

Assembly and Operation  
of the



# SSB TRANSMITTER

MODEL SB-401



HEATH COMPANY  
BENTON HARBOR, MICHIGAN 49022

# TABLE OF CONTENTS

INTRODUCTION . . . . .	3	21 Megahertz Trap . . . . .	97
UNPACKING INSTRUCTIONS . . . . .	4	Heterodyne Oscillator . . . . .	97
CIRCUIT BOARDS		Carrier Generator . . . . .	97
Mixer-Bandpass Circuit Board		Driver . . . . .	98
Parts List #1 . . . . .	5	8.6 Megahertz Trap Adjustment . . . . .	99
Step-By-Step Assembly . . . . .	6	Carrier Null Adjustment . . . . .	99
Carrier Generator Circuit Board		Neutralizing . . . . .	99
Parts List #2 . . . . .	8	Final Bias . . . . .	100
Step-By-Step Assembly . . . . .	10	Microphone Connection . . . . .	101
CHASSIS PARTS MOUNTING		LMO Adjustment . . . . .	101
Parts List #3 . . . . .	13	Frequency Shift Adjustment . . . . .	102
Step-By-Step Assembly		Final Transmitter Adjustment . . . . .	102
Parts Mounting-Chassis Bottom . . . . .	16	FINAL ASSEMBLY . . . . .	103
Coil Mounting-Chassis Top . . . . .	21	INSTALLATION AND OPERATION . . . . .	105
Parts Mounting-Chassis Top . . . . .	24	Meter Readings . . . . .	108
CHASSIS WIRING		Reading Transmitter Frequency . . . . .	108
Parts List #4 . . . . .	33	Operating Conditions . . . . .	109
Step-By-Step Assembly		Transmitter Operation . . . . .	109
Preliminary Wiring-Chassis Top . . . . .	35	Operation With SB-303 Receiver . . . . .	109
Preliminary Wiring-Chassis Bottom . . . . .	39	CW . . . . .	110
Parts Mounting On Carrier Generator Shield . . . . .	54	SSB . . . . .	111
Wiring Carrier Generator Shield To Chassis . . . . .	55	Transmitter Operation Only . . . . .	112
Transformer Wiring . . . . .	63	CW Tune-Up . . . . .	113
Preliminary Wiring-Band Switch . . . . .	64	SSB Tune-Up . . . . .	115
FINAL WIRING		IN CASE OF DIFFICULTY . . . . .	117
Parts List #5 . . . . .	73	Troubleshooting Chart . . . . .	118
Step-By-Step Assembly		Factory Repair Service . . . . .	120
Dial Assembly . . . . .	75	SPECIFICATIONS . . . . .	121
Parts Mounting-Front Panel . . . . .	78	CIRCUIT DESCRIPTION	
Wiring Front Panel To Chassis . . . . .	79	Schematic Diagram . . . . .	125
Front Panel Mounting . . . . .	81	Frequency Chart . . . . .	125
Final Wiring-Chassis Top . . . . .	82	Audio Preamplifier And Cathode Follower . . . . .	126
Final Wiring-Chassis Bottom . . . . .	85	VOX Amplifier . . . . .	126
INITIAL TEST . . . . .	87	Relay And Anit-VOX Amplifier . . . . .	126
ALIGNMENT		Tone Oscillator And Tone Amplifier . . . . .	128
Alignment With SB-303 Receiver As A Transceiver . . . . .	90	LSB-USB-CW Carrier Generator And	
8.6 Megahertz Trap . . . . .	90	Cathode Follower . . . . .	129
21 Megahertz Trap . . . . .	90	Balanced Modulator . . . . .	130
Carrier Generator . . . . .	90	Isolation Amplifier . . . . .	130
Driver . . . . .	91	Symmetrical Crystal Bandpass Filter . . . . .	131
8.6 Megahertz Trap Adjustment . . . . .	92	Linear Master Oscillator . . . . .	131
Carrier Null Adjustment . . . . .	93	LMO Mixer . . . . .	132
Neutralizing . . . . .	94	Heterodyne Oscillator And Heterodyne-Oscillator	
Final Bias . . . . .	94	Amplifier . . . . .	132
Microphone Connection . . . . .	95	Heterodyne Mixer . . . . .	132
LMO Adjustment . . . . .	95	Driver . . . . .	134
Final Transmitter Adjustment . . . . .	96	Final Amplifiers . . . . .	134
Alignment With SBA-401-1 Crystal Accessory Kit Installed		Automatic Level Control . . . . .	134
Crystal Installation . . . . .	96	Power Supply . . . . .	136
Equipment Required . . . . .	97	Metering Circuits . . . . .	137
8.6 Megahertz Trap . . . . .	97	CIRCUIT BOARD X-RAY VIEWS . . . . .	139
		CHASSIS PHOTOGRAPHS . . . . .	141
		SCHEMATIC . . . . . (fold-out from Page)	147
		REPLACEMENT PARTS PRICE LIST . . . . .	148

# INTRODUCTION

The Heathkit Model SB-401 SSB Transmitter is capable of SSB (upper or lower sideband) and CW operation on all amateur bands from 3.5 to 30 megahertz. A crystal-controlled heterodyne oscillator and a preassembled, prealigned linear master oscillator insure highly accurate and stable operation.

Complete Transceive capabilities are available when the Transmitter is used with the Heathkit Model SB-300, SB-301, or SB-303 Receiver. The Transmitter can also be used with other receivers by installing the SBA-401-1 Crystal Accessory Kit in the Transmitter. This Transmitter is compatible with the Heathkit Model SB-200 SSB Linear Amplifier.

Other operating features include: voice operated (VOX) and push-to-talk (PTT) control in the SSB mode; break-in keying in the CW mode; built-in antenna change-over relay; switched 120 VAC to operate an external antenna relay; crystal filter type SSB generator;

and automatic level control to prevent distortion while providing high talk power. The large circular dial has calibration marks every kilohertz and covers 100 kilohertz for every revolution to provide a bandwidth equal to approximately 10 feet per megahertz. A slide-rule-type dial pointer clearly indicates the number of rotations of the circular dial. The knob-to-dial ratio is approximately 4:1.

All-aluminum metal parts provide light-weight and sturdy construction. Assembly time-saving features include circuit boards, wiring cable assemblies, and a preassembled LMO tuning unit. The transformer-operated, silicon diode power supply is a long-life, low-heat power source.

Refer to the "Kit Builders Guide" for complete information on parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

# INITIAL TEST

Before installing the fuse or tubes, the following resistance checks should be performed. If the actual resistance readings vary more than  $\pm 20\%$  from those listed, refer to the In Case Of Difficulty section of the Manual on Page 117.

Refer to Figure 1-2 (fold-out from Page 86).

Set all controls and switches as follows:

FINAL - 80.

LEVEL - 0 (fully counterclockwise).

FREQ CONTROL - UNLOCKED.

DRIVER - Fully counterclockwise.

LMO - Any point.

METER - REL PWR.

FUNCTION - TRAN.

BAND - 3.5.

MODE - CW.

BIAS ADJUST - 1/2 rotation.

VOX GAIN - fully clockwise.

VOX DELAY - fully counterclockwise.

ANTI-VOX - fully counterclockwise.

ALC ADJUST - 1/2 rotation.

SIDEBAND AMPLITUDE BALANCE -  
1/2 rotation.\*

CARRIER NULL capacitor - 1/2 meshed.

CARRIER NULL control - 1/2 rotation.

Relative Power control - fully clockwise.

Neutralizing capacitor - 1/3 meshed from fully open.

\*This is the final adjustment of this control. No further adjustment required.

Connect the common test lead of an ohmmeter to the chassis and make the checks listed in the following chart. Refer to Figure 1-1 (fold-out from Page 86) for location of test points.

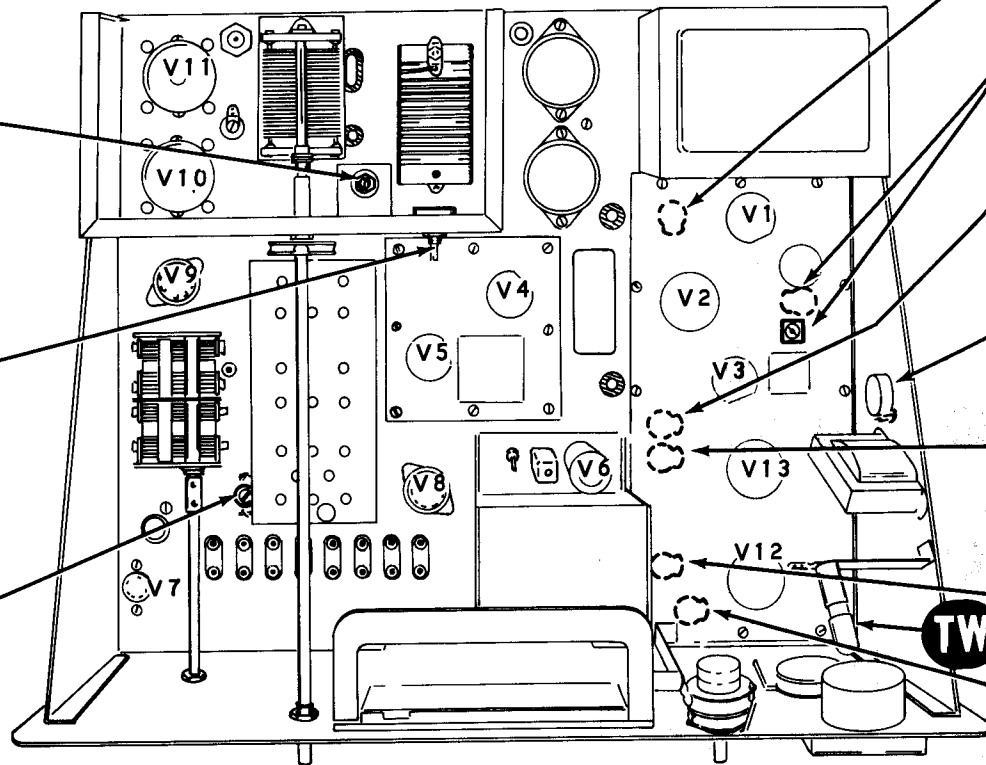
**IMPORTANT:** The word "Diode" in the NOTES column of the following chart indicates that a diode is in the circuit under test. Therefore, the measured resistance can vary due to the forward current of the diode, and depending on the range setting of the ohmmeter. The ohmmeter readings in the chart were made with a VTVM. Readings made with a VOM will be considerably different than those listed.

TEST POINT	RESISTANCE	NOTES
Terminal strip J		
Lugs 1 and 2	.2 $\Omega$ . Remove tubes V10 and V11; the reading should increase to .8 $\Omega$ . Remove pilot lamp TW; reading should increase to 1 $\Omega$ .	
Lug 3	0 $\Omega$ (ground).	
Lug 4	Infinity.	
Lug 5	Infinity.	
Terminal strip H		
Lugs 1, 2, 4, and 5	At least 10 K $\Omega$ .	(Diode)
Lug 3	0 $\Omega$ (ground).	
Terminal strip AC		
Lug 1	At least 10 K $\Omega$ after 10 seconds.	(Diode)
Lug 2	At least 15 K $\Omega$ after 10 seconds.	(Diode)
Lug 3	0 $\Omega$ (ground).	
Lug 4	At least 10 K $\Omega$ after 10 seconds.	(Diode)
Lug 5	At least 15 K $\Omega$ after 10 seconds.	(Diode)
Terminal strip AD		
Lug 2	At least 10 K $\Omega$ after 10 seconds.	(Diode)
Lug 3	0 $\Omega$ (ground).	
Lug 4	3 $\Omega$ .	
Lug 5	Approximately 600 $\Omega$ or higher.	(Diode)

**NEUTRALIZING:** This capacitor is adjusted to balance out the grid-to-plate capacity of the output tubes.

**RELATIVE POWER:** Adjust this control for a meter reading of 1/2 full scale when the transmitter is fully loaded on 80 meters.

**BIAS ADJUST:** With driver tube (V9) removed and key down, adjust this control for 50 ma of plate current.



**FINAL LOAD:** This control is adjusted for maximum meter indication (REL PWR). It tunes the Transmitter for maximum output by matching the output impedance to the antenna.

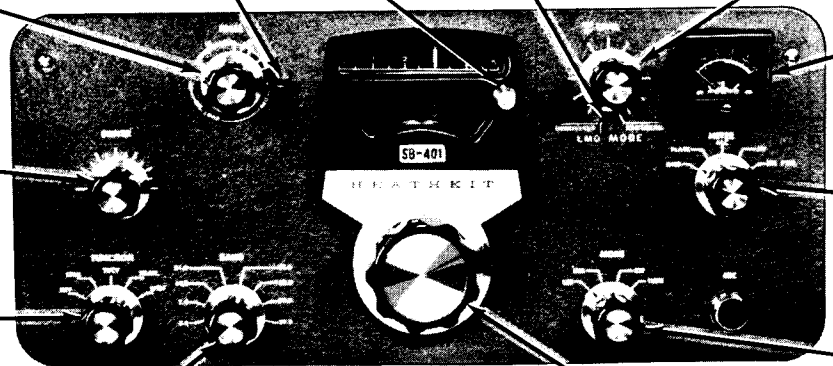
**FINAL:** This control is adjusted for maximum meter indication (REL PWR). It tunes the Transmitter for maximum output by resonating the final tank.

**DRIVER:** This control is adjusted for maximum meter indication (REL PWR). It tunes the driver stage for maximum output.

**FUNCTION:** This switch is set for the desired Transmitter function, such as OFF, STBY, TRCV, TRAN, and SPOT.

**FREQ. CONTROL:** This switch permits the selection of either the internal LMO or the external LMO in the SB-301 Receiver. In the UNLOCKED position, the LMO in the Transmitter and the LMO in the Receiver operate independent of each other. In the LOCKED (RCVR) position, the LMO in the Receiver controls both units.

**ZERO SET KNOB**



**BAND:** This switch determines the amateur band or the 500 kHz segment of the band on which the Transmitter is to operate.

**LMO DIAL KNOB:** This knob tunes the Transmitter for the desired frequency of the selected band when LMO is used.

**FIGURE 1-2**

**SIDEBAND AMPLITUDE BALANCE:** This control is adjusted for equal amplitude of each sideband.

**CARRIER NULL:** Balances the modulator to eliminate carrier from the output signal for the USB or LSB operating mode.

**ALC ADJUST:** This control is set for a 0 meter indication (ALC) with no modulation.

**TONE OUTPUT LEVEL:** This control is used to set the level of CW tone supplied to the receiver for monitoring the CW signal being transmitted.

**ANTI-VOX:** This control is adjusted so audio output from the receiver does not trip the transmitter VOX circuit for VOX and CW operation.

**VOX DELAY:** This control is adjusted for the desired hold-in time after the operator stops talking in SSB (VOX) or keying in CW operation.

**VOX GAIN:** This control is adjusted for the desired microphone sensitivity for VOX operation.

switch permits the selection of the internal LMO or the external LMO Receiver. In the UNLOCKED position, the internal LMO in the Transmitter and the external LMO in the Receiver operate. In the LOCKED position, the internal LMO in the Receiver con-

**LEVEL:** This control adjusts for maximum permissible (midscale top edge of ALC meter area) modulation without distortion to the driver. Also adjusts RF drive to the drive stage in the CW mode.

**METER:** Indicates grid current 0-1 ma, final plate current 0-500 ma, ALC maximum modulation (right edge of ALC area; final plate voltage 0-1000 volts, and relative power 0-10.

**METER:** Setting this switch to its various positions gives the operator a quick check of the Transmitter functions, on the meter.

**MODE:** This switch permits the operator to select the desired mode of operation, such as LSB, USB, CW and TUNE.

**LMO DIAL KNOB:** This knob is used to set the Transmitter for the desired operating frequency of the selected band when the internal LMO is used.

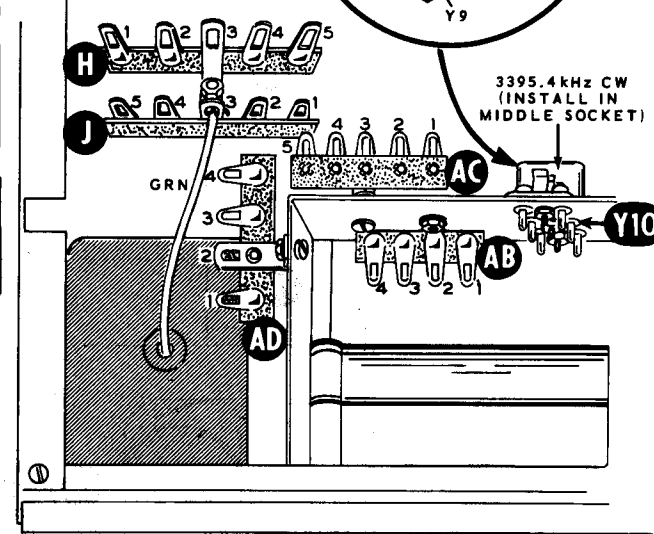
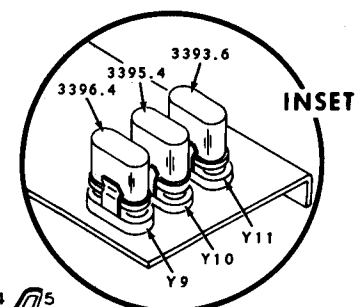
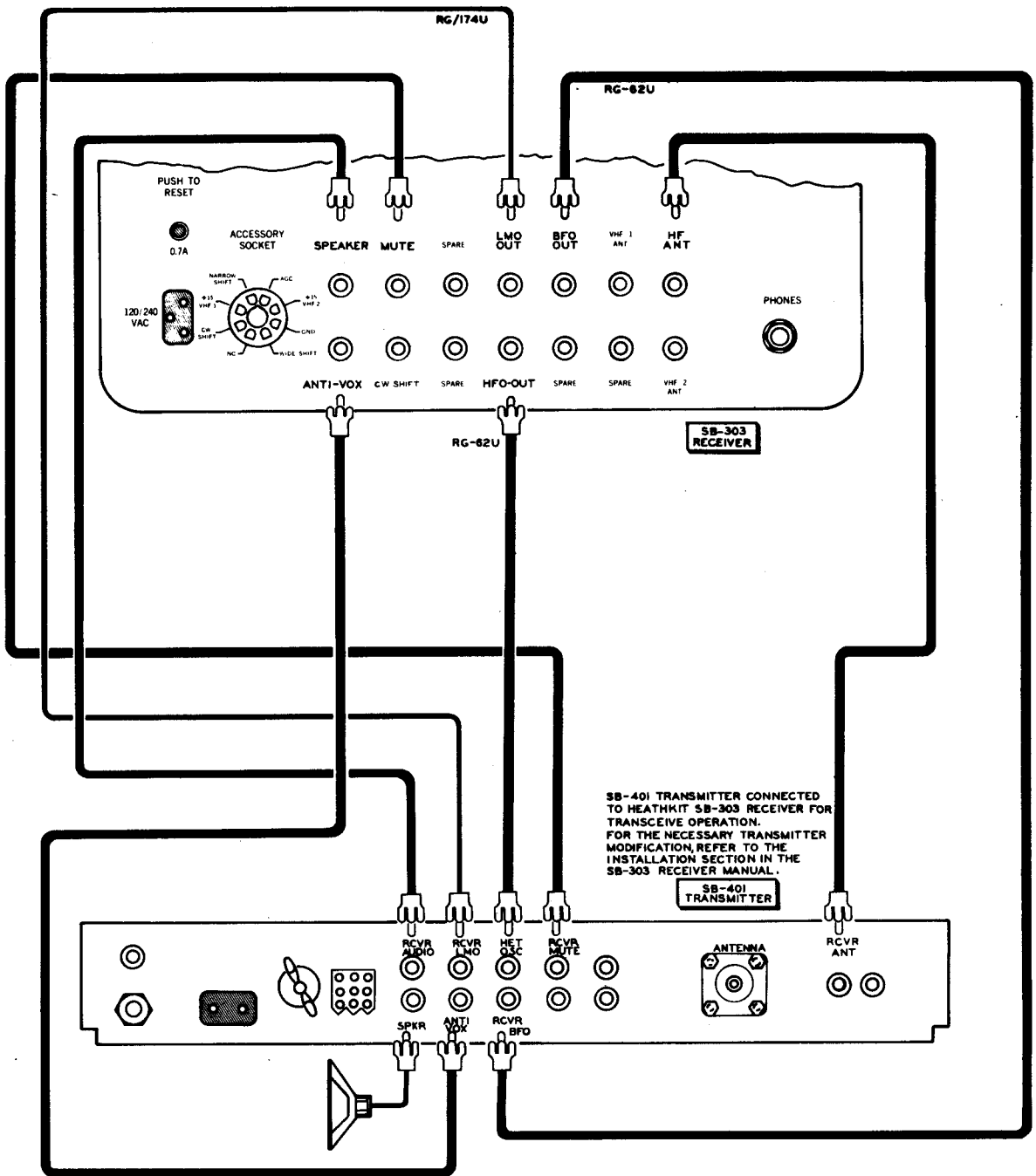


