NATIONAL SERVICE TRAINING

PLANTATION, FLORIDA

ADVANCE INFORMATION DIGEST

PORTABLE PRODUCTS

PT500 "HANDIE-TALKIE"

PORTABLE RADIO

136 - 174 MHz

PREPARED BY
NATIONAL SERVICE TRAINING DEPARTMENT
PLANTATION, FLORIDA
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NATIONAL SERVICE TRAINING

PLANTATION, FLORIDA

PREFACE

The Advance Information Digest, A.I.D., published by the National Service Training Department, is designed to provide preliminary service information for new Motorola products prior to any customer shipment. These technically oriented publications are intended to give the Field Service Technician some basic maintenance and installation information about a new product before actually seeing it. The A.I.D. also contains general theory of operation and troubleshooting sections, plus a list of recommended test equipment and service aids useful in servicing the product. In addition, A.I.D.s contain the service manual part number, allowing the technician to order the manual in advance.

Although the information in this booklet is as accurate as possible at the time of publication, it is recommended that the current service manual be consulted before servicing the product.

MOTOROLA
Communications and Electronics Inc.

NATIONAL SERVICE TRAINING
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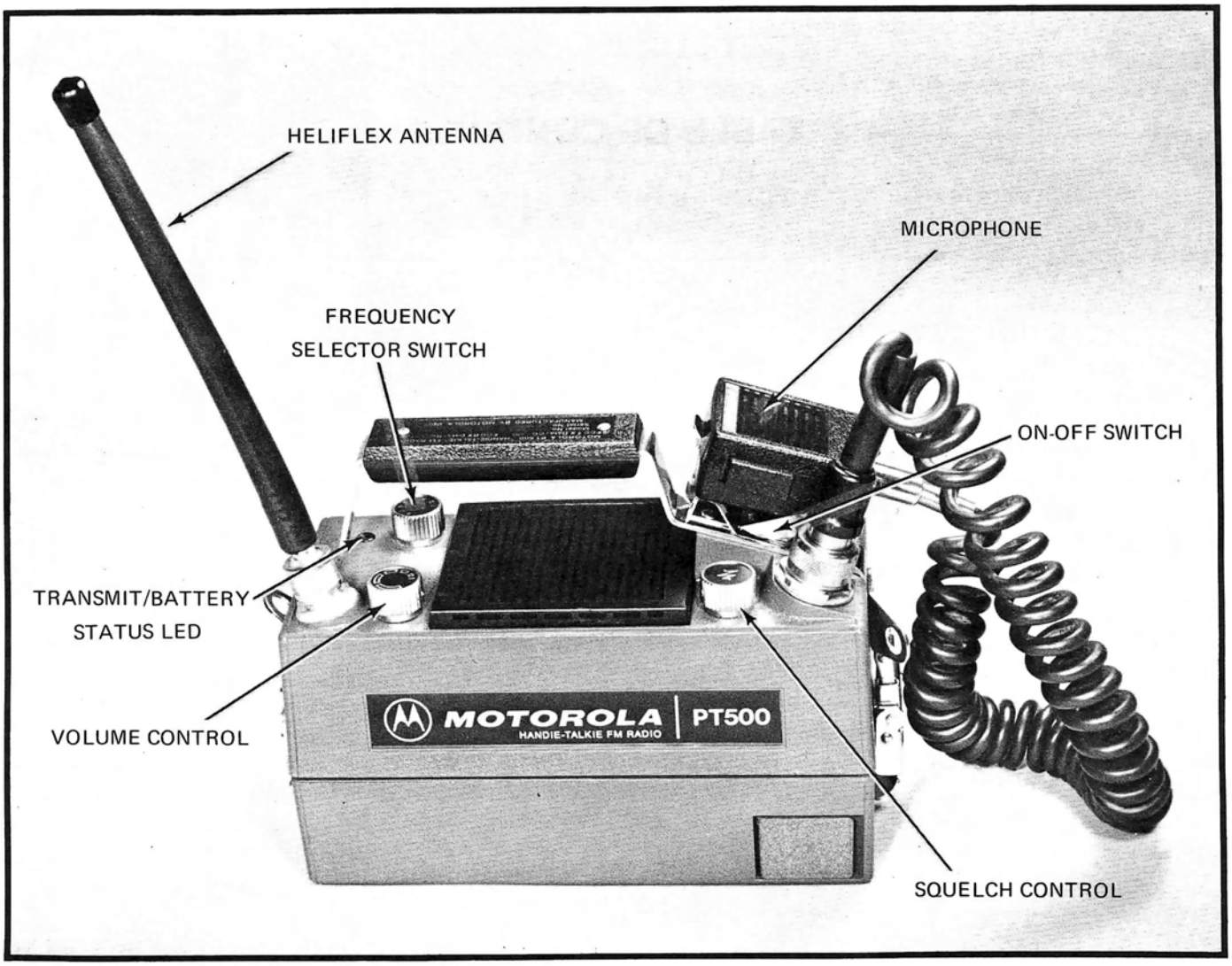

PT500 "HANDIE-TALKIE" PORTABLE RADIO

I. INTRODUCTION

The new PT500 series "Handie-Talkie" FM radio has been designed as a replacement for the PT200/PT300 series radio. These new two-way "Handie-Talkie" portables are very similar in appearance to the PT200/PT300 series radios, and have been designed to be compatible with most of the existing PT200/PT300 series accessories, including the power supplies and chargers. In addition, most of the existing PT200/PT300 series service aids are also compatible with the PT500 series portables.

The transceiver incorporated in the PT500 series portables is basically the same design and configuration used in the recently developed MT500 series "Handie-Talkie" radios. This transceiver design makes extensive use of Hybrid modules, as well as integrated circuits.

The majority of the circuitry is located on three circuit boards; the transceiver board, the interconnect board, and the audio interface board. The transceiver board and the interconnect board are contained within the radio frame assembly, which swings out of the main housing , as shown in Figure 1. This allows easy servicing of the transceiver circuitry, as well as the audio interface board and other components located underneath the radio frame assembly.

The instruction manual number for the PT500 series portables is 68P81015C70-0, and the service sheet number is 68P81015C80-0. Both of these publications can be ordered in advance of equipment shipment.

NOTE: Both of the above-listed manuals are NLA, but servicing information is found in the MT500 manuals.

