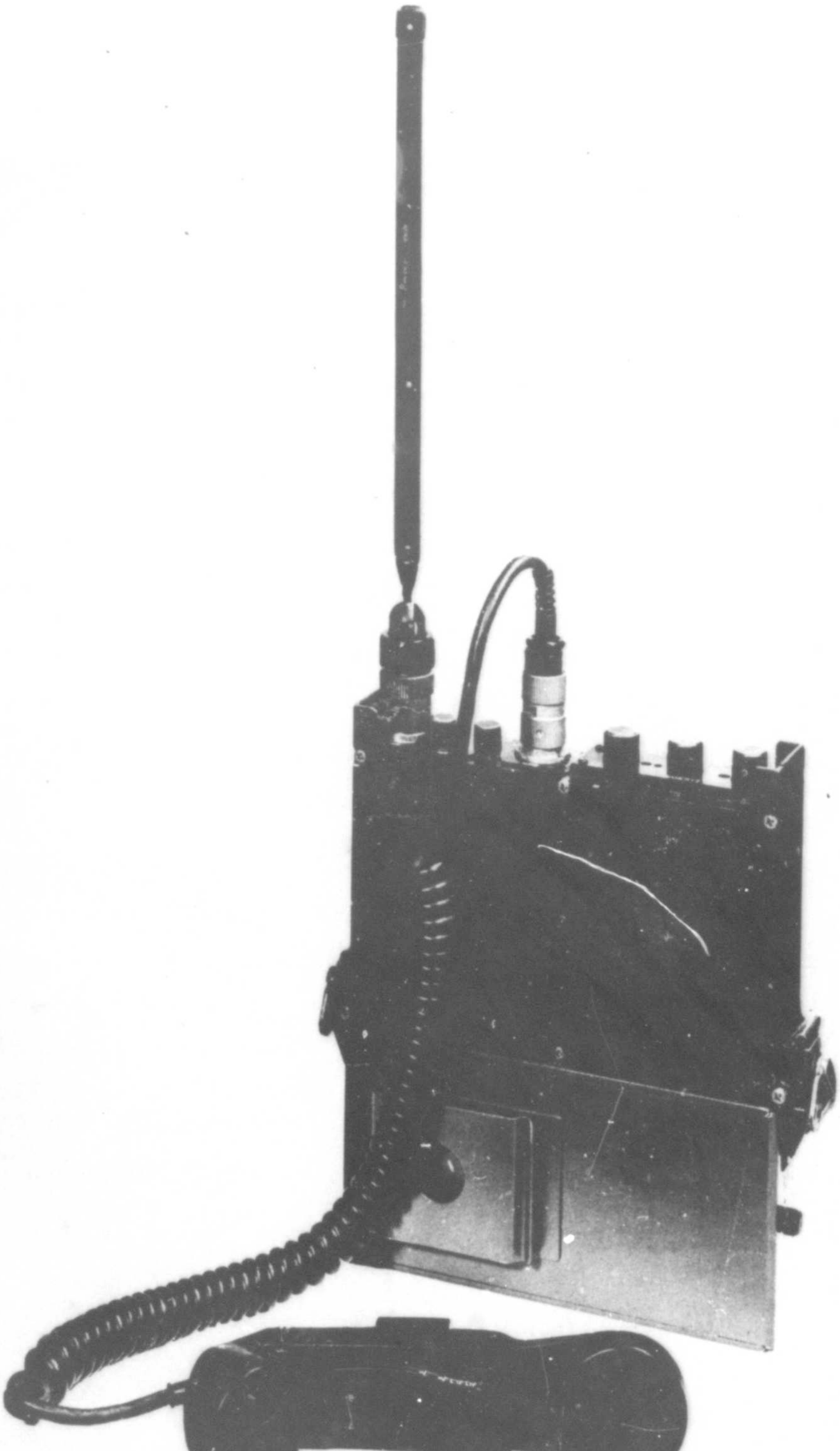
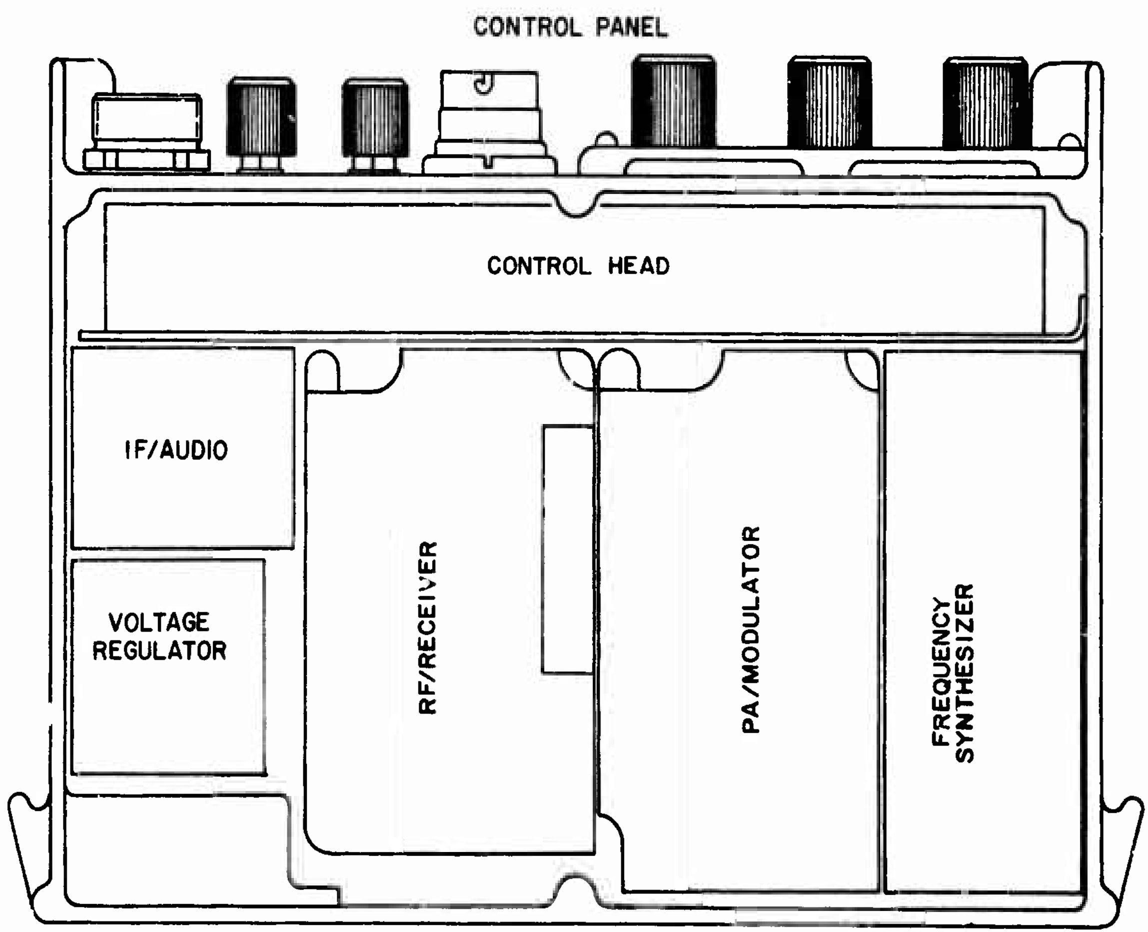


FIG. 2-1A AN/PRC-66 TRANSCEIVER



PRC 66 TRANSCEIVER LAYOUT, COVER REMOVED

FIG 2-2

4. RF/Receiver (1A6)

5. Voltage Regulator (1A2)

Details of the individual modules will be presented in Section 4 of this report.

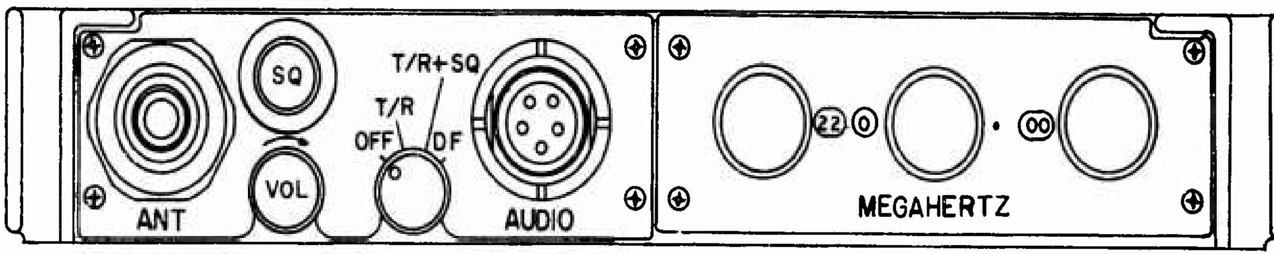
The transceiver has been designed, using only solid state devices. Furthermore, the majority of all active devices are of the silicon monolithic integrated circuit type or in the thin film hybrid circuit form.

2.1.3.1.2 Control Panel

Control panel layouts of the AN/PRC-66 transceiver unit with and without squelch are shown in Figure 2-3 and 2-4. All controls of the AN/PRC-66 system are accessible externally and are located on this panel.

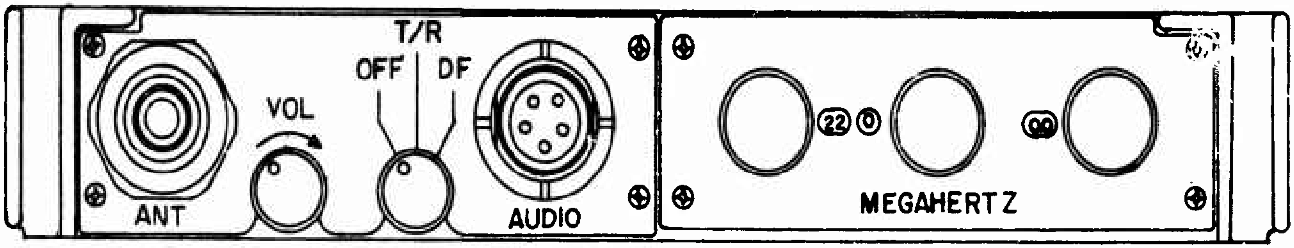
(a) Frequency Selection

Frequency selection is accomplished by rotation of the three frequency controls on the control panel. Two functions, mechanical and electrical are performed by these controls within the transceiver. These functions are to mechanically position the RF tuners within the PA modulator and receiver modules, and electrically provide the properly coded frequency control logic information to the frequency synthesizer module. Mechanical positioning of the R.F. tuning is performed by a simple gearing mechanism,whereas coded information for the frequency synthesizer module is furnished by a set of switch contacts actuated by the position of the control knobs.



RT-865A/PRC-66 CONTROL PANEL LAYOUT

FIG. 2-3



RT-865/PRC-66 CONTROL PANEL LAYOUT

FIG 2-4

The position of the frequency selector controls is maintained by detents included in the gearing mechanism. These detents also include stops so that under conditions of darkness the operator can count detent positions from the stop to select the desired frequency.

(b) Function Switch

The function switch has the following described positions:-

OFF: This position disconnects battery power from the transceiver.

T/R: This position provides transmit-receive operation of the transceiver, with the receiver audio continuously unsquelched.

T/R + SQ: This position (available on the RT 865A/PRC-66 unit only) provides transmit-receive operation while also providing a squelch function during receive.

DF: This position provides continuous tone modulated transmitter operation for direction finding (MCW beacon) during search and rescue missions.

(c) Volume and Squelch Controls

The volume control enables the operator to control the level of the audio output signal.

The squelch control (RT-865A/PRC-66 unit only) enables the operator to control the receiver squelch threshold.

2.1.3.2 Antennas AS-2117/PRC-66 and AS-1404/PRC-41

A flexible tape antenna AS-2117/PRC-66 complete with swivel base forms part of the equipment and mounts directly on the control panel of the transceiver. This antenna was developed specifically for use with the AN/PRC-66 equipment.

A dipole antenna AS-1404/PRC-41 is also supplied as part of the AN/PRC-66 for fixed installation use remote from the transceiver.

A separate antenna jack (type B.N.C.) is provided on the control panel for use with remote 50 ohm antennas or for connection to test equipment. Removal of the the flexible tape antenna provides access to this connector.

2.1.3.3 . Batteries BB 636/PRC-66, BB ( )/PRC-66 and BA 3515/PRC-66

Two rechargeable batteries and one expendable battery were developed for the AN/PRC-66 system. The nickel-cadmium rechargeable batteries BB 636/PRC-66 and BB ( )/PRC-66 are complete with integral battery case and attach directly to the bottom of the transceiver without the need for making electrical connections manually. The design goals have been batteries providing for continuous operation of the transceiver on a duty cycle of 9 minutes receive and 1 minute transmit for at least 8 hours (BB 636/PRC-66) and 12 hours (BB ( )/PRC-66.

The alkaline non rechargeable battery BA 3515/PRC-66 is a dry expendable type battery. The design goal has been a battery capable of operating the transceiver for a least 12 hours continuously on a 9 minute receive and 1 minute transmit duty cycle. A re-useable case is provided to house the expendable battery.

Further flexibility in operation of the AN/PRC-66 system has been made possible by the provision of a battery extension cable. This cable permits operation of the transceiver while mechanically separated from the battery. Such operation may be desirable under conditions of low ambient temperatures when it may be advisable to thermally insulate the battery.

2.2 AN/PRC-75 (XN-1) SYSTEM DESCRIPTION

2.2.1 General

The AN/PRC-75 (XN-1) system is a lightweight portable UHF system providing AM communication over the frequency range of 225.00 to 399.95 megahertz. This frequency range is covered in 3500 channels, spaced 50 kHz and operator selectable by means of three controls on the control panel of the transceiver. The small size of the transceiver, complete with integral audio transducer, makes it suitable for hand-held operation. A photograph of the AN/PRC-75 (XN-1) system is shown in figure 2-5 and a table of performance characteristics is provided in table 2-2.

2.2.2 Physical Description

The system is composed of the following units:-

Item	Quantity	Description
1	1 each	Transceiver
2	1 each	Antenna
3	1 each	Battery, Dry
4	1 each	Battery Case
5	1 each	Battery Extension Cable
6	1 each	Headset
7	1 each	Carrying Harness

The dimensions and weights of the major system components delivered per the development contract are as follows:-

Transceiver

Height:	7.4 inches	
Width:	4.0 inches	(including antanna)
Depth:	1.5 inches	
Weight:	3.32 pounds	

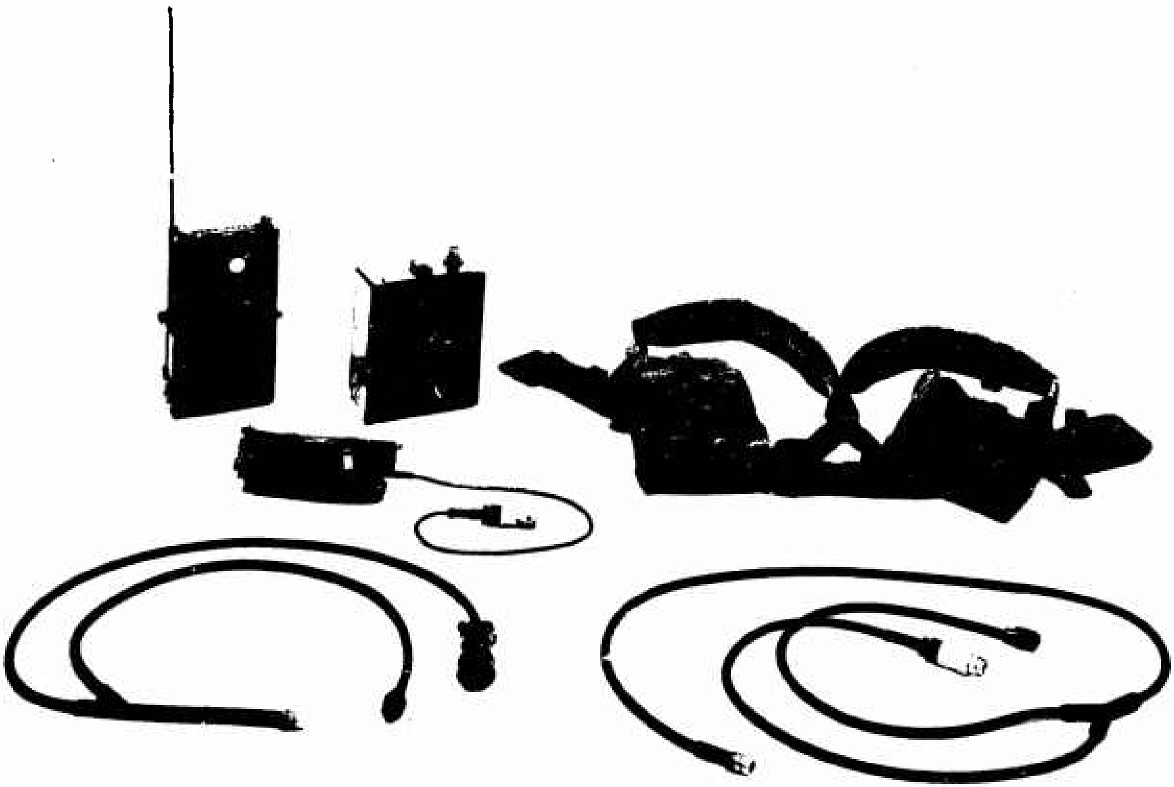


FIG. 2-5 AN/PRC-75 SYSTEM

Table 2-2 Performance Characteristics

CHARACTERISTICS	DESCRIPTION
	A. GENERAL
Frequency range	225 to 399.95 MHz
Number of channels	3500 spaced at 50 kHz intervals
Frequency selection	Thumb-operated dials with direct readout
Reselectability	Upon rechanneling the set will be within 1 part in 10^5 Hz of original frequency
Frequency stability	Within 1 part in 10^5 per day
Frequency accuracy	± 4 kHz on any channel within the operating frequency range
Duty cycle	9 minutes receive, 1 minute transmit
Primary input voltage	24 vdc from dry cell battery supply
Battery life	At least 10 hours operation on 9:1 duty cycle
	B. TRANSMITTER SECTION
RF power output	Not less than 1 watt on any individual channel (90% modulated with 1000 Hz tone) into antenna or equivalent load
Modulation	AM and MCW
Modulator capability	90% minimum at 1000 Hz sinusoidal audio tone
Spurious output	Harmonically related spurious output at least 40 db below transmitter output. Spurious radiation at least 60 db below transmitter output.
	C. RECEIVER SECTION
RF input impedance	50 ohms, nomiual
Sensitivity	4 microvolts (open circuit) at an rf signal modulated 30% at 1000 Hz for a minimum (S+N)/N ratio of 10 db and an audio output of not less than 10 milliwatts into a 500-ohm load.

Table 2-2 (Cont)

CHARACTERISTICS	DESCRIPTION
	C. RECEIVER SECTION (CONT)
Selectivity	3 db: minimum bandwidth 60 kHz. 30 db: minimum bandwidth 82 kHz. 60 db: minimum bandwidth 120 kHz.
Response to spurious signals:	
If. rejection	Attenuated at least 50 db below desired signal level.
Image rejection	Attenuated with other spurious responses to a level not greater than 60 db relative to the response of a 3 microvolt input signal.
AGC characteristics:	Output is maintained to within ± 3 db of nominal, for a signal input variation of 14 to 200,000 microvolts (open circuit).
Oscillator radiation:	Less than 500 picowatts.
	D. OUTPUT AUDIO
Audio output:	10 milliwatts into 400 ohms.
Audio distortion:	Total harmonic distortion does not exceed 15% of the rated audio output with an rf input signal of 1000 microvolts modulated 90%.
Narrow Band audio response:	Not more than +2, -6 db relative to 1000 Hz from 300 to 2700 H.
Wideband audio response:	Within ± 3 db from 300 Hz to 27 kHz using 18.5 kHz as reference.
Volume control:	Up to 50 db attenuation.

Battery (including case)

Height:	4.1 inches
Width:	6.5 inches
Depth:	1-3/4 inches
Weight:	3.3 pounds

It should be noted that item 5 Battery Extension Cable is not the same cable as previously called out for the AN/PRC-66 system.

2.2.3 Operational Description

2.2.3.1 Transceiver Unit

2.2.3.1.1 General

A photograph of the transceiver unit is shown in Figure 2-5A. All operating controls are contained on the single control panel of the transceiver unit. Selection of any one of the 3500 communication channels is accomplished by the rotation of one or more of the three frequency controls on the panel. The frequency to which the transceiver is tuned is automatically displayed. Also included on the control panel is a volume control and a function switch.

The transceiver and battery pack are joined by the use of an interconnecting cable provided as part of the equipment.

The transceiver is constructed on a modular basis, consisting of a main chassis (1A1) (with control head and voltage regulator module) that accepts the following plug-in modules (refer to Figure 2-6):-

1. Frequency Synthesizer (1A3)
2. IF/Audio (1A4)
3. RF Modulator (1A5)

Details of the individual modules will be presented in Section 4 of this report.

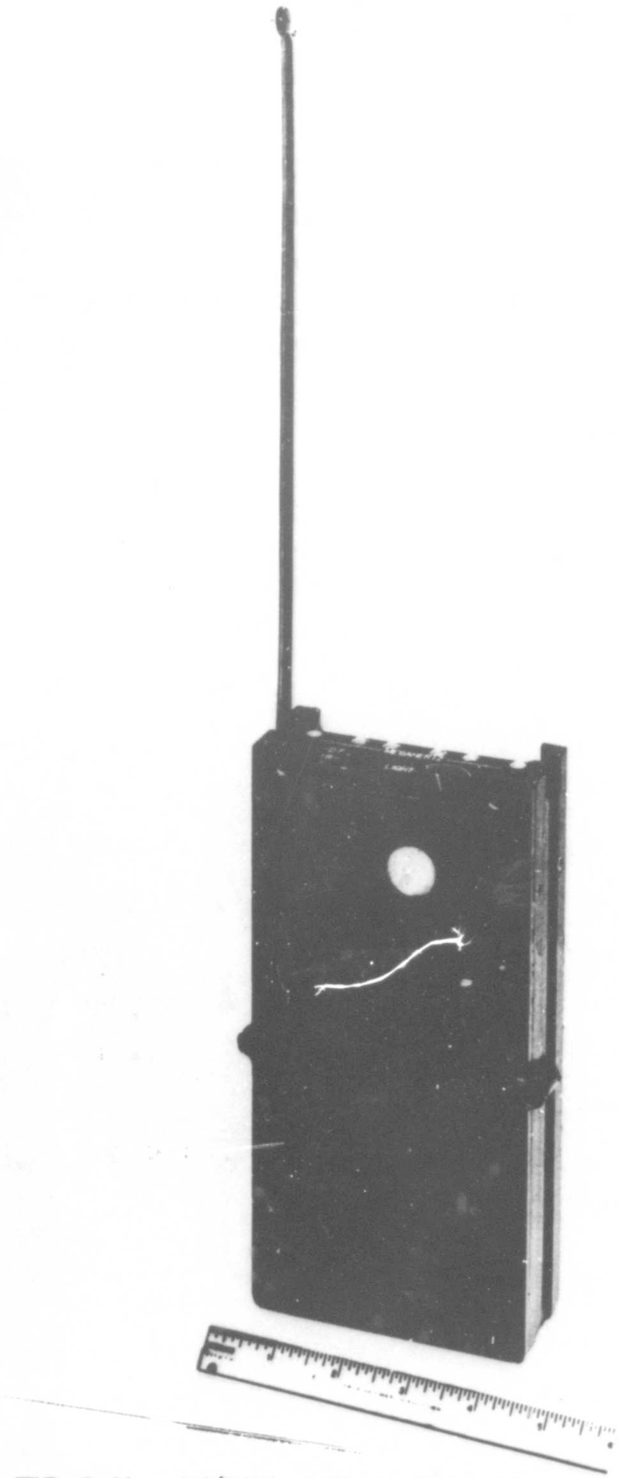
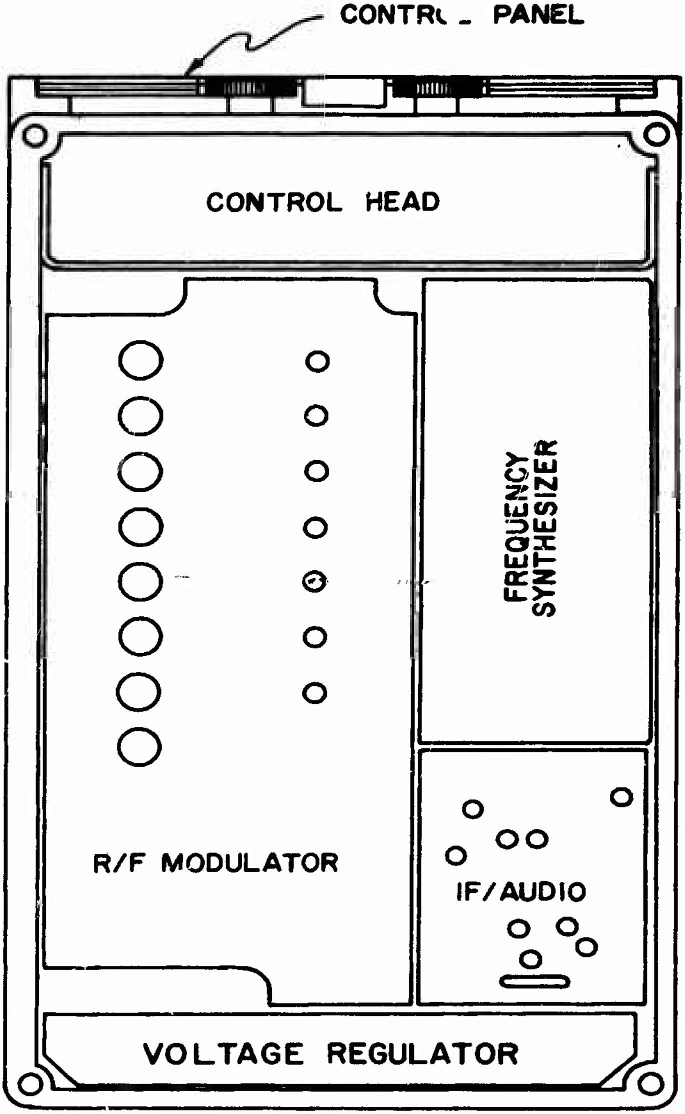


FIG. 2-5A AN/PRC-75(XN-1) TRANSCEIVER



PRC 75 TRANSCEIVER
LAYOUT, COVER REMOVED

FIG. 2-6

The transceiver has been designed using only solid state devices. Furthermore, the majority of all active devices are of the silicon monolithic integrated circuit type or in the thin film hybrid circuit form.

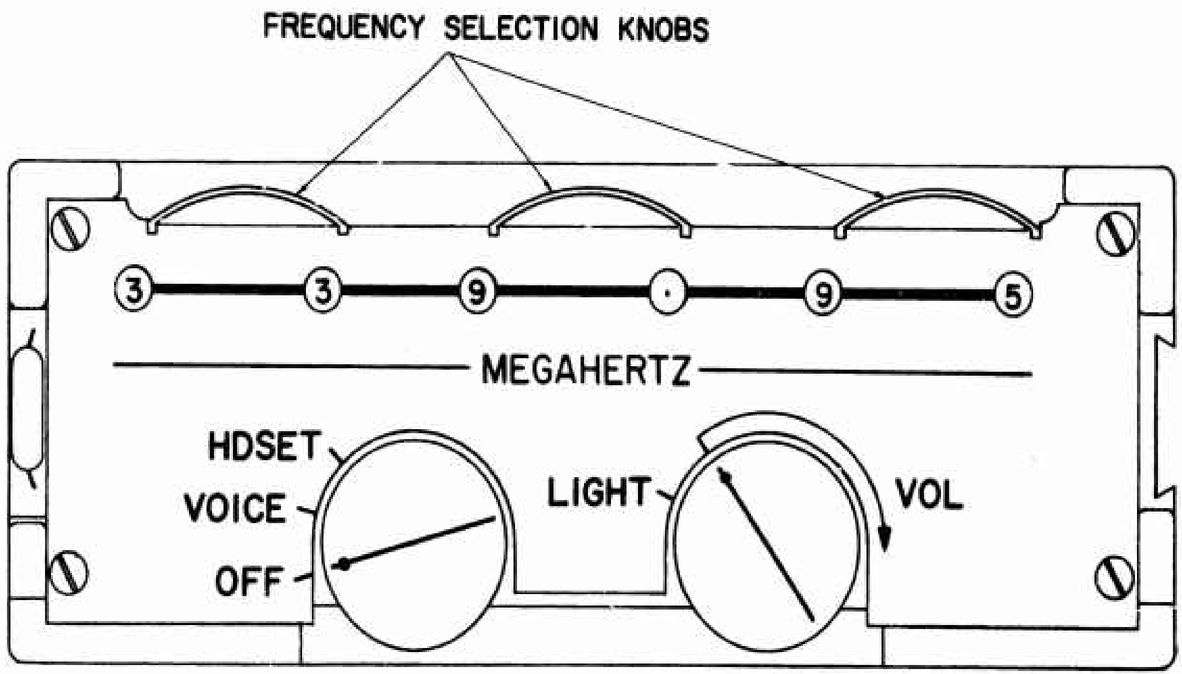
2.2.3.1.2 Control Panel

The control panel layout of the transceiver is shown in Figure 2-7. All controls of the transceiver unit are accessible externally and are located on this panel.

(a) Frequency Selection

Frequency selection is accomplished by rotation of the three frequency controls on the control panel. Two functions, mechanical and electrical are performed by these controls within the transceiver. These functions are to mechanically position the RF tuners within the RF amplifier/modulator module, and electrically provide the properly coded frequency control logic information to the frequency synthesizer module. Mechanical positioning of the RF tuning is performed by a simple gearing mechanism, whereas coded information for the frequency synthesizer module is furnished by a set of switch contacts actuated by the position of the control knobs.

The positions of the frequency selector controls are maintained by detents included in the gearing mechanism. These detents also include stops so that under conditions of darkness the operator can count detent positions from the stop to select the desired frequency.



AN/PRC 75(XN-1) CONTROL PANEL LAYOUT

FIG. 2-7

(b) Function Switch

The function switch has the following described positions:-

OFF: This position disconnects battery power from the transceiver.

VOICE: This position provides transmit-receive operation of the transceiver, with the integral audio transducer used as microphone and loudspeaker.

HEADSET: This position provides transmit-receiver operation using the audio transducer as microphone only (loudspeaker function disabled). Audio output is made available for headset operation.

(c) Volume Control

The volume control enables the operator to control the level of the audio output signal. The volume control has a "LIGHT" position for momentary illumination of the frequency readout when required by the operator.

2.2.3.2 Antenna

A flexible "tape" antenna forms part of the equipment and is mounted directly on the transceiver unit. This antenna was developed specifically for use in the AN/PRC-75 system. When not in use, the antenna is storable by folding it across the top and down into a slot on the opposite side of the transceiver case.

2.2.3.3 Battery

The battery unit of the AN/PRC-75 is a dry alkaline expendable type battery. The design goal has been a battery capable of operating the transceiver for at least 12 hours continuously on a duty cycle of 9 minutes receive and 1 minute transmit. A re-useable case is provided to house the battery.

2.2.3.4 Interconnection Cable

This cable provides interconnection between battery and transceiver unit. The battery is retained in the carrying harness while the transceiver is relatively free, and lightweight, for hand-held operation. The cable also incorporates a "T" junction section to which the operator's headset may be connected. The extension cable incorporates connectors that will disengage before cable failure in the event the cable is subjected to unexpected excessive strain.

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3.0 PERFORMANCE CHARACTERISTICS - STANDARD CONDITIONS

The AN/PRC-66 and AN/PRC-75 have undergone acceptance testing under both standard and environmental conditions. This section covers performance under standard conditions. Environmental testing is covered in Section 5 of this report.

The data presented in the following tables of this section was obtained at normal room temperature, pressure, humidity and a nominal power source voltage of 24.0 volts dc. The tables present a summary comparison of equipment specifications with performance achieved. Following the tables are figures showing overall radio performance with respect to such parameters as:-

RECEIVER:	Sensitivity (Figs. 3-1 and 3.2)
	IF Selectivity (Fig. 3-3)
	Cross Modulation (Figs. 3-4 and 3-5)
	AGC Characteristics (Fig. 3-6)
	Audio Fidelity (Fig. 3-7)
	Power Consumption (Figs. 3-14 and 3-15)
TRANSMITTER:	Power Output (Fig. 3-8 and 3-9)
	Modulation Percentage (Figs. 3-10 and 3-11)
	Modulation Fidelity (Figs. 3-12 and 3-13)
	Power Consumption (Figs. 3-14 and 3-15)

TABLE I

STANDARD CONDITIONS

RECEIVER PERFORMANCE

	PRC-66 SPECIFICATION RADC-5137A	PRC-66 PERFORMANCE	PRC-75 SPECIFICATION USMC PD CSY-FY64-12	PRC-75 PERFORMANCE
SENSITIVITY	Not more than 3.0 microvolts (closed circuit) for 10 db (S + N)/N ratio - 30% mod. at 1000 cps	Minimum 0.9 microvolts Maximum 2.2 microvolts (closed circuit)	Same as PRC-66	Minimum 0.8 microvolts Maximum 2.2 microvolts Audio output greater than 10 milliwatts
AUDIO OUTPUT	Not less than 10 milliwatts into 500 ohms	10 milliwatts minimum into 500 ohm load	At an axial distance of one foot, an audio intensity of 50 db above 10^{-16} watts/centimeter^2 with a 5 microvolt signal modulated 90% at 1000 cps. With a 3 microvolt signal the audio transducer shall deliver a minimum audio intensity of 40 db above 10^{-16} watts/centimeter^2.	With 3 or 5 microvolt signals 59 to 63 db above 10^{-16} watts per square centimeter. Room ambient noise level was 50 - 55 db above 10^{-16} watts per square centimeter. Audio output into 500 ohm load exceeded 10 milliwatts at 10 db (S + N)/N ratio with 30% modulation.
AUTOMATIC GAIN CONTROL	The receiver output shall vary no more than 3 db with signal input variation from 5 to 100.000 microvolts.	Less than 2 db variation	Same as PRC-66	Less than 2 db variation
IMAGE AND OTHER SPURIOUS REJECTION	Not less than 60 db	More than 60 db	At least 50 db at the IF frequency and at least 60 db for images and other spurious signals.	Greater than 100 db at IF frequency Image 74 db down at 225 MHz 52 db down at 312 MHz and higher

TABLE I (Cont.)

STANDARD CONDITIONS

RECEIVER PERFORMANCE

	PRC-66 SPECIFICATION RADC-5137A	PRC-66 PERFORMANCE	PRC-75 SPECIFICATION USMC PD CSY-FY64-12	PRC-75 PERFORMANCE
RECEIVER SELECTIVITY	40 kHz minimum at 6 db 75 kHz maximum at 60 db	As measured through receiver front end: Average 44.5 kHz at 6 db points Average more than 75 kHz at 60 db points as much as 110 kHz 64 kHz at 50 db points As measured through receiver IF: 6 db bandwidth 44.05 KC 60 db bandwidth 71.4 KC See Figure 3-3	Same as PRC-66	As measured through receiver front end: Average 42 kHz at 6 db From 111 kHz to 164 kHz at 60 db From 69 kHz to 89 kHz at 50 db As measured through receiver IF: Same as for PRC-66 See Figure 3-3
AUDIO DISTORTION	Not specified	Average 12.0%	With an RF input signal of 1000 microvolts and modulation set to the threshold of clipping, distortion shall not exceed 10% when measured across a 500 ohm resistive load and at a minimum power level of 10 milliwatts	Between 10 and 12.5% distortion
AUDIO FIDELITY	Not specified	Less than ±6 db from 300 to 2700 cps	Using a resistive 500 ohm load, not more than ±6 db relative to response at 1000 Hz from 300 to 2700 Hz	Worst Case: From 2.0 db at 300 cps to -6.4 db at 2700 cps Average: From +1.25 db at 300 cps to -5.55 db at 2700 cps

TABLE I (Cont.)

STANDARD CONDITIONS

RECEIVER PERFORMANCE

	PRC-66 SPECIFICATION RADC-5137A	PRC-66 PERFORMANCE	PRC-75 SPECIFICATION USMC PD CSY-FY64-12	PRC-75 PERFORMANCE
FREQUENCY ACCURACY	Better than 1 part in 10^5 per day and within 4 kHz of indicated frequency	Frequency accuracy within 4 kHz of indicated frequency	Same as PRC-66	Frequency accuracy within 4 kHz of indicated frequency
POWER INPUT	Not specified	Squelch radio 5.5 watts Radio without squelch 5.05 watts over a 9:1 duty cycle	Not more than 5.8 watts	5.31 watts
SQUELCH QUIETING	Not less than 30 db below audio output with a 3 microvolt (closed circuit) signal modulated 30% at 1000 Hz	From 54 to 57 db	Not applicable	
SQUELCH OVERLAP	Ratio between RF voltage required to unsquelch the receiver output and the RF voltage at which the output is again squelched shall not exceed 6 db	From 1 to 2 db	Not applicable	

TABLE II

STANDARD CONDITIONS

TRANSMIT PERFORMANCE

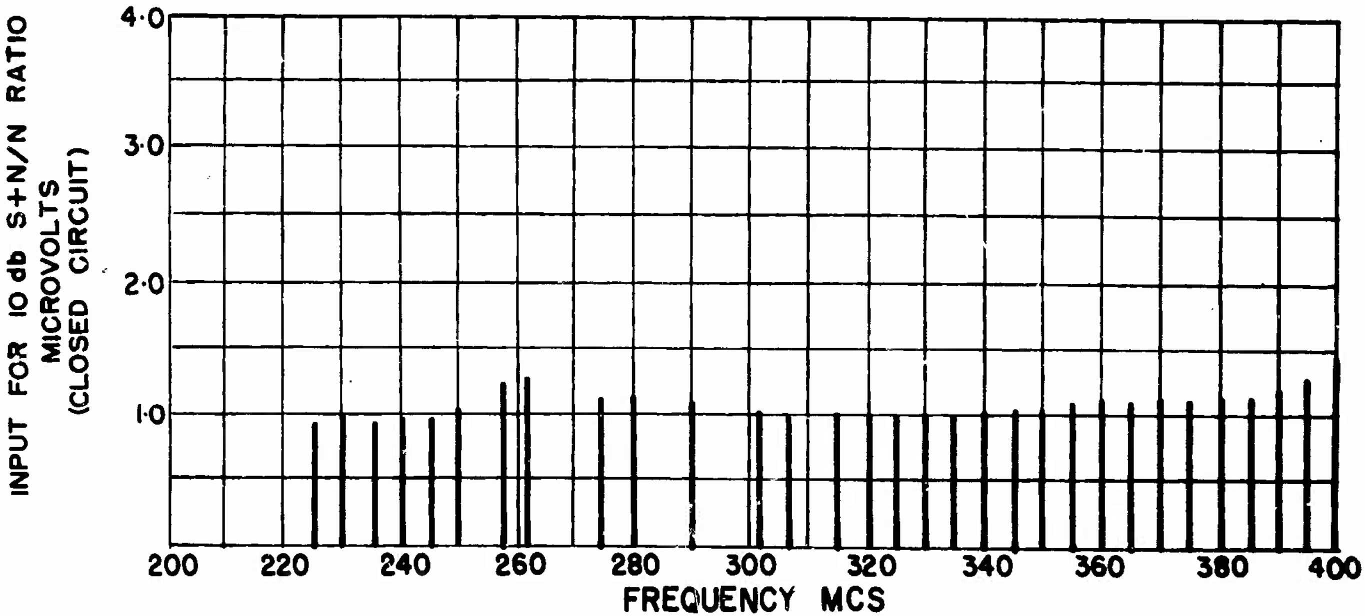
	PRC-66 SPECIFICATION RADC-5137A	PRC-66 PERFORMANCE	PRC-75 SPECIFICATION USMC PD CSY-FY64-12	PRC-75 PERFORMANCE
POWER OUTPUT	Not less than 2 watts average power (90% modulated at 1000 Hz)	Greater than 2 watts	Not less than 1.0 watt average power (90% modulated at 1000 Hz)	Greater than 1.0 watt
MODULATION FIDELITY	From 300 Hz to 2700 Hz the audio frequency response shall vary no more than ±6 db from the response at 1000 Hz	Less than ±6 db from 300 - 2700 cps	Same as PRC-66	Less than ±6 db
SPURIOUS OUTPUT	Harmonics of operating frequency shall be at least 40 db below carrier output at operating frequency. All other spurious shall be attenuated at least 60 db	Harmonically related spurious greater than 40 db. All others greater than 60 db.	Same as PRC-66	Radiated spurious 2nd harmonic 23 db down 3rd harmonic 31 db in 3 channels across band 5 close-in spurious less than 60 db. Poorest was 49.5 db
MODULATION CAPABILITY	The modulator section of the transmitter shall modulate the RF signal at least 90% over the entire RF range.	More than 90%	The modulator section of the transmitter shall modulate the carrier at least 30% with a 1000 Hz audio input level of 65 db above 10^{-16} watts/centimeter^2. 90% modulation shall be maintained over a wide range of audio input levels.	Modulation level varied between 27 and 33% over the operating RF frequency range. Modulator is capable of greater than 90% modulation.

TABLE II (Cont.)

STANDARD CONDITIONS

TRANSMIT PERFORMANCE

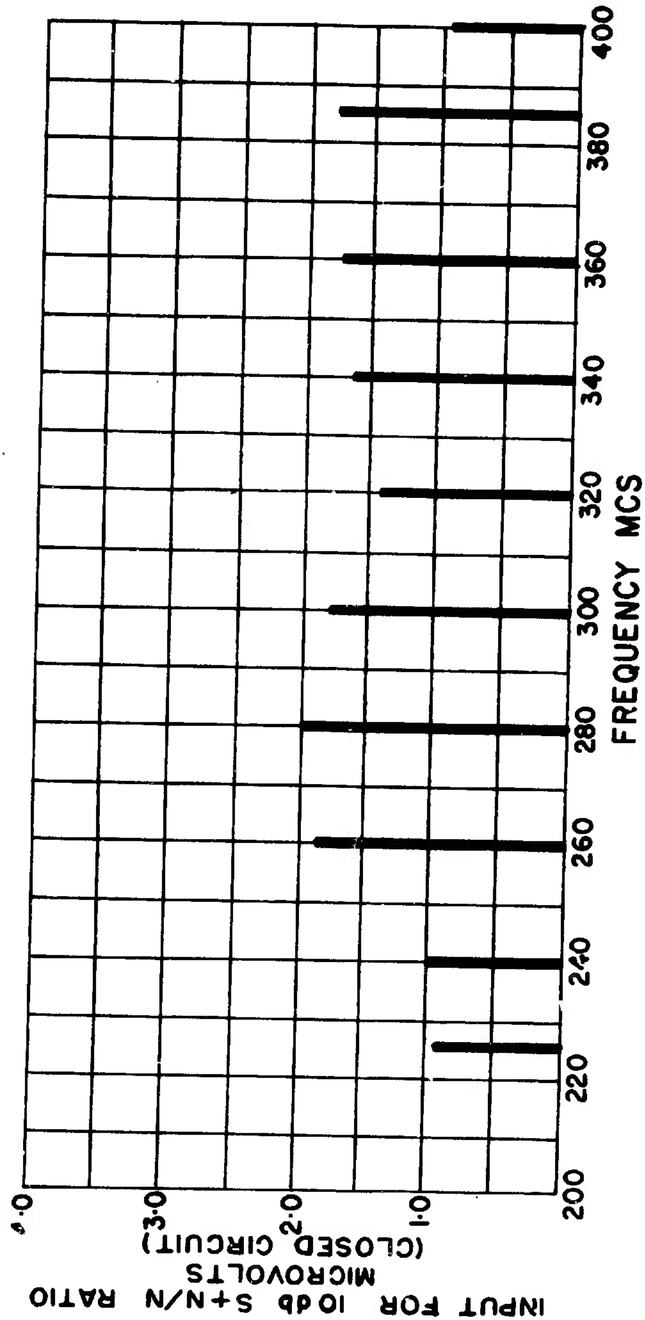
	PRC-66 SPECIFICATION RADC-5137A	PRC-66 PERFORMANCE	PRC-75 SPECIFICATION USMC PD CSY-FY64-12	PRC-75 PERFORMANCE
ENVELOPE DISTORITON	Not more than 10% at any frequency in the 300 Hz to 2700 Hz range	Less than 10% 300 - 2700 cps	Same as PRC-66	Less than 10%
NOISE LEVEL	At least 40 db down at 90% modulation	Greater than 40 db at 90% modulation	Not specified	38 db
FREQUENCY STABILITY AND ACCURACY	Better than 1 part in 10^5 per day and within 4 kHz of indicated frequency	Frequency stability better than 0.08 parts in 10^5 over a 2 hour test period. Frequency accuracy within 4 kHz of nominal.	Same as PRC-66	Frequency stability better than 0.22 parts in 10^5 over a 2 hour test period Frequency accuracy within 4 kHz of nominal.



PRC-66

SENSITIVITY VS FREQUENCY

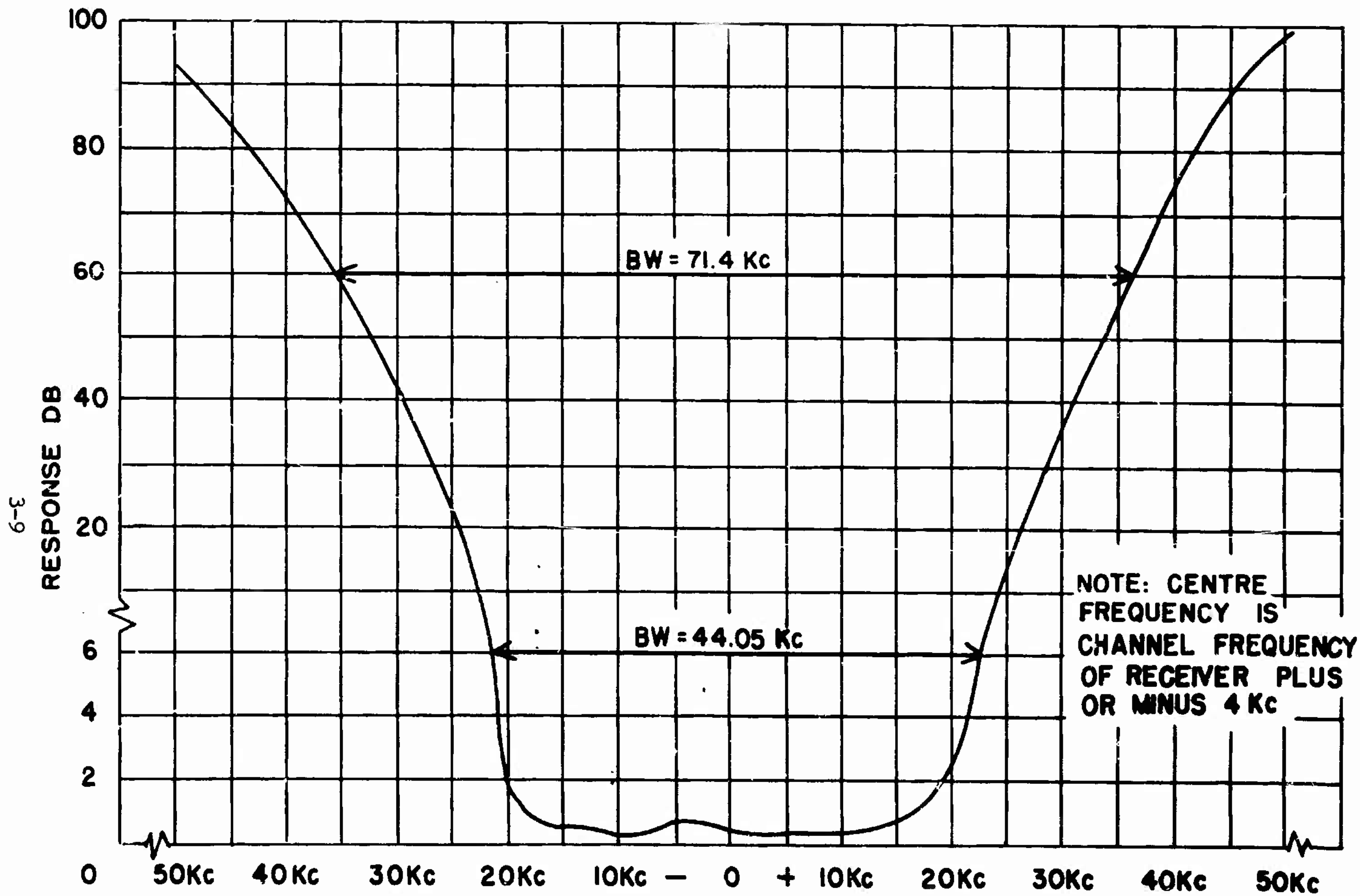
FIG 3-1



PRC-75

SENSITIVITY vs FREQUENCY

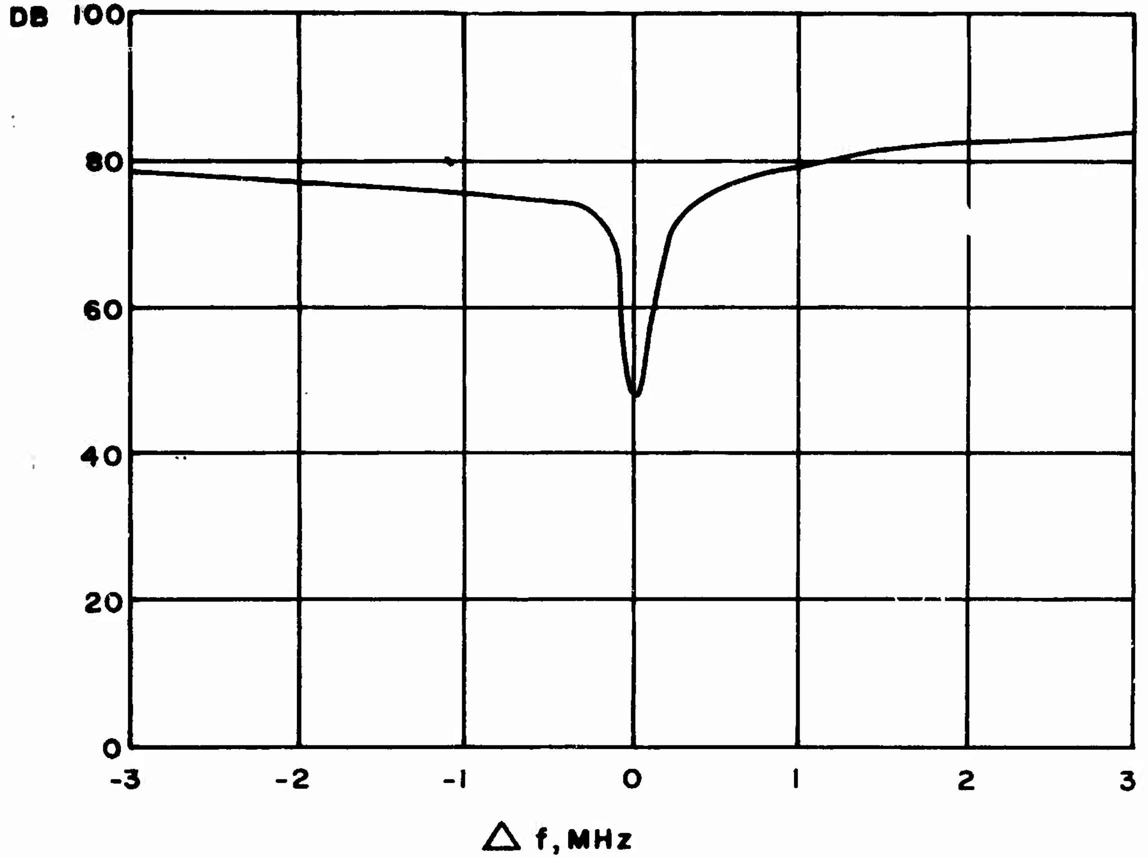
FIG. 3-2



PRC 66 AND PRC 75

RECEIVER IF SELECTIVITY

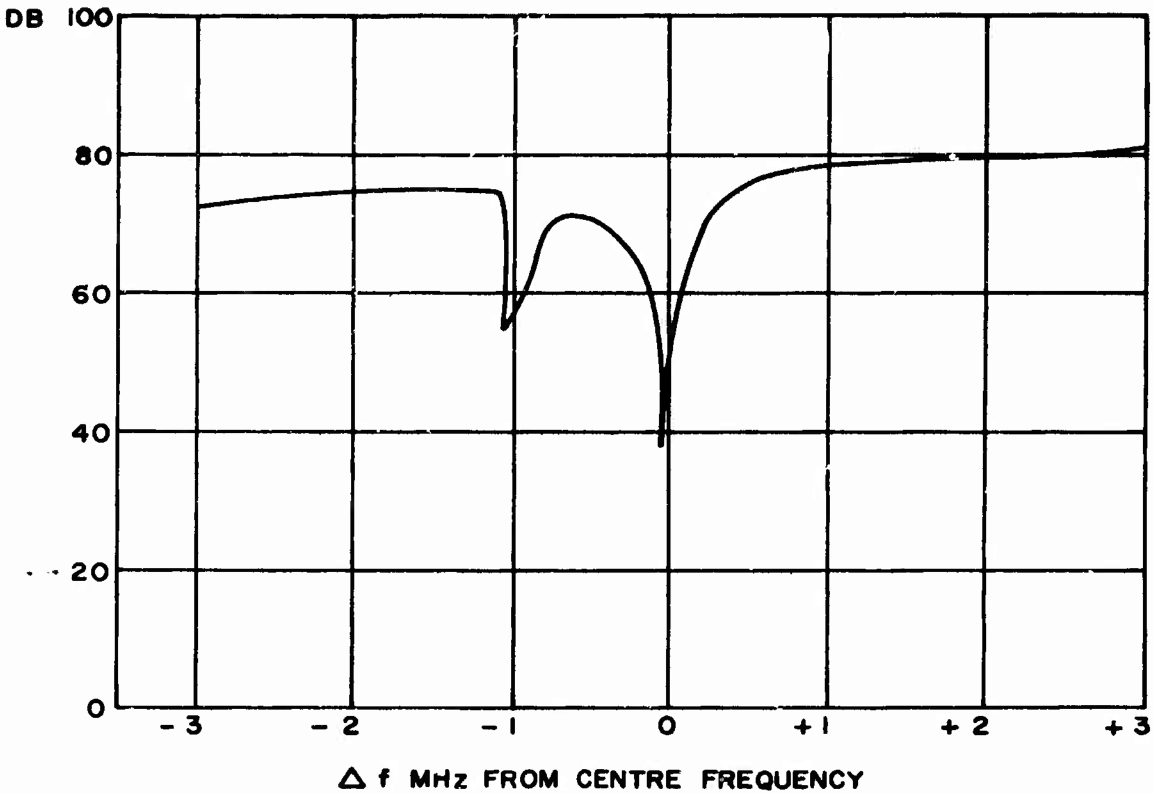
FIG. 3-3



NOTE: CURVE REPRESENTS LEVEL ABOVE DESIRED SIGNAL REFERENCE AT WHICH UNDESIRED SIGNAL DEGRADES $\frac{S+N}{N}$ RATIO FROM 10 DB TO 6 DB

AN/PRC-66 CROSS MODULATION CHARACTERISTICS

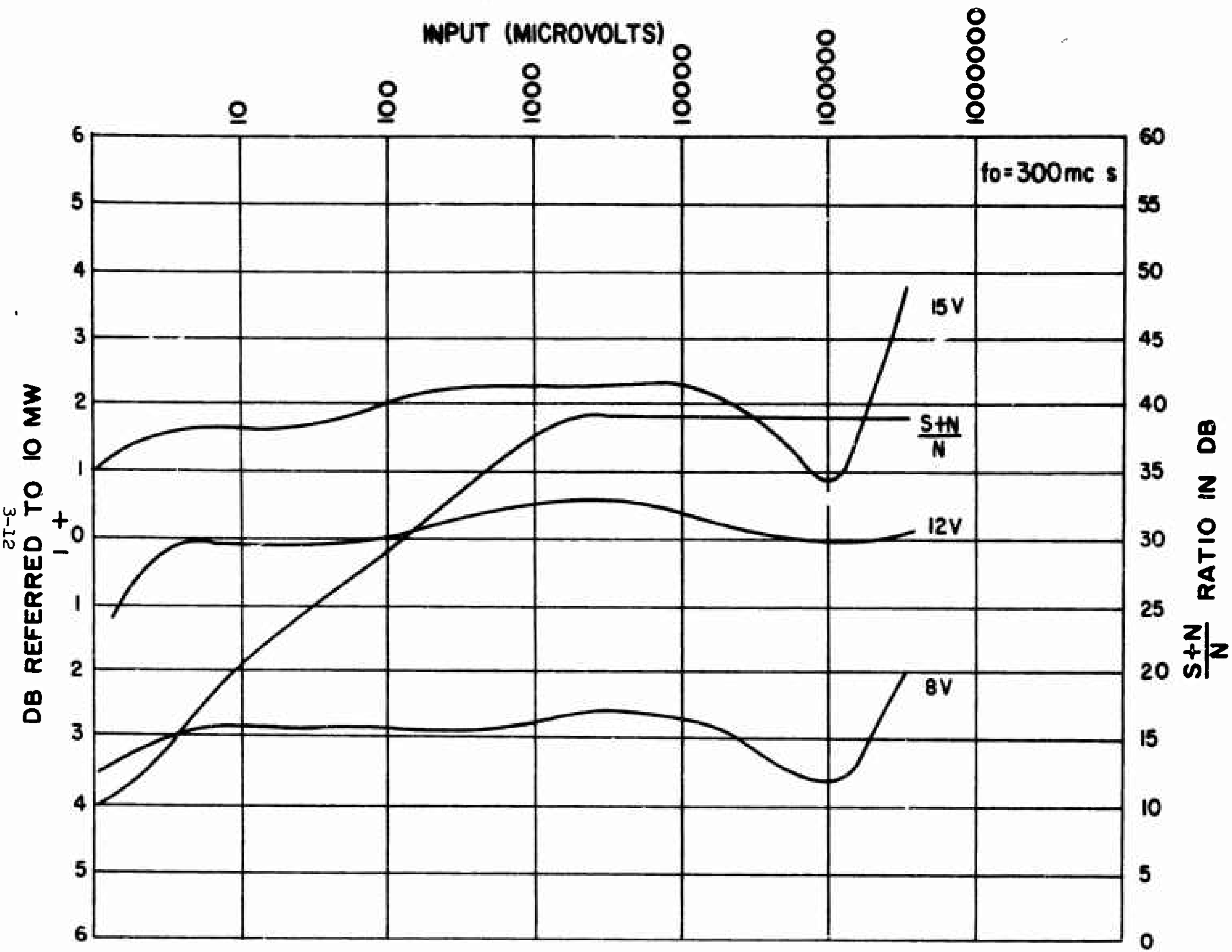
FIG. 3-4



NOTE: CURVE REPRESENTS LEVEL ABOVE DESIRED SIGNAL REFERENCE AT WHICH UNDESIRED SIGNAL DEGRADES $\frac{S+N}{N}$ RATIO FROM 10 DB TO 6 DB

AN/PRC-75 CROSS MODULATION CHARACTERISTICS

FIG. 3-5



PRC-66 AND PRC-75 RECEIVER AGC CHARACTERISTICS

FIG. 3-6

PRC-66 AND PRC-75

RECEIVER AUDIO FIDELITY

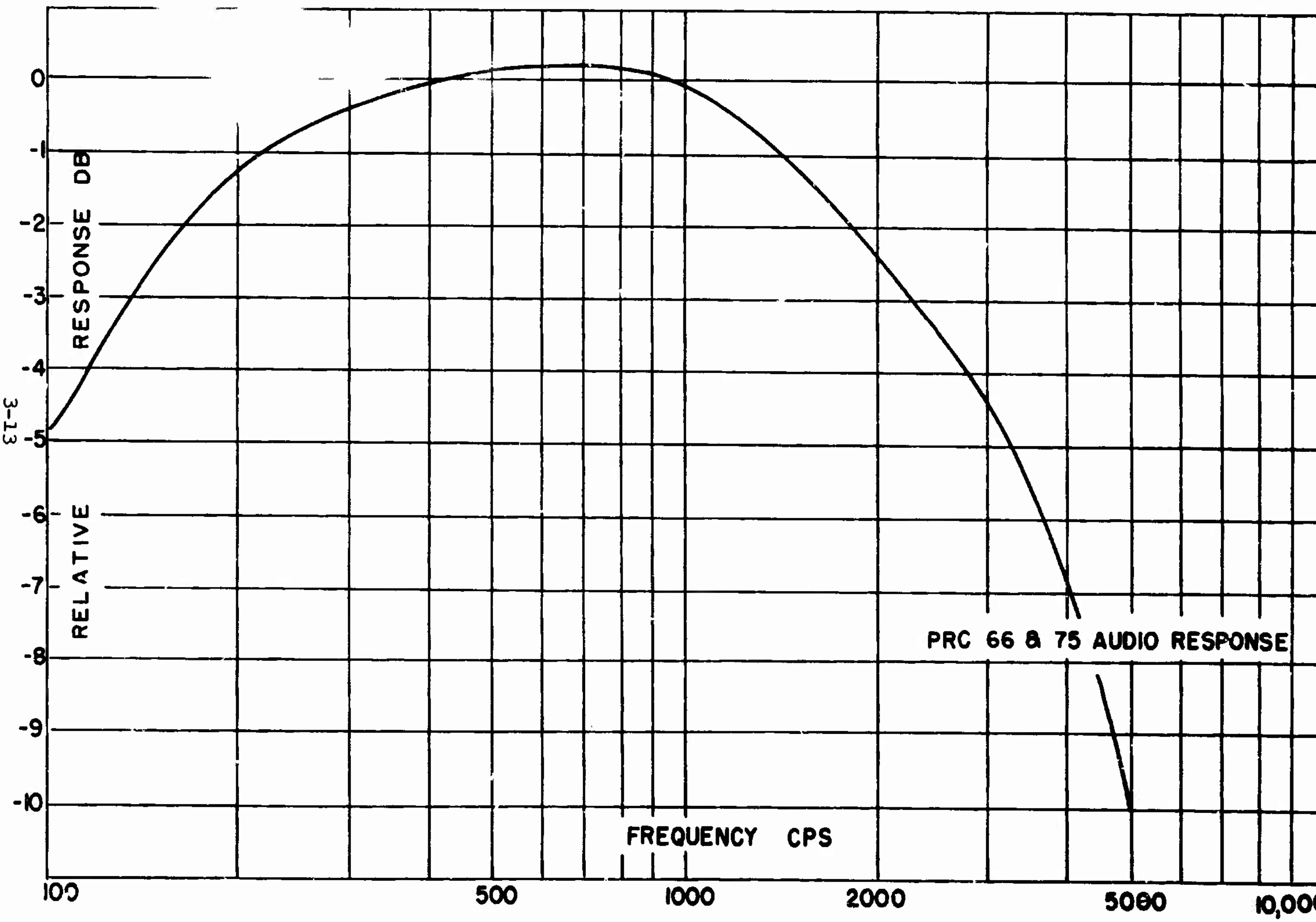
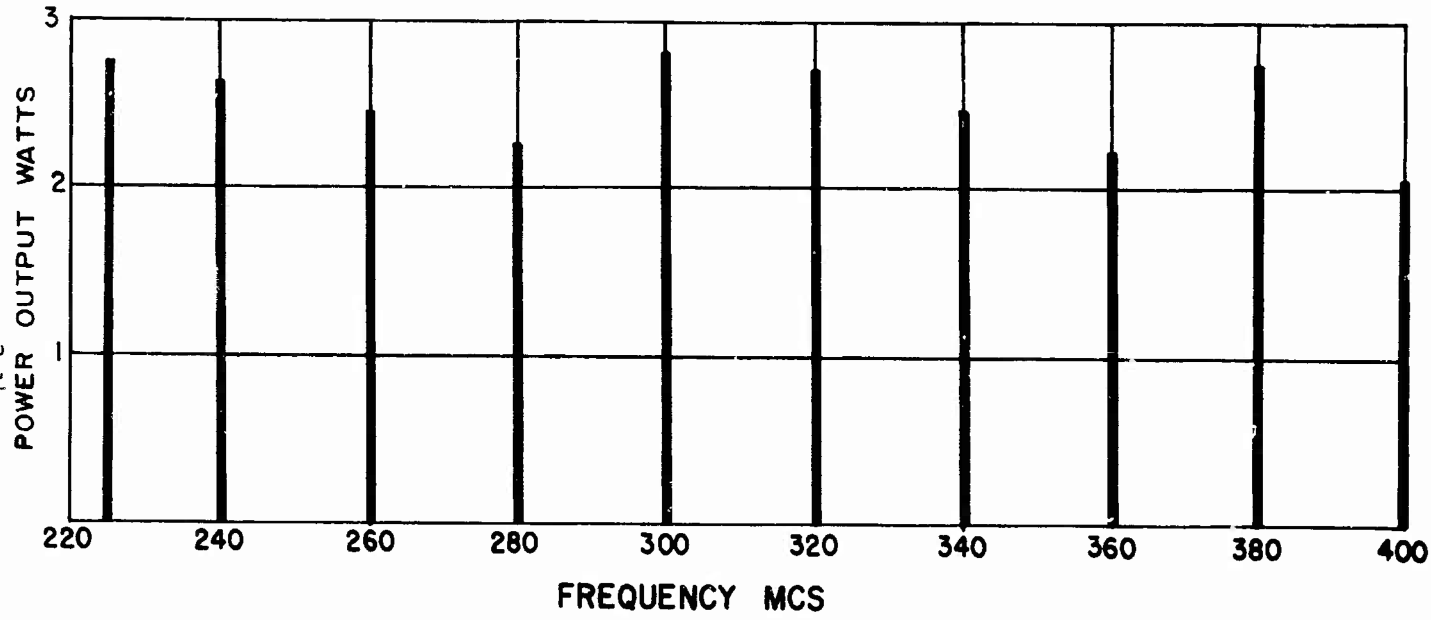