FIGURE 1-1

TEST POINT	RESISTANCE	NOTES
Terminal strip AB		
Lug 1	At least 10 K $\Omega$ after 10 seconds.	
Lug 2	0 $\Omega$ (ground).	
Lug 3	Infinity.	
Lug 4	0 $\Omega$ - with MODE switch in CW or TUNE. At least 15 K $\Omega$ - with MODE switch in LSB or USB.	(Diode)

- ( ) Turn the FUNCTION switch to OFF.
- ( ) Plug the line cord into a 120 VAC wall outlet (or 240 VAC if you wired the Transmitter for this voltage).
- ( ) Connect the green power transformer lead to lug 3 of terminal strip J (S-2). See Figure 1-1.
- ( ) Turn the FUNCTION switch to STBY.
- ( ) Refer to Figure 1-1 and install the 3395.4 kHz CW crystal in socket Y10. The crystal frequency is stamped on the crystal.
- ( ) A VTVM reading of approximately -170 V DC should be present between pins 5 of tube sockets V10 and V11 and the chassis.
- ( ) Install all tubes in their respective sockets, except driver tube V9 (6CL6), and replace the pilot lamp in socket TW.
- ( ) Turn the FUNCTION switch to OFF.
- ( ) Install the 4 ampere slow-blow fuse in the fuseholder. (Use a 2 ampere fuse if you wired the Transmitter for 240 VAC operation. NOTE: The 2 ampere fuse is not furnished with the kit.)
- ( ) Unplug the Transmitter line cord and install small tube shields on tubes V3, V4, and V5.
- ( ) Attach the line cord to the 120 VAC INPUT connector.
- ( ) Install a medium tube shield on tube V1.
- ( ) Install a large tube shield on tube V8.
- CAUTION: This Transmitter has operating voltages up to 800 volts; it is very important that much care be taken when the Transmitter is turned "on". These voltages can be fatal.
- ( ) Reconnect the line cord to the 120 VAC outlet, then turn the FUNCTION switch to STBY.
- NOTE: The Transmitter will be turned on for the first time in the next step. Check visually to see that all tubes and pilot lamps light. If there is any overheating of components, unplug the Transmitter line cord and refer to the In Case Of Difficulty section of the Manual on Page 117.
- ( ) Turn the METER switch to HV. The meter should read 800 V.
- ( ) Turn the METER switch to PLATE. The meter should read "0."





**Figure 2-1A**

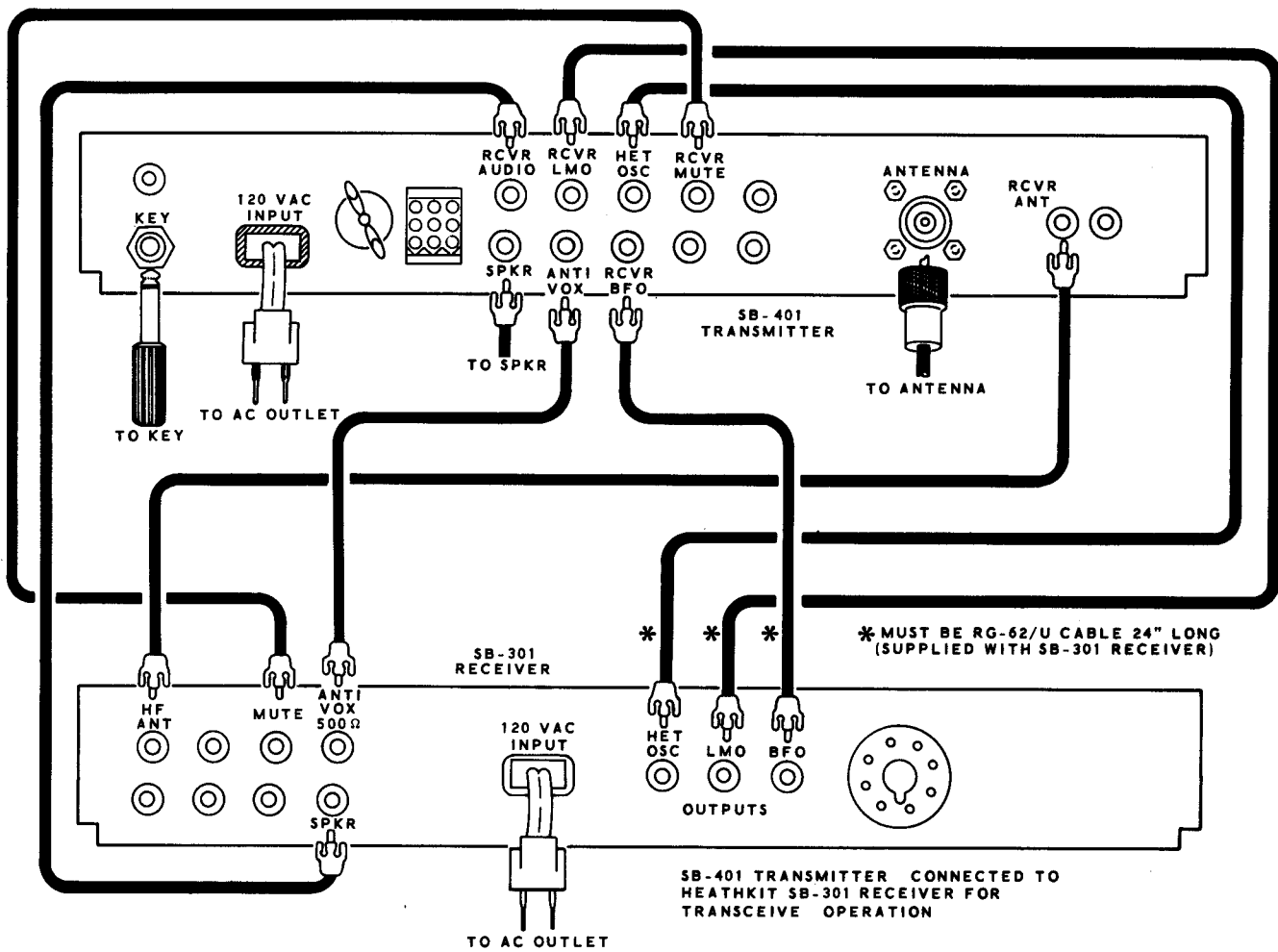


Figure 2-1B

# ALIGNMENT

Two methods of alignment for your SB-401 Transmitter are given. When the Model SBA-401-1 Crystal Accessory Kit is installed, the SB-401 Transmitter is aligned as an independent transmitter. If the Crystal Accessory Kit is not installed, the SB-401 must be connected for transceiver operation to an

operating SB-303 (or SB-300, or SB-301) Receiver prior to starting alignment. If an SB-303 Receiver is used, incorporate the SB-401 Modifications listed in the SB-303 Receiver Manual under "Installation." Perform the appropriate group of steps following.

## ALIGNMENT WITH SB-303 RECEIVER AS A TRANSCEIVER

If the Accessory kit is not going to be used, the Transmitter should be connected to an SB-303 or SB-301 Receiver. Refer to Figures 2-1A and 2-1B on the fold-out from this page.

The following test equipment is required for alignment of the Transmitter.

1. A 50  $\Omega$  nonreactive dummy load (such as Heathkit Model HN-31 Cantenna).
2. An 11 megohm input VTVM (such as Heathkit Model IM-11).
3. An RF probe for the VTVM (such as Heathkit Model 309-C).
4. A CW key plugged into the Key jack. CAUTION: Do not depress the key until specifically instructed to do so.

NOTE: In the following steps, the switches and controls to be set are on the Transmitter unless otherwise stated.

Refer to Figure 2-2 (fold-out from Page 93) for test points and adjustment locations.

- ( ) Remove tube V9 from the transmitter.
- ( ) Connect the SB-401 Transmitter to the SB-303 Receiver as shown in Figure 2-1A.

### 8.6 MEGAHERTZ TRAP

- ( ) Preset the notch of the variable capacitor on terminal board #1 as it is shown in inset #1 of Figure 2-2.

### 21 MEGAHERTZ TRAP

The 21 MHz trap (RFC1) was preset at the factory. Do not change the setting of this trap.

### CARRIER GENERATOR

- ( ) Plug the line cord into a 120 volt AC outlet.
- ( ) Set the Transmitter controls as follows:

FUNCTION switch	TRCV
<u>Receiver</u> FUNCTION switch	STBY
FREQ. CONTROL	LOCKED
MODE switch	CW
LEVEL control	Fully clockwise



- ( ) Connect the VTVM RF probe to pin E on the top of the carrier generator circuit board.
- ( ) Depress the key. This should close both relays.
- ( ) Use the alignment tool to adjust the balanced modulator transformer for a maximum indication on the VTVM. If there are two peaks, the peak that occurs with the slug nearest the top of the transformer is the correct one. (Approximately 1 to 1.5 volts.)
- ( ) Open the key.
- ( ) Set the Receiver and Transmitter MODE switches to USB.
- ( ) Short lug 2 (marked) of the MIC connector to the chassis with a jumper wire, or connect a microphone and press the push-to-talk button; then, with the VTVM still connected to Pin E, alternately adjust the CARRIER NULL control and the capacitor for a minimum indication on the VTVM.
- ( ) Disconnect the VTVM.
- ( ) Turn the METER switch to ALC.
- ( ) Adjust the ALC ADJUST control for a zero meter reading.
- ( ) Remove the jumper wire from lug 2 of the MIC connector, or release the microphone button.
- ( ) Return the Transmitter MODE switch to the CW position.

NOTE: When the METER switch is in the ALC position during transmitter standby, the meter will normally indicate full-scale deflection.

## DRIVER

- ( ) Set the DRIVER control to the first mark from the fully counterclockwise marking on the panel as shown in inset #2.
- ( ) Set the slide rule and the LMO dials to zero.
- ( ) Insert the VTVM RF probe into pin 2 of tube socket V9.

NOTE: Leave the LEVEL control in the fully clockwise position.

- ( ) Set the FUNCTION switch to the TRCV position.

NOTE: When you align each driver and heterodyne oscillator coil in the following steps, first read the step all the way through. Then, key the Transmitter and perform the adjustment with the alignment tool. Release the key as soon as the step is completed.

Some of the coils are on the bottom of the chassis, but can be adjusted from the top of the chassis.

- ( ) Set both BAND switches to 3.5.
- ( ) Adjust the slug of the 3.5 DRIVER grid coil for a maximum indication on the VTVM. (Readings of approximately 1.5 volts or higher are normal. A definite peak should be obtained.)
- ( ) Peak the 3.5 HET OSC. (heterodyne oscillator) coil for maximum.
- ( ) Set the Receiver and Transmitter BAND switches to 7.0 and adjust the slug of the 7.0 DRIVER grid coil for a maximum indication on the VTVM.
- ( ) Adjust the 7.0 HET OSC coil for maximum.
- ( ) In the same way, adjust the DRIVER grid coil and the HET OSC coil at each band switch position 14.0 through 28.0. Be sure both receiver and transmitter band switches are always set to the same band.
- ( ) In the same way, turn the BAND switches to 28.5 and 29.5 and peak the HET OSC coil for each band.
- ( ) Remove the VTVM probe from tube socket V9.

- ( ) Install the 6CL6 driver tube (V9). The tube shield will be installed later.

- ( ) Turn the FUNCTION switch to the TRCV position.
- ( ) Connect the VTVM RF probe to the bare wire connected between pins 5 of tube sockets V10 and V11 on the bottom of the chassis.

NOTE: Leave the LEVEL control in the fully clockwise position.

- ( ) Turn both BAND switches to 3.5.

- ( ) Key the Transmitter and adjust the slug of the 3.5 driver PLATE coil for a maximum indication on the VTVM. (Readings of 35 volts or higher should be obtained, depending on band.)
- ( ) Readjust the slug of the 3.5 GRID driver coil for a maximum indication on the VTVM.
- ( ) Place both BAND switches in the 7.0 position.
- ( ) Adjust the slug of the 7.0 PLATE driver coil for a maximum indication on the VTVM.
- ( ) Readjust the slug of the 7.0 GRID coil for a maximum indication on the VTVM.
- ( ) Repeat this same procedure for each setting of the BAND switch through 28.0 by adjusting the corresponding PLATE and GRID driver coils for a maximum indication on the VTVM.
- ( ) Set the BAND switches to 29.0. Adjust the DRIVER control on the panel for a maximum indication on the VTVM.
- ( ) Adjust the slug of the 29.0 driver grid coil (on the chassis by the rear section of the driver capacitor) for a maximum indication on the VTVM.

## 8.6 MEGAHERTZ TRAP ADJUSTMENT

NOTE: Leave the VTVM RF probe connected to the bare wire between pins 5 of V10 and V11.

- ( ) Remove the 15.895 megahertz crystal from the SB-303 Receiver.
- ( ) Place the Transmitter BAND switch in the 7.0 position and set the LMO slide rule Dial to 3.
- ( ) Place the FUNCTION switch in the SPOT position.
- ( ) Turn the MODE switch on the Transmitter to the CW position.
- ( ) Advance the LEVEL control fully clockwise.
- ( ) Set the DRIVER control fully clockwise.
- ( ) Set the FREQ control to UNLOCKED.
- ( ) Adjust the variable capacitor on terminal board #1 (see Figure 2-2 fold-out from Page 93) for minimum on the VTVM.

- ( ) Disconnect the VTVM.
- ( ) Replace the 15.895 MHz crystal.

### CARRIER NULL ADJUSTMENT

NOTE: Leave the VTVM RF probe connected to the bare wire between pins 5 of V10 and V11.

- ( ) Place the BAND switches in the 3.5 position.
- ( ) Key the Transmitter and adjust the DRIVER control for a maximum indication on the VTVM.
- ( ) Rotate the LEVEL control fully counterclockwise.
- ( ) Place the MODE switch in the USB position.

NOTE: The object of the following CARRIER NULL adjustments is to reduce the carrier output as much as possible. If the following adjustments will not reduce the VTVM reading to approximately "0", perform the balanced modulator transformer adjustment again (to eliminate possible interaction).

- ( ) Short lug 2 of the MIC connector to the chassis with a jumper wire, or connect a microphone and press the push-to-talk button; then alternately adjust the CARRIER NULL control and capacitor for a minimum indication on the VTVM.
- ( ) Place the MODE switch in the LSB position and adjust the CARRIER NULL capacitor to the same VTVM reading obtained in the USB position.
- ( ) Place the MODE switch in the USB position and adjust the CARRIER NULL control for a minimum indication on the VTVM.
- ( ) Place the MODE switch in the LSB position and adjust the CARRIER NULL capacitor to the same VTVM reading obtained in the previous step.
- ( ) Repeat the previous two steps until the same VTVM reading is obtained in the USB and LSB positions of the MODE switch.

NOTE: The preceding five adjustments can be checked after the Transmitter is in the cabinet by using a receiver set to the operating frequency and observing the "S" meter for minimum readings as the adjustments are made.

- ( ) Return the FUNCTION switch to STBY.

## NEUTRALIZING

- ( ) Rotate the BAND switch to 28.5.
- ( ) Place the VTVM RF probe in the ANTENNA connector.
- ( ) Set the FUNCTION switch to TRCV.
- ( ) Rotate the LEVEL control fully clockwise.
- ( ) Key the transmitter.
- ( ) Adjust the DRIVER control for a maximum indication on the VTVM.
- ( ) Adjust the FINAL control for a maximum indication on the VTVM, with the LOAD control set at the 50  $\Omega$  position.
- ( ) Using an insulated screwdriver, adjust the Neutralizing Capacitor for a minimum indication on the VTVM.
- ( ) Readjust the FINAL control for maximum indication on the VTVM.
- ( ) Readjust the Neutralizing Capacitor for a minimum indication on the VTVM.
- ( ) Turn the FUNCTION switch to the OFF position.
- ( ) Unplug the Transmitter line cord.
- ( ) Disconnect the VTVM RF probe from the Transmitter.

**CAUTION:** Be sure to use an insulated handle screwdriver in the next step to discharge the high voltage capacitors.

- ( ) Discharge the high voltage capacitors by shorting the lower lead of feedthrough capacitor Q to the chassis with the blade of a screwdriver. Be sure to touch the metal blade of the screwdriver to the chassis first, then to the capacitor lead. Repeat this step several times to be sure the capacitors are completely discharged.

Refer to Figure 2-3 (fold-out from this Page) for the following steps.

- ( ) On top of the chassis, connect the lead of feedthrough capacitor Q to lug 2 of coil TB

(S-1). Bend the lead of the capacitor carefully to prevent breaking the ceramic form.

- ( ) On the bottom of the chassis, connect a 680  $\Omega$  (blue-gray-brown) resistor from lug 3 of terminal strip P (S-3) to the center of the bare wire connected between lugs 3 of tube sockets V10 and V11 (S-1).