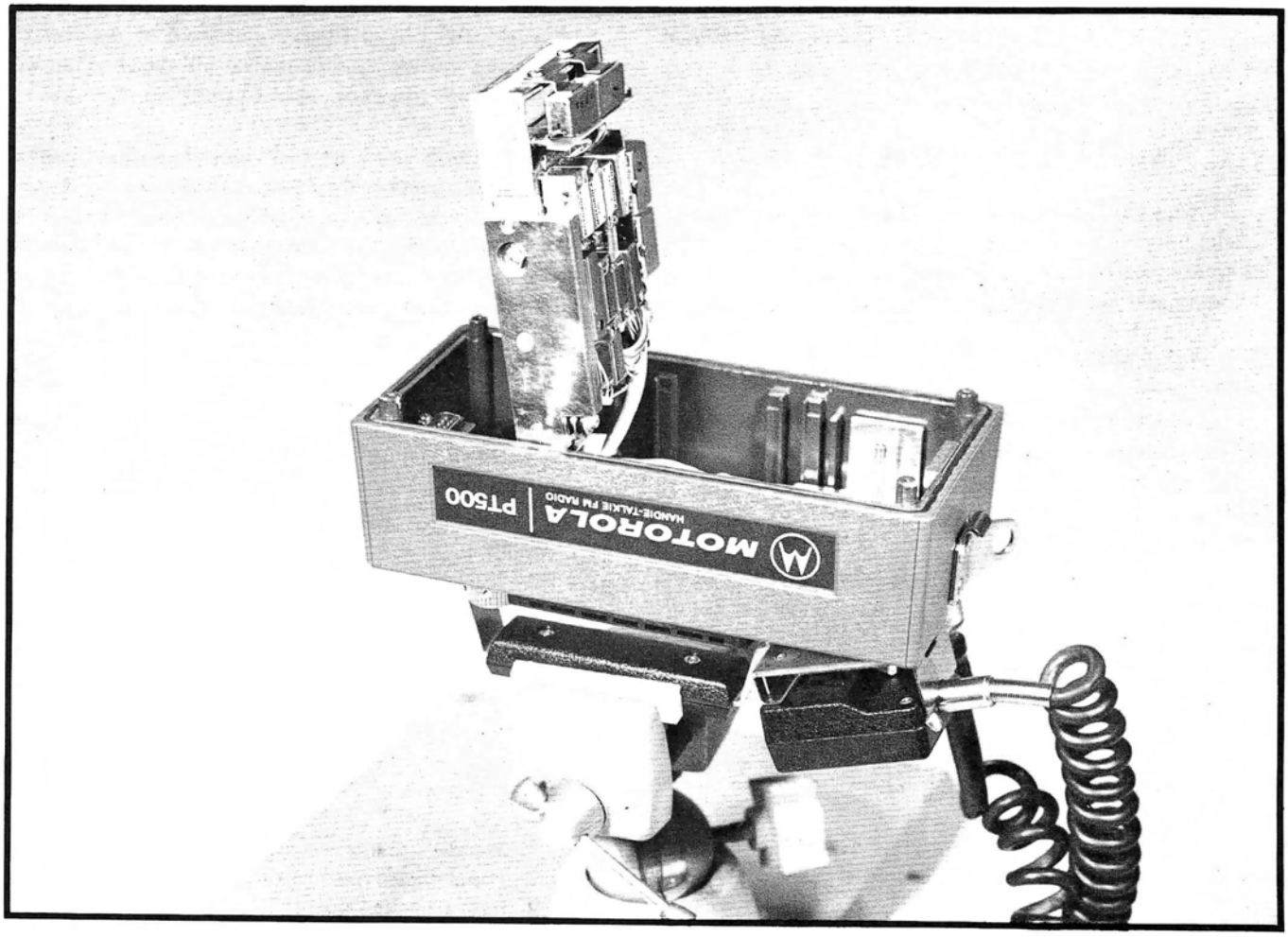

FIGURE 1

II. FEATURES AND OPTIONS

A. Models Available

The PT500 portables are currently available only in the VHF, 136 to 174 MHz range, with an RF power output of either two watts or five watts.

The standard portable is equipped with a palm microphone, and has up to eight frequency operation.

B. Battery Status and Transmit Indicator

The PT500 series radio is equipped with a battery status indicator, consisting of a red light-emitting diode located on the top of the radio. When the battery reaches a low level of charge, the "LED" flashes as the radio is keyed.

The red "LED" is standard, however, an optional amber "LED" is also available.

C. "Squelch-Tail" Elimination

"Squelch-Tail" elimination is provided on all coded squelch models by a special "reverse burst" circuitry. This eliminates the burst of noise that is heard at the receiver following each message.

D. Handset Option

The PT500 series radios are available with an optional speaker/handset instead of the standard palm microphone. Unlike the PT200/PT300 series radios, this option can be field installed.

The only difference between the standard palm microphone type portable and the optional speaker/handset type portable is the handle on the PT500 housing. This handle is attached to the housing by stainless steel "pop rivets" and can be easily changed from one type to the other.

E. Protected Receiver Option

A protected receiver option is available, allowing the PT500 series radios to be operated in areas subject to severe interference. Intermodulation, selectivity, and spurious rejection have been increased. However, with this option installed, the receiver sensitivity is slightly reduced.

F. Time-Out Timer

The time-out timer option shuts off the transmitter if the transmission exceeds a 60-second duration. The transmitter is automatically reverted to standby and an audible alert tone is emitted to signal this condition to the operator.

G. "Private-Line" Options

Both the tone coded and digital coded squelch options are available for the PT500 series radios.

H. Selective Call Signalling

This option allows a particular PT500 series radio to be called individually. The selective call circuitry is primarily a decoder which detects and decodes the two-tone sequential paging signal transmitted to the receiver. The radio containing the proper code will then emit an alert tone after which the voice message can be heard.

In addition, there are two types of group call options offered. First, there is the four-tone selective call which is basically two single-address circuits with the second address used for group call. The second type is the long tone "B" selective call that can be implemented by adding a group call module to the two-tone selective call circuit.

I. Single Tone Remote Signalling

This tone emitting option allows the radio operator to activate relays on other devices from a remote location, or allows the transmission of a tone signal which could have a predetermined meaning to the monitoring station. The standard option provides up to five selectable tones, plus an "off" position.

J. Power Packs

The power packs listed below are directly interchangeable between all PT500 series radios.

1. Standard charge nickel-cadmium
2. Rapid charge nickel-cadmium
3. Industrial "D" cell
4. Latern cell
5. 117 VAC. 60 Hz

K. Chargers

The chargers available for the PT500 series portables are listed below:

1. Multiple unit nickel-cadmium battery charger
2. Integral AC/DC charger (6/12/24 VDC; 117/234 VAC)
3. 6/12 VDC vehicular charger
4. Wall socket type single unit charger
5. Single unit rapid charger

L. Antennas

The PT500 series radios come equipped with a flexible whip antenna designed for the radio's particular carrier frequency range. The rubber coated Heliflex is also available as an option on these portables.

M. Miscellaneous Accessories

The accessories listed below for the PT500 series radios are the same accessories that were available for the PT200/PT300 series portables.