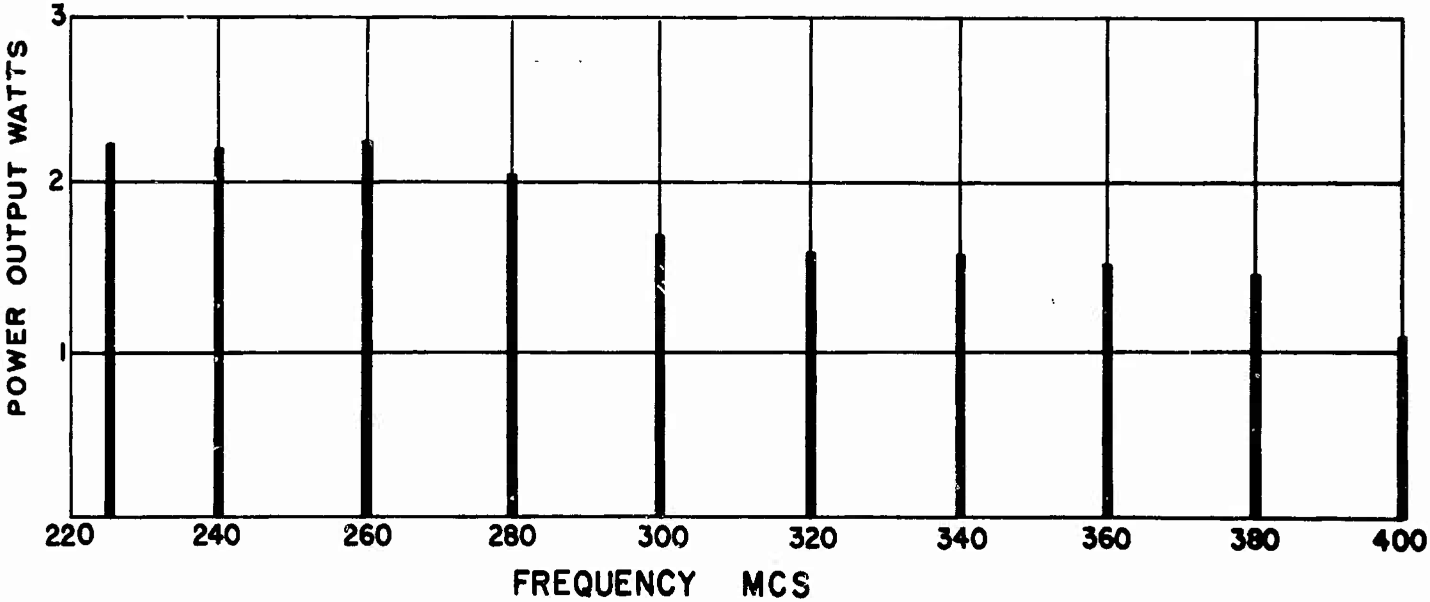
FIG.3-7



PRC-66

TRANSMITTER POWER OUTPUT vs FREQUENCY

FIG 3-8



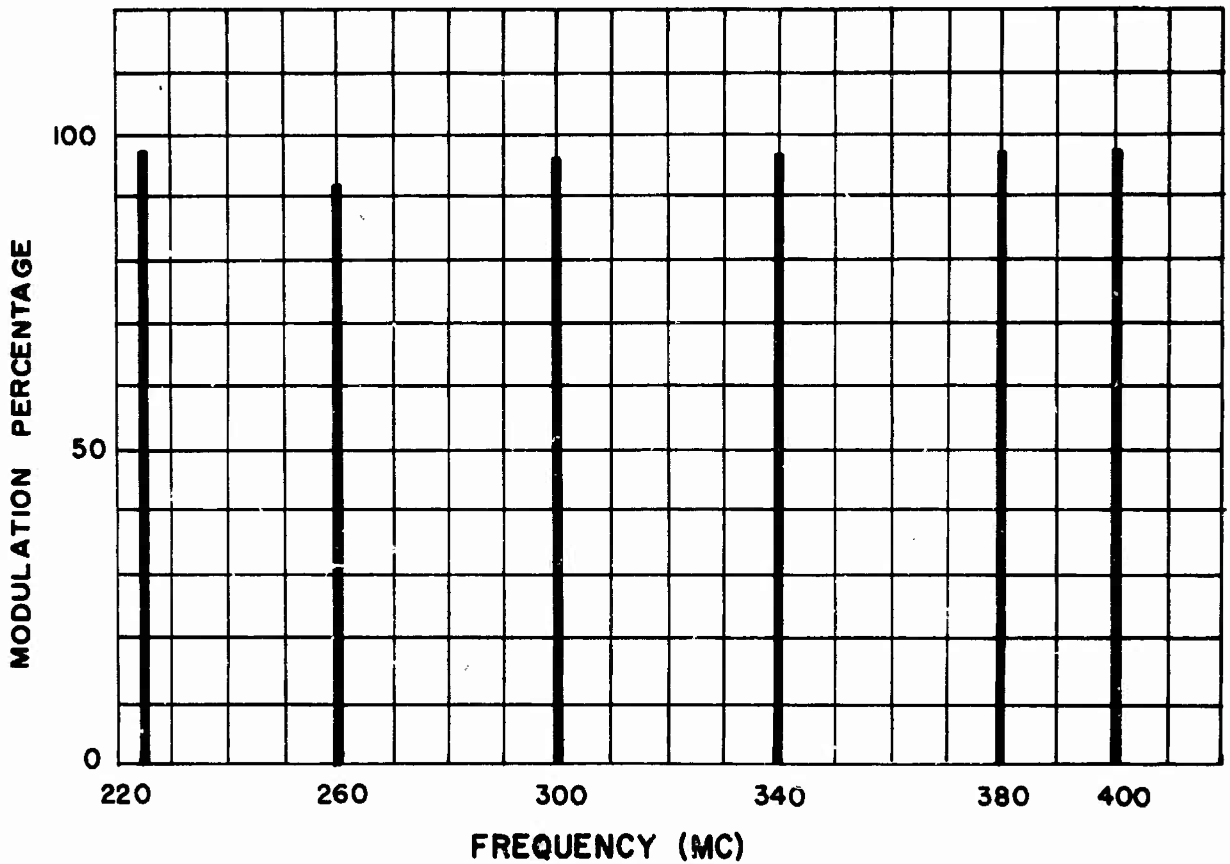
PRC-75

TRANSMITTER POWER OUTPUT vs FREQUENCY

FIG. 3-9

PRC-66

MODULATION PERCENTAGE FOR
CONSTANT INPUT INTO MODULATOR



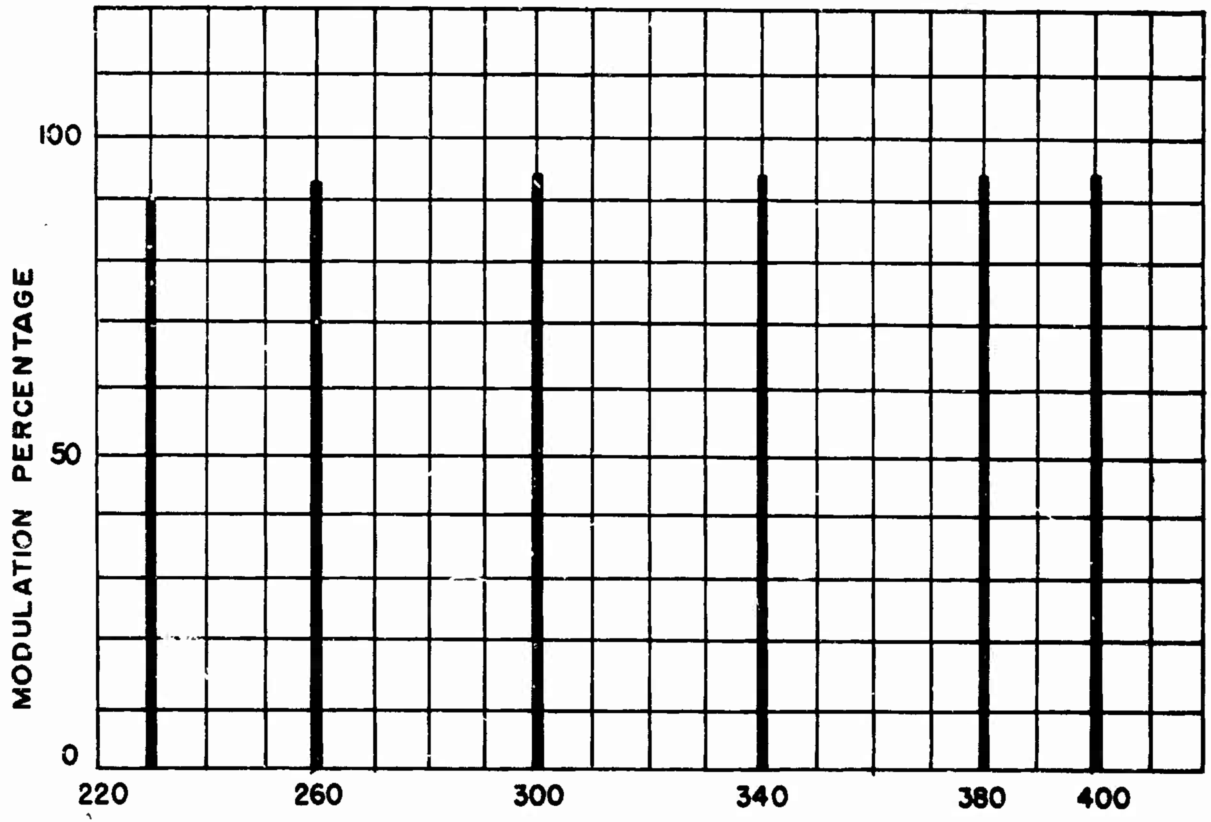
INPUT LEVEL INTO MICROPHONE

PREAMP = 1000 Microvolts

FIG 3-10

PRC-75

MODULATION PERCENTAGE FOR
CONSTANT INPUT INTO MODULATOR



INPUT 1000 Microvolts

FIG. 3-11

PRC-66

TRANSMITTER MODULATION FIDELITY

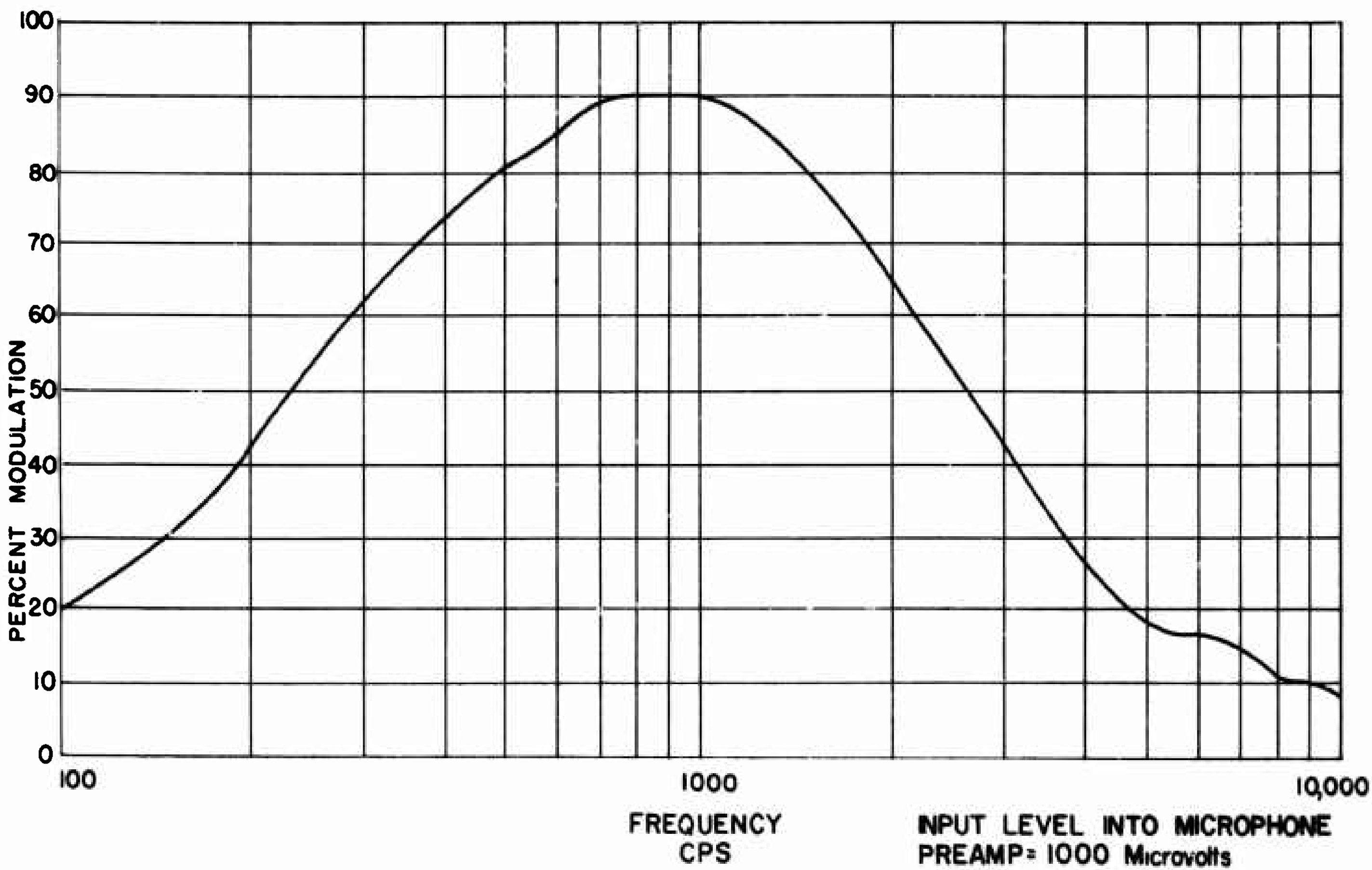


FIG. 3-12

TRANSMITTER MODULATION FIDELITY PRC-75

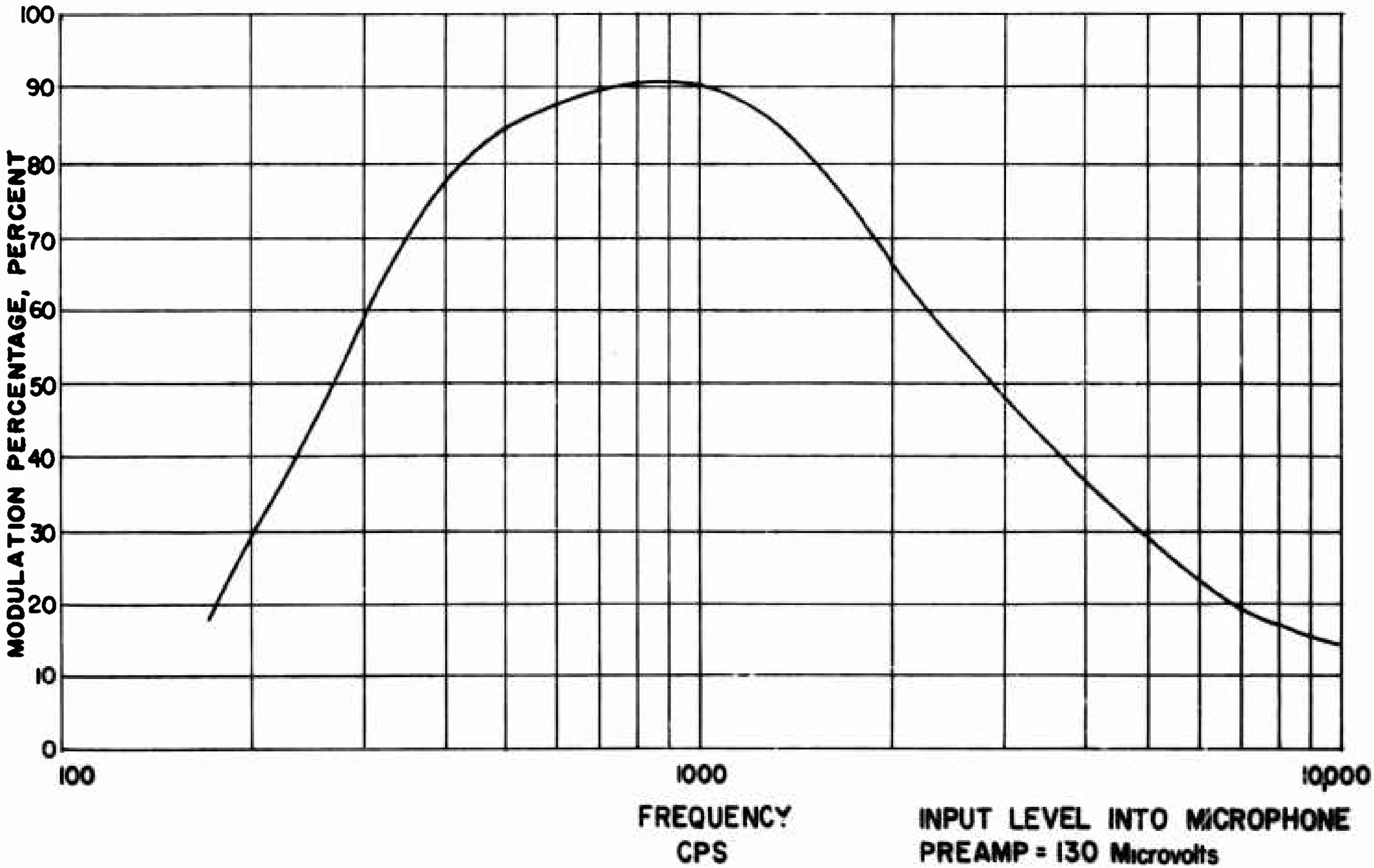


FIG. 3-13

PRC-66

DC POWER CONSUMPTION

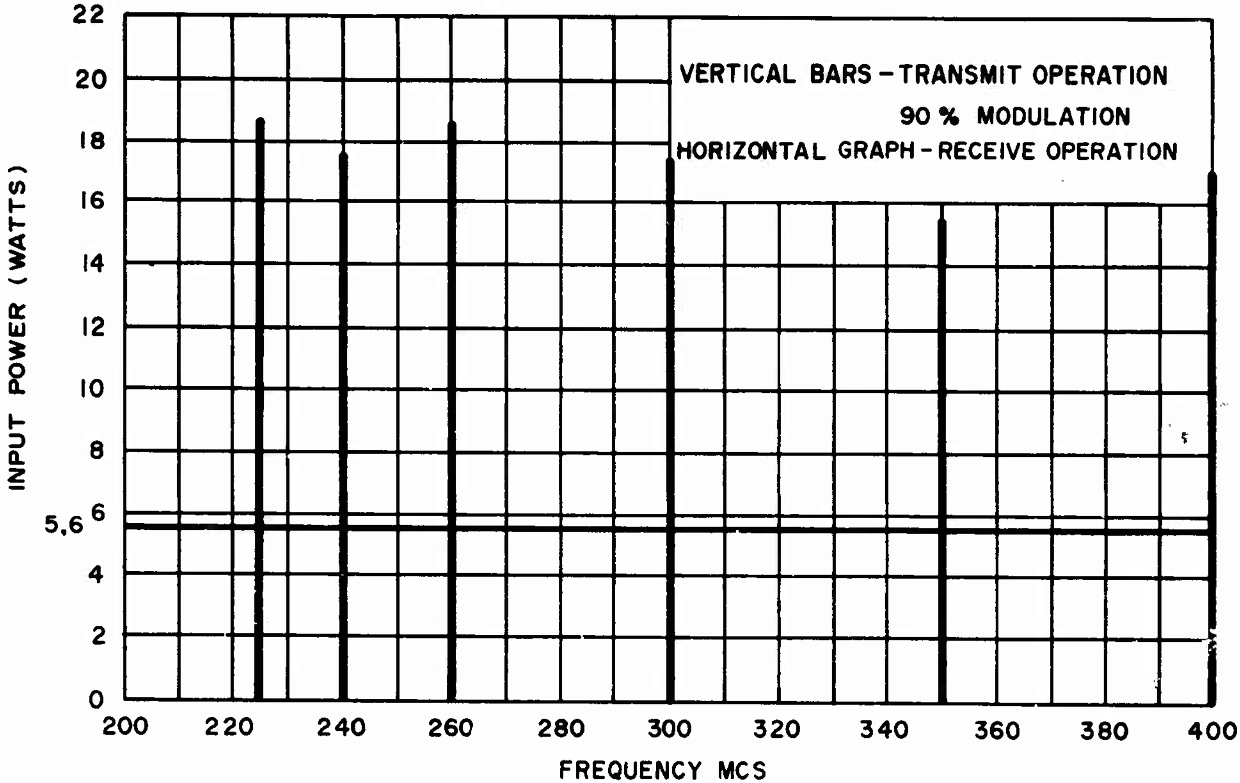


FIG. 3-14

PRC-75

DC POWER CONSUMPTION

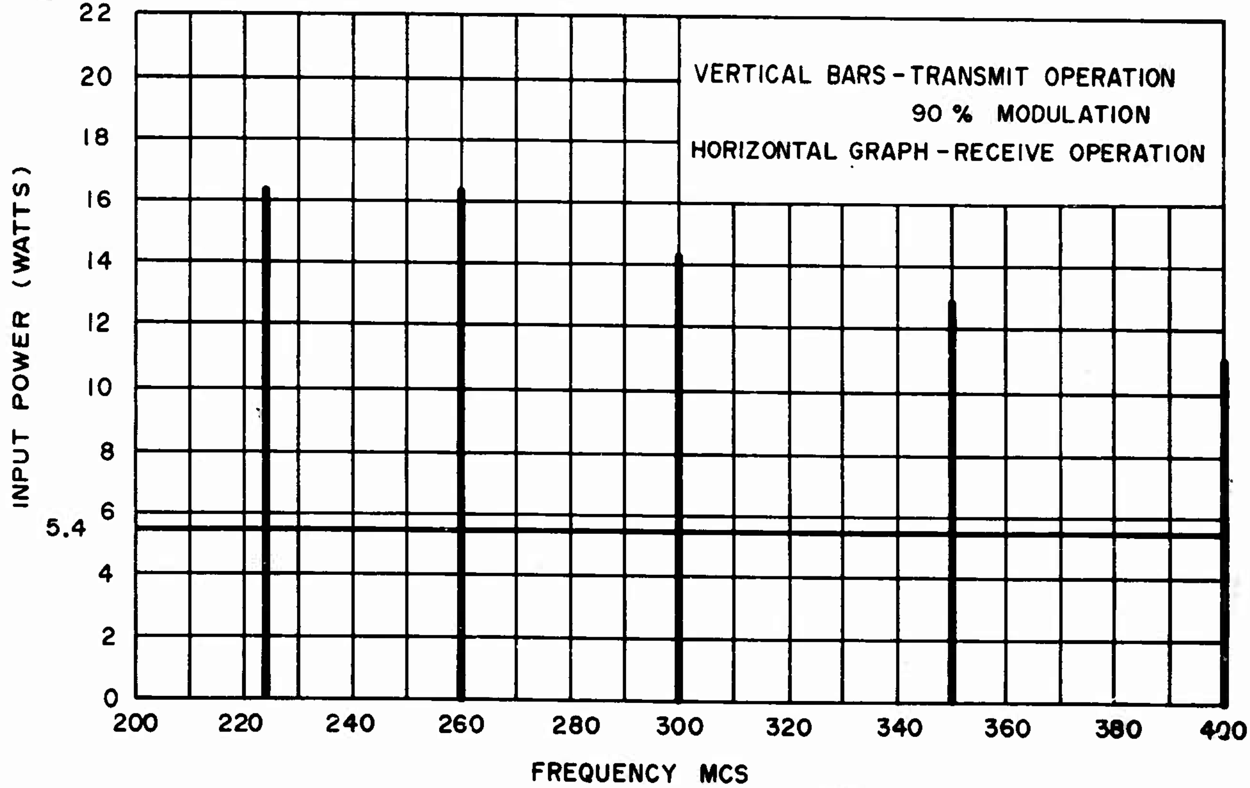


FIG 3-15

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4.0 DETAILED DESIGN DESCRIPTION

4.1 GENERAL

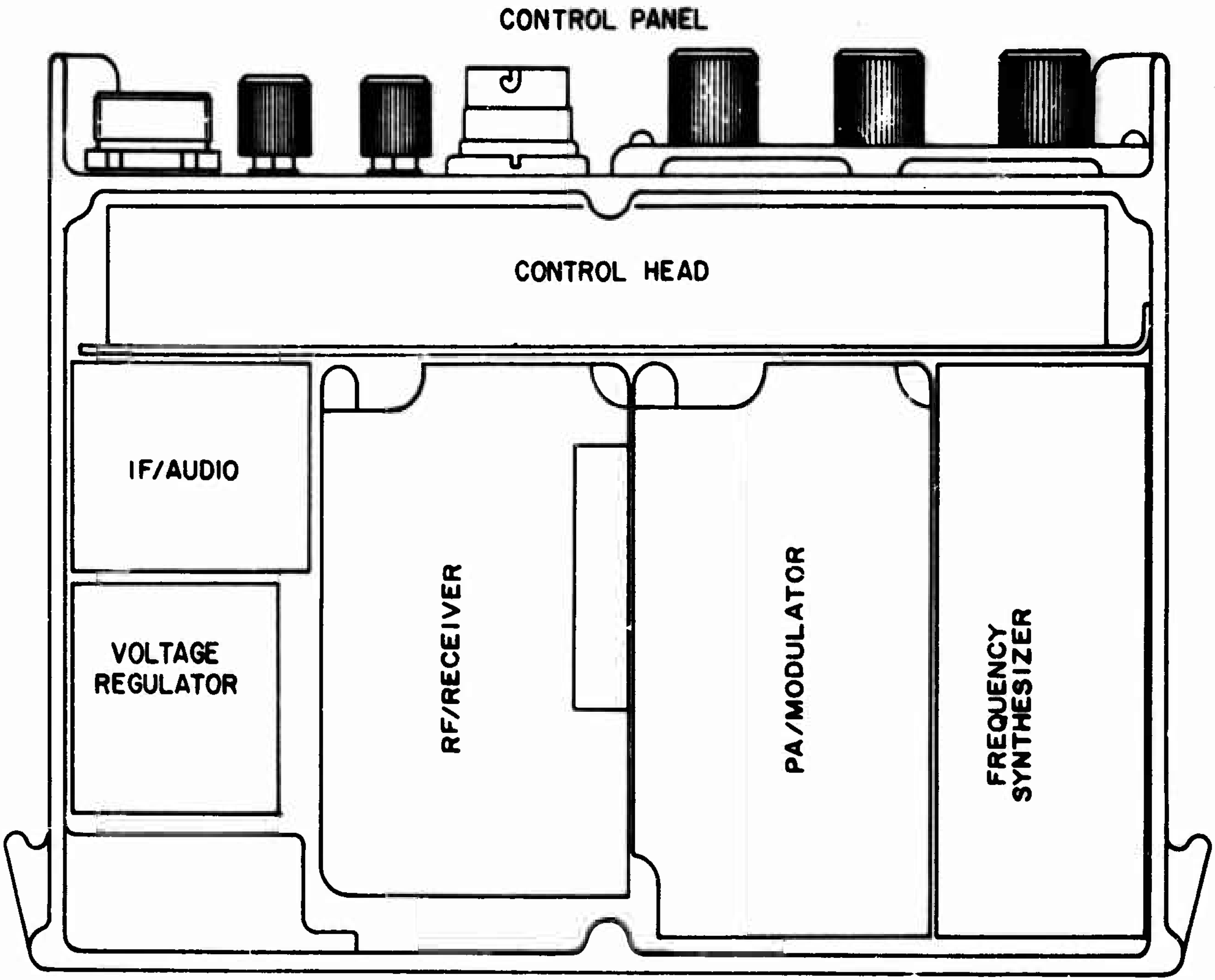
Mechanical and electrical design is covered in detail in this section. Construction techniques, human factors and other mechanical considerations are discussed in paragraph 4.2. Circuit design, module performance, component selection, and other electrical considerations are discussed in paragraph 4.3.

4.2 MECHANICAL DESIGN

4.2.1 PRC-66 Mechanical Design

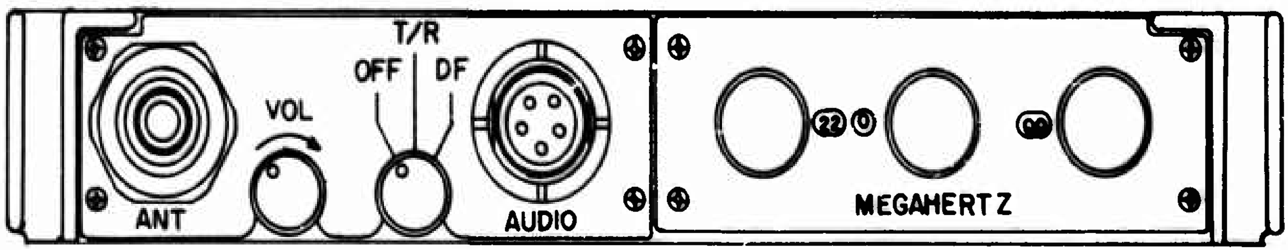
(a) R/T Unit - General Description

Figure 4-1 shows the radio set with the cover removed. The design objective has been to make all modules readily accessible and removable from the chassis. To this end, the PA/modulator module, the RF/receiver module, the frequency synthesizer module (smo), the IF/audio module, and the voltage regulator module are all plugged into connectors mounted in the chassis. The frequency selector switches situated in the control head are permanently wired to the chassis interwiring. Figures 4-2 and 4-3 illustrate the control panel layouts for the RT-865/PRC-66 and RT-865A/PRC-66 transceivers. These consist of a display panel with reading apertures over 3 selector dials which indicate the frequency in megahertz, a function switch control knob, a volume control knob, an antenna connector and an audio connector for the



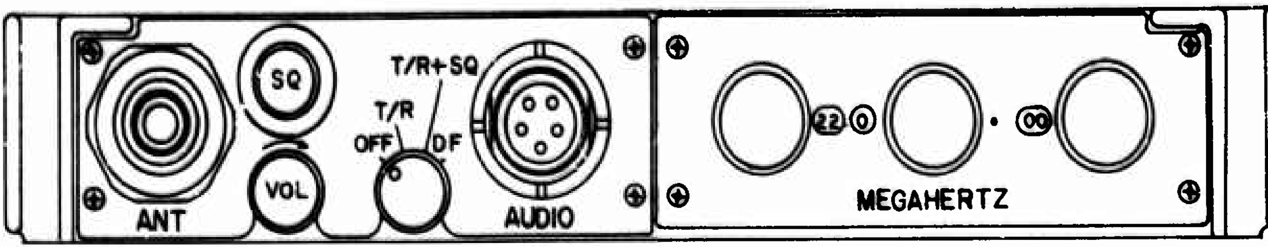
PRC 66 TRANSCEIVER
LAYOUT, COVER REMOVED

FIG. 4-1



RT-865/PRC-66 CONTROL PANEL LAYOUT

FIG. 4-2



RT-865A/PRC-66 CONTROL PANEL LAYOUT

FIG. 4-3

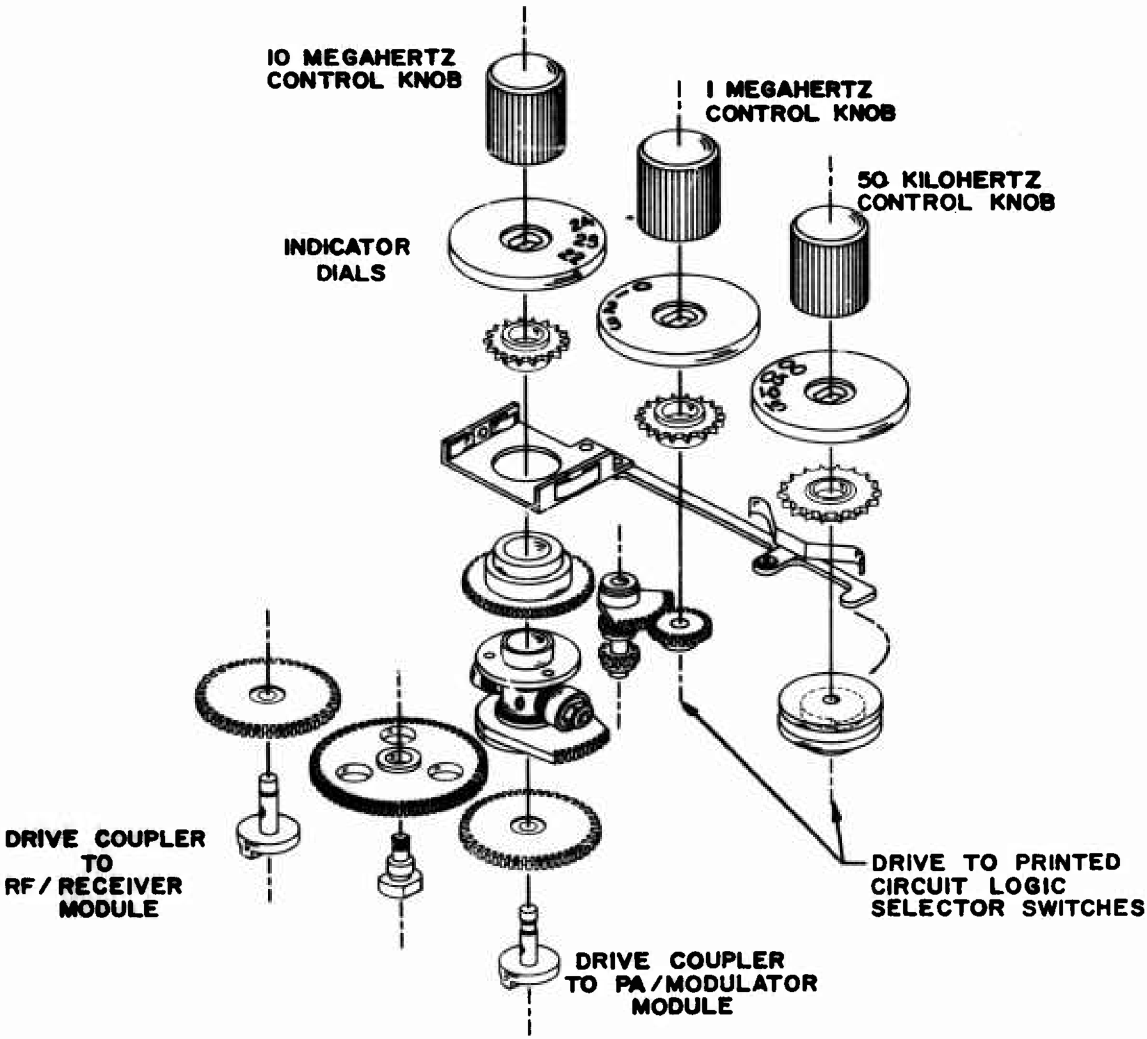
handset. Finger grip type knobs are used for the control knobs and for rotating the 3 frequency readout dials. The RT-865A/PRC-66 control panel layout has only one extra control knob for squelch operation.

(b) Control Head and Chassis

Frequency selection is accomplished with three control knobs and covers the range of 225 to 399.95 MHz. A composite mechanical output of the rotation of the knobs is used to drive the RF tuner sections. An illustration of the drive is shown in Figure 4-4. The 10 MHz knob is connected directly to an input of a differential. The 1 MHz knob is geared to the other differential input and the .05 MHz knob rotates a cam whose follower arm rotates the complete detent assembly on the 10 MHz knob. The resultant output of the differential is then used to directly drive the PA/Modulator RF section. The tuning circuits of the RF/receiver module are driven from the differential output through gears with a 1 to 1 ratio. The frequency selection knobs are detented with simple spring and ball assemblies.

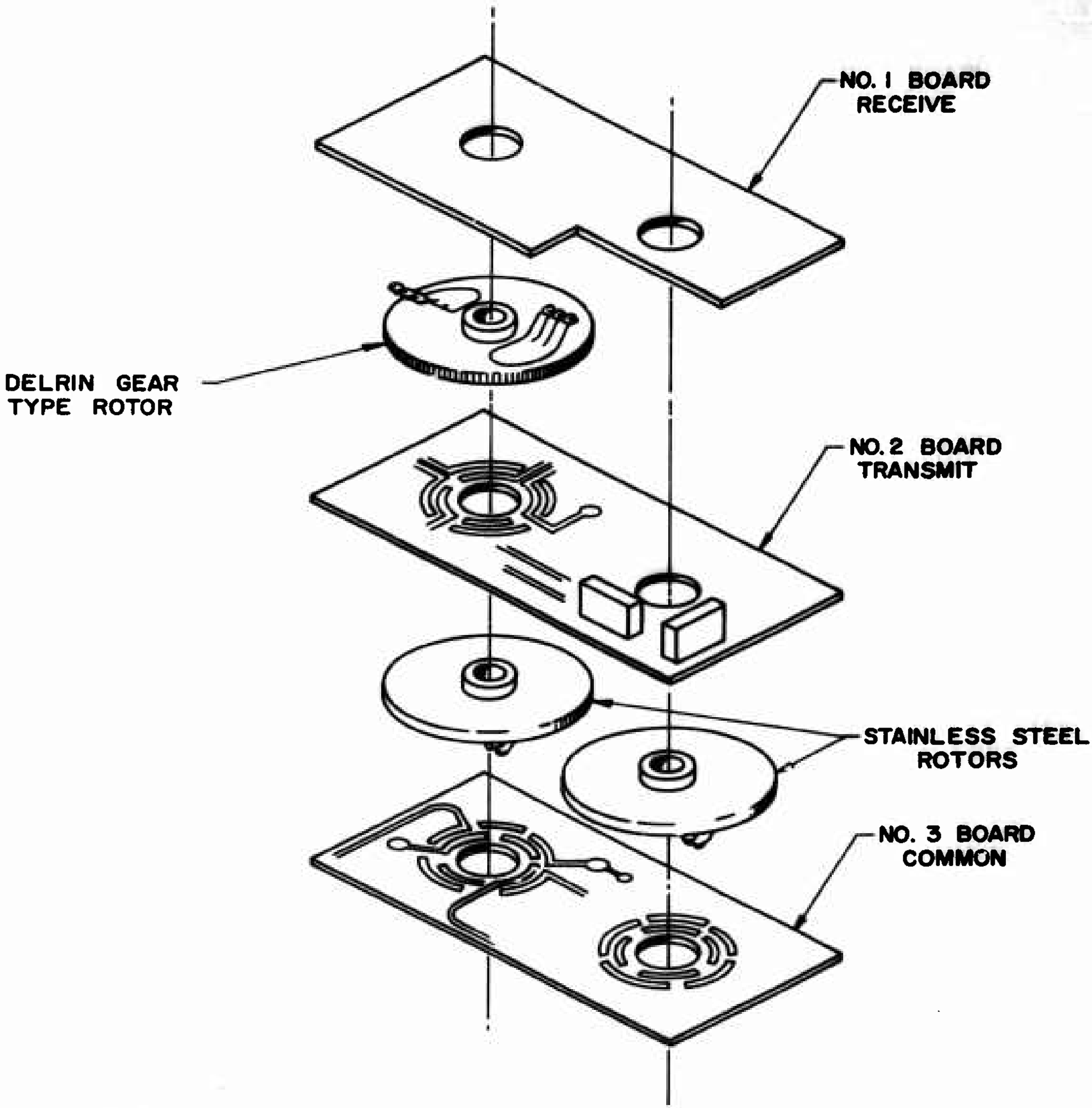
In addition to the above mechanical tuning functions, the frequency selection knobs also operate printed circuit type selector switches which provide the necessary electrical logic input signals to the frequency synthesizer module. An illustration of the switching assembly is shown in Figure 4-4A

The switching circuitry is an integral part of the printed circuit selector switch and all the frequency band switching components, function switching components and receive/ transmit switching components are mounted on the switch boards. Fig. 4.5 illustrates a typical board assembly. The No. 1 and No. 3 boards are used to provide the electrical logic input signals to the Frequency Synthesizer module in the receive mode.

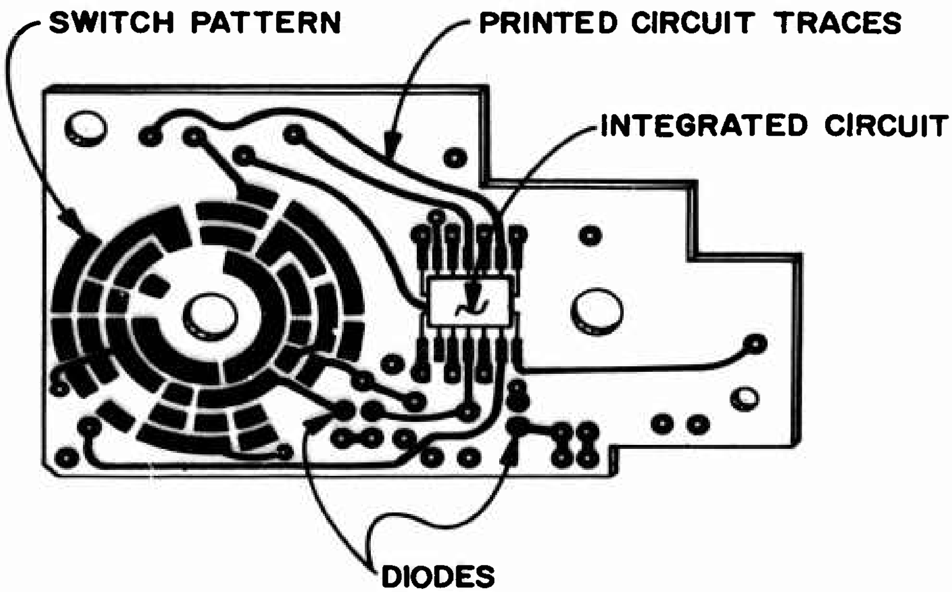


MECHANICAL DRIVE

FIG. 4-4



SWITCHING ASSEMBLY
FIG. 4-4A



PRINTED CIRCUIT
SELECTION SWITCH

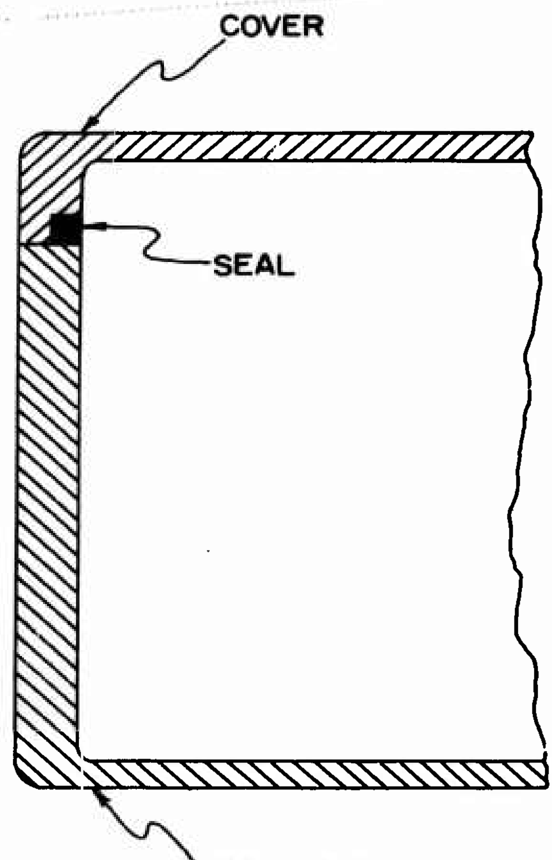
FIG. 4-5

The No. 2 and No. 3 boards provide the signals in the transmit mode. In the receive mode there is a 10 MHz offset difference between the receive and transmit rotor positions. This offset is used to provide the frequency synthesizer module output with the necessary 10 MHz offset which results in the required 30 MHz if offset at the operating frequency of the radio.

The switching patterns are etched onto copper clad glass epoxy (G-10) boards which are then plated. Two different plating processes are used, the first, Rhodium plating, is deposited on the actual switch pattern and provides a good contact and wear resistant surface for the rotor contacts. The second plating finish is the regular tin-lead type plating and is used to cover the remainder of the circuitry. The two lower rotors are constructed of stainless steel and have beryllium-copper finger type contacts. The beryllium-copper has good electrical conductivity and also provides sufficient spring pressure to maintain good contact between the rotor and the switching circuit pattern. The upper gear type rotor is constructed of Delrin and again has beryllium-copper finger type contacts. Delrin is used for the consturction of the gear to provide insulation between the No. 1 and No. 2 boards during the receive or transmit modes.

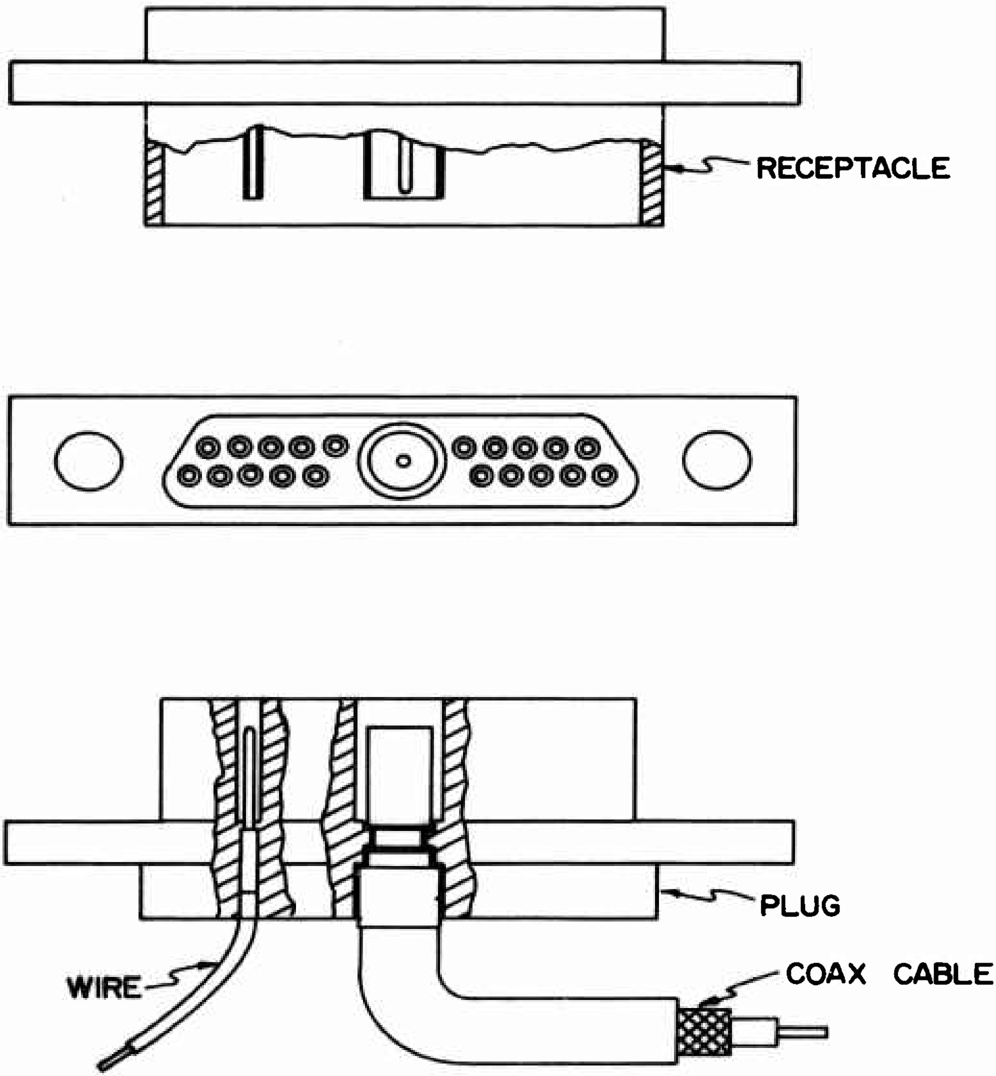
The chassis and cover of the RT unit are constructed of cast aluminum. The properties of good mechanical strength, durability, thermal conductivity and RF shielding afforded by aluminum have made it the most desirable choice for this application. The chassis is a simple box-like structure with provision for mounting the modules and components forming part of the casting. The chassis seal, Figure 4-6, is contained in a step cast on the inside of the cover to chassis mounting surface. All shaft, connector and chassis seals are constructed from broad temperature range elastomers.

Internal module connectors have been developed for the radio and are of the "poke home" design which allows the pin or socket to be withdrawn from the connectors without disconnecting the lead. One of these connectors includes RF filtering on the dc pins and several incorporate coaxially shielded RF lines in the body of the connectors. A typical example is shown in Figure 4-7. In addition, two external connectors have been developed for the radios. The first which is located on the lower surface of the radio is a power connector, the mating half of which is mounted on the battery. Because the halves are rigidly mounted, the full weight of either the battery or the radio could be imposed on the connector and the connector has been designed to release under these conditions. The second connector is designed to mate with either the swivel base antenna or a standard BNC connector and is located on the top surface at the end. The remaining external connector is a MIL-STD-182G/U. This is the audio output to the handset and is located in the centre of the top surface.



CHASSIS SEAL

FIG. 4-6



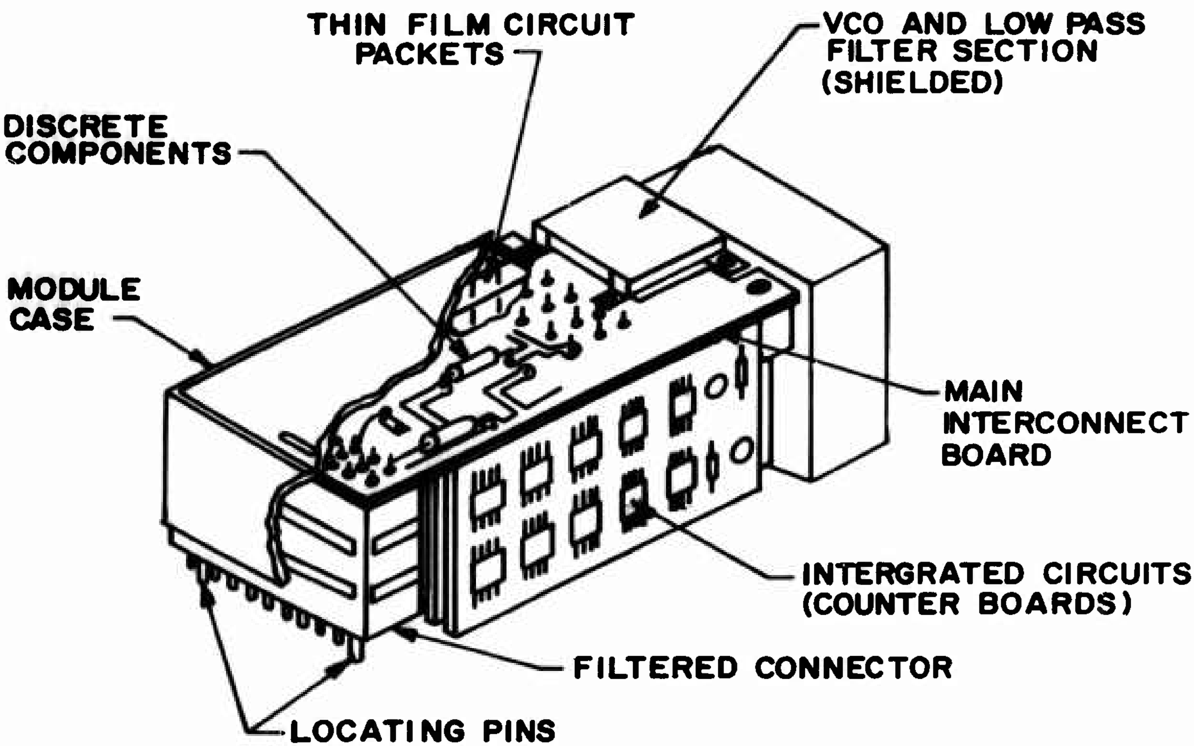
IF/AUDIO SUBMINIATURE CONNECTOR ASSY

FIG 4-7

(c) Frequency Synthesizer

The frequency synthesizer (see figure 4-8) is a two-section module. The smaller of the two sections contains the VCO and low-pass filter and is isolated from the larger section by having an rf shielded enclosure. The construction of both sections is similar in that a printed circuit board is used as a main interconnect board and interconnects a number of thin film circuits whose leads attach to the board.

Three counter boards consisting of several integrated circuit packets, together with some discrete components mounted on a printed circuit board, are also attached to the main interconnect board of the larger section of the module. The main interconnect board also carries the module connector which plugs into a mating connector section mounted in the radio main chassis. Electrical filtering of the frequency synthesizer connector is built into the module half of the connector pair. All the additional discrete components are located on the upper surface of the main interconnect boards. All components, packets and subassemblies attached to the main interconnect board can be removed and replaced during servicing. The whole assembly is mounted in a module chassis and a cover is installed to provide complete rf shielding. Installation of the cover causes the interior assembly to be pressed down into a foam rubber cushion which dampens the forces imposed by shock and vibration. The module chassis has a locating hole on the bottom side which allows it to be properly located and held in the main chassis when installed.



FREQUENCY SYNTHESIZER

FIG. 4-8

(d) IF/Audio Module With & Without Squelch

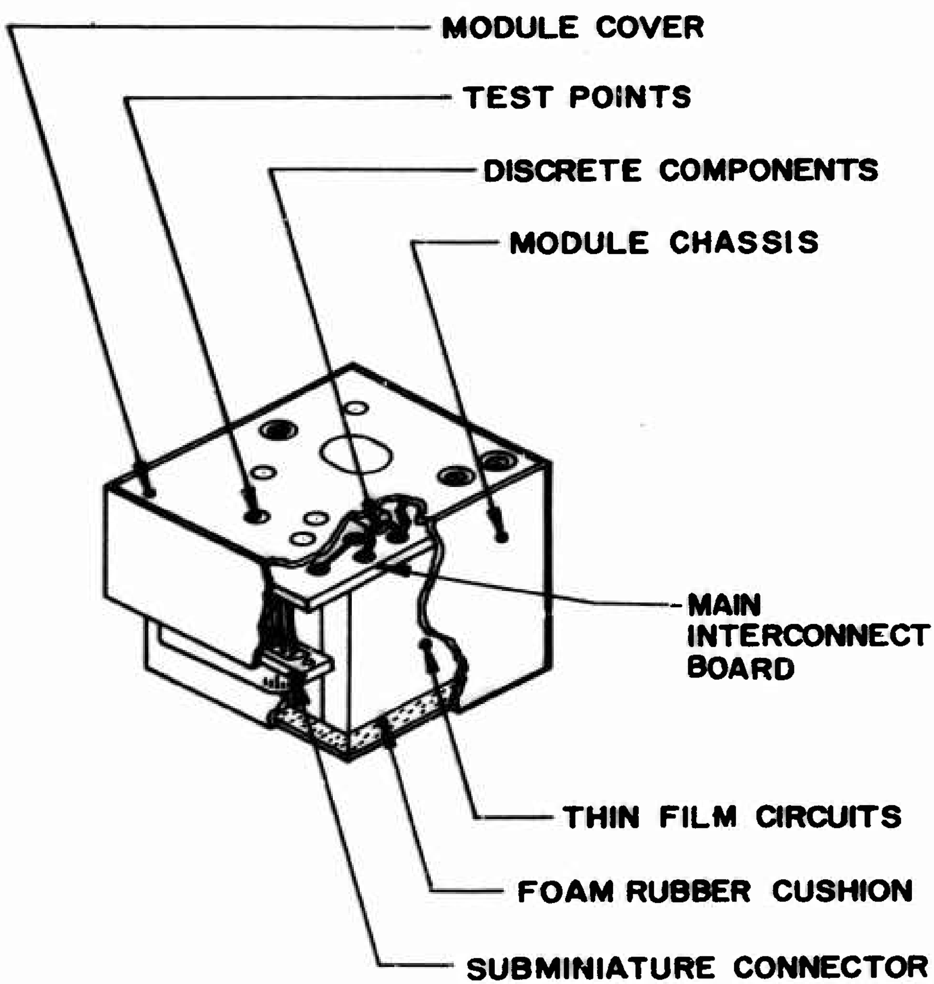
The IF/audio modules for the RT-865/PRC-66 and for the RT-865A/PRC-66 transceiver have the same basic mechanical design (see Figure 4-9) as the frequency synthesizer, the principal components again being a main interconnect board, several thin film circuits, a number of discrete components, a connector and a metallic container or chassis. These components are mechanically arranged as described for the frequency synthesizer module.

(e) Voltage Regulator Module

Figure 4-10 illustrates the voltage regulator module design. The module utilizes 3 printed circuit boards to which a number of discrete components are connected. The upper printed circuit board is also used to terminate the leads from the connector and to mount the fuse and test points. The boards are held in position by two metal posts and the assembly is contained in a metallic module chassis with cover to provide complete rf shielding.

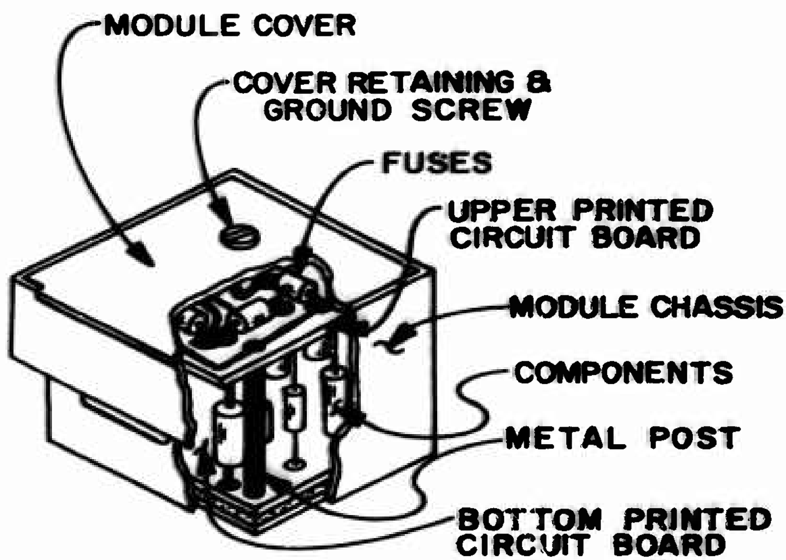
(f) Power Amplifier/Modulator Module

Figure 4-11 shows the power amplifier/modulator module with the top cover removed. Tuning of the module is accomplished by the rotation of the shaft. This shaft is driven from the control head through a coupler mounted at the end of the shaft. There are 5 rotors attached to the shaft, and each of these rotors is located between 2 stator capacitor plates to form a complete and separate tuning circuit having a linear frequency/angle relationship. The



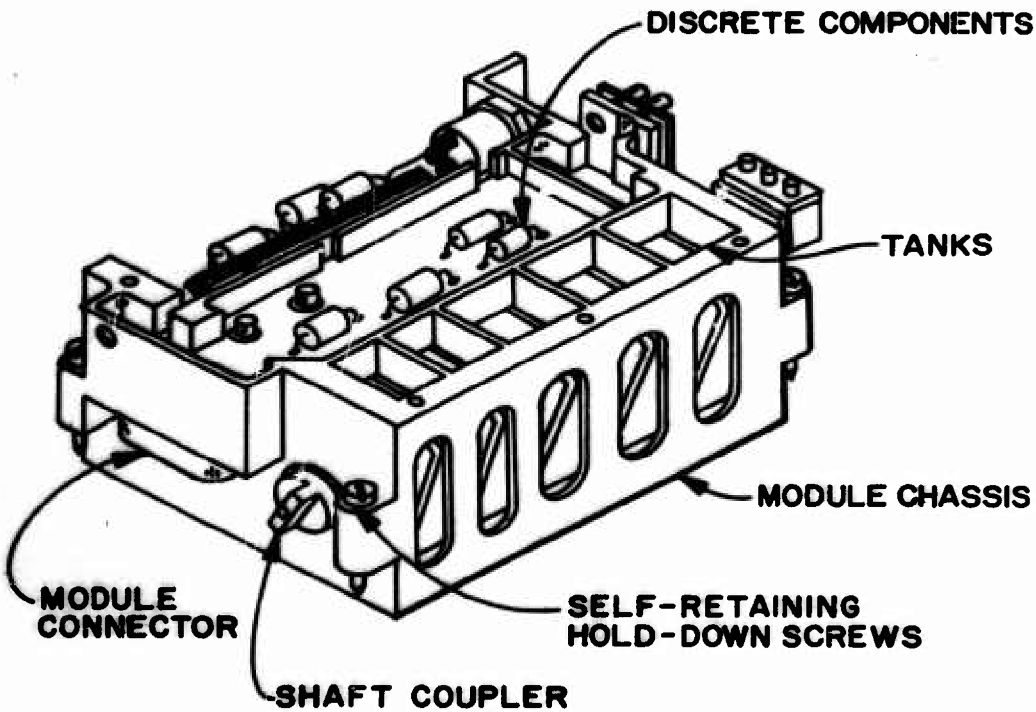
IF/AUDIO MODULE

FIG. 4-9



VOLTAGE REGULATOR MODULE

FIG. 4-10



POWER AMPLIFIER / MODULATOR MODULE

FIG. 4-11

remaining circuitry and associated components are mounted in a tray on top of the module and on brackets at the side of the module. The shaft bearings and tuning circuits are firmly located in a rugged silver plated brass frame which minimizes the effects of vibration, shock and thermal expansion on the fine-tuning sections and also provides adequate shielding between the compartments. Silver plated aluminum chassis are presently being evaluated as a weight saving and vibration improvement measure.

Effective RFI shielding is provided by silver plated brass covers that almost completely enclose the module. The module connector is located in the front end plate and coaxial connector is located at the rear end plate. The module is secured with four captive screws which hold the module rigidly in place in the main chassis.

(g) RF/Receiver Module

Figure 4-12 illustrates the RF/Receiver Module which is of the same basic mechanical design as the power amplifier/ modulator module. The major difference in the mechanical design is in the number of tuning circuits required which is increased to six.

The module has a similar physical outer appearance to the power amplifier/modulator module, but accidental interchange of the modules in the chassis is prevented by differences in the module end plates.

(h) Antenna (Flexible) AS 2117/PRC-66

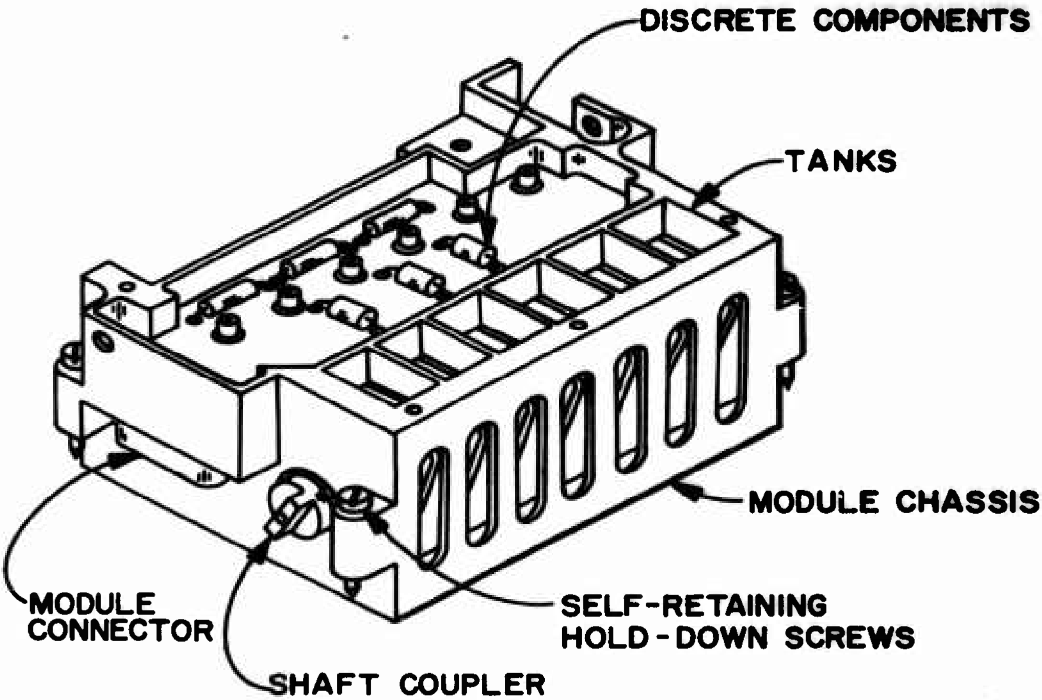
The antenna shown in Figure 4-13 has a swivel base and flexible radiator. The radiator is fabricated from two beryllium copper strips which are curved in the horizontal plane to impart vertical rigidity in a similar manner to a flexible metallic measuring tape. The radiator itself is connected to the swivel base mount through a ball and socket type arrangement which has been designed for this application and allows the radiator to be tilted up to 90° from the vertical position in any direction. The mount itself has a built in impedance matching section. The antenna is mounted to the radio by screwing the mount to a special connector on the top of the main chassis. The connector serves a double function. Besides providing a mount for the antenna, its center portion will accept a regular BNC connector, allowing an auxiliary 50 ohm antenna or an external higher power amplifier to be connected to the radio by means of a standard coaxial cable when the flexible antenna is removed

While the radio is being carried, the antenna may be removed from the radio and stored in a special bag attached to the carrying harness.

4.2.1.2 Batteries

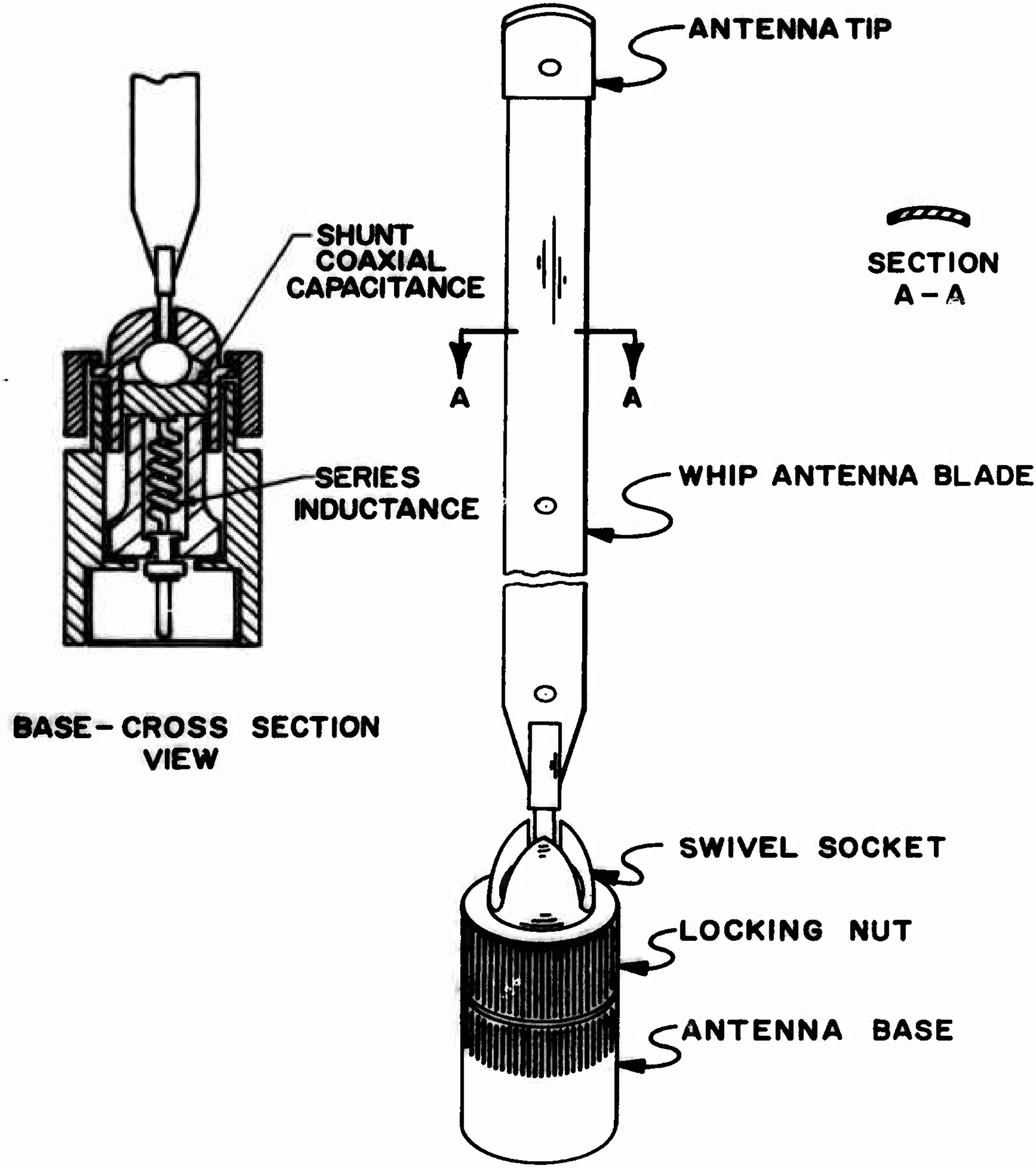
(a) Alkaline Battery Pack BA3515/PRC-66

The alkaline battery pack shown in Figure 4-14 consists of a reuseable outer aluminum case containing a disposable battery. The battery is connected to the main connector on the outer case with a 2-pin connector which, when mated, provides the correct battery polarity to the radio. The outer case is designed so that it can be mounted directly to the transceiver and carried in the harness.

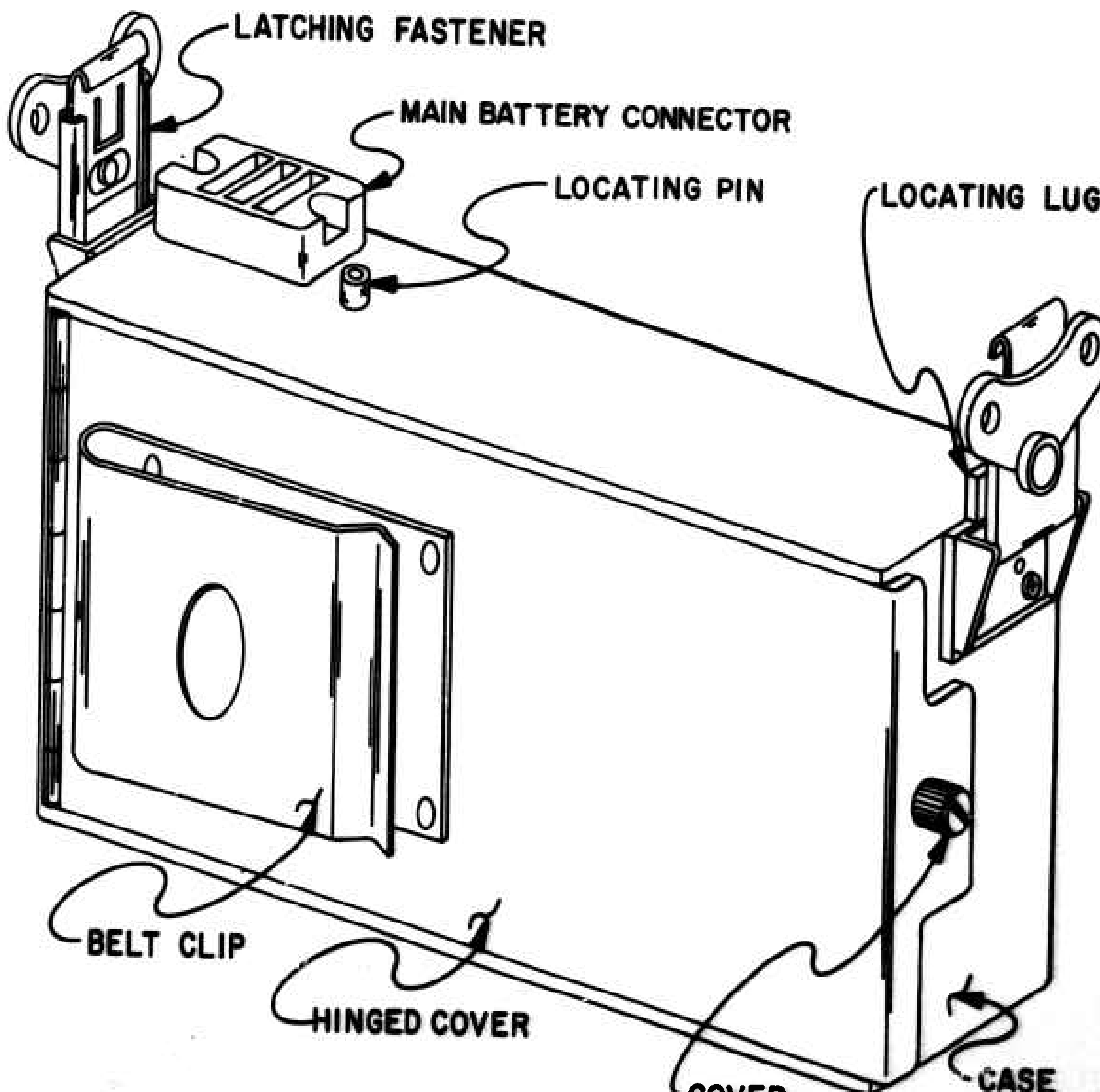


RF/RECEIVER MODULE

FIG. 4-12



SWIVEL BASE ANTENNA (FLEXIBLE)
AS 2117 /PRC-66
FIG. 4-13



ALKALINE BATTERY PACK FIG. 4-14

There is also a clip on the case which allows the battery pack to be carried on the operator's belt. When the battery pack is carried in this position, the external battery extension cable provided is used. The battery pack-to-transceiver connector has been designed to prevent connector damage when the transceiver is assembled or disassembled to the battery pack. Positioning of the transceiver relative to the battery pack is accomplished with locating pins and the transceiver is locked to the battery pack by applying two latching fasteners which are mounted on the outer case.

The life of the battery is approximately 12 hours based on a 9 to 1 duty cycle of 9 minutes on receive and one minute on transmit.

(b) Nickel-Cadmium Battery Packs
BB636/PRC-66 & BB ( )/PRC-66

The nickel-cadmium battery packs represented in Fig. 4-15 are both rechargeable units. Both packs have an aluminum case which contains the cell assemblies. The battery and case are an integral unit. These cells are interwired and secured together before being assembled into the case. The cell assembly is encapsulated in a urethane foam after being assembled into the case. This foam provides a rigid support for the cells and protects them from harmful vibration and shock.

The main connector and latches used on these batteries are the same as those described and used on the alkaline battery packs. The method of connecting the batteries to the radio is also the same as for the alkaline battery.

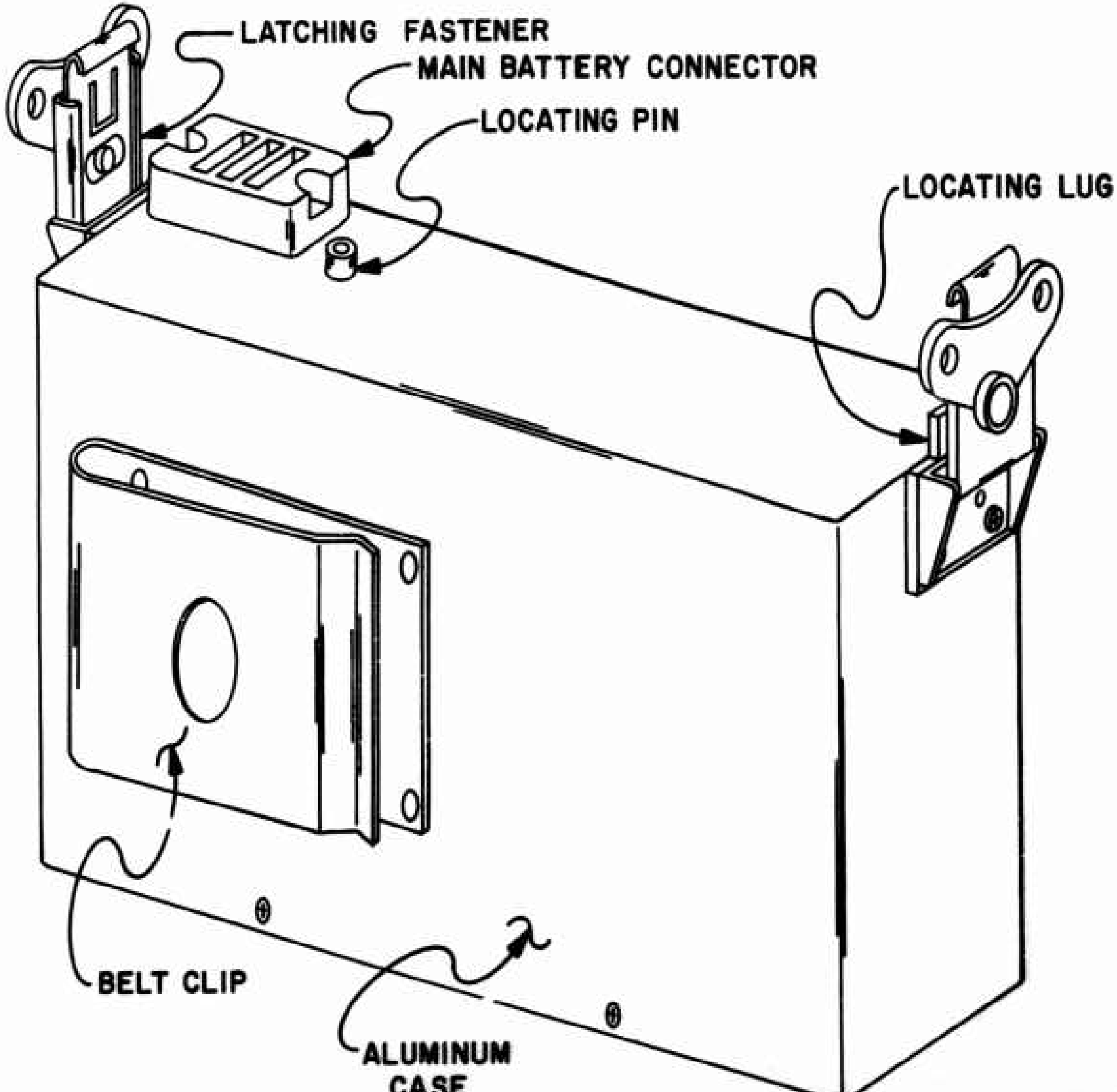


FIG. 4-15 TYPICAL NICKEL CADMIUM BATTERY PACK

The smaller of the two rechargeable batteries has an operational life of approximately 8 hours based on a 9 to 1 duty cycle of 9 minutes on receive and 1 minute on transmit before recharging is required. The other battery has an operational life of 12 hours approximately.