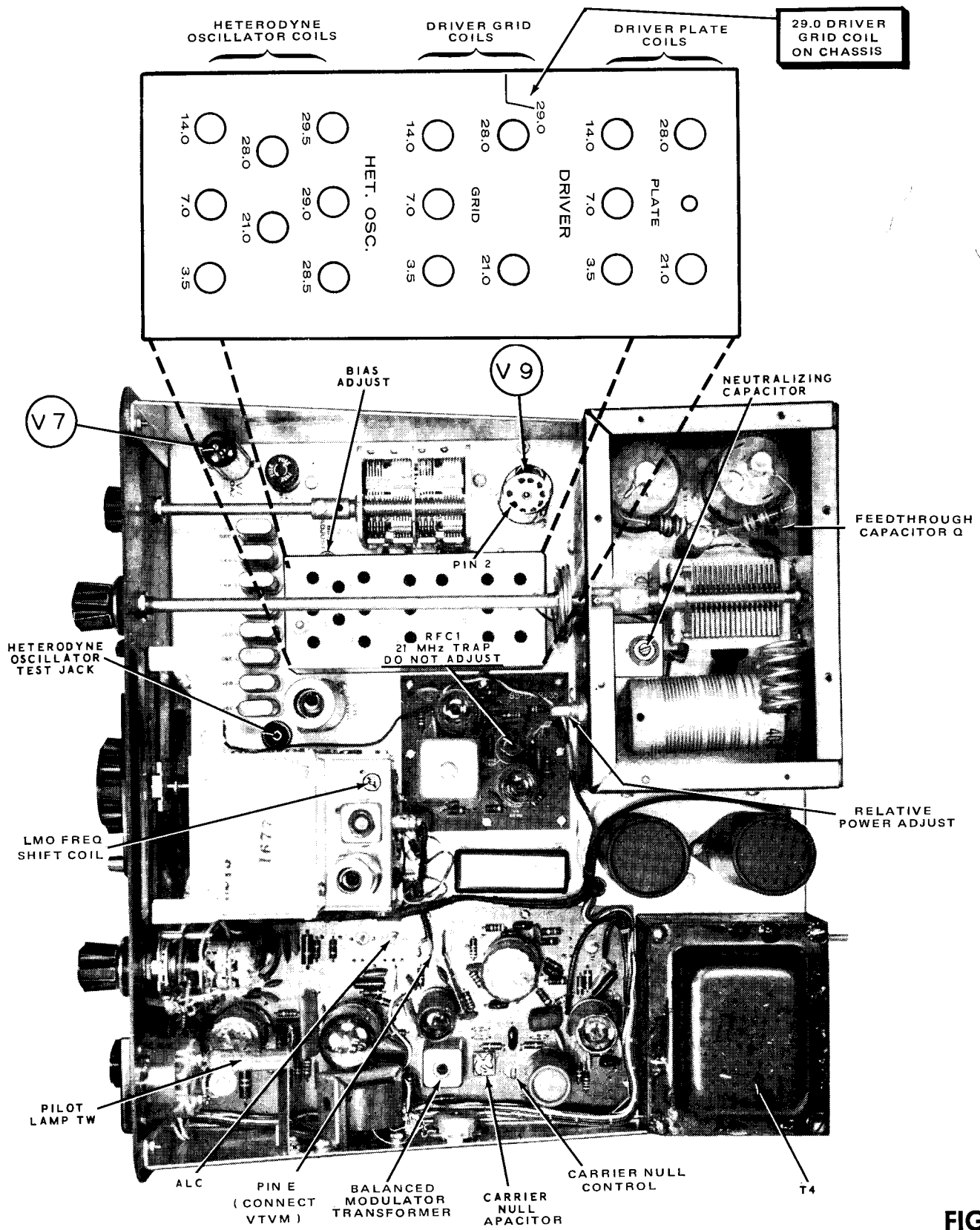
Refer to Figure 2-4 (fold-out from this Page) for the following steps.

- ( ) Install the final amplifier rear plate on the final amplifier enclosure, using #6 x 3/8" sheet metal screws.
- ( ) Install the final amplifier top plate on the final amplifier enclosure, using #6 x 3/8" sheet metal screws.

**IMPORTANT:** Do not key the Transmitter for more than 30 seconds at a time until after you have completed the Final Transmitter Adjustments.

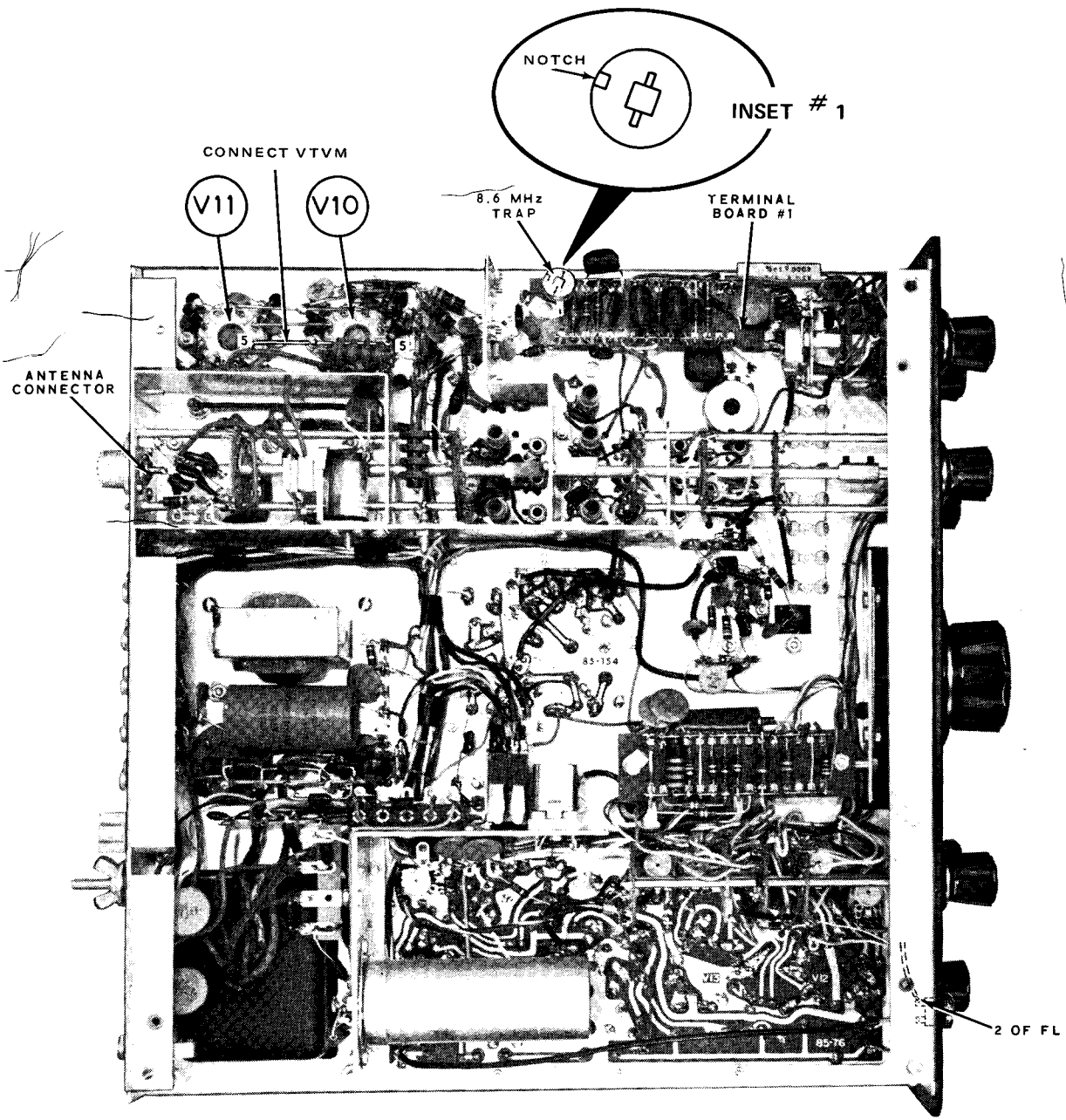
## FINAL BIAS

- ( ) Connect the dummy load to the ANTENNA connector. Do not use a light bulb as a dummy load.
- ( ) Plug in the Transmitter line cord.
- ( ) Remove the 6CL6 driver tube (V9).
- ( ) Set the METER switch to PLATE.
- ( ) Place the BAND switches in the 3.5 position.
- ( ) Turn the FUNCTION switch to TRCV.
- ( ) Turn the MODE switch to USB.
- ( ) Allow a few minutes warmup time.
- ( ) Key the Transmitter by pushing the PTT button on the microphone or by shorting lug 2 of the microphone connector to the chassis with a screwdriver blade. Then adjust the BIAS ADJUST control for a 50 ma indication on the meter of the Transmitter. Refer to Figure 5-1 on Page 108 for the explanation of the meter scales.



**FIGURE 2-2**





THROUGH  
INDICATOR Q

VE  
ADJUST

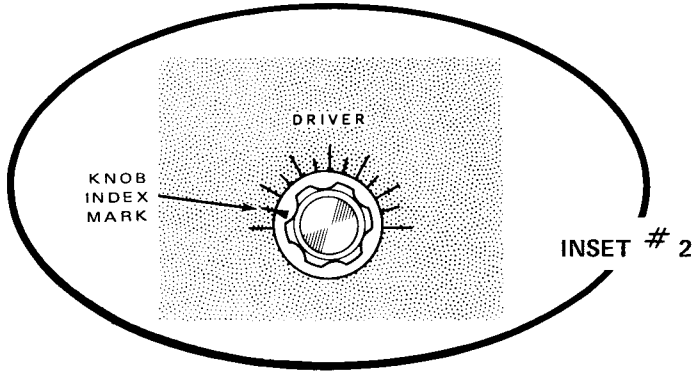


FIGURE 2-2

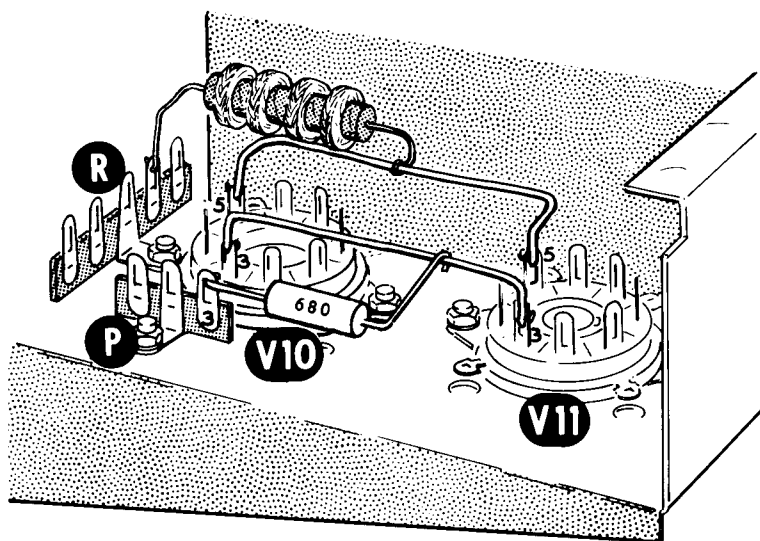
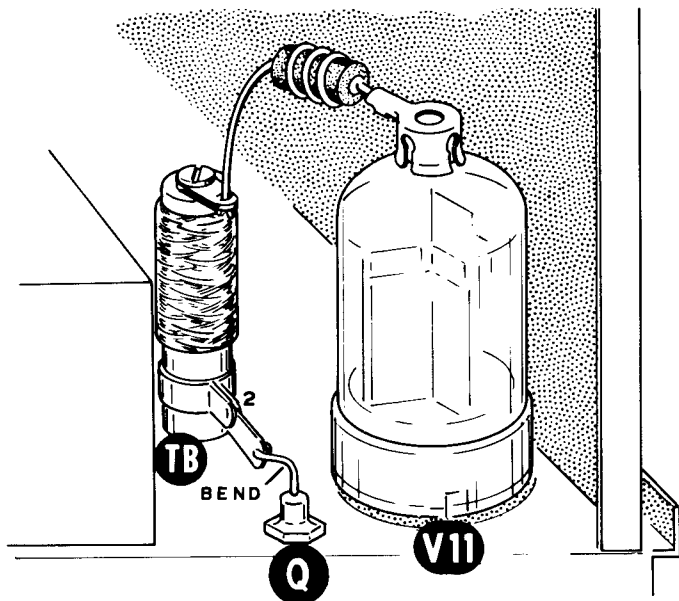


FIGURE 2-3

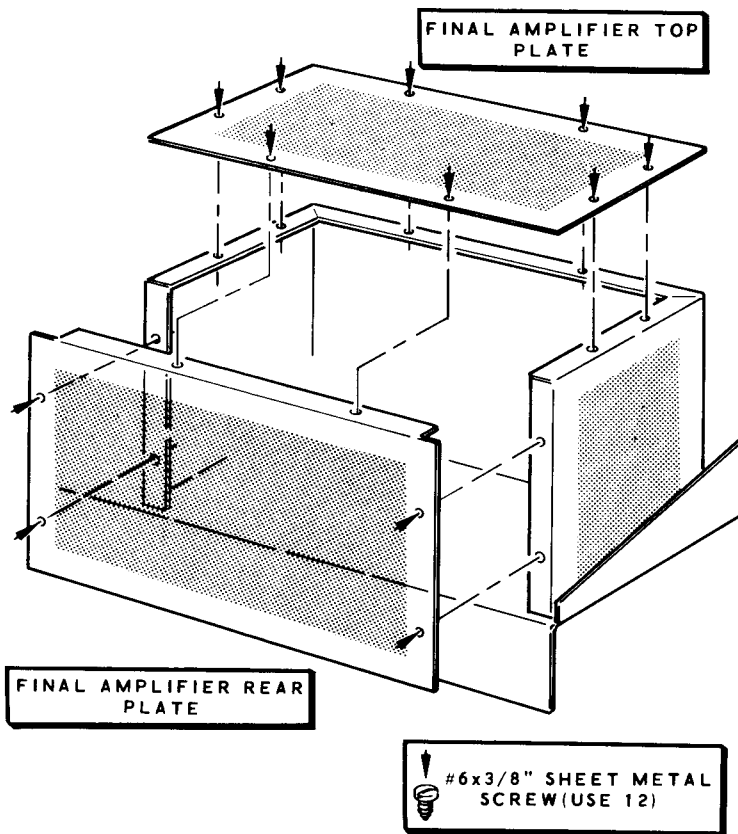


FIGURE 2-4

- ( ) Return the FUNCTION switch to STBY.
- ( ) Set the METER switch to REL PWR.
- ( ) Install the 6CL6 driver tube (V9).
- ( ) Install a large tube shield on V9.
- ( ) Turn the FUNCTION switch to TRCV.
- ( ) Turn the MODE switch to CW.
- ( ) Key the Transmitter and readjust the Driver plate and grid coils for maximum relative power output on each band. Be sure the receiver and transmitter band switches are always set on the same band.
- ( ) Return the FUNCTION switch to STBY.

**MICROPHONE CONNECTION**

NOTE: Before the LMO can be adjusted with an Amateur Band receiver, a microphone must be connected to the Transmitter. It is recommended that a high impedance microphone that is equipped with a push-to-talk switch be used with this Transmitter, so advantage may be taken of both the PTT and VOX operation. A 2-pin male microphone connector (Amphenol 80MC2M) is furnished for this purpose.

Figure 2-5 shows a typical microphone and its connections. Install the microphone connector on the end of the cable as shown in the Figure. Then connect the microphone to the MIC socket on the Transmitter.

**LMO ADJUSTMENT**

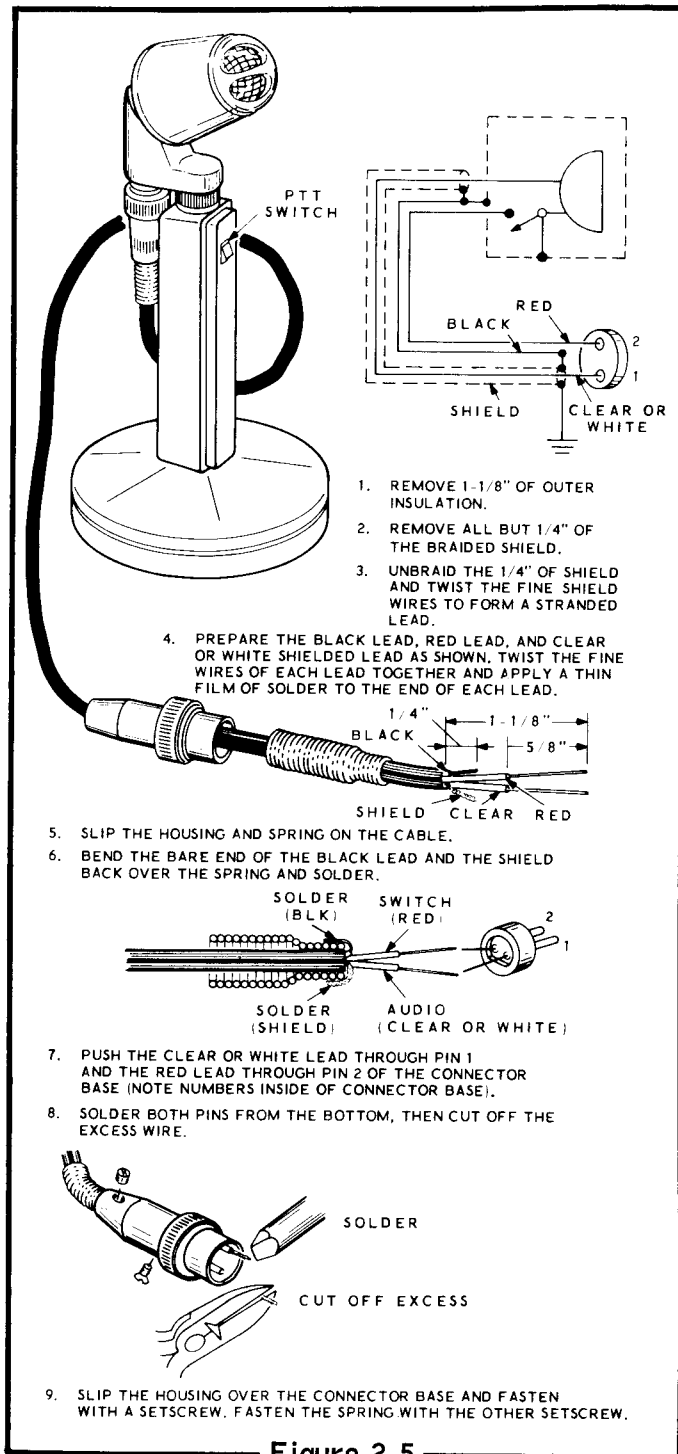
- ( ) Set the controls on the SB-303 Receiver as follows:

LMO Dial	3.5 MHz*
BAND switch	3.5
RF GAIN control	Full clockwise
AF GAIN control	1/4 clockwise
ANTENNA switch	HF
FUNCTION switch	STBY
MODE	USB

- ( ) Set the controls on the Transmitter as follows:

LMO Dial	3.5 MHz*
BAND switch	3.5
FUNCTION switch	TRCV

\*Both slide rule and LMO dials at 0.



**Figure 2-5**

MODE	CW
FREQ CONTROL	UNLOCKED
METER	GRID
MIC/CW LEVEL	COUNTERCLOCKWISE

- ( ) Now load the Transmitter into a 50  $\Omega$  dummy load for maximum CW output. Refer to steps B through I on Page 114.
- ( ) Turn the Transmitter FUNCTION switch to SPOT.
- ( ) Turn the Transmitter MODE switch to USB.
- ( ) Turn the METER switch to ALC.
- ( ) Set the Transmitter Zero Set Line directly under the 2-1/2 mark (center) of the slide rule dial.
- ( ) Advance the MIC/CW LEVEL to the 12 o'clock position.
- ( ) Talk into the microphone and turn the Transmitter LMO DIAL knob until your voice sounds clear and normal in the Receiver.
- ( ) Without changing the circular dial setting, remove the LMO DIAL knob. Loosen the setscrew on the circular dial. Hold the LMO shaft with a screwdriver through the front panel and turn the circular dial until the "O" is directly behind the Zero Set Line. Retighten the setscrew in the circular dial.
- ( ) Replace the LMO DIAL knob on the LMO drive shaft.
- ( ) Talk into the microphone and be sure the signal is tuned in properly.
- ( ) Switch the Receiver and Transmitter MODE switches to LSB. Talk into the microphone. If the signal is not the same as when all MODE switches were in USB, adjust the LMO FREQ SHIFT coil of the Transmitter until your voice is clear.
- ( ) Set the MODE switches of both units back to USB. If your voice is not clear, readjust the LMO DIAL of the Transmitter until your voice is clear, and switch both units back to the LSB mode. If the signal is not clear adjust the LMO FREQ SHIFT coil. Repeat this

procedure until it is possible to go from the USB to LSB mode without the sound of your voice being changed (always switch both units simultaneously).