1. Aircraft type headset and microphone
2. Back pack harness
3. Carrying strap
4. Canvas carrying bag
5. Vehicular mounting rack

OPTION LOCATION

When some options are added to the radio, additional circuit boards are required. These additional circuit boards are wired to the interconnect board in one of four option slots shown below in Figure 2.

OPTION	OPTION SLOT MOUNTED IN
Tone PL Deck	A
Digital PL Deck	A
Selective Call	
Two-Tone	A
Four-Tone*	D
Long-Tone B*	D
Subaudible*	D
Single-Tone	A
Multiple Single-Tone**	C
C7R7 Deck	C
C8R8 Deck	D
Time-Out Timer	C or D
Transmit-Only Tone PL Deck	B
Transmit-Only Digital PL Deck	B
"PAC●RT" Transmit-Only Tone PL Deck	A

*Includes Two-Tone Selective Call Kit
**Includes Singlt-Tone Kit

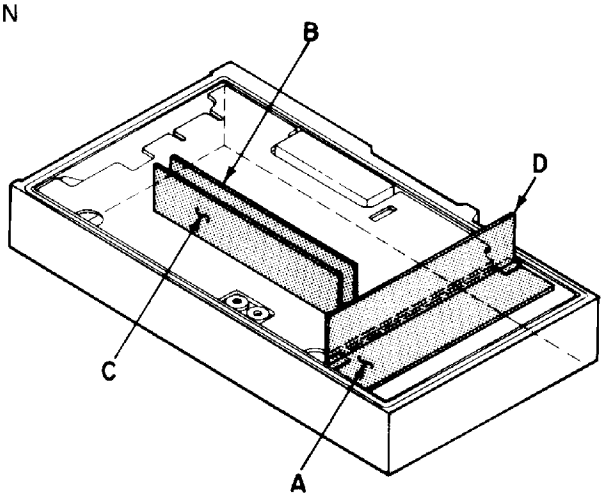

FIGURE 2

III. SERVICEABILITY

To service the PT500 series portables, first remove the power pack by unsnapping the spring snaps located at each end of the radio. Now, the radio can be lifted off of the power pack as shown in Figure 3.

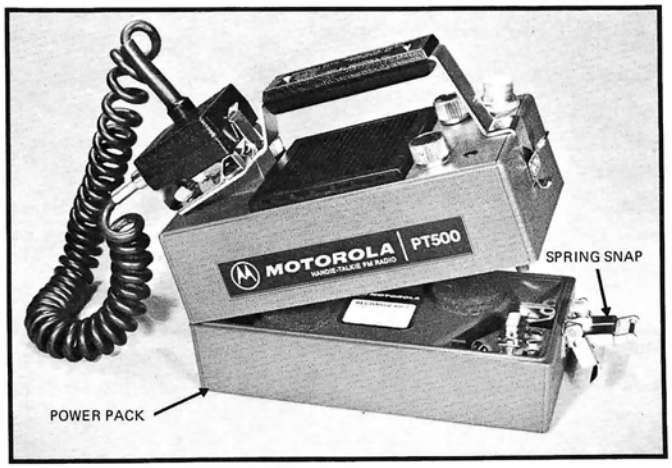

FIGURE 3

With the radio turned upside down, the bottom cover plate can be removed by loosening two captive screws, as shown in Figure 4. This allows access to the solder side of the transceiver board which is part of the radio frame.

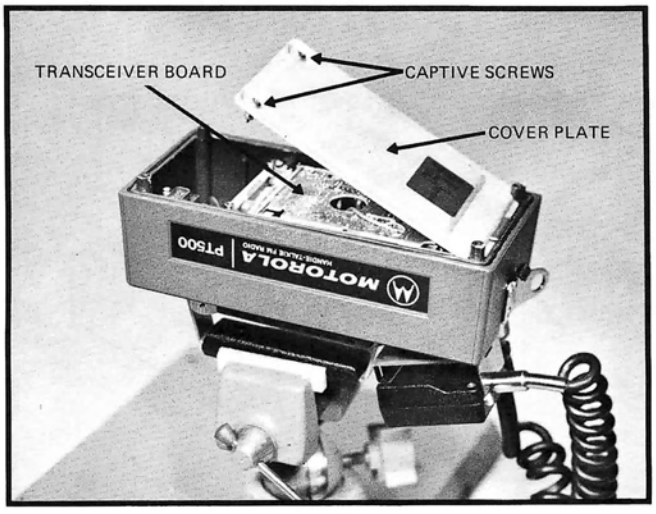

FIGURE 4

With the bottom cover plate removed, the radio frame can be raised after loosening two captive screws. Figure 5 shows the radio frame in the raised position allowing access to the solder side of the interconnect board and option circuit boards. The radio frame pivots on a spring loaded hinge and will remain in the upright position until it is pushed back down. This allows for easy servicing of the transceiver board and the interconnect board.

If further servicing of the interconnect board or the transceiver board is required, the transceiver board can be separated from the radio frame assembly. This can be done while maintaining the radio electrically functional, through the use of the RTK4008A interconnect cable.

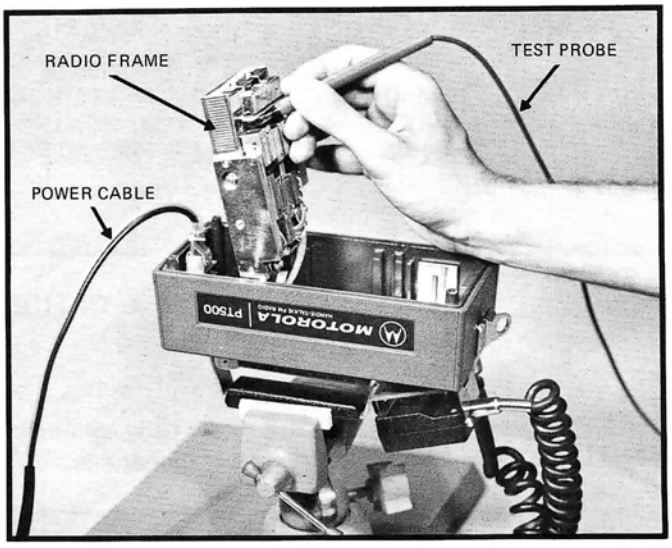

FIGURE 5

With the radio frame in the raised position, the interface board can be accessed by loosening three more captive screws and lifting up the regulator heat sink plate. The interface board is attached to the bottom of the heat sink plate and troubleshooting can be done on the component side of the interface board as shown in Figure 6.

If further servicing of the interface board is required, the interface board/heat sink assembly can be unplugged from the cable harness and completely removed from the radio.