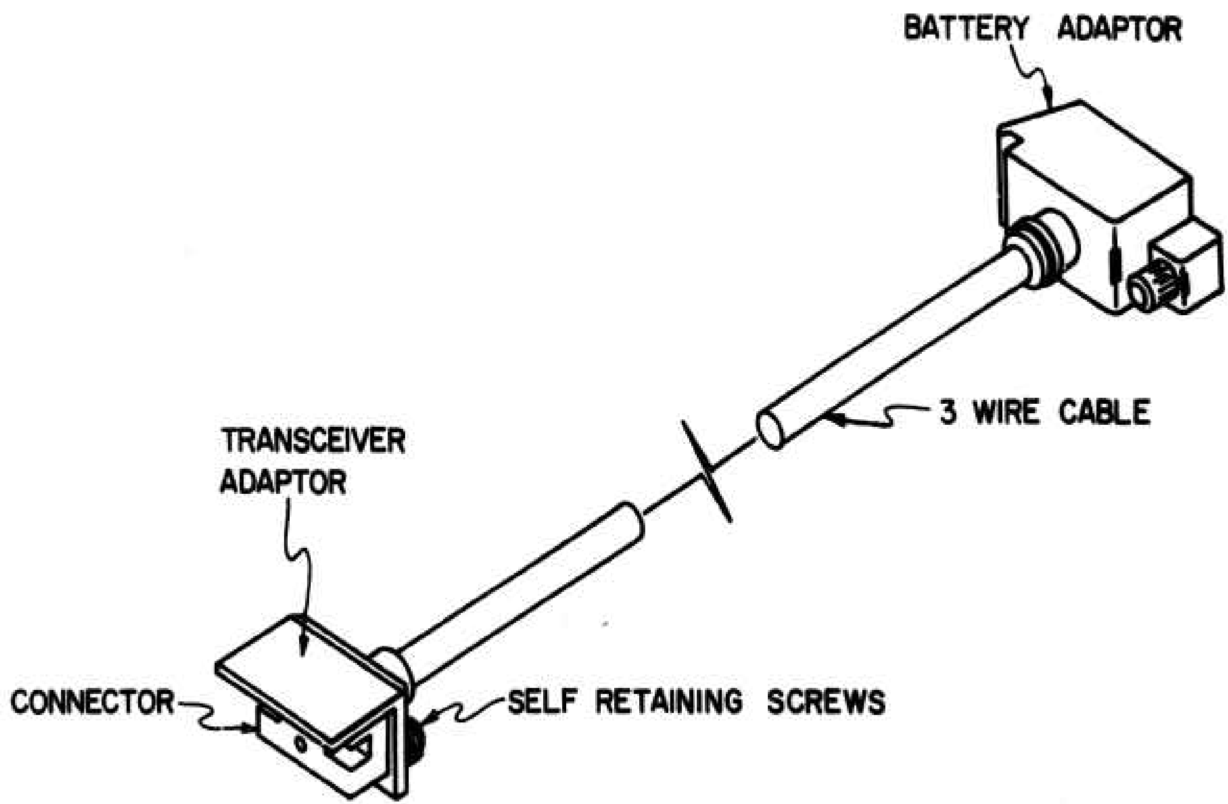
4.2.1.3 Cables and Accessories

(a) Special Purpose Extension Cable

The special purpose extension cable, illustrated in Figure 4-16, consists of a teflon insulated 3-wire cable with connectors and adaptors at each end. These adaptors are designed to attach to the transceiver and to the battery and are secured with two self-retaining screws at the transceiver end and with one self-retaining screw and a latch at the battery end. This cable has been developed for use in low ambient temperatures and allows the operator to carry the battery pack on his belt beneath his outer garments. The cable is of sufficient length to allow it to pass from the transceiver over the operator's shoulder, and then beneath his outer garments at the collar to his waist, without restricting his normal movements in any way.

(b) Carrying Harness

The carrying harness has been developed for carrying the transceiver with or without the battery packs attached. The harness is manufactured from canvas and has an aluminum frame for supporting the transceiver when the harness is mounted on the operator's back.



SPECIAL PURPOSE BATTERY EXTENSION CABLE

FIG. 4-16

The harness is secured to the operator's back with body and shoulder straps which have been positioned to prevent interference with his normal movements. The harness and shoulder straps are padded to prevent chafing of the operator's shoulders and back while he is carrying the radio set. The transceiver is secured to the harness by straps which hold it securely in the aluminum frame. Two straps are used if the battery pack is attached to the transceiver and one strap when the transceiver is mounted alone. The carrying harness also contains a carrying bag for the components.

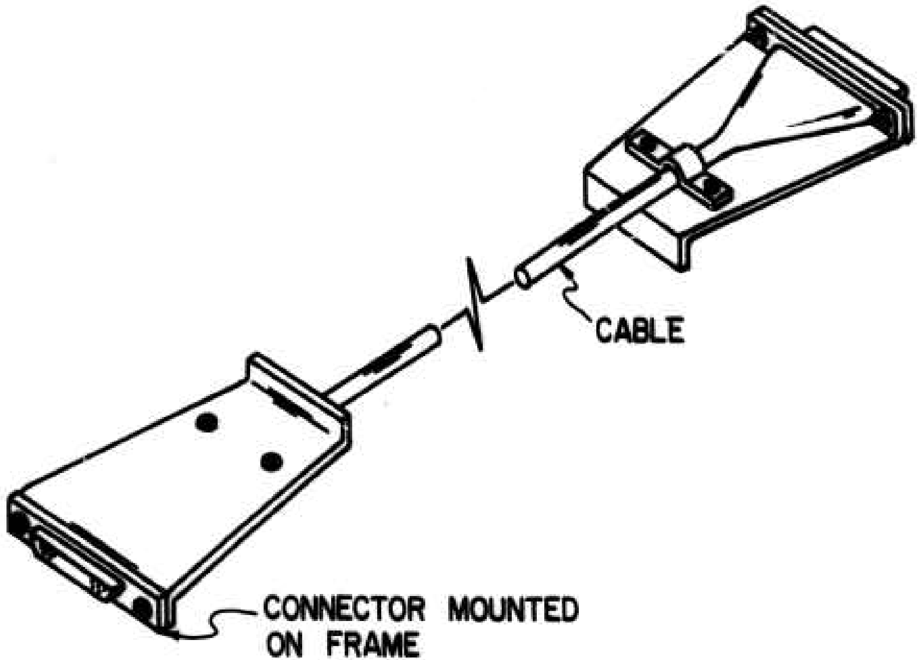
(c) Module Extension Cables

Figure 4-17 illustrates a typical module extension cable. The connectors on the extension cables mate with the connector in the module and with the corresponding connector in the chassis. They are used to connect the removable modules to the chassis and allow the modules to be tested with the radio while disassembled for servicing. The connectors at both ends of the cable are mounted on a small frame to facilitate mating or unmating. Cables are marked at both ends to ensure that the correct cable is used with each module.

4.2.2 AN/PRC-75 Mechanical Design

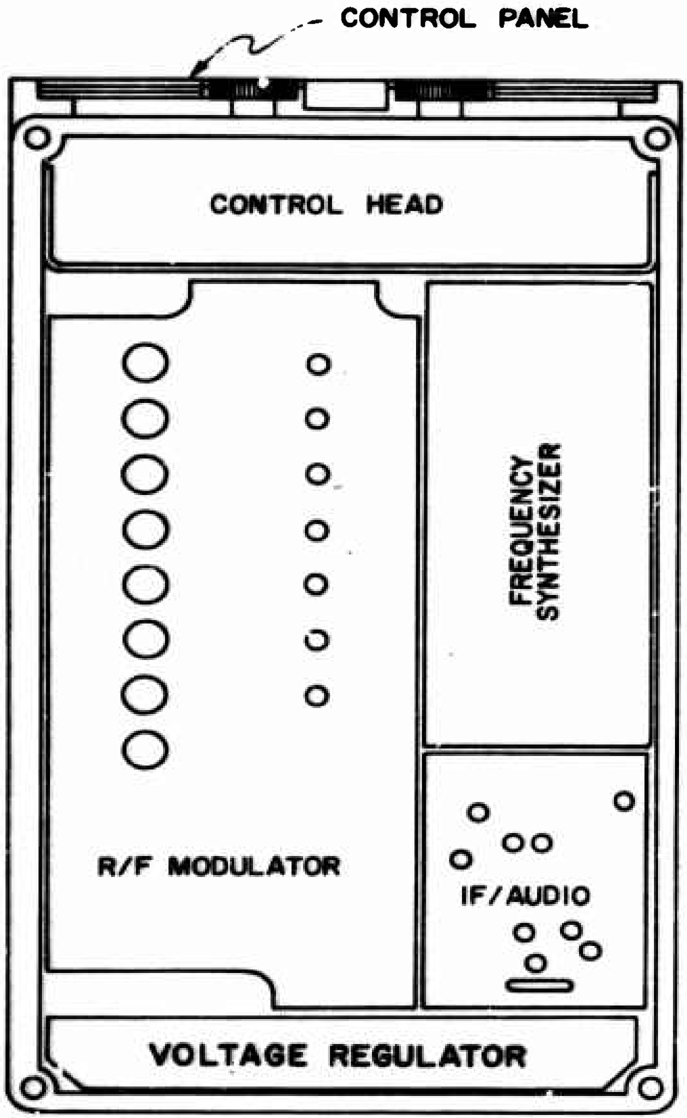
4,2,2,1 (a) R/T Unit - General Description

Figure 4-18 shows the radio set with the cover removed. The radio has been designed so that all components and modules are interfaced in or with the chassis. The design objective has been to make all modules readily accessible and removable from the chassis.



TYPICAL MODULE EXTENSION CABLE

FIG. 4-17



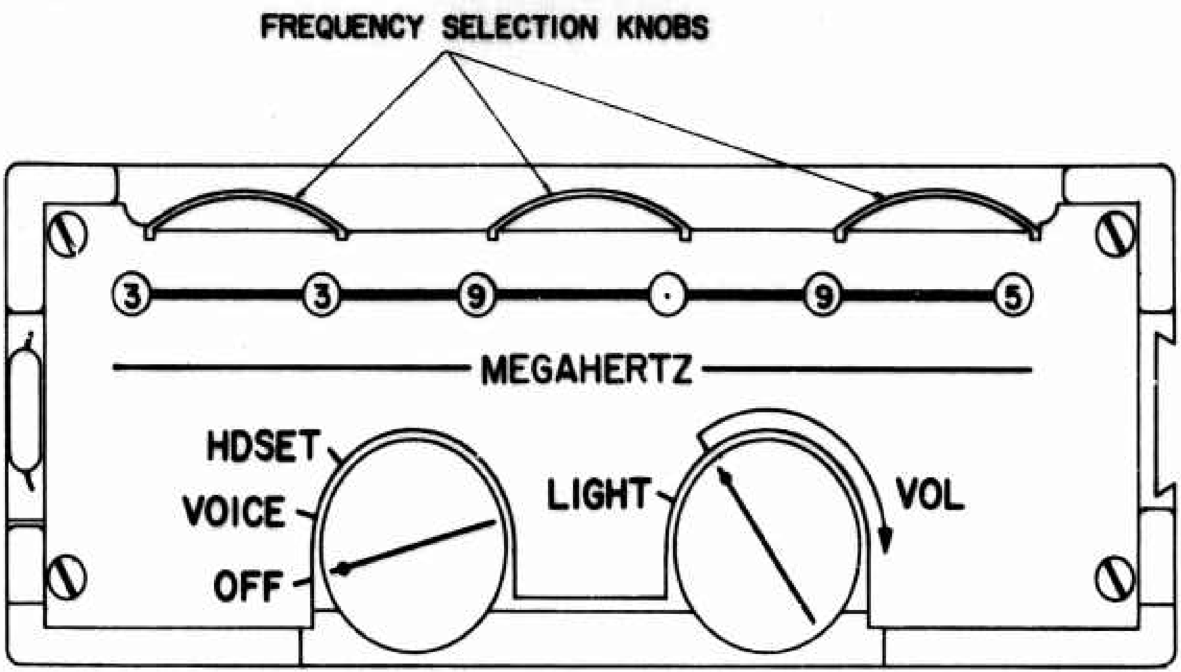
PRC 75 TRANSCEIVER LAYOUT, COVER REMOVED

FIG. 4-18

To this end the RF/modulator module, the frequency synthesizer module (smo), the IF/audio module and the voltage regulator module are all plugged into connectors mounted in the chassis. The voltage regulator module is semi-captive within the chassis in that it has the transceiver main connector as an integral part that must be released before the module can be removed. The frequency selector switches situated in the control head are permanently wired to the chassis interwiring. Figure 4-19 illustrates the control panel layout for the AN/PRC-75 (XN-1) transceiver. This consists of a display panel with reading apertures over 3 selector dials which indicate the frequency in megahertz, a function switch control knob and a volume control knob. The volume control knob is also used to operate the light switch mounted inside the transceiver. The dials or knobs are rotated by applying finger pressure to the knurled rims of the dials or knobs.

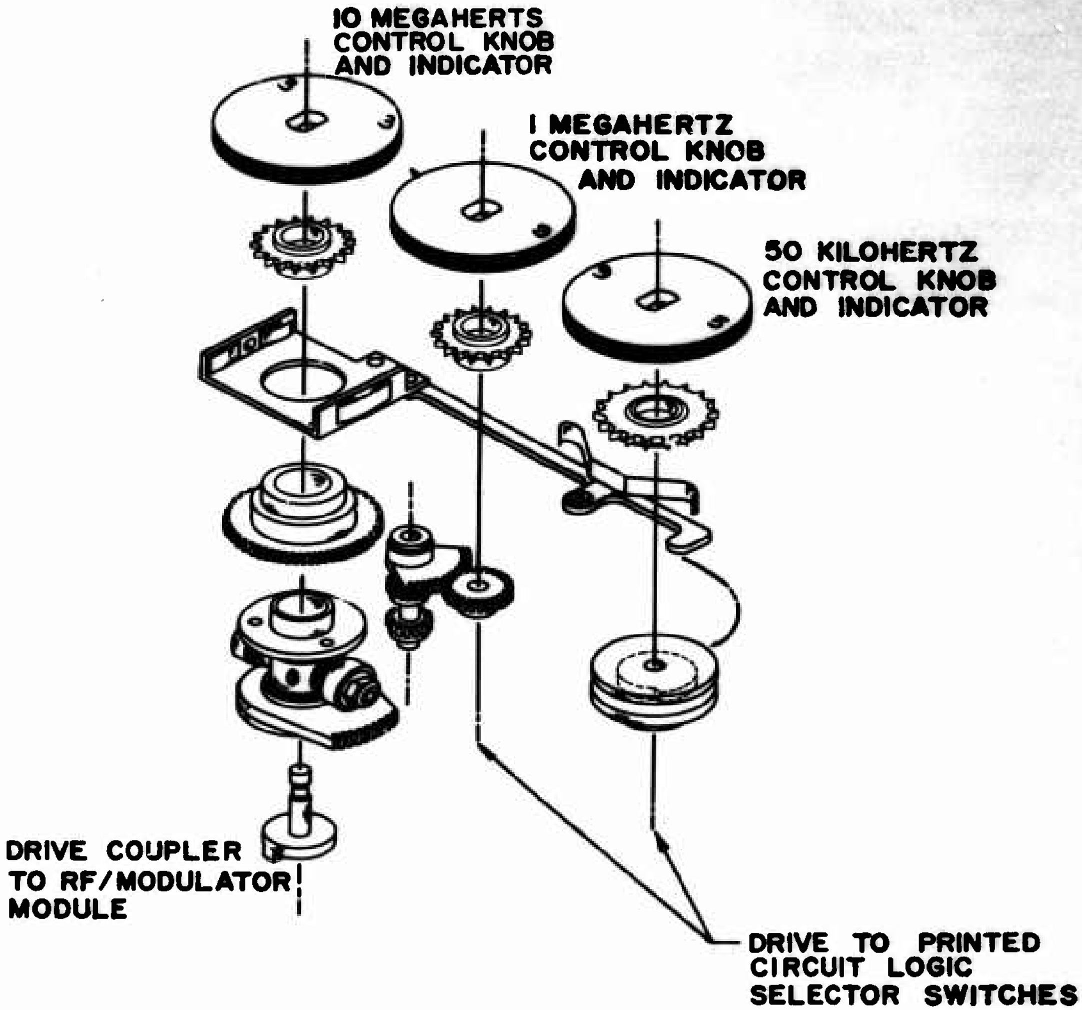
(b) Control Head and Chassis

Frequency selection is accomplished with three control knobs and covers the range of 225.00 to 399.95 MHz. Direct frequency readout is available from the dial markings which can be illuminated when required by operating the light switch. A composite mechanical output of the rotation of the knobs is used to drive the RF tuner sections. An illustration of the drive is shown in Figure 4-20. The 10 MHz knob is connected directly to an input of a differential. The 1 MHz knob is geared to the other differential input, and the 0.5 MHz knob rotates a cam whose follower arm rotates the complete detent assembly on the 10 MHz knob. The resultant output of the differential is then used to directly drive the RF section. The frequency selection knobs are detented with a spring and ball assembly.



AN/PRC 75(XN-1) CONTROL PANEL LAYOUT

FIG. 4-19



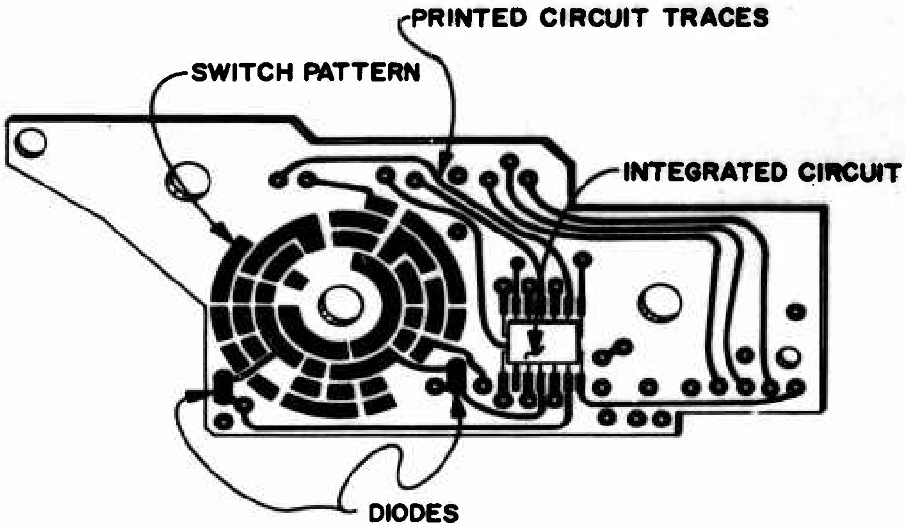
MECHANICAL DRIVE

FIG. 4-20

In addition to the above mechanical tuning functions, the frequency selection knobs also operate printed circuit type selector switches which provide the necessary electrical logic input signals to the frequency synthesizer module. An illustration of the switching assembly in shown in Fig. 4-4A.

The switching circuitry is an integral part of the printed circuit selector switch and all the frequency band switching components, function switching components and receive/transmit switching components are mounted on the switch boards. Fig. 4-21 illustrates a typical board assembly. The No.1 and No.3 boards are used to provide the electrical logic input signals to the Frequency Synthesizer module in the receive mode. The No.2 and No.3 boards provide the signals in the transmit mode. In the receive mode there is a 10 MHz offset difference between the receive and transmit rotor positions. This offset is used to provide the frequency synthesizer module output with the necessary 10 MHz offset which results in the required 30 MHz if offset at the operating frequency of the radio.

The switching patterns are etched onto copper clad glass epoxy (G-10) board which are then plated. Two different plating processes are used, the first, Rhodium plating, is deposited on the actual switch pattern and provides a good contact and wear resistant surface for the rotor contacts. The second plating finish is the regular tin-lead type plating and is used to cover the remainder of the circuitry. The two lower rotors are constructed of stainless steel and have beryllium-copper finger type contacts. The beryllium-copper has good electrical conductivity and also provides sufficient spring pressure to maintain good contact between the rotor and the switching circuit pattern. The upper gear type rotor is constructed of Delrin and again has beryllium-copper finger type contacts. Delrin is used



PRINTED CIRCUIT
SELECTION SWITCH

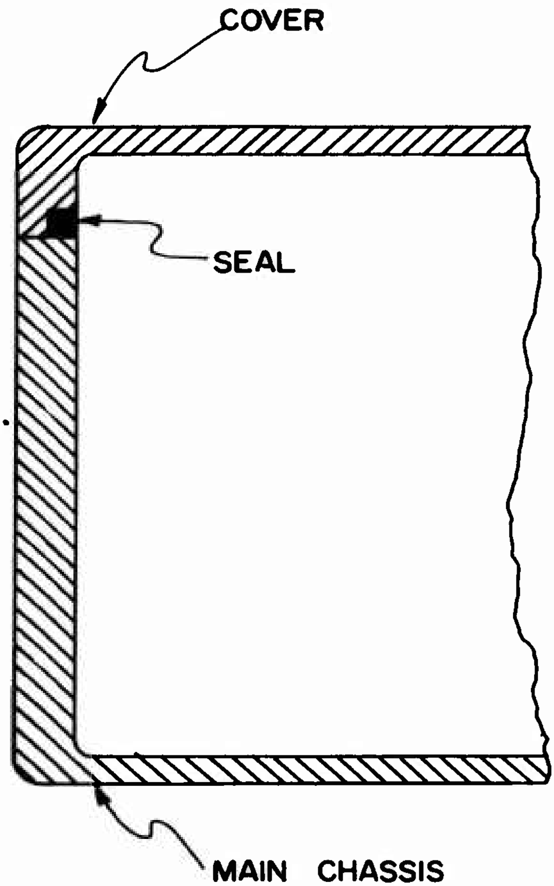
FIG. 4-21

for the construction of the gear to provide insulation between the No. 1 and No. 2 boards during the receive or transmit modes.

The chassis and cover of the RT unit are constructed of cast aluminum. The properties of good mechanical strength, durability, thermal conductivity and RF shielding afforded by aluminum have made it the most desirable choice for this application. The chassis is a simple box-like structure with provision for mounting the modules and components. The chassis seal, Figure 4-22, is contained in a step cast on the inside of the cover to chassis mounting surface. All shaft, connector and chassis seals are constructed from broad temperature range elastomers. The design of the seal provides water-tightness along with metal-to-metal contact for RFI shielding.

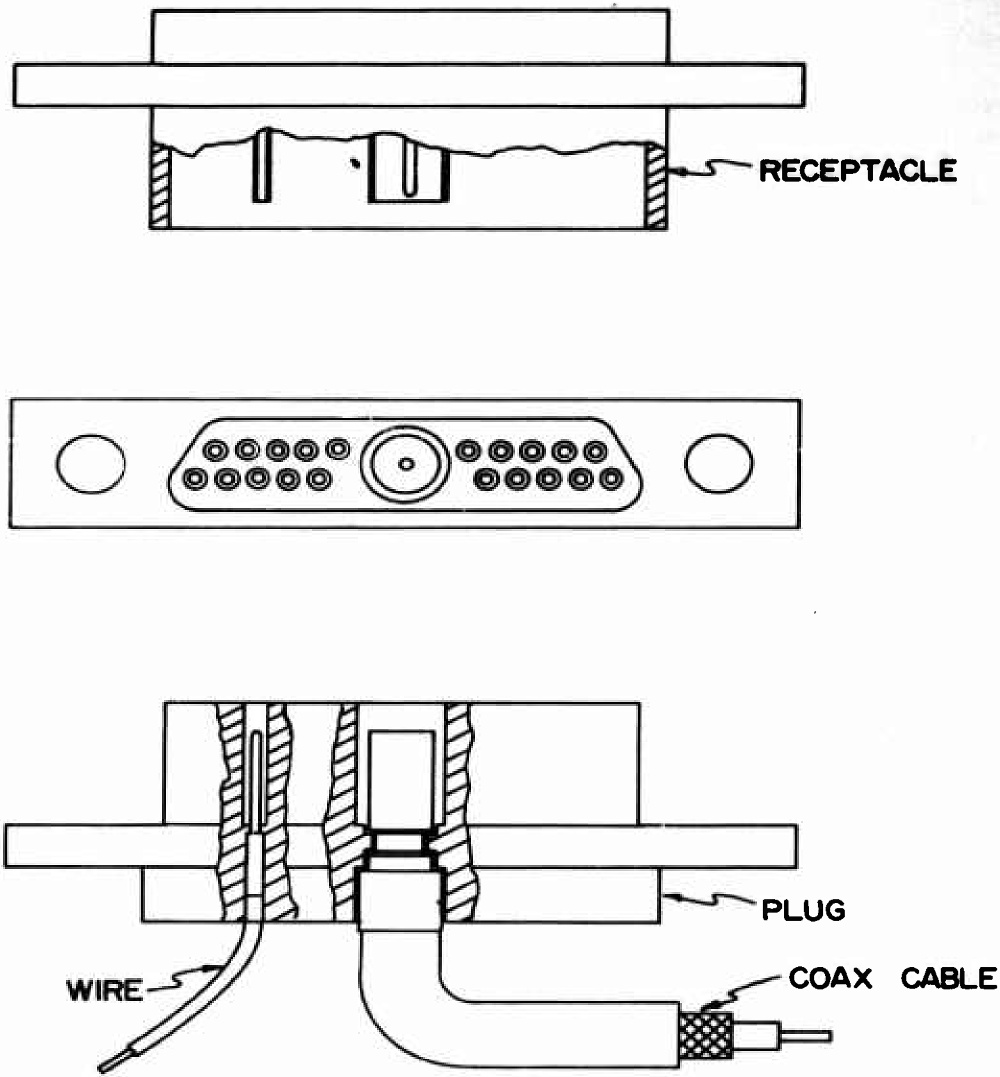
Internal module connectors have been developed for the radio and are of the "poke home" design which allows the pin or socket to be withdrawn from the connectors without disconnecting the lead.

One of these connectors includes RF filtering on the dc pins and several incorporate coaxially shielded RF lines in the body of the connectors. A typical example is shown in Figure 4-23. In addition, two external connectors have been developed for the radios. The first, which is located in the lower part of the radio, serves as a power input from the battery and audio output to the headset. The second connector is designed to mate with a connector on the fixed antenna and is located on the side of the radio close to the control head.



CHASSIS SEAL

FIG. 4-22



IF/AUDIO SUBMINIATURE CONNECTOR ASSY

FIG. 4-23

(c) Frequency Synthesizer Module

This module is identical to the frequency synthesizer module of the AN/PRC-66 transceiver described in paragraph 4.2.1 (c).

(d) IF/Audio Module

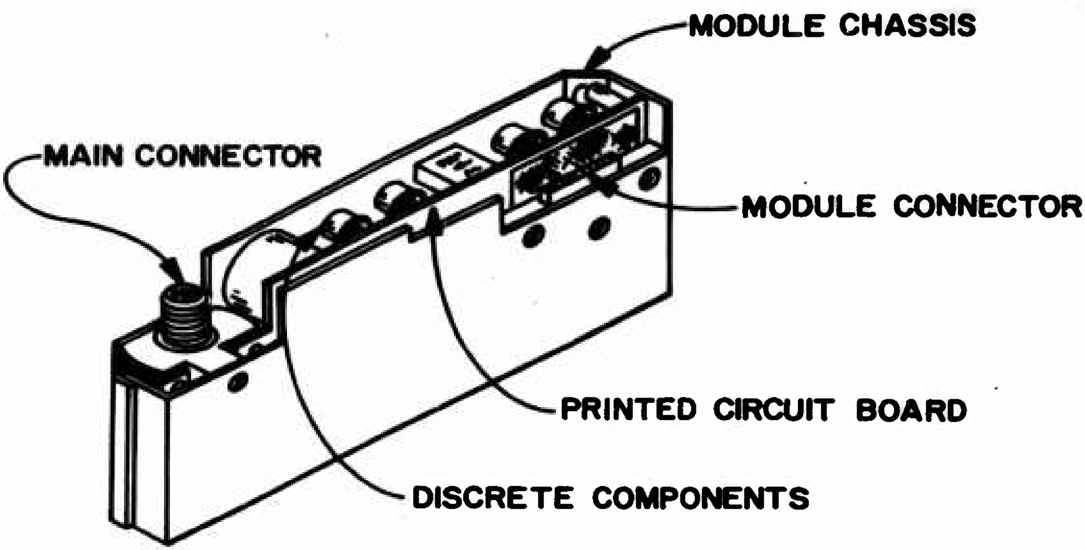
The IF/audio module for the PRC-75 transceiver embodies similar basic mechanical design concepts (Figure 4-9) as the frequency synthesizer and is identical to the IF/audio module of the AN/PRC-66 transceiver (without squelch). A detailed description of this module is given in paragraph 4.2.1.(d).

(e) Voltage Regulator Module

Figure 4-24 illustrates the voltage regulator module mechanical design. The module utilizes a printed circuit board to which a number of discrete components are connected. The printed circuit board is also used to mount the strip type connector and fuses. The board is contained in an insulated metallic module chassis which provides the necessary rf shielding.

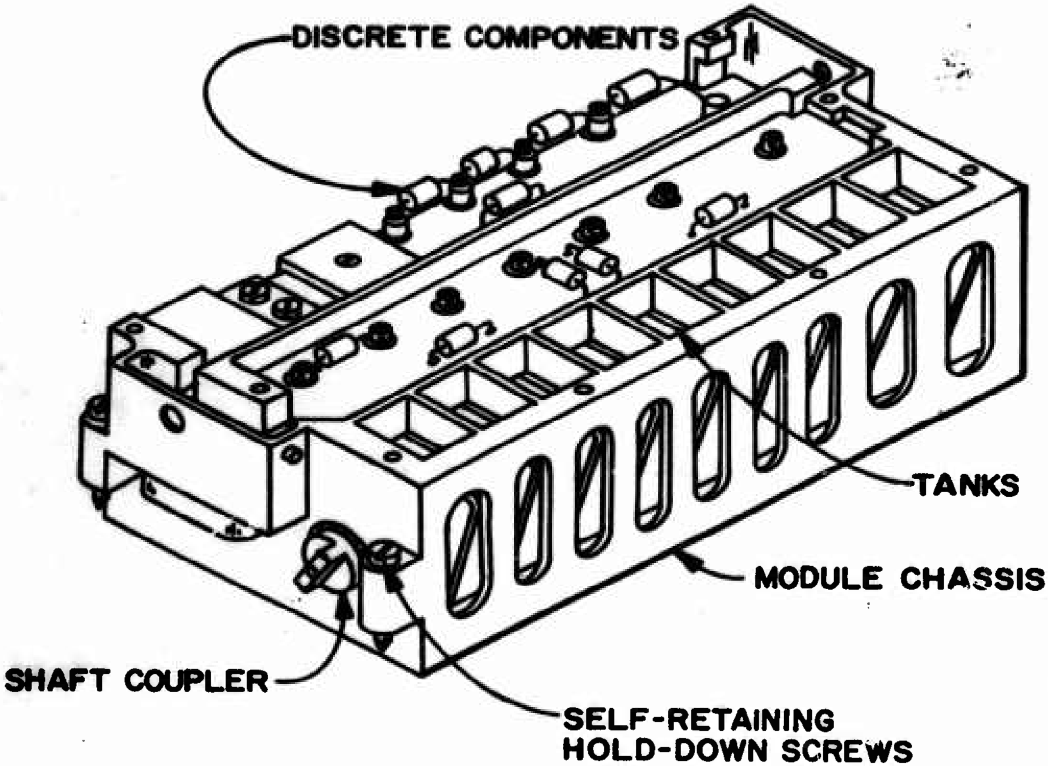
(f) RF/Modulator Module

Figure 4-25 shows the RF/modulator module with the top cover removed. Tuning of the module is accomplished by rotation of the shaft. This shaft is driven from the control head through an Oldham coupler mounted at the end of the shaft. There are 9 rotors attached to the shaft and each one of these rotors is located between 2 stator capacitor plates to form a complete and separate tuning circuit so designed that a linear relationship between frequency and angular position is obtained. The remaining circuitry and associated components are mounted in a tray on top of the module and on brackets



VOLTAGE REGULATOR MODULE

FIG. 4-24



RF/MODULATOR MODULE

FIG. 4-25

at the side of the module. The shaft bearings and tuning circuits are firmly located in a rugged silver plated brass frame which minimizes the effects of vibration, shock and thermal expansion on the fine-tuning sections and also provides adequate shielding between the compartments. Silver plated brass covers enclose the complete module and completely shield the enclosure. The module connector is located in the front end plate and a separate coaxial connector is located at the rear end plate. The module is secured with 3 captive screws which hold the module rigidly in place in the main chassis.

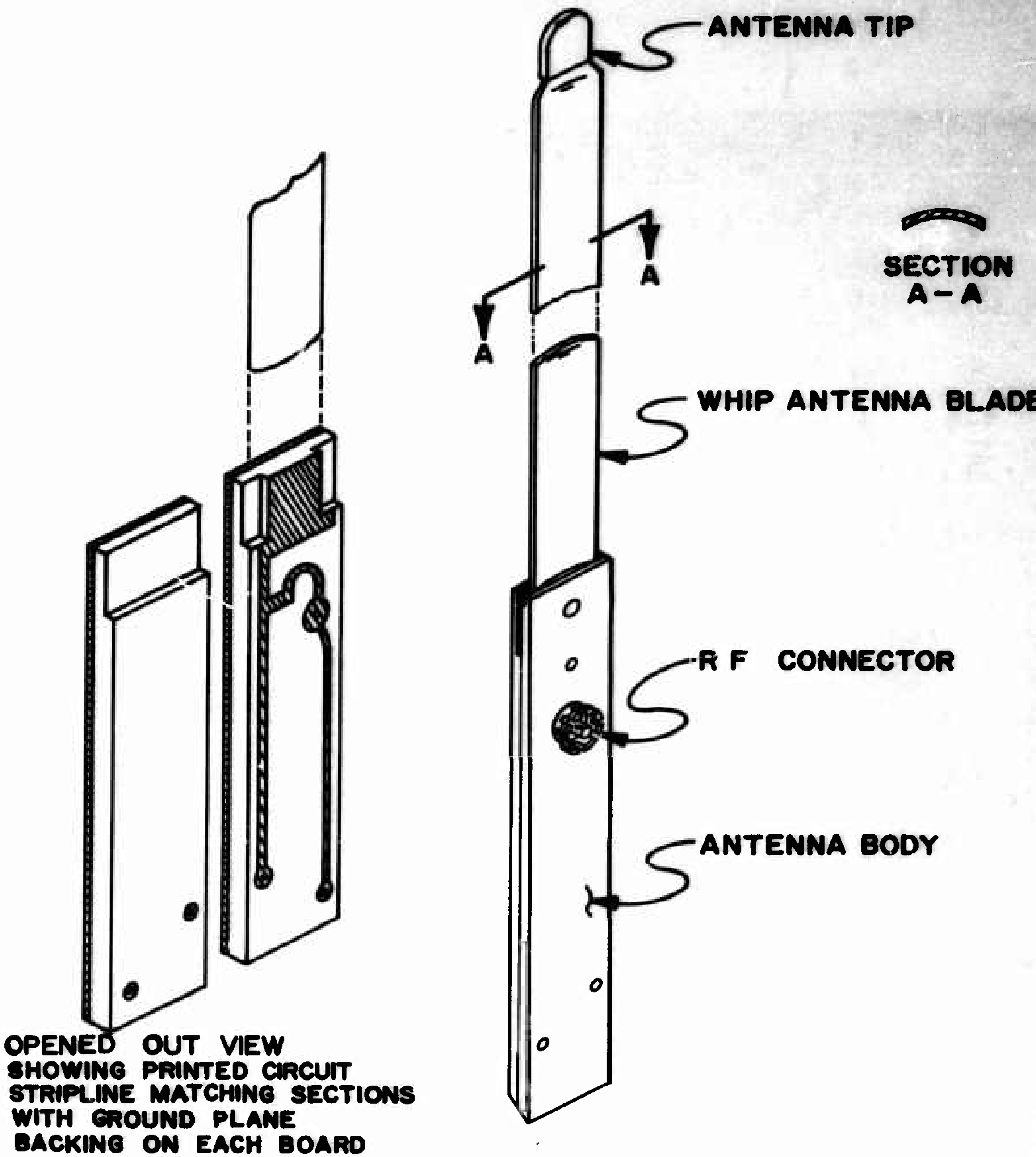
(g) Antenna (Fixed)

The antenna, shown in Figure 4-26, is fabricated from two beryllium copper strips which have been curved in the horizontal plane in a similar manner to a flexible metallic measuring tape. This allows the radiator to be free standing while retaining sufficient flexibility so that may be folded down into a stored position. The body of the antenna consists of two copper clad epoxy boards on which a strip line circuit is etched to form an impedance matching section. The feed to the antenna is accomplished through an RF connector which is also mounted on the copper clad boards. Storage of the antenna is accomplished simply by folding it over the top of the radio and inserting the end into a dove-tailed groove on the opposite side of the radio. The frequency readout display is arranged so that the display is still visible when the antenna is in the stored position.

4.2.2.2 Battery

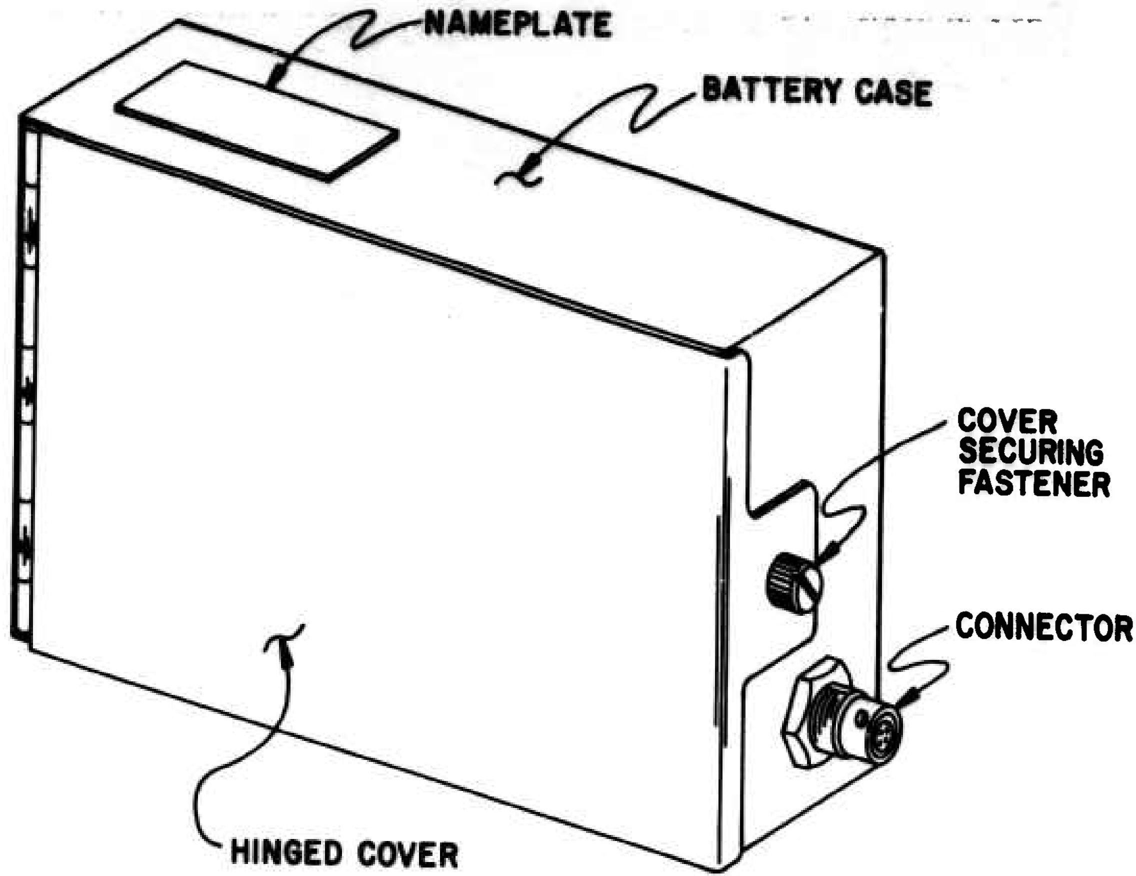
(a) Alkaline Battery Pack

The alkaline battery pack shown in Figure 4-27 consists of a reuseable outer aluminum case containing a disposable battery. The battery is connected to the main connector on the outer case with a 2-pin connector which, when mated, provides the correct battery polarity to the radio. The outer case is designed so that it can be connected to the transceiver with the special purpose cable.



FIXED ANTENNA (FLEXIBLE)

FIG. 4-26



ALKALINE BATTERY PACK

FIG. 4-27

The life of the battery is approximately 12 hours based on a 9 to 1 duty cycle of 9 minutes on receive and one minute on transmit.

4.2.2.3 Cables and Accessories

(a) Special Purpose Cable

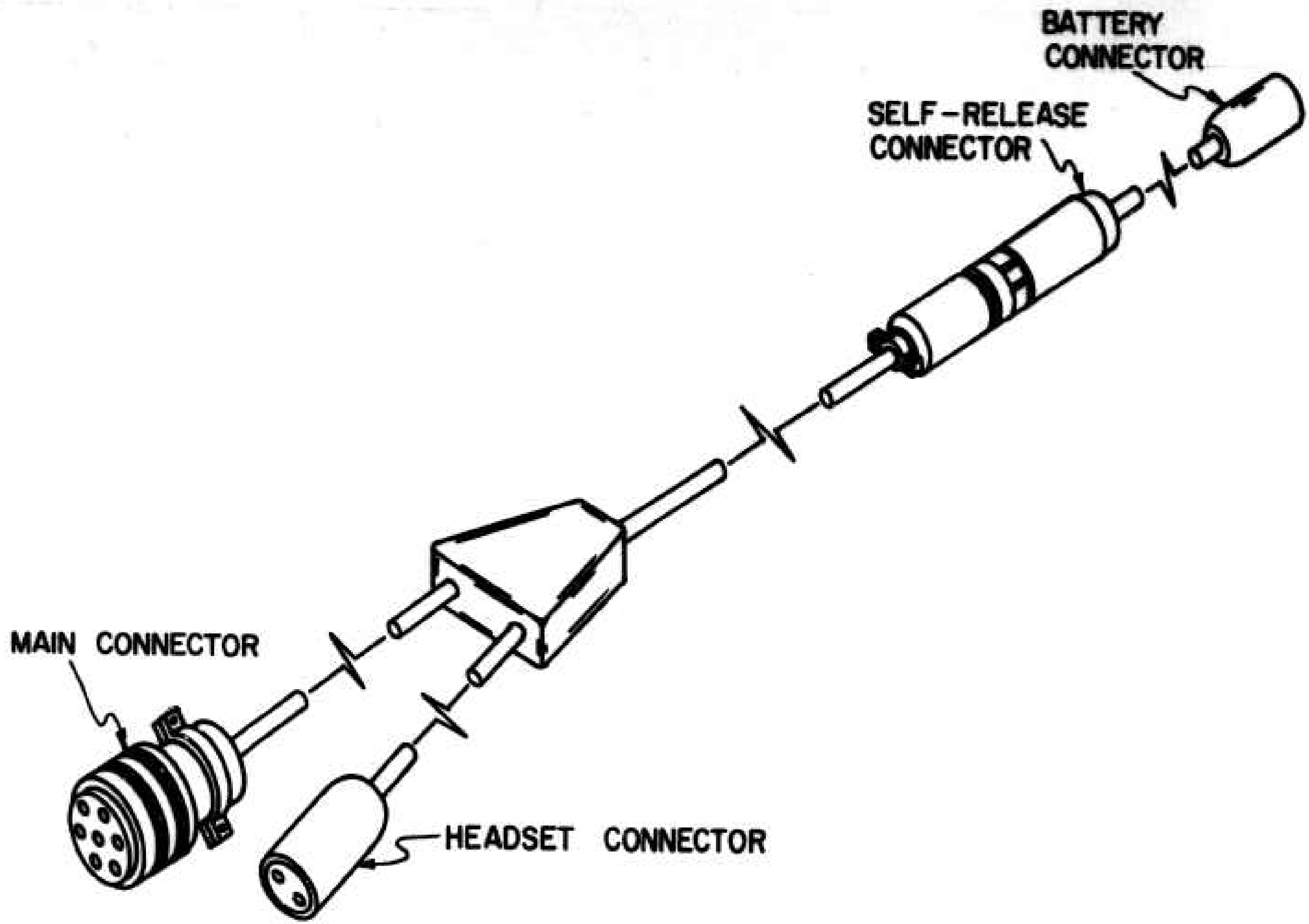
The special purpose cable, illustrated in Figure 4-28, is designed to connect the battery pack and headset to the radio. The connector joining the branched section of the cable to the main cable has a self-release feature which allows the cable to disconnect if it should become caught on any object. The cable is of sufficient length to allow it to be connected to the transceiver, battery and headset without restricting the operator's movements in any way.

(b) Carrying Harness

The carrying harness has been developed for carrying the transceiver and battery pack. The harness is secured to the operator's body with body and shoulder straps which have been positioned to prevent interference with his normal movements. The shoulder straps are padded to prevent chafing of the operator's shoulders and back while he is carrying the radio set. The transceiver and battery are held in position in the canvas pockets by two straps.

4.3 ELECTRICAL DESIGN

As reflected in the equipment specifications, size and weight are factors of major importance in man-carried radio sets such



SPECIAL PURPOSE CABLE
FIG. 4-28

as the AN/PRC-66 and AN/PRC-75. Furthermore, in the design and development of these equipments considerable emphasis has also been placed on producibility, reliability and maintainability. In considering the various factors it is therefore felt that the present design approach and degree of modularization represents the best construction of these equipments.

4.3.1 Transceiver Units

Figures 4-29 and 4-30 present simplified block diagrams of the AN/PRC-66 and AN/PRC-75 transceiver units respectively. The two units are similar in a number of areas. A major difference is that the AN/PRC-75 unit has a single RF module containing receiver and transmitter sections with integral T/R relay, whereas the AN/PRC-66 unit has separate RF modules with the T/R relay and hybrid matching transformer forming part of the main chassis. An additional difference between the two transceivers is that the AN/PRC-75 contains a PTT (press-to-talk) push button switch and an audio transducer, whereas the AN/PRC-66 operates in conjunction with remote microphone, speaker and PTT switch. In both transceiver units, the major electrical circuitry has been organized into a main chassis containing control head and interwiring cabling and a number of plug-in modules.

Figures 4-31 and 4-32 show the chassis layouts, with cover removed, of the AN/PRC-66 and AN/PRC-75 transceivers respectively.

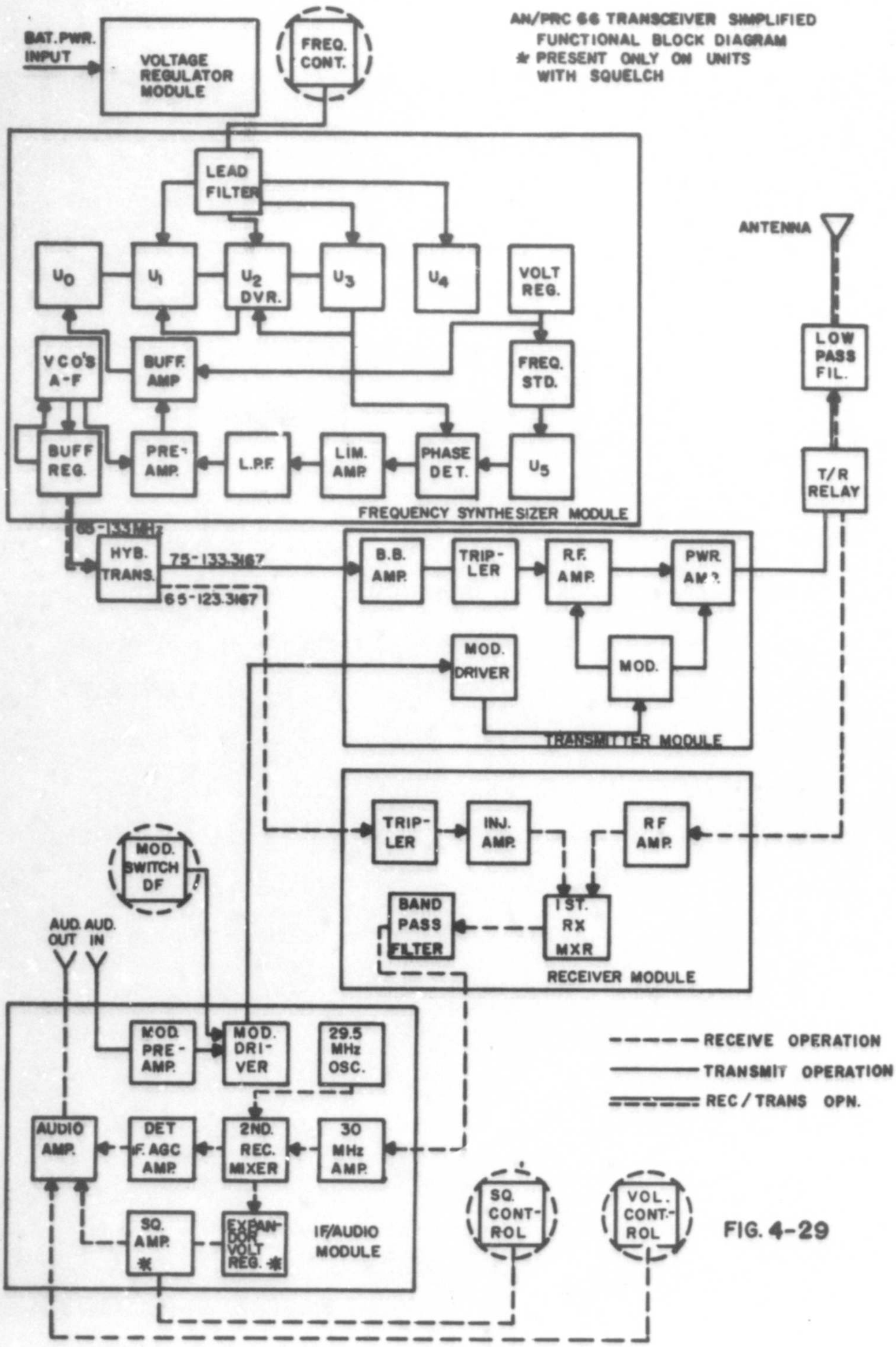
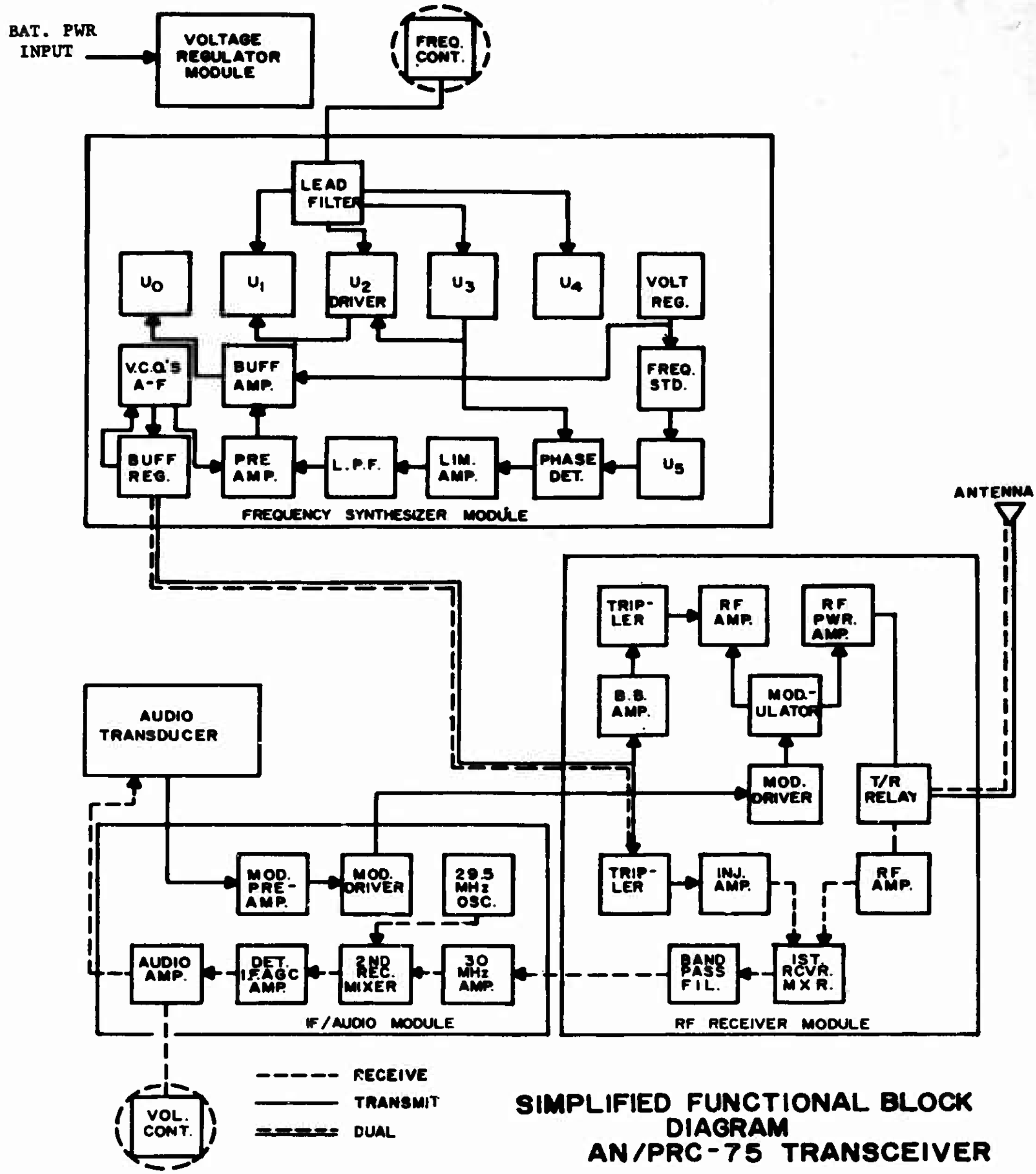
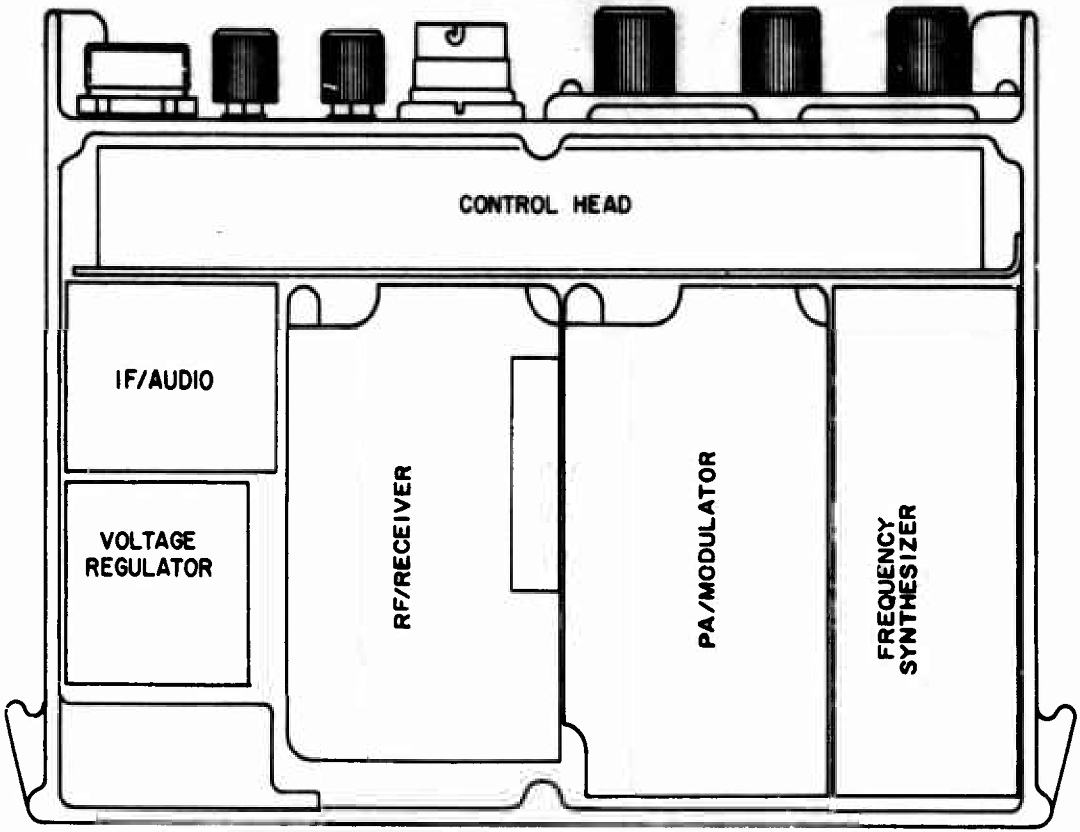

AN/PRC 66 TRANSCEIVER SIMPLIFIED
FUNCTIONAL BLOCK DIAGRAM
* PRESENT ONLY ON UNITS
WITH SQUELCH
BAT. PWR. INPUT
VOLTAGE REGULATOR MODULE
FREQ. CONT.
LEAD FILTER
U0
U1
U2 DVR.
U3
U4
VOLT REG.
VCO'S A-F
BUFF. AMP
FREQ. STD.
BUFF REG.
PRE-AMP.
L.P.F.
LIM. AMP.
PHASE DET.
U5
FREQUENCY SYNTHESIZER MODULE
ANTENNA
LOW PASS FIL.
T/R RELAY
65-133 MHz
HYB. TRANS.
75-133.3167
65-123.3167
B.B. AMP.
TRIP-LER
R.F. AMP.
PWR. AMP.
MOD. DRIVER
MOD.
TRANSMITTER MODULE
TRIP-LER
INJ. AMP.
RF AMP.
1ST. RX MXR
BAND PASS FILTER
RECEIVER MODULE
MOD. SWITCH DF
AUD. OUT
AUD. IN
MOD. PRE-AMP.
MOD. DRI-VER
29.5 MHz OSC.
AUDIO AMP.
DET & AGC AMP.
2ND. REC. MIXER
30 MHz AMP.
SQ. AMP. *
EXPANDOR VOLT REG. *
IF/AUDIO MODULE
SQ. CONT-ROL
VOL. CONT-ROL
RECEIVE OPERATION
TRANSMIT OPERATION
REC/TRANS OPN.

FIG. 4-29

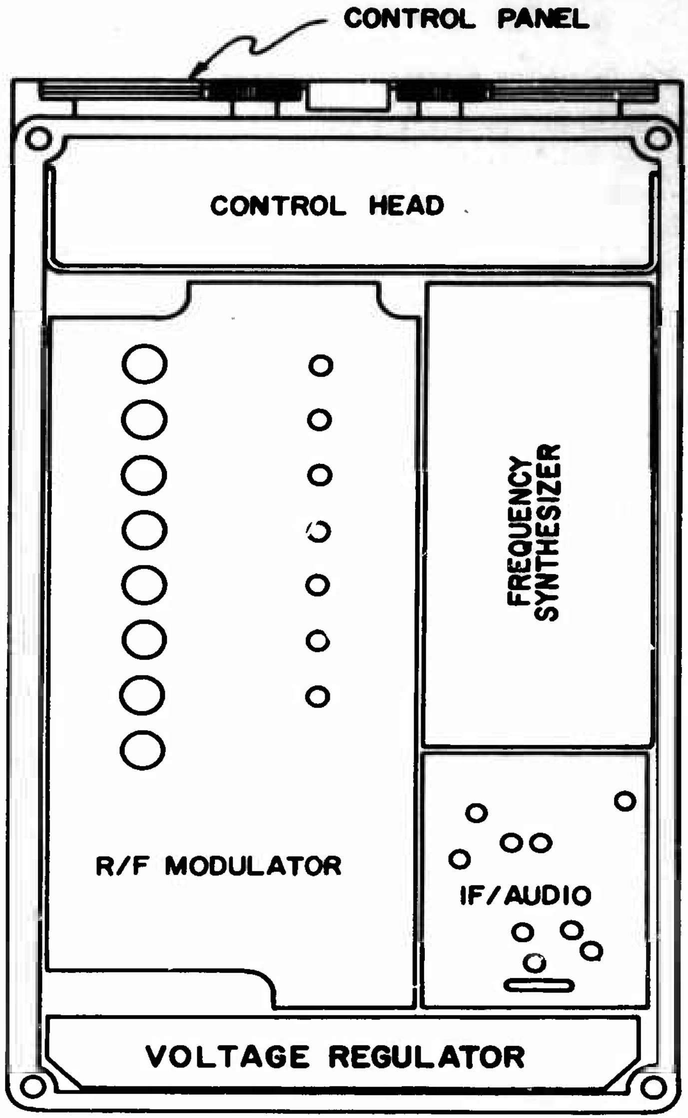


SIMPLIFIED FUNCTIONAL BLOCK DIAGRAM
AN/PRC-75 TRANSCEIVER
FIG. 4-30



PRC 66 TRANSCEIVER
LAYOUT, COVER REMOVED

FIG. 4-31



PRC 75 TRANSCEIVER
LAYOUT, COVER REMOVED

FIG. 4-32

The following paragraphs describe in more detail the electrical aspects of the modules and chassis.

4.3.1.1 Chassis and Control Head (AN/PRC-75)

The electrical design of the chassis and control head of the AN/PRC-75 has changed very little since the inception of the program. The chassis is simply a mechanical and interwiring base for the plug-in modules. The control head section performs a number of complex functions such as setting up correct mode of operation and providing operating frequency logic information to other areas of the transceiver.

4.3.1.2 Chassis and Control Head (AN/PRC-66)

The AN/PRC-66 chassis is electrically similar to the AN/PRC-75 chassis except for the following additional items it contains.

(a) 400 Megahertz Low-Pass Filter

This filter has been added in series with the antenna output line to effectively suppress undesired second harmonic output from the transmitter when operating in the low (225 megahertz) region of the band. Second harmonic is now down at least 40 db below the fundamental. The low insertion loss (0.35 db) of the filter produces very little reduction in power output or receiver sensitivity. An additional benefit obtained through the use of the filter is in the suppression of receiver susceptibility to spurious signals outside the band. Spurious responses on receive to frequencies above 500 megahertz and below 8000 megahertz have been improved by at least 40 db.

(b) Transmit-Receive (T/R) Relay

The T/R relay is necessary in the AN/PRC-66 transceiver chassis because of the use of separate receive and transmit modules. Neither module has an integral T/R relay as is the case of the AN/PRC-75 RF module.

(c) Hybrid Transformer

The hybrid transformer is necessary on the AN/PRC-66 transceiver because of the use of separate receive and transmit modules. This transformer provides the necessary power division and impedance match for proper distribution of the frequency synthesizer module output to the PA/modulator module and the RF/receiver module. Due to the physical separation of the transmit and receive modules, coaxial cables having a considerable part of a wavelength have to be used. Over a wide (almost 2:1) frequency range then the hybrid transformer prevents "suck out" stub effect of the uncased coaxial lead.

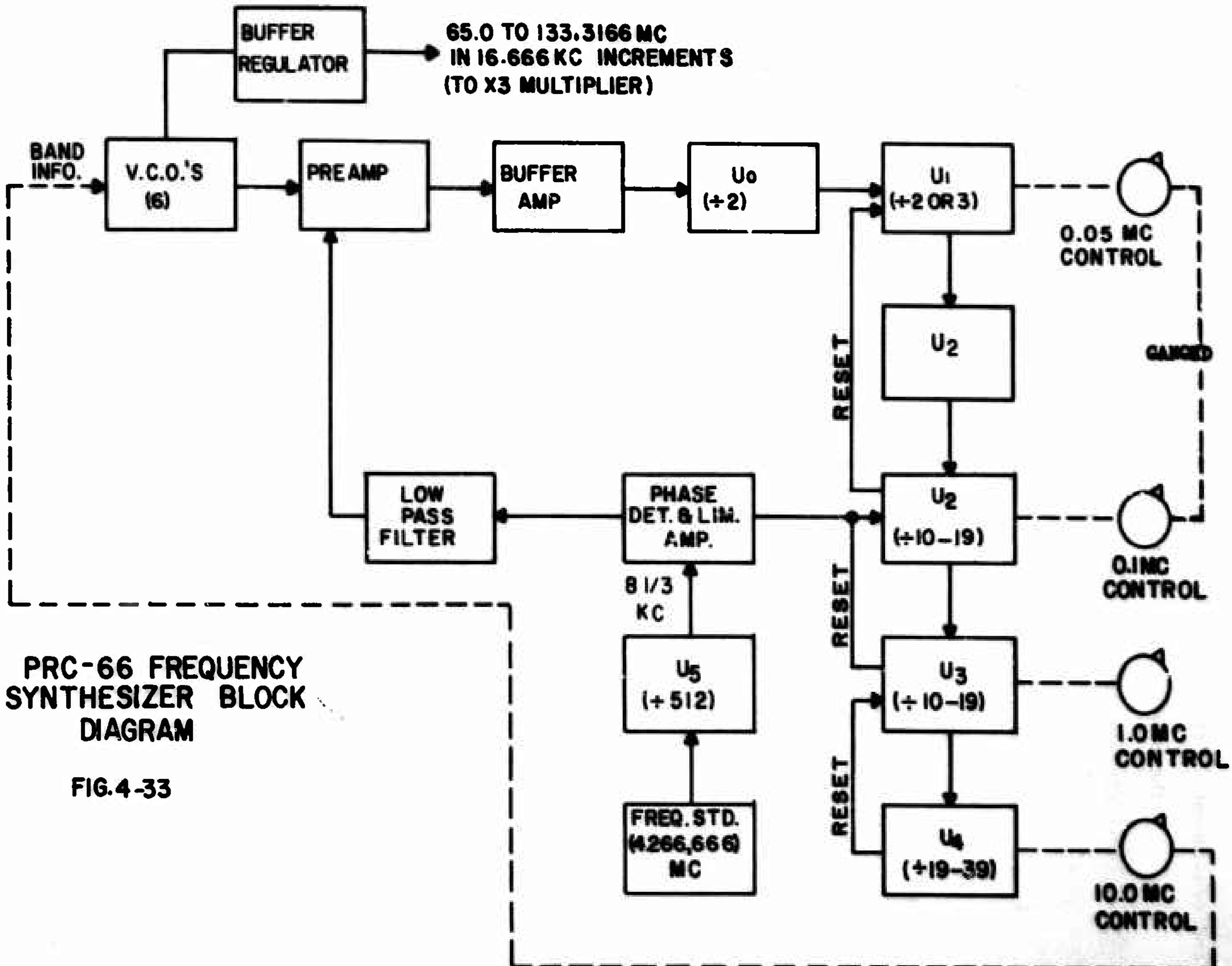
4.3.2. Frequency Synthesizer Module

4.3.2.1 GENERAL

a) Operation

This module is common to both the AN/PRC-66 and AN/PRC-75 transceivers and provides transmitter power amplifier excitation as well as receiver RF mixer injection for operation of the radio set on any of 3500 channel frequencies in the range 225 MHz to 399.95 MHz (50 KHz channel spacing). As both transmit and receive RF circuits have a tripler circuit, the output frequency range of the synthesizer is from 65 MHz to 133.3167 MHz and the frequency spacing is 16 2/3 KHz. On transmit the synthesizer operates at 1/3 frequency setting of the radio (i.e. 75 MHz to 133.3167 MHz.) On receive the tripled output must be 30 MHz lower since the first IF is 30 MHz. In this case, the synthesizer output frequency range is from 65 MHz to 123.3167 MHz.

Refer to block diagram, Figure 4-33. The synthesizer utilizes a single phase-locked loop. The output signal from the voltage controlled oscillator (VCO) after buffering and amplification feeds a series of frequency dividers (U0 to U4). The division ratio of counters U1 to U4 is determined by the digital code information from the frequency control knobs in the control head such that the output frequency will be 8 1/3 KHz after phase lock. A reference frequency of 8 1/3 KHz for the digital phase detector is produced by dividing a highly stable crystal controlled oscillator operating at 4.266 2/3 MHz by 512. The phase detector produces output pulses proportional to the phase difference. After amplification and limiting, a low pass filter is used to integrate the output pulses. The resultant dc voltage varies the voltage variable capacitor of the VCO to a value required for proper phase lock



PRC-66 FREQUENCY SYNTHESIZER BLOCK DIAGRAM

FIG. 4-33

and consequently, the proper operating frequency.

The block diagram for a simple system appears in figure 4-33A. When the system is phase locked, the frequency at the counter output is exactly the same as the reference frequency. The frequency of the VCO must therefore be:

$$F_{vco} = p(F_r)$$

where F_r is the reference frequency and p is the counter ratio. The counter ratio is the number of input pulses required to produce one output pulse. If p is reduced by 1, for example from 810 to 809, the frequency of the vco becomes

$$F'_{vco} = (p-1)(F_r)$$

and

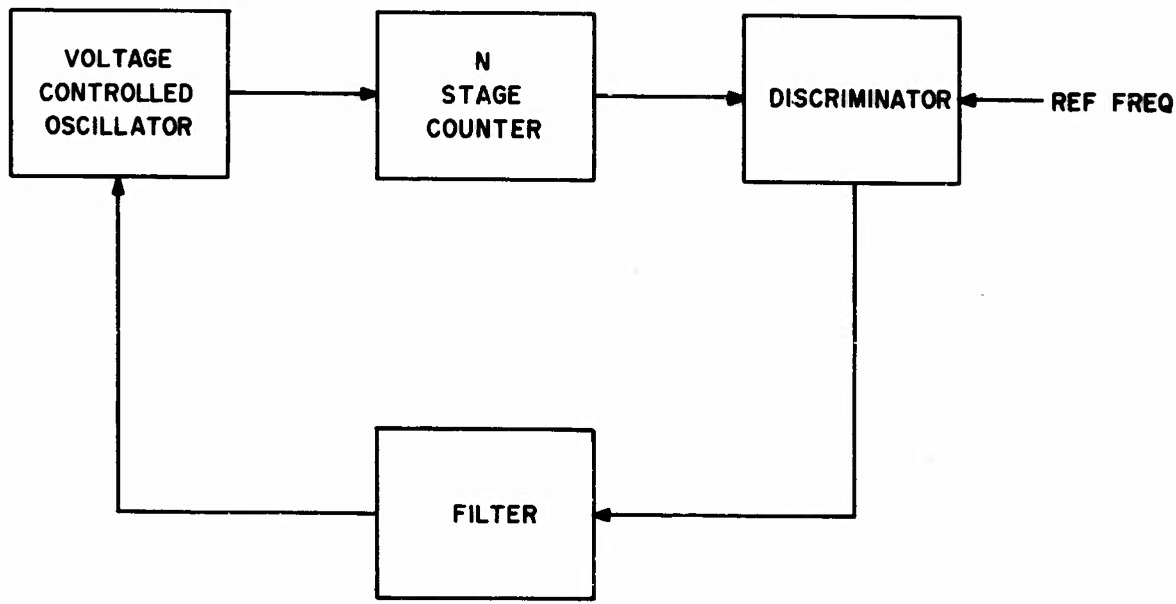
$$\Delta F_{vco} = F_{vco} - F'_{vco} = p(F_r) - p(F_r) + F_r = F_r$$

Consequently, the minimum change in frequency that can be realized is equal to the reference frequency.