#### FINAL TRANSMITTER ADJUSTMENT

- ( ) Tune the Transmitter for maximum relative output power into a 50  $\Omega$  dummy load on the 3.5 band.
- ( ) Turn the METER switch to GRID.

#### NOTES:

1. In each of the following steps, set the LEVEL control for approximately .2 milliamperes indication on the meter for the band being adjusted.
  2. If the grid current indication will not come up as high as .2 ma with the LEVEL control fully clockwise, adjust the DRIVER and FINAL controls to increase the current.
  3. When adjusting the coils in the following steps, you may obtain two voltage peaks. The correct peak is the one when the slug is nearest the top of the coil.
- ( ) Key the Transmitter and adjust the LEVEL control for a meter reading of .2 ma.
  - ( ) Adjust the Receiver 3.5 HET OSCILLATOR control for a peak meter reading. If necessary, keep the meter needle on scale with the LEVEL control.
  - ( ) Repeat the preceding two steps at each setting of the BAND switches (except the Receiver 21.0 band).
  - ( ) Turn the FUNCTION switch to OFF.

This completes the alignment of the Transmitter. Refer to the Final Assembly section on Page 103.

## ALIGNMENT WITH SBA-401-1 CRYSTAL ACCESSORY KIT INSTALLED

#### CRYSTAL INSTALLATION

- ( ) Refer to the lettering on top of the chassis and install the proper crystals in the eight crystal sockets. The crystal frequency is stamped on the top of each crystal.
- ( ) Refer to Figure 1-1 (fold-out from Page 86) and install the 3396.4 kHz USB and 3393.6 kHz LSB crystals in sockets Y9 and Y11 on the carrier generator shield.

## EQUIPMENT REQUIRED

The following test equipment is required for alignment of the Transmitter.

1. A 50  $\Omega$  nonreactive dummy load (such as Heathkit Model HN-31 Antenna).
2. An 11 megohm input VTVM (such as Heathkit Model IM-11).
3. An RF probe for the VTVM (such as Heathkit Model 309-C).
4. A Ham band or good general coverage receiver with calibrated S meter (such as Heathkit Model SB-303).
5. A CW key plugged into the KEY jack. CAUTION: Do not depress the key until specifically instructed to do so.

Refer to Figure 2-2 (fold-out from Page 93) for test point and adjustment locations.

### 8.6 MEGAHERTZ TRAP

- ( ) Preset the variable capacitor on terminal board #1 as it is shown in Figure 2-2, if it was not aligned previously using the SB-303 Receiver.

### 21 MEGAHERTZ TRAP

The 21 MHz trap (RFC1) was preset at the factory. Do not change the setting of this trap.

### HETERODYNE OSCILLATOR

- ( ) Set the transmitter panel controls as follows:

FINAL (Knob)	80
(Lever)	50 $\Omega$
LEVEL	counterclockwise
FREQ. CONTROL	UNLOCKED
METER	REL. PWR.
FUNCTION	OFF
BAND	3.5
MODE	CW

- ( ) Plug the line cord into a 120 V AC wall outlet.
- ( ) Turn the FUNCTION switch to STBY.
- ( ) Connect the DC probe of the VTVM to the oscillator test jack.

- ( ) Adjust the slug of the 3.5 HET OSC coil for a maximum indication on the VTVM (negative DC).

CAUTION: Be sure the alignment tool is fully seated in the coil before attempting to turn the coil slug. It may be necessary to turn the coil slug several turns counterclockwise to start the oscillator.

- ( ) Turn the slug 1/4 turn counterclockwise to insure positive starting of the oscillator.
  - ( ) Turn the BAND switch from 3.5 to 7.0 and back to 3.5 to see that the oscillator starts oscillating. If it does not, turn the slug slightly until positive operation of the oscillator is obtained. (Readings of approximately -3 volts or higher are normal. They will vary from band to band.) NOTE: When adjusting this coil in one direction, the oscillator output voltage will change rapidly; when adjusting the coil in the opposite direction from the peak, the output voltage will change slowly. Adjust the coil in the direction that gives the slower change in output voltage.
  - ( ) Place the BAND switch in the 7.0 position.
  - ( ) Adjust the slug of the 7.0 HET OSC coil for a maximum indication on the VTVM.
  - ( ) Turn the slug 1/4 turn counterclockwise to insure positive starting of the oscillator.
  - ( ) Turn the BAND switch from 7.0 to 3.5 and back to 7.0 to check for positive oscillator operation on the 7.0 band.
  - ( ) Repeat the same procedure for the 14.0, 21.0, 28.0, 28.5, 29.0, and 29.5 positions of the BAND switch, and adjust the corresponding HET OSC coil. Check each band for proper oscillator operation by switching to a different band and back again.
  - ( ) Return the BAND switch to the 3.5 position.
  - ( ) Disconnect the DC probe of the VTVM from the oscillator test jack.
- ### CARRIER GENERATOR
- ( ) Set the FUNCTION switch to TRAN.
  - ( ) Rotate the LEVEL control fully clockwise.
  - ( ) Connect the VTVM RF probe to the E pin on the top of the carrier generator circuit board.
  - ( ) Depress the key. This should close both relays.

- ( ) Adjust the balanced modulator transformer T1 for a maximum indication on the VTVM. There are two peaks; the peak that occurs with the slug nearest the top of the can is the correct peak. (Approximately 1 to 1.5 volts.)
- ( ) Open the key.
- ( ) Rotate the LEVEL control fully counterclockwise.
- ( ) Set the MODE switch to USB.
- ( ) Short lug 2 of MIC connector FL to the chassis, using a jumper wire, or connect a microphone and press the push-to-talk button. This should again close both relays (See Page 95 for microphone connection).
- ( ) Adjust the CARRIER NULL control and capacitor for a minimum indication on the VTVM.
- ( ) Turn the METER switch to ALC.
- ( ) Adjust the ALC ADJUST control for a zero meter reading.

NOTE: When the METER switch is in the ALC position during transmitter standby, the meter will normally indicate full-scale deflection.

- ( ) Return the MODE switch to the CW position.
- ( ) Set the FUNCTION switch to STBY.

#### DRIVER

- ( ) Set the DRIVER control to the first mark from the fully counterclockwise marking on the panel.
- ( ) Set the LMO dial to zero (counterclockwise).
- ( ) Insert the VTVM RF probe into pin 2 of tube socket V9.
- ( ) Set the FUNCTION switch to the TRAN position.
- ( ) Rotate the LEVEL control fully clockwise.

NOTE: When you align each driver and heterodyne oscillator coil in the following steps, first read the step all the way through. Then key the transmitter and perform the adjustment. Release the key as soon as the step is completed.

- ( ) Adjust the slug of the 3.5 DRIVER grid coil for a maximum indication on the VTVM. (Readings of approximately 1.5 volts or higher are normal. A definite peak should be obtained.)
- ( ) Set the BAND switch to 7.0 and adjust the slug of the 7.0 DRIVER grid coil for a maximum indication on the VTVM.

- ( ) Repeat this same procedure for each setting of the BAND switch through 28.0 by adjusting the corresponding DRIVER grid coil for a maximum indication of the VTVM.
- ( ) Return the FUNCTION switch to STBY.
- ( ) Rotate the BAND switch to 3.5.
- ( ) Rotate the LEVEL control fully counterclockwise.
- ( ) Connect the VTVM RF probe to the bare wire connected between pins 5 of tube sockets V10 and V11 on the bottom of the chassis.
- ( ) Install the 6CL6 driver tube (V9). The tube shield will be installed later.

NOTE: Some VTVM RF probes may load a circuit and cause faulty tuning. To check for this, first adjust the coil for a maximum VTVM reading as directed in the step. Then disconnect the RF probe from the Transmitter, set the METER switch to GRID, and readjust the coil for maximum indication on the panel meter. (Turn the LEVEL control slightly counterclockwise if the meter reads off-scale.)

- ( ) Turn the FUNCTION switch to the TRAN position and key the transmitter.
- ( ) Rotate the LEVEL control fully clockwise.
- ( ) Adjust the slug of the 3.5 PLATE driver coil for a maximum indication on the VTVM. (Readings of 35 volts or higher, should be obtained, depending on band.)
- ( ) Readjust the slug of the 3.5 GRID driver coil for a maximum indication on the VTVM.
- ( ) Repeat the 3.5 HET OSC coil for maximum.
- ( ) Place the BAND switch in the 7.0 position.
- ( ) Adjust the slug of the 7.0 PLATE driver coil for a maximum indication on the VTVM.
- ( ) Readjust the slug of the 7.0 GRID coil for a maximum indication on the VTVM.
- ( ) Repeat the 7.0 HET OSC coil for maximum.
- ( ) Repeat this same procedure for each setting of the BAND switch through 28.0 by adjusting the corresponding PLATE and GRID driver and Het Osc coils for a maximum indication on the VTVM.
- ( ) Set the BAND switch to 29.0. Adjust the DRIVER control for a maximum indication.

- ( ) Adjust the slug of the 29.0 GRID coil for maximum indication.
- ( ) Adjust the DRIVER control for a maximum indication.
- ( ) Readjust the 29.0 GRID coil for a maximum indication.
- ( ) Repeat the preceding four steps until no further increase is obtained.
- ( ) Repeak the 29.0 heterodyne oscillator coil for maximum.

### 8.6 MEGAHERTZ TRAP ADJUSTMENT

NOTE: Leave the VTVM RF probe connected to the bare wire between pins 5 of V10 and V11.

- ( ) Remove the 15.895 megahertz crystal from the SB-401 Transmitter.
- ( ) Place the BAND switch in the 7.0 position and set the LMO Dial to 3.
- ( ) Place the FUNCTION switch in the SPOT position.
- ( ) Turn the MODE switch on the Transmitter to the CW position.
- ( ) Advance the LEVEL control on the Transmitter fully clockwise.
- ( ) Set the DRIVER control fully clockwise.

NOTE: It is normal for the variable capacitor plates to touch the coil cover.

- ( ) Adjust the variable capacitor on terminal board #1 (see Figure 2-2 fold-out from Page 93) for minimum on the VTVM.
- ( ) Replace the 15.895 MHz crystal.
- ( ) Set the DRIVER control to the first mark above full counterclockwise.
- ( ) Repeak the DRIVER grid and plate coils.

### CARRIER NULL ADJUSTMENT

- ( ) Place the BAND switch in the 3.5 position.
- ( ) Adjust the DRIVER control for a maximum indication on the VTVM.
- ( ) Rotate the LEVEL control fully counterclockwise.

- ( ) Place the FUNCTION switch in the TRAN position.
- ( ) Place the MODE switch in the USB position.
- ( ) Short lug 2 of the MIC connector to the chassis with a jumper wire, or connect a microphone and press the push-to-talk button.
- ( ) Adjust the CARRIER NULL control and capacitor for a minimum indication on the VTVM.
- ( ) Place the MODE switch in the LSB position and adjust the CARRIER NULL capacitor to the same VTVM reading obtained in the USB position.
- ( ) Place the MODE switch in the USB position and adjust the CARRIER NULL control for a minimum indication on the VTVM.
- ( ) Place the MODE switch in the LSB position and adjust the CARRIER NULL capacitor to the same VTVM reading obtained in the previous step.
- ( ) Repeat the previous two steps until the same VTVM reading is obtained in the USB and LSB positions of the MODE switch.

NOTE: The preceding five adjustments can be checked after the Transmitter is in the cabinet by using a receiver set to the operating frequency and observing the "S" meter for minimum readings as the adjustments are made.

- ( ) Return the FUNCTION switch to STBY.
- ( ) Place the MODE switch in the CW position.
- ( ) Disconnect the RF probe of the VTVM.

### NEUTRALIZING

- ( ) Rotate the BAND switch to 28.5.
- ( ) Place the VTVM RF probe in the ANTENNA connector.
- ( ) Set the FUNCTION switch to TRAN.
- ( ) Rotate the LEVEL control fully clockwise.
- ( ) Key the transmitter.



- ( ) Adjust the DRIVER control for a maximum indication on the VTVM.
- ( ) Adjust the FINAL control for a maximum indication on the VTVM, with the LOAD control set at the 50  $\Omega$  position.
- ( ) Using an insulated screwdriver, adjust the Neutralizing Capacitor for a minimum indication on the VTVM.
- ( ) Readjust the FINAL controls for maximum indication on the VTVM.
- ( ) Readjust the Neutralizing Capacitor for a minimum indication on the VTVM.
- ( ) Turn the FUNCTION switch to the OFF position.
- ( ) Unplug the Transmitter line cord and wait approximately 5 minutes before continuing.

Refer to Figure 2-3 (fold-out from Page 94) for the following steps.

**CAUTION:** Be sure to use a screwdriver with an insulated handle to discharge the high voltage capacitors in the next step.

- ( ) Discharge the high voltage capacitors by shorting the lower lead of feedthrough capacitor Q to the chassis with a screwdriver. Be sure to touch the metal blade of the screwdriver to the chassis first, then to the capacitor lead. Repeat this step a number of times to be sure the capacitors are completely discharged.
- ( ) On top of the chassis, connect the lead of feedthrough capacitor Q to lug 2 of coil TB (S-1). Bend the lead of the capacitor carefully to prevent breaking the ceramic form.

- ( ) On the bottom of the chassis connect a 680  $\Omega$  (blue-gray-brown) resistor from lug 3 of terminal strip P (S-3) to the center of the bare wire connected between lugs 3 of tube sockets V10 and V11 (S-1).

Refer to Figure 2-4 (fold-out from Page 94) for the following two steps.

- ( ) Install the final amplifier rear plate on the final amplifier enclosure, using #6 x 3/8" sheet metal screws.
- ( ) Install the final amplifier top plate on the final amplifier enclosure, using #6 x 3/8" sheet metal screws.

**IMPORTANT:** Do not key the Transmitter for more than 30 seconds at a time until after you have completed the Final Transmitter Adjustments.

#### FINAL BIAS

- ( ) Connect the 50  $\Omega$ , 100 watt dummy load to the ANTENNA connector.
- ( ) Plug in the Transmitter line cord.
- ( ) Remove the 6CL6 driver tube (V9).
- ( ) Set the METER switch to PLATE.
- ( ) Place the BAND switch in the 3.5 position.
- ( ) Turn the FUNCTION switch to TRAN.
- ( ) Allow a few minutes warmup time.

- ( ) Key the Transmitter and adjust the BIAS ADJUST control for a 50 ma indication on the meter of the Transmitter. Refer to Figure 5-1 on Page 108 for the explanation of the meter scales.
- ( ) Return the FUNCTION switch to STBY.
- ( ) Set the METER switch to REL PWR.
- ( ) Install the 6CL6 driver tube (V9).
- ( ) Install a large tube shield on V9.
- ( ) Turn the FUNCTION switch to TRAN.
- ( ) Set the Transmitter MODE switch to USB.
- ( ) Set the receiver MODE switch to USB.
- ( ) Set the dial of the receiver to 3.5 megahertz.
- ( ) Adjust the FINAL control to 80 M.
- ( ) Adjust the FINAL LOAD to 50  $\Omega$ .
- ( ) Adjust the LEVEL control fully counter-clockwise.
- ( ) Connect a coaxial cable between the REC ANT jack on the transmitter and the Antenna input jack on an SSB receiver, such as the SB-303.

NOTE: In the following step, after the Transmitter is keyed, quickly adjust both the DRIVER and FINAL knobs for maximum output before adjusting the Driver coils.

- ( ) Key the transmitter and readjust both the Driver plate and grid coils for maximum relative power output at each position of the band switch.

### MICROPHONE CONNECTION

NOTE: It is recommended that a high impedance microphone that is equipped with a push-to-talk switch be used with this Transmitter, so advantage may be taken of both the PTT and VOX operation. A 2-pin male microphone connector (Amphenol 80MC2M) is furnished for this purpose.

Figure 2-5 on Page 95 shows a typical microphone and its connections. Install the microphone connector on the end of the cable as shown in the Figure. Then connect the microphone to the MIC socket on the Transmitter.

### LMO ADJUSTMENT

NOTE: For the following steps a receiver with an accurate calibrator must be used.

- ( ) If an SB-303, SB-301, or SB-300 Receiver is being used, set the FUNCTION switch to OPR.
- ( ) Set the Transmitter FUNCTION switch to SPOT.
- ( ) Place the BAND switch in the 3.5 position.
- ( ) Adjust the Zero set knob so the line of the zero set dial is directly under the 2-1/2 mark (center) of the slide rule dial.
- ( ) Adjust both the LMO dial and the slide rule pointer to zero.
- ( ) Set the Transmitter MODE switch to CW.
- ( ) The Transmitter and the receiver should be at zero beat with each other. If not, adjust the LMO DIAL for zero beat as follows: This setting should be very close to the original zero setting of the LMO.
- ( ) Remove the LMO DIAL knob and loosen the circular dial setscrew.

- ( ) While holding the LMO shaft, with a screwdriver, turn the circular dial back to zero.
- ( ) Without disturbing the zero beat setting, tighten the circular dial setscrew. Be sure the circular dial is set at zero.
- ( ) Replace the LMO DIAL knob on the LMO drive shaft.
- ( ) Turn the FUNCTION switch to the STBY position.

### FREQUENCY SHIFT ADJUSTMENT

- ( ) Turn the LEVEL control 1/4 turn clockwise.
- ( ) Turn the FUNCTION switch of the Transmitter to the SPOT position.
- ( ) Turn the Transmitter MODE switch to USB.
- ( ) Turn the receiver MODE switch to USB.
- ( ) Talk into the microphone and tune the Receiver until you hear your voice and it sounds natural.
- ( ) Change the Receiver and Transmitter to LSB without disturbing their frequency settings.

- ( ) Adjust the FREQ SHIFT slug on top of the Transmitter LMO until your voice sounds natural in the receiver.
- ( ) Repeat the previous four steps as often as necessary until there is no change in your voice in the USB and LSB modes of the Transmitter and receiver.
- ( ) Turn the FUNCTION switch to STBY.

### FINAL TRANSMITTER ADJUSTMENT

- ( ) Tune the Transmitter to full REL PWR output into a 50  $\Omega$  dummy load on the 3.5 band. Refer to steps B through I on Page 114. Then return to the steps below.
- ( ) Turn the METER switch to GRID.
- ( ) Set the LEVEL control for a usable grid current indication.
- ( ) Peak the 3.5 HET OSC coil for a maximum meter indication. If necessary, keep the meter needle on scale with the LEVEL control.
- ( ) Repeat the two preceding steps at each BAND switch position.
- ( ) Turn the FUNCTION switch to OFF and unplug the line cord.

This completes the alignment of the Transmitter. Refer to the Final Assembly section.