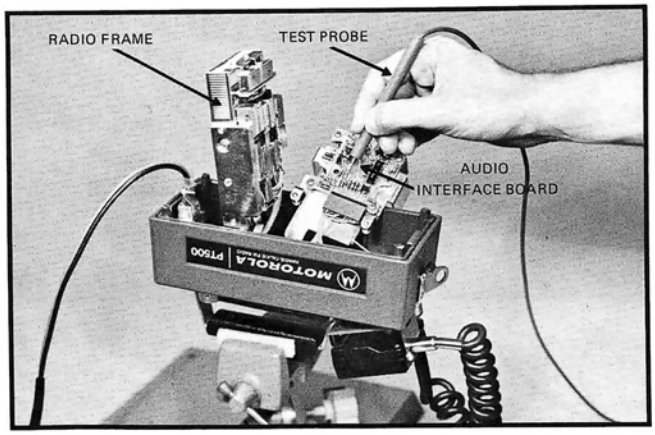

FIGURE 6

IV. THEORY OF OPERATION

A. INTRODUCTION

Since the PT500 series portables incorporate the same basic transceiver design as the MT500 series portables, the theory of operation section of this publication will be limited to a simplified block diagram type explanation of the basic transceiver board. However, a more detailed explanation will be given of the circuitry contained on the smaller audio interface board which is unique to the PT500 series portables.

B. BASIC RECEIVER OPERATION

Figure 7 shows the block diagram for the receiver of the VHF PT500 series portable which is a dual conversion superhetrodyne type.

The RF signal is coupled into the receiver by the antenna, and is applied to Q1, the RF amplifier, through the push-to-talk relay, K101. The RF signal is amplified by Q1, and is hetrodyned with the injection signal in Q2, the first mixer. The channel element provides the input signal for U8, the injection module. The output signal from U8 is three times the channel element frequency, and is the injection input for Q2, the first mixer.

The 17.9 MHz high IF signal developed on the output of Q2 is coupled to the high IF circuitry. Here, the signal is filtered by crystal filters FL1, FL2 and FL3, and amplified by U2, the high IF amplifier. These crystal filters provide the majority of the selectivity for the receiver. The output of FL3 is applied to U3, the low conversion module, where the 17.9 MHz high IF is converted to 35 KHz, the low IF frequency. This 35 KHz low IF is then coupled to U4, the 35 KHz IF detector module, where the audio is removed from the low IF signal.

The recovered audio is then coupled to U6, the audio preamp, whose output is used to drive U7, the audio power amplifier. The output of U7 is then used to drive the speaker. The audio output from U4, the IF detector module, is also applied to U5, the squelch module. The purpose of U5 is to control the squelch switch located inside U7, the audio power amplifier module. The squelch switch then turns the audio stages on and off, providing the squelch function for the receiver.

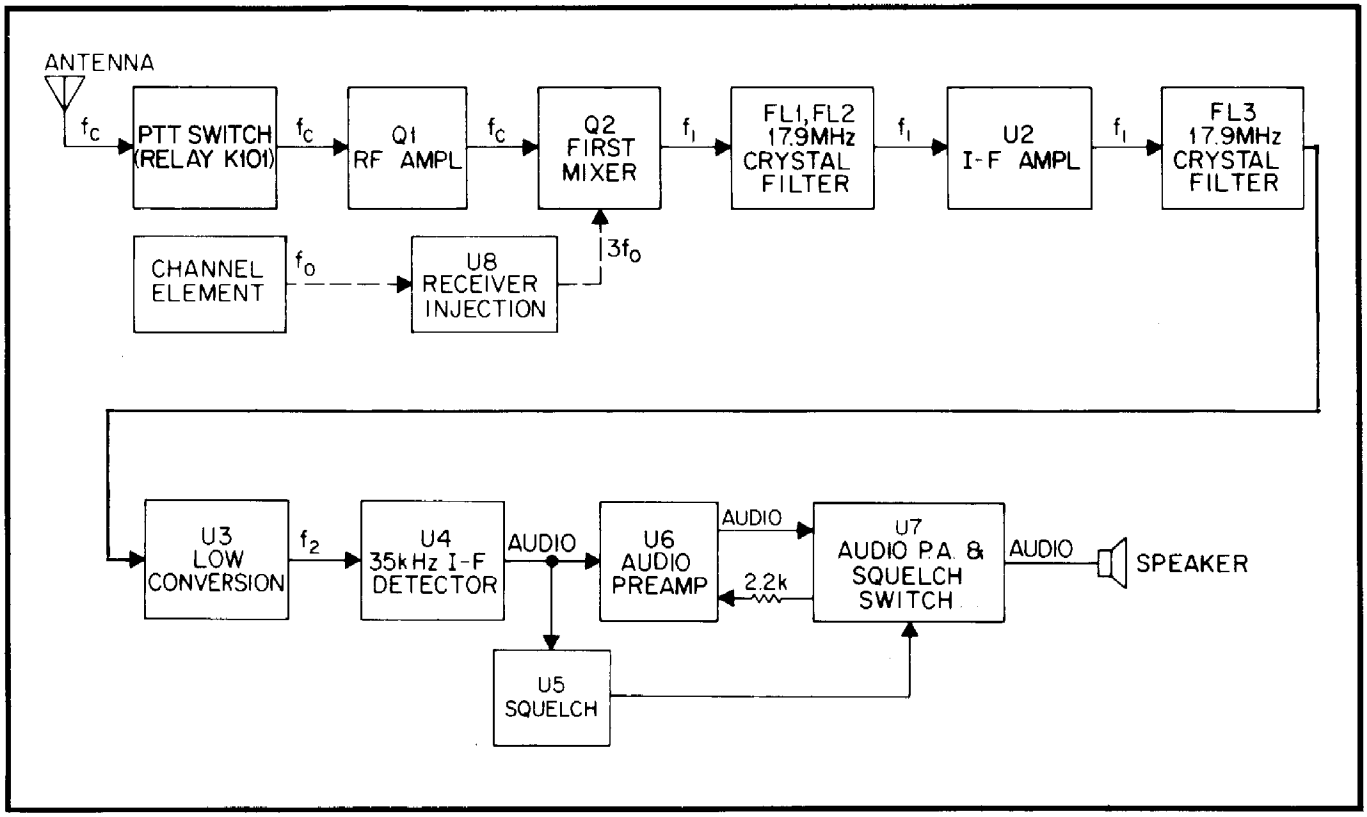

FIGURE 7 RECEIVER BLOCK DIAGRAM

C. BASIC TRANSMITTER OPERATION

Shown in Figure 8 is the block diagram for the VHF two and five watt transmitter for PT500 series portables.