The discriminator is a combination phase and frequency detector. It is a simple bistable multivibrator or set-reset flip-flop. Figure 4-33B is the circuit of such a discriminator. Figure 4-33C section (a) shows the waveform at the right-hand collector of the discriminator when the reference frequency (1000 cps) exceeds the counter output frequency by 100 cps. This waveform can be considered to be a series of 1-kc pulses of varying width. Each pulse will have an average value of

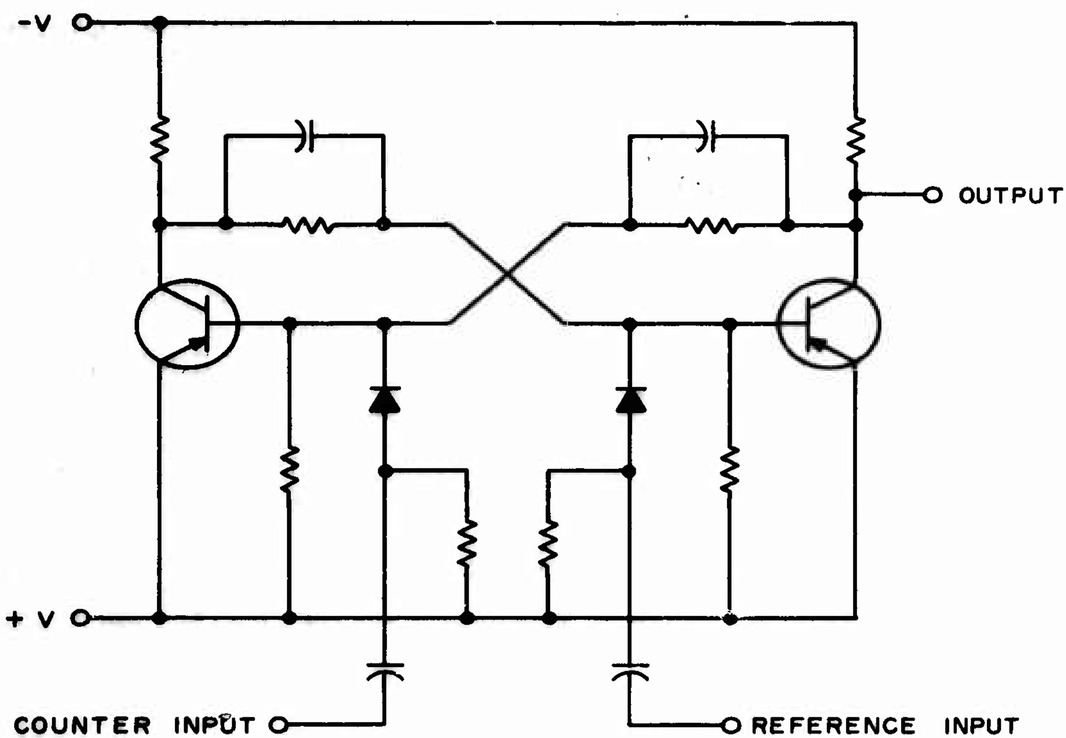
$$V_{avg} = (t_n)(V_{max}) / (T)$$

where t_n is the pulse width in seconds and T is the period. The



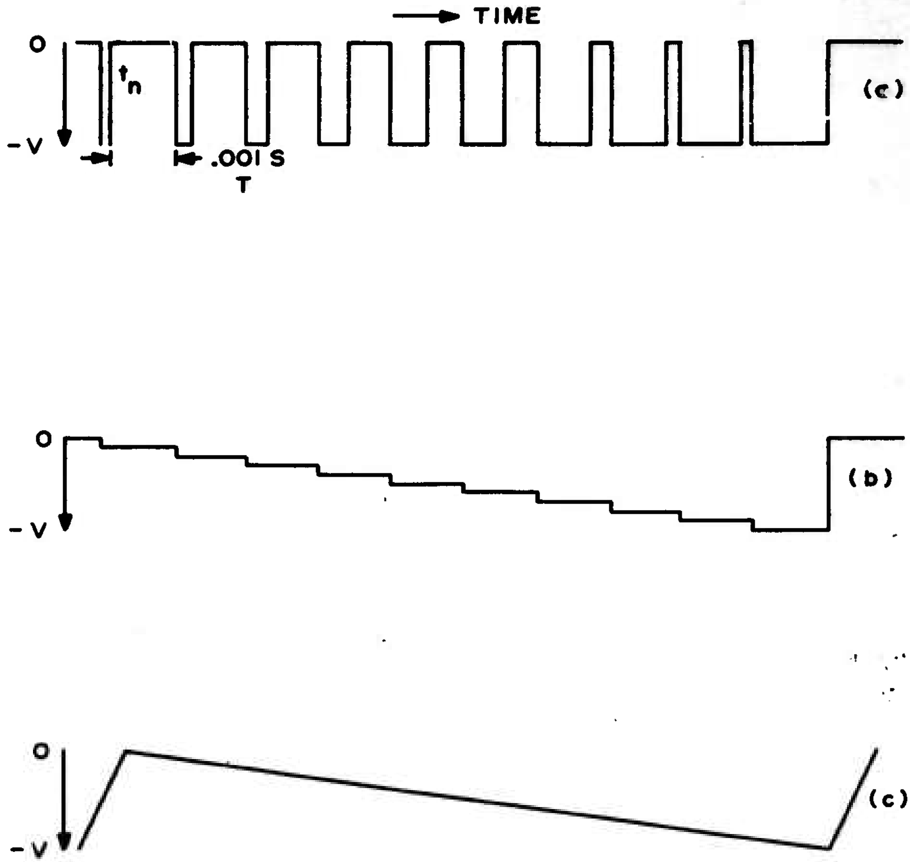
SYSTEM SIMPLIFIED BLOCK DIAGRAM

FIG. 4-33A



PHASE DISCRIMINATOR

FIG. 4-33B



DISCRIMINATOR OUTPUT – Fr EXCEEDS Fc+
FIG. 4-33C

composite average value wave shape is shown in section (b) of Figure 4-33C. The low-pass or notch filter passes the average value of each pulse, but attenuates the 1-kc step function, resulting in the curve of figure 4-33C section (c). It is this voltage that is applied to the solid-state capacitor in the vco.

Figure 4-33D section (a) shows the waveform at the same point when the reference frequency is 100 cps lower than the counter output. This voltage, when integrated by the filter, is the saw-tooth wave of figure 4-33D section (c). Consequently, a saw-tooth of voltage with a positive slope is generated when the reference frequency is lower than the counter output and a saw-tooth of voltage with a negative slope is generated when the reference frequency is higherthan the counter output. Under these conditions, the circuit is a frequency discriminator.

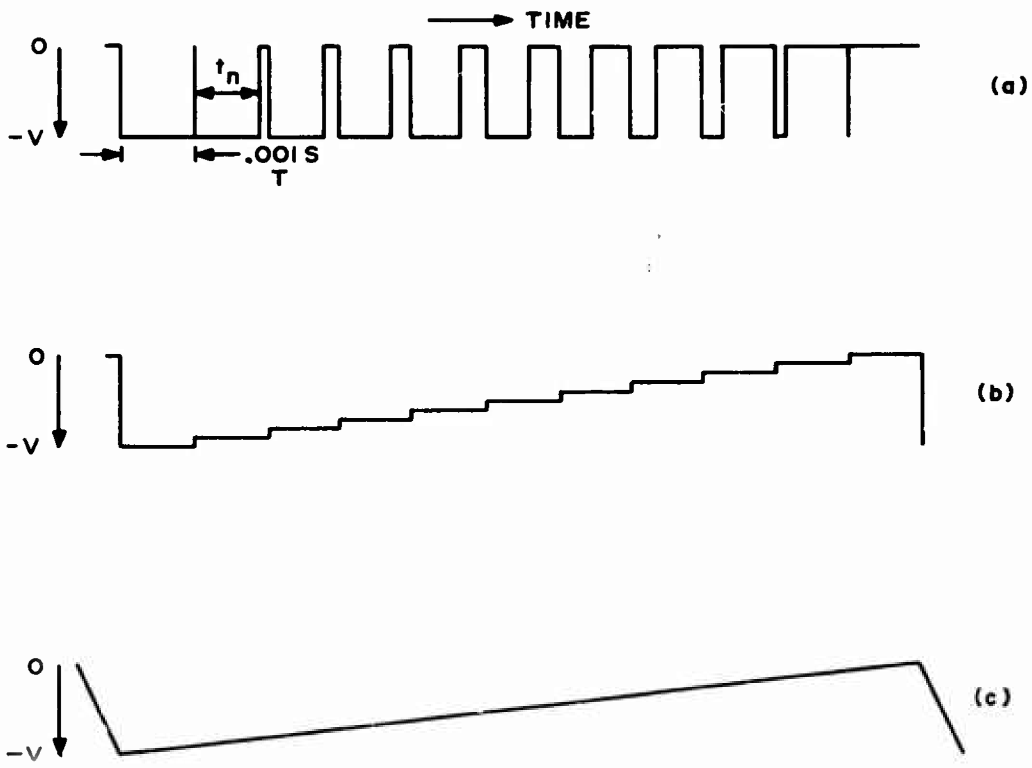
When the reference frequency just equals the counter output frequency, the wave shapes of figure 4-33E are obtained. The average value of this voltage is

$$V_{avg} = (T_1)\ (V_{max})/T$$

This must be the exact value to hold the vco at $p(F_r)$. If it is not, the phase of the vco is shifted until this condition is met. Figure 4-33E section (a) is the discriminator output for a frequency at the low end of a given tuning range and figure 4-33E section (b) is the output for a frequency at the high end of the same tuning range. In this respect, the circuit of figure 4-33B is a phase discriminator. Power drain of the phase discriminator is 30 mW.

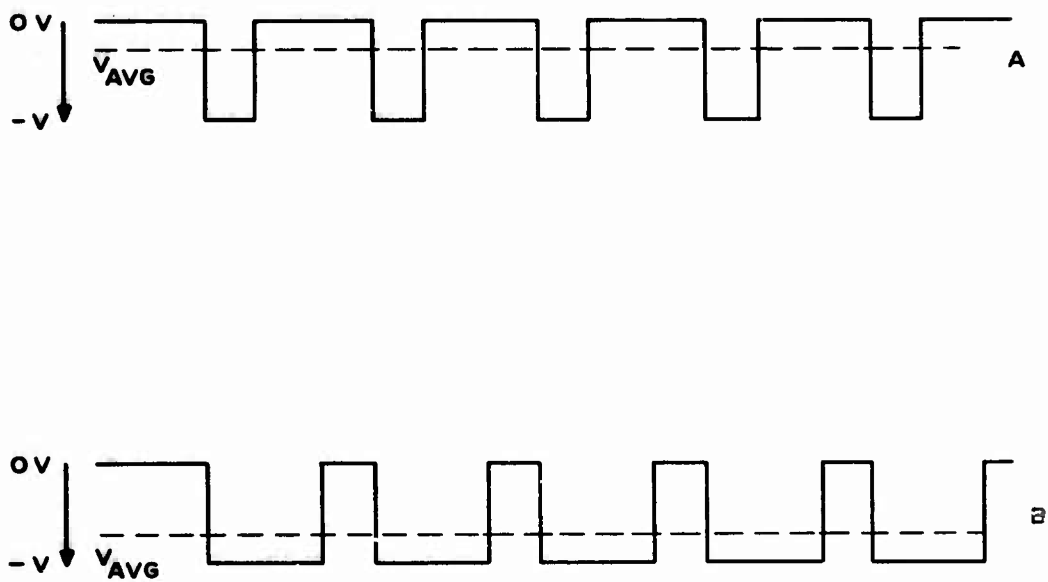
(b) External Performance Characteristics

In addition to the operating frequency range outlined in paragraph 4.3.2.1 (a), the following important characteristics are of interest. The coaxial output circuit furnishes a minimum level



DISCRIMINATOR OUTPUT – Fct EXCEEDS Fr

FIG. 4-33D



DISCRIMINATOR OUTPUT FOR
PHASE-LOCK CONDITIONS

FIG. 4-33E

of +7 dbm into 50 ohms. The frequency accuracy of the synthesizer output (which almost exclusively determines the frequency accuracy of the complete transceiver) is held within ± 10 parts per million (ppm) over the operating temperature and supply voltage range.

Much attention has been paid to minimizing non-harmonic spurious output signals, particularly those which are generated by the frequency dividers. Proper attention to ground paths, use of a double-filtered module connector, adequate shielding, and improved circuit configuration and buffering enhance the isolation between these dividers and susceptible circuits in the rest of the transceiver. These measures have been successful in reducing the spurious output levels well beyond the 60 db level previously given, particularly in those regions where they could create "birdie" responses in the receiver. It was necessary to increase the overall length of the frequency synthesizer by about 0.3 inches over the size given in the Interim TDR to incorporate these improvements. The width and height remained unchanged.

Adequate design margin has been provided to ensure proper operation from -30°C to +52°C transceiver ambient and storage capability from -54°C to +68°C. Total power drain is approximately 3.7 watts.

(c) Packaging

The frequency synthesizer is made up of a combination of thin film integrated circuits and silicon monolithic integrated circuits as well as some discrete component circuits. Discrete circuits have been kept to a minimum for size and reliability reasons.

Thin film circuits are used for linear circuits such as the VCO's and the voltage regulators. Thin film circuits are very versatile and, in most cases, superior to semiconductor integrated circuits for custom designed linear circuits. The advantages are lower cost, shorter turn around time, lower current drain, tighter tolerance and wider range in resistor and capacitor values.

Thin film circuits are also used for the highest speed logic switching required in the synthesizer. Technology at present is such that flip flops with sufficiently small propagation delays and current drain are not available with semiconductor integrated circuits. In some applications where the distributed capacitance and inductance are hard to control, thin film circuits have worked at higher speeds than even the discrete component models. The high speed counters utilizing thin film integrated circuits are U0, U1 and U2.

Lower speed counters U3, U4 and U5 utilize the semiconductor integrated circuits in order to take advantage of their smaller size, increased reliability, and potential lower production cost. Cost tends to be lower in those cases where digital circuits are produced in sufficiently high volume by several semiconductor integrated circuit manufacturers. Interconnection is of major importance in a circuit as complex as the frequency synthesizer. One double-sided printed circuit board is used to interconnect the various thin film packets and integrated circuit counter assemblies with each other and with the module connector. Plated through holes are used to interconnect the two sides of this board.

4.3.2.2 Frequency Synthesizer Module Design

The following paragraphs describe the functional units in the frequency synthesizer module.

(a) Frequency Standard

The frequency standard operates at a frequency of 4.2666 MHz. It is designed around a semiconductor integrated circuit (IC), with the crystal and other frequency determining components external to the IC flat pack. It is constructed on a small circuit board and then encapsulated. The circuitry is a conventional Pierce oscillator circuit driving a direct coupled common emitter stage. Another common emitter amplifier stage is ac coupled and provides buffering as well as wave shaping. Power consumption is approximately 111 mW.

(b) Voltage Regulator

The voltage regulator is contained in one thin film package and provides the stringent filtering requirement and dc voltage stability required by the buffer amplifier, frequency standard and the limiter amplifier. Two series regulators are used; one supplies 12 volts regulated output from 24 volts input and feeds the frequency standard and the limiter amplifier, the other supplies 6 volts regulated output from 12 volts input and feeds the buffer amplifier. Both regulators obtain their reference voltage from Zener diode circuits. The total power consumption is approximately 1.0 W.

(c) Voltage Controlled Oscillator

The voltage controlled oscillators are the only variable frequency tuned circuits required in the frequency synthesizer. The required oscillator range of 65 MHz to 133.3166 MHz is divided into 6 bands. Each band is covered by a separate oscillator. The oscillators are electronically tuned by application of a dc control voltage to the voltage variable capacitors in the oscillator circuits. No tuning information other than band information is required. The frequency range covered by the six oscillators is as follows:

Band	Frequency Range
A	65.0000 - 73.3167
B	73.333 - 83.3167
C	83.333 - 93.3167
D	93.333 -106.5000
E	106.666 -119.983
F	120.000 -133.316

The six oscillators are contained in three thin film packages with two oscillators in each package. Power consumption of any one VCO is approximately 12 mW.

(d) Buffer Amplifier

The buffer amplifier provides amplification and isolation for the voltage controlled oscillator output signals. It has a single output which provides the input to the first divider in the stabilized master oscillator control loop. The buffer amplifier requires one thin film package. Power consumption is approximately 216 mW.

(e) Binary Divider UO

Binary divider UO provides a fixed division by two of the input frequency. It must operate with input frequencies over the range of 65 to 133.3 MHz. Because of the high input frequencies and the accompanying high digital switching speeds, a satisfactory logic circuit cannot be realized by the semiconductor integrated circuit process at the present. Binary divider UO requires one thin film package. Power consumption is approximately 166 mW.

(f) Digit Counter U1

Digit counter U1 must operate with input frequencies over the range of 32.5 MHz to 66.6 MHz. Basically, the counter divides the input frequency by 2.

However, where the frequency controls are set for a frequency ending in 50 KHz, it must divide by 3 once during each full counter sequence. Thus, a resettable sequential circuit is required. The requirement of small propagation delay again precludes this circuit function from being attained by the use of semiconductor integrated circuits. A logic diagram of U1 is shown in Figure 4-34.

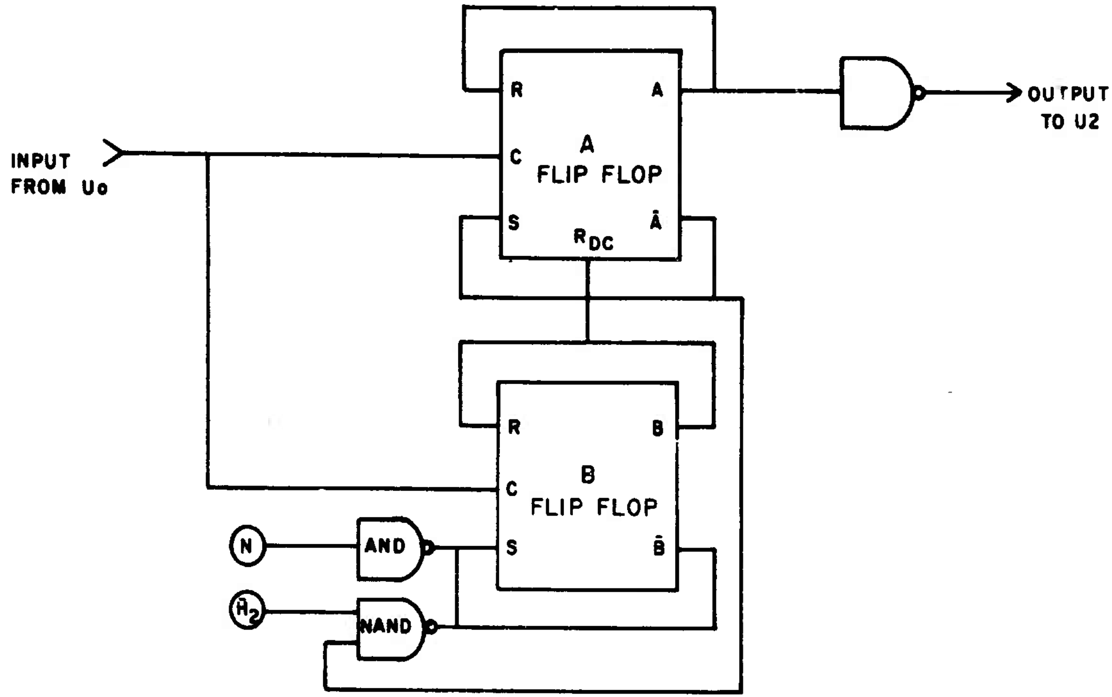
U1 Detailed Description

U-1 is a thin film packet containing two flip-flops and associated control gates. It may be seen that if the N line is grounded (ie: 50 KHz switch in the .XO position) point S is held low and the B flip-flop remains with a 0 on its true output. This is connected to the reset terminal of the A flip-flop and permits it to divide by 2 continuously.

When the 50 KHz control is in a .X5 position, wire N is opened enabling the control of the B flip-flop to perform by $\overline{H2}$ and $\overline{A}$. The method of accomplishing the desired single divide by 3 can be seen from the idealized timing diagram Fig. 4.34A. Power consumption is approximately 223 mW.

(g) Decade Counter U2

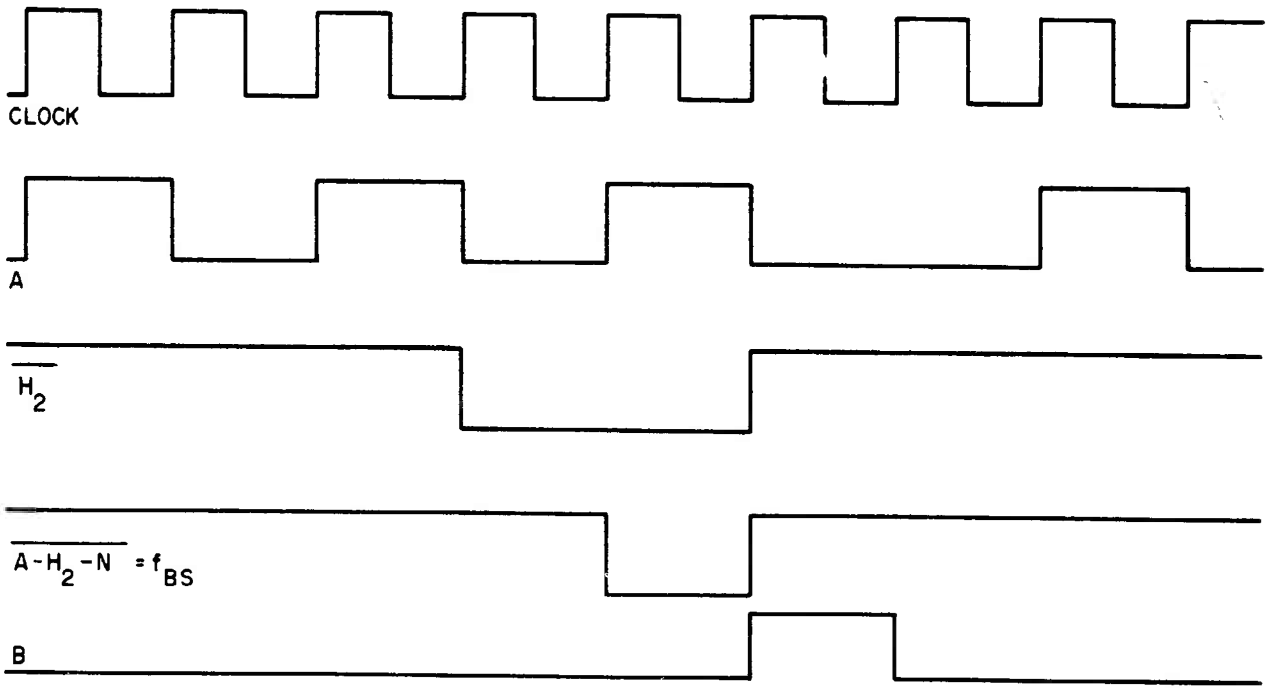
Decade counter U2 is a high speed synchrouous counter. Basically, it divides the input pulse rate by 10. However, when the frequency controls are set for 0.100 MHz digit other than a zero, it must make a "long count" once during each full counter sequence. The long count duration is determined by the 0.1 MHz control setting and is in the range of from 11 to 19. The maximum input pulse rate to U2 is 33.3 MHz and the maximum output pulse rate is 3.33 MHz. Decade counter U2 is constructed using 4 thin film packets at the present. A diagram of the circuit is shown in Figure 4-35. Power consumption is approximately 1.15 watts.



LOGIC DIAGRAM

U_1 DIGIT COUNTER

FIG. 4-34



IDEALIZED TIMING DIAGRAM U-I

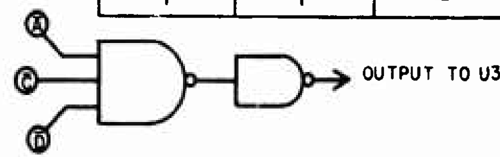
FIG 4-34A

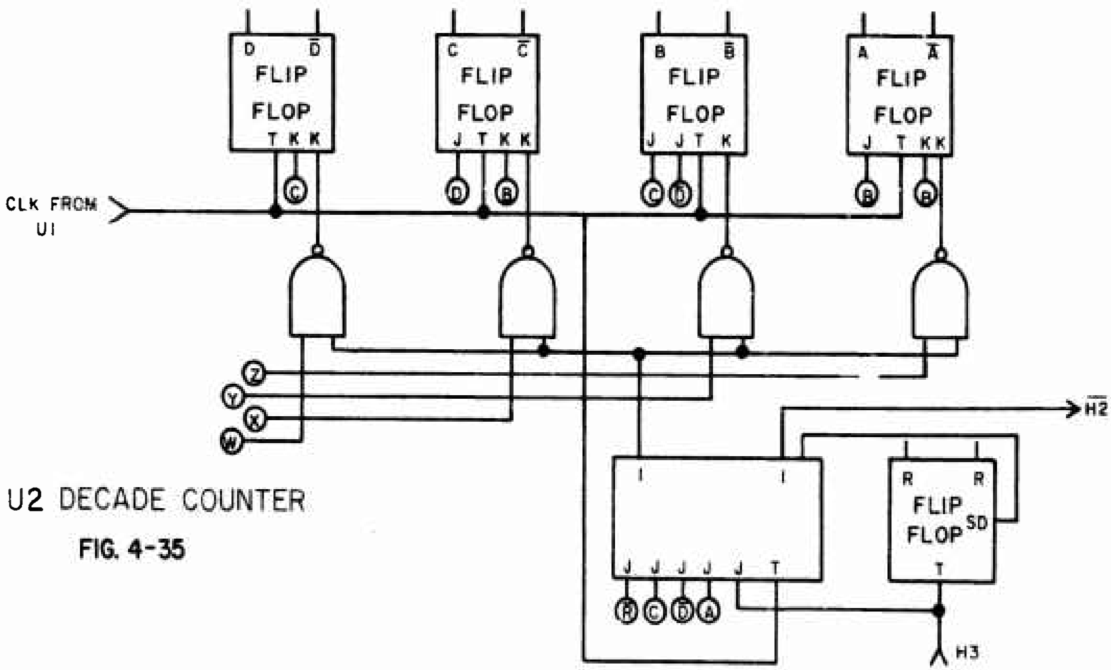
DIAL DIGIT	CONTROL CODE			
	W	X	Y	Z
0	0	0	0	0
1	1	1	1	1
2	0	1	0	1
3	1	1	0	1
4	1	0	0	1
5	0	0	0	1
6	1	1	1	0
7	0	1	0	0
8	1	1	0	0
9	1	0	0	0

COUNT SEQUENCE			
A	B	C	D
0	0	0	0
0	0	0	1
0	0	1	1
0	0	1	0
0	1	1	1
1	0	0	0
1	0	0	1
1	0	1	1
1	0	1	0
1	1	1	1

J K FLIP-FLOP TRUTH TABLE

TRUE OUTPUT		J	K
PRESENT	NEXT		
0	0	0	–
0	1	1	–
1	0	–	1
1	1	–	0





U2 DECADE COUNTER

FIG. 4-35

U-2 Detailed

Figure 4-35 shows the count sequence of U-2 and the associated control code to "long-count" by the desired number. Note that the count sequence does not follow in the normal binary number order but is an "odd-ball" designed to provide maximum simplicity in the basic decade gating.

Normally, with H-3 reset pulse absent, the resetting flip-flops I and R remain in the 0 state and this output from the I binary forms one input of each of the 4 reset NAND gates forcing their outputs to the 1 state regardless of the control wire code. These 1's are AND'ed with the other inputs to the K terminals of the basic flip-flops A thru D permitting the counter to perform continuous division by 10. The output state is the all 0 state since it is not used when performing the long count. Note also that the function $\overline{H2}$ is normally at a 1 level.

However, when the decade is to perform its single long count, H-3 becomes a 1 and the function $AC\overline{D}RH3$ recognizes the 8th counter state (1010) and sets up the J terminal of the I flip-flop so that the next incoming pulse changes its output to a 1. This same clock pulse also sets the basic counter to the 9th state (1111). As soon as this occurs (and before the next clock pulse,) R is set to a 1 by its DC Set terminal. The 1 output of the I binary is NAND'ed with the prevailing control code produced by the 0.1 MHz control knob, generating a 1 on the K terminals of those basic flip-flops (A thru D) which require resetting to 0 to enter the desired counter state for the counter ratio required. Conversely, a 0 is generated on the K terminals of those flip-flops which are to remain a 1.

The next clock pulse effects this transition into the desired state as well as resetting the I binary to 0 (since its K terminal is a 1). Note that the I flip-flop cannot return to a 1 again when passing thru the count sequence until H3 has returned to a 0 since the function $AC\overline{DR}H3$ on the J terminal of I is held to a 0 by $\overline{R}$ and the R binary is clocked by H3. Fig. 4-35A is a sample idealized timing diagram where the counter is resetting to the 7th state (i.e. the 0.1 MHz control is in the 3 positions

(h) Decade Councer U3

Decade counter U3 is a synchronous counter with a synchronous reset. Basically, it divides the input pulse rate by 10 with a long count of from 11 to 19 once each full counter sequence as determined by the 1.0 MHz control setting and if the 1.0 MHz setting is not zero. With the use of a synchronous reset, the counter is not required at any time to operate at a speed higher than the maximum input pulse rate of 3.33 MHz. The maximum output pulse rate is 0.333 MHz. Decade counter U3 is constructed using semiconductor integrated circuit flat-packs mounted on a double-sided printed circuit board. A diagram of the circuit is shown in Figure 4-36. Power consumption is approximately 295 mW.

(i) Digit Counter U4

Digit counter U4 is a low speed asynchronous, or long chain, counter. The maximum input pulse rate is 333 kHz. The counter is simply a frequency divider with a controllable division ratio. Any division ratio from 19 to 39 can be selected and is determined by the setting of the 10.0 MHz frequency control. The counter is constructed using integrated circuit flat packs mounted on a double-sided printed circuit board. A diagram of the counter is shown in Figure 4-37. Power consumption is approximately 236 mW.

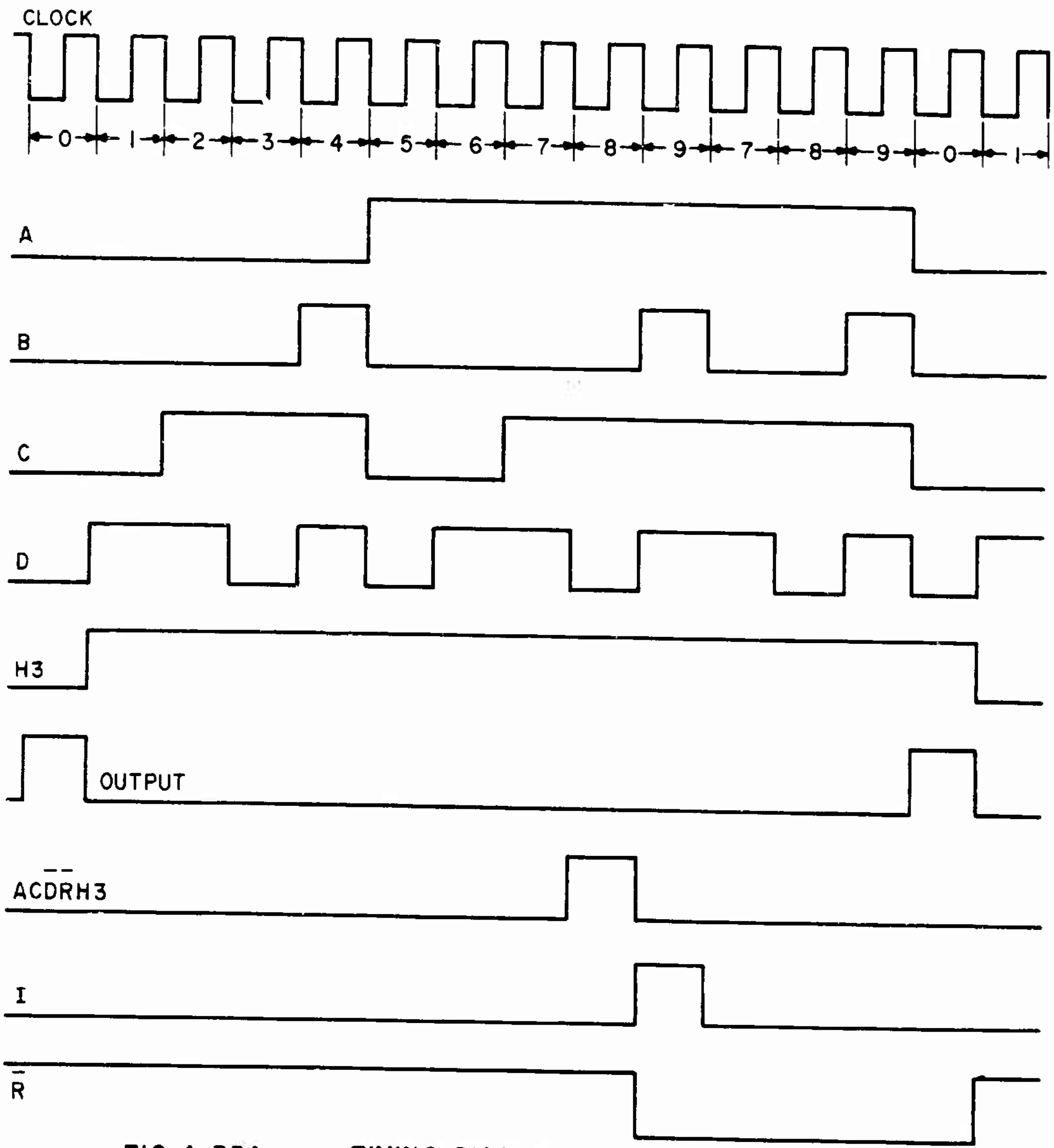
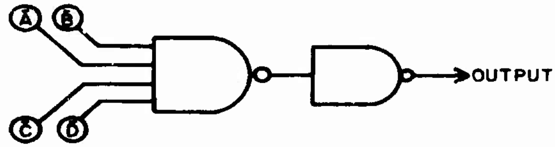
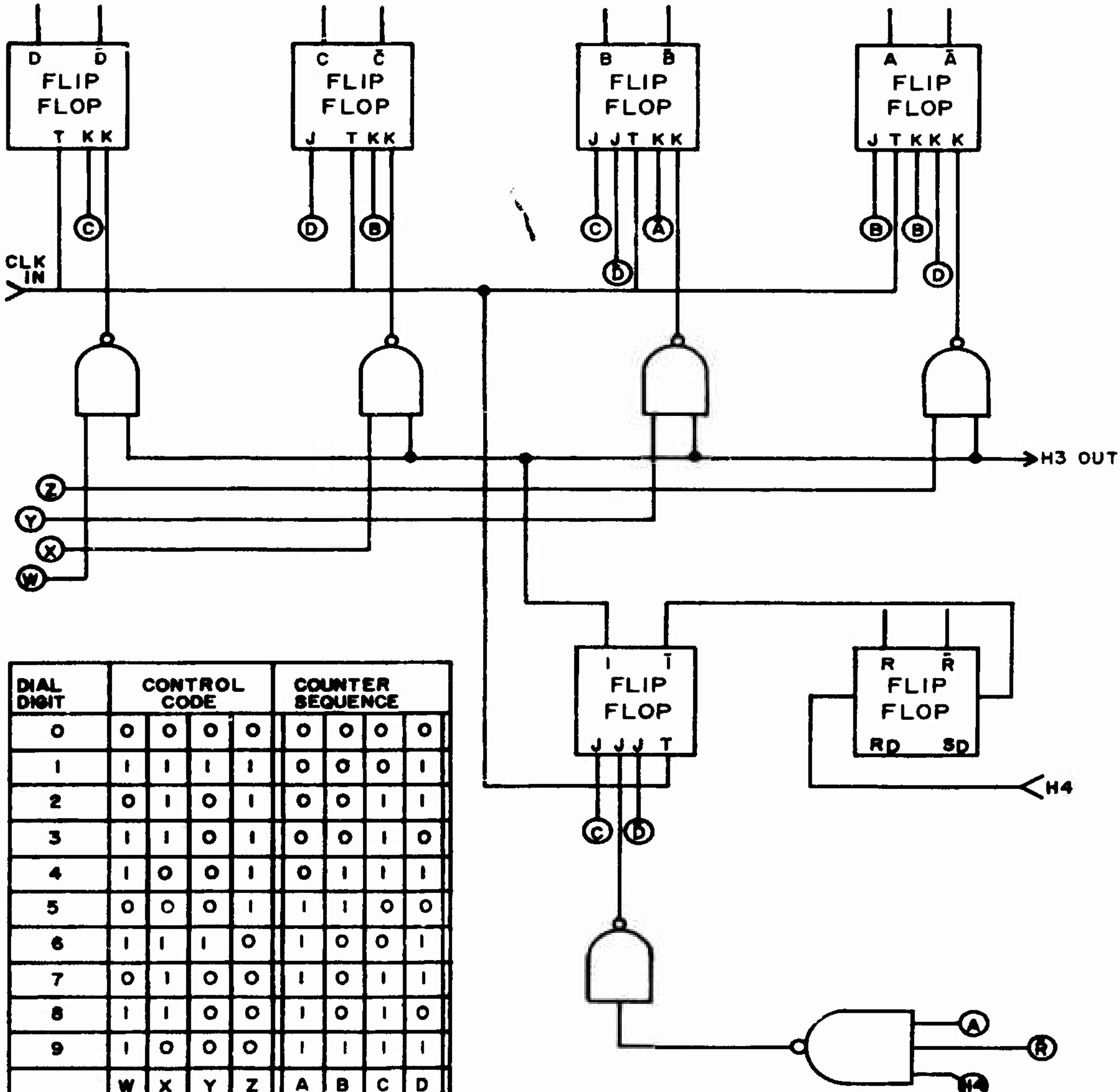


FIG 4-35A TIMING DIAGRAM U-2

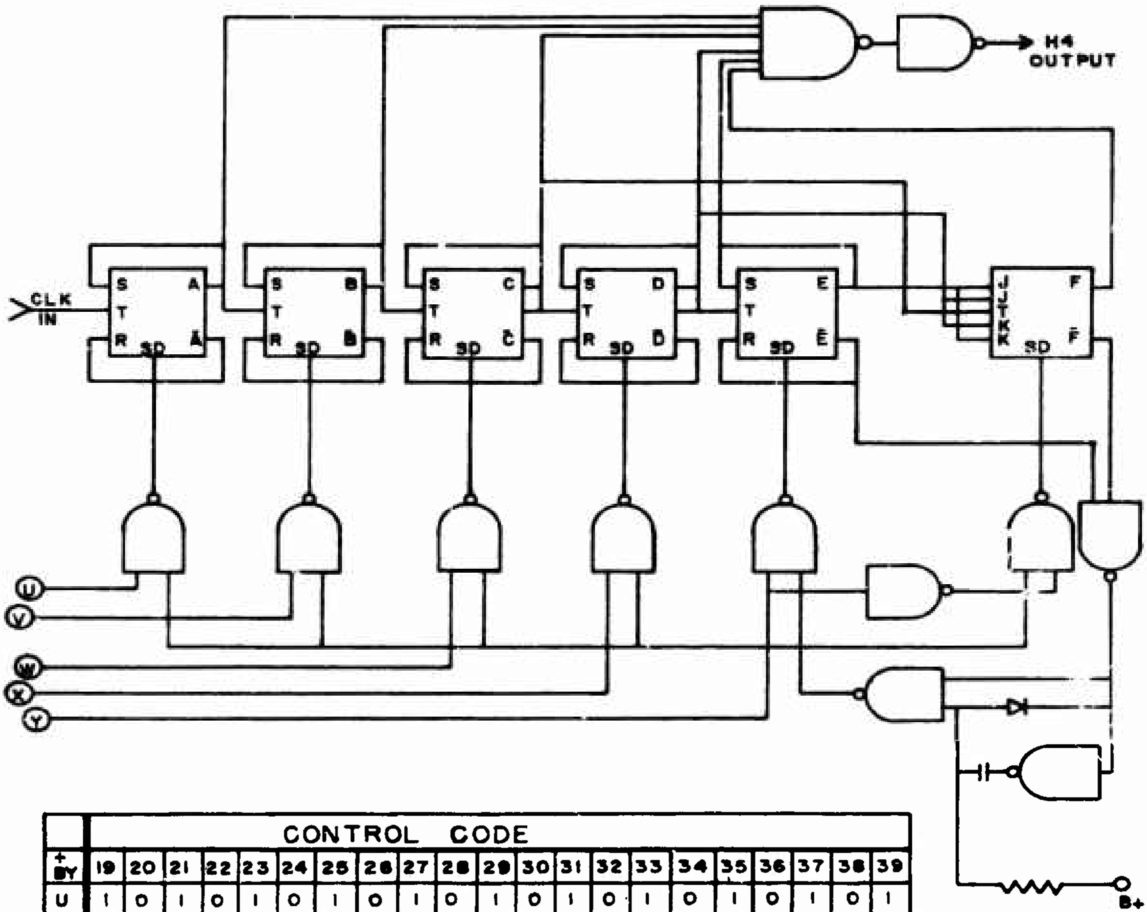




DIAL DIGIT	CONTROL CODE				COUNTER SEQUENCE			
0	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	1
2	0	1	0	1	0	0	1	1
3	1	1	0	1	0	0	1	0
4	1	0	0	1	0	1	1	1
5	0	0	0	1	1	1	0	0
6	1	1	1	0	1	0	0	1
7	0	1	0	0	1	0	1	1
8	1	1	0	0	1	0	1	0
9	1	0	0	0	1	1	1	1
	W	X	Y	Z	A	B	C	D

(ALL GATES ARE NAND)

U-3 DECADE COUNTER FIG. 4-36



	CONTROL CODE																				
+ BY	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
U	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
V	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
W	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
X	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

U4 DIGIT COUNTER

FIG. 4-37

U-4 Detailed Operation

The following table 4-37A shows the count sequence of U4 and the associated control codes to divide by the desired number. It is primarily a long-chain, divide-by-sixty-four (asynchronous) in which only certain of the possible 64 states are used. Note here that the count sequence follows in a normal binary number order in contrast with U-2 and U-3.

The resetting operation in U-4 is accomplished as follows. Assume the counter has counted thru to state 63 (A thru F are all "1's"). The next clock pulse will reset all the true outputs to "0". A resetting function $\overline{E}\,\overline{F}$ is generated by the two NAND gates which becomes a "1" as both E and F go to "0". This function is NAND'd with the control line signals on lines U, V, W, X, and Y and produces a setting "0" into the DC SET terminal of each flip-flop whose associated control line is a "1". This setting "0" will cause the the true output of that flip-flop to change to a "1". The true output of those flip-flops whose control lines were "0" will remain a "0".

Note from the Count Sequence Table 4-37A that either the E or F flip-flops must always be set by this action (ie. either $\overline{E}$ or $\overline{F}$ must go to a "0") and the setting function $\overline{E} \cdot \overline{F}$ will become an "0" again and the next clock pulse will initiate counting down from the state into which the counter was set (towards state #63).

TABLE 4-37A

COUNT SEQUENCE & CONTROL CODES FOR U-4

STATE #	F	E	D	C	B	A	RESET TO THIS STATE TO DIVIDE BY NUMBER SHOWN	CONTROL CODE U	V	W	X	Y	BAND	10 MHZ CONTROL TX	RX
25	0	1	1	0	0	1	39	1	0	0	1	1		39	--
26	0	1	1	0	1	0	38	0	1	0	1	1	F	38	--
27	0	1	1	0	1	1	37	1	1	0	1	1		37	--
28	0	1	1	1	0	0	36	0	0	1	1	1		36	39
29	0	1	1	1	0	1	35	1	0	1	1	1		35	38
30	0	1	1	1	1	0	34	0	1	1	1	1		34	37
31	0	1	1	1	1	1	33	1	1	1	1	1	E	33	36
32	1	0	0	0	0	0	32	0	0	0	0	0		32	35
33	1	0	0	0	0	1	31	1	0	0	0	0		31	34
34	1	0	0	0	1	0	30	0	1	0	0	0	D	30	33
35	1	0	0	0	1	1	29	1	1	0	0	0		29	32
36	1	0	0	1	0	0	28	0	0	1	0	0		28	31
37	1	0	0	1	0	1	27	1	0	1	0	0		27	30
38	1	0	0	1	1	0	26	0	1	1	0	0	C	26	29
39	1	0	0	1	1	1	25	1	1	1	0	0		25	28
40	1	0	1	0	0	0	24	0	0	0	1	0		24	27
41	1	0	1	0	0	1	23	1	0	0	1	0	B	23	26
42	1	0	1	0	1	0	22	0	1	0	1	0		22	25
43	1	0	1	0	1	1	21	1	1	0	1	0		--	24
44	1	0	1	1	0	0	20	0	0	1	1	0	A	--	23
45	1	0	1	1	0	1	19	1	0	1	1	0		--	22
46	1	0	1	1	1	0									
47	1	0	1	1	1	1									
48	1	1	0	0	0	0									
49	1	1	0	0	0	1									
50	1	1	0	0	1	0									
51	1	1	0	0	1	1									
52	1	1	0	1	0	0									
53	1	1	0	1	0	1									
54	1	1	0	1	1	0									
55	1	1	0	1	1	1									
56	1	1	1	0	0	0									
57	1	1	1	0	0	1									

Note: 0 indicates ground

Continued - Table 4-37A

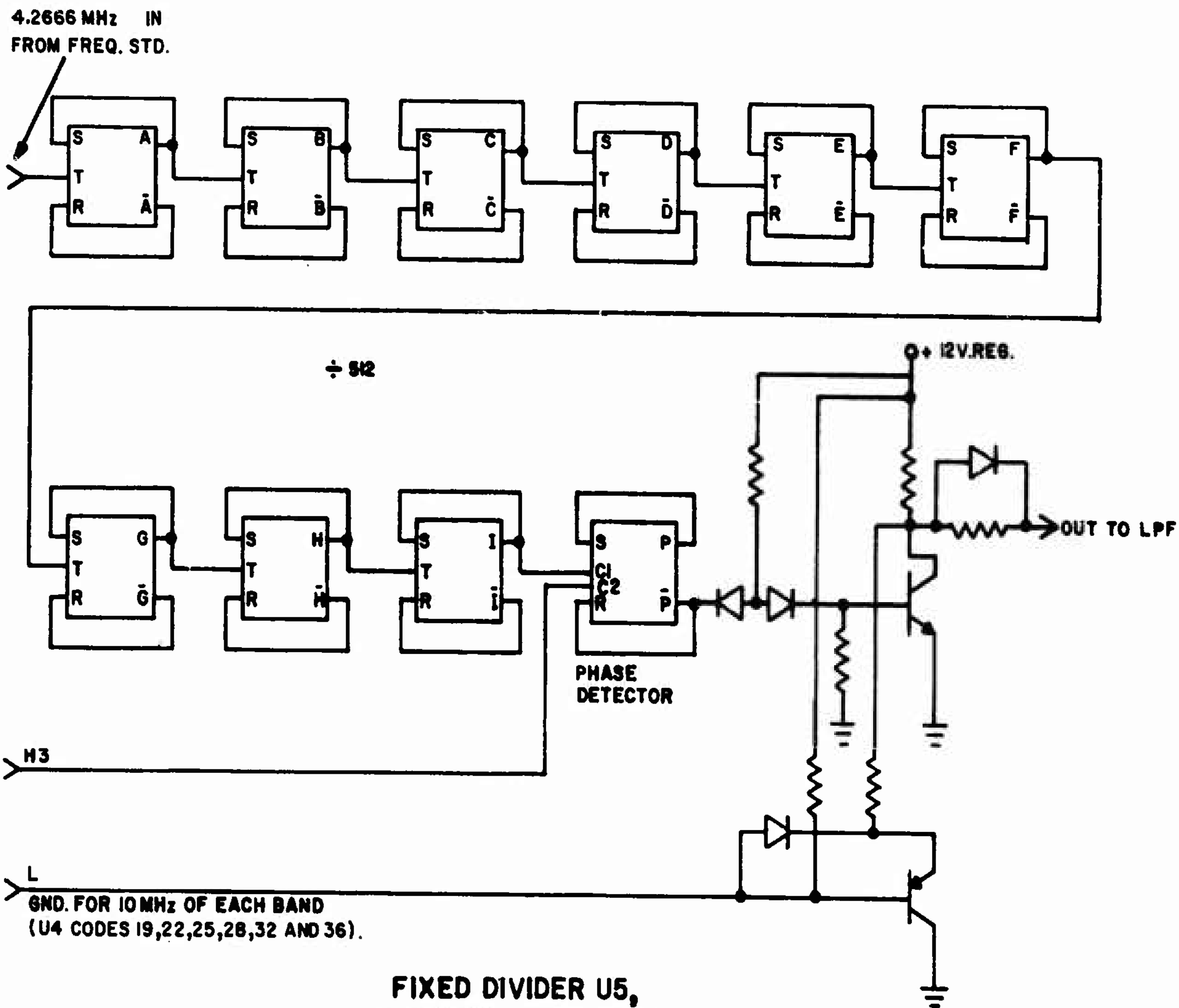
STATE #	F	E	D	C	B	A	RESET TO THIS STATE TO DIVIDE BY NUMBER SHOWN	CONTROL CODE U	V	W	X	Y	BAND	10 MHZ CONTROL TX	RX
58	1	1	1	0	1	0									
59	1	1	1	0	1	1									
60	1	1	1	1	0	0									
61	1	1	1	1	0	1									
62	1	1	1	1	1	0									
63	1	1	1	1	1	1	Output state								
0	0	0	0	0	0	0	Transitory resetting state								

(j) Fixed Divider U5

This circuit includes the fixed divide-by-512 counter, the digital phase detector and the voltage amplifier. The fixed divider provides the 8-1/3 kHz reference frequency for the phase detector. The phase detector compares the signal from the variable divider with the reference frequency. The resulting phase detector output is amplified by the voltage amplifier to obtain the voltage variation required to control the voltage controlled oscillators. This circuit is constructed using integrated circuits, except for the voltage amplifier which uses discrete components, mounted on a double-sided printed circuit board. A circuit diagram is shown in Figure 4-38. Power consumption is approximately 255 mW.

(k) Low Pass Filter

The low pass filter is required in the system to integrate the phase discriminator output and eliminate the 8-1/3 kHz reference frequency from the voltage controlled oscillator dc control line.



FIXED DIVIDER U5,
PHASE DETECTOR AND
LIMITER AMPLIFIER
FIG 4-38

The filter must have 140 db attenuation at the 8-1/3 kHz reference frequency to adequately meet the 70 db sideband requirements. Furthermore, the phase shift must not exceed 90 degrees at frequencies below 900 cps to provide adequate loop stability. A graph of the measured low pass filter attenuation and phase characteristics is shown in Figure 4-39.

(1) Loop Data

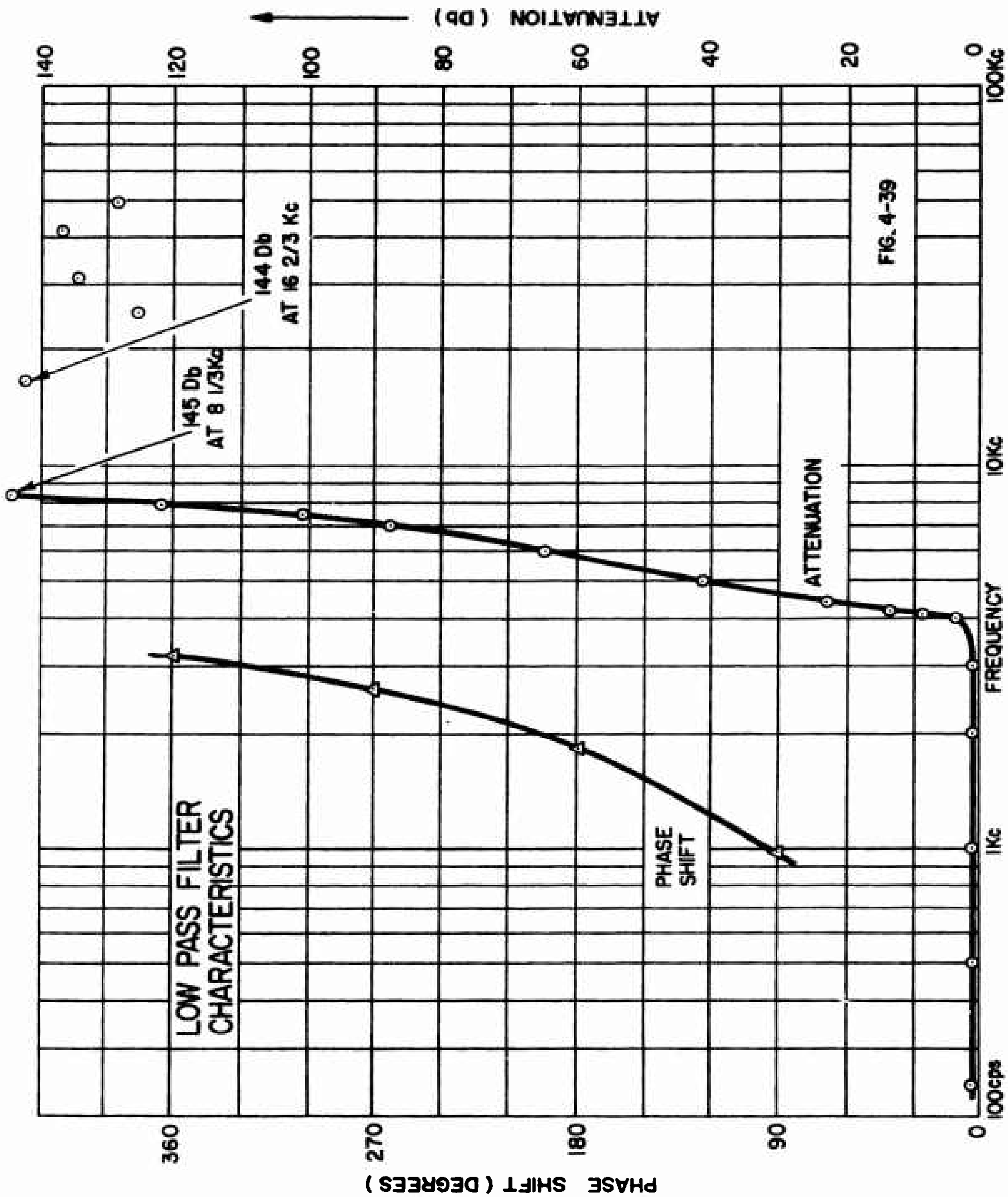
To ensure loop stability, plots of open circuit loop gain versus phase shift were drawn for Band A and Band D. See Figures 4-40 and 4-41. Analysis of the Bode plot shows that the loop, including a lag network, has a loss of at least 6 db when the phase shift is equal to 180°. The lag network is a simple series R, parallel R and C circuit. It decreases the bandwidth of the loop and improves its stability.

A series of curves showing VCO operating frequency versus the dc control voltage are shown in Figures 4-42 to 4-47. The lock range and capture capability are shown and compared with the required capture range as determined by VCO drift vs temperature and tuning error. The results obtained are in accordance with calculated figures and show that adequate margin has been provided in the design.

NOTE

In the preceeding figures 4-34 through 4-38 all the logic gates shown are NAND gates unless otherwise indicated. Operation of the flip flops is described by the following J-K Flip Flop truth table.

J	K	True Output Present	True Output Next
0	-	0	0
1	-	0	1
-	1	1	0
-	0	1	1


LOW PASS FILTER CHARACTERISTICS
FIG. 4-39
ATTENUATION (Db)
0
20
40
60
80
100
120
140
PHASE SHIFT (DEGREES)
0
90
180
270
360
FREQUENCY
100cps
1Kc
10Kc
100Kc
145 Db AT 8 1/3Kc
144 Db AT 16 2/3 Kc
ATTENUATION
PHASE SHIFT

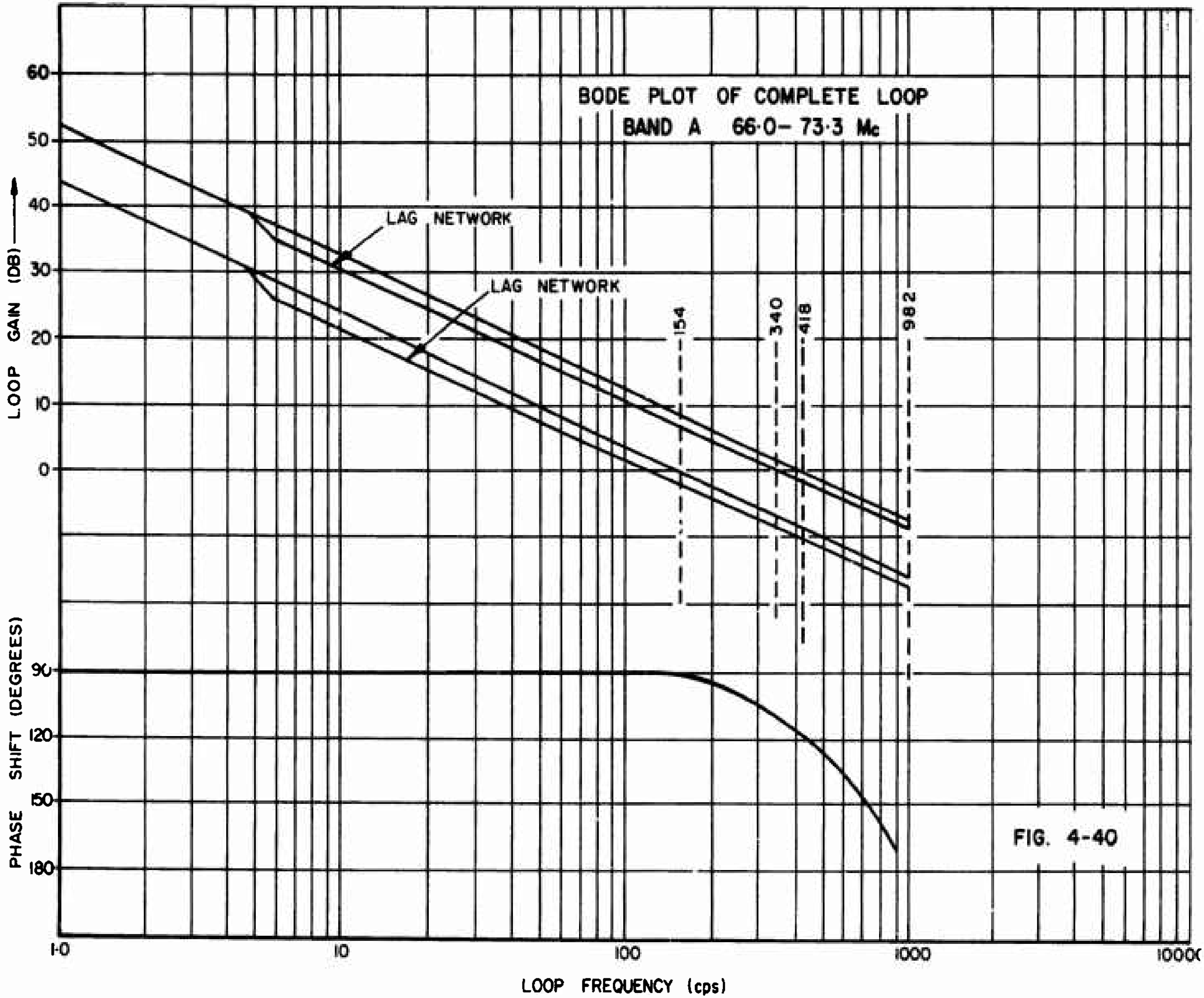

BODE PLOT OF COMPLETE LOOP
BAND A 66·0– 73·3 Mc
LAG NETWORK
LAG NETWORK
154
340
418
982
60
50
40
30
20
10
0
LOOP GAIN (DB)
90
120
150
180
PHASE SHIFT (DEGREES)
1·0
10
100
1000
LOOP FREQUENCY (cps)

FIG. 4-40

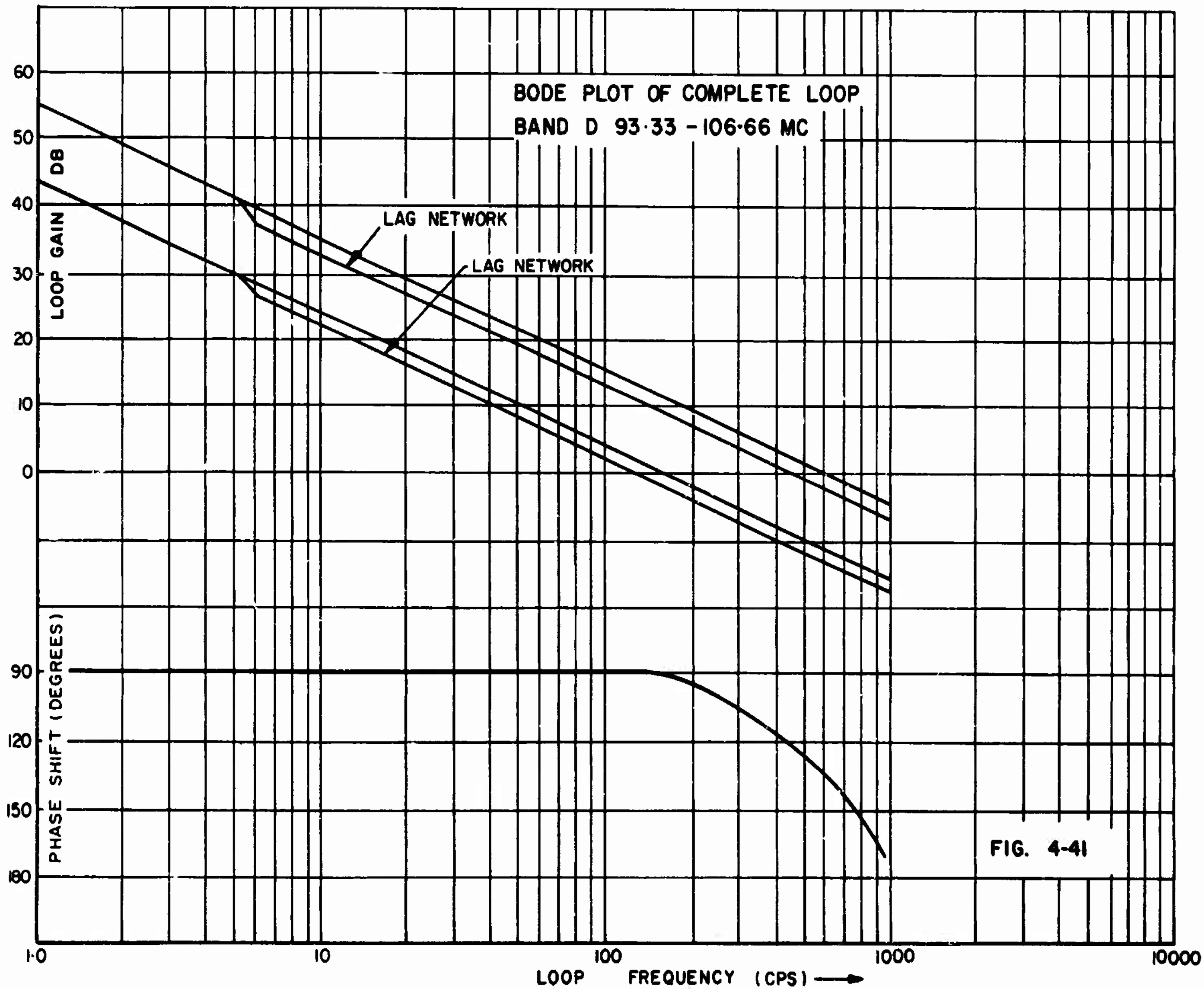
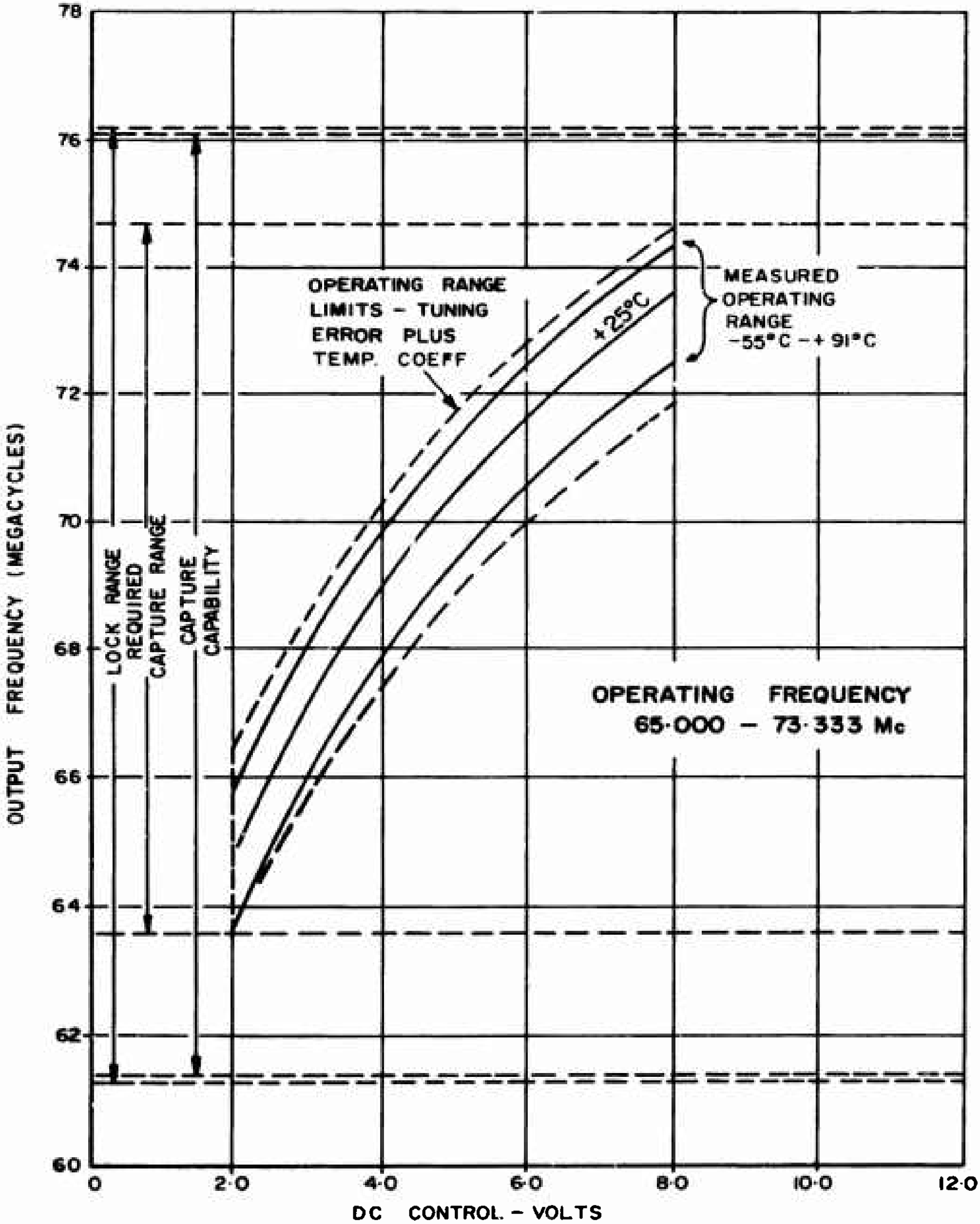
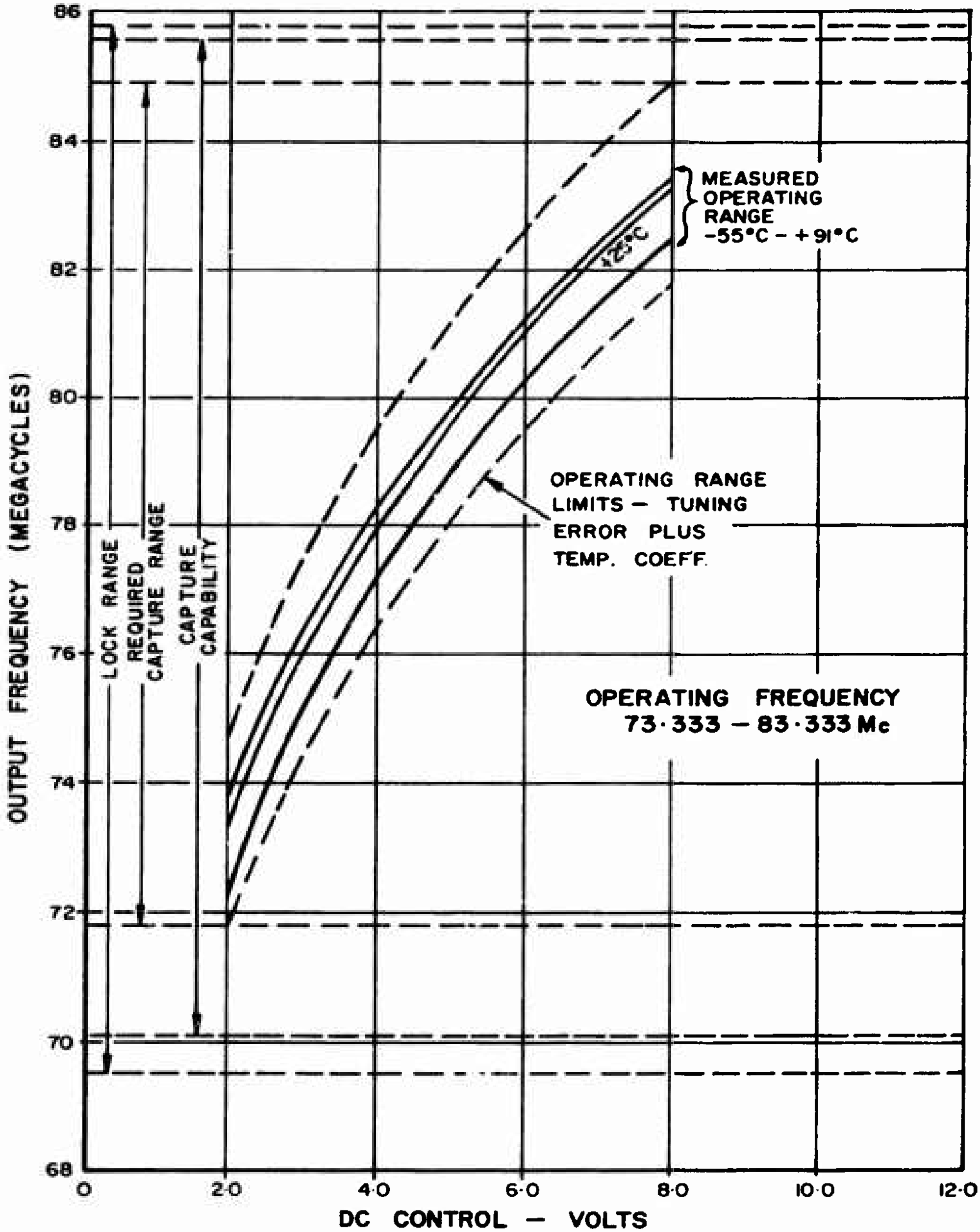