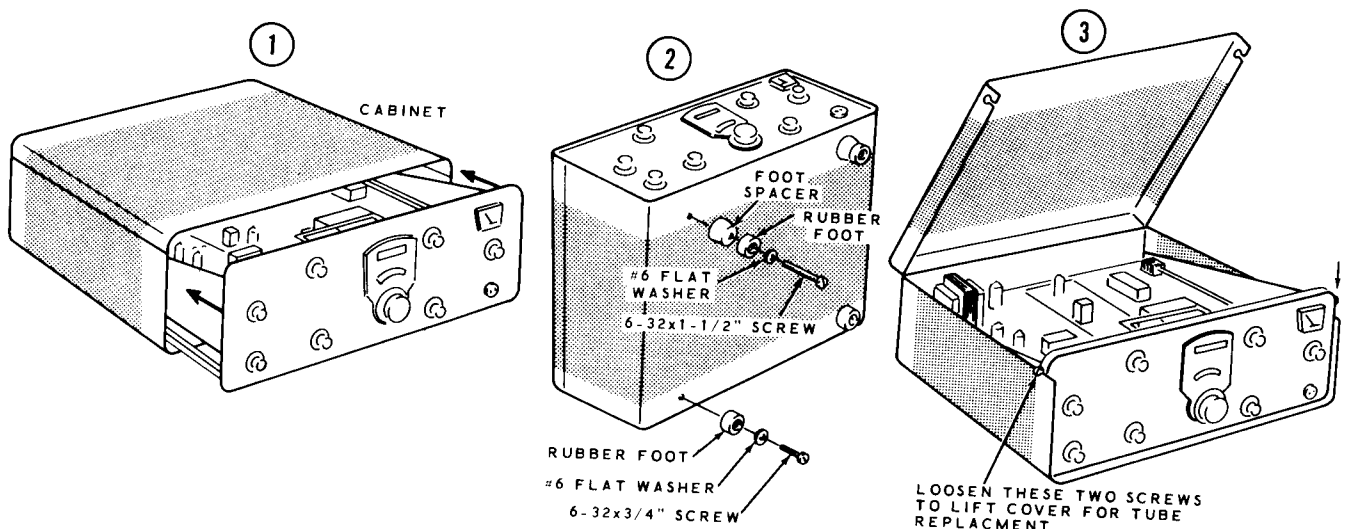


Figure 3-2

# FINAL ASSEMBLY

- ( ) Refer to Figure 3-1, and install the long angle brackets, using 6-32 x 3/8" flat head hardware.

Refer to Figure 3-2 for the following steps.

- ( ) Turn the chassis over and slide it into the cabinet from the front.
- ( ) Carefully turn the chassis and cabinet over and install a rubber foot at each rear corner using 6-32 x 3/4" screws and #6 flat washers. The screws fit through the cabinet holes into the threaded holes in the chassis.
- ( ) Install rubber feet and 3/4" to 1" tapered spacers at the front corners of the cabinet, using 6-32 x 1-1/2" screws and #6 flat washers. NOTE: Extra 6-32 x 3/4" screws are supplied so that the spacers may be eliminated if desired.
- ( ) Install the 8-32 x 1/4" nickel screws into the front-side holes of the cabinet.

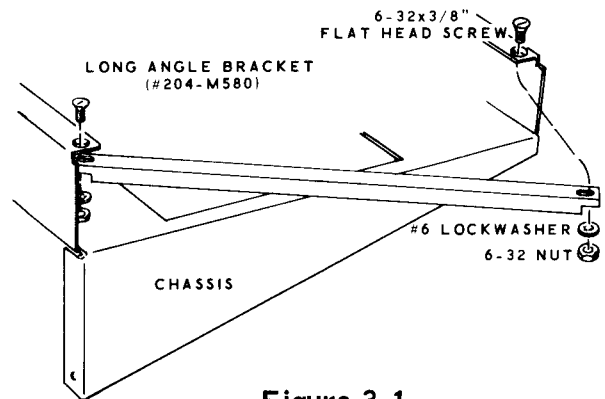


Figure 3-1

NOTE: The blue and white identification label shows the Model Number and Production Series Number of your kit. Refer to these numbers in any communications with the Heath Company; this assures you that you will receive the most complete and up-to-date information in return.

- ( ) Carefully peel away the backing paper from the blue and white label. Then press the label onto the side of the chassis or other location where it can easily be referred to.

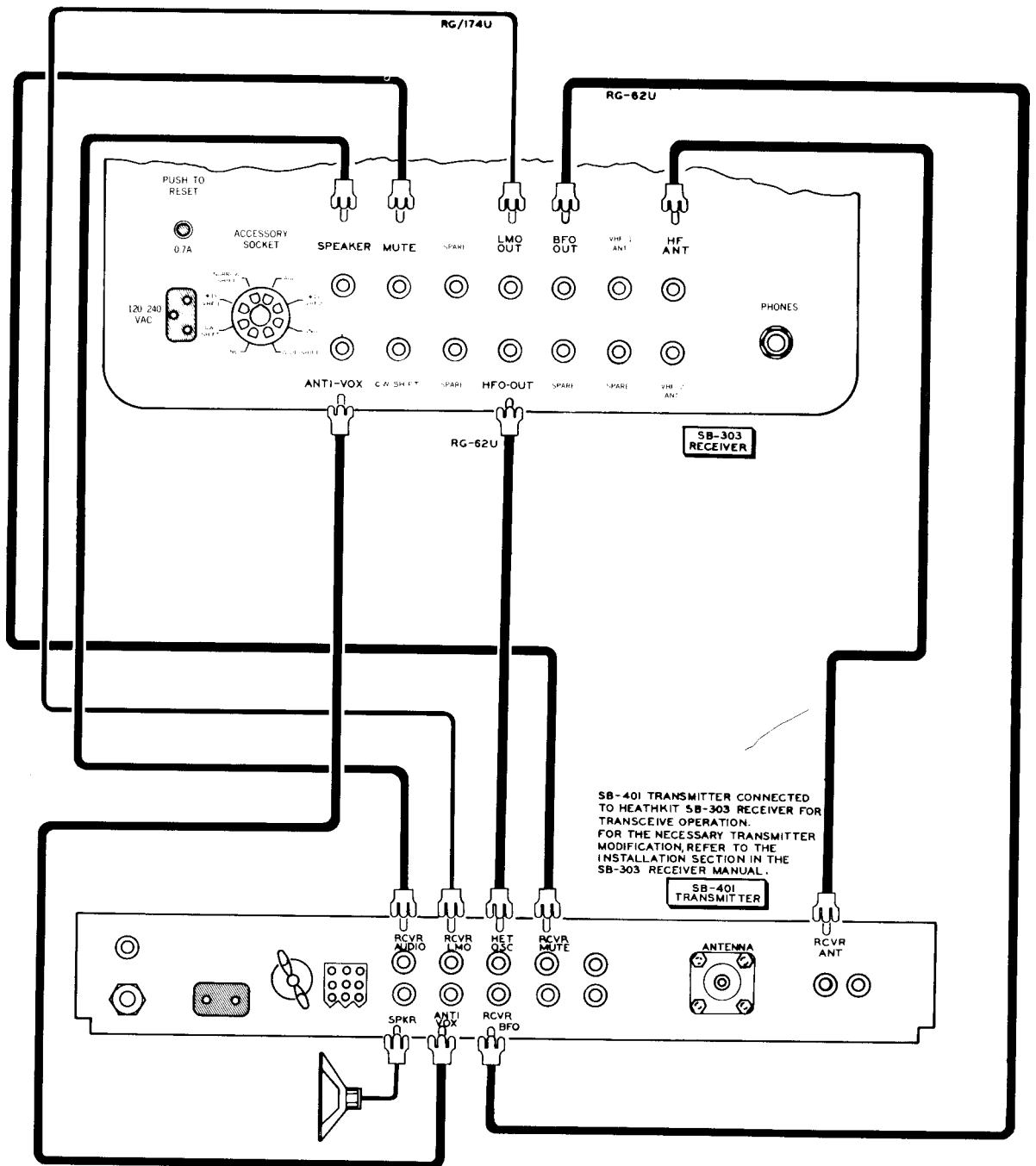


Figure 4-1A

# INSTALLATION AND OPERATION

Because of the heat generated by the tubes of the Transmitter, it should be placed where adequate air circulation is present. Do not place papers or other objects under or on top of the Transmitter as this would cut off air circulation through the chassis.

Figure 4-1A shows the Transmitter connected to a Model SB-303 Receiver for transceiver operation. Refer to the SB-303 Manual for modifications that must be made in the SB-401 Transmitter for this arrangement. Refer to Figure 4-1B if an SB-401 Transmitter is used with a Model SB-301 Receiver for transceiving. The Transmitter includes an antenna switching relay.

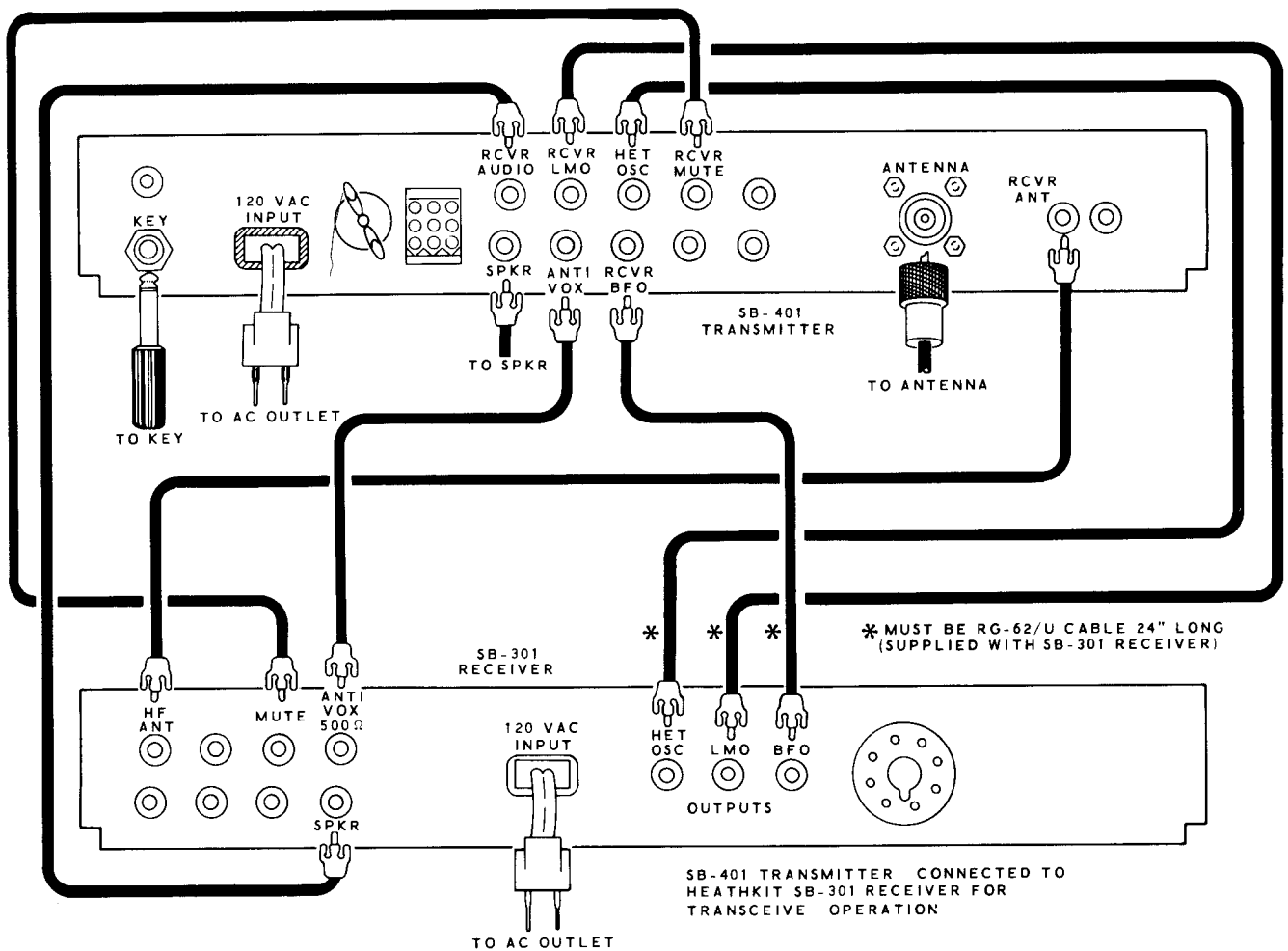


Figure 4-1B

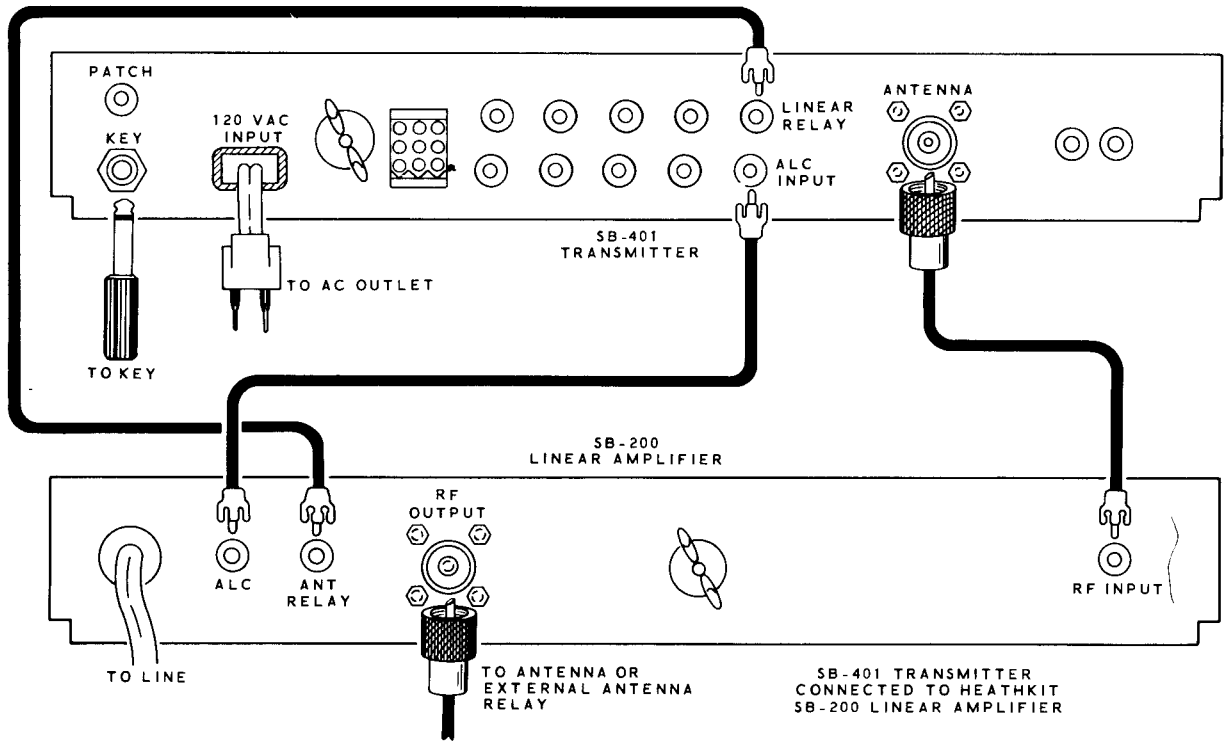


Figure 4-2

Figure 4-2 shows the Transmitter connected to the Heathkit Model SB-200 Linear Amplifier. The Receiver and an external antenna relay are connected for "transceiver" operation, as shown in Figure 4-1, except that the antenna cable from the linear amplifier connects to the antenna relay, instead of the cable from the transmitter.

If the Transmitter has been wired with the SBA-401-1 Accessory kit and is going to be connected as a transmitter

for use with a receiver other than the SB-303, SB-301, or SB-300, refer to Figure 4-3. In this case transceiver is not possible.

**NOTE:** An amateur radio operator and station license is required to place this Transmitter on the air. Information regarding licensing and amateur frequency allocation may be obtained from publications of the Federal Communications Commission, or from the American Radio Relay League in the U.S.A.

SB-401 TRANSMITTER  
CONNECTED TO RECEIVERS  
OTHER THAN HEATHKIT  
SB-303, SB-301 OR SB-300

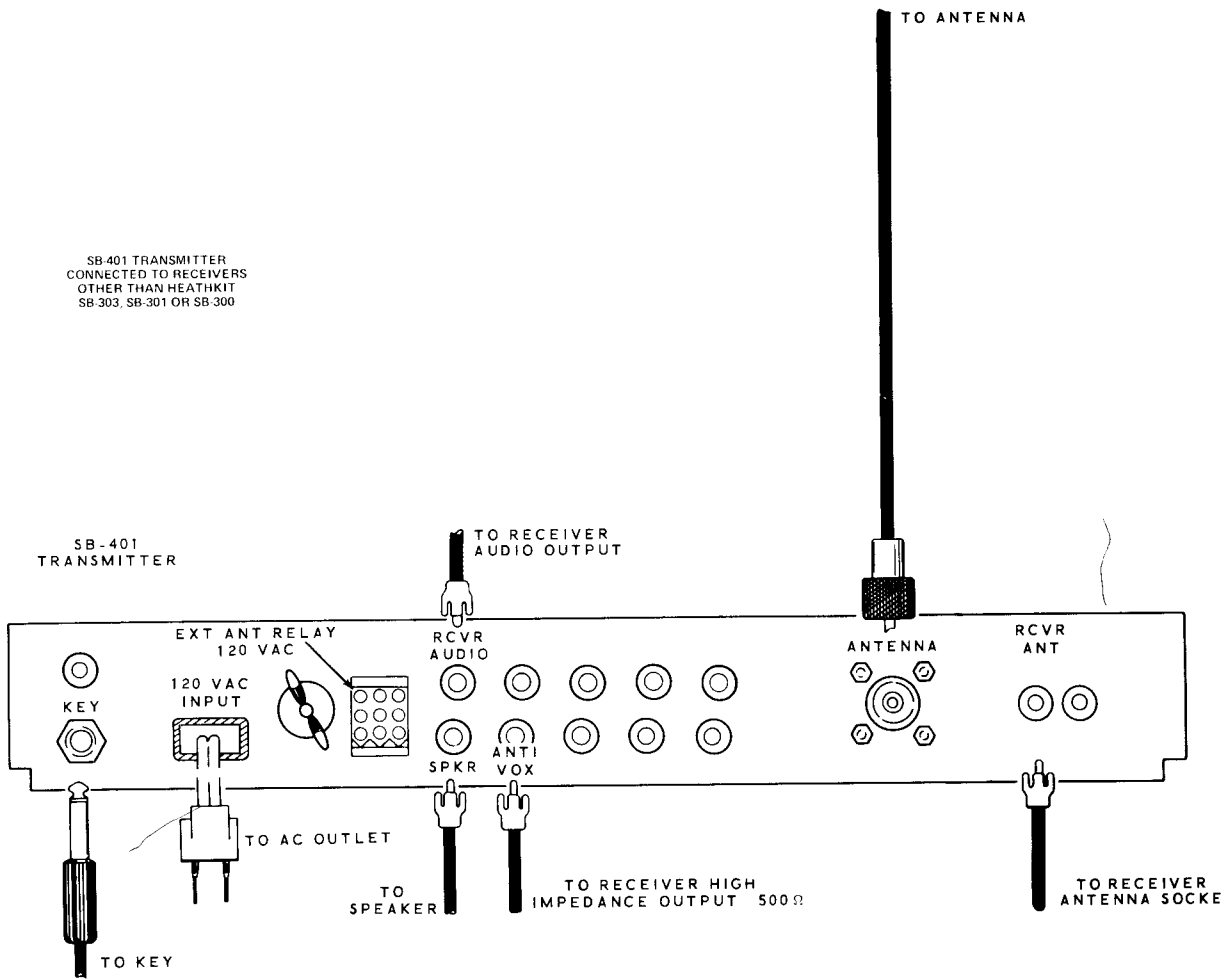


Figure 4-3



### METER READINGS

Refer to Figure 5-1, and study the meter scale. Note how it reads for various positions of the Meter switch. Observe that the meter has two main scales and an ALC area. The scale numbered from 0 to 10 is read directly for relative power indications. For Grid Current readings, each small scale division represents .1 milliamperes. For High Voltage readings, each small scale division represents 100 volts.