Beginning at the left of the diagram, an audio signal is coupled to U13, the "Instantaneous Deviation Control" (IDC) module via the microphone. The IDC module amplifies, shapes, limits, and filters the audio signal which is then applied to the appropriate channel element. Generation and modulation of the RF signal occurs in the transmit channel element. The output of the channel element is applied to U10, the buffer/tripler module, where the channel element frequency is tripled and applied to Q101, the predriver stage. U10 also serves to isolate the channel element from the rest of the transmitter.

After the channel element frequency has been tripled in the U10 module, the output RF signal is now equal in frequency to the carrier frequency of the transmitter. The RF signal applied to the input of Q101 is now amplified by Q101 and coupled to Q102, the driver, where it is amplified again and applied to the input of U12, the two or five watt power amplifier and filter. The U12 module amplifies the RF signal and applies it to a low pass filter which attenuates all frequencies above the carrier frequency. The output of the U12 module passes through the K101 relay, and is applied to the antenna where the modulated on carrier RF signal is radiated from the transmitter.

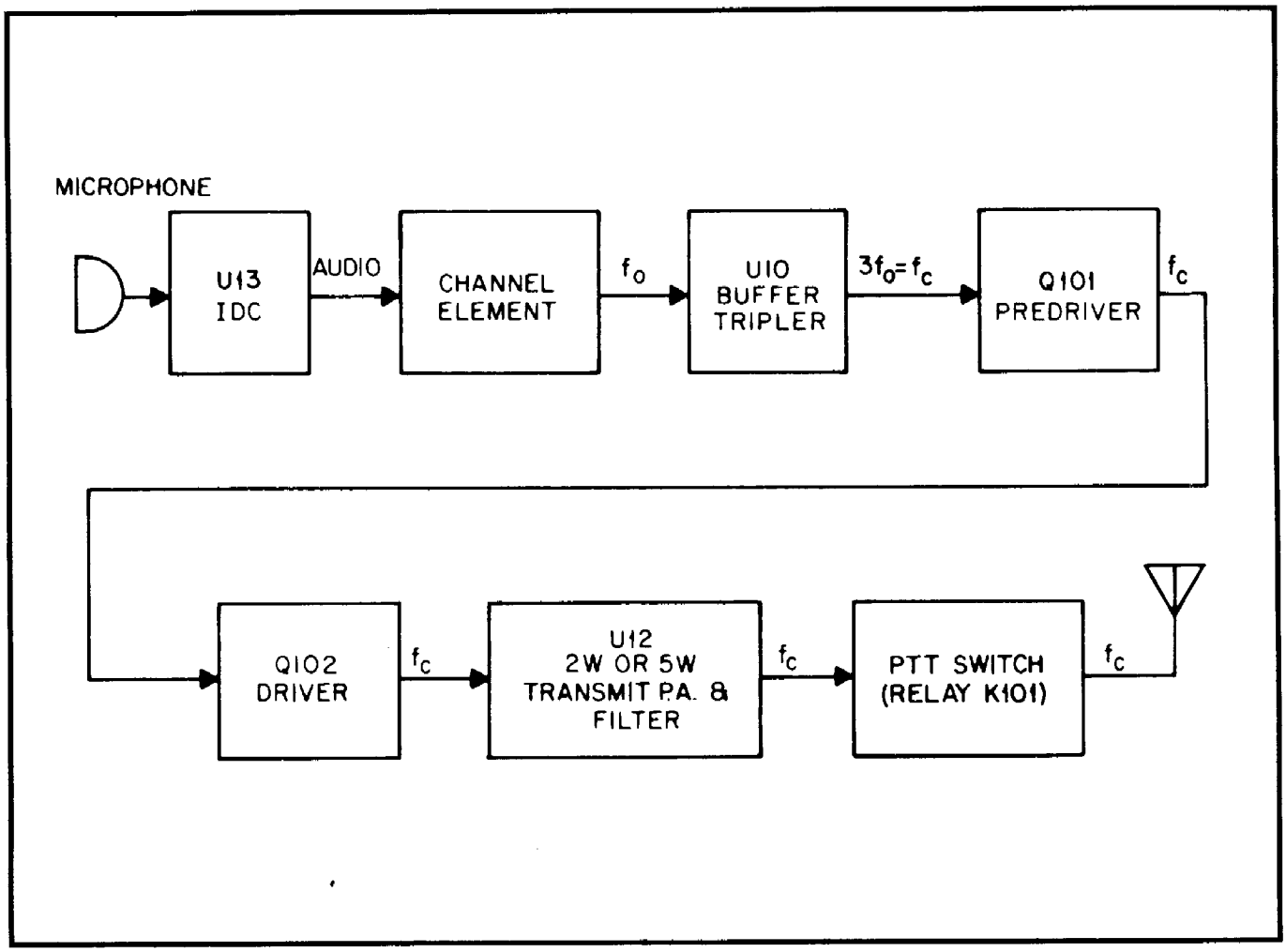

FIGURE 8 TRANSMITTER BLOCK DIAGRAM

D. AUDIO INTERFACE BOARD

The audio interface board contains the circuitry for the voltage regulator, the transmit/battery indicator, and the PTT relay switching. The operation of these circuits will be explained in detail, starting with the voltage regulator circuitry.

1. Voltage Regulator Circuit

The schematic diagram for the voltage regulator is shown in Figure 9. This voltage regulator uses a dc negative feedback reference amplifier, Q405, to control the output voltage. The desired regulated voltage is obtained by adjusting R423. Once set, any variation in the regulated voltage is applied to the emitter of Q405, due to the constant voltage drop across Zener diode VR401. A fraction of the variation, determined by the voltage divider action of R422, R423, and R420, is applied to the base of Q405. The resultant change in base-emitter voltage varies the collector current through Q405, which then changes the base drive to Q404, returning the regulated voltage to its original value.

Voltage divider resistors R417 and R418 provide start-up voltage through CR403 to the base of Q405 when unregulated battery voltage is initially applied. Once regulation is achieved, CR403 becomes back-biased, isolating the start-up circuit from the rest of the regulator.

In the transmit mode, resistor R421 is returned to ground. This increases the collector-to-emitter current in Q405, which biases Q404 to carry the higher current required for transmitting.

2. Transmit/Battery Indicator Circuit

This circuit, shown in Figure 10, uses a quad NAND gate module (U401) to generate the logic sequence. The LED indicator is normally off when in the receive mode. When the PTT switch is engaged, and the battery voltage is above the limit set by R410, transistor Q402 is turned off and no current flows in R412. This keeps pins 1 and 2 of NAND gate 1 in U401 low (0). Pin 3 is forced high (1), which means that pin 4 goes low (0). Similarly, pin 13 is low and pin 11 is forced high continuously. Q403 is then biased on and current flows to the LED.