BODE PLOT OF COMPLETE LOOP
BAND D 93·33 - 106·66 MC
LAG NETWORK
LAG NETWORK
LOOP GAIN DB
PHASE SHIFT (DEGREES)
60
50
40
30
20
10
0
90
120
150
180
1·0
10
100
1000
10000
LOOP FREQUENCY (CPS)

FIG. 4-41



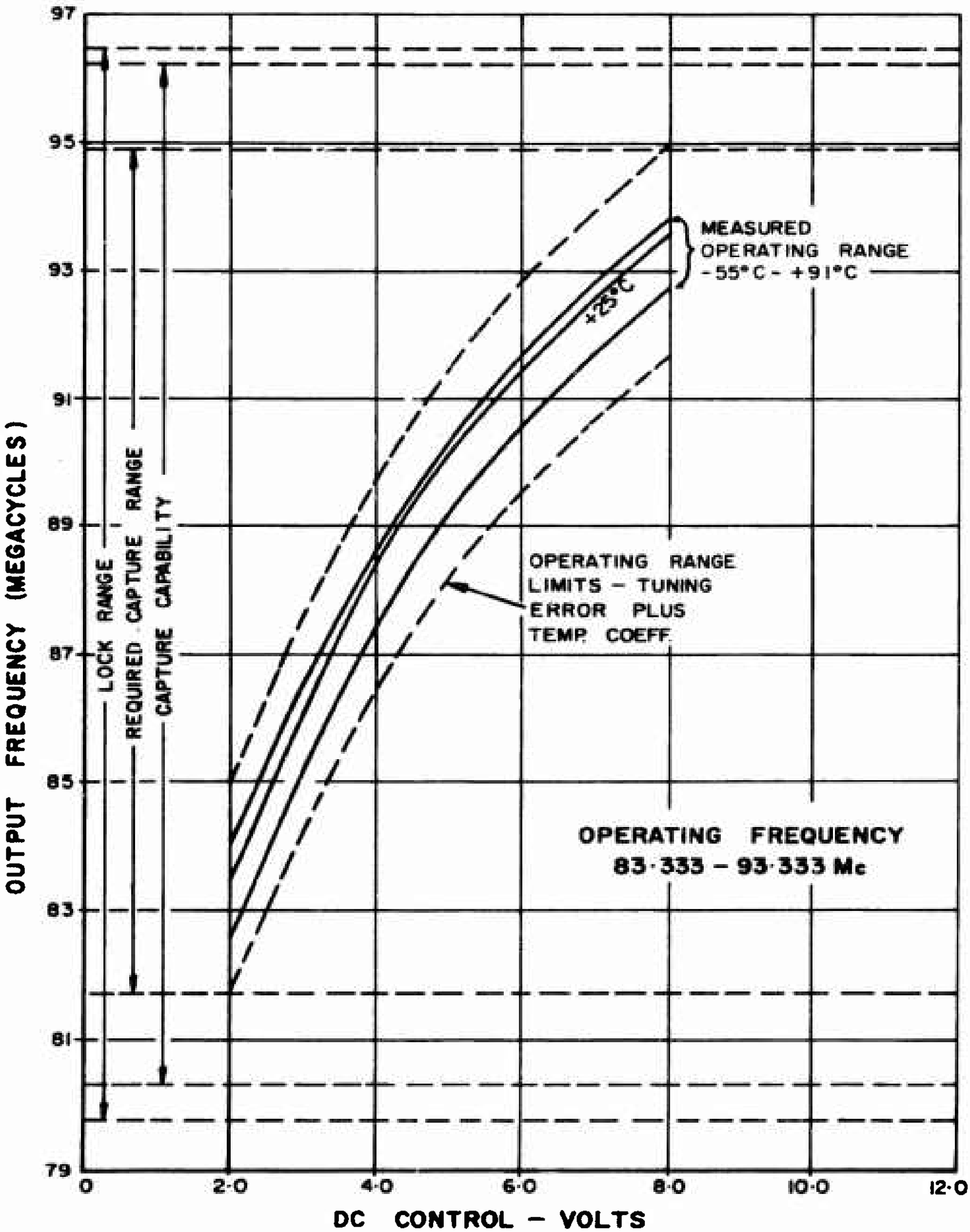
BAND A VOLTAGE CONTROLLED OSCILLATOR

FIG. 4-42



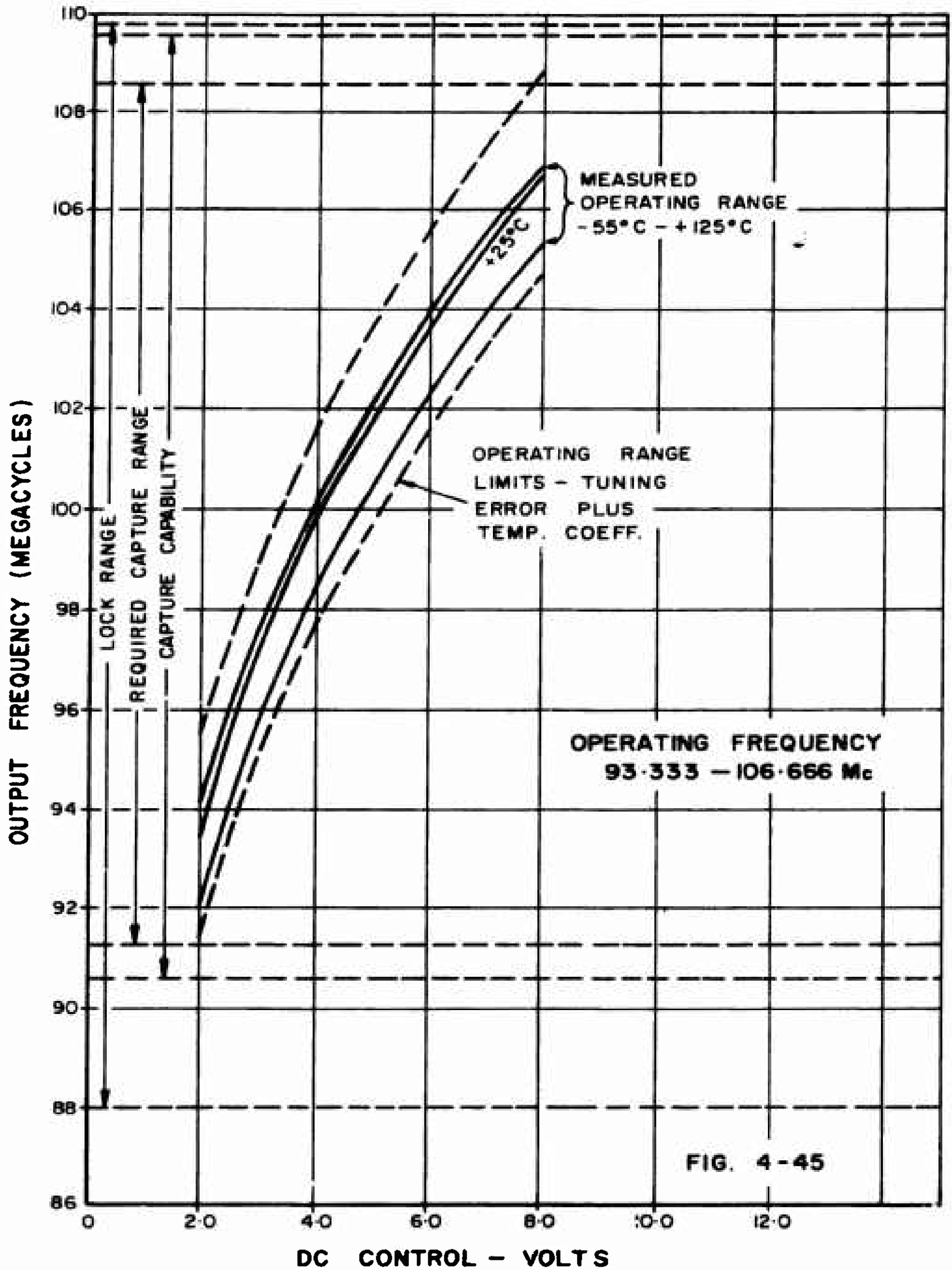
BAND B VOLTAGE CONTROLLED OSCILLATOR

FIG. 4-43



BAND C VOLTAGE CONTROLLED OSCILLATOR

FIG. 4·44



BAND D VOLTAGE CONTROLLED OSCILLATOR

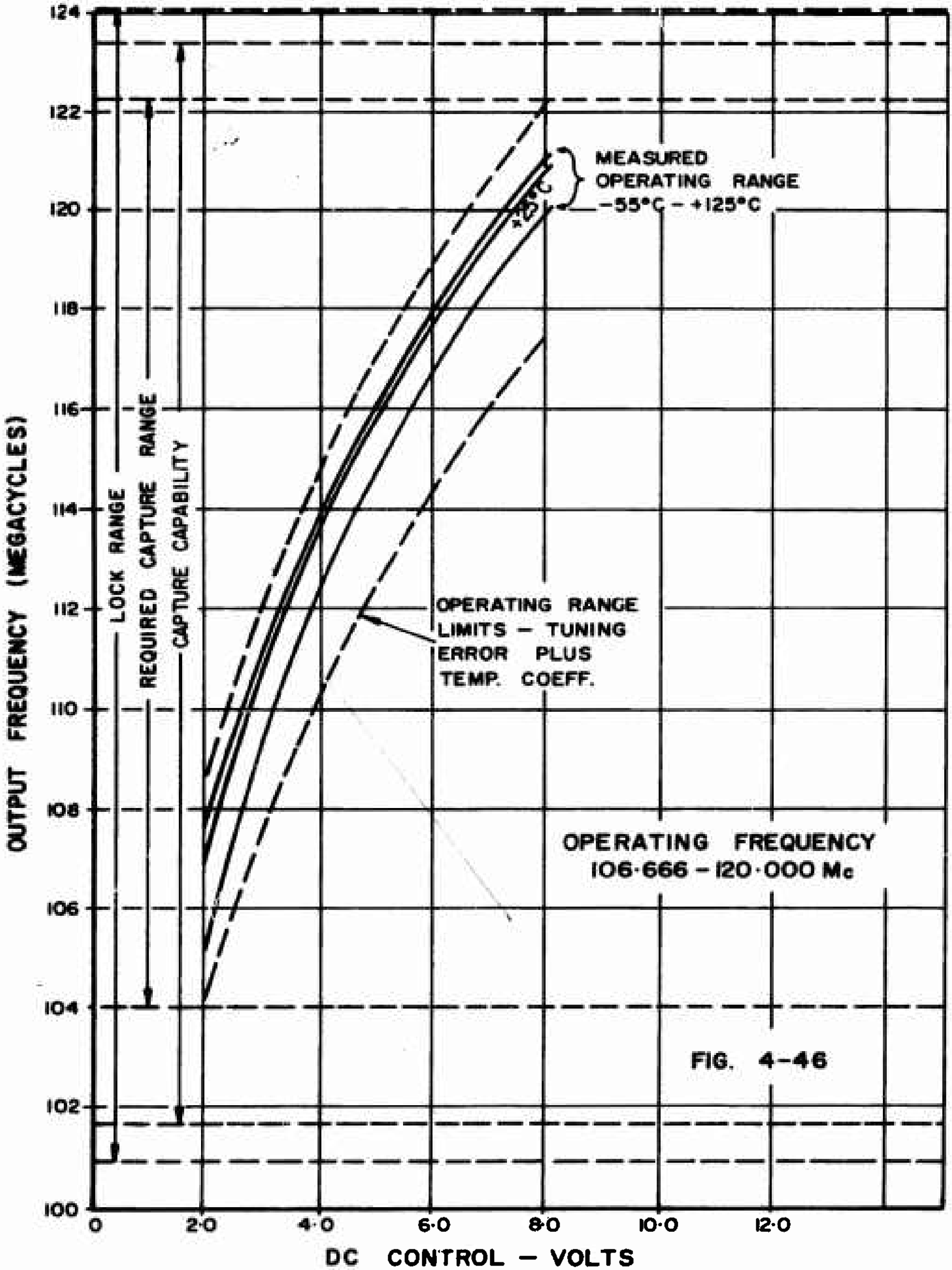
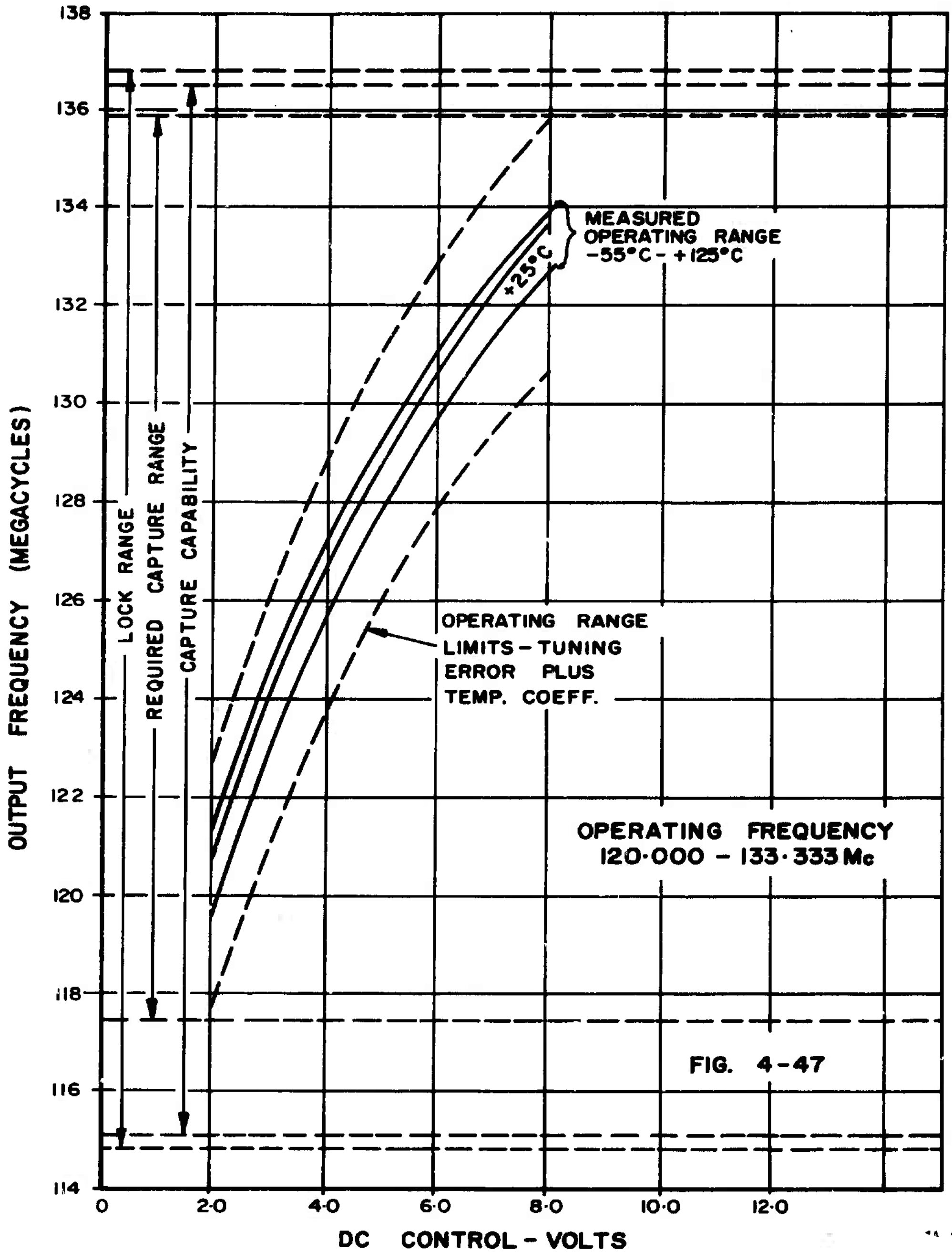


FIG. 4-46

BAND E VOLTAGE CONTROLLED OSCILLATOR



BAND F VOLTAGE CONTROLLED OSCILLATOR

4.3.3 IF/Audio Module

Two versions of the AN/PRC-66 transceiver have been developed, namely with and without squelch capability. The IF/audio modules of the two radios are sufficiently different to warrant individual description.

4.3.3.1 IF/Audio Module - Without Squelch

(a) General

The IF/audio module performs functions on both transmit and receive. On receive, the 30 MHz signal input from the receiver is amplified, converted to 500 kHz, amplified and detected. The dc output of this detector is amplified and feeds the IF AGC line which controls the gain of the 30 MHz and 500 kHz IF amplified stages. The audio output of the detector is amplified and drives the headset. Also, a delayed AGC voltage is made available from the 30 MHz signal in this module to control the gain of the receiver first RF stage, thereby increasing the dynamic range of the radio. On transmit, the audio power from the microphone is amplified by the modulator preamplifier stages in the IF/Audio module and then fed to the input of the modulator. AGC is provided for speech processing. Another feature is the DF (direction finding) tone generated in the DF position of the function switch (AN/PRC-66 only). Frequency of the tone is approximately 1000 Hz. The output of the modulator preamplifier is connected back to its input through a phase shift network, causing the oscillation to occur. The phase shift network is made up of the output impedance of the modulator preamplifier, a series resistor, and the input impedance of the modulator preamplifier.

(b) Packaging

The IF/Audio module without squelch consists of 7 hermetically sealed, shielded, thin film packets. Each packet is 0.868 x 0.928 inches and either 0.15 or 0.20 inches thick. A potted assembly using discrete components and a semiconductor integrated circuit is used to make up the 29.5 MHz oscillator. An exploded view of the

IF/audio module is shown on Figure 4-48. Of the 8 thin film packets, 2 are used for the modulator preamplifier and 6 plus the 29.5 MHz oscillator constitute the receiver IF and audio circuits.

Two trimmer potentiometers are mounted on top of the interconnect board. One adjusts the gain of the receive circuits and the other adjusts the gain of the modulator preamplifier. Test points are soldered to pads on the interconnect board and are accessible through holes in the module cover. A miniature connector is used to provide the plug-in feature of the module.

4.3.3.1.1 Module Design - Receiver Circuits

(a) General

A block diagram of the IF/audio module is shown on Figure 4-49. The module operates from 12 vdc and draws 22 ma current. Total module power gain is 97 db. To eliminate the possibility of instability, the power gain at any frequency was kept below 45 db. The gain at 30 MHz is approximately 40 db. The 500 kHz gain is approximately 42 db and the audio amplifier gain is approximately 41 db. Losses in the detector and volume control circuitry total 26 db. The gain is dependent on AGC voltage stabilization, transistor gain and component part tolerances. A curve showing the AGC characteristics of the module as well as the RF-AGC voltage characteristic is shown on Figure 4-50. Variation in the AGC characteristics and signal handling capability with temperature and supply voltage changes is shown on Figure 4-51. Distortion characteristics of the module

IF & AUDIO MODULE,(WITHOUT SQUELCH) EXPLODED VIEW

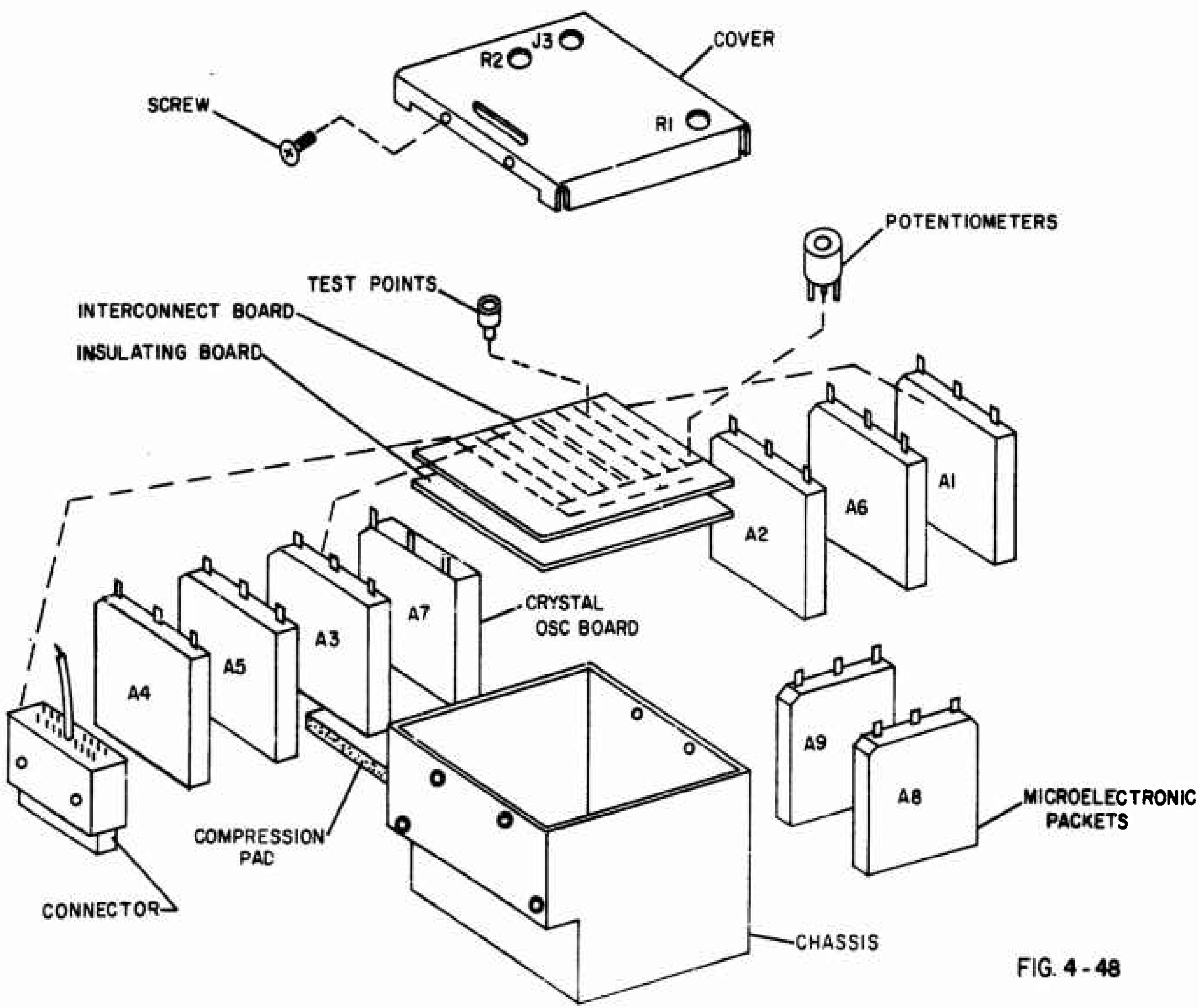
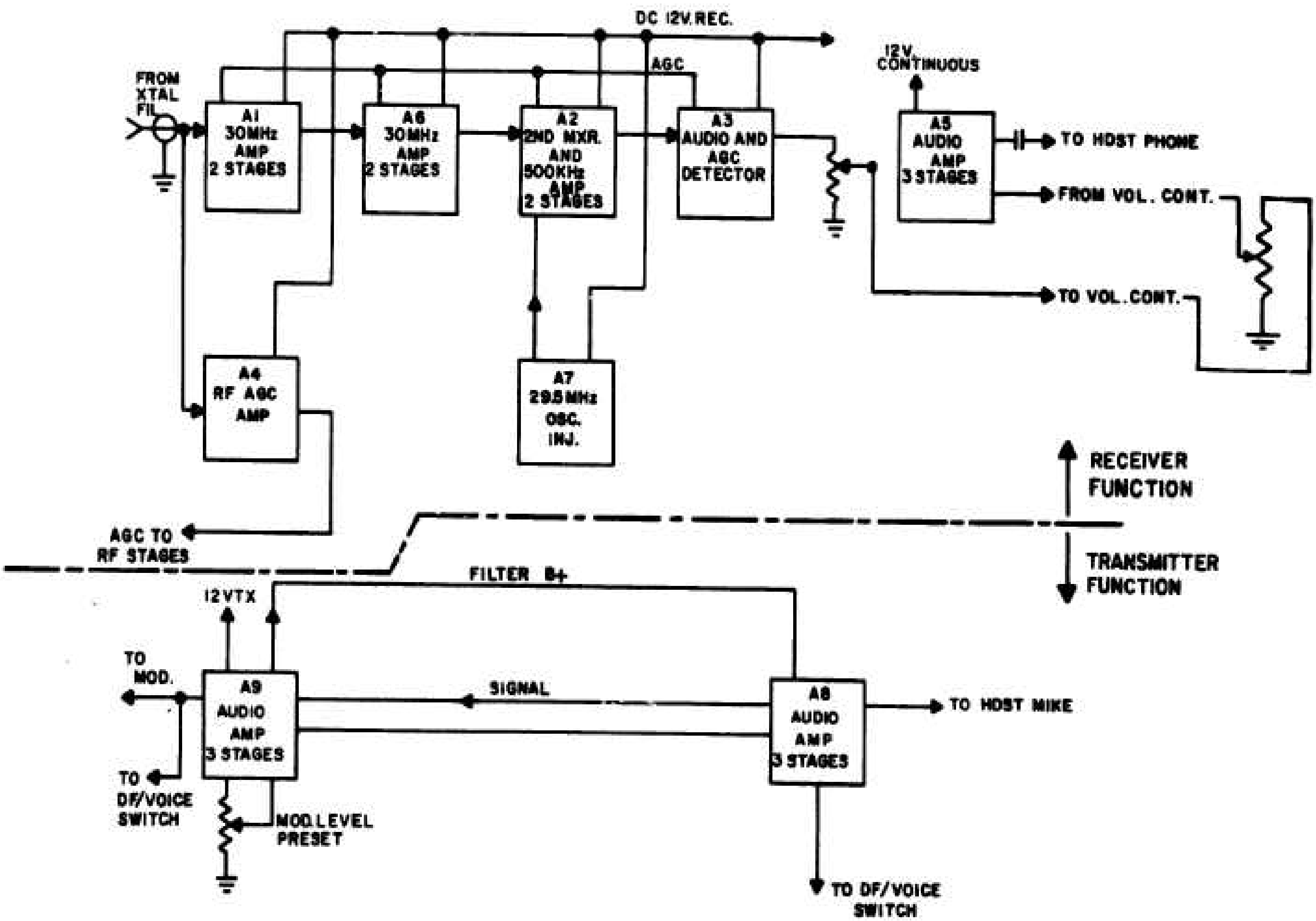
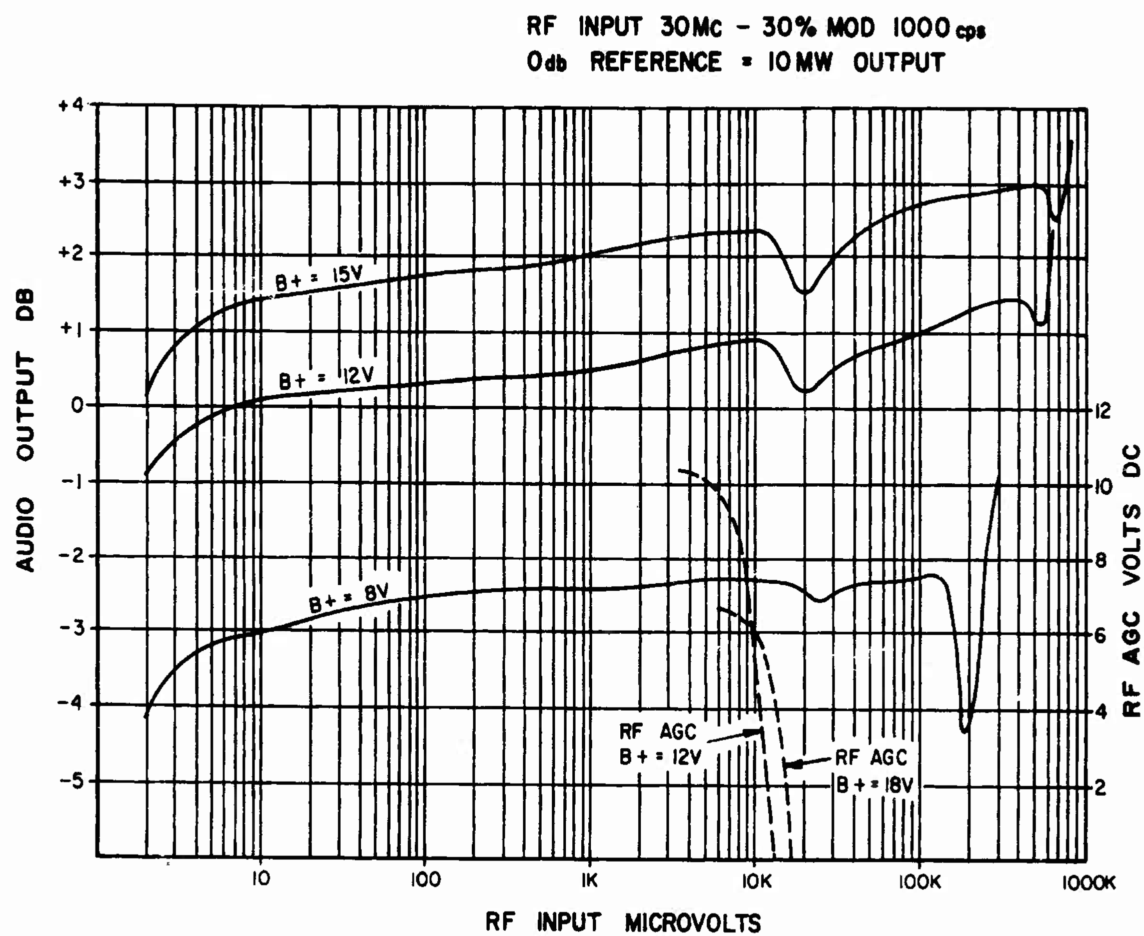


FIG. 4-48



IF/AUDIO MODULE WITHOUT SQUELCH
BLOCK DIAG.

FIG. 4-49



IF/AUDIO MODULE, AGC CHARACTERISTICS

FIG. 4-50

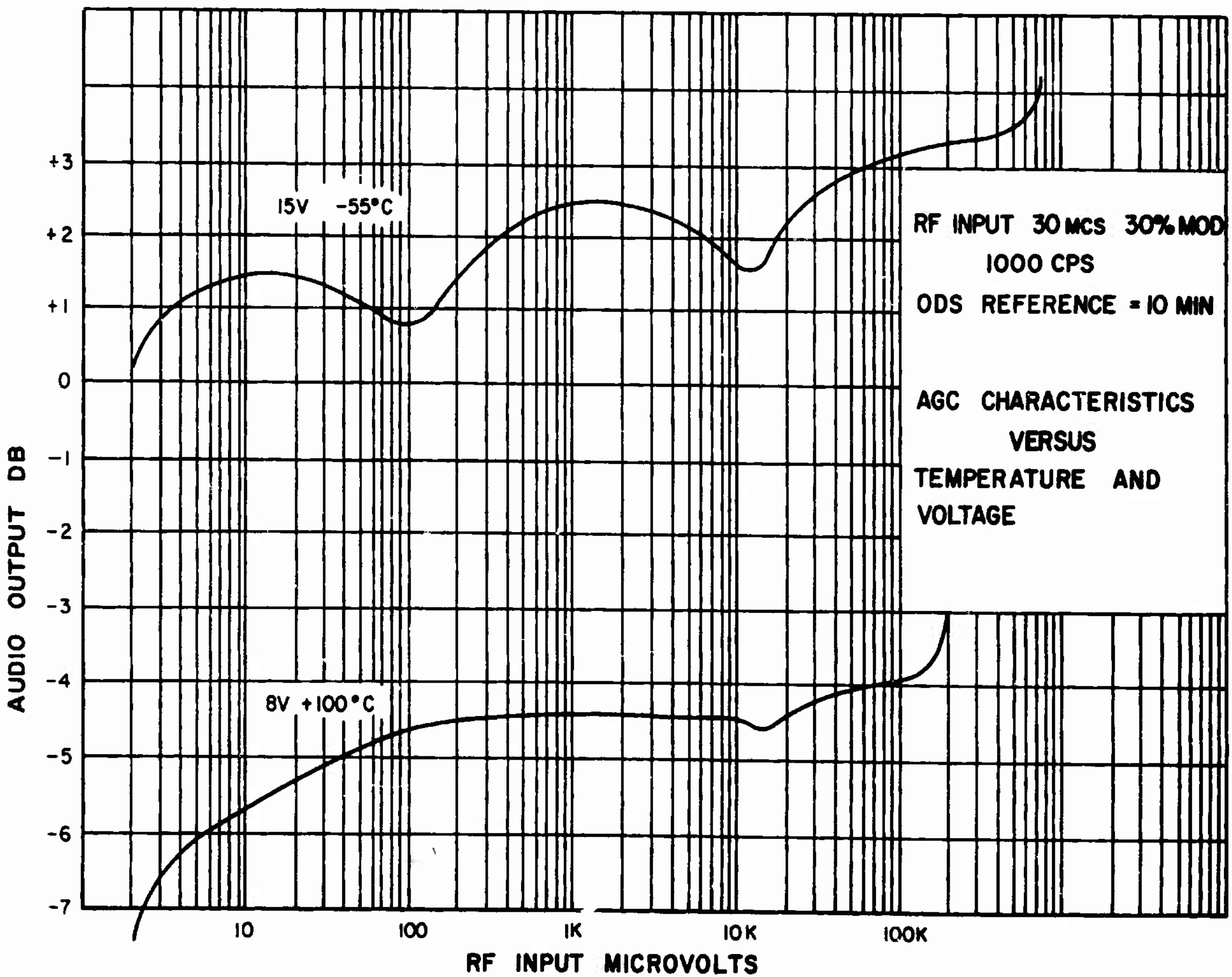

+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
AUDIO OUTPUT DB
15V -55°C
8V +100°C
10
100
1K
10K
100K
RF INPUT MICROVOLTS
RF INPUT 30 MCS 30% MOD
1000 CPS
ODS REFERENCE = 10 MIN
AGC CHARACTERISTICS
VERSUS
TEMPERATURE AND
VOLTAGE

FIG. 4-51

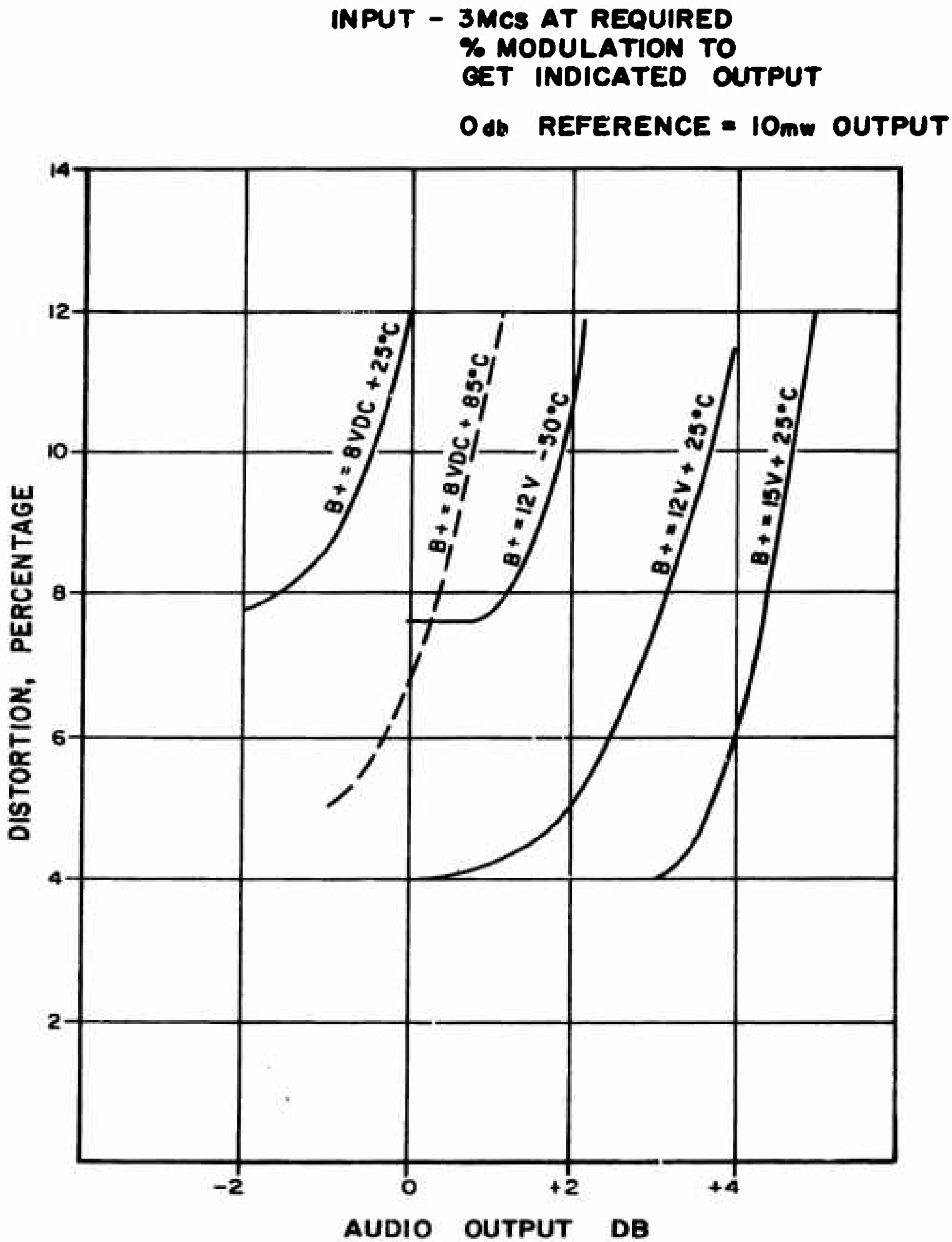
are shown on Figure 4-52. Audio frequency response is shown in Figure 4-53. The following paragraphs describe the thin film packets which make up the IF/audio module.

(b) 30 MHz Amplifiers A1 and A6

Two packets A1 and A6 provide the required gain at 30 MHz. Input impedance of A1 is 50 ohms. Each packet contains two common emitter Class A amplifiers. The collector load of each stage is a tuned LC circuit with sufficient loading to eliminate any instability. Each stage was analyzed using conventional and computer-aided techniques to determine the required loading of the tank circuits. Since A6 operates at a higher level than A1, more AGC control is required in packet A1 to achieve wide dynamic range. To accomplish this, a fixed bias voltage is introduced into the emitter of the first and second stage of packet A1 and the AGC voltage is applied to the base bias networks. In packet A6 the fixed bias is not provided. Maximum current drain from the 12 volt supply is 10.3 ma for both packets.

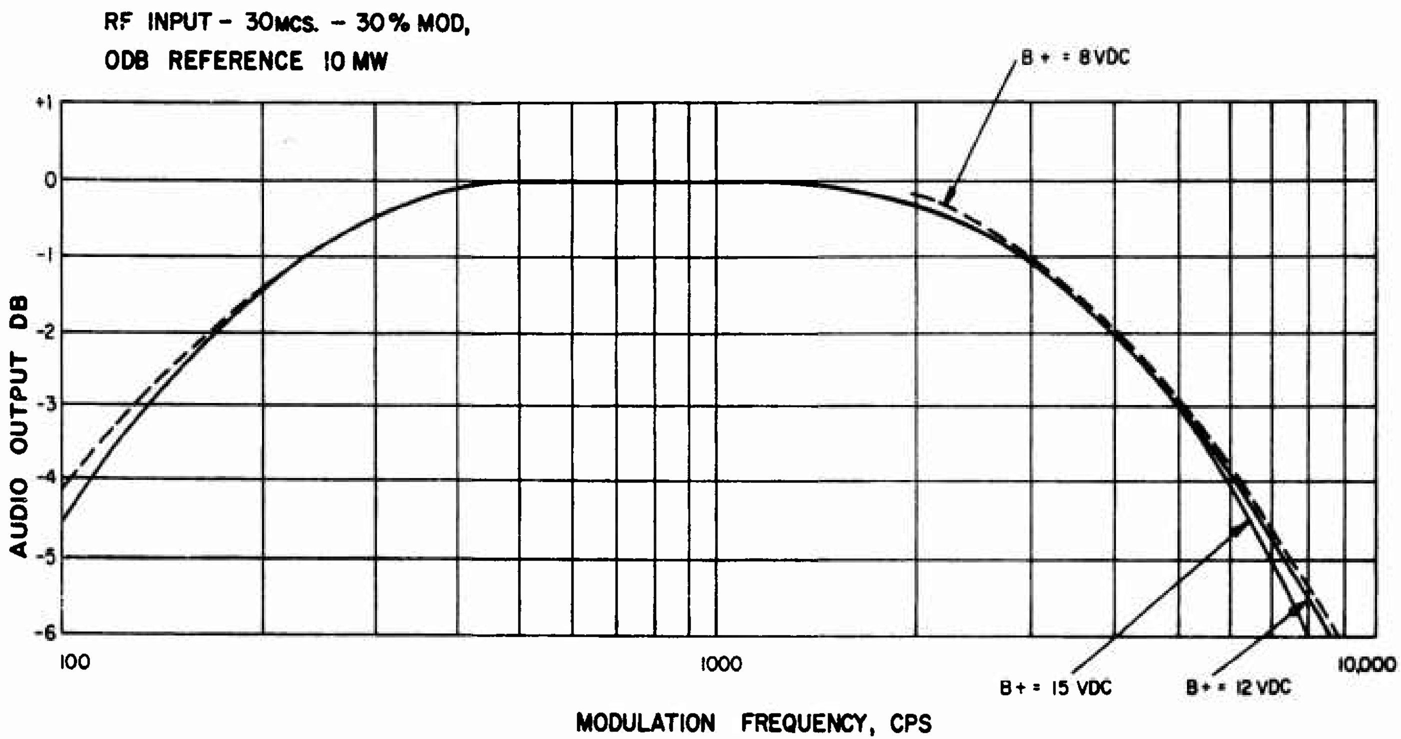
(c) Mixer & 500 kHz Amplifier A2

The second mixer is a transistor circuit with injection to the base circuit. Injection voltage level is 0.15 volts which is sufficiently high for proper mixing and linear operation for the range of input levels at this point in the radio. The collector of the mixer is shunted to ground with a 150 pf capacitor to provide attenuation of the injection signal. The 500 kHz amplifier is a two stage amplifier providing about 20 db of voltage gain at



AUDIO DISTORTION Vs OUTPUT LEVEL

FIG. 4-52



IF/AUDIO MODULE, AUDIO FIDELITY CHARACTERISTICS

FIG. 4-53

500 kHz. The first stage is a common emitter stage and is direct coupled to an emitter follower second stage. AGC is applied to the first stage only and is required to prevent blocking in subsequent stages, especially at high input levels. Maximum current drain of this packet is 3.5 ma.

(d) Audio Detector & AGC Amplifier A3

This circuit uses one stage of gain at 500 kHz to drive the audio detector with a minimum level of 1.5 vrms. The collector of this stage has a fixed tuned LC circuit comprised of a miniature toroid and a capacitor. This network provides sufficient selectivity to prevent the amplified IF noise from activating the IF AGC network. The IF AGC amplifier consists of a two stage dc amplifier. The first stage is an emitter follower and the second stage is a common emitter stage. Temperature compensation is obtained by using a reverse biased diode at the input of the dc amplifier. Maximum current drain in this packet is 5.1 ma.

(e) Audio Amplifier A5

The audio amplifier is a three stage amplifier with a double ended class AB output stage for maximum efficiency. The first stage is an emitter follower stage with sufficiently high input impedance to properly terminate the detector circuit. The second stage is a common emitter stage which provides approximately 20 db of voltage gain. The double ended output stage is connected in an emitter follower arrangement using an NPN and a PNP transistor. This arrangement allows the maximum mismatch in beta between the two output transistors. The current drain of this amplifier is kept to a minimum with no drive and may rise to a maximum of 3.9 ma when driven to the nominal audio output power of 10 milliwatts.

(f) RF AGC Amplifier A4

The RF AGC packet bridges the input circuit of A1 and is not involved in the IF-AGC loop. In this way delayed RF AGC is provided to ensure maximum sensitivity and wide dynamic range of the radio. The 30 MHz signal is amplified by a two stage amplifier connected in a cascade arrangement. This arrangement minimizes the Miller effect, thereby reducing the input capacitance of the packet. A transistor detector-amplifier converts the signal to dc as well as providing 180° phase shift required for reverse AGC. A direct coupled emitter follower is used in the final stage of the amplifier. Maximum current drain is 3.7 ma.

(g) 29.5 MHz Oscillator A7

Here a semiconductor integrated circuit is connected in a Pierce crystal oscillator arrangement with a third overtone crystal providing the required frequency stability. Discrete components are required to prevent possible oscillation at the fundamental crystal frequency. Maximum current drain is 4 ma.

4.3.3.1.2 **Module Design - Transmitter Circuits**

(a) General

Refer to block diagram Figure 4-49. In the transmit mode, the IF/audio module operates from 12 volts and draws 8 ma. Total module power gain is 58 db but since amplification is at audio frequencies, proximity effects are not serious. Graphs showing AGC characteristics, audio output temperature stability and DF oscillator output temperature stability are shown in Figures 4-54, 4-55 and 4-56 respectively. Other important characteristics are listed below. The frequency response of the module does not vary more than ± 3 db from 300 to 2700 Hz relative to 1000 Hz. Distortion is less than 5% at any frequency from 300 to 2700 Hz with a nominal output of 1.0 volts into 1000 ohms.

(b) Modulator Preamplifier Packet A8

This thin film packet has an input impedance of 350 ohms and, in conjunction with modulator driver packet A9 provides sufficient gain to drive the modulator. It has three grounded emitter stages utilizing both voltage and current feedback to stabilize operating points. The second stage emitter is connected to ground through an N channel FET (field effect transistor) for automatic gain control. Included in the packet is also a half-wave rectifier driven by the signal frequency to provide the AGC voltage required at the gate lead of the FET. The FET was chosen as the control element since its high imput impedance allows the use of smaller capacitor values for a given time constant.

MODULATOR PREAMP, OUTPUT Vs INPUT CHARACTERISTICS

NOTE: ODB REFERENCE = IV RMS   NO CLIPPING ON OUTPUT

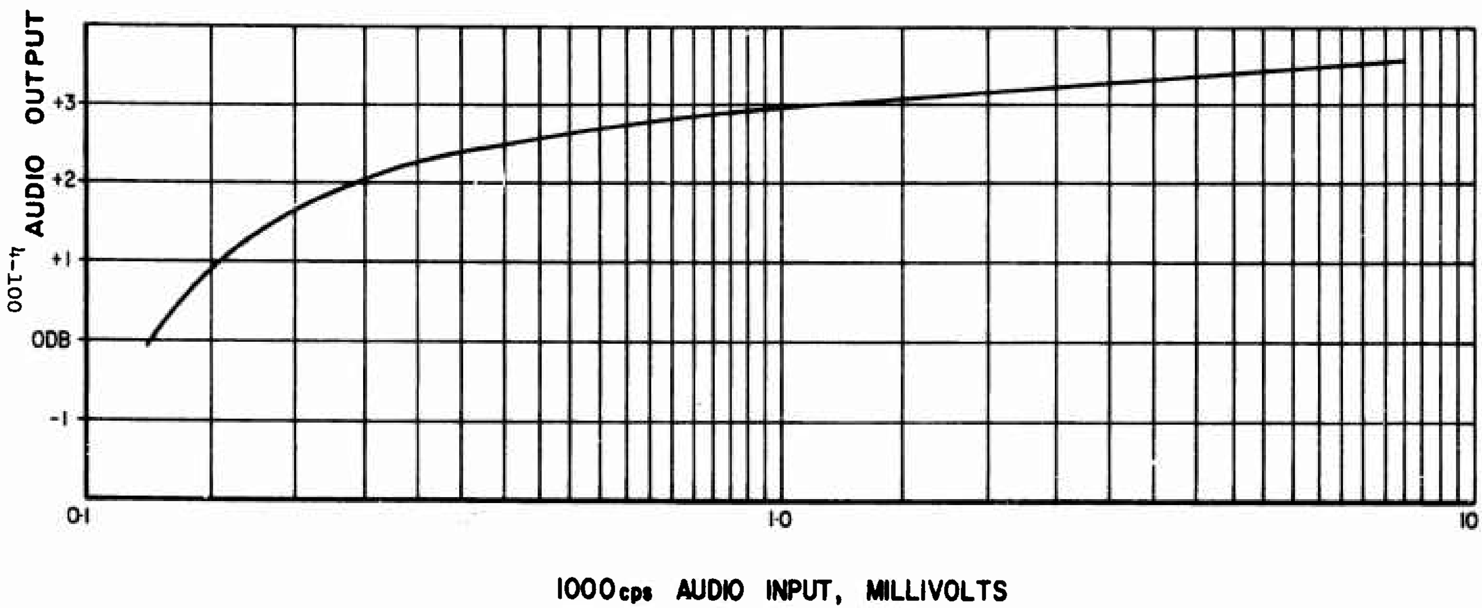


FIG. 4-54

MODULATOR PREAMP

AUDIO OUTPUT Vs TEMPERATURE

NOTE: INPUT 1000 CPS, 125μV

ODB REFERENCE = 1V (RMS)

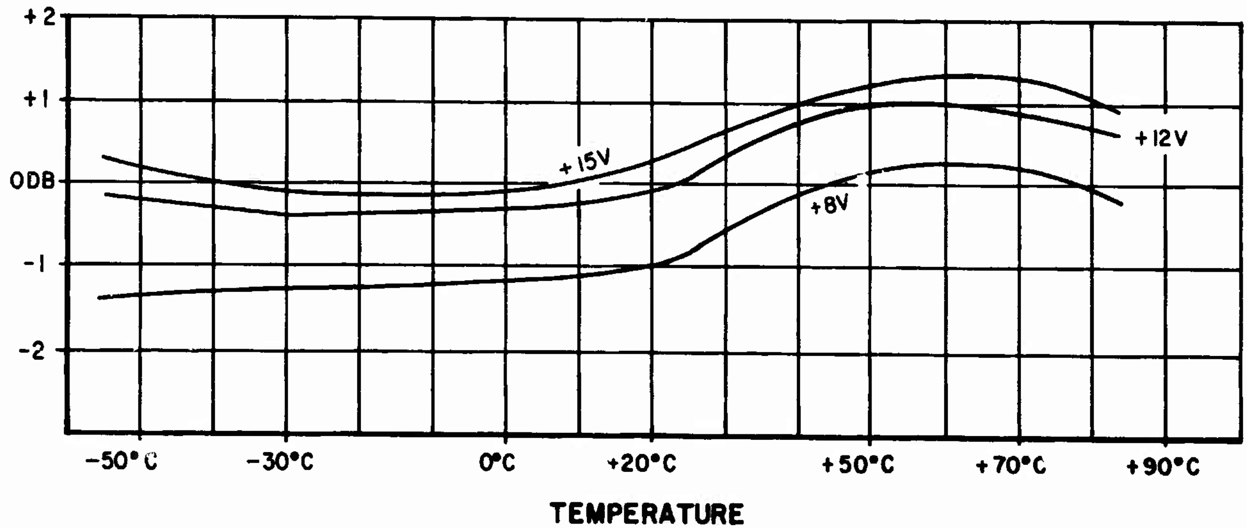


FIG. 4-55

DF OSCILLATOR OUTPUT Vs TEMPERATURE
ODB REFERENCE = 1 VOLT RMS

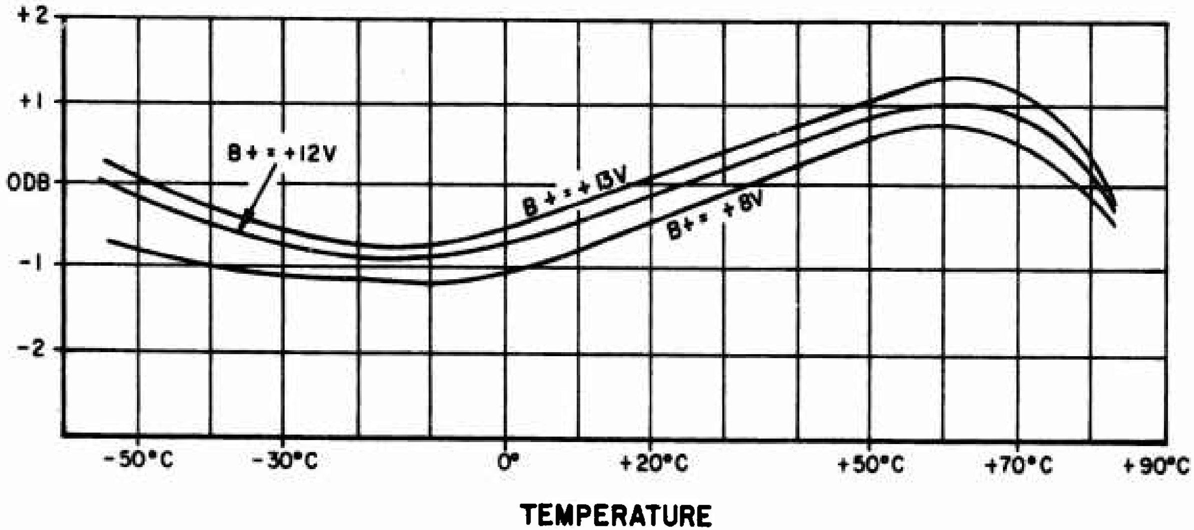


FIG 4-56

(c) Modulator Driver A9

This packet consists of three stages, two of which are similar to the stages used in A8. The output stage is an emitter follower and provides required drive power to the modulator without excessive distortion. Leads are brought out from this packet between the first and second stage for transmit modulation control. Provisions are made in this packet to supply filtered dc power for packet A8 to reduce susceptibility to extraneous audio frequencies.

4.3.3.2 IF/Audio Module (With Squelch)

When the requirement for an AN/PRC-66 transceiver with squelch first became known, a survey was made of existing squelch systems to select the most desirable squelch system for this application. Squelch schemes considered were carrier squelch, signal-plus-noise-to-noise squelch, coherent carrier squelch, and carrier-to-noise squelch. The carrier squelch was selected for the following reasons:-

a) Performance. Some performance degradation when compared with carrier-to-noise squelch only. This degradation can be troublesome for airborne application but not considered significant for packset application.

b) Power Requirements. Power consumption is lowest for all squelch systems evaluated.

c) Simplicity of Circuitry. Only one additional thin film packet is required, and packset volume does not increase with this additional capability.

To provide carrier squelch capability in the AN/PRC-66 radio, an additional thin film packet was added in the IF/audio module (without squelch). The additional thin film packet A10 comprises a 500 kHz amplifier stage, detector and a Schmidt trigger circuit. Also, two of the existing thin film packets for the non-squelch module were modified to include more functional elements. In thin film packet A2, an expander stage and a voltage regulator circuit have been added. The thin film packet A5 was modified by the addition of a diode to include a squelch gating circuit. A simplified block diagram is provided in Figure 4-57 and an exploded view of the packaging is provided in Figure 4-58. Overall radio dimensions were not affected by the changes required for squelch operation. The IF/audio module increased 0.2 inches in length only.

Performance of the squelch circuit is quite stable over the temperature range. The squelch trip point will vary no more than ±3 db over the temperature range of $-30^{\circ}C$ to $+85^{\circ}C$. However, operation of the circuit with the receiver module will show some temperature dependence as well as variation with frequency of operation. See Figure 4-59. This variation is caused by the receiver module gain dependence on frequency and temperature but is not considered severe from an operational standpoint. Hysteresis of the

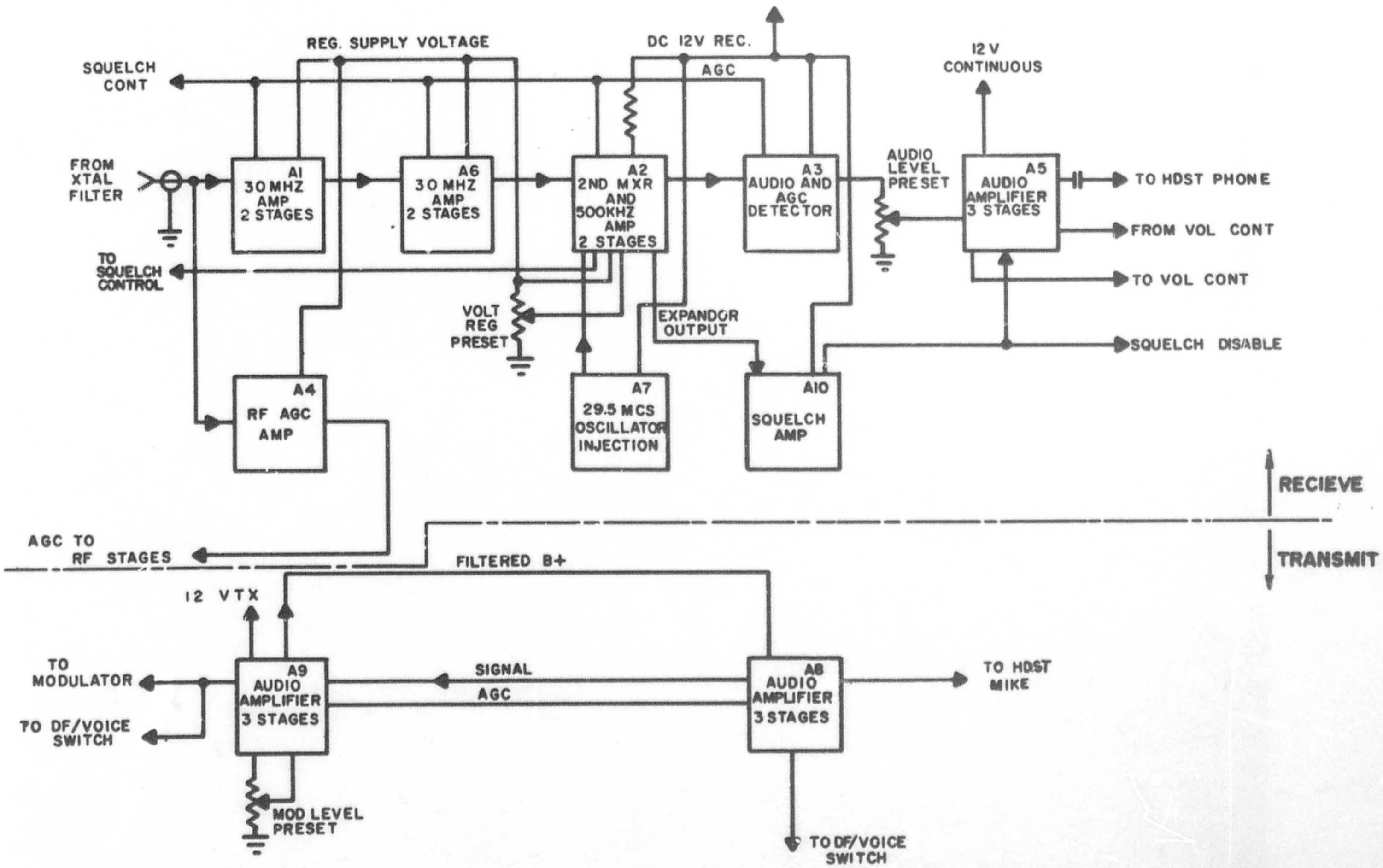


FIG. 4-57

IF/AUDIO MODULE (WITH SQUELCH) BLOCK DIAGRAM

IF & AUDIO MODULE, (WITH SQUELCH) EXPLODED VIEW

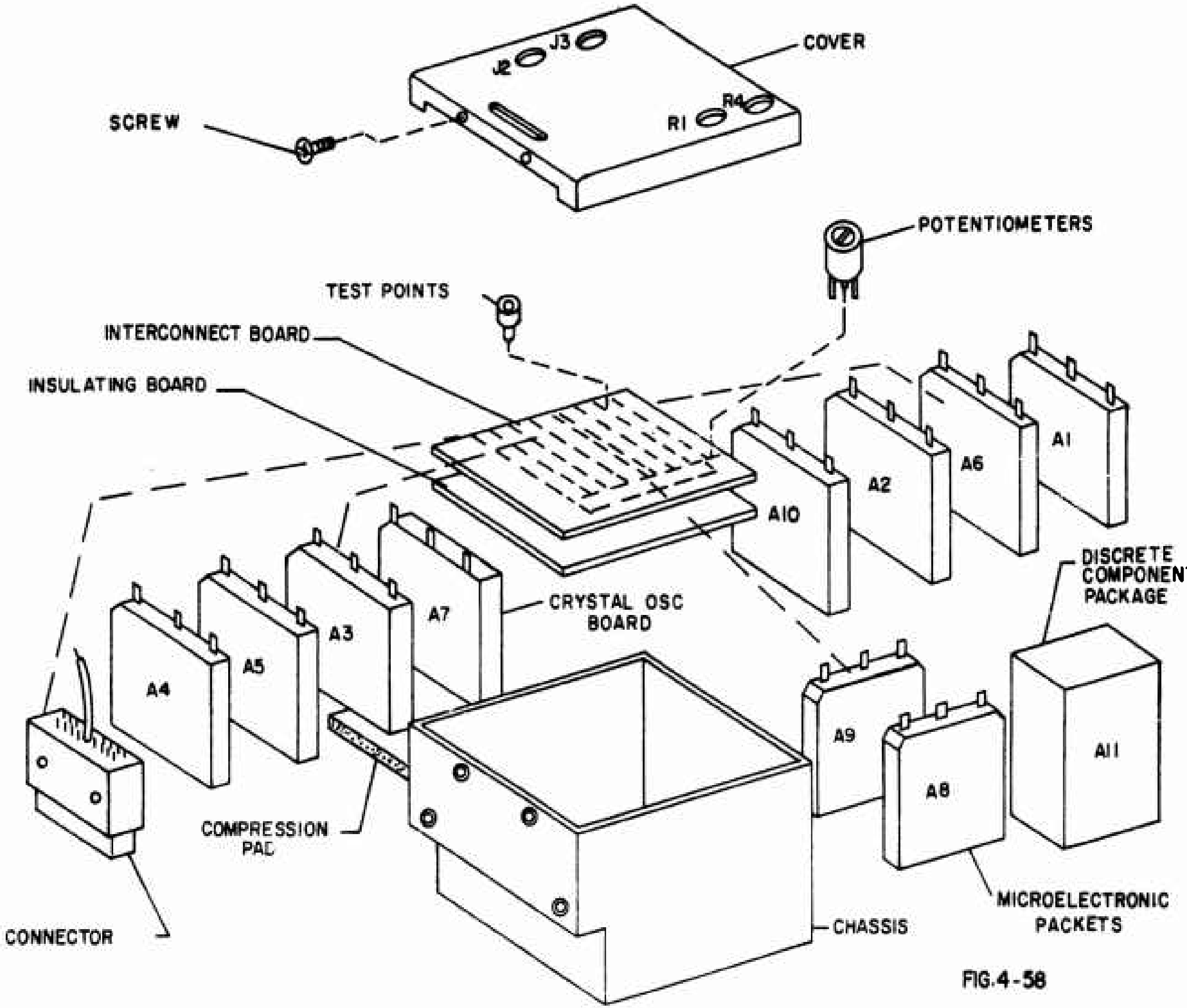
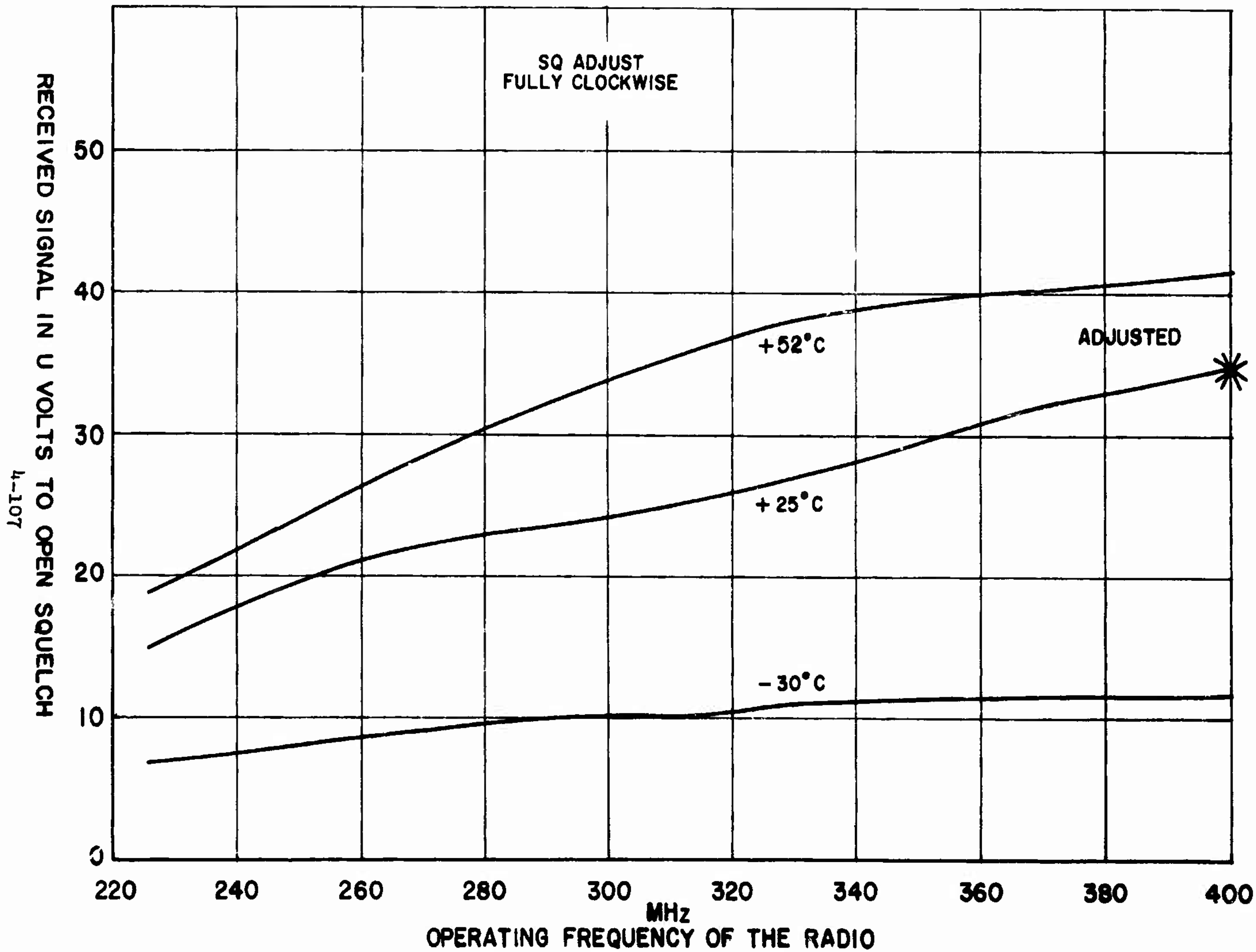


FIG. 4-58



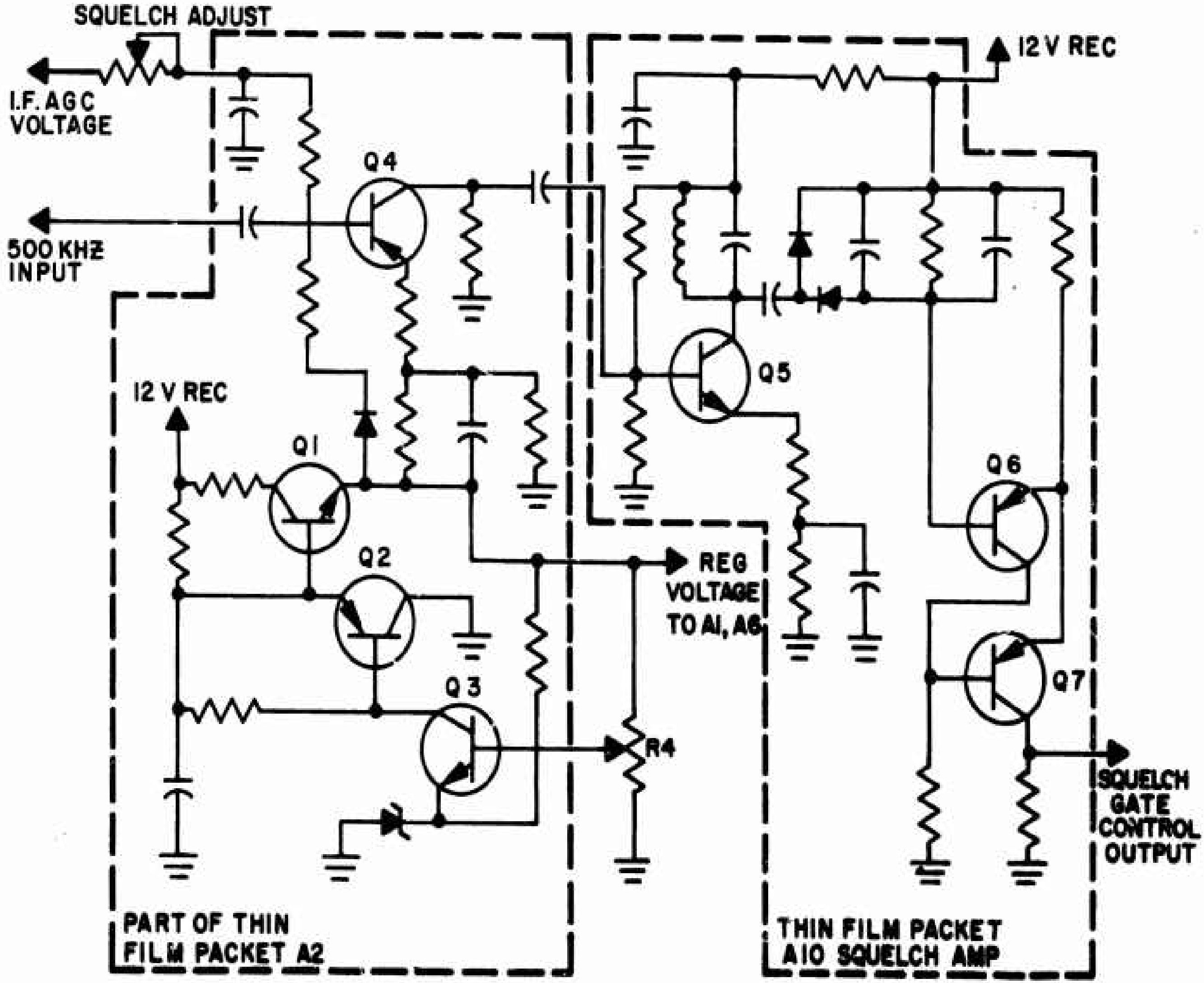
RECEIVER SQUELCH DEPENDANCE ON TEMPERATURE AND OPERATING FREQUENCY

FIG 4-59

squelch circuit is typically 2 db which assures stable operation of the squelch circuit when the received signal is close to the squelch trip point. Also, when squelched, the audio output will be attenuated at least 50 db. Power consumption increase due to the squelch circuit is typically 180 milliwatts and will cause less than 5% change in battery life of the PRC-66 radio.