The 0 to 500 scale is read directly to indicate plate current in milliamperes. The meter scales should be interpreted as follows:

TOP EDGE OF ALC AREA REPRESENTS MAXIMUM ALLOWABLE MODULATION DETERMINED BY MICROPHONE LEVEL CONTROL

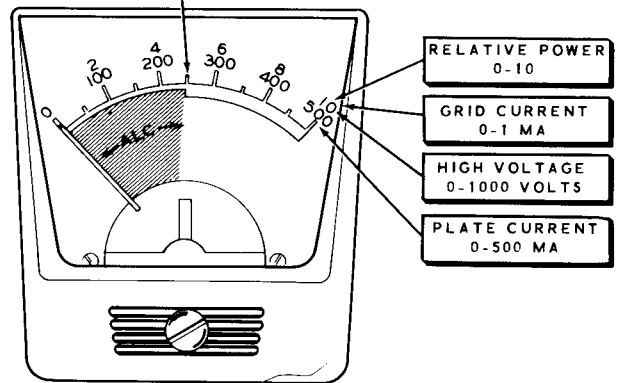


FIGURE 5-1

METER SWITCH POSITION	MEASURES	SCALE READING	RANGE OF READING
GRID	FINAL GRID CURRENT	0 - 10 ÷ 10	0 - 1 MA (Normal, 0-0.1)
PLATE	FINAL PLATE CURRENT	0 - 500	0 - 500 MA (Normal, 250 ma)
ALC	ALC VOLTAGE	ALC AREA ONLY POINTER SET AT 0	MAXIMUM MODULATION AT RIGHT EDGE OF ALC AREA
HV	FINAL HIGH VOLTAGE	0 - 10 x 100	0 - 1000 VOLTS (Normal 700-800 volts)
REL PWR	RELATIVE POWER OUTPUT	0 - 10	ADJUSTABLE ZERO TO MAXIMUM WITH REL PWR CONTROL

### READING TRANSMITTER FREQUENCY

To read the desired frequency, add the BAND switch setting in megahertz, to the slide rule pointer setting in hundreds of kilohertz and the circular dial setting in kilohertz.

For Example: If the BAND switch is set to 3.5, the slide rule pointer is between 2 and 3, and the

circular dial is set to 53, the frequency is 3.753 MHz. If the BAND switch is set to 14.0, the slide rule pointer between 0 and 1, and the circular dial is set to 12, the frequency is 14.012 MHz.

Figure 1-2 (fold-out from Page 86) explains each front panel control.

## OPERATING CONDITIONS

Before proceeding to the Transmitter Operation section, you should know the operating conditions available using different combinations of equipment and control settings. These allowable oper-

ating conditions are listed in the following chart. After you are familiar with this information, proceed to Transmitter Operation.

**ALLOWABLE OPERATING CONDITIONS**

Equipment Combination	Transmitter		SBA-401-1 Crystal Accessory Package	LMO, BFO, and HET OSC Transceive Cables	FUNCTION Switch
	FREQ CONTROL Switch	Frequency Controlled By			
SB-401 and SB-303, or SB-301, or SB-300.	Unlocked	Transmitter	Not Installed	Connected	TRCV
	Locked	Receiver	Not Installed	Connected	TRCV
	Unlocked	Transmitter	Installed	Connected	TRCV (a)
	Locked	Receiver	Installed	Connected	TRCV (a)
SB-401 and Other Receiver	Unlocked	Transmitter	Installed	Disconnected	SPOT or TRAN
	Unlocked	Receiver	Installed	Disconnected	SPOT or TRAN

(a) When using the SB-401 Transmitter in combination with the SB-303, SB-301, or SB-300 Receiver with the transceive cables connected and the SBA-401-1 Crystal Accessory package installed, the Transmitter FUNCTION switch must be at STBY or TRCV, otherwise a steady tone will be heard in the Receiver.

## TRANSMITTER OPERATION

The following operation information is divided into two separate sections: Operation with SB-303 Receiver (transceiver operation), and Transmitter Operation Only. Each of these sections, in turn, is divided into CW and SSB operation.

### OPERATION WITH SB-303 RECEIVER

When operating the SB-401 Transmitter and SB-303 Receiver as a transceiver, the LMO mode is selected from the Transmitter front panel. Either the Transmitter or Receiver can be used for frequency control of the Transmitter. If the FREQ CONTROL switch is in the LOCKED (RCVR) position, the Transmitter will be transmitting on the frequency at which the Receiver is set. Therefore, it is important that the Receiver dial always be set within one of the amateur bands when the Transmitter is used. If the FREQ CONTROL switch is in the UNLOCKED position, the LMO in the Transmitter controls the operating frequency.

**NOTE:** It may be necessary to readjust the heterodyne oscillator coils of the Receiver due to the loading by the Transmitter heterodyne oscillator circuit. Follow the SB-303

heterodyne Oscillator Adjustment procedure (using the SB-303 calibrator signal) with the Transmitter connected to the Receiver. It is not necessary to turn the Transmitter on for these adjustments.

Turn the Transmitter chassis on edge. With the Receiver connected to the Transmitter, place an RF probe on the center pin of the BFO jack on the rear apron of the Transmitter. With the Receiver turned on (the Transmitter need not be on for this adjustment), adjust the Receiver BFO output Coil (L20) until a maximum is obtained (approximately 5 volts). This coil in the Receiver is now properly set for transceiver operation and will not need further adjustment.

**CAUTION:** Do not attempt to transceive with the Receiver in the AM or CAL modes, as the units will not function properly.

Make sure the BAND switches of the Transmitter and Receiver are always in the same positions.

## CW

Set the switches and controls of the Transmitter and Receiver as follows:

SWITCH OR CONTROL	TRANSMITTER	RECEIVER	COMMENTS
FUNCTION	TRCV	STBY	
MODE	CW	USB	Key plugged into KEY jack with key open
BAND	SAME AS RECEIVER	DESIRED BAND	Adjust the Receiver main tuning for desired frequency or open spot on band
METER	REL PWR		
VOX DELAY	As desired		
RF GAIN		Fully clockwise	
AF GAIN			Use as volume control
ANTI-VOX	Not used		
LEVEL	Fully counterclockwise		
FREQ CONTROL	LOCKED (RCVR)		
FINAL LOAD	50 $\Omega$		
FINAL tune	Desired band		
Preselector		Adjust for portion of band used	
SIDE TONE LEVEL	Desired intensity		

- ( ) Tune up the Transmitter, using steps A through I of the CW (Transmitter Only) tune-up chart on Page 114.
- ( ) Tune in the desired CW signal and set the Receiver main tuning dial 1 kHz higher than the zero beat. Switch the Receiver MODE switch to CW only if the CW narrow band-pass filter is in the Receiver. The Receiver and Transmitter are now on the same fre-

quency. In this mode, the Transmitter CW carrier crystal is used when the key is down and the Receiver BFO crystal is used when the key is open. (The Transmitter carrier crystal frequency is 1 kHz removed from the Receiver BFO frequency.) This procedure places both the received and transmitted signals on the same frequency, providing the tuning instructions are followed properly.

**SSB**

Set the switches and controls of the Transmitter and Receiver as follows:

SWITCH OR CONTROL	TRANSMITTER	RECEIVER	COMMENTS
FUNCTION	TRCV	STBY	
MODE	USB or LSB	USB or LSB	Receiver and Transmitter must be set the same
BAND	Desired band	Desired band	Same band
MAIN TUNING (LMO DIAL)		Desired frequency	
VOX GAIN	Normal setting		
VOX DELAY	As desired		
ANTI-VOX	Normal setting		
RF GAIN		Fully clockwise	
AF GAIN			Used as volume control
AGC		As desired, Slow recommended	
PRESELECTOR		Adjust for portion of band used	
FINAL LOAD	50 $\Omega$		
FINAL tune	Desired band		
FREQ CONTROL	LOCKED (RCVR)		

- ( ) Tune up the Transmitter, using steps A through I of the CW (Transmitter Only) tune-up chart on Page 114. The only difference is that the operating frequency is determined by the Receiver.

NOTE: Because all frequency determining stages are in the Receiver, there is no error between transmit and receive frequencies in the transmitter mode of operation.

- ( ) With the Receiver set to a strong station and with proper listening level, advance the Transmitter ANTI-VOX control clockwise

until the Receiver audio will no longer trip the VOX circuit of the Transmitter.

NOTE: The VOX DELAY and VOX GAIN controls should be adjusted to suit your operating convenience.

- ( ) Speak into the microphone normally, using VOX operation. Adjust the VOX GAIN control for the microphone sensitivity that you want to turn on the Transmitter. The VOX DELAY control should be set for the hold-in time that is desired after the operator stops talking.

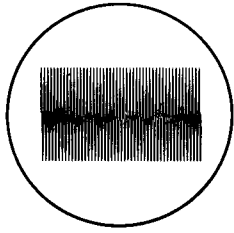


Figure 5-2

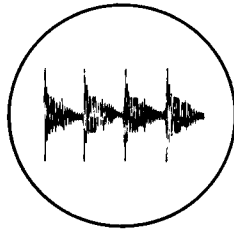


Figure 5-3

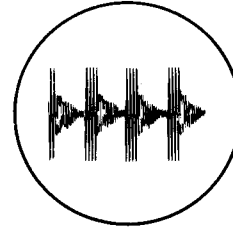


Figure 5-4

NOTE: Movement of the meter pointer, with the Meter switch in the ALC position, indicates that the Automatic Level Control stage is automatically cutting down the final amplifier driving voltage. There is nothing to be gained by modulating so the pointer reaches peaks outside the ALC area, since only distortion and interference to adjacent frequencies will result. See Figures 5-2, 5-3, and 5-4. These Figures illustrate typical oscilloscope patterns. Plate current in SSB will normally run between 80 and 100 ma. No grid current will be indicated in this mode. Relative power will normally run 1/4 to 1/3 of that indicated in CW.

The oscilloscope pattern in Figure 5-2 results from CW or single-tone modulation. The meter indicates full plate current of 240 ma.

The oscilloscope pattern in Figure 5-3 results from SSB voice modulation. Notice the peaks on the oscilloscope pattern. They are sharp, indicating a clean signal, and they attain the same

height as the CW or "single tone" pattern of Figure 5-2, indicating maximum power input. NOTE: Plate current peak reading is approximately 1/2 of the amplitude, or less of the maximum "single tone" reading, due to meter inertia and voice characteristics. Plate current is approximately 100 ma.

The oscilloscope pattern in Figure 5-4 results from SSB overmodulation. The meter reads higher than before, but the scope indicates peak flattening. Operation in this manner causes distortion and severe interference to adjacent frequencies. Plate current is approximately 150 ma.

#### TRANSMITTER OPERATION ONLY

Before attempting to operate the Transmitter other than as a transceiver, with the SB-303 Receiver, be sure to follow the crystal installation and Heterodyne Oscillator Adjustment described on Page 97 of this Manual.

**CW TUNE-UP**

Set all switches and controls as follows:

SWITCH OR CONTROL	SWITCH OR CONTROL POSITION	COMMENTS
FUNCTION	STBY	
BAND	Desired Band	Adjust Main Tuning for desired frequency or open spot on band.
MODE	CW	Plug key into KEY jack with key open.
METER	REL PWR	
VOX DELAY	As desired	
ANTI-VOX	Not used	
LEVEL	Fully counterclockwise	
FREQ CONTROL	UNLOCKED	
FINAL LOAD	50 $\Omega$	
FINAL tune	Desired band	

Tune up the Transmitter as follows:

SWITCH OR CONTROL	SWITCH OR CONTROL POSITION	COMMENTS
A. FUNCTION	TRAN or TRCV	
B. MODE	TUNE	Adjust LEVEL control for approximately .5 ma (midscale) with METER switch in GRID position.
C. FINAL tune		Turn the METER switch to REL PWR and adjust for maximum meter indication (plate current will be approximately 220 ma).
D. DRIVER		Adjust for maximum relative power meter reading. Then turn METER switch to PLATE. (Ip should be about 220 ma.)
E. REL PWR ADJUST		Set METER switch to REL PWR and adjust for a half-scale reading when fully loaded on the 3.5 band.
F. MODE	CW	
G. LEVEL		Key the Transmitter and <u>quickly</u> adjust the LEVEL control <u>only</u> to the point where meter reading ceases to increase.
H. FINAL LOAD		Adjust for maximum meter reading.
I.		Repeat steps C, D, and H.
J.		Key open.
K. METER	GRID	Close the key and adjust the LEVEL control for a meter reading of approximately .5 ma.
L. LEVEL		Key the Transmitter and adjust for approximately 0.5 ma meter reading.

For final adjustment of the Relative Power control, refer to Figure 1-2 (fold-out from Page 86).

The Transmitter is now properly loaded for maximum CW performance at the chosen operating frequency.

For Single Sideband operation, change the MODE switch to either USB or LSB, and adjust the LEVEL control. Use the following chart for the initial setup for SSB operation.

## SSB TUNE-UP

Tune up the Transmitter on the desired band as for CW. Then position switches and controls as follows:

SWITCH OR CONTROL	SWITCH OR CONTROL POSITION	COMMENTS
FUNCTION	STBY	
MODE	USB or LSB	Usually LSB on 3.5 and 7.0 bands, and USB on 14.0 and higher bands.
METER	REL PWR	
VOX GAIN	Fully clockwise	If background noise trips VOX, reduce VOX GAIN until noise has no effect.
ANTI-VOX	As required	If the receiver audio output trips the Transmitter VOX, advance the ANTI-VOX until the receiver audio has no effect.
LEVEL	Fully counterclockwise	
FREQ CONTROL	LOCKED/UNLOCKED	See note.

### NOTES:

1. When aligned as a Transceiver: use the LOCKED position for transceive operation with the Receiver (or an external) LMO; use the UNLOCKED position for independent operation of the Receiver and Transmitter on the same band.
2. When aligned with the SB-401-1 Crystal Kit: use the UNLOCKED position for independent operation; use the LOCKED position for operation with the SB-303/SB-301/SB-300 or SB-640 LMO, independent of band.



Tune up the Transmitter using steps A through I of the CW tune-up chart, and then continue as follows:

SWITCH OR CONTROL	SWITCH OR CONTROL POSITION	COMMENTS
A. METER	ALC	With the Meter switch in the ALC position during transmitter standby periods, it is normal for the meter to deflect full scale.
B. ALC ADJUST		Adjust for zero meter indication with no modulation and with the push-to-talk button depressed. It is normal for the meter to indicate full scale when the Transmitter is in STBY.
C. LEVEL		Adjust for midscale (top of ALC area) meter reading on <u>peaks</u> while the Transmitter is being modulated.
D. ANTI-VOX		With the Receiver set to a strong station and with proper listening level, advance the ANTI-VOX control clockwise until the Receiver audio will no longer trip the VOX circuit of the Transmitter.

The VOX DELAY and VOX GAIN controls should be adjusted to suit your operating convenience.

- ( ) Speak into the microphone normally, using VOX operation. Adjust the VOX GAIN control for the microphone sensitivity desired to turn on the Transmitter. The VOX DELAY control should be set for the hold-in time desired after the operator stops talking.

# IN CASE OF DIFFICULTY

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the builder.
2. About 90% of the kits that are returned for repair, do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the Soldering section of the Kit Builders Guide.
3. Check to be sure that all tubes are in their proper locations. Make sure that all tubes light up properly.
4. Check the tubes with a tube tester or by substitution of tubes of the same types and known to be good.
5. Check the values of the parts. Be sure that the proper part has been wired into the circuit, as shown in the pictorial diagrams and as called out in the wiring instructions.
6. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring or bridging a foil on the circuit board.
7. A review of the Circuit Description will prove helpful in indicating where to look for trouble.
8. Check the antenna and coaxial cable for an open or shorted connection.
9. Retighten all hardware.

NOTE: To aid in servicing or troubleshooting the Transmitter, refer to the Resistance and Voltage Charts (fold-out from Pages 145 and 146), the Circuit Board X-Ray Views on Page 139, and the Chassis Photographs shown in Figures 6-21 through 6-27 on Pages 141 through 144.

Breaks in the foil of the circuit boards can easily be detected by placing a bright light under the foil side of the board and looking through the board from the lettered side. A break will appear as a hair-line crack in the foil.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the Service and Warranty section of the "Kit Builders Guide", and to the "Factory Repair Service" information on Page 120 of this Manual.

## TROUBLESHOOTING CHART

TRANSMITTER DIFFICULTY	POSSIBLE CAUSE
Some or all of the tube filaments fail to light. <u>TURN TRANSMITTER OFF IMMEDIATELY.</u>	<ol style="list-style-type: none"> <li>1. Green power transformer lead not connected.</li> <li>2. Short or open in the filament circuit.</li> <li>3. Fuse not installed or blown.</li> <li>4. Pinched wires under chassis shields.</li> </ol>
No DC voltage at heterodyne oscillator test socket. NOTE: Applies only if SBA-401-1 Crystal Accessory kit is installed.	<ol style="list-style-type: none"> <li>1. Check voltages and wiring of tube socket V8.</li> <li>2. Check Band switch wiring.</li> <li>3. See that crystals are in proper sockets.</li> <li>4. Poor or no ground connection at crystal sockets.</li> <li>5. Incorrect wiring of coils.</li> <li>6. Regulator tube V7 (OA2) not functioning.</li> <li>7. Function switch incorrectly wired.</li> </ol>
No final plate current.	<ol style="list-style-type: none"> <li>1. Check voltages and wiring of tube sockets V10 and V11.</li> <li>2. Check cathode metering circuit.</li> <li>3. Check meter.</li> <li>4. Check wiring of Bias Adjust control.</li> </ol>
Full scale plate current meter reading with no signal input.	<ol style="list-style-type: none"> <li>1. Check grid voltages of tube sockets V10 and V11 (should be -50 V DC).</li> <li>2. Check cathode metering circuit.</li> <li>3. Check wiring of Bias Adjust control.</li> <li>4. Check wiring of bias power supply.</li> </ol>
Relay does not close when key is down with Mode switch in CW, and the Function switch in	<ol style="list-style-type: none"> <li>1. Defective relay RL1 or RL2.</li> <li>2. No B+ voltage present.</li> <li>3. Check wiring and voltages of tube sockets V1, V12, and V13.</li> <li>4. Tone oscillator not working.</li> </ol>
<p>...sew too high.</p> <p>...n Anti-VOX line.</p> <p>...a shorted to power trans-</p>	<ol style="list-style-type: none"> <li>5. Anti-VOX control</li> <li>6. Excessive hum o</li> <li>7. Phone patch jac</li> <li>8. Low line voltage.</li> <li>9. Diode D105 open.</li> </ol>
<p>...s are properly installed.</p> <p>...rrectly wired.</p> <p>...nd wiring of tube sockets</p> <p>...elay RL1.</p> <p>...removed from tube socket</p> <p>... cable to Mode switch.</p>	<p>the TRAN or FROV position.</p>
No carrier generator output. NOTE: Applies only in CW or TUNE modes unless SBA-401-1 Crystal Accessory kit is installed.	<ol style="list-style-type: none"> <li>1. See that crystal</li> <li>2. Mode switch incor</li> <li>3. Check voltages a</li> <li>4. Check wiring of r</li> <li>5. Bias voltage not</li> <li>6. Shorted coaxial</li> </ol>

TRANSMITTER DIFFICULTY	POSSIBLE CAUSE
Carrier Null does not null properly.	<ol style="list-style-type: none"> <li>1. Defective crystal diodes.</li> <li>2. Balanced modulator transformer improperly installed.</li> <li>3. Carrier Null control open or shorted.</li> <li>4. Level control not counterclockwise.</li> </ol>
No RF voltage at pin 2 of driver tube socket (6CL6) V9.	<ol style="list-style-type: none"> <li>1. Shorted coaxial cable from tube socket V5.</li> <li>2. Band switch incorrectly wired or positioned.</li> <li>3. Coils improperly wired.</li> <li>4. Bandpass filter improperly installed.</li> <li>5. Heterodyne oscillator not functioning.</li> <li>6. Check voltages and wiring of tube sockets V4 and V5.</li> <li>7. Relay RL1 improperly wired.</li> <li>8. Bias not removed from pin 1 of tube socket V5.</li> <li>9. Pin 2 foil of tube socket V5 shorted to ground.</li> <li>10. Cable to SB-301 not connected or FREQ CONTROL switch not in LOCKED position.</li> </ol>
No RF voltage at pin 5 of tube sockets V10 and V11.	<ol style="list-style-type: none"> <li>1. Open choke, RFC4.</li> <li>2. Open chokes, RFC5 and RFC6.</li> <li>3. Check voltages and wiring of tube sockets V9, V10, and V11.</li> <li>4. Check wiring of Band switch.</li> <li>5. Check wiring of coils.</li> <li>6. Check wiring of relay RL1.</li> <li>7. Bias not removed from pin 2 of tube socket V9.</li> <li>8. 8.645 MHz trap improperly adjusted C303.</li> <li>9. Cable to SB-301 not connected (Transceive only).</li> </ol>
Neutralizing not possible.	<ol style="list-style-type: none"> <li>1. Insufficient drive to final tubes V10 and V11.</li> <li>2. Check bypass capacitor wiring to driver coils and Band switch.</li> <li>3. Check wiring in final amplifier compartment.</li> </ol>
No RF output.	<ol style="list-style-type: none"> <li>1. Check voltages and wiring of tube sockets V10 and V11.</li> <li>2. Resistor R17 open.</li> <li>3. Feedthrough capacitor C67 not connected to lug 2 of coil RFC9.</li> <li>4. Check loading circuits.</li> <li>5. Check wiring of Band switch.</li> <li>6. Check antenna relay circuit (RL2).</li> <li>7. Band switch incorrectly wired or positioned.</li> </ol>

TRANSMITTER DIFFICULTIES	POSSIBLE CAUSE
Weak spotting signal.	1. Wire from antenna relay to RCVR ANT jack not positioned close enough to bare wire connected between lugs 5 of tube sockets V10 and V11.
Low drive on the 7.0 and 14.0 MHz bands.	1. 8 MHz trap set improperly.
Instability.	1. Open ground connections to shielded cable. 2. Poor lead dress. 3. Loose hardware. 4. Improper neutralization.

## FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) If you wish, you can deliver your kit to a nearby Heath Authorized Service Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heath Authorized Service Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heath Authorized Service Center, please ship it to the factory at Benton Harbor, Michigan and follow the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan.

Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least **THREE INCHES** of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company  
Service Department  
Benton Harbor, Michigan 49022

# SPECIFICATIONS

Frequency Coverage (megahertz) . . . . .	3,5 to 4,0; 7,0 to 7,5; 14,0 to 14,5; 21,0 to 21,5; 28,0 to 28,5; 28,5 to 29,0; 29,0 to 29,5; and 29,5 to 30,0.
Frequency Selection. . . . .	LMO (linear master oscillator).
Frequency Stability. . . . .	Less than 100 Hz drift per hour after 20 minutes warmup under normal ambient conditions. Less than 100 Hz drift for $\pm 10\%$ line voltage variations.
Types of Emission. . . . .	Single sideband (SSB)-suppressed carrier, with selectable upper or lower sideband.  Continuous wave (CW).
DC Power Input. . . . .	SSB: 180 watts P.E.P. CW: 170 watts.
RF Power Output. . . . .	100 watts on 80 through 15 meters; 80 watts on 10 meters (50 $\Omega$ nonreactive load).
Output Impedance. . . . .	50 to 75 $\Omega$ with less than 2:1 standing wave ratio (SWR).
Visual Dial Accuracy. . . . .	Within 200 Hz on all bands.
Electrical Dial Accuracy. . . . .	Within 400 Hz on all bands, after calibration at the nearest 100 kHz point.
Backlash. . . . .	No more than 50 Hz.
Carrier Suppression. . . . .	55 db down from rated output.
Oscillator Feedthrough or Mixer Products. . . . .	55 db below rated output (except at 3910 kHz crossover which is 45 db).

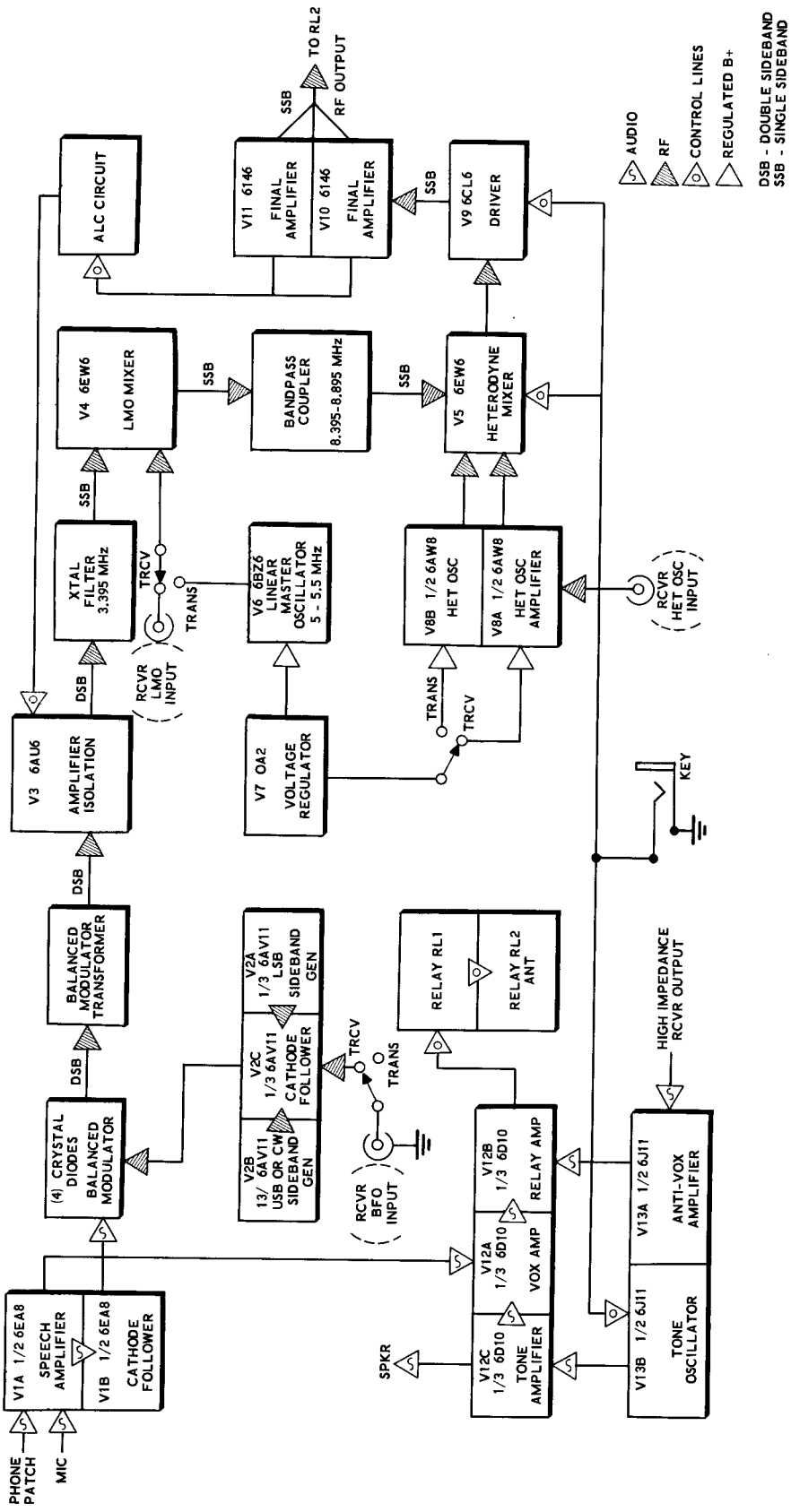
Harmonic Radiation. . . . .	35 db below rated output.
Unwanted Sideband Suppression. . . . .	55 db down from rated output at 1000 Hz and higher.
Third Order Distortion. . . . .	30 db down from rated P.E.P. output.
Noise Level. . . . .	At least 40 db below rated carrier.
Audio Frequency Response. . . . .	350 to 2450 Hz $\pm$ 3 db.
Audio Compression. . . . .	10 db nominal at 0.2 ma final grid current.
Audio Input. . . . .	High impedance or phone patch.
CW Sidetone. . . . .	Internally switched to speaker with transmitter in CW mode and key depressed. Approximately 1000 Hz tone.
Keying Characteristics. . . . .	Break-in CW; provided by operating VOX from a keyed tone, using grid-block keying.
Front Panel Controls. . . . .	Main (LMO) Tuning. Function switch. Band switch. Mode switch. Driver tuning. Final tuning. Final loading. Mic and CW Level control. FREQ CONTROL switch. Meter switch.
Internal Controls. . . . .	Bias Adjust control. VOX Gain control. VOX Delay control. Anti-VOX control. ALC Adjust control. Carrier Null control and capacitor. Sideband Amplitude Balance control. Relative Power Adjust control. Sidetone Level control.

Tube Complement. . . . .	1 - OA2: Regulator. 1 - 6AU6: Isolation Amplifier, 1 - 6AV11: USB, CW, and LSB Carrier Generator, and Carrier Generator Cathode Follower. 1 - 6AW8: Heterodyne Oscillator and Receiver Heterodyne Oscillator Amplifier. 1 - 6CL6: Driver, 1 - 6D10: VOX, Relay, and Side Tone Amplifier. 1 - 6EA8: Audio Preamplifier and Cathode Follower. 2 - 6EW6: LMO Mixer, Heterodyne Mixer. 1 - 6J11: Anti-VOX Amplifier and Tone Oscillator. 2 - 6I46: Final Amplifiers. 1 - 6BZ6: LMO.
Diode Complement. . . . .	5 - Crystal Diodes: Balanced Modulator and Relative power metering. 12- Silicon Diodes: Power Supply, VOX Rectifiers, ALC Rectifiers, and DC Blocking.
Power Supply. . . . .	Transformer operated.
Power Requirements. . . . .	105-125 or 210-250 volts AC, 50/60 Hz. Standby: 80 watts. CW: 260 watts (key down).
Cabinet Dimensions. . . . .	14-7/8" wide x 6-5/8" high x 13-3/8" deep.
Net Weight. . . . .	26-1/2 lbs.
Equipment Used To Prepare Specifications. . . . .	Heath IG-72 Audio Generator. Heath IM-11 VTVM with 309-C RF Probe. Heath IM-21 AC VTVM. Heath HN-31 "Cantenna," Panoramic Radio Products, Inc. "Panalyzer," Model SB-12A. Measurements Corporation, Standard Signal Generator, Model 80. Hewlett Packard Electronic Counter, Model 5248. Boonton RF Voltmeter, Model 91-C and 91-CA. Bird Thruline Wattmeter, Model 43.

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to

incorporate new features in instruments previously sold.





**BLOCK DIAGRAM**

# CIRCUIT DESCRIPTION

Refer to the Schematic (fold-out from Page 147) and the Block Diagram (fold-out from Page 124) while reading the Circuit Description.

is used throughout the Schematic. Read the NOTES on the Schematic for further information.

## SCHEMATIC DIAGRAM

The letter-number designations on the Schematic Diagram are used to identify resistors, capacitors, chokes, etc. Each of these designations is related by the first number to the physical placement of the part in the unit. For example, resistors (and other parts) mounted on the carrier generator circuit board are designated by numbers in a series of 100 to 199, while parts mounted on the chassis are in a series from 1 to 99. This system of component designation

## FREQUENCY CHART

To make the various functions of the Transmitter easier to understand, a selected lower sideband frequency of 3.895 megahertz will be used when tracing through the circuit in this Description. All switches are shown in their fully counter-clockwise positions on the Schematic. The Frequency Chart lists the various frequencies that will be found throughout the Transmitter. The first line contains the frequencies referred to in this Circuit Description.

## FREQUENCY CHART

BAND	CARRIER GENERATOR OUTPUT CRYSTAL FILTER (FIXED)	LMO (BETWEEN 5 AND 5.5)	BANDPASS COUPLER FREQUENCY (BETWEEN 8.395 AND 8.895)	HETERODYNE OSCILLATOR FREQUENCY (CRYSTAL FIXED)	HETERODYNE MIXER OR TRANSMITTED SIGNAL FREQUENCY
3.5 to 4	3.395	5.105	8.5	12.395	3.895
7 to 7.5	3.395	5.3	8.695	15.895	7.2
14 to 14.5	3.395	5.3	8.695	22.895	14.2
21 to 21.5	3.395	5.2	8.595	29.895	21.3
28 to 28.5	3.395	5.4	8.795	36.895	28.1
28.5 to 29	3.395	5.3	8.695	37.395	28.7
29 to 29.5	3.395	5.3	8.695	37.895	29.2
29.5 to 30	3.395	5.4	8.795	38.395	29.6

Frequencies In Megahertz

### AUDIO PREAMPLIFIER AND CATHODE FOLLOWER (Figure 6-1)

An audio signal applied through the Microphone input is coupled by capacitor C101 to the grid of Audio preamplifier tube V1A. Capacitor C101 limits the low frequency response of the input signal, while capacitor C102 limits the high frequency response. Any RF signals that may be picked up by the microphone are bypassed to ground by capacitor C102.

The amplified signal from V1A is coupled through capacitor C105 and Mic Level control R1 to the cathode follower tube, V1B. V1B is used to match the low impedance input of the balanced modulator circuit.

The push-to-talk (PTT) and voice operated (VOX) transmitter circuits are disabled by the Mode switch in the CW and Tune positions.

### VOX AMPLIFIER (Figure 6-2)

When the Mode switch is in either the LSB or USB positions, the amplified audio signal from V1A is also applied through VOX GAIN control R131 and resistor R132 to the VOX amplifier tube, V12A. Any distortion that may occur by grid rectification in V12A is limited by resistor R132.

In the CW mode of operation, a signal (approximately 1000 Hz) from sidetone amplifier V12C is coupled through capacitor C131 to VOX amplifier V12A. Depending on the mode of operation, either the audio signal from V1A or the sidetone signal from V12C is amplified by V12A and then is coupled by C133 to diode D105. Diode D105 rectifies this signal to produce a positive DC voltage.

### RELAY AND ANTI-VOX AMPLIFIERS (Figure 6-3)

The positive DC voltage from diode D105 is coupled directly to the grid of relay amplifier V12B.

For VOX operation, V12B has its bias level set by a voltage divider network, consisting of resistors R136 and R135. This fixed value is at such a level that a small amount of positive voltage applied to the grid of V12B will cause current to flow through V12B and close relay RL1. The closing of RL1 causes the circuit changes required to place the Transmitter on the air.

VOX delay is determined by the time constant of the resistance-capacitance combination of resistor R149, capacitor C141, and VOX Delay control R148. The delay time is made variable

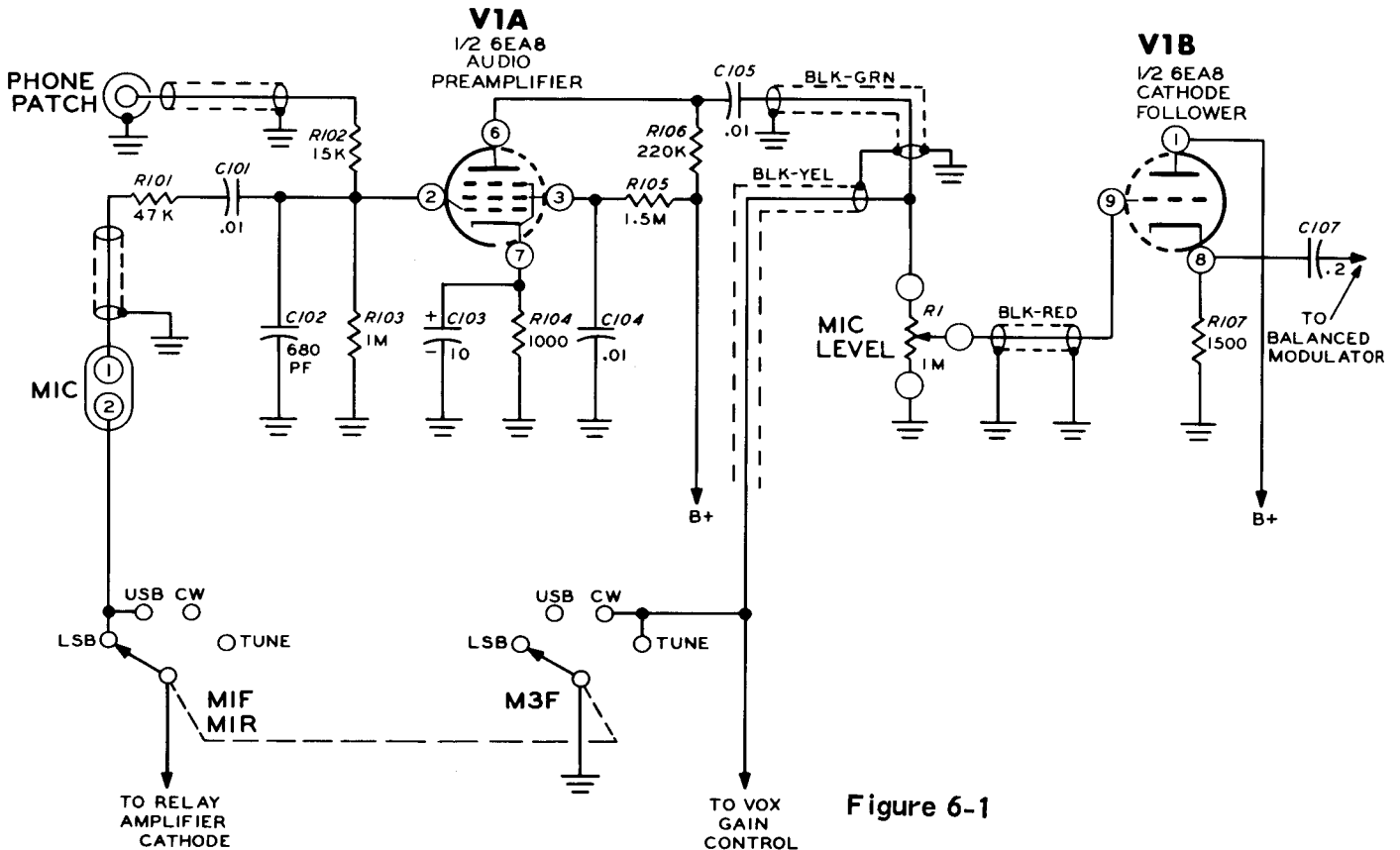


Figure 6-1

over a considerable range by the VOX Delay control.

In the LSB, USB, and Tune modes, V12B is biased through resistor R137 to ground, causing relay RL1 to close. The grounding of resistor R137 is automatic in the Tune position of the Mode switch, and is controlled by the button on the microphone for PTT (LSB, USB) operation.

V13A functions as an Anti-VOX control circuit. Anti-VOX prevents the transmitter from being keyed by audio picked up from the receiver speaker by the microphone. An audio signal from the station receiver is coupled through the Anti-VOX input socket and Anti-VOX control resistor R141 to the grid of V13A. This signal is amplified by V13A, coupled through capacitor C138, and rectified by diode D106. The negative voltage present at the resistance-capacitance network of resistor R146 and capacitor C139 is coupled to the input side of diode D105. This negative voltage will bias D105 so that it will not conduct, and relay RL1 will not close. Additional audio voltage caused by talking into the microphone will overcome the bias and allow the VOX circuit to close the relay.