If the battery voltage drops below the threshold level set by R410, Q402 turns on. This causes a voltage drop across R412 and pins 1 and 2 of U401 go high (1). Pin 3 is forced low and pin 4 goes high. Since pin 13 is high, pin 12 oscillates high and low. (If pin 11 goes high, then pins 13 and 12 are both high, forcing pin 11 low. When pin 11 goes low, pins 13 and 12 are forced high, etc.) Pin 11, therefore, changes state periodically so that Q403 turns on and off to control the LED accordingly.

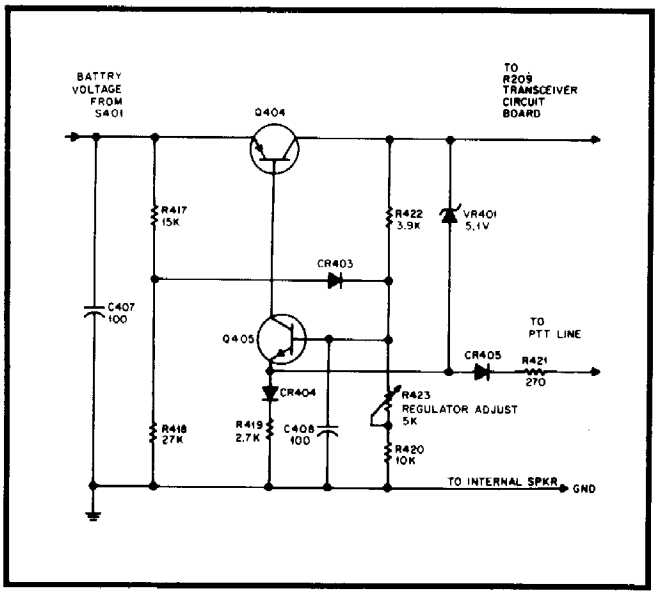

FIGURE 9

VOLTAGE REGULATOR SCHEMATIC

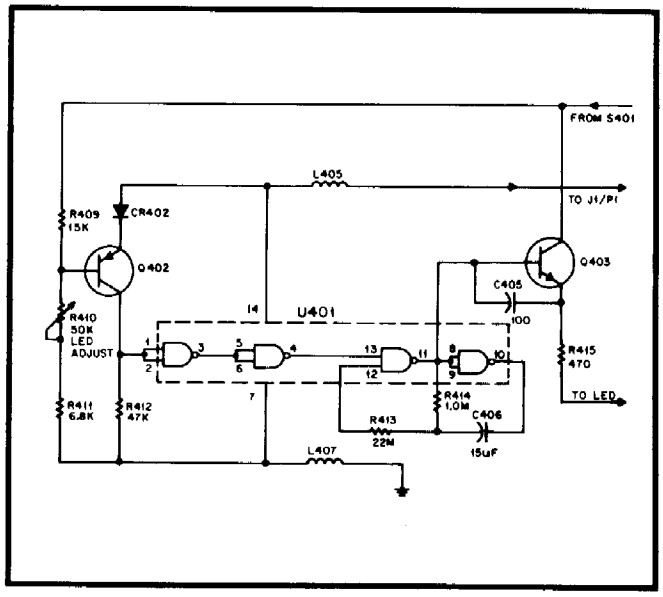

FIGURE 10

TRANSMIT/BATTERY INDICATOR SCHEMATIC

3. PTT Relay Switching Circuitry

To implement the changeover from the receiver mode to the transmitter mode of operation, relay K101 must be energized. This is accomplished by grounding one end of the relay coil via circuitry that extends back to the push-to-talk (PTT) switch in the microphone.

Referring to Figure 11, the K101 relay located on the transceiver board is connected to the collector of the PTT relay switch, Q401, through pin 4 of P404. When the PTT switch is depressed, a positive voltage is applied to the base of transistor Q401, turning it on. This action supplies the isolated ground on the collector of Q401 required to energize the relay.

With the relay energized, the DC operating voltages from the battery and the +7.5 volt regulator are switched to the transmitter circuits. Also, the antenna circuit is switched from the receiver input to the transmitter output.

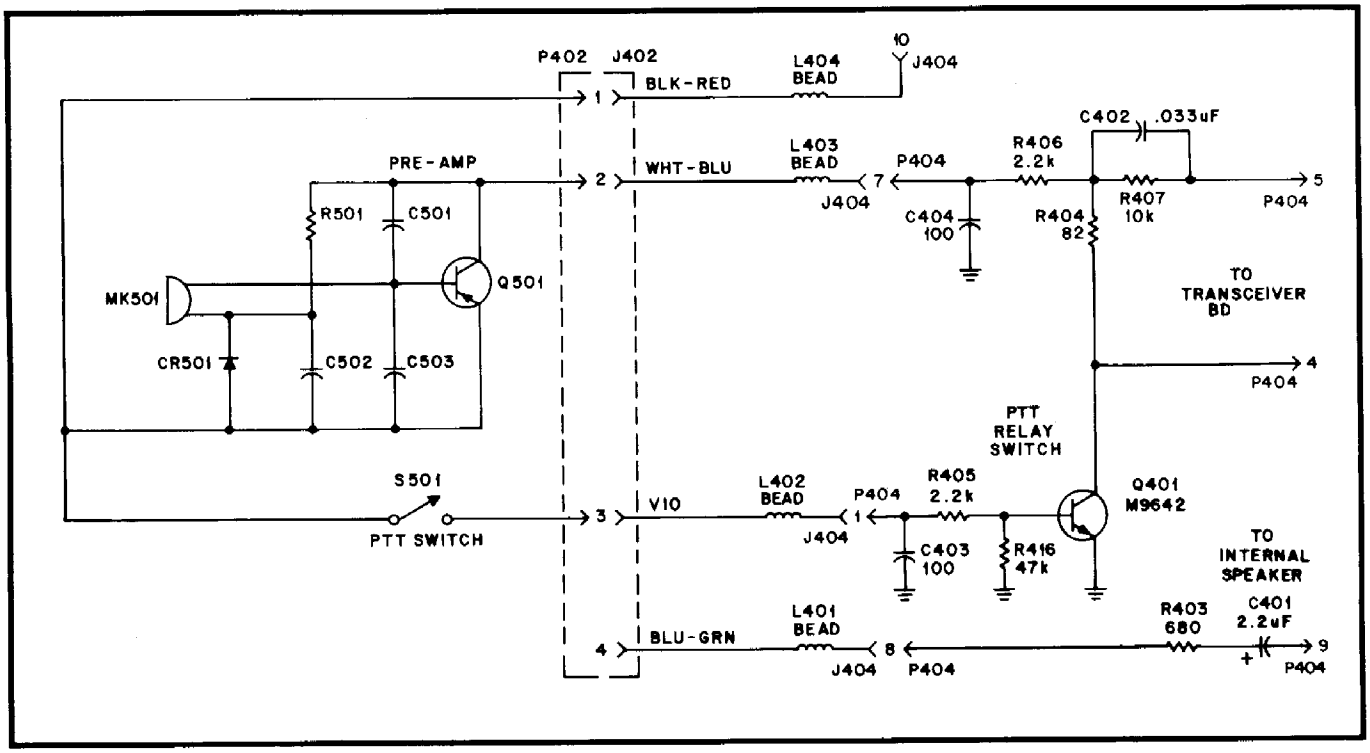

FIGURE 11 PTT RELAY SWITCHING SCHEMATIC

V. POWER PACK AND CHARGER COMPATIBILITY

All of the existing PT200/PT300 series power packs and chargers are directly compatible with the PT500 series portables, except the NPN1007A nickel-cadmium power pack.