The SQ adjust potentiometer mounted in the front panel of the radio set will permit the operator to adjust the squelch trip point for a received signal level of 0 μv to at least 5 μv at one operating extreme of temperature and voltage or adjust for a received signal level of NMT 3 μv and NLT 50 μv at the other operating extreme. The operator may disable the squelch function by operating the 4-position function switch to the T/R position.

A simplified schematic of the carrier squelch system is shown in Figure 4-60. The circuitry ahead of the mixer is unchanged from the non-squelch module and is not shown. The circuitry of transistors Q1, 2 and 3 constitutes the voltage regulator. The voltage regulator assures stable operation of the squelch circuit for variations in power supply voltage from 10 to 14 volts. Factory adjusted potentiometer R4 is used to control the regulated dc output voltage and is set to compensate for variations in gain of the IF circuits and the expander circuit.



CARRIER SQUELCH SIMPLIFIED SCHEMATIC FIG. 4-60

The 500 kHz second IF output is fed to an expander circuit (Q4). This stage gain is controlled by the IF AGC voltage and is designed to increase the stage gain with increasing carrier level. This then, works opposite to the main IF AGC circuit and restores, or even increases, the carrier level variations at the input to the module. In this wa lose control of the desired trip point of the squelch system is obtained and the inherent instability of a dc carrier squelch is overcome. The expanded output is fed to the thin film packet A10. The signal is further amplified by the transistor stage Q5 and detected. The resulting dc voltage is applied to the Schmidt trigger circuit comprised of transistors Q6 and Q7. Sufficient carrier signal will change the state of the Schmidt trigger and operate a squelch gate in the audio amplifier. The radio set is then unsquelched.

4.3.4 Voltage Regulator Module

4.3.4.1 General

The voltage regulator module is electrically the same for both the PRC-66 and PRC-75 radios. Mechanically, however, the two modules differ appreciably. The PRC-66 regulator module is a plug-in unit consisting of one connector and three separate printed circuit boards. These boards are interconnected by wires and are arranged into a cubic shape. The PRC-75 module is made up on one printed circuit and two connectors, one of which acts as the external power and audio connector to the radio and is fastened to the main chassis. The other connector plugs into the chassis.

The voltage regulator consists of two stepdown self-triggered switching regulator sections which accept a nominal input voltage of 24 volts from a battery pack and deliver two regulated outputs of 12 volts and 5 volts respectively. Whereas the 12 volt section operates from only the battery voltage, the 5 volt section requires both the battery voltage and the 12 volt output for its operation.

The circuit operation is basically that of an ON-OFF feedback control system in which the switching element is a series pass transistor made to operate alternately in its saturated (ON-state) and cut-off (OFF-state) conditions. The switching transistor does not operate in the linear region except for short intervals when transferring from the ON state to the OFF state, and vice versa. Voltage regulation is obtained by varying the ratio of the ON and OFF periods or in other words, the duty cycle of the switching transistor.

The main advantage of the switching (non-linear) type of voltage regulator over a linear series voltage regulator is that regulation can be achieved with high efficiency, typically 80 percent.

This degree of efficiency is obtained by making the transition periods between the ON and OFF states of the switching transistor as short as possible.

The particular choice of transistors for this unit was based on the optimization of efficiency for the space available. A significant effort was devoted to selecting transistors having maximum gain and power handling capability, rapid transient response coupled with minimum power drain and minimum size.

A representative block diagram of the voltage regulator module is shown in Figure 4-61 and a schematic diagram is provided in the figure AP-1 of the appendix. In operation, the series pass element of the regulator is a saturated switching transistor which is switched ON and OFF by a rectangular waveform. Assuming a perfect switch, the voltage waveform at the output of the switching transistor will be a rectangular wave with an average value, V_0, given by

$$V_0 = V_{in} \frac{t_{on}}{t_{on} + t_{off}}$$

where V_{in} is the applied battery voltage,

t_{on} is the output pulse duration,

t_{off} is the OFF period of the switching transistor.

The above voltage relationship also assumes that there is negligible voltage drop across the "catch" diode (CR1 or CR4.). The purpose of this diode is to clamp the output of the switching transistor to ground during the OFF period, thus providing a continuous path for the current through the inductor in the low-pass filter.

It can be seen that variations in the input voltage, V_{in}, can be compensated for by varying the duty cycle of the switched waveform. Each of the two switching regulators uses this duty cycle control for voltage regulation. The low-pass filter following each switching transistor consists of two LC filter sections. The voltage comparator is a differential amplifier stage which compares the output of the first LC filter section (or a portion of it as in the case of the 12 volt regulator) with a 5 volt dc reference obtained from Zener diode CR3.

4.3.4.2 12 Volt Regulator

The 5 volt reference is applied to the base of Q3, and a sample of the integrated output (roughly a triangular waveform) from the switching transistor Q5 is applied to the base of Q2, the other transistor in the differential amplifier. If the 12 volt output drops below 12 volts, the voltage at the base of Q2 will drop sufficiently below 5 volts to turn Q2 off. This action causes the Darlington pair, Q1 and Q4, to turn on, thus turning on the switching transistor Q5. The reverse action occurs when the output rises above 12 volts. Positive feedback around the Darlington pair causes it to switch regeneratively.

4.3.4.3 5 Volt Regulator

In this case, the 5 volt reference is applied to the base of Q6. The output of the first LC filter section is applied to the other differential input, the base of Q7. When the partially filtered output falls below 5 volts, Q6 turns on harder, lowering the voltage at the base of O8, and thus turns Q8 and Q9 on.

VOLTAGE REGULATOR MODULE
SIMPLIFIED BLOCK DIAGRAM

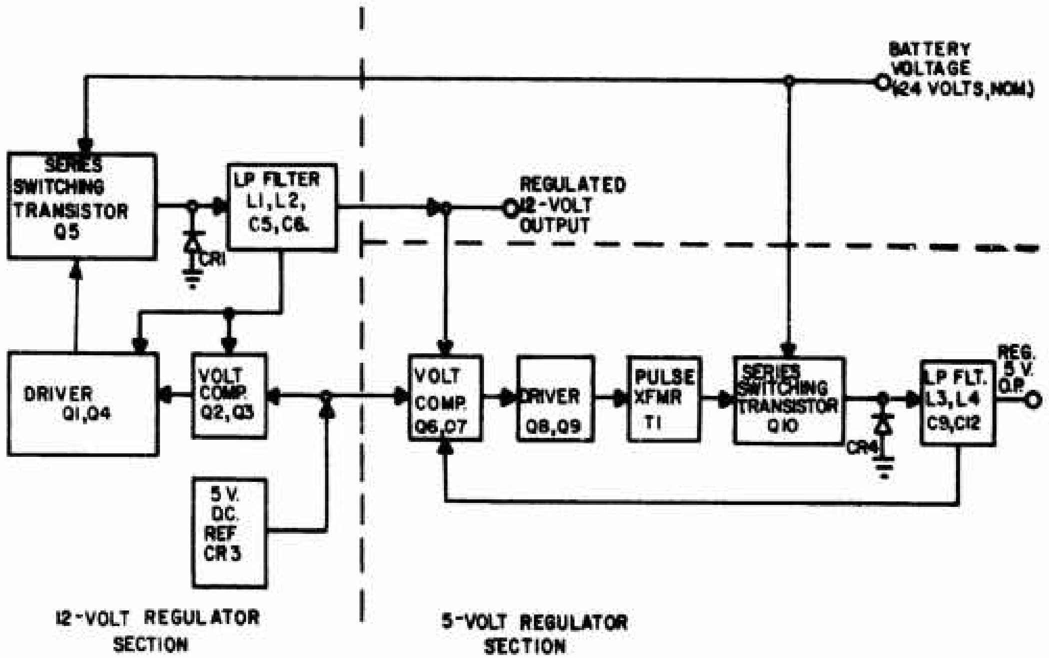


FIG 4-61

This action causes regenerative switching of Q8 and Q9. The voltage pulse at the emitter of Q9 is stepped down by the pulse transformer T1 and applied to the base of the switching transistor Q10. Q10 is thus turned on and load current flows until the output voltage rises above 5 volts, whereupon the reverse switching action takes place to cut Q10 off.

Adequate filtering is provided on the 24 volts, 12 volt and 5 volt lines to prevent high frequency switching transients from being coupled to other circuits in the radio. Approximate power distribution within the AN/PRC-66 and AN/PRC-75 is provided in table AP-1 of the appendix.

4.3.5. Receiver & Transmitter Modules

4.3.5.1 GENERAL

The AN/PRC-66 uses separate receiver and transmitter modules, whereas the AN/PRC-75 has one module that combines both receiver and transmitter functions. There are a number of similarities between the respective modules, but the following descriptions will consider each module on its own merit.

4.3.5.2 RF/Receiver Module (AN/PRC-66)

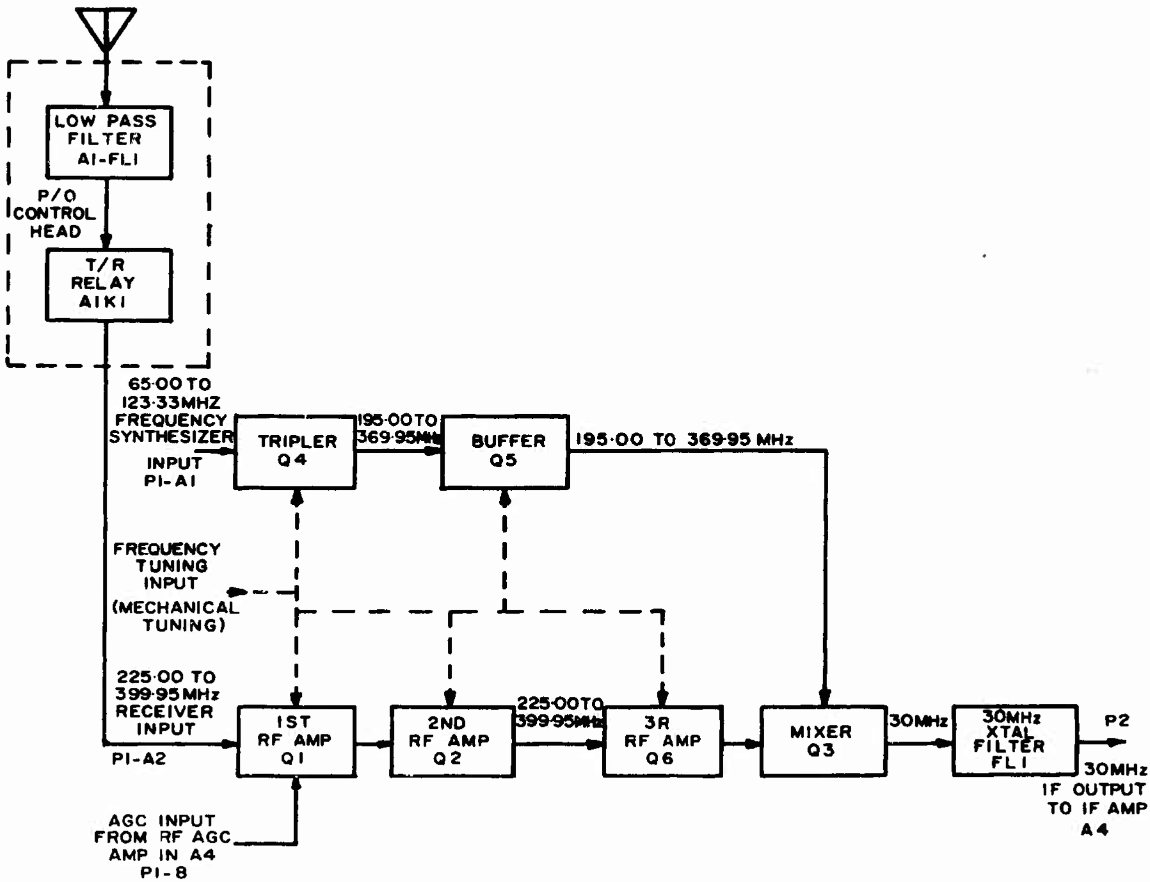
Figure 4-62 is a simplified block diagram of the RF/receiver module, a schematic of this module is provided in the appendix. This module consists of a translator with input frequency range from 225 to 400 MHz and an output frequency of 30.0 MHz. Receiver mixer injection is required over the frequency range of 65 to 123.3 MHz.

The receiver is continuously tunable over the frequency range. Required input power for the module is 12 volts d.c. at approximately 30 milliampere over the operating frequency range.

When the transceiver is in receive condition, power is removed from the transmitter section. The signal from the antenna is fed through the 400 MHz LP filter and the transmit/receive antenna relay (found on the main chassis) to the RF amplifiers and mixer sections of the module. Here it is mixed with the proper injection signal to produce the 30 MHz IF output which is then fed to the IF/audio module. The following paragraphs describe each portion of the RF/receiver module in detail.

The input section of the module consists of three tuned RF amplifier stages. Four tuned circuits are used to provide selectivity to meet the spurious response requirements. Three transistors are used to provide approximately 8.5 db net power gain to the mixer input. For gain distribution of the entire receiver, refer to Figure 4-63. The gain obtained is necessary to satisfy the receiver sensitivity requirement of less than 3 microvolts (closed circuit) for 10 db S+N/N ratio at the output. A TA2663 transistor is used in the first two stages to obtain good noise figure and sensitivity. The third RF stage utilizes a 2N918 transistor in a TO-50 case.

Following the third RF amplifier is a conventional transistor mixer circuit using a 2N918 transistor. The output of the mixer is fed to the 30 MHz crystal filter. Conversion gain of the mixer is 5 db.



AN/PRC-66
RECEIVER RF AMPLIFIER
MODULE
FUNCTIONAL BLOCK DIAGRAM

FIG. 4-62

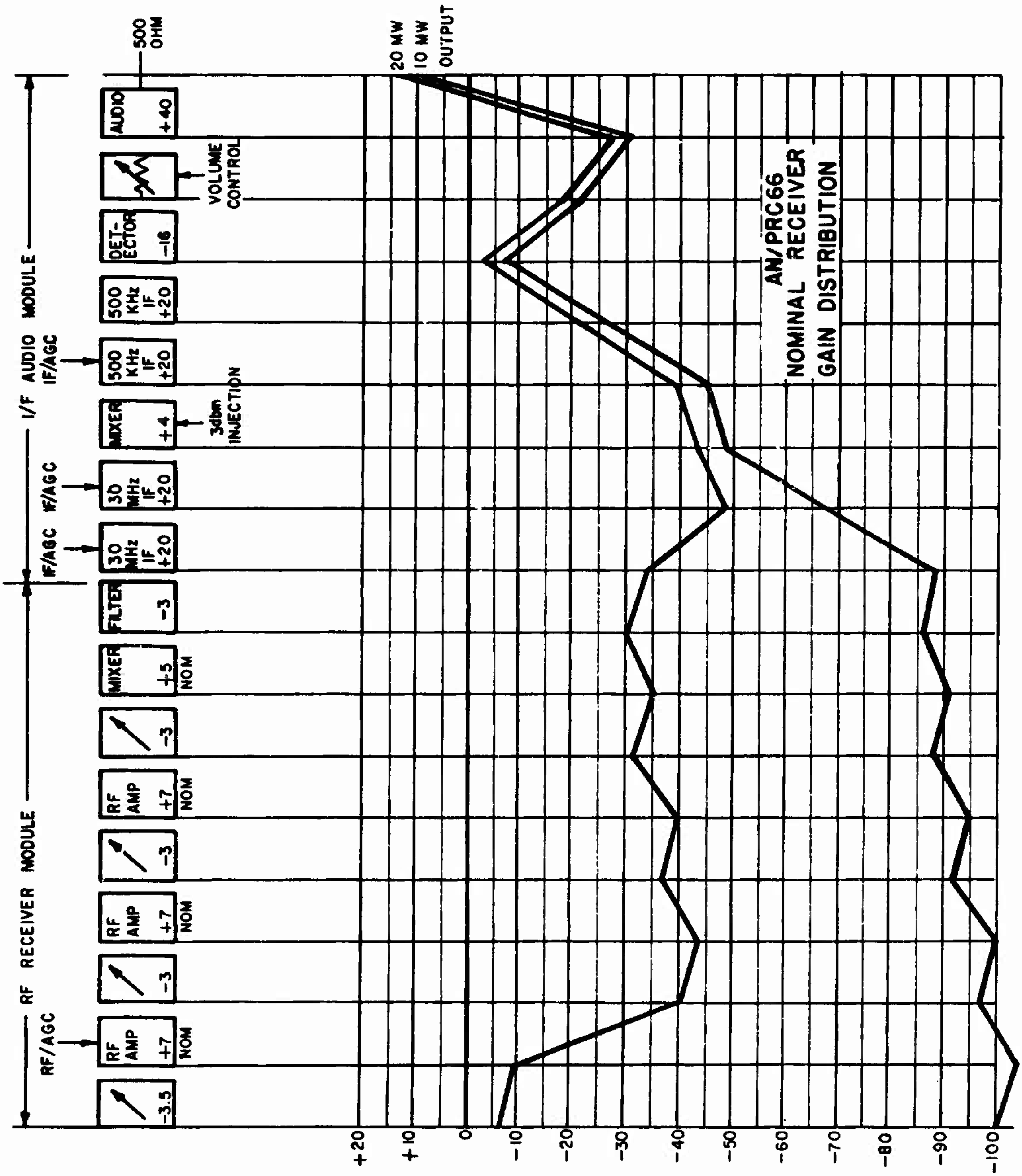

RF/AGC
RF RECEIVER MODULE
IF/AGC
IF/AGC
IF/AGC
I/F AUDIO MODULE
IF/AGC
-3.5
RF AMP +7 NOM
-3
RF AMP +7 NOM
-3
RF AMP +7 NOM
-3
MIXER +5 NOM
FILTER -3
30 MHz IF +20
30 MHz IF +20
MIXER +4
3dbm INJECTION
500 KHz IF +20
500 KHz IF +20
DET-ECTOR -16
VOLUME CONTROL
AUDIO +40
500 OHM
20 MW
10 MW
OUTPUT
AN/PRC66
NOMINAL RECEIVER
GAIN DISTRIBUTION
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

FIG. 4-63

The 30 MHz filter determines the overall selectivity of the receiver. The 6 db points are 30 MHz ±22 kHz minimum, and the 60 db points are 30 MHz ±37.5 kHz maximum with frequencies outside this range being attenuated more than 60 db. Insertion loss of the filter is less than 3 db and ripple in the passband is held to less than 1 db over 90% of the passband.

The injection and signal are both fed to the base of the mixer transistor. This is done to permit bypassing of the emitter circuit at 30 MHz without special networks. The base is bypassed to 30 MHz by a series resonant circuit. Bypassing of both the base and emitter at 30 MHz increases the conversion gain of the stage. No difficulty with interaction between the RF amplifier and injection tuned circuits is encountered since both are lightly coupled to the mixer.

The injection is derived from the frequency synthesizer operating at one third the required injection frequency. This input is tripled and fed to a broadband amplifier. The X3 multiplier output and the broadband amplifier output are tuned to the injection frequency to prevent spurious response of the receiver with the fundamental and the undesired harmonic outputs of the tripler.

The output level of the frequency synthesizer is at least +3 dbm, and the gain of the broadband amplifier is 10 db. This provides sufficient drive, with margin, for the mixer transistor.

Performance data for the receiver module is shown in Figures 4-64 through 4-66. Figure 4-64 shows the worst case front end selectivity which occurs at 400 MHz. Sensitivity is shown in Figure 4-65. A number of design improvements have made possible more margin in sensitivity as well as improved spurious performance of the receiver. The equipment specification requires all spurious responses to be at least 60 db down relative to the desired signal and this has been obtained. Cross-modulation performance is shown in Figure 4-66. This test shows the level of off-channel signal required to degrade the desired signal response from 10 db $\frac{S+N}{N}$ ratio to 6 db $\frac{S+N}{N}$ ratio.

A description of the design changes follows:-

Improvements were made in the following areas:-

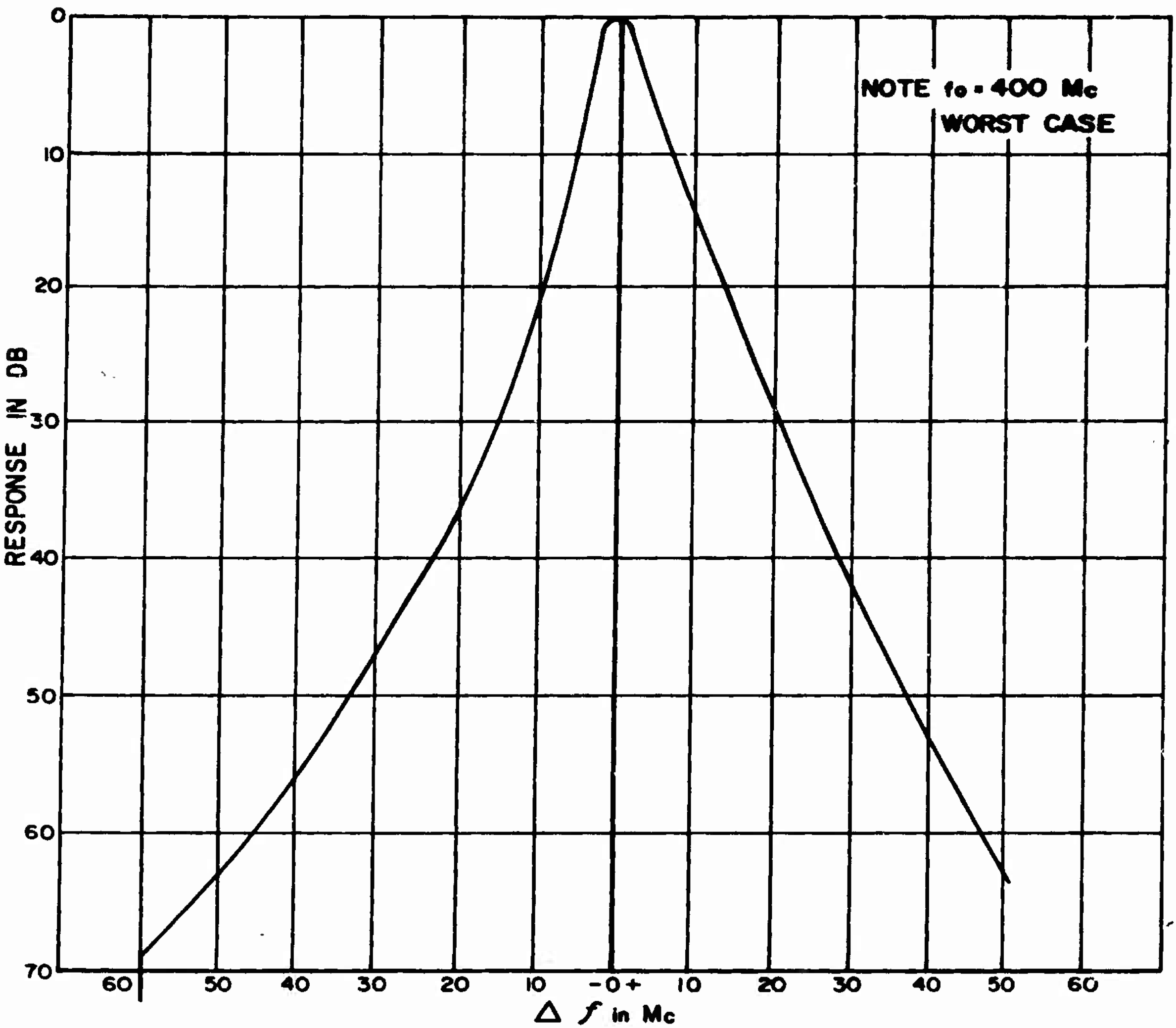
(1) Spurious response

(2) Sensitivity

(3) RF/AGC

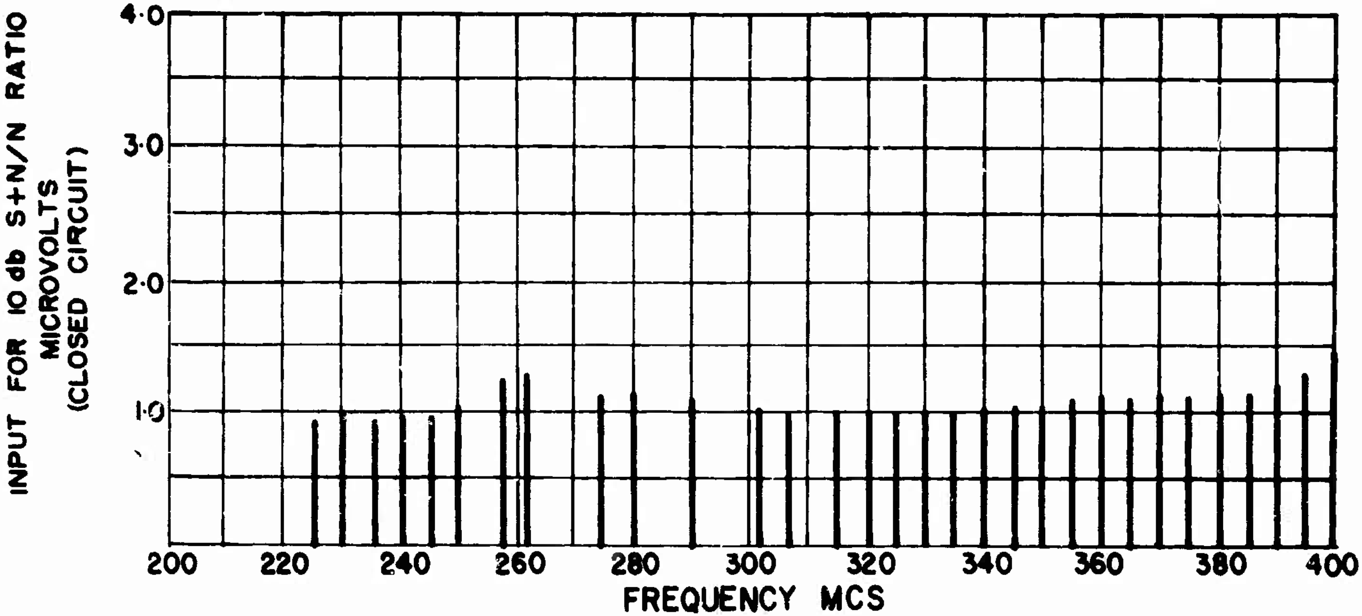
(1) <u>Spurious Response</u>

Fourth harmonic spurious response of the receiver is most critical at the low end of the band. For example, operation at 230 MHz requires first injection at 200 MHz, frequency synthesizer operating frequency of 200/3 = 66-2/3 MHz. Fourth harmonic of the frequency synthesizer output frequency is 266-2/3 MHz creating a possible low-side response at 236-2/3 MHz. Since front end selectivity is not sharp enough, additional selectivity is required in the injection circuit. Here a broadband amplifier and a second resonant tank circuit were added to give a minimum of 30 db additional attenuation to the



AN/PRC-66 RECEIVER MODULE
FRONT END SELECTIVITY

FIG. 4-64

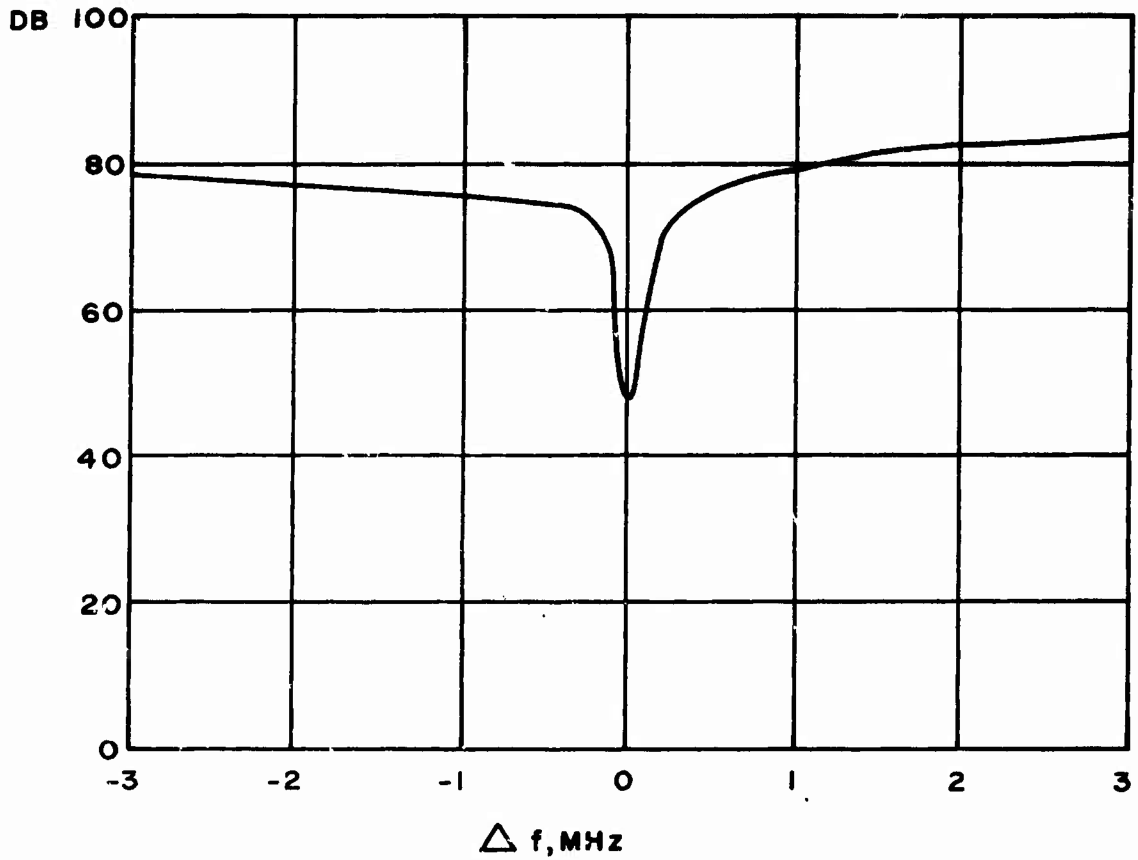


PRC-66

SENSITIVITY VS FREQUENCY

RF RECEIVER MODULE

FIG. 4-65



NOTE: CURVE REPRESENTS LEVEL ABOVE DESIRED SIGNAL REFERENCE AT WHICH UNDESIRED SIGNAL DEGRADES $\frac{S+N}{N}$ RATIO FROM 10 DB TO 6 DB

AN/PRC-66 CROSS MODULATION CHARACTERISTICS

FIG. 4-66

fourth harmonic. Spurious response to 236-2/3 MHz when operating at 230 MHz is now at least 60 db down.

Spurious response to image frequency at high end, 399.95 MHz operation, is the worst case condition for the PRC-66 radio. Here, response to image frequency was marginal in the early models of the PRC-66. To improve image rejection such that sufficient margin exists necessitated additional selectivity. Consequently, an additional tank circuit was added to the RF/receiver module and coupling to and from existing tank circuits reduced. Spurious response to image frequency is greater than 60 db down at all channel settings of the radio.

(2) Sensitivity

Sensitivity was also improved in the PRC-66 radio. Sensitivity was marginal and dependent upon careful tuning of the tank circuits in the RF amplifier line-up. When the additional tank circuit was incorporated and coupling in and out of existing tank circuits reduced for image rejection, the overall gain of the RF amplifier stages was reduced by approximately 6 db. Hence, the second RF amplifier and the IF/audio module noise figures became significant. To improve receiver module sensitivity, the following changes were made.

(1) Low noise figure transistor TA2663 was used in the second stage transistor Q2.

(2) An additional amplifier stage was added between the third tank circuit and the additional tank circuit required for image rejection.

These changes improved the sensitivity of the transceiver such that at 399.95 MHz the typical closed circuit uV signal for 10 db S+N/N ratio is approximately 2.2 uV.

(3) RF AGC

AGC performance was also improved in the RF/receiver module. Here delayed RF/AGC voltage, derived in the IF/audio module thin film packet A4, is fed back to reduce the gain of the first amplifier stage Q1. AGC voltage is applied to the collector of the transistor Q1 rather than the base circuit. In this way transistor Q1 is biased to saturation at high carrier levels and provides approximately 30 db control range. Formerly the AGC voltage was fed to the base of both transistors Q1 and Q2. Problems arose in getting proper sequential operation, i.e. Q1 control before Q2 and in maintaining the signal handling capability of the stages as the AGC voltage biased them towards cutoff. With the present method of RF/AGC, a more repeatable performance between modules is achieved as well as obtaining flatter AGC characteristics. The audio output is within 3 db for an RF signal input variation from 5 uv to 100,000 uv (a total change of 86 db).

With the above changes the receiver module is more produceable and less critical in alignment. However, careful alignment is necessary for good spurious performance.

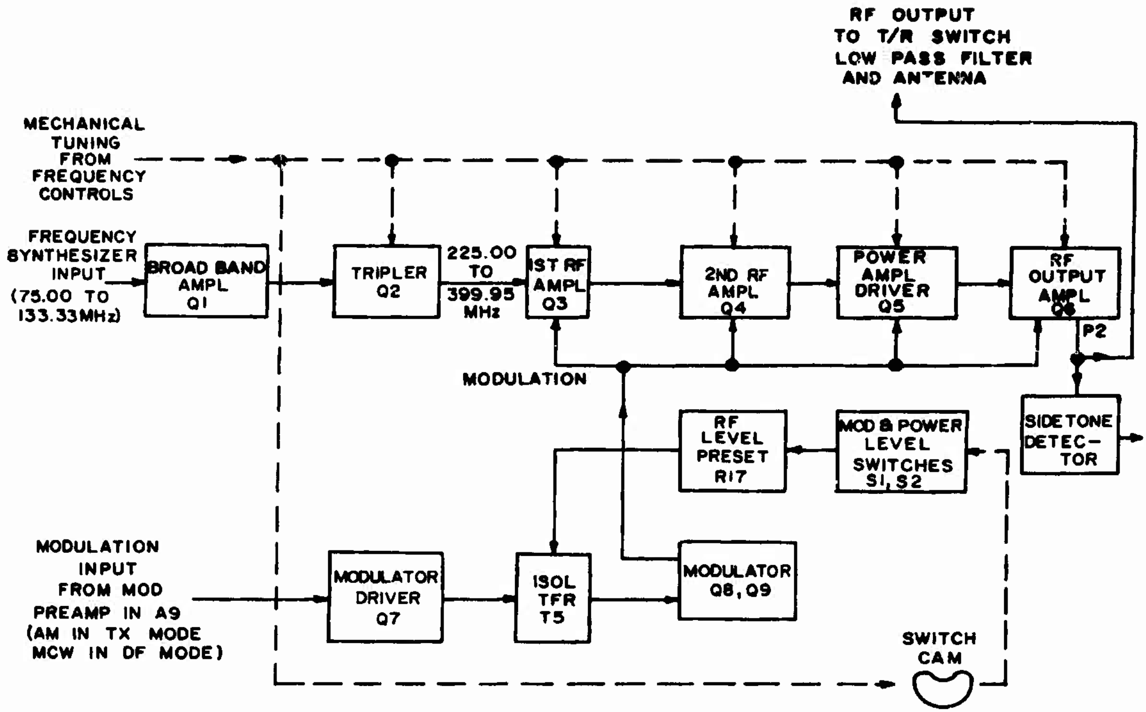
A minor change involved the output circuit of mixer transistor Q6. Formerly, the collector load was a 15 uH choke plus the coupling capacitor to the crystal filter. This arrangement was unstable for a portion of the tuning range of the variable capacitor in the crystal filter. To correct this condition, a 470 ohm resistor is placed parallel with the 15 uH choke, and the coupling capacitor C28 was reduced in value to 8.2 pF. This arrangement permits the tuning of the the variable capacitor over the entire range with stability and when adjusted, the circuit provides a proper impedance match from the collector circuit to the 2000 ohm input impedance of the crystal filter.

4.3.5.3 P A Modulator Module (PRC-66)

(a) General

The development of UHF power transistors has made possible the successful design of the PA modulator module. However, to use these transistors, new circuits had to be designed, tuning circuits designed and miniature components tested and adapted to a wide range of environmental conditions.

A functional block diagram of the module is provided in Figure 4-67 and a schematic of the module is provided in the appendix. Preceding the first power amplifier is a broadband amplifier and a tripler amplifier. The transistors are 2N918's in miniature TO-50 case. Input to the broadband amplifier is obtained from the frequency synthesizer module. Frequency synthesizer output is at a +3 dbm level and operates at one-third the channel frequency range of 75 to 133.3166 MHz and the power gain of the broadband amplifier is approximately 12 db. This level is sufficient to drive the conventional triple amplifier. The output of the tripler is tuned to the channel frequency and drives the first power amplifier.



AN/PRC-66
POWER AMPLIFIER/MODULATOR MODULE A5
FUNCTIONAL BLOCK DIAGRAM
FIG. 4-67

The power amplifier portion employs four UHF NPN silicon planar transistor amplifiers, coupled by special tuning circuits designed for small size, high "Q" and providing a linear relationship between tuning frequency and angular position (one megahertz per degree). The first two stages use 2N3866 transistors coupled by parallel tuned tank circuits. The driver and power output stages use type 2N3375 transistors, coupled by series tuned tank circuits.

The output tuned circuit is designed to couple the collector circuit of the final 2N3375 to the antenna and, at the same time, to suppress harmonic output. The suppression across the band varies from 25 db to 40 db. A following low pass filter further improves the suppression to greater than 40 db.

The five tanks in the RF section of this module are tuned by a common shaft coupled to the tuning selector mechanism in the control head and main chassis section of the transceiver.

Forward bias is used on all stages except the final. All the dc current fed to the power amplifier, including the bias on the second and third stages is modulated by a series type modulator (Q8 and Q9)

(b) <u>Modulation</u>

The microphone amplifier and input level control are located in the IF and audio module section of the transceiver. The power portion of the modulator is confined to the transmitter module. This has the advantage of eliminating high level r-f modulation being conducted through the chassis and causing regeneration problems.

The first audio stage (Modulation driver Q7) uses a 2N956 transistor in a wideband circuit. A switched resistor network is provided in the emitter circuit of Q7 to provide necessary gain adjustment and hence modulation depth control over the operating frequency range of the transmitter. The second 2N956 (Q8) acts as a driver for the 2N3748 Q9 transistor connected as a series modulator. All of the power for the transmitter passes through, and is contolled by the modulator transistor Q9. With no modulation signal input Q9 provides approximately 12 volts quiescent DC voltage to the collectors of power amplifier stages Q3, Q4, Q5, Q6, to produce unmodulated carrier power output. Upon the application of a modulation signal, audio drive to the base of Q9 varies the impedance of the collector-emitter circuit of Q9 which in turn varies the voltage applied to the collectors of power amplifiers Q3, Q4, Q5, Q6 about the quiescent value of 12 volts in accordance with the input A.C. modulating siganl. This varying collector supply voltage results in the desired amplitude modulation of the R F power output.

(c) Control of Output RF Power

The steady state bias of the modulation transistors Q8 and Q9 is adjustable and is used to set the operating dc supplied to the power amplifier and thus becomes a power output control.

The RF power capability of the transistors is not constant across the band or over the temperature range, so an additional level control circuit was devised. The power output level of the transmitter was used as a reference for an A.L.C. circuit. This worked well when the power output was applied to a well matched 50 ohm load, but the specification requires that the transmitter will operate with a mismatch of 3:1. Under these conditions neither power demand nor power output may be relied upon as a reference, so the circuit was abandoned in favour of a simple 3 step voltage control circuit that is mechanically switched by a cam operated by the tuning shaft. Modulation depth is also controlled by this circuit.

To maintain RF power output to -30°C, the quiescent voltage supplied to the power amplifier must be increased by about 2 volts at low temperature. This is done by means of a thermistor in the bias network of the modulator.

(d) General Thermal Considerations

Efficient use of battery power has been a prime consideration during this development programme. This in turn has resulted in the minimization of power loss in each transistor, concurrent with cooler operation. Coupled with this has been the provision of good thermally conductive paths, where necessary, by which heat may be dissipated in the chassis. The 2N3866 transistors are enclosed in boron nitride heat sinks. A thermal compound is also used to fill any voids between the transistor case and the heat sink. The 2N3375 transistors are mounted by means of a #10 - 32 copper screw to provide an excellent heat path to the chassis. The normal duty cycle of the transmitter is 1:9 but 30 minute continuous operation tests have been made with the module in an environment of 95°C, without failure.

(e) Power Input

Power input to the module is at a 12 volt and a 24 volt level. Input currents vary across the operating frequency range. The 12 volt current varies from 23 ma to 28 ma. approximately. The 24 volt current varies from 500 ma. to 600 ma. approximately.

4.3.5.4 RF Modulator Module (AN/PRC-75)

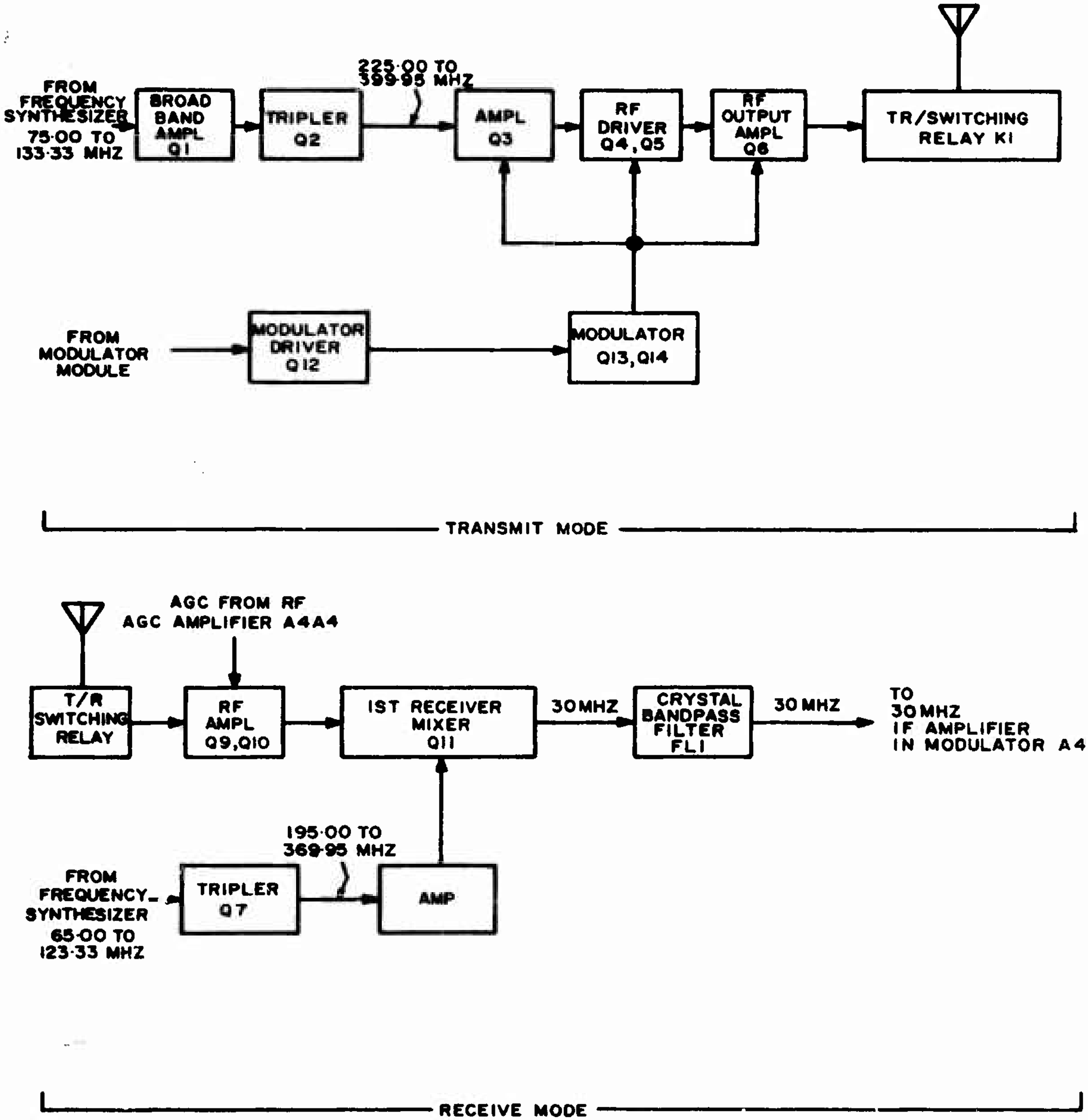
4.3.5.4.1 General

The receiver and transmitter sections of the AN/PRC-75 transceiver are combined into one module designated "RF/Modulator" module.

The RF modulator module performs all the functions required at the UHF frequencies associated with the transceiver. The circuitry and their main functions are:-

1. Continuously tunable receiver front end, providing selectivity and gain.
2. Receiver mixer, and 30 MHz bandpass filter, for translation of the incoming signal and overall receiver selectivity.
3. Continuously tunable transmitter, for amplification and selectivity at the channel frequency to provide the required power output and spurious attenuation.
4. Modulator power stages to provide power required for amplitude modulation of the transmitter.

The following paragraphs describe operation and design of the various sections of the module. Figure 4-68 shows a block diagram of the module, and a schematic of the module is provided in the appendix Figure AP-4.



AN/PRC-75
RF MODULATOR MODULE
FUNCTIONAL BLOCK DIAGRAM

FIG. 4-68

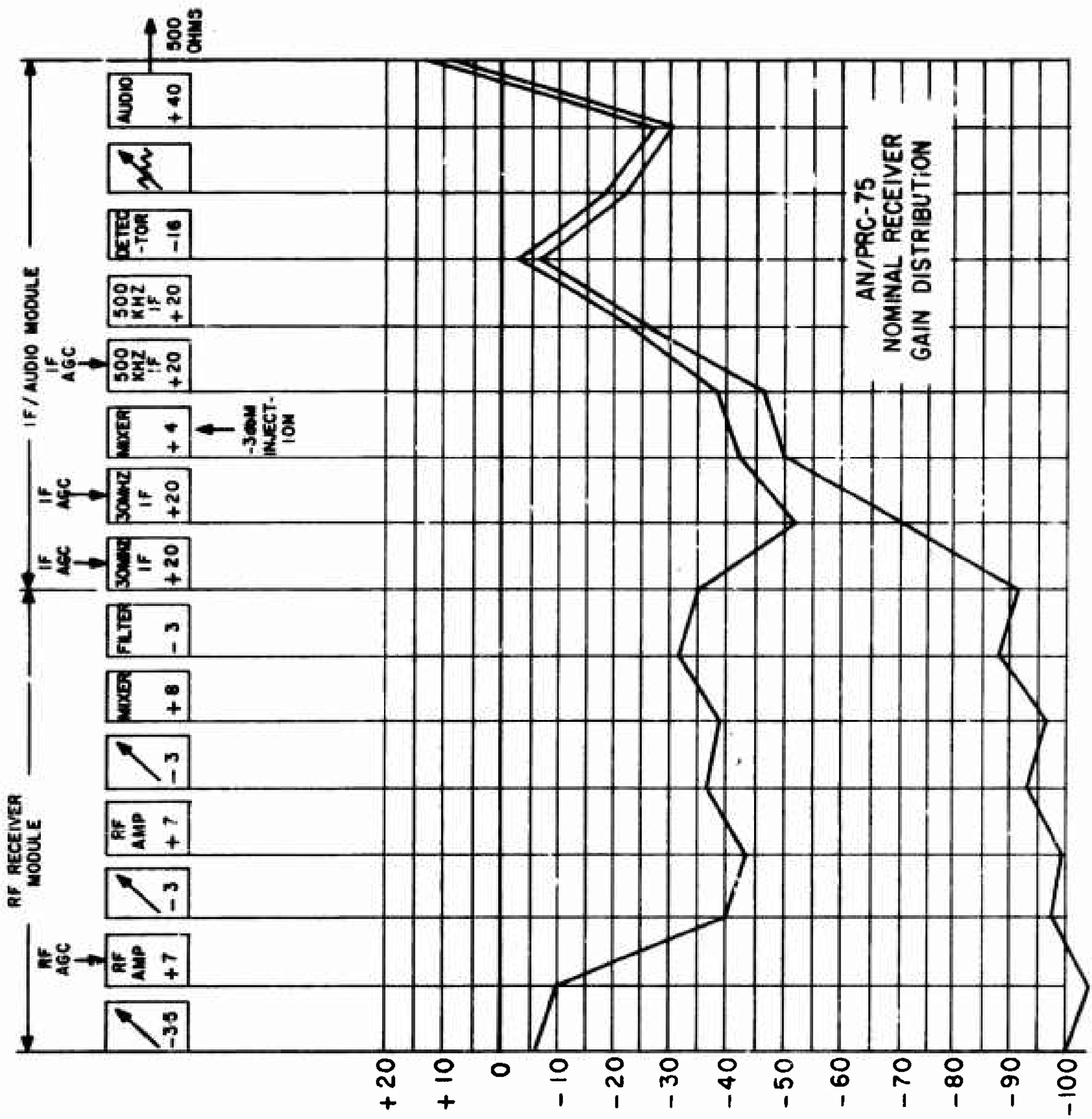
4.3.5.4.2. Receiver Section (AN/PRC-75)

The receiver module consists of a translator with input frequency range from 225.00 to 399.95 MHz and an output frequency of 30.0 MHz. Receiver mixer injection is required over the frequency range of 65.00 to 123.3167 MHz. The receiver is continuously tunable over the frequency range. Power consumption is 23 ma. at 12 volts.

When the transceiver is in receive condition, power is removed from the transmitter section. The signal from the antenna is fed through the transmit/receive antenna relay to the RF amplifiers and mixer sections of the module. Here it is mixed with the proper injection signal to produce the 30 MHz IF output which is then fed to the IF/audio module. The following paragraphs describe each portion of the receiver in detail.

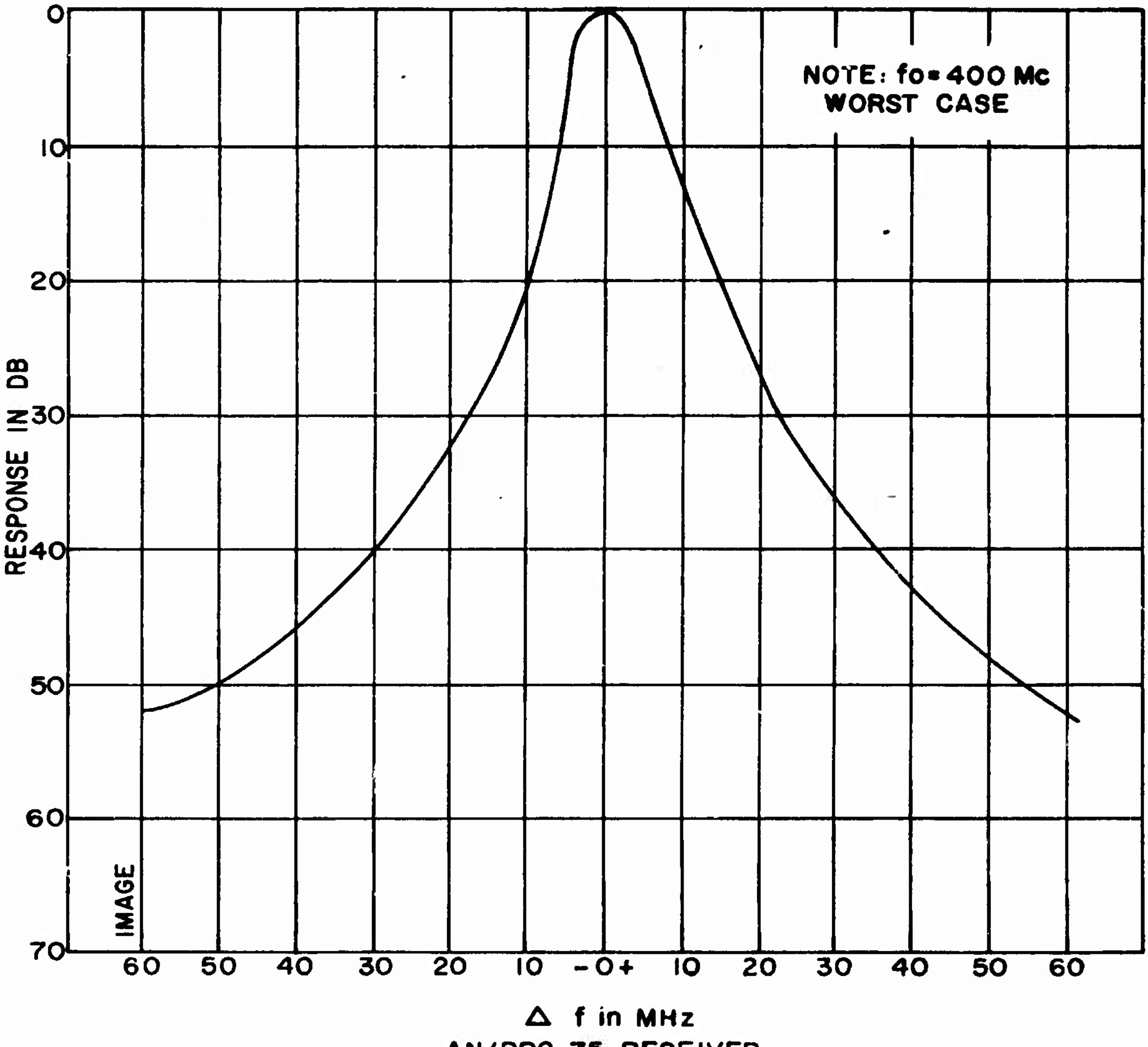
The input section of the receiver consists of two tuned RF amplifier stages. Three tuned circuits are used to provide selectivity to meet the spurious response requirements. Two transistors are used to provide approximately 5 db net power gain to the mixer input. For gain distribution of the entire receiver refer to Figure 4-69. The gain obtained is necessary to satisfy the receiver sensitivity requirement of less than 3 microvolts (closed circuit) for 10 db S+N/N ratio at the output. A TA2663 transistor is used in the first two RF stages to obtain good noise figure and sensitivity.

Following the second RF amplifier is a conventional transistor mixer circuit again using a TA2663 transistor. The output of the mixer if fed to the 30 MHz XTAL filter. Conversion gain of the mixer is 8 db. The 30 MHz filter determines the overall



AN/PRC-75
NOMINAL RECEIVER
GAIN DISTRIBUTION
RF RECEIVER MODULE
IF / AUDIO MODULE
RF AGC
IF AGC
IF AGC
IF AGC
-35
RF AMP +7
-3
RF AMP +7
-3
MIXER +8
FILTER -3
30MHZ IF +20
30MHZ IF +20
MIXER +4
500 KHZ IF +20
500 KHZ IF +20
DETEC-TOR -16
AUDIO +40
500 OHMS
-3dBM INJECT-ION
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

FIG. 4-69



AN/PRC-75 RECEIVER
MODULE
FRONT END SELECTIVITY

FIG. 4-70

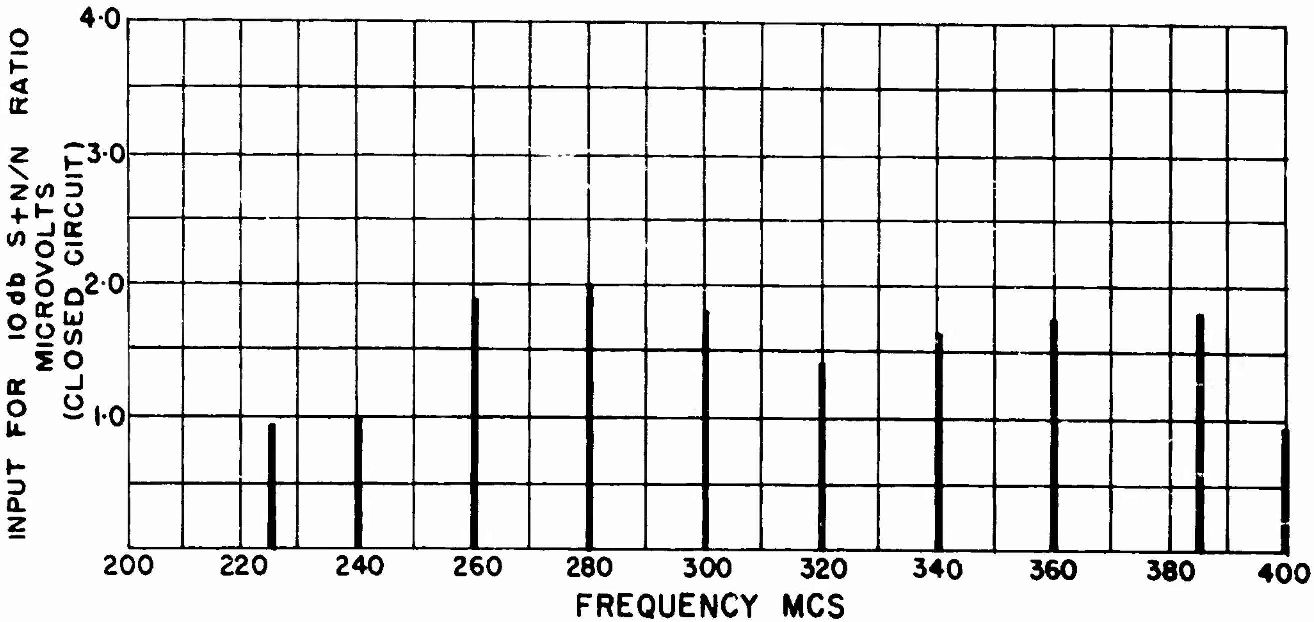
selectivity of the receiver. The 6 db points are 30 MHz ± 20 kHz min. and the 60 db points are 30 MHz ± 37.5 kHz max, with frequencies outside this range being attenuated more than 60 db. Insertion loss of the filter is less than 3 db and ripple in the passband is held to less than 1 db over the passband.

The injection and signal are both fed to the base of the mixer transistor. This is done to permit by-passing of the emitter circuit at 30 MHz without special networks. The base is by-passed to 30 MHz by a series resonant circuit. By-passing of both the base and emitter at 30 MHz increases the conversion gain of the stage. No difficulty with interaction between the RF amplifier and injection tuned circuits is encountered since both are lightly coupled to the mixer.

The injection is derived from the frequency synthesizer module operating at one third the required injection frequency. This input is tripled and fed to a broadband amplifier. The X3 multiplier output and the broadband amplifier are tuned to the injection frequency to prevent spurious response of the receiver with the fundamental and the undesired harmonic outputs of the tripler.

The output level of the frequency synthesizer is at least +3 dbm, and the gain of the broadband amplifier is 10 db. This provides sufficient drive, with margin, for the mixer transistor.

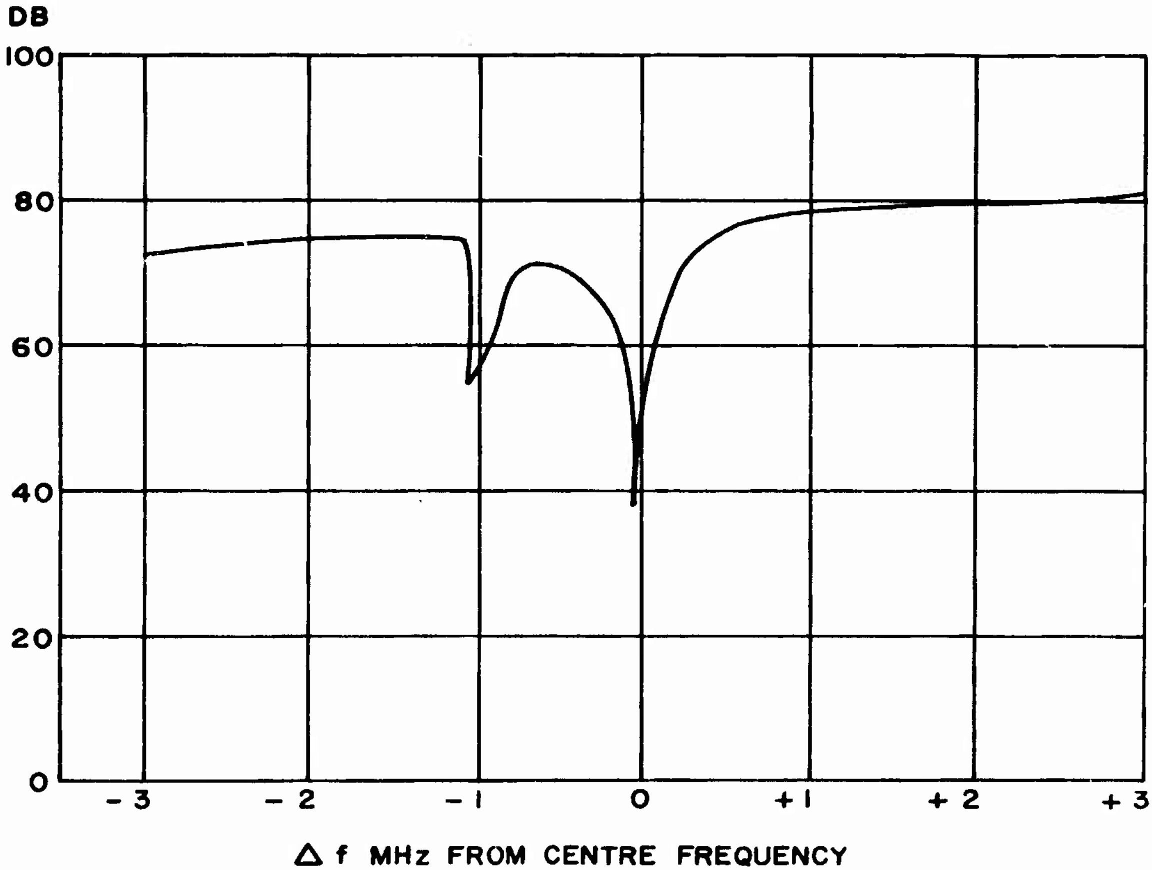
Performance data for the receiver module is shown in Figure 4-70 through 4-72. Figure 4-70 shows the worst case front



PRC-75

SENSITIVITY vs FREQUENCY

FIG. 4-71



NOTE: CURVE REPRESENTS LEVEL ABOVE DESIRED SIGNAL REFERENCE AT WHICH UNDESIRED SIGNAL DEGRADES $\frac{S+N}{N}$ RATIO FROM 10DB TO 6DB

AN/PRC-75 CROSS MODULATION CHARACTERISTICS

FIG. 4-72

end selectivity which occurs at 400 MHz. Sensitivity is shown in Figure 4-71. A number of design improvements have made possible improved spurious performance of the receiver. The equipment specification requires all spurious responses to be at least 60 db down relative to the desired signal, and this has been obtained for the most part. Cross-modulation performance is shown in Figure 4-72. This test shows the level of off-channel signal required to degrade the desired signal response from 10 db $\frac{S+N}{N}$ ratio to 6 db $\frac{S+N}{N}$ ratio.

A description of the design changes follows. Improvements were made in the following areas:-

(1) Spurious response

(2) Sensitivity, and

(3) RF/AGC

(1) Spurious Response

Fourth harmonic spurious response of the receiver is most critical at the low end of the band. A broadband amplifier and a second resonant tank circuit were added to a minimum of 30 db additional attenuation to the fourth harmonic of the synthesizer injection signal. Spurious response to 236-2/3 MHz when operating at 230 MHz is now at least 60 db down.

Spurious response to image frequency at high end, 399.95 MHz operation, is the worst case condition for PRC-75 radio. Here, response to image frequency was marginal and approximately 52 db down. To improve this spurious response would necessitate addition of an extra RF tank circuit with its associated amplifier stage. This was not done because of space limitations. The spurious response to image frequency is better than 60 db down below an operating frequency of 320 MHz.

(2) Sensitivity

Sensitivity was also improved in the PRC-75 radio. Sensitivity was marginal and dependent upon careful tuning of the tank circuits in the RF amplifier line-up. To improve the receiver module sensitivity the following changes were made:-

(1) Low noise figure transistor TA2663 was used in the second stage transistor Q2.

(2) Low noise figure transistor TA2663 was used in the first mixer circuit.

These changes improved the sensitivity of the receiver such that at 399.95 MHz, the typical closed circuit signal for 10 db S+N/N ratio is approximately 2.2 microvolts

(3) RF AGC

AGC performance was also improved. Here, delayed RF/AGC voltage, derived in the IF/audio module thin film packet A4, is fed back to reduce the gain of the first amplifier stage Q9. AGC voltage is applied to the collector of the transistor Q1 rather than the base circuit. In this way, transistor Q1 is biased to saturation at high carrier levels and provides approximately 30 db control range. Formerly, the AGC voltage was fed to the base of both transistors Q9 and Q10. Problems arose in getting proper sequential operation, i.e. Q9 control before Q10 and in maintaining the signal handling capability of the stages as the AGC voltage biased them towards cutoff. With the present method of RF/AGC, a more repeatable performance between modules is achieved as well as obtaining flatter AGC characteristics. The audio output is within 3 db for an RF signal input variation from 5uV to 100,000 uV (a total change of 86 db).

With the above changes, the receiver module is more producible and less critical to alignment. However, careful alignment is necessary for good spurious performance.

A minor change involved the output circuit of mixer transistor Q11. Formerly, the collector load was a 15 uH choke plus a coupling capacitor to the crystal filter. This arrangement was unstable for a portion of the tuning range of the variable capacitor in the XTAL filter. To correct this condition, the choke has been replaced by a 470 ohm resistor, and the coupling capacitor C28 has been reduced in value to 8.2 pF. This arrangement permits the tuning of the variable capacitor over the entire range with stability and when adjusted, the circuit provides a proper impedance match from the collector circuit to the 2000 ohm input impedance of the crystal filter.

4.3.5.4.3 Transmitter Section

(a) General

The circuitry of this section is very similar to the circuitry found in the P.A. Modulator module of the AN/PRC-66 except that this section has one less tuned circuit and its RF power output is one watt (minimum) whereas the RF power output of the AN/PRC-66 transmitter is two watts (minimum). Power input to this module is approximately 27 ma. at 12 volts and 400 ma. at 24 volts.

Preceding the first power amplifier is a broadband amplifier and a tripler amplifier. The transistors are 2N918's in miniature TO-50 case. Input to the broadband amplifier is obtained from the frequency synthesizer module. Frequency synthesizer output is at a ± 3 dbm level and operates at one-third the channel frequency. The broadband amplifier operates over the frequency range of 75 to 133.3166 MHz and has a power gain of approximately 12 db. This level is sufficient to drive the conventional tripler amplifier. The output of the tripler is tuned to the channel frequency and drives the first RF amplifier.

The first RF amplifier, a type 2N3866 transistor, is broadband coupled to the following first RF driver stage which is also a type 2N3866 transistor. Following this first driver are the second driver (2N3866) and the RF output stage using a type 2N3375 transistor. The basic difference between the AN/PRC-66 and AN/PRC-75 is the use of broadband coupling between the first and second driver stages, and the use of 2N3866 (in lieu of a 2N3375) transistor as second driver in the AN/PRC-75 transmitter section. Broadband coupling was chosen as a space economy measure, making available an additional tuned tank circuit to improve receiver spurious response immunity without increasing the size of the module. Use of a 2N3866 transistor in lieu of 2N3375 in the second driver stage was considered sufficient to drive the final 2N3375 at the lower power level (1 watt) of the AN/PRC-75.

The output tank of the transmitter section is designed to couple the collector circuit of the final 2N3375 to the antenna and at the same time to suppress second and higher order harmonics. The suppression across the band varies from 25 to 40 db.

(b) Modulation

The microphone amplifier and input level control are located in the IF and audio module section of the transceiver. The power portion of the modulator is confined to the transmitter module. This has the advantage of eliminating high level r.f. modulation being conducted through the chassis and causing regeneration problems. The first audio stage (modulation driver Q12) uses a 2N956 transistor in a wideband circuit. The second 2N956 (Q13) acts as a driver for the 2N3748 transistor connected as a series modulator. All of the power for the transmitter passes through, and is controlled by, the modulator transistor Q14.

With no modulation signal input, Q14 provides approximately 12 volts quiescent DC voltage to the collectors of power amplifier stages Q3, Q4, Q5, Q6, to produce unmodulated carrier power output. Upon the application of a modulation signal, audio drive to the base of Q14 varies the impedance of the collector-emitter circuit of Q14 which in turn varies the voltage applied to the collectors of power amplifiers Q3, Q4, Q5, Q6, about the quiescent value of 12 volts in accordance with the input a.c., modulating signal. This varying collector supply voltage results in the desired amplitude modulation of the R.F. power output.

(c) Control of Output RF Power

The steady state bias of the modulation transistors Q13, Q14 is adjustable and is used to set the operating dc level supplied to the power amplifier and thus becomes a power output level control.

To maintain RF power output to -30°C the voltage supplied to the power amplifier must be increased by about 2 volts. This is done by means of a thermistor in the bias network of the modulator.

(d) General Thermal Considerations

Efficient use of battery power has been a prime consideration during this development program. This in turn has resulted in the minimization of power loss in each transistor, concurrent with cooler operation. Coupled with this has been the provision of good thermally conductive paths where necessary by which heat may be dissipated in the chassis. The 2N3866 transistors are enclosed in boron nitride heat sinks. A thermal compound is also used to fill any voids between the transistor case and the heat sink. The 2N3375 transistor is mounted by means of a #10 - 32 copper screw to provide an excellent heat path to the chassis. The normal duty cycle of the transmitter is 1:9 but 30 minute continuous operation tests have been made with the module in an environment of 95°C without failure.

4.3.6 Antennas

The AN/PRC-66 system provides a choice of two antennas: flexible tape type AS-2117/PRC-66 for portable operation and dipole AS-1404/PRC-41 for fixed station operation. The AN/PRC-75 system provides one flexible tape antenna.

Only the flexible tape antennas developed expecially for the AN/PRC-66 and AN/PRC-75 systems will be described here.

The major part of the antenna development program was devoted to arriving at an antenna suitable for the AN/PRC-75 equipment configuration -- an ultra-small hand held transceiver with integral storeable antenna. Information obtained through this development formed the groundwork of the antenna development for the AN/PRC-66 configurations.

4.3.6.1 AN/PRC-75 Antenna

4.3.6.1.1 Design Considerations

In designing the antenna for the AN/PRC-75 equipment, there were a number of requirements which had to be considered. They are listed as follows:-

(a) Electrical Requirements

1. Nominal input impedance of 50 ohms, unbalanced.

2. Maximum VSWR of 3:1 in the frequency band of 225 - 400 MHz without tuning.

3. Minimum efficiency of 50 percent in the frequency band of 225 - 400 MHz

4. Desirable to operate equally well while handheld, in the jacket pocket or on the ground.

(b) Mechanical Requirements

1. Physically small.

2. Storable without removing.

3. Mechanically rugged.

4. Easily replaceable.

Because the antenna was to be small and was to cover almost a 2:1 frequency range without tuning, a broadbanding impedance matching network, using stripline techniques, was developed. The small size of the transceiver, relative to the wavelengths involved, causes the transceiver to act not as a simple ground plane, but as a radiating element contributing significantly to the overall radiation and impedance properties of the antenna. This effect, not being predictable by any simple antenna theory, necessitated a largely empirical design of the antenna and matching network.

4.3.6.1.2 Preliminary Antenna Designs

A number of different preliminary antenna models were developed for this application, enumerated as follows:-

(a) Telescoping Whip Antenna

This antenna was a three section 11 inch long whip-type element with associated coaxial impedance-matching network.

The electrical performance of the telescopic antenna with matching network was found to be satisfactory. VSWR was less than 3 over the operating frequency range. Unfortunately, this antenna presented a number of undesirable features that ruled out its adoption:-

a. The antenna was subject to easy breakage.

b. The antenna had a number of sliding joints that would require sealing.

c. The antenna and matching network required more space within the transceiver case than could be tolerated.