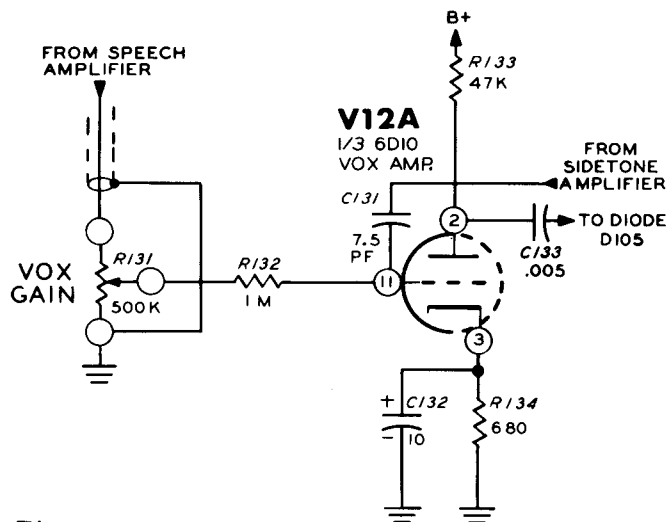


Figure 6-2

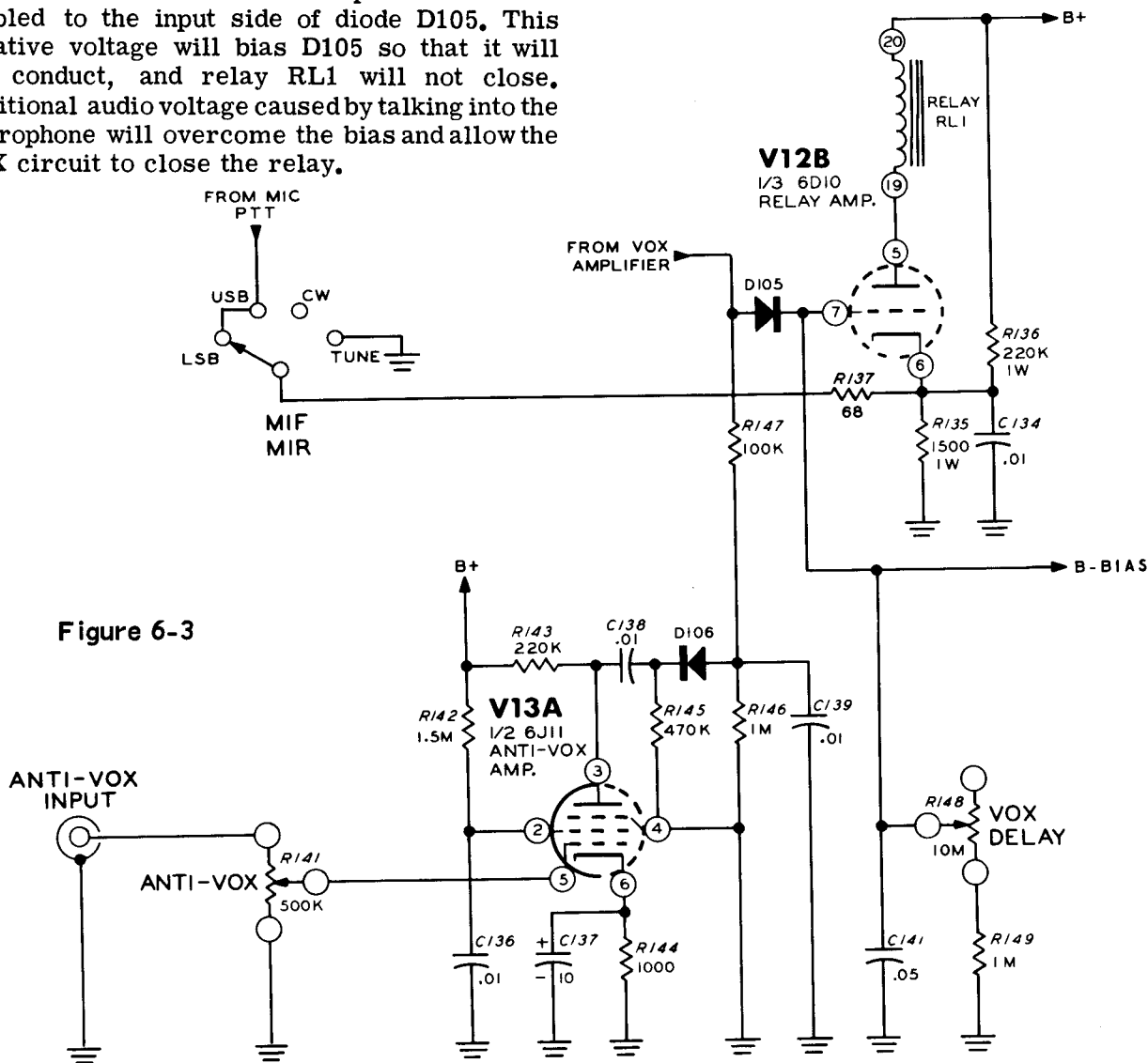


Figure 6-3

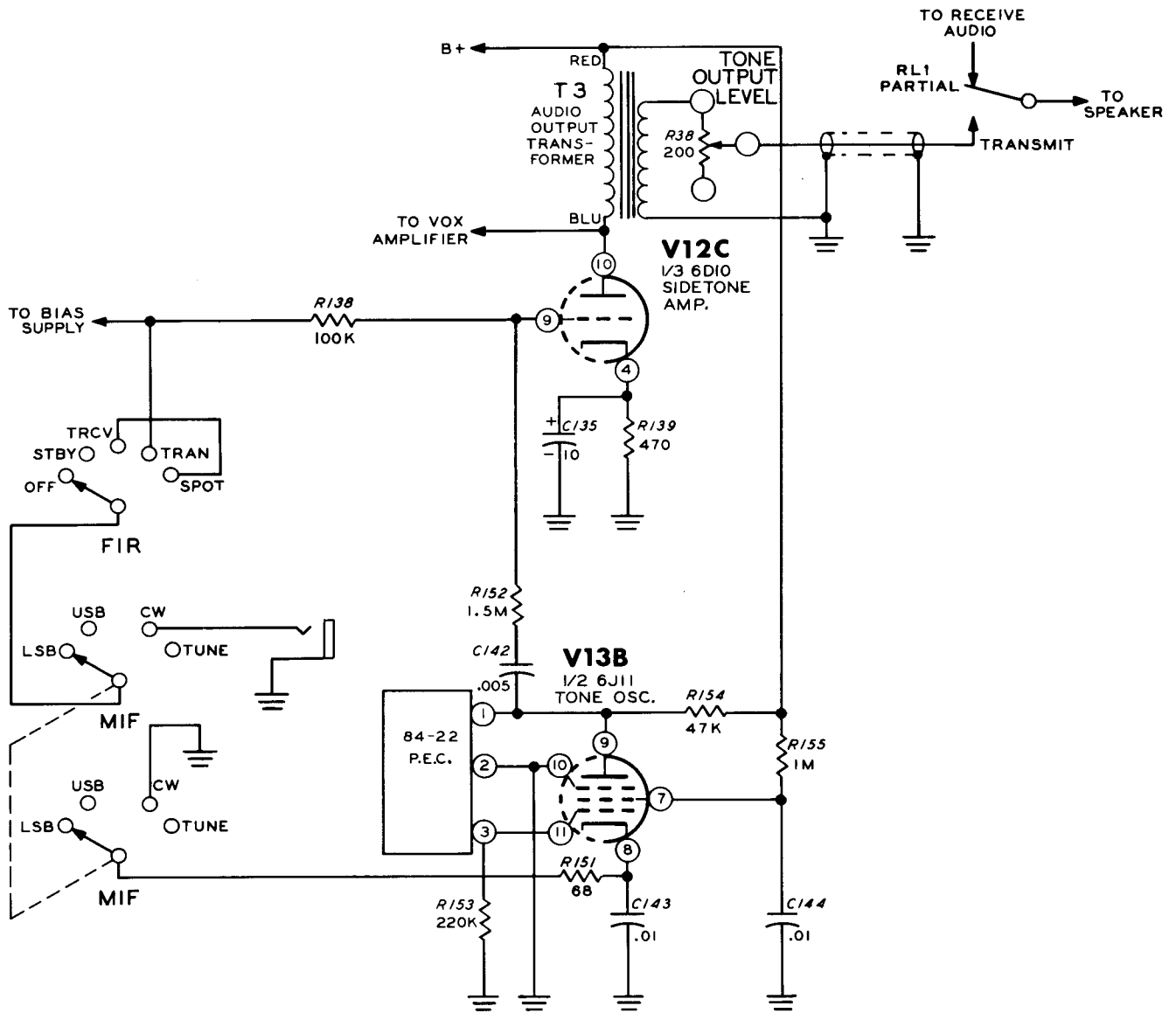


Figure 6-4

**TONE OSCILLATOR AND TONE AMPLIFIER (Figure 6-4)**

Tone oscillator V13B operates only when the Mode switch is in the CW position. The output audio frequency (approximately 1000 Hz) is determined by the phase shift network (P.E.C.). This audio tone is used to perform two functions: first, to key the VOX amplifier so that break-in CW operation is instantaneous with the

closing of the key; and second, the output of tone amplifier V12C is coupled to the receiver speaker (by relay RL1) so the operator may hear his keying during transmission.

Grid-block type key control is used for V13B. The output level of V13B to the receiver speaker is adjusted by control R38 to suit the individual requirements.

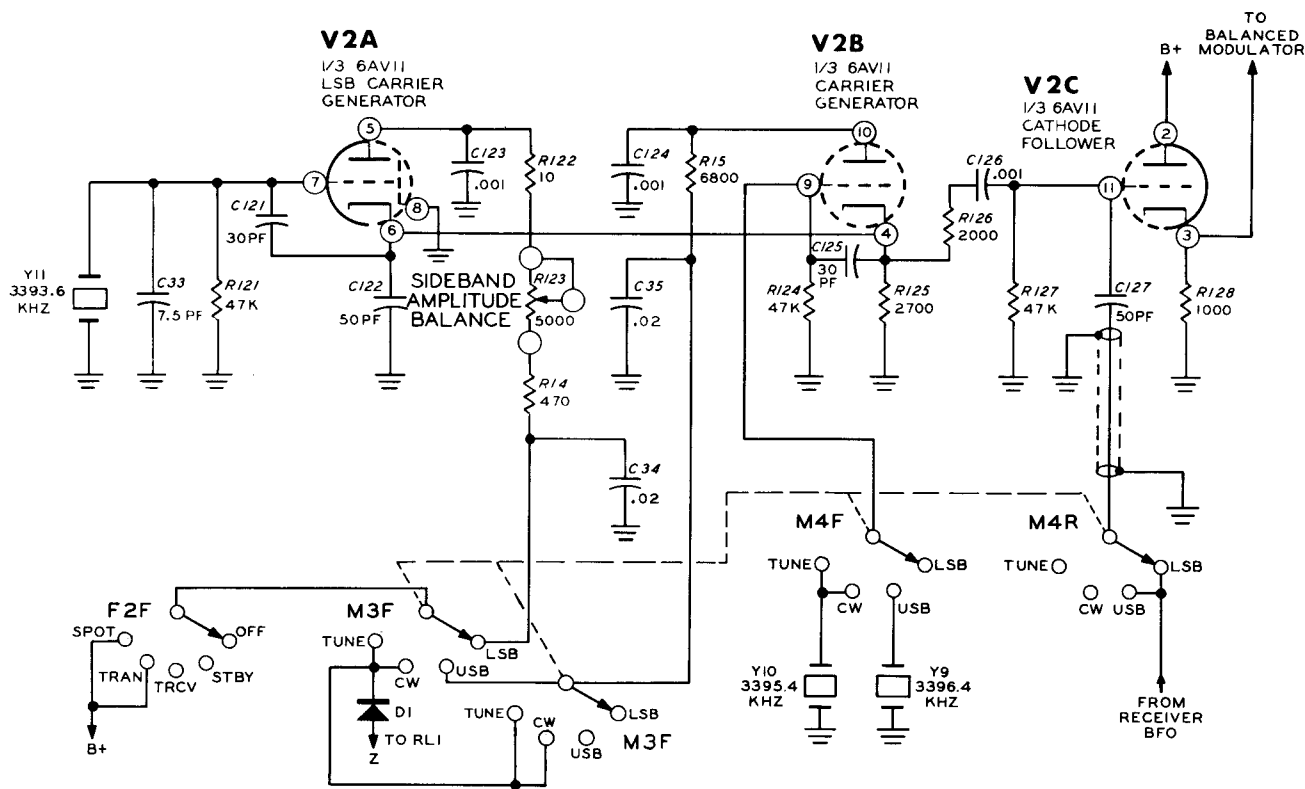


Figure 6-5

**LSB-USB-CW CARRIER GENERATOR AND CATHODE FOLLOWER (Figure 6-5)**

V2A and V2B are Colpitts type crystal oscillators. The setting of the Mode switch determines which of these tube sections will be in operation. This is done by switching B+ to the desired generator, and also selecting the proper frequency crystal for V2B. V2B serves as the USB and CW carrier generator, and V2A serves as the LSB carrier generator.

The output of the carrier generator is coupled through capacitor C126 to the grid of cathode follower V2C. Sideband Amplitude Balance control R123 is adjusted for equal USB and LSB output by slightly lowering or raising the B+ voltage on V2A. This adjustment is not critical and a preset value is sufficient.

For transceiver operation in the CW mode, the receiver must be tuned one kilohertz above the frequency of the received CW signal, thus

producing a 1000 Hz beat note. If the transmitter and the receiver were tuned to the same frequency, as in normal transceiver operation, no beat note could be heard. With the receiver tuned 1000 Hz above the received signal, the transmitter CW carrier generator automatically compensates and transmits a signal 1000 Hz below the receiver dial setting. This allows the transmitted and received signals to be on the same frequency, yet allowing the receiver to produce an audible tone.

For transceiver operation in either USB or LSB modes, the carrier generator in the Transmitter is inoperative on both transmit and receive modes. The required carrier generator signal for both transmit and receive is obtained from the receiver BFO. On transmit, the BFO receiver signal is coupled through capacitor C127 to the grid of V2C. Cathode follower V2C is an impedance matching stage for the low input impedance of the balanced modulator.

## BALANCED MODULATOR (Figure 6-6)

When the audio signal from V1B and the RF signal from carrier generator cathode follower V2C is applied to the 4-diode balanced modulator, two different frequencies are produced. This ring-type balanced modulator uses diodes D101 through D104.

One of the two signals produced by the balanced modulator is the sum of the audio and carrier frequencies; the other signal is the difference between the audio and carrier frequencies. These signals are the upper and lower sidebands.

The carrier signal is applied across the modulator diode ring in a balanced circuit, consisting of one winding of the balanced modulator transformer, resistors R108 and R111, and Carrier Null control R109. The Carrier Null control and variable capacitor C109 are used to balance out the carrier signal in the modulator, leaving only the upper and lower sideband signals at the modulator output.

The output from the balanced modulator is the result of combining the audio and carrier signals. Neither the audio or carrier signal appears in the output, but the effect of the audio signal unbalancing the nulled circuit at an audio rate produces the sum-and-difference frequencies called sidebands. With no audio, there is no output from the balanced modulator.

With the Mode switch in the CW position, a small amount of DC voltage is applied through R401 to upset the balance of the modulator when the Transmitter is keyed. This unbalance produces an output on the CW carrier frequency of 3395.4 kHz from the balanced modulator, which is controlled by CW Level control R16.

## ISOLATION AMPLIFIER (Figure 6-7)

The sideband signals from the balanced modulator are coupled through balanced modulator

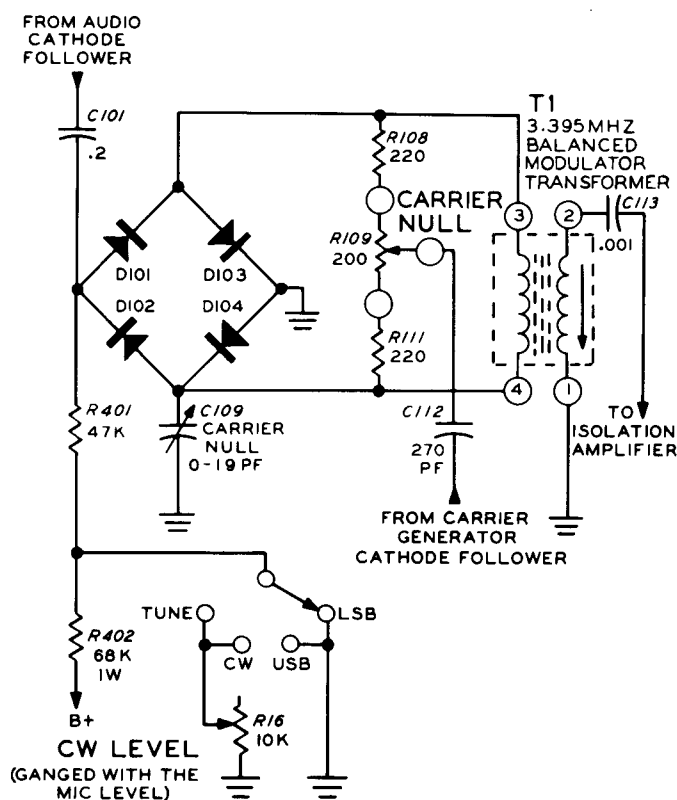


Figure 6-6

transformer T1 to the grid of isolation amplifier tube V3. The secondary of the transformer is tuned to the CW carrier frequency. V3 serves to isolate the balanced modulator from the crystal filter and provides proper impedance matching to the crystal filter. A secondary purpose of V3 is to provide the automatic level control (ALC) function in the Transmitter. The ALC function will be discussed later.

The output of V3 is coupled through capacitor C118 to the crystal filter. During receive periods, this stage is biased sufficiently to cut the tube off and prevent any signal leak-through.

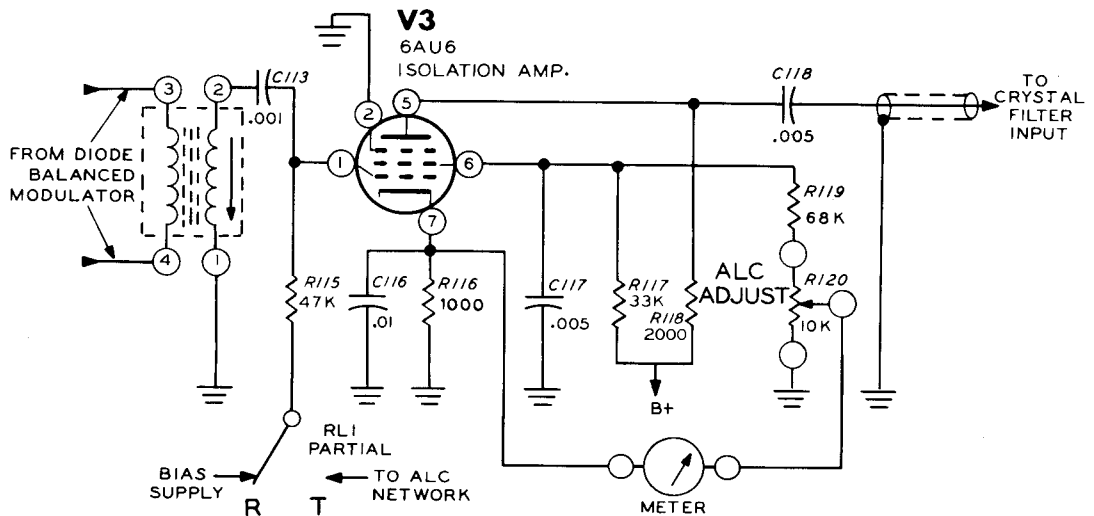