The NPN1007A power pack is very similar in appearance to the new NPN6174A nickel-cadmium power pack designed for the PT500 series portables. However, the NPN1007A power pack should not be used with the PT500 series portables without modification.

To make this modification, remove the wire that connects pin 9 of the power pack connector to the metal lug riveted to the housing, as shown in Figure 12. If the

NPN1007A power pack is used without this modification, the 3 Amp fuse will open.

It should be noted that slightly reduced transmitter and receiver performance will result when the modified 14 volt NPN1007A power pack is used with the PT500 series portables. However, the new 15 volt NPN6174A power pack is directly compatible with PT200/PT300 series portables without any modifications or reduction in performance.

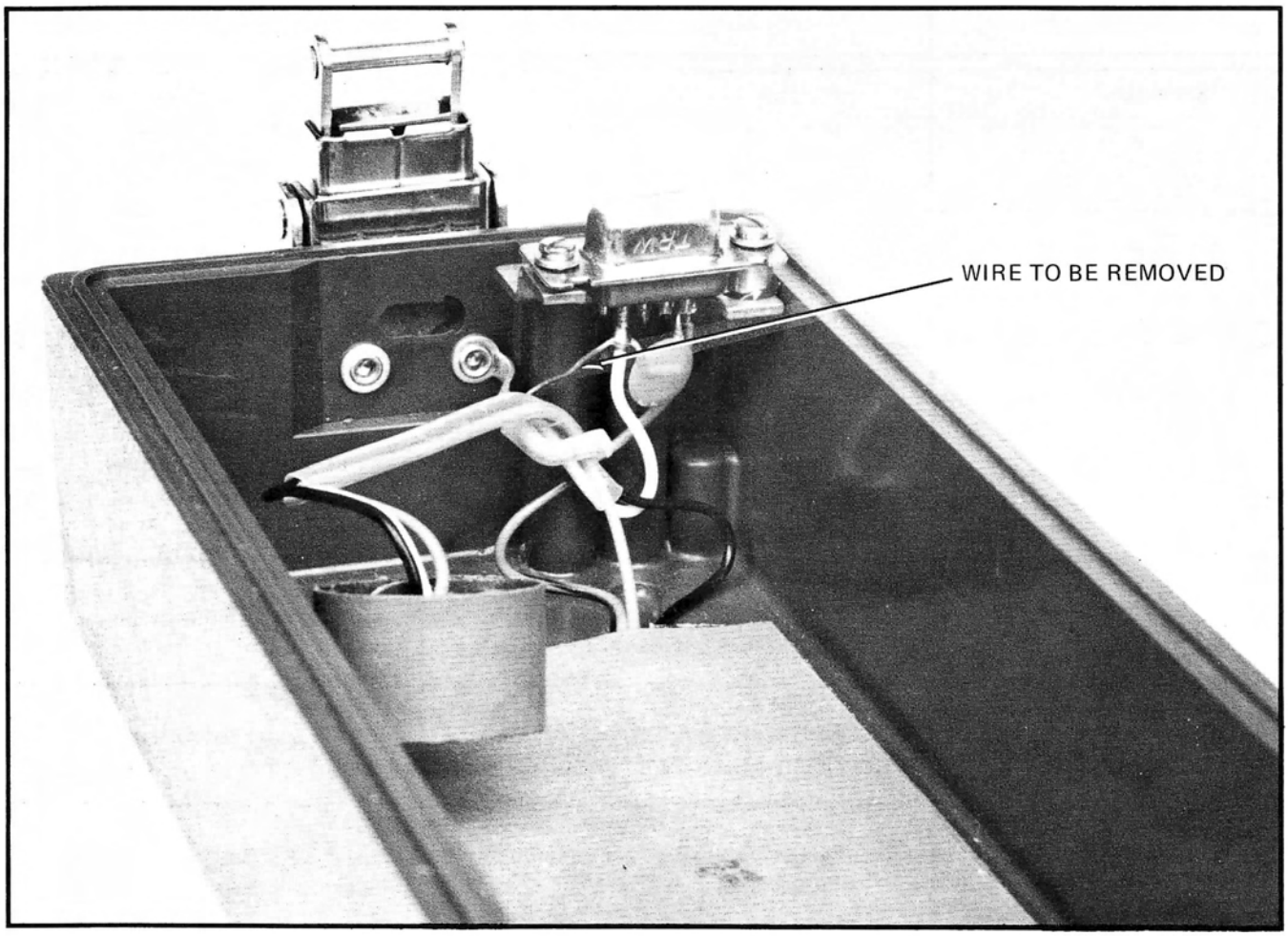

FIGURE 12 NPN1007A POWER PACK MODIFICATION

VI. SERVICE AIDS

The following service aids are available to facilitate servicing of the PT500 series Handie-Talkie radio.

MODEL NUMBER	DESCRIPTION
S-1056B	Portable Test Set - Used to test the PT500, as well as the PT200/PT300 series portables. It provides capability for keying, applying modulation to the transmitter, and monitoring the receiver audio without opening the radio.
TEKA-52	Adapter Cable - Used to adapt the S-1056B test set to the PT500 or PT200/PT300 series radios.
RTX-4005A	Portable Test Set - Used to test the PT500 series radios. Provides capability for keying, applying modulation to the transmitter, and monitoring the receiver audio without opening the radio. This test set is also used to test the MT500 and MX300 series radios. It is not compatible with the PT200 and PT300 series radios.
RTK-4013A	Adapter Cable - Allows the PT500 series portables to be tested with the RTX-4005A test set.
TEKA-28	Extension Cable - Allows PT500 or PT200/PT300 series radios to be battery powered with the battery separated from the radio.
TEKA-53	Power Cable - Provides a method of connecting the PT500 or PT200/PT300 series radios to a DC power supply other than the battery pack.
RTX-4008A	Interboard Connector - Allows the interconnect and transceiver boards used in the PT500 portables to be serviced while they are separated.
ST-1144/ST-1146	Module Desoldering Iron - Allows the removal of soldered-in modules without damaging the module or the printed circuit board.
NLN4605A	Tuning Tool Kit - Consists of one 6605607E01 tuning tool for channel elements and tunable coils, and one 6605599E01 tuning tool for pre-selector tuning and other servicing needs.
SLN-6213A	Battery Tester - Plugs directly into the battery supplies of PT500 or PT200/PT300 units and provides an indication of battery pack condition under actual load.