(b) Tape Antenna With Tapered Base

Some of the disadvantages of the telescoping antenna were eliminated by using a fixed-length spring tape in place of the telescoping element. The first tape antenna was 10 inches long and 1/2 inch wide with the lower region tapered almost to a point to provide an intermediate transition into the coaxial matching network.

Electrical performance of this tape antenna was satisfactory but, although it overcame some of the problems associated with the telescoping antenna, the use of a tapered base made the antenna subject to easy breakage. This mechanical design difficulty prompted an effort to eliminate the need for the tapered base.

(c) Uniform Tape Antenna

It was found that the need for a tapered feed point at the base of the antenna could be eliminated by increasing the number of elements in the matching network from three to four.

Electrical performance of the uniform tape antenna and matching network was satisfactory. VSWR was less than 2.6 over the whole band and less than 2 over more than 75% of the band. Since there appeared to be no major mechanical problems, this form of antenna was adopted. An important characteristic of the tape antenna is that, when not in use, it is stored by folding it across the top and down into a slot on the opposite side of the transceiver case.

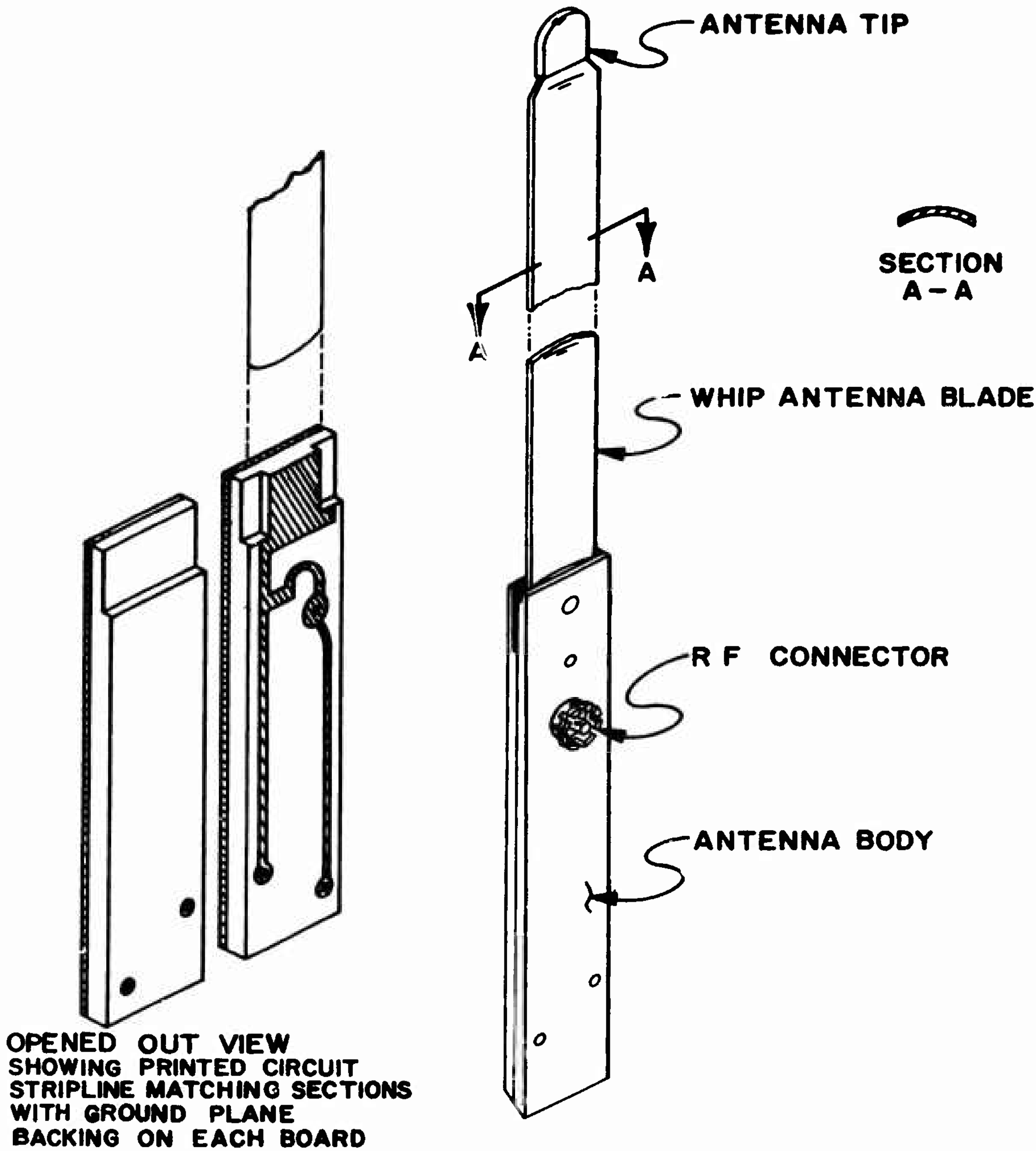
(d) Stripline Matching Network

Because of the advantages of stripline techniques over coaxial systems where miniaturization is important, it was considered desirable to replace the coaxial matching network with a stripline network. No difficulties were encountered in arriving at the stripline equivalent of the coaxial network, and the final form of the antenna system is a uniform tape with stripline matching network forming a physical part of the base of the antenna as shown in Figure 4-73. A number of dielectric materials were evaluated for use in the stripline network. Electrical characteristics such as losses, dielectric constant, and mechanical properties such as strength, rigidity, susceptibility to cold flow were considered before finally selecting a G-10 type fibreglass board material.

4.3.6.2 AN/PRC-66 Antenna

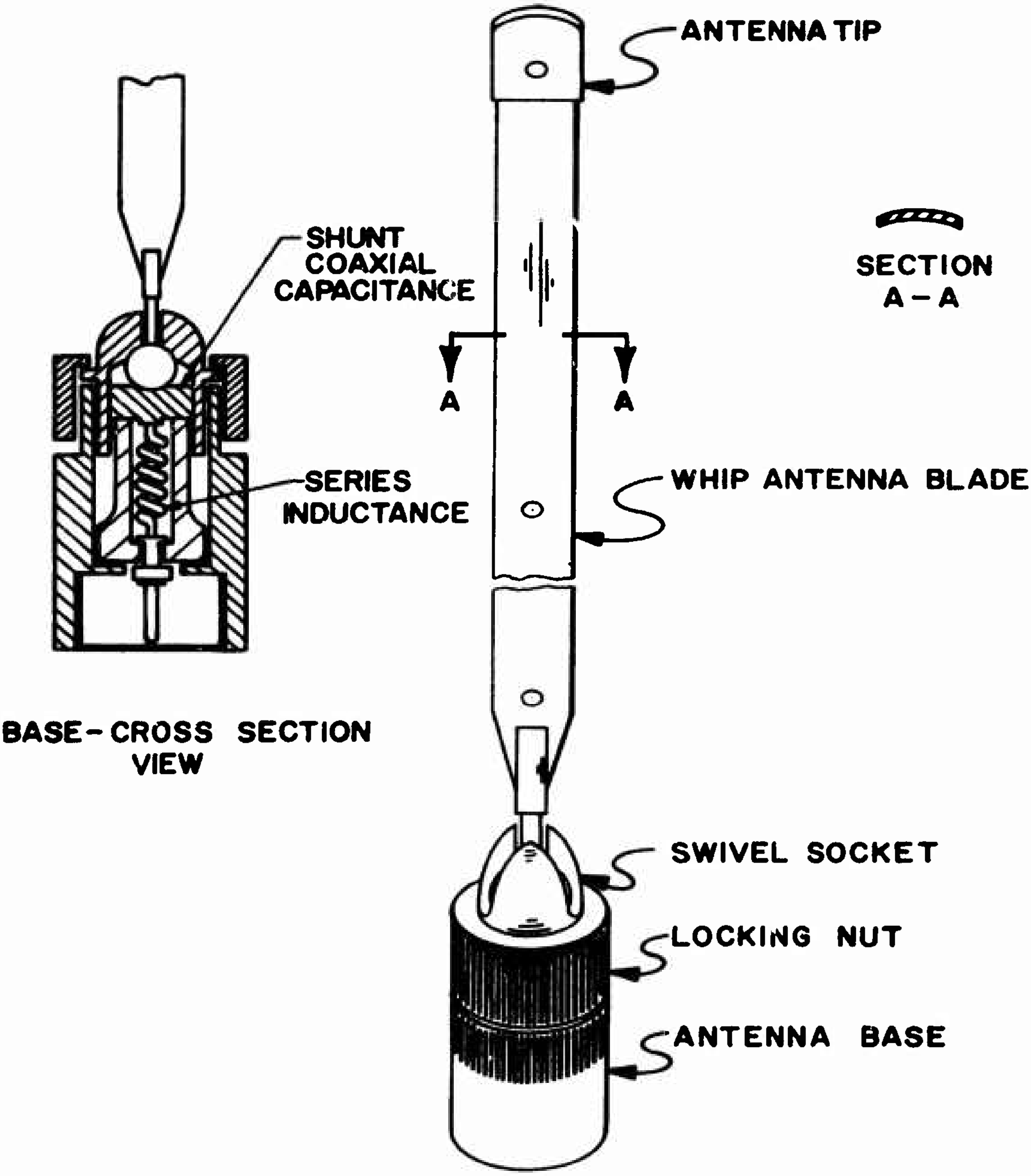
The basic design of the AN/PRC-66 antenna shown in Figure 4-74 is founded upon the results obtained during the development of the antenna for the AN/PRC-75 configuration.

One of the requirements of the AN/PRC-66 was the ability to (a) operate using its own small "whip" antenna or (b) to operate into any standard 50 ohm system (antenna or other load) using standard BNC connectors. Since operation into an external system would require removal of the small whip antenna, and in order to conserve transceiver control panel space, a single antenna connector was developed which operates at a 50 ohm level and provides a dual whip antenna/BNC capability. The small whip antenna supplied with the AN/PRC-66 system is complete with a swivel base connector that contains the required 50 ohm matching network. A coaxial type



FIXED ANTENNA (FLEXIBLE)

FIG 4-73



SWIVEL BASE ANTENNA (FLEXIBLE)
AS 2117 /PRC-66
FIG. 4-74

of matching network was used in this antenna application as the most simple form (as opposed to stripline techniques) compatible with the required 50 ohm coaxial output from the radio.

4.3.7 Batteries

Both disposable and rechangeable battery packs were developed as part of the AN/PRC-66 radio set. Disposable battery packs only were developed for the AN/PRC-75 radio set.

Investigations were carried out, considering such factors as: chemical types, cell sizes, energy storage, current handling capability, volumetric efficienty, weight, cost, life, charge retention, shelf life and environmental (low temperature) performance. Having considered all apparent factors, the development was settled upon nickel-cadmium rechargable and alkaline disposable cells as representing optimum types in the light of the present state-of-the-art.

During development of the 12 hour rechargable battery for the AN/PRC-66, it was found that a 12 hour capacity could not be met by a battery pack limited by the dimensions given in the purchase description, but that an 8 hour battery pack could be provided within the specified dimensions. As a result, two battery packs were developed: an 8 hour pack meeting the dimensional requirements, and a 12 hour pack exceeding the dimensional requirements. Quantities of prototypes of both battery packs have been supplied under contract as support items for customer evaluation of the AN/PRC-66 equipments. The 12 hour pack was subsequently discontinued in favour of an 8 hour pack following development of wideband AN/PRC-66B described in section 6 of this report. Additional power requirements of the AN/PRC-66B system made it impossible to provide a 12 hour pack in the space allowed.

The following is a brief summary of the characteristics of the batteries developed for the AN/PRC-66 and AN/PRC-75.

PRC-66 Nickel Cadmium Rechargeable Battery

Number of Cells: 21

Type of Cells used: Nickel-Cadmium type C - size cells.

Arrangement of Cells: Cells are series-connected and arranged in a honeycomb configuration inside an aluminum battery box size 9.00" x 3.25" x 2.25".

Battery Capacity: 1.9 Ampere - Hours

Recharge Cycles: In excess of 200.

Limitations: Cold temperature Operation: Approx. 60% of Capacity remaining at -30°C.

PRC-66 Alkaline Disposable Battery

Number of Cells: 80

Type of Cells used: Alkaline Primary Type E91 cell

Arrangement of Cells: Cells are connected 20 in series and 4 banks of these in parallel.

Size of battery: 8-5/8" x 4-1/8" x 1-3/4" max.

Battery Capacity: Will operate PRC-66 RT unit on a 9:1 RCV/XMT duty cycle for not less than 12 hours.

Recharge Cycles: Not applicable

Limitations: Very poor low temperature performance Approx. 15 minutes life at -30°C

PRC-75 Alkaline Disposable Battery

Number of Cells: 60

Type of Cells used: Alkaline Primary Type E91 Cell.

Arrangement of Cells: Same as for PRC-66 except 3 banks parallel

Size of Battery: 5-11/16" x 4-7/16" x 1-29/32" max.

Battery Capacity: Will operate AN/PRC-75 RT unit on a 9:1 RCV/XMT duty cycle for not less than 8 hours.

Recharge Cycles: Not applicable.

Limitations: Very poor low temperature performance. Approx. 10 minutes life at -30°C.

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5.0 Acceptance Testing

5.1 General

The AN/PRC-66 and AN/PRC-75 (XN-1) have undergone extensive acceptance testing under both standard and environmental conditions in accordance with section 4 of RADC exhibit 5137 and purchase description USMC CSY-FY 64-12 respectively.

The equipments were subjected to the following tests. During the environmental testing, regular standard condition verification tests were performed to monitor the equipments for any sign of permanent degradation.

5.1.1 AN/PRC-66

(paragraph numbers in paranthesis are those of RADC 5137)

A) Standard Conditions Acceptance Tests

1. General Inspection - Dimensions and weight (3.6)
2. Receiver Sensitivity, Audio power output, input (3.5.2.5 and 3.5.2.2)
3. AGC Dynamic Range (3.5.2.1 and 3.5.2.11)
4. Audio Frequency Response (3.5.1.7)
5. Audio Distortion
6. Volume Control Attenuation (3.5.2.3)
7. Receiver Selectivity (3.5.2.12)
8. I.F. Rejection
9. Image rejection and other spurious (3.5.2.10)
10. Squelch adjust, quieting and overlap (3.5.2.13.1/2/3)
11. Transmitter power output and power input (3.5.1.2)
12. Envelope distortion (3.5.1.9)
13. Audio frequency response (3.5.1.7)

14. Modulation capability (3.5.1.6)

15. Frequency stability and accuracy (3.5.1.5)

16. MCW Capability (3.5.1.10)

17. Sidetone operation (3.5.2.6)

B) General Tests

1. Case temperature continuous transmit (3.4.5 and 3.4.7)

2. Battery life (3.5.2.13.4)

3. Silent operation (3.4.2)

4. Resetability (3.4.3)

C) Environmental Acceptance Tests

1. Temperature (4.4.4.1)

   Low temperature soak (-54°C) non operating

   Low temperature (-30°C) normal voltage (24 volts)

   Low temperature (-30°C) battery life

   Low temperature (-30°C) low supply voltage (18 volts)

   Low temperature (0°C) normal voltage (24 volts)

   High temperature soak (+68°C) non operating

   High temperature (+52°C) normal voltage (24 volts)

   High temperature (+52°C) continuous transmit normal voltage (24 volts)

   High temperature (+52°C) High voltage (30 volts)

2. Altitude (4.4.5)
   MIL-STD-810 Method 500, 10,000 ft.

3. Humidity (4.4.5)
   MIL-STD-810 Method 507

4. Vibration (4.4.6)
   MIL-STD-810 Method 514 class 1,5,6, Mtrg. a, b.

5. Immersion (4.4.5)
   Water, 2 hours, 3 foot depth, non operating

6. Sand and Dust (4.4.5)
MIL-STD-810 Method 510

7. Salt Fog (4.4.5)
MIL-STD-810 Method 509, 100 hours duration

8. Bench Handling (4.4.6 c)
MIL-T-4807 Method 4A

9. Drop Test (4.4.6. b)
20 feet on wooden floor, 10 drops in drop bag.

10. Interference (4.4.3)
Conducted interference on Antenna, receive and transmit

Radiated interference 0.15 to 10,000 MHz with antenna and dummy load-transmit operation.

11. Maintainability (4.4.8)
MIL-M-26512 and Appendix A- Confidence level 90%.

12. Rain (4.4.5) MIL-STD-810 Method 506, operating.

13. Shock tests (4.4.6. d)
MIL-T-4807 Method 3A.

14. Reliability tests (4.4.7)

5.1.2 AN/PRC-75 (XN-1): (Paragraph numbers in paranthesis are those of USMC PD CYS-FY 64-12)

A) Standard Conditions Acceptance Tests

1. General inspection-Dimensions and weight (3.3.2)

2. Receiver sensitivity audio power output, input power (3.4.2.1, 3.4.2.6.1, 3.3.1.2)

3. AGC Dynamic range (3.4.2.5)

4. Audio Frequency response (3.4.2.6.3)

5. Audio distortion (3.4.2.6.2)

6. Volume control attenuation (3.4.2.6.4)

7. Audio transducer Output (3.4.2.6.1)

8. Receiver Selectivity (3.4.2.3.)

9. I.F. Rejection (3.4.2.4.1)

10. Image rejection and other spurious (3.4.2.4.2)

11. Transmitter power output, power input (3.4.3.1)

12. Envelope distortion (3.4.3.3)

13. Modulation frequency response (3.4.3.3)

14. Modulation capability (3.4.3.6)

15. Frequency accuracy (3.3.5.3)

B) General Tests

1. Case temperature, continuous transmit (3.3.16, 3.4.3.2)

2. Battery life (3.3.13)

C) Environmental Acceptance Tests

1. Temperature (4.7 and 4.8)

   Low temperature soak (-54°C) non operating

   Low temperature (-30°C normal voltage (24 volts)

   Low temperature (-30°C) Battery Life

   Low temperature (-30°C) low voltage (18 volts)

   High temperature soak (+68°C) non operating.

   High temperature (+52°C) normal voltage (24 volts)

   High temperature (+52°C) high voltage (30 volts)

   Temperature shock (+65°C to -40°C three cycles (4.8)
   MIL-STD-810 Method 503

2. Altitude (4.10)
   MIL-STD-810 Method 500 - 10,000 feet

3. Humidity (4.9)
   MIL-STD-810 Method 507

4. Vibration (4.4.6)
   MIL-STD-810 Method 514 Procedure 1 for class 7

5. Immersion (4.5)

Water, 2 hours, 3 foot depth, non operating

6. Sand and Dust (4.12)

MIL-STD-810 Method 510 Procedure I.

7. Salt Fog (4.11)

MIL-STD-810 Method 509

8. Bench handling

9. Drop Test (4.4)

42 inch drop onto concrete, three planes.

10. Interference (3.4.2.7, 3.4.3.5, 4.13)

Conducted interference on power leads, receive and transmit

Oscillator radiation and conducted interference on antenna receive mode.

Radiated interference, transmit mode with antenna 0.15 to 10,000 MHz.

11. Maintainability testing (3.2.4)

12. Reliability testing (3.2.2)

MIL-STD-441

13. Shock Tests

MIL-T-4807 Method 3A

5.2 Test Results - PRC-66

A) Standard Conditions Tests

Refer to section 3 of this report for results of testing under standard conditions

B) General Tests

1. Case temperature Continuous Transmit

In an ambient temperature of 70°F the highest spot temperature observed on the case was 93.2°F. (specification limit: 100°F)

2. Battery Life

The 8 hour rechargeable battery voltage had dropped to 18 volts after 8 hours and 55 minutes at which transmitter power output had dropped from 2.95 watts to 1.86 watts.

The non-rechargeable battery voltage had dropped to 18.8 volts after 12 hours of operation at which transmitter power output was 2.35 watts.

3. Silent Operation

All controls and switches were operated in a reasonably quiet environment. No unusually loud noises were found to occur.

4. Resetability

During this test greatest change in transmitter frequency observed was 200 Hertz @ 399.95 megahertz.

C) Environmental Acceptance Tests

1. Temperature and supply voltage extremes
($-30^{\circ}C$ to $+52^{\circ}C$ and 30 VDC to 18 VDC)

The transceiver met the specification requirements when subjected to temperature and supply voltage extremes with the exception of transmitter power output and modulation distortion under combined low temperature and low voltage. Power output (90% modulated) dropped to 0.75 watts. Modulation envelope distortion (64% modulation) rose to 29 percent. It is considered that these combined conditions are extremely severe and that performance degradation beyond the specified service condition allowance of only 3 db (for power output) from standard conditions specification limits is to be expected.

2. Altitude
(10,000 feet)

Performance during altitude testing was the same as under room ambient standard conditions.

3. Humidity
(240 hours, 95% humidity)

The humidity test showed up a number of problems (internal corrosion and poor receiver sensitivity) attributed to an insufficient seal of the antenna connector and the coaxial cable to the low pass filter. This problem has been overcome by potting of the antenna connector. The following observations were made following the exposure:

a) Audio connector rust on two places.

b) 50 KHz control set screws rusted

c) Three module surfaces showed small dots of tarnish

d) On the second day of exposure, the 10 MHz control stiffened but was worked loose.

Immediately following the humidity exposure, a number of inoperative channels were also found. This problem cleared up after about one hour, before an adequate investigation could be carried out. It was considered that a major cause of this problem was poor contact pressure of the 10 megahertz logic switches. Contact pressure was increased by increasing the thickness of the pickup fingers in the control head.

The above changes to the control head switches and to the radio sealing has resulted in a successfully sealed radio as proved in the subsequently successful immersion test. A brief humidity test of 3 days was also run after the changes were made. Results of this test indicated satisfactory performance.

4. <u>Vibration - Preliminary</u>

Vibration testing indicated that covers on the voltage regulator and IF/Aduio modules were not satisfactory. In addition, there was insufficient amounts of rubber pad damping material between the transceiver cover and the modules. With re-designed covers and thicker pads of damping material, vibration testing progressed successfully. No catastrophic failures occurred. Some performance degradation occurred with resonances observed during vibration in the X and Z direction. The degradation showed up as isolated increases in receiver and transmitter noise levels. Performance of the transceiver returned completely to normal following the vibration test.

During vibration in the X direction, the spot increases in noise levels were due to vibration of the tuning capacitor plates of the receiver and transmitter tank circuits (this vibration is in the direction of the axes of the tuner shafts, which are normal to the tuning capacitor plates, of the R.F. modules).

The degradations are not considered serious since they are isolated, sharply tunable and not actually sufficient to make voice communication impossible (worst cases were: 9 db and 30db below desired audio level on receive and transmit respectively) The plates of the tuning elements are prevented from making electrical contact (shorting out) by the addition of a teflon coating to the rotor plates. Some degradation in performance was observed during vibration in the Z direction. This direction is perpendicular to the two larger dimensions of the unit, and the unit is thus vibrating as a "plate" in flexure. Fairly large excursions "g" force multiplications were observed near the centre of the "plate". It was considered that the components of these forces acting in the X direction were the cause of receiver and transmitter noise. As a counter-measure, to reduce the mass at the centre of the "plate" and thus reduce the displacement and "g" forces, the weights of the receiver and transmitter modules have been reduced. A weight reduction of 25% was accomplished by changing the module chassis material from brass to aluminum. Modules having aluminum chassis are presently being evaluated. In addition, the casting of the radio chassis has been modified to provide additional rigidity at the module mounting bosses.

5. **Immersion**

(3 feet of water for 2 hours)

After two hours, the following observations were made.

(a) Approximately 1 ounce of water had leaked into the radio.

(b) Leakage through antenna connector was evident

(c) Radio cover gasket was broken in region near P.A. Modulator module.

(d) Non rechargeable battery case and rechargeable battery leaked.

(e) Green coloured substance formed between 24 volt and ground terminal of both batteries.

(f) Both batteries performed satisfactorily when used to power another AN/PRC-66.

Two immersion re-tests were performed, with the last test successful. Changes made to the radio were as follows:

(a) Radio cover gasket replaced.

(b) Radio chassis battery connector replaced (original was warped)

(c) Antenna connector was replaced and was sealed at back.

6. **Sand and Dust**

(2 hours @ +25°C followed by 2 hours at +65°C)

Following sand and dust exposure, there was evidence of sand accumulation between the surfaces of the frequency control knobs and the cover over these knobs. This produced a slight grating when the knobs were rotated. The cover design has subsequently been modified to include small cut-outs so that the sand could be easily shaken out.

Both non-rechargeable and rechargeable batteries successfully passed the sand and dust exposure test.

7. <u>Salt Fog</u>

(100 hours exposure)

Following exposure to salt fog the following observations were made.

(a) <u>Battery Connector</u> - Rust coloured corrosion at one contact, possibly from contact mounting screw. (It was later determined that the wrong type screw had been installed).

(b) <u>Radio Case</u>

1. Rust coloured corrosion at one area of audio connector and mounting nut,not considered to impair performance.

2. Discolouration streaks on paint where salt solution had run down. Paint surface did not appear to be broken and no corrosion evident. Discolouration essentially disappeared after case cooled off and dried.

3. The Antenna connector lockwasher was later found to be badly corroded. It was later determined that the wrong washer had been installed.

From the above observations of minimal damage, it was considered that the equipment successfully passed the salt fog test.

8. **Bench Handling**

(equipment upset on bench four times)

The transceiver and battery successfully passed this test.

9. Drop Test

In compliance with para. 4.4.6.B of RADC5137, The AN/PRC-66 with rechargeable battery was packed in a drop bag and subjected to 10 drops of 20 feet onto a wooden floor.

Electrical performance of the transceiver showed no degradation following the drops.

The following damage was encountered during the drop programme.

Battery: a. Screws holding clamp hinge sheared off - 2 near connector, 1 at other end of battery.

Radio: a. Chassis metal damaged approximately 1/32 inch at clamp hook near battery connector.

b. C-34 in IF/Audio module- solder connection broken-repaired

c. Chassis damaged at frequency selector corner-Megahertz identification plate

d. Antenna relay intermittent - open circuit on transmit. (Radio had previously been vibrated for informal tests).

e. Frequency synthesizer - Band C wire from connector to V.C.O. was pinched between coaxial cable and connector pin.

The various non-operative electrical conditions described above were considered to be of a workmanship/inspection nature and along with the minor radio chassis damage were considered irrelevant for the purpose of this very severe test. During these tests, transceiver and battery were mated. It was subsequently negotiated with RADC that transceiver and battery would be separately packaged within the drop bag.

10. <u>Interference Test</u>

1. All antenna conducted interference measurements made during receiver operation were within specification requirements.
2. All antenna radiated harmonics were within specification. Radiated interference from case and cabling exhibited some out-of-specification levels of both harmonics and fundamental.
3. All measurements above 1000 megahertz were found to be within specification requirements.
4. Close-in spurious interference levels exceeding the specification limits were recorded during most of the interference testing during transmitter measurements.

The highest level of spurious recorded was 38 db below carrier level. (specification limit - para 3.5.1.11 of RADC-5137A - is 60 db below carrier for spurious signals during transmitter operation.) General, the spurious occupied a band ±3 to 5 megahertz about the carrier frequency and separated by 1.5 to 3 MHz. Investigation revealed that the close-in spurious were generated by the 2N3375 transistors and were greatly reduced when transistors from a particular source (Fairchild) were used. The improving characteristic of the particular transistors was the introduction of resistive substrate internal emitter leads to introduce required degeneration. Test performed showed that spurious were down 65.5 db or better below the carrier using the Fairchild transistors. The module design has subsequently been changed to call out the use of Fairchild transistors.

11. Maintainability

The maintainability activities during the equipment design were defined by sections IV V and VI of the "Reliability/Maintainability Program Plan for Radio Sets AN/PRC-66 (USAF) and AN/PRC-( ) (USMC) dated June 29, 1964. This plan was submitted to and approved by the contracting agency.

Results of the maintainability test performed on the AN/PRC-66 indicate that it possesses a mean corrective maintenance time of 7.8 minutes at a module replacement level. This is well within the limit of 30 minutes specified in RADC-5137A.

12. Rain Test

(two hours exposure-operating)

The transceiver and batteries successfully passed the rain exposure test. No deterioration of performance was observed.

13. Shock Test

14 inch drops, both directions along each axis for a total of 6 drops.

Following each drop, mechanical inspection and electrical performance checks were carried out on the transceiver unit and battery. No deterioration was observed.

14. Battery Life - Low Temperature

The results of recent reliability tests performed using batteries of the AN/PRC-66B radio set operating the transceiver unit RT/865D/PRC-66 provided the following data.

Item	Battery Life	
	Room Ambient	$-30^{\circ}C$
Rechargeable		
BB-3515A/PRC-66	Greater than 8 hours	5.5 hours
Non-Rechargeable		
BA-3515A/PRC-66	Greater than 12 hours.	0.8 hours

End of battery life was defined when:

1. Receiver sensitivity decreases to 6 microvolts input.
2. Transmit power output decreases to 0.5 watts on any channel.
3. Failure to operate on any channel constitutes an inoperable R/T unit.
4. Battery voltage falls to 18V with the R/T unit on receive.

5.3 TEST RESULTS AN/PRC-75

1. Temperature and Voltage Extremes

The transceiver met the specification requirements when subjected to temperature and supply voltage extremes with the exception of transmitter power output and modulation distortion.

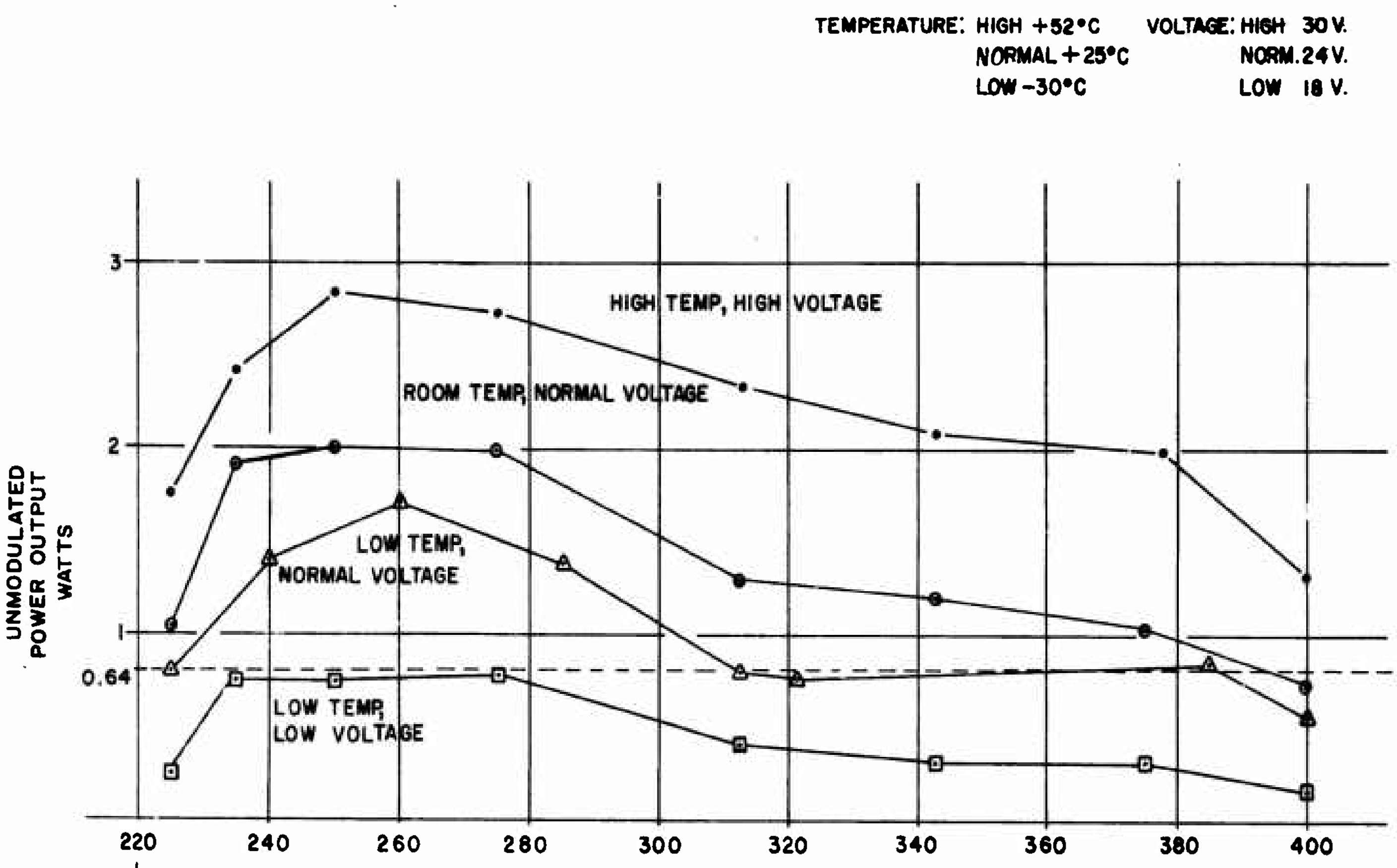
Figures 5-1 and 5-2 show power output and modulation distortion measured during these tests. Except for one power output reading at 400 MHz, all out-of-specification performance occurred during exposure to combined service conditions; i.e. low temperature, low voltage or high temperature, high voltage. It is considered that these combined conditions are extremely severe and that performance degradation beyond the specified service condition allowance of only 10% (Paragraph 3.4 of USMC PD CSY-FY 64-12) from standard conditions specification limits is to be expected.

2. Altitude

Performance during altitude tests was essentially the same as at room ambient standard.

3. Humidity

All performance characteristics were in reasonable agreement before and after humidity, except for the audio transducer. The audio transducer showed evidence of corrosion and was capable of modulating the transmitter between 7 and 18 percent



AN/PRC 75 TRANSMITTER CARRIER
POWER OUTPUT OVER TEMPERATURE RANGE

FIG. 5-1

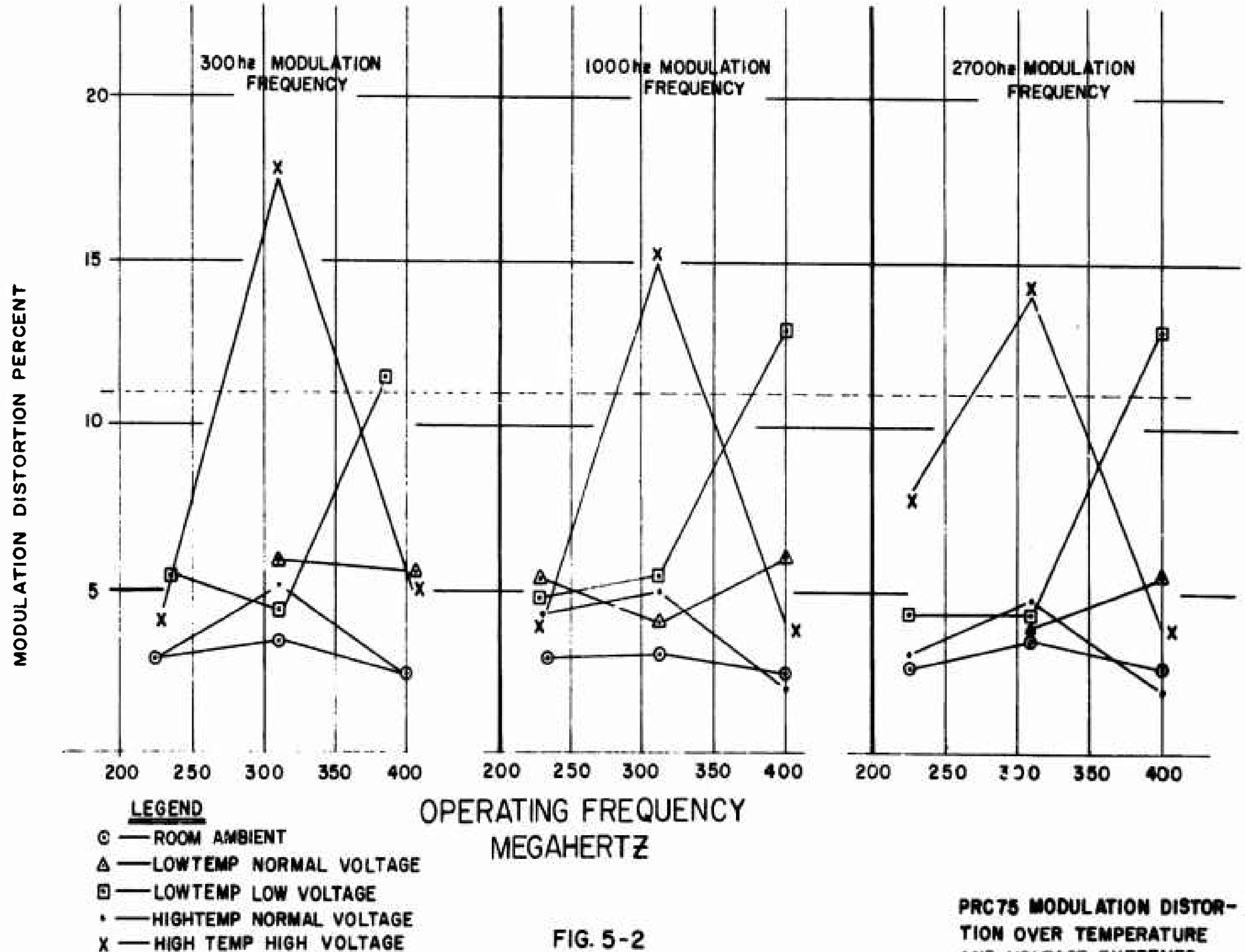


FIG. 5-2

PRC75 MODULATION DISTORTION OVER TEMPERATURE AND VOLTAGE EXTREMES

(specification limit 30%). A replacement corrosion-resistant transducer is currently being evaluated.

4. Vibration

The transceiver performed very well under vibration. No catastrophic failures occurred. Some performance degradation occurred with resonances observed during vibration in the X direction (vibration in the direction of the axes of the tuner shafts of the RF module). The degradation showed up as isolated increases in receiver and transmitter noise levels. Performance of the transceiver returned completely to normal following the vibration test.

The spot increases in receiver and transmitter noise levels were due to vibration of the tuning capacitor plates of the receiver and transmitter tank circuits. The degradations are not considered serious since they are isolated, sharply tunable and not actually sufficient to make voice communication impossible (worse cases were -19 db on receive and -25 db on transmit). The plates of the tuning elements are prevented from making electrical contact (shorting out) by the addition of a teflon coating to rotor plates.

Vibration testing of the battery, complete with carrying case, was entirely satisfactory. There was no evidence of damage or performance degradation during or after the test.

5. Immersion

The transceiver and battery successfully passed this test.

6. Sand and Dust

The transceiver and battery successfully passed this test.

7. Salt Fog

Salt fog exposure testing was performed using a chassis without modules. Examination following exposure indicated that the radio had suffered external chemical damage as enumerated below:-

1. Paint on the base of antenna completely stripped off and paint on the adjoining surface of the radio was badly attacked. Corrective action taken for subsequent radios. Better protection added.
2. Slight blistering of paint on one side of radio case.
3. Slight corrosive penetration of joint between case and cover as far as gasket.
4. Red paint on cover screws flaking off.
5. Slight corrosion on screws holding front cover plate.
6. Viking connector (part of radio set accessories) corroded. (Corrosion was external - no effect on electrical performance.)

The battery case appeared to be unaffected by the salt fog.

8. <u>Bench Handling</u>

The transceiver and battery successfully passed this test.

9. <u>Drop Test</u>

The transceiver and battery were subjected to a very severe drop test - six drops (one for each surface of the unit) from 42 inches onto a concrete floor - without protective packing.

The drop tests were carried out on the "in-house" engineering model because of the urgent delivery schedule on the USMC development models and because of the possibility of damage to the test sample.

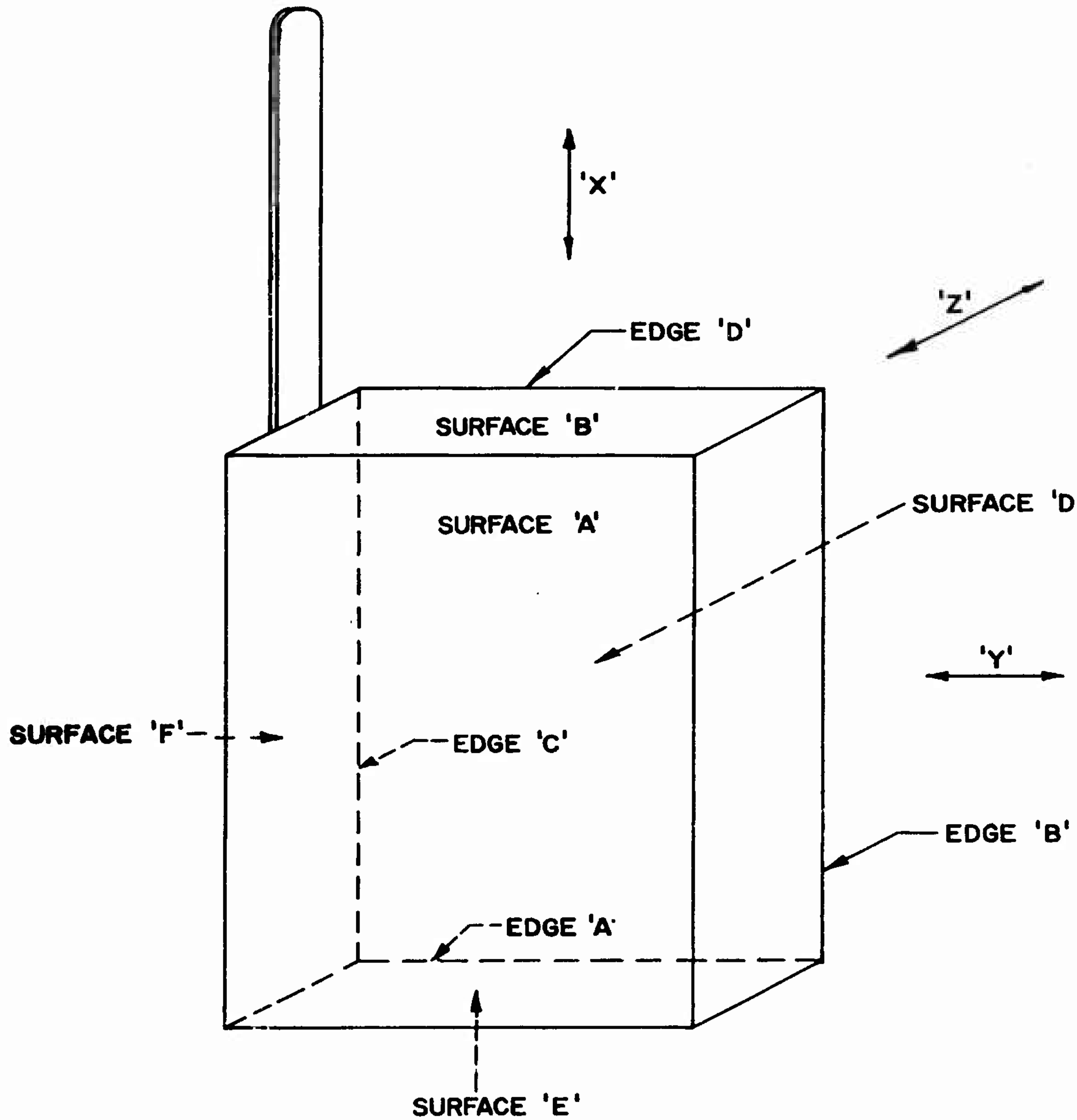
The battery and battery box suffered negligible damage from the six drops. Battery performance was normal after the test.

The transceiver suffered a marked amount of internal damage as a result of the test, although its case and cover remained relatively intact with only a small amount of deformation (bowing) of the cover, but with no fractures.

It was reasoned that, although the "in-house" engineering model had not been subjected to the normal inspection for workmanship, and had also been used for other experimental investigations, the tests on this model could still give meaningful results as far as any deficiencies that might be inherent in the design.

Various non-operative conditions did occur during the drop tests, but except as noted below, the causes were of a workmanship nature (poor soldering connections, stripped insulation on wires, potential shorts, etc.) and considered irrelevant to the purpose of these tests.

TEST	RESULTS	COMMENTS
	Drop Sequence (Figure 5-3) Surface E D C A F B Drop 1 2 3 4 5 6	
R/T UNIT		
Drop No. 1	Satisfactory, radio operational	
2	(a) Voltage regulator coil loose and lead broken. L1 replaced.	Better bonding of coil will be provided. No further problems experienced in subsequent drops.
	(b) Transmitter oscillated at 225 MHz. Tank circuit realigned.	Improper initial alignment. No further problems during subsequent drops.
3	Satisfactory	
4.	R2 (trimpot) center pin opened. R2 replaced.	Cause of failure is being investigated. No further problems during subsequent drops.



DESIGNATION OF AXES, EDGES, AND SURFACES

FIG. 5-3

Drop No. 5	Satisfactory	
6	(a) 1/8" crack noticed base of antenna blade.	Bend-radius relief will reduce the likelihood of reoccurrence.
	(b) Upper corners of cover slightly dented (less than 1/64").	No corrective action necessary.
	(c) Short spacer on control head showed signs of pulling loose. No repair carried out.	Improved staking being incorporated.
	(d) Main chassis cover developed 1/64" bow.	Will be improved by the proposed holddown screws.
	(e) R1 (trimpot) center pin opened. R1 replaced	Cause of failure being investigated. No further problems with R1.

(SURFACE CONTAINING HINGED COVER IS DESIGNATED SURFACE "A")
BATTERY PACKAGE (SURFACE CONTAINING CONNECTOR IS DESIGNATED SURFACE "B")

Drop No. 1	Slight bend outwards at case surface "E" (less than 1/64")	No corrective action considered necessary.
2	Satisfactory	
3.	Nameplate fell off. Top surface "C" bowed 1/32" outward.	No corrective action considered necessary.

10. Interference Testing

Antenna conducted and antenna radiated interference test results showed up some out-of-specification performance. All other interference test results were within specification.

(a) Antenna Conducted Interference

On the three test operating frequencies, there was a total of six observed interference levels that exceeded the specified limit of 40 db above one microvolt. Four of these exceeded the specification by 5 db or less. The remaining two were 8 db and 15 db in excess of the specified limit. Only one interference level occurred within the 225 to 400 MHz operating range of the system (360 MHz)

These interference levels are not considered serious since the majority were not only outside of the operating frequency range of the transceiver, but were conducted levels into a dummy load replacing the antenna that would normally form part of the system. In actual operation, radiation of noise signals outside of the 225.00 to 400 MHz would be attenuated by the antenna.

(b) Antenna Radiated Interference

Approximately half of the undesired emissions that were observed (9 out of 17) were in excess of the specification limit. Investigations carried out on the AN/PRC-66 programme have indicated that the relatively close-in spurious are coming out of the frequency synthesizer module on the 12 volt line. Work is presently underway to further evaluate this situation and to arrive at a solution.

Approximately half of the nine out-of-specification emissions are harmonics of the operating frequency, with the second harmonic showing up most frequently. Performance of the AN/PRC-66 has been found to be better in this respect; the reason being that the AN/PRC-66 output circuit is of a different configuration. The AN/PRC-75 output circuit is a parallel tank device, whereas the output circuit of the AN/PRC-66 is a series-type circuit with series inductance. This latter circuit provides the desired tuning characteristics at the operating frequency while also providing additional attenuation in the higher frequency region of the harmonics, to insure adequate rejection of harmonic outputs.

11. Maintainability

Results of maintainability tests performed on the AN/PRC-75 indicate that it possesses mean corrective maintenance time of 4.9 minutes at module replacement level. This is well within the specification limit of 30 minutes.

5.4 Reliability Testing

Three AN/PRC-66's and two AN/PRC-75 (XN-1)'s were subjected to a reliability demonstration test under temperature cycling and vibration conditions. The test was conducted in accordance with procedure dated January 17, 1967 (Revised) and approved by RADC on March 29, 1967, the results of the test show that the equipment designs have sufficiently high inherent reliability and that MTBF requirements for the test were met.

Detail test results are contained in an extensive reliability Demonstration test Report dated January 25, 1968. The test results indicate that the equipments tested exceeded the specified MTBF requirement of 500 hours, throughout the entire test (except the early part of the test when less than 500 operating hours had been accumulated.

Total test operating hours were 2194. Criteria "C" as shown on page 16 of MIL-STD-781, dated 15 May 1963, was used to determine acceptance or rejection of the equipments.

SECTION 6.0 DEVELOPMENT OF AN/PRC-66 HAVING WIDEBAND AND GUARD CHANNEL CAPABILITY

6.1 General

In accordance with revised change "F" (dated October 18, 1968) to contract AF30 (602) 3378, development of AN/PRC-66 having wideband and guard channel capability was carried out. The development program included the modification of two AN/PRC-66 radios, supplied by RADC, into two forms of wideband radios, namely, "A" (wideband only) and "B" (wideband with guard channel) configuration.

A limited qualification test program was successfully carried out on the two radios to assure proof of performance of the radios in areas affected by the modifications. Wideband interface testing was carried out at Collins Radio, Cedar Rapids facility with the results reported directly to the procuring activity. Concurrent with the retrofit of the two development radios, a number of general design improvements were incorporated into the modified units.

Sections of the transceiver that underwent changes to provide wideband and guard channel capability were:-

a. Main Chassis.
b. IF/Audio Module
c. PA/Modulator Module.
d. RF/Receive Module.

6.2 Details of Development Program

6.2.1 Configuration "A"

A chassis and panel layout of the Configuration "A" radio is shown in Figure 6-1. This radio has the same dimensions as the radios produced under the original development contract. The only major external difference is in the audio connector which has been changed from a 5 pin to a 13 pin unit to accomodate the additional wideband signals. Internal construction of the radio is relatively unchanged in appearance with the exception of the addition of a wideband amplifier and current source circuit board located between the RF/Receiver and PA/Modulator modules. Change from the 5 pin to 13 pin connector, necessitates the use of a special adapter cable for operation of "Configuration A" with the standard H189 or equivalent handset.

6.2.2 Configuration "B"

Figure 6-2 shows a chassis and panel layout of the configuration "B" radio. This configuration has retained the audio connector of the original developmental units, but has an added 13 pin wideband connector. Addition of the wideband connector resulted in an increase of 1 inch in the width of the radio from 8 to 9 inches. The T/R + SQ position of the function switch has been replaced by T/R + G to accomodate the guard channel facility. A squelch disable function is now provided when the squelch control (SQ) knob is rotated to its maximum counterclockwise position. Internal construction of the radio is changed from the development units in that a wideband amplifier and current source circuit board has been added between the RF/Receiver and PA/Modulator Modules, and guard channel connector has been located in the additional one inch space between the IF/Audio - Voltage Regulator modules and the RF/Receiver module. Additional changes involved major chassis wiring changes, and relocation of boss positions to accomodate the wideband and guard channel modifications. Guard Channel operation has been evaluated using an AN/ARC-109 guard receiver mounted outboard on a special adaptor cover for the transceiver.

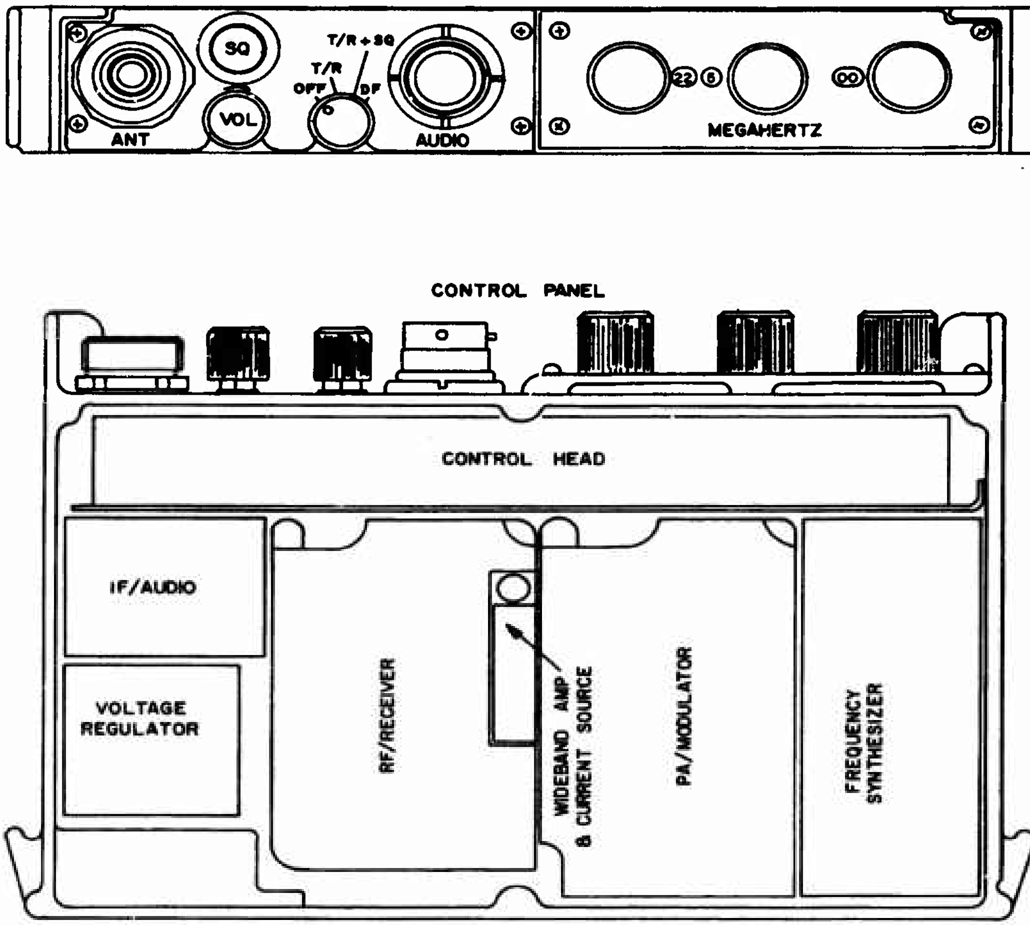


FIG 6-1

CHASSIS LAYOUT, CONFIGURATION "A"

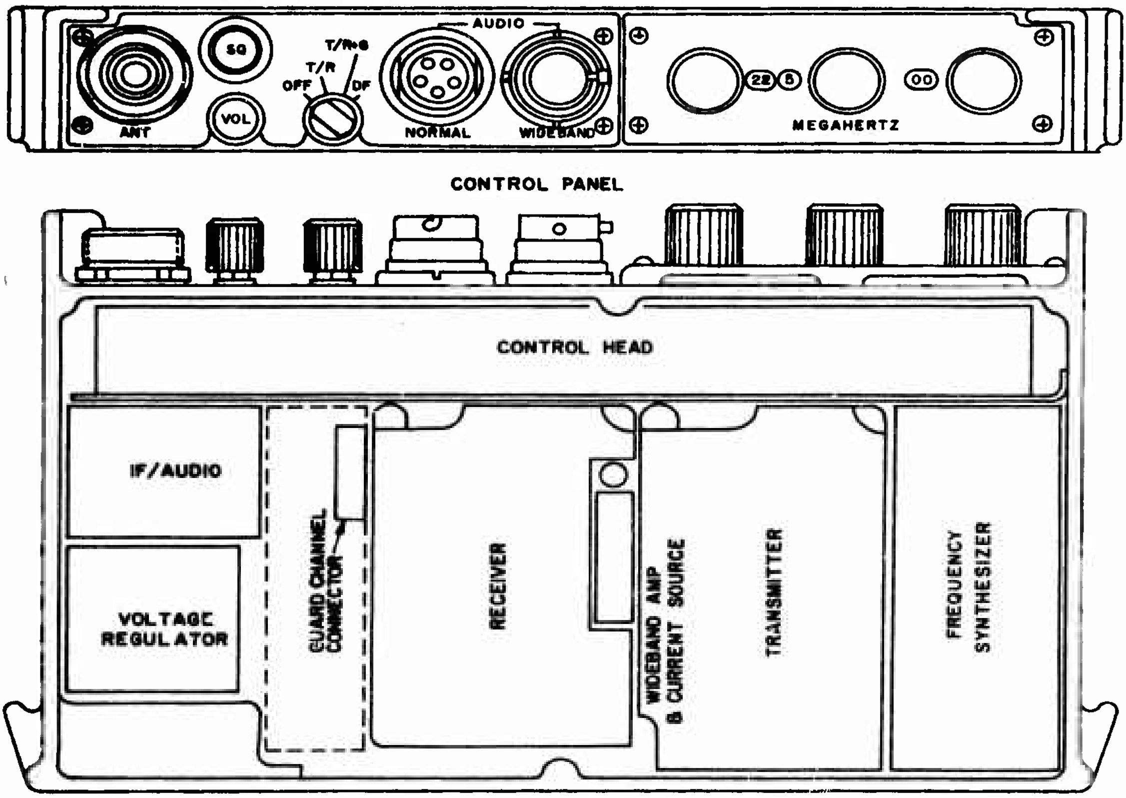


FIGURE 6-2 CHASSIS LAYOUT
"B" CONFIGURATION

6.2.3. General Design Improvements

Advantage was taken of the modification programme to incorporate a number of general design improvements:

(a) Dials

Visibility of the readout dial was improved by changing from round to rectangular apertures and by changing from white-on-black to black-on-white numerals. Also, to minimize accumulation of sand and dust particles, the space behind the dial wheels has been increased by 0.1".

(b) Chassis Watertight Seal

The chassis seal of the Configuration "B" radio was changed from a rectangular cross section gasket to an "O" ring type gasket. Cover hold-down screws have been relocated to minimize bends in the gasket path.

(c) Carrying Handle

A canvas web carrying handle has been added to the Configuration "B" radio.

(d) Control Knobs

General improvements in the sizes and shapes of control knobs have been made. For example, the function switch knob is now a bar type knob.

(e) R.F.I. Filtered Connectors

The normal and wideband audio connectors now contain integral R.F.I. filters to eliminate a problem of r.f. pick-up when the external associated audio cables are brought close to the antenna during transmitter operation.

6.2.4 Design Change Details

6.2.4.1 Main Chassis

Changes to the main chassis consist of addition of a wideband board and current source along with the addition of a 13 pin wideband panel connector, a guard channel connector, and a "T" coaxial cable system to accomodate the guard channel. The wideband board consists of a wideband amplifier and a 55 milliampere carbon microphone current source. A schematic of the wideband board is shown in Figure 6-3. The wideband signal input is derived directly from the detector circuit of the IF/Audio module. Signal output is fed to the audio output (wideband) pin of the main connector. Figure 6-4 is a partial functional block diagram of the AN/PRC-66 showing signal flow paths peculiar to the wideband/guard channel modifications. The module having major involvement in these modifications is the IF/Audio module. To retain simplicity in the figure, which is a signal flow diagram, interconnections with the voltage regulator module have been omitted.

6.2.4.2 I/F Audio Module

Changes were made in the I/F Audio Module to increase the circuit bandwidths on receive and transmit and also to provide for guard channel audio injection independent of main receiver squelch.

These changes required widebanding of the film packets A3 (Audio and AGC detector), A8 (Modulator preamplifier), A9(Audio amplifier) was modified to provide for guard channel audio input at a point following the main receiver squelch gate. Figure 6-5 shows a block diagram of the IF audio module modified for wideband and guard capability. Consequent to the thin film pack changes, the printed

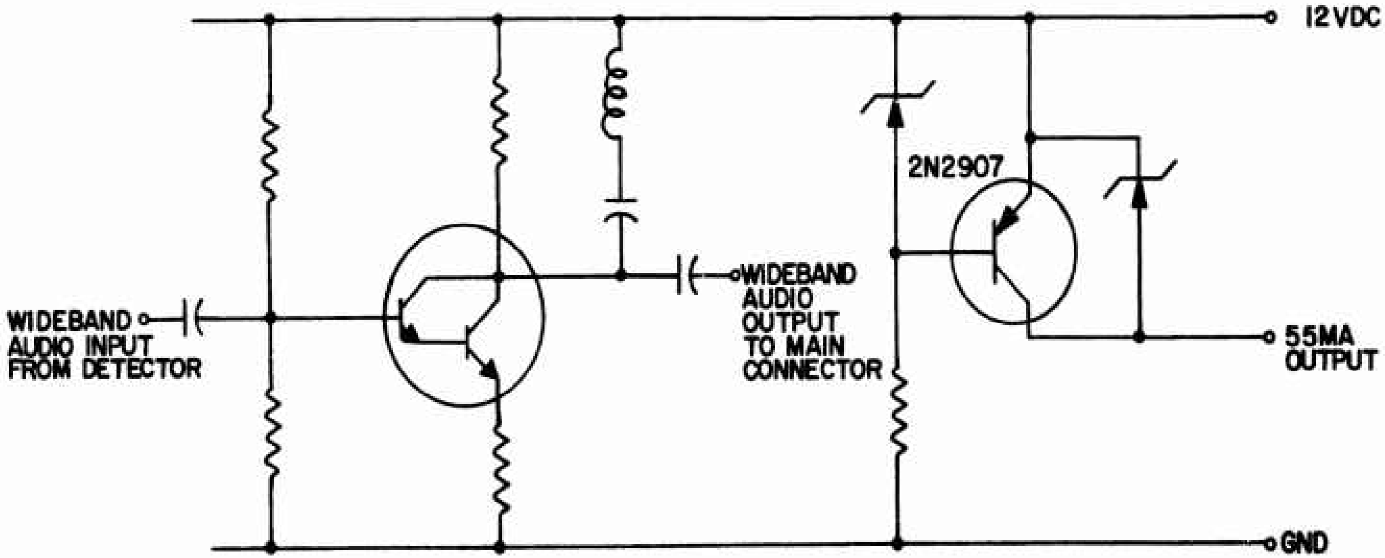


FIG. 6-3

SCHEMATIC WIDEBAND BOARD

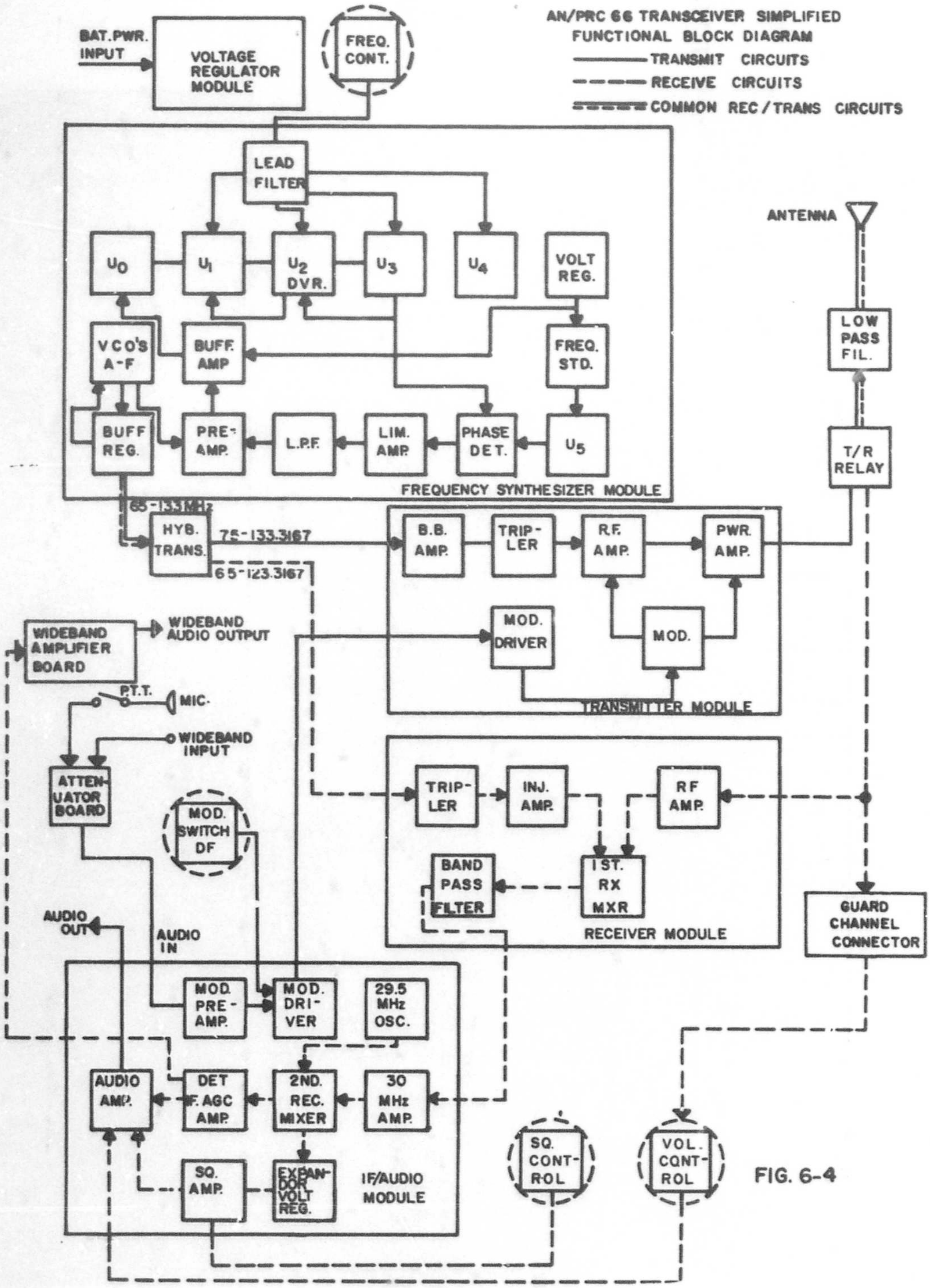
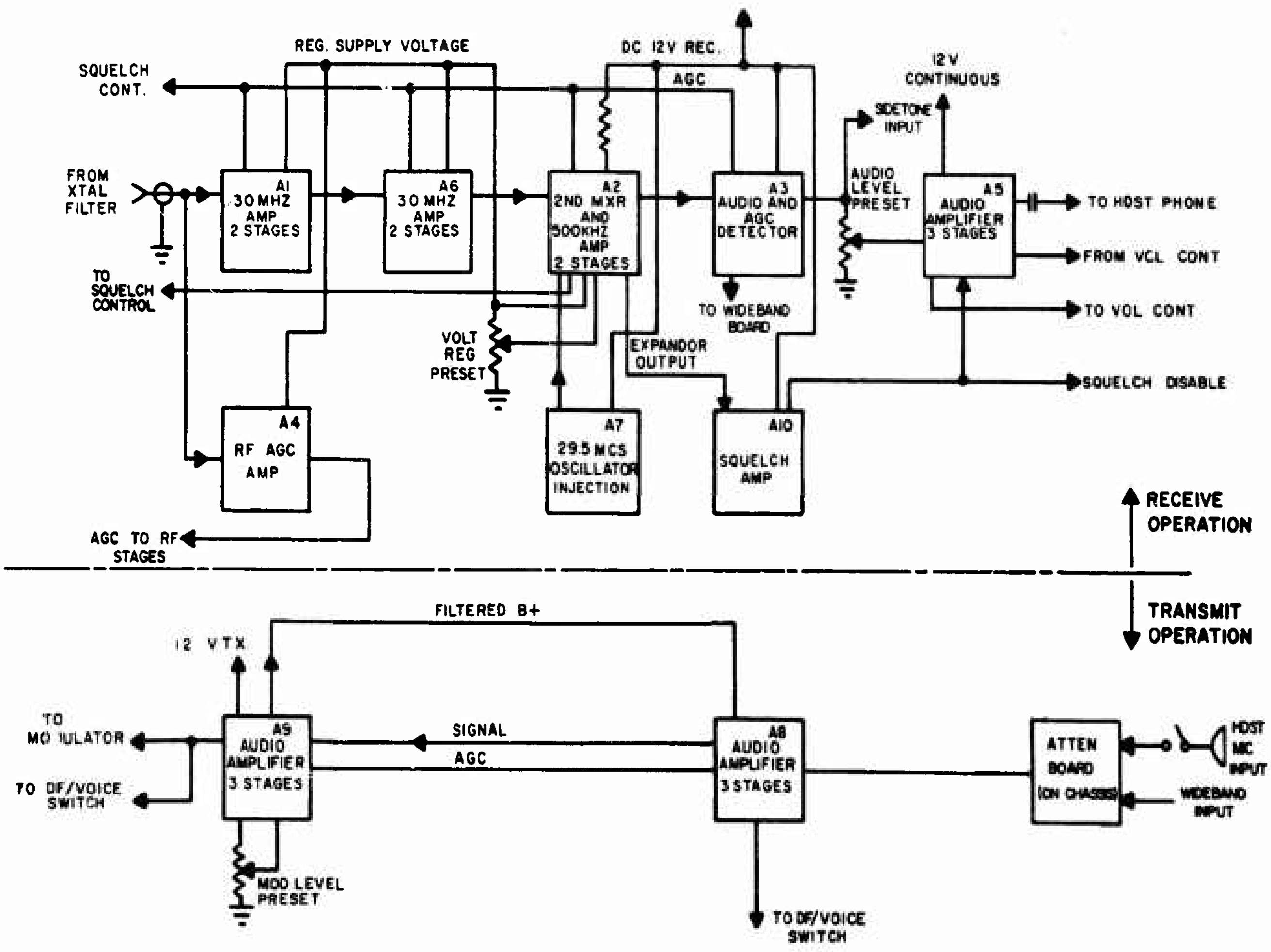

AN/PRC 66 TRANSCEIVER SIMPLIFIED
FUNCTIONAL BLOCK DIAGRAM
TRANSMIT CIRCUITS
RECEIVE CIRCUITS
COMMON REC / TRANS CIRCUITS
BAT. PWR. INPUT
VOLTAGE REGULATOR MODULE
FREQ. CONT.
LEAD FILTER
U0
U1
U2 DVR.
U3
U4
VOLT REG.
VCO'S A-F
BUFF. AMP
FREQ. STD.
BUFF REG.
PRE-AMP.
L.P.F.
LIM. AMP.
PHASE DET.
U5
FREQUENCY SYNTHESIZER MODULE
ANTENNA
LOW PASS FIL.
T/R RELAY
65-133MHz
HYB. TRANS.
75-133.3167
65-123.3167
B.B. AMP.
TRIP-LER
R.F. AMP.
PWR. AMP.
MOD. DRIVER
MOD.
TRANSMITTER MODULE
WIDEBAND AMPLIFIER BOARD
WIDEBAND AUDIO OUTPUT
P.T.T.
MIC.
WIDEBAND INPUT
ATTENUATOR BOARD
MOD. SWITCH DF
TRIP-LER
INJ. AMP.
RF AMP.
BAND PASS FILTER
1ST. RX MXR
RECEIVER MODULE
GUARD CHANNEL CONNECTOR
AUDIO OUT
AUDIO IN
MOD. PRE-AMP.
MOD. DRI-VER
29.5 MHz OSC.
AUDIO AMP.
DET & AGC AMP.
2ND. REC. MIXER
30 MHz AMP.
SQ. AMP.
EXPANDOR VOLT REG.
IF/AUDIO MODULE
SQ. CONT-ROL
VOL. CONT-ROL

FIG. 6-4



IF/AUDIO MODULE (WIDEBAND) BLOCK DIAGRAM FIG. 6-5 wiring board upon which the packs were mounted, was revised to provide the new interconnect wiring.

The above changes do not change the size or general mechanical construction of the module as described elsewhere in this report.

6.2.4.3 PA/Modulator Module

Wideband modifications to the PA/Modulator module are relatively minor. The changes involved only the deletion of one capacitor and addition to two capacitors to widen and control the bandwidth of modulator driver stage Q7 (refer to figure 4-68 for a block diagram of the PA/Modulator module.)

6.2.4.4 RF/Receiver Module

The RF/Receiver module modification for wideband involved changing only the 30 megahertz IF crystal filter from one having a 6 db bandwidth of 40 kilohertz to one having a 3 db bandwidth of 60 kilohertz.