VII. RECOMMENDED TEST EQUIPMENT

EQUIPMENT	CHARACTERISTICS	APPLICATIONS
Service Monitor R1200A		Signal generator and frequency/deviation meter for alignment and troubleshooting.
DC Power Supply S-1347A or S-1348A	0-20 VDC 0-5 Amps Current limited	Bench Supply for 15 volts DC.
AC Voltmeter HP400FL	Measures to -90 dBm	Aduio voltage and noise takeover measurements.
DC Multimeter S-1063B	100 mV min. full scale, 1 ma - 300 ma, 11 megohms input resistance, 0.2 ohms - 50 megohms	DC voltages and resistance measurement.
RF Probe SLN-6055A with SLN-6038A termination	0.3 to 10 volts full scale, 10 MHz to 400 MHz	Plugs into S1063 DC multimeter for making transmitter RF measurements.
RF Millivoltmeter S1339A	100 mV to 3V RF 10 KHz to 1.2 GHz	For making transmitter and receiver RF measurements.
Wattmeter S-1350A	2.5 and 10 watt ranges terminating type	Transmitter power output measurement.
Oscilloscope Motorola R-1004A	15 MHz bandwidth 5 mv/cm	Waveform measurements.
Audio Oscillator S-1067B		Audio circuit testing.
Digital Encoder/ Decoder SLN-6413		For servicing digital "Private Line" circuits.
Tone Generator S-1333B or Audio Frequency Synthesizer SLN-6381A	10 to 9999 Hz tones	For servicing audio circuits and tone "Private Line."

VIII. TROUBLESHOOTING

Checking the battery voltage under load is one of the first checks that should be made in troubleshooting the PT500 series portables. The easiest way to do this is to turn the unit on and key up the transmitter while noting whether the battery indicator LED is flashing or on steady. If the LED is flashing, the battery pack should be recharged or replaced. If the LED is on steady, the battery pack is of sufficient charge to operate the portable.

The SLN-6213A battery tester can also be used to check the battery pack under load. This device uses a meter movement to indicate the battery pack condition.

The next step in troubleshooting is to determine what section of the portable is not functioning properly. This can be done through the use of performance checks such as 20 dB quieting, power output, deviation, etc. Many of these performance checks can be made using the S-1056B test set. This is the same test set that has been recommended for the PT200/PT300 series portables.

The RTX-4005A, MT500/MX300 test set can also be used to test the PT500 series portables. The RTK-4013A adapter cable has been designed to connect the microphone connector on the PT500 series portable to the RTX-4005A test set. Receiver audio, transmitter keying, and deviation are available through the microphone connector, however, chassis ground cannot be accessed at this point. Therefore, the RTK-4013A adapter cable has been designed with a microphone connector and an alligator clip on the radio end of the cable. With the adapter cable connected to the microphone jack, the alligator clip should be connected to the metal handle of the unit being tested, providing a ground for the test set.

After the general problem area of the radio has been identified, localizing and isolating a defective component constitutes the most time-consuming part of troubleshooting. A thorough understanding of the circuits involved will aid the technician in performing efficient servicing. An in-depth technical explanation of the circuitry used in the PT500 series portables is beyond the scope of this publication. However, due to the many similarities in the circuitry between the MT500 and the PT500 series portables, it is recommended that MAV-PACK PQF, produced for the MT500 radio, be reviewed before servicing the PT500 series portables.

IX. REPAIR

The PT500 series portables contain some MOS devices which are susceptible to damage by static discharge or high voltage charges. Care must be taken when selecting soldering equipment to be used on units containing these devices. All soldering irons used should have grounded, temperature controlled tips such as the Motorola Model ST-1087 low voltage soldering iron.

Another useful tool for repairing the PT500 series portables is the Motorola ST-1148 solder pot. This tool is excellent for removing modules without damaging the circuit board. The ST-1148 solder pot has been recommended for servicing the MT500 portables and many of the paging receivers. The Pace SX300 desoldering tool, or its equivalent, can also be used for PT500 module replacement.

X. TECHNICAL SPECIFICATIONS

RECEIVER			
	STANDARD	PROTECTED RECEIVER OPTION	
Frequency Stability - (30°C to +60°C; +25°C Ref.):	± .0010% (± .005% optional)	± .0010% (± .0005% optional)	
Channel Spacing:	30 KHz	30 KHz	
Selectivity (EIA Sinad)			
Channel Spacing (30 KHz)	-80 dB	-85 dB	
Channel Spacing (25 KHz)	-75 dB	-75 dB	
Modulation Acceptance:	± 7 KHz	± 7 KHz	
Intermodulation (EIA Sinad):	-70 dB	-80 dB	
Sensitivity -			
20 dB Quieting:	.35 uV	.50 uV	
12 dB Sinad:	.25 uV	.35 uV	
Squelch/PL:	.18 uV	.25 uV	
Spurious and Image Rejection:	-75 dB	-80 dB	
Frequency Spacing -	1 MHz	2.5 MHz	5.5 MHz
(Degradation)			
20 dB Quieting:	No deg.	3 dB deg.	5 dB deg.
Spurious:	No deg.	15 dB deg.	25 dB deg.
Intermodulation:	No deg.	5 dB deg.	10 dB deg.
Audio Output (At less than 5% distortion):	500 mW		
Current Drain (Using 15 VDC Supply) -			
Receive:	*75 ma		
Standby:	*16 ma		
TRANSMITTER			
RF Power Output: (Using 15 VDC NI-CAD Battery)	2W or 5W		
Modulation (± 5 KHz for 100% Modulation at 1000 Hz):	16F3		
Frequency Stability - (30°C to +60°C; +25°C Ref.):	.0010% - 2.0W (Optional .0005% 2.0W), .0005% - 5.0W		
FM Noise - (Below ± 3.3 KHz Deviation at 1000 Hz):	55 dB		
Audio Distortion - (At 1000 Hz, 3 KHz Deviation):	3%		
Frequency Spacing -			
No Degradation:	1 MHz		
1.5 dB Power Degradation:	2.5 MHz		
3 dB Power Degradation:	5.5 MHz		
Current Drain (Using 15 VDC Supply) -			
Transmit 2.0W:	*460 ma		
5.0W:	*990 ma		

Specifications are subject to change without notice.

*Add 4 ma for "Private Line" Options.

END OF DOCUMENT