6.3 Test Program

6.3.1 General

The test program consisted of standard conditions, temperature, and immersion tests only. Since relatively few basic design areas of the radios were changed, it was considered that these tests would sufficiently augment the data obtained during the earlier extensive development program tests. Temperature testing of both "A" and "B" Configurations was considered necessary to assure proper operation of the new circuits over the temperature range. Immersion tests were performed on the "B" radio to prove the performance of the new seals on the main chassis and cover.

Special wideband compatibility tests were performed on the "B" radio at the Collins, Cedar Rapids facility and will be reported by that facility directly to the procuring activity.

The following is a list of the tests to which the wideband modified radios were subjected. The abbreviations N.M. and W.M. have been used to indicate "Normal Mode" and "Wideband Mode".

(a) Standard Conditions Acceptance Tests

1. General Inspection - Dimensions and weight.
2. Receiver Sensitivity, audio power output, power input - N.M. and W.M.
3. AGC Dynamic range.
4. Receiver Audio Frequency response - N.M. and W.M.
5. Audio Distortion - N.M. and W.M.
6. Volume Control Attenuation
7. Receiver I.F. Selectivity
8. I.F. Rejection
9. Image rejection and Other Spurious
10. Squelch adjust, Quieting and overlap.
11. Guard Receiver Interface

11a. AN/ARC-109 Guard Sensitivity

11b. AN/ARC-109 Guard AGC Dynamic range.

11c. AN/ARC-109 Guard audio frequency response

11d. AN/ARC-109 Guard audio distortion

11e. AN/ARC-109 Guard I.F. selectivity

11f. AN/ARC-109 Guard I.F. rejection

11g. AN/ARC-109 Guard Image rejection

11h. AN/ARC-109 Guard squelch threshold, quieting and overlap.

12. Transmitter power output, power input N.M. and B.M.

13. Envelope distortion N.M. and B.M.

14. Audio Frequency response N.M. and B.M.

15. Modulation Capability N.M. and B.M.

16. Frequency stability and accuracy.

17. MCW Capability

18. Sidetone operation

19. Carrier noise level.

(b) Environmental Tests

1. Temperature (4.4.4.1)

Low temperature soak (-54°C) non operating

Low temperature (-30°C) normal voltage (24V)

Low temperature (-30°C) low voltage (18V)

Low temperature (0°C) Normal voltage (24V)

High temperature soak (+68°C) non operating

High temperature (+52°C) normal voltage (24V)

High temperature (+52°C) continuous transmit normal voltage (24V)

High temperature (+52°C) High voltage (30V)

2. Room Ambient tests

3. Immersion Test

- Water, 2 hours, 3 foot depth.

4. Final Tests at room ambient.

6.3.2 Test Results

Figures 6-6, 6-7 and 6-8 show receiver I.F. selectivity, receiver audio fidelity and transmitter audio fidelity measured under standard conditions. Comparison of these figures with figures 3-3, 3-7 and 3-12 will illustrate the wideband characteristic of the radio.

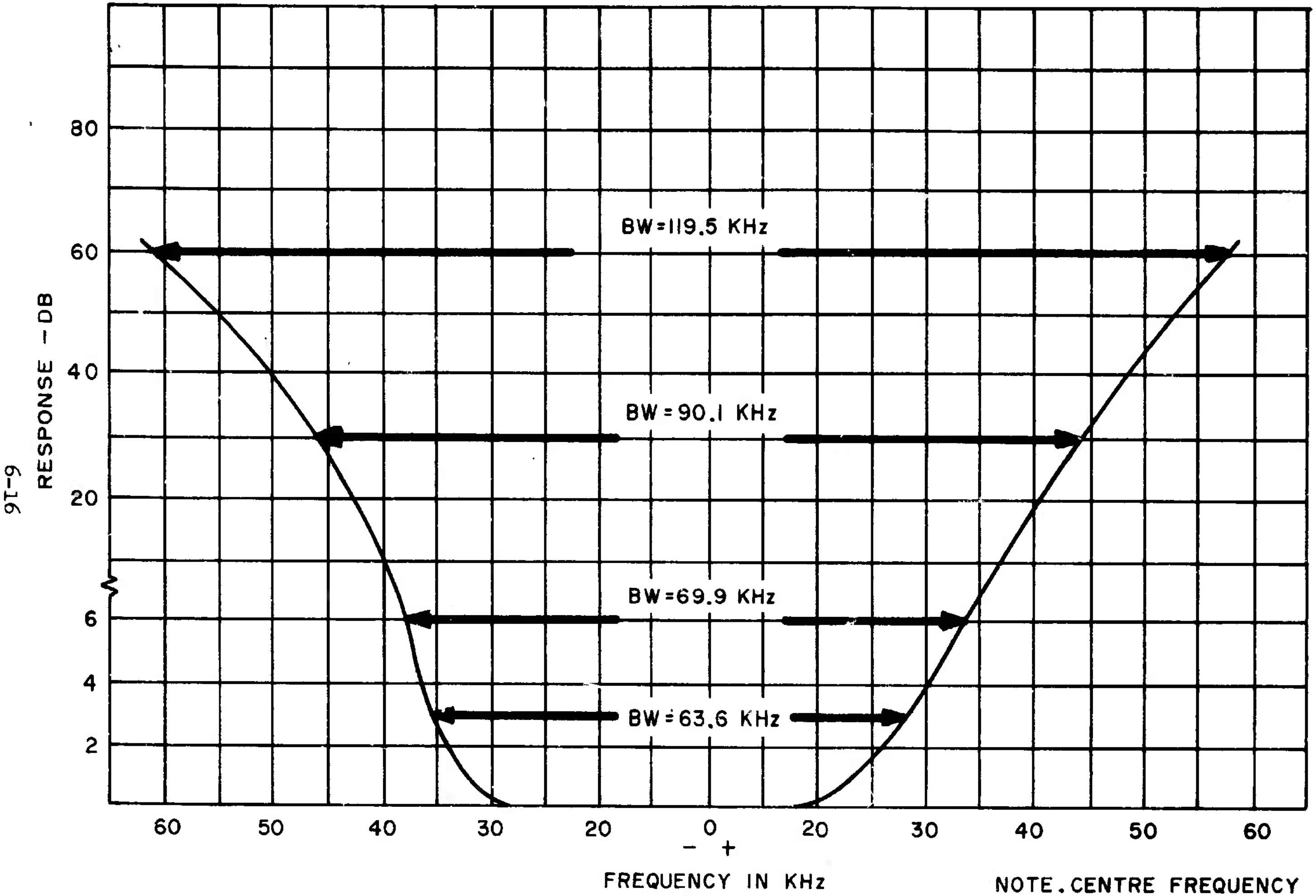
6.3.2.1 Test Data

In addition to the figures, the following is a brief summary of results of tests on the "B" radio over the temperature range of -30°C to +52°C and supply voltage range of 18 volts to 30 volts DC.

FUNCTION TESTED	PERFORMANCE	SPECIFICATION LIMIT
Receiver Sensitivity		
(Wideband)		
Room Ambient	2.2 to 5.0 microvolts	NMT 10 microvolts
-30°C 24V	2.0 to 5.5 microvolts	NMT 14 microvolts
-30°C 18V	1.9 to 4.2 microvolts	NMT 20 microvolts
+52°C 24V	2.1 to 5.5 microvolts	NMT 10 microvolts
+52°C 30V	2.0 to 5.5 microvolts	NMT 10 microvolts
Receiver Audio Distortion 300 to 23 kHz		
Room Ambient	5.2 to 9.5 percent	NMT 15%
-30°C 24V	9.0 to 12.5 percent	NMT 15%
-30°C 18V	9.5 to 14.0 percent	NMT 15%
+52°C 24V	5.5 to 8.0 percent	NMT 15%
+52°C 30V	5.8 to 8.0 percent	NMT 15%

FUNCTION TESTED	PERFORMANCE	SPECIFICATION LIMIT
Receiver audio frequency response at 399.95 MHz. (REF 18.75 kHz) (Wideband)	+1.2 db @ 300 Hz -2.4 db @ 23 kHz -4.5 db @ 29 kHz -4.5 db @ 32 kHz -6.0 db @ 36 kHz -7.0 db @ 40 kHz	NMT -3db @ 300 Hz -3db @ 23 kHz -10db @ 29 kHz -12db @ 36 kHz -20db @ 36 kHz 30db @ 40 kHz
Transmitter Power Output -90 per cent modulation (Wideband)		
Room Ambient	2.13 to 2.85 watts	NLT 2W
$-30^{o}C$ 24V	1.23 to 2.0 watts	NLT 1W
18V	0.45 to 1.0 watts	NLT 0.5W
$+52^{o}C$ 24V	1.8 to 2.6 watts	NLT 2W
$+52^{o}C$ 30V	2.05 to 2.75 watts	NLT 2W
Envelope distortion (Wideband)		
Room Ambient	2.0 to 8.6 percent	NMT 10%
$-30^{o}C$ 24V	2.5 to 7.5 percent	NMT 10%
$-30^{o}C$ 18V	5.5 to 22.5 percent	Not specified
$+52^{o}C$ 24V	2.0 to 5.5 percent	NMT 10%
$+52^{o}C$ 30V	2.0 to 7.0 percent	NMT 10%
Carrier Noise Level (Wideband)		
Room Ambient	-37.6 to -40 db	NLT 30 db down
$-30^{o}C$ 24V	-37.5 to -38 db	NLT 30 db down
$-30^{o}C$ 18V	-31.5 to -34.5 db	NLT 30 db down
$+52^{o}C$ 24V	-41 to -41.2 db	NLT 30 db down
$+52^{o}C$ 30V	-39 to -40 db	NLT 30 db down

FUNCTION TESTED	PERFORMANCE	SPECIFICATION LIMIT
Guard Channel (Using AN/ARC-109 guard receiver) Room Ambient Sensitivity/Audio Power		For information purposes only - Guard Receiver used is mounted outboard and is not receiver proposed for production.
Main Receiver @ 225 MHz	2.4 microvolts/ 12 milliwatts	NMT 3 microvolts/ NLT 10 milliwatts
240 MHz	3.8 microvolts/ 10 milliwatts	NMT 3 microvolts/ NLT 10 milliwatts
250 MHz	1.3 microvolts/ 12.5 milliwatts	NMT 3 microvolts/ NLT 10 milliwatts
399.95 Mhz	1.6 microvolts/ 12 milliwatts	NMT 3 microvolts/ NLT 10 milliwatts
Audio Distortion		
300 Hz	7.0 percent	NMT 15 ercent
1000 Hz	7.0 percent	
2700 Hz	7.2 percent	
I.F. Selectivity		
- 6 db	49.1 kHz	NLT 40 kHz
-60 db	83.8 kHz	NMT 200 kHz
-30^{o}C & 18 VDC Sensitivity/ Audio Power		
Main Receiver @ 225 MHz	1.8 microvolts/ 8.5 milliwatts	NMT 6 microvolts/ NLT 2.5 M.W.
240 MHz	3.6 microvolts/ 7 milliwatts	NMT 6 microvolts/ NLT 2.5 M.W.
250 MHz	1.2 microvolts/ 10 milliwatts	NMT 6 microvolts/ NLT 2.5 M.W.
399.95 MHz	1.2 microvolts/ 10 milliwatts	NMT 6 microvolts/ N.T 2.5 M.W.



AN/PRC-66

WIDEBAND MODIFIED CONFIG. B

REC_IVER I.F. SELECTIVITY

NOTE. CENTRE FREQUENCY IS CHANNEL FREQUENCY PLUS OR MINUS 4 KHz.

FIG 6-6

AN/PRC-66
WIDEBAND MODIFIED CONFIG. "B"
RECEIVER AUDIO RESPONSE

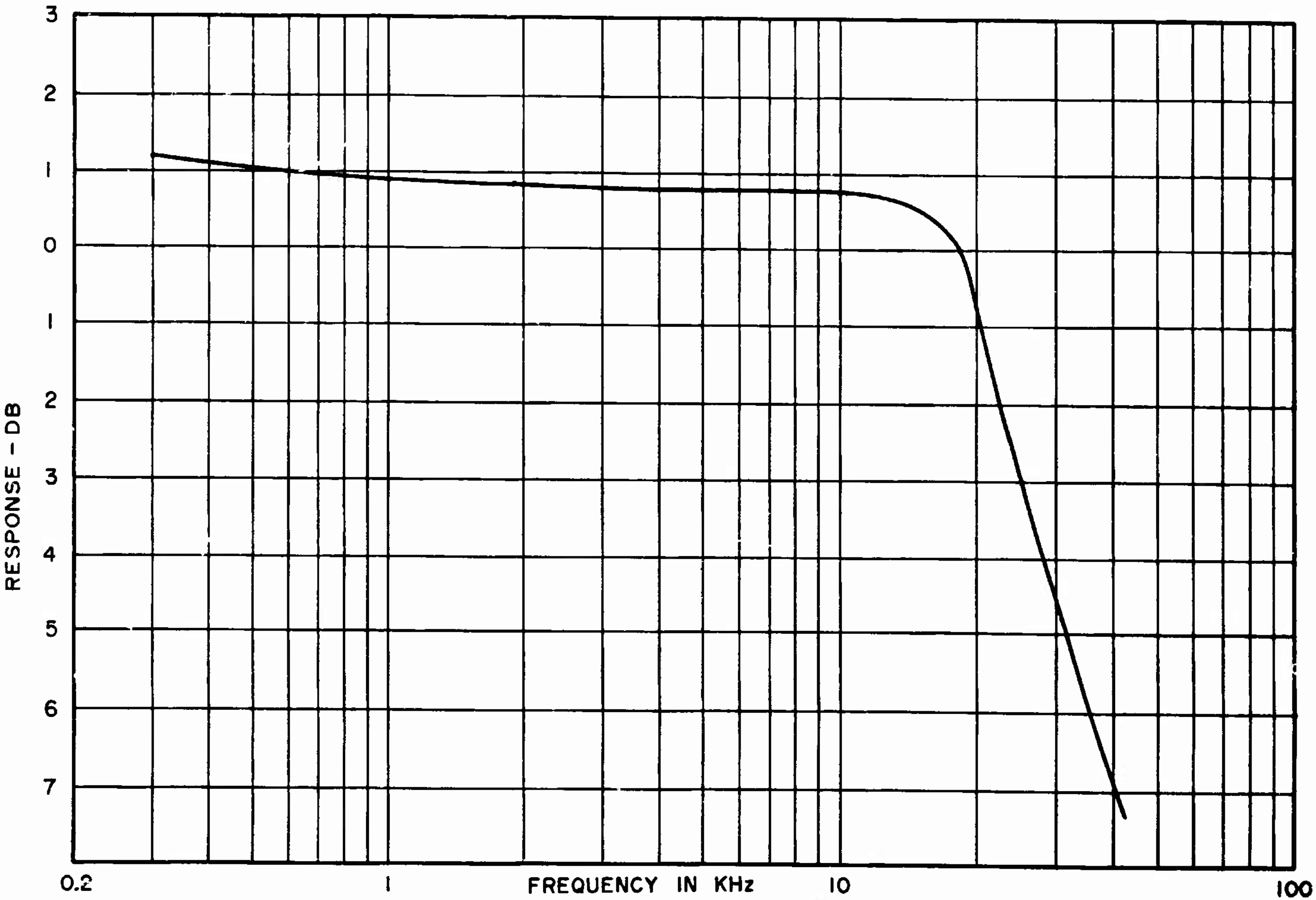


FIG 6-7

AN/PRC-66

WIDEBAND MODIFIED CONFIG. "B"

TRANSMITTER MODULATION FIDELITY

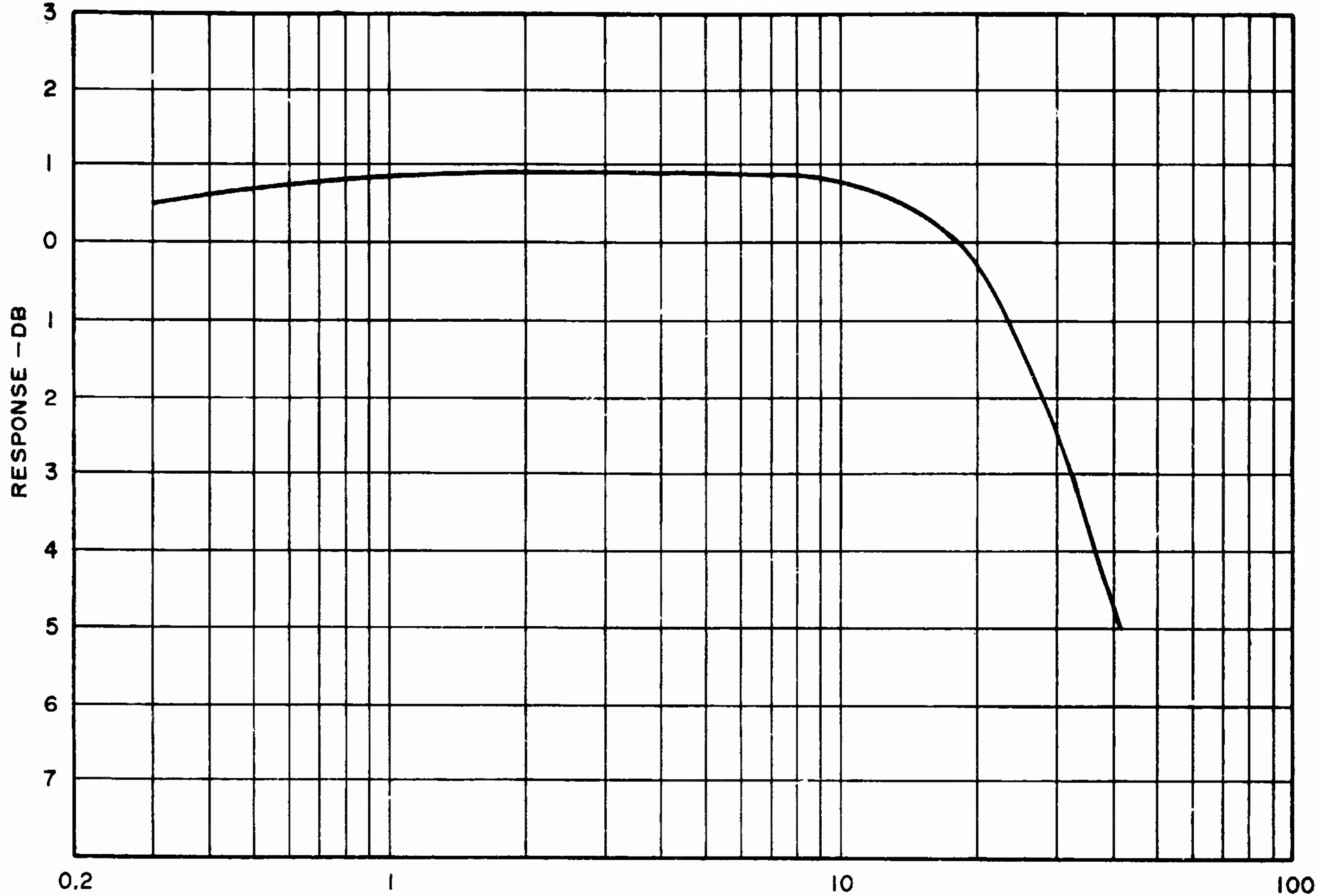


FIG 6-8

6.3.2.2 Comments on Test Results

The modified radios performed very well during all tests including the severe combined low temperature (-30°C) and low voltage (18 volts DC) test conditions, although specification RADC 5137, to which the two supplied radios were originally developed, placed no performance limits beyond providing "reliable communications" under these conditions.

The greatest performance variations encountered during the low temperature-low voltage tests were in power output and modulation distortion at the high end of the operating frequency range (399.95 megahertz). Lowest measured R F power output was 0.45 watts including losses in test circuit and highest modulation distortion was 22.5 percent. (R F power output over eight readings across the operating frequency range averaged out to 0.71 watts for the "B" radio and 0.77 watts for the "A" radio. Envelope distortion was less than 9 percent on both radios over at least the lower half of the operating frequency range (from 225.00 to 312.00 megahertz).

Guard channel performance was checked at room ambient and low temperature, using an AN/ARC-109 guard receiver mounted outboard on the side of the transceiver using a special test adaptor cover. The test data is provided for general information only, since the AN/ARC-109 guard receiver bears little resemblance to the receiver proposed for incorporation into the transceiver in ›mpliance with the equipment specification.

SECTION 7 CONCLUSIONS

This program has resulted in the successful development of two types of small, lightweight radio sets, AN/PRC-66 and AN/PRC-75. As required by the contract, state-of-the-art techniques were utilized to a large extent in achieving the design objective. Examples include the antenna, digital frequency synthesizer and the R/T unit.
New Packaging techniques, new devices such as monolithic integrated circuits, and hybrid thin film circuits were utilized to their maximum advantage in the design.

The severe environmental test conditions to which the radios were subjected, and the excellent performance obtained points up the liberal performance margins provided in the designs. Maintainability test results and the relative ease with which the AN/PRC-66 wideband modifications were accomplished provides ample demonstration that the modular concept (and general construction principles) has resulted in radios having a high level of maintainability.
The relatively large numbers of developmental models produced (two AN/PRC-75 and eight AN/PRC-66 radios) on a pilot production line is indicative of an exceptional potential for production on a much larger scale.

SECTION 8

Appendix

The following module schematics are provided.

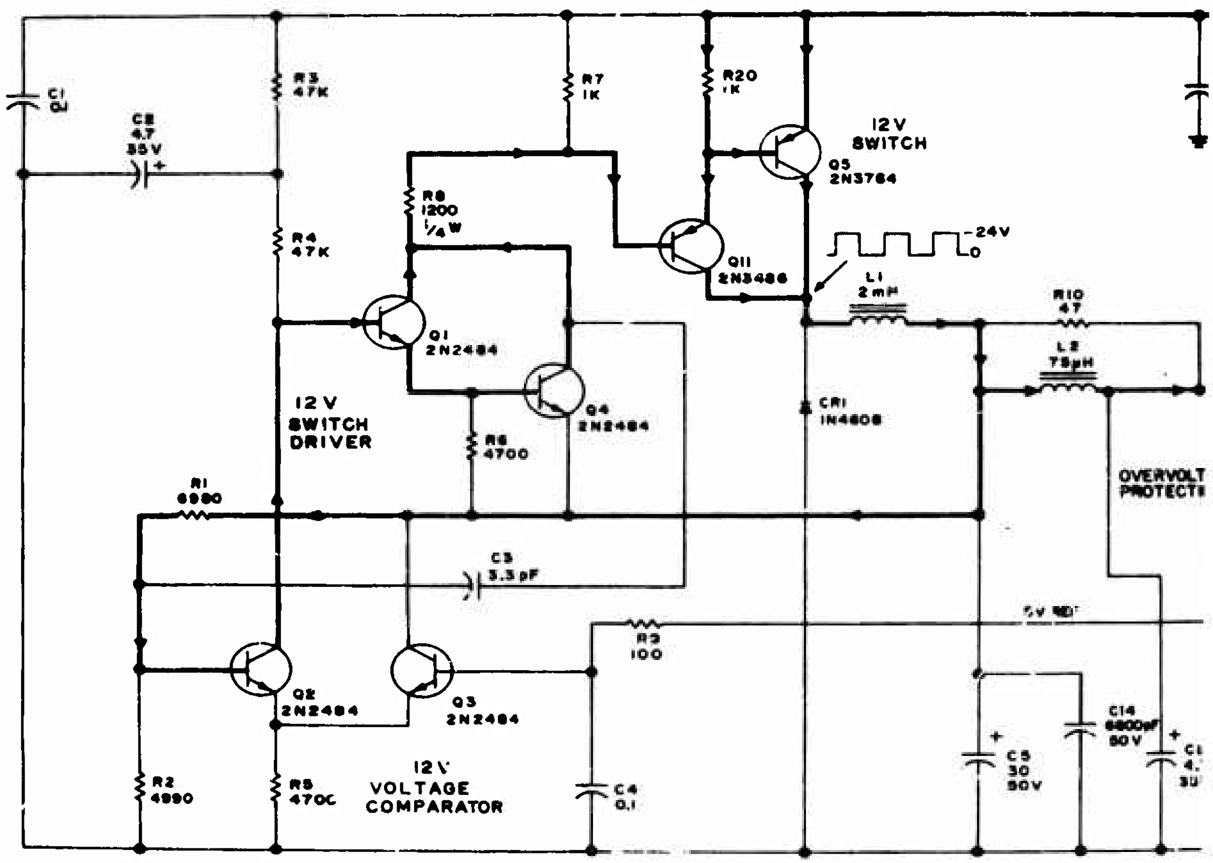
TABLE AP-1

Power Distribution

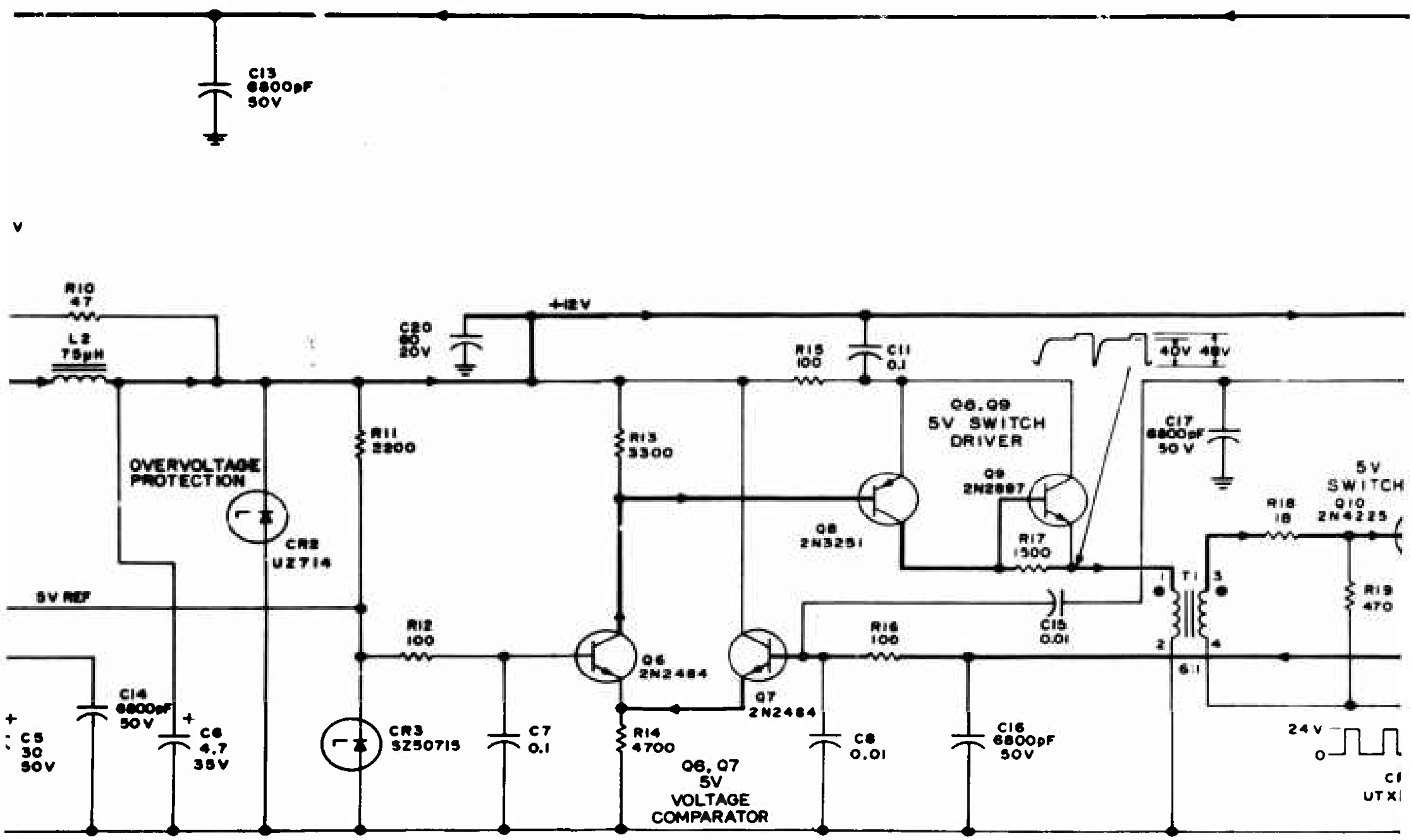
The following table provides approximate distribution of major power loads within the AN/PRC-66 and AN/PRC-75. Also included is the power provided for Carbon Microphone operation (55 MA current cource) and projected power consumption of the guard receiver in the AN/PRC-66B system.

TABLE AP-1

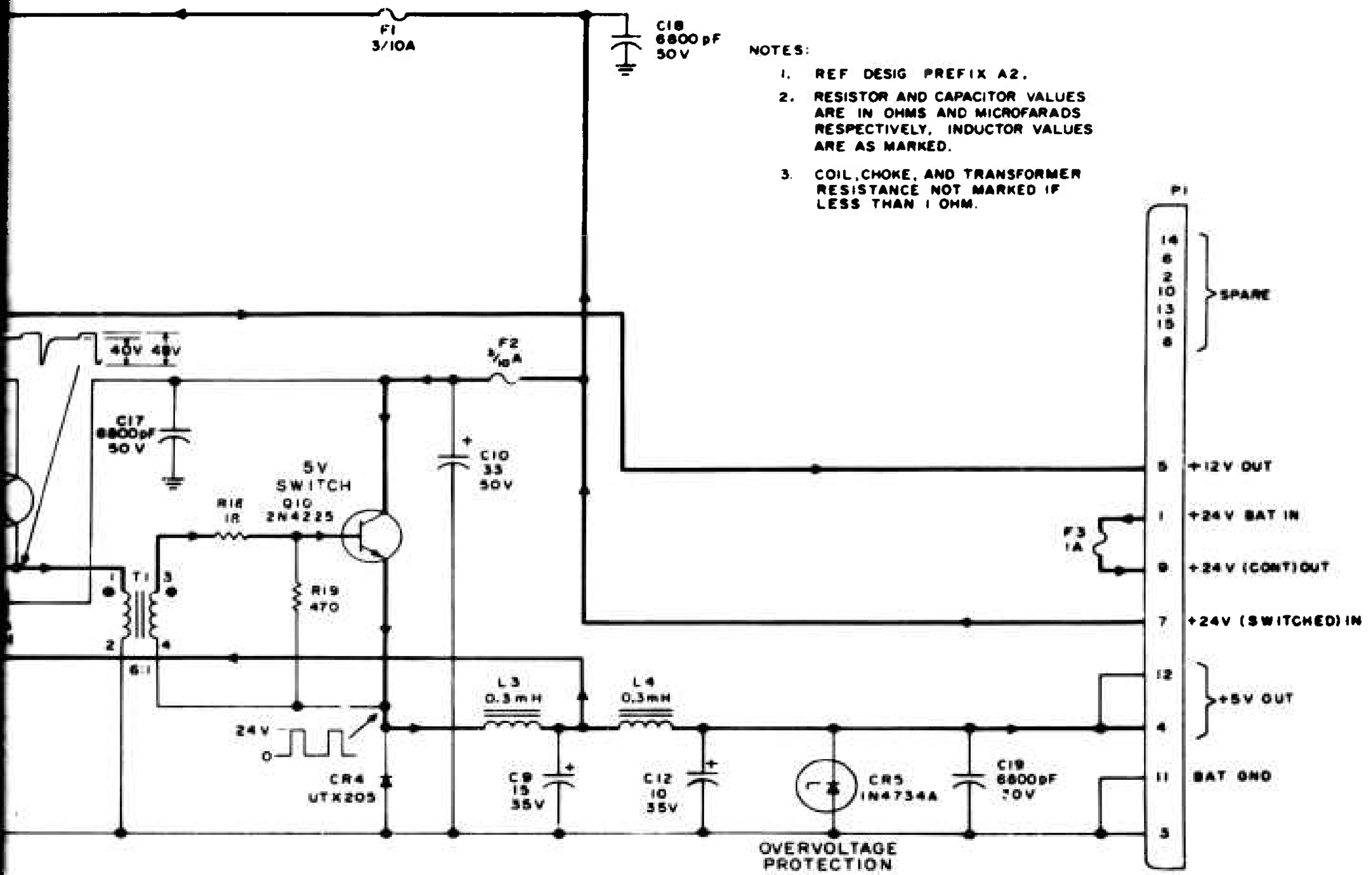
Unit/Module	Power Consumption During Receive (Watts)			Power Consumption During Transmit (Watts)		
	24V	12V	5V	24V	12V	5V
AN/PRC-66						
Freq. Synth.	0.31	0.96	2.4	0.31	0.96	2.4
RF/Receiver		0.36				
PA/Modulator				13.2	0.25	
IF Audio (with SQ)		0.31			0.10	
Wideband Board* (55 ma current source)					0.66	
Guard Receiver* (*AN/PRC-66B system)		0.66				
AN/PRC-75						
Freq. Synth.	0.31	0.96	2.4	0.31	0.96	2.4
RF/Modulator		0.28		9.6	0.32	
IF/Audio (without Squelch)		0.26			0.10	


C1 0.1
C2 4.7 35 V
R3 47K
R7 1K
R20 1K
12 V SWITCH
Q5 2N3764
R8 1200 1/4 W
R4 47K
Q11 2N3486
-24V
0
L1 2 mH
R10 47
L2 75μH
Q1 2N2484
Q4 2N2484
12 V SWITCH DRIVER
R6 4700
CR1 1N4606
OVERVOLT PROTECTI
R1 6980
C3 3.3 pF
5V REF
R3 100
Q2 2N2484
Q3 2N2484
C14 6800μF 50 V
C5 30 50V
R2 4990
R5 4700
12 V VOLTAGE COMPARATOR
C4 0.1

A


C13
6800pF
50V
R10
47
L2
75μH
+12V
C20
80
20V
R15
100
C11
0.1
40V
48V
OVERVOLTAGE
PROTECTION
CR2
U2714
R11
2200
R13
3300
Q8, Q9
5V SWITCH
DRIVER
Q9
2N2887
Q8
2N3251
R17
1500
C17
6800pF
50 V
5 V
SWITCH
Q10
2N4225
R18
18
5V REF
R12
100
R16
100
C15
0.01
T1
R19
470
6:1
Q6
2N2484
Q7
2N2484
C14
6800pF
50 V
C5
30
50V
C6
4.7
35V
CR3
SZ50715
C7
0.1
R14
4700
Q6, Q7
5V
VOLTAGE
COMPARATOR
C8
0.01
C16
6800pF
50V
24 V
0

B



NOTES:

1. REF DESIG PREFIX A2.
2. RESISTOR AND CAPACITOR VALUES ARE IN OHMS AND MICROFARADS RESPECTIVELY. INDUCTOR VALUES ARE AS MARKED.
3. COIL, CHOKE, AND TRANSFORMER RESISTANCE NOT MARKED IF LESS THAN 1 OHM.

Figure AP-1 Voltage Regulator Module 1A2, Schematic Diagram

C

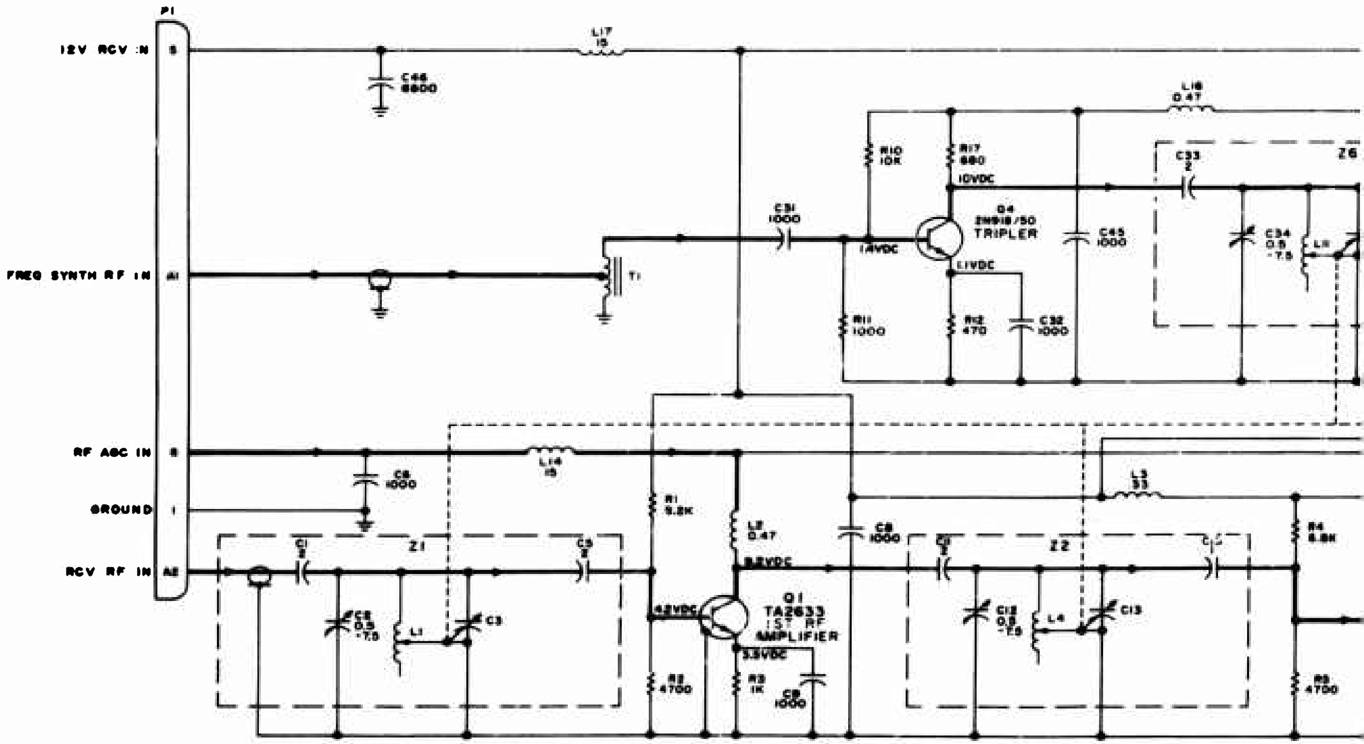
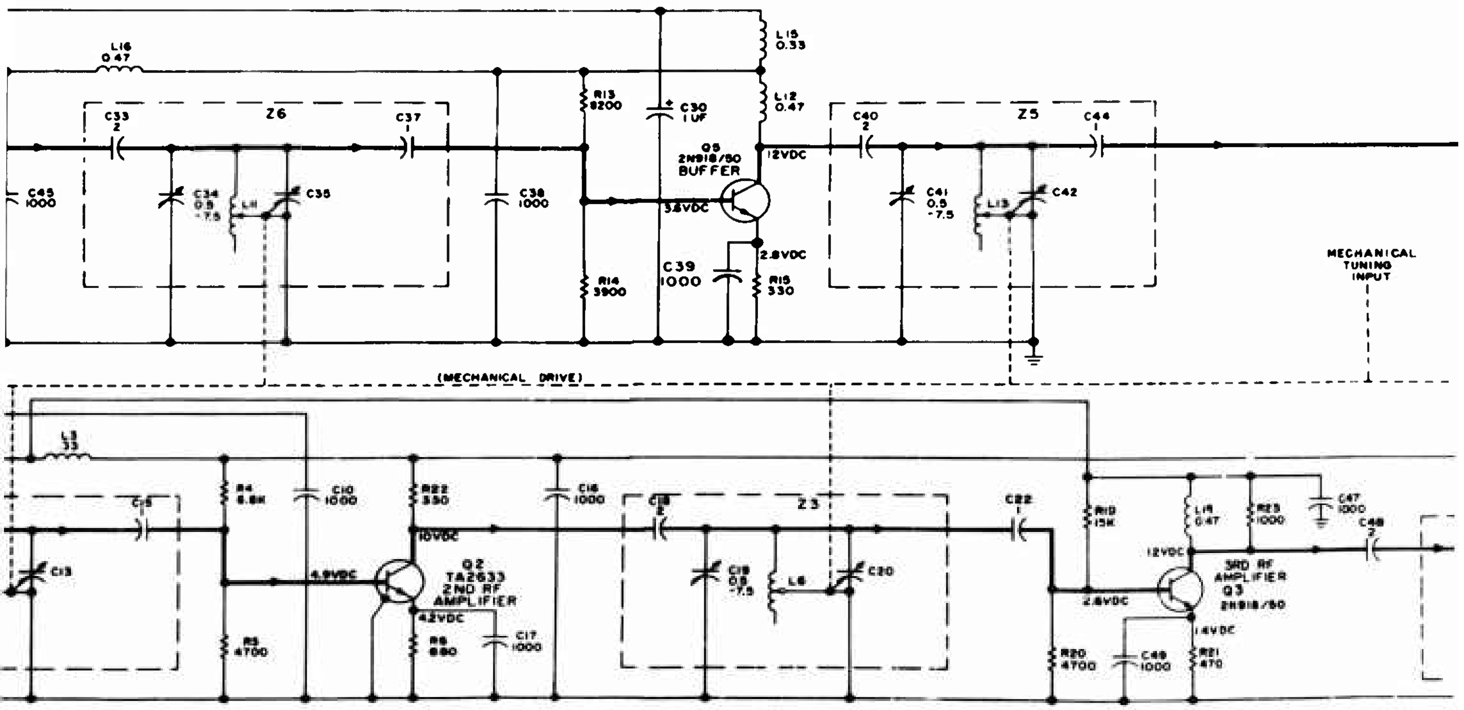


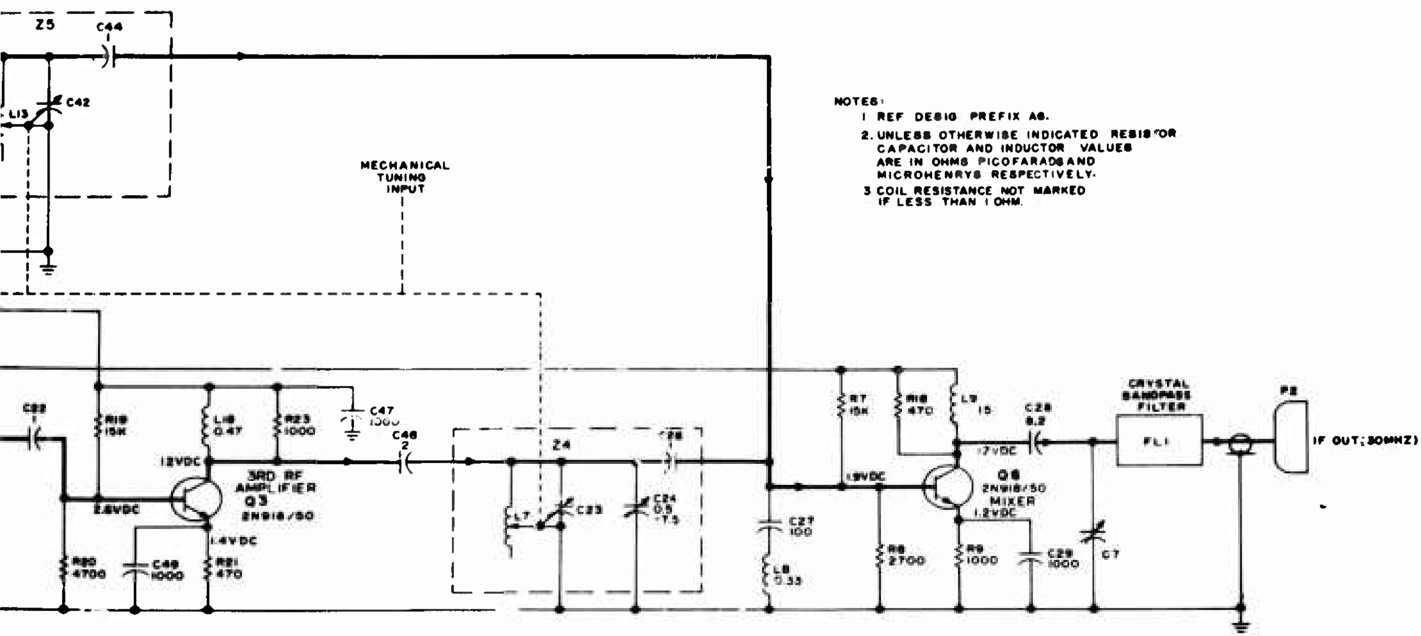
Figure AP-2 Receive RF Module 1A6, Schematic Diagram

A



L16
0.47
L15
0.33
L12
0.47
C33
2
Z6
C37
1
C45
1000
C34
0.5
-7.5
L11
C35
C38
1000
R13
8200
C30
1 UF
Q5
2N918/50
BUFFER
12VDC
3.8VDC
2.8VDC
R14
3900
C39
1000
R15
330
C40
2
Z5
C44
1
C41
0.5
-7.5
L13
C42
MECHANICAL
TUNING
INPUT
(MECHANICAL DRIVE)
L3
33
R4
6.8K
C10
1000
R22
330
C16
1000
C13
10VDC
4.9VDC
Q2
TA2633
2ND RF
AMPLIFIER
4.2VDC
R5
4700
R6
680
C17
1000
Z3
C19
0.5
-7.5
L6
C20
C22
1
R10
15K
L19
0.47
R23
1000
C47
1000
C48
2
12VDC
3RD RF
AMPLIFIER
Q3
2N918/50
2.8VDC
1.4VDC
R20
4700
C49
1000
R21
470

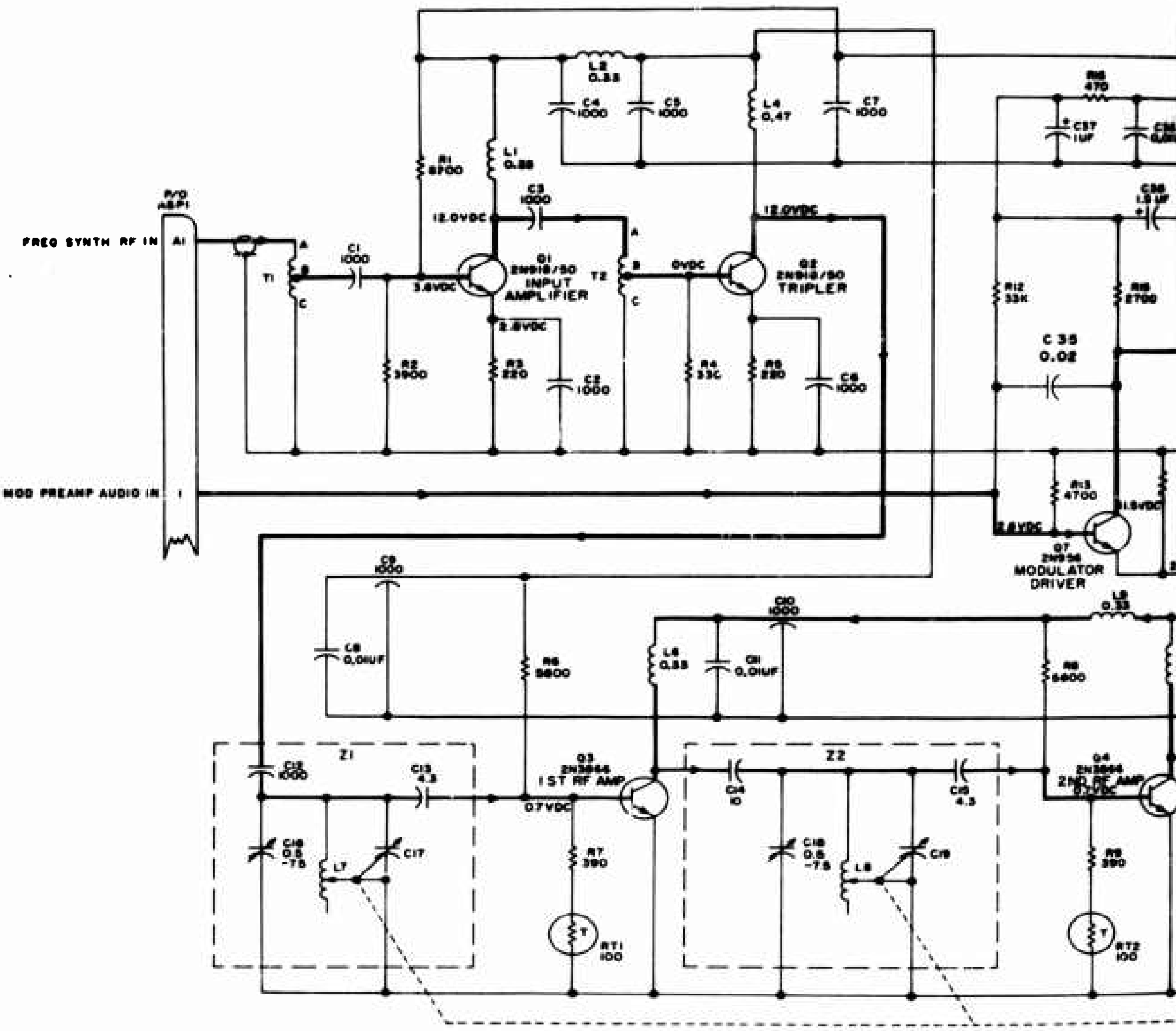
B



NOTES:

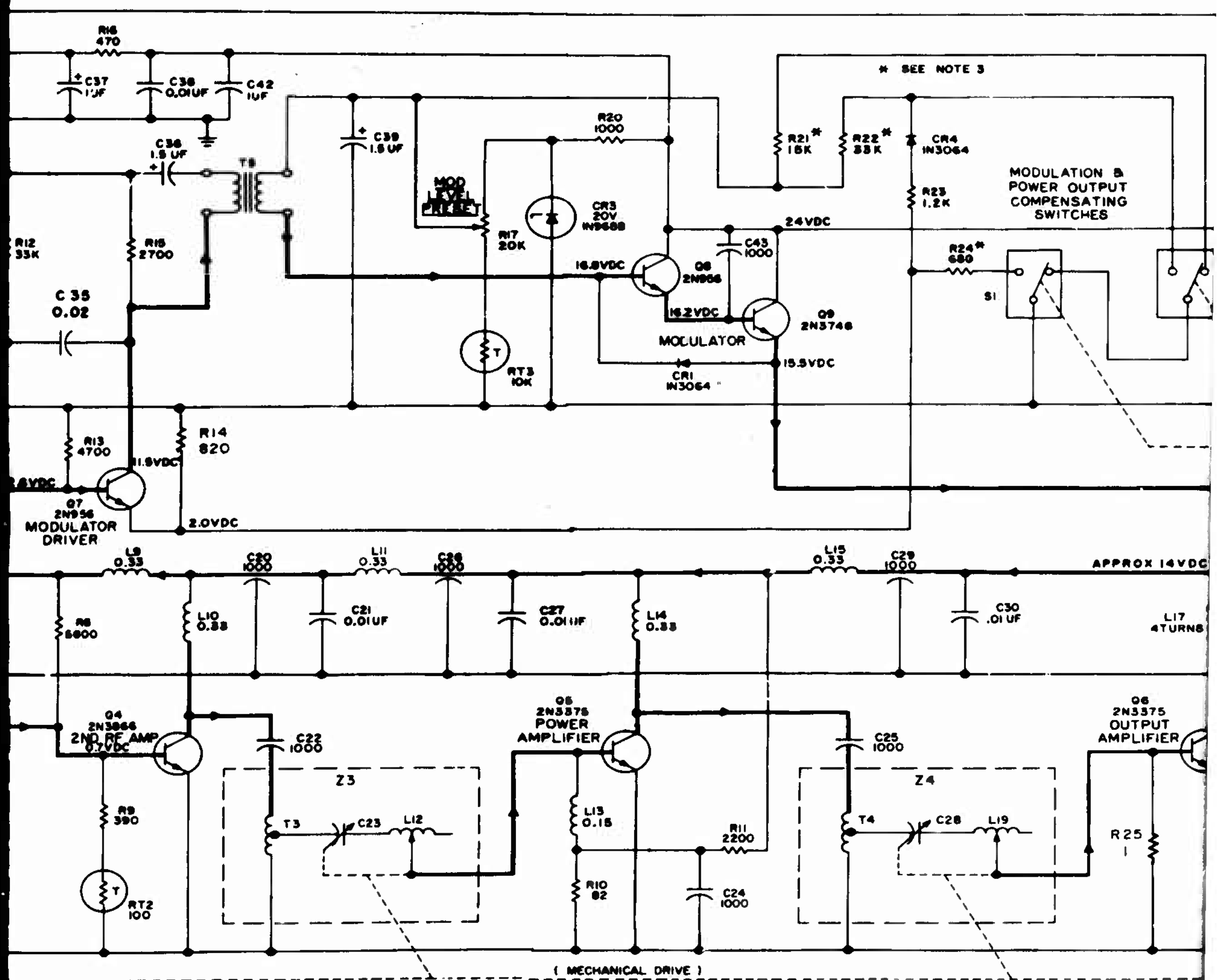
1. REF DESIG PREFIX A6.
2. UNLESS OTHERWISE INDICATED RESISTOR CAPACITOR AND INDUCTOR VALUES ARE IN OHMS PICOFARADS AND MICROHENRYS RESPECTIVELY.
3. COIL RESISTANCE NOT MARKED IF LESS THAN 1 OHM.

C

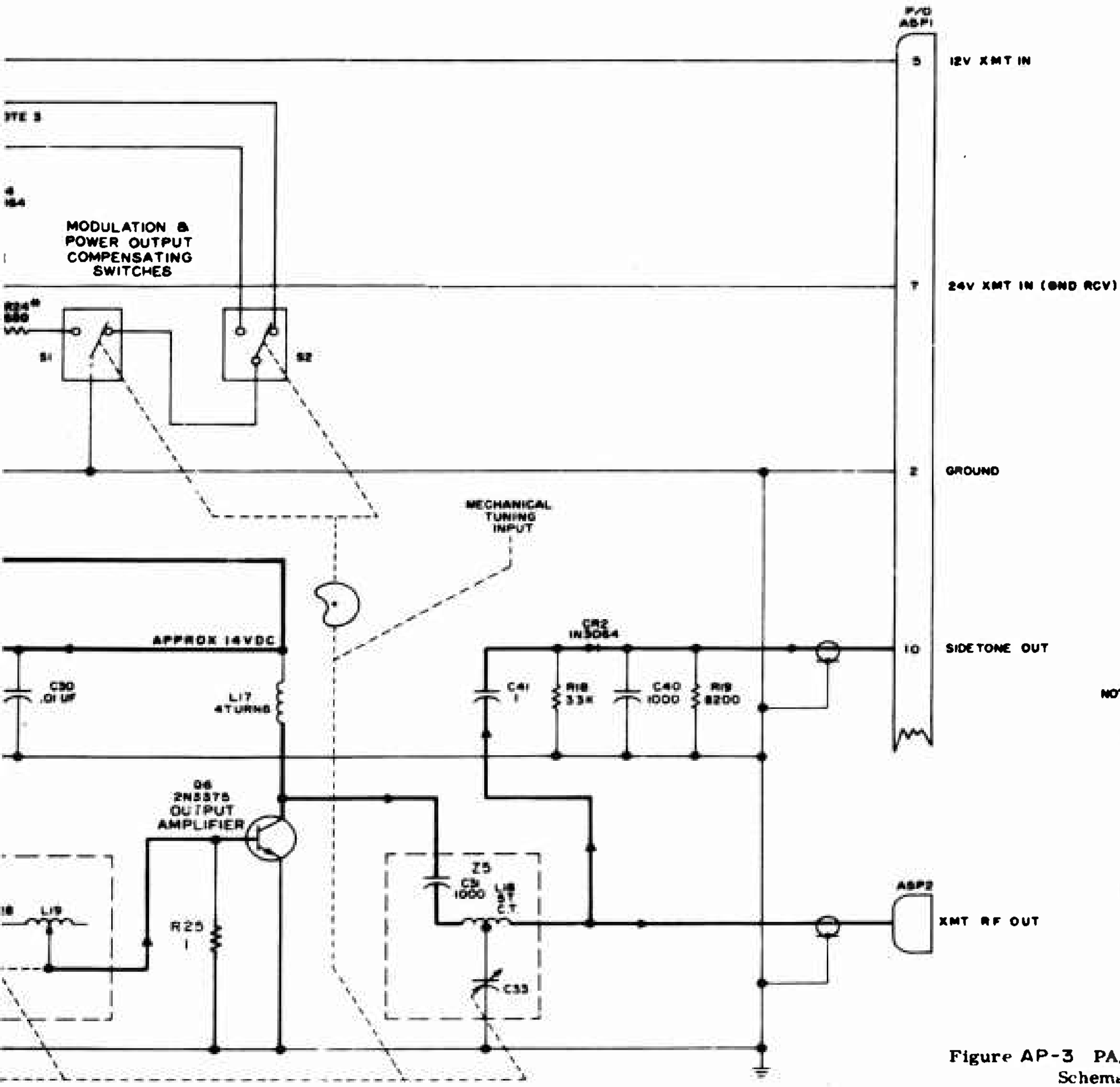


FREQ SYNTH RF IN
MOD PREAMP AUDIO IN
A1
T1
C1 1000
R1 8200
L1 0.33
C3 1000
12.0VDC
Q1 2N918/50 INPUT AMPLIFIER
L2 0.33
C4 1000
C5 1000
R2 3900
R3 220
C2 1000
T2
0VDC
Q2 2N918/50 TRIPLER
L4 0.47
C7 1000
R4 33K
R5 220
C6 1000
R16 470
C37 1UF
C35 0.02
R12 33K
R15 2700
R13 4700
Q7 2N956 MODULATOR DRIVER
C9 1000
C8 0.01UF
R6 5600
L6 0.33
C11 0.01UF
C10 1000
L5 0.33
Z1
C12 1000
C13 4.3
C16 0.5 -7.5
L7
C17
Q3 2N3866 1ST RF AMP
R7 390
RT1 100
Z2
C14 10
C15 4.3
C18 0.5 -7.5
L8
C19
Q4 2N3866 2ND RF AMP
R8 390
RT2 100

A


R16 470
C37 1UF
C38 0.01UF
C42 1UF
C36 1.5 UF
T5
C39 1.5 UF
R20 1000
* SEE NOTE 3
R21* 15K
R22* 33K
CR4 1N3064
MOD LEVEL PRESET
CR3 20V 1N5688
R17 20K
R23 1.2K
MODULATION & POWER OUTPUT COMPENSATING SWITCHES
24VDC
C43 1000
R24* 680
S1
R12 33K
R15 2700
C 35 0.02
16.8VDC
Q8 2N956
16.2VDC
Q9 2N3746
MODULATOR
RT3 10K
CR1 1N3064
15.5VDC
R13 4700
R14 820
11.5VDC
Q7 2N956 MODULATOR DRIVER
2.0VDC
L9 0.33
C20 1000
L11 0.33
C26 1000
L15 0.33
C29 1000
APPROX 14VDC
R8 5600
L10 0.33
C21 0.01UF
C27 0.01UF
L14 0.33
C30 .01 UF
L17 4TURNS
Q4 2N3866 2ND RF AMP
0.7VDC
C22 1000
Q5 2N3375 POWER AMPLIFIER
C25 1000
Q6 2N3375 OUTPUT AMPLIFIER
Z3
T3
C23
L12
Z4
T4
C28
L19
R9 390
L13 0.15
R11 2200
R25 1
RT2 100
R10 82
C24 1000
(MECHANICAL DRIVE)

B



NOTES:

1. REF DESIG PREFIX A5.
2. UNLESS OTHERWISE INDICATED RESISTOR CAPACITOR AND INDUCTOR VALUES ARE IN OHMS PICOFARADS AND MICROHENRYS RESPECTIVELY.
3. * RESISTOR VALUES ARE DETERMINED DURING ASSEMBLY.
4. ALL D-C VOLTAGES ARE MEASURED WITH FREQUENCY SYNTHESIZER MODULE REMOVED FROM RT UNIT.
5. COIL RESISTANCE NOT MARKED IF LESS THAN 1 OHM.

Figure AP-3 PA/Modulator Module 1A5, Schematic Diagram

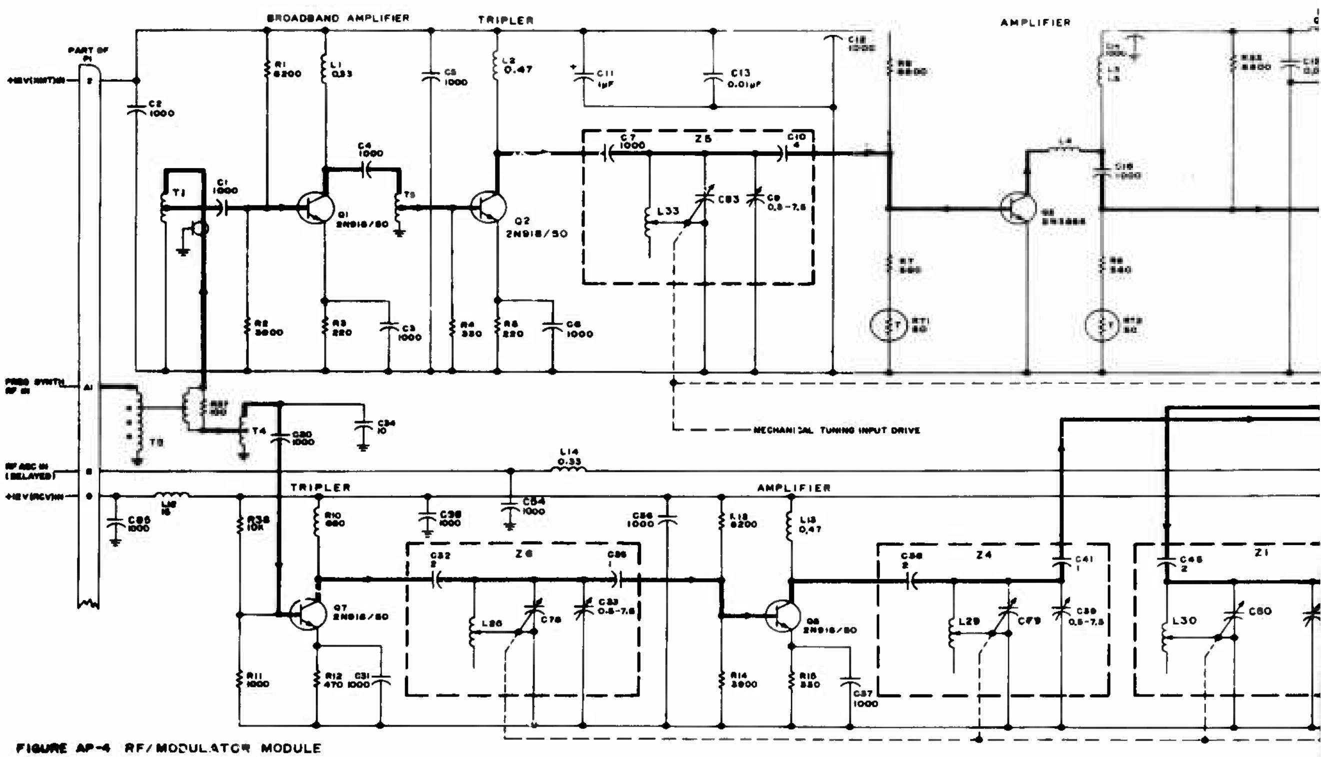
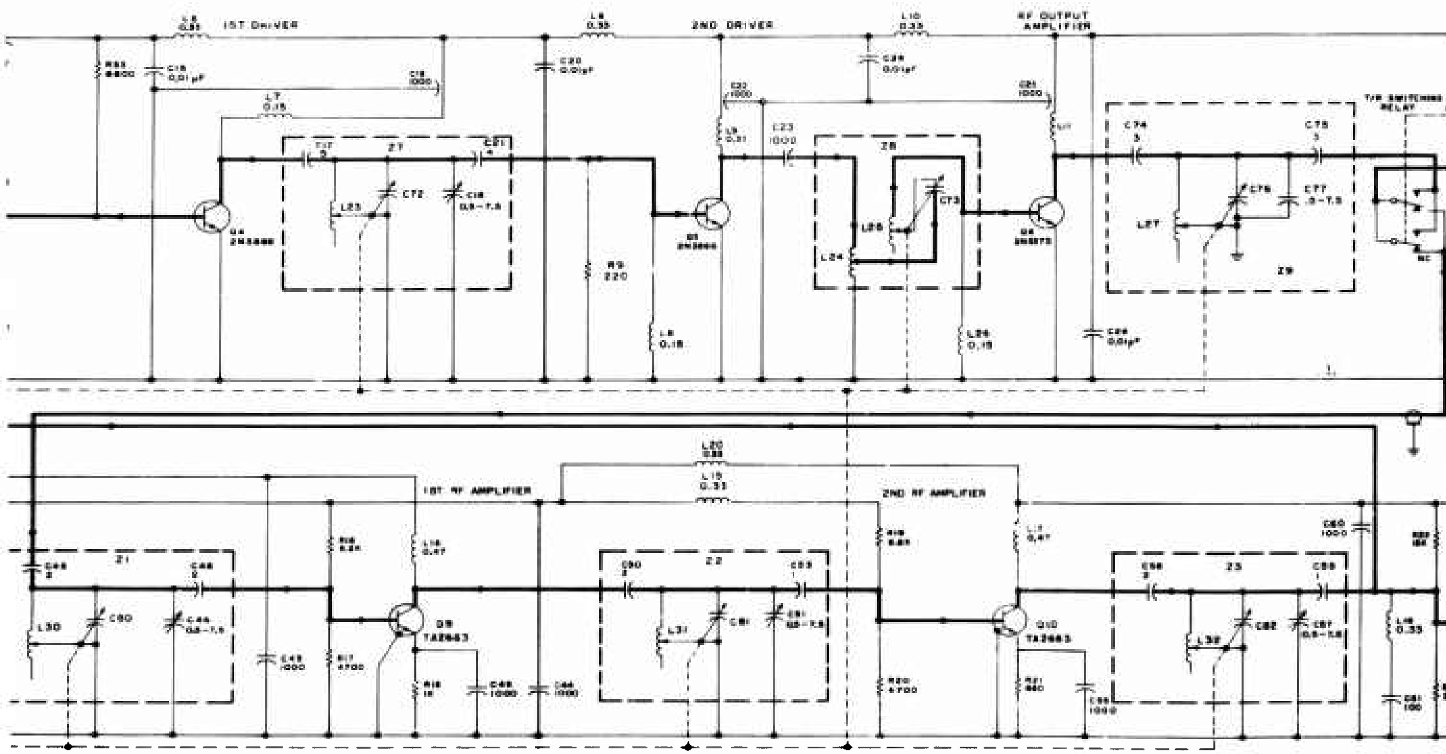
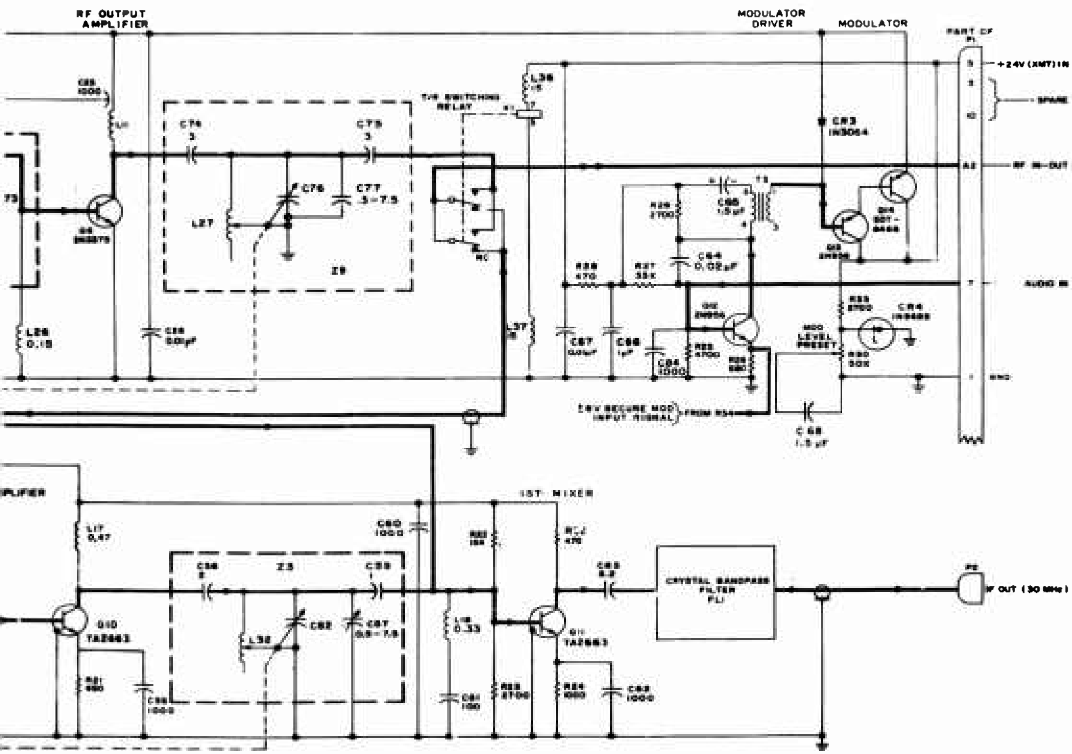


FIGURE AP-4 RF/MODULATOR MODULE
SCHEMATIC DIAGRAM

A


1ST DRIVER
2ND DRIVER
RF OUTPUT AMPLIFIER
T/R SWITCHING RELAY
1ST RF AMPLIFIER
2ND RF AMPLIFIER
R9 220
C23 1000
Z8
Z9
L24
L22 0.15
L26 0.15
C27 0.01μF
C20 0.01μF
C24 0.01μF
L20 0.33
L19 0.33
Q9 TA2663
Q10 TA2663
Z1
Z2
Z3
C45 1000
R17 4700
R20 4700

B



NOTES:

1. PARTIAL REFERENCE DESIGNATION PREFIX A5.
2. UNLESS OTHERWISE INDICATED RESISTOR CAPACITOR AND INDUCTOR VALUES ARE IN OHMS PICOFARADS AND MICROHENRIES RESPECTIVELY.
3. C9, C18, C33, C39, C51, C57, AND C72 ARE TRIMMER CAPACITORS.
4. TANK-COIL SWITCH S1 (IN Z9) JUST CLOSES (OR OPENS) AT 300 MHZ (APPROX) TUNING SHAFT POSITION.
5. R30 VALUE IS NOMINALY 68K SELECTED BY FACTORY TEST FOR 1.2 WATTS RF OUTPUT POWER AT 300.00 MHz MODULATED 90% BY 1000 Hz. OTHER VALUES MAY BE 56K, 82K, 100K, OR 120K.
6. R34 VALUE IS NOMINALLY 2.7K SELECTED BY FACTORY TEST FOR 90% MODULATION AT 225.00 MHz WITH 3.5 VRMS 1000 Hz INPUT TO P1-4. OTHER VALUES MAY BE 3.6K, 4.7K, 5.2K, OR 6.2K.

C

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13. ABSTRACT

This report summarizes the results of the design and development of Radio Set AN/PRC-66 for the United States Air Force and Radio Set AN/PRC-75 for the United States Marine Corps. Both transceivers are completely solid state and utilize the latest micro-miniature techniques and most recent advances in modular construction. The AN/PRC-66 represents a major breakthrough in portable manpack equipment and the AN/PRC-75 represents, likewise, a major breakthrough in handheld UHF equipment.

The results of the design and development indicate that major advances have been realized in the areas of reliability, weight, and size. Both transceiver units have a predicted MTBF in excess of 2000 hours and weigh no more than 5.5 pounds (AN/PRC-66) and 3.9 pounds (AN/PRC-75), excluding battery. Also, the size of these radio sets is at least 80% smaller than similar equipment in production and use today.

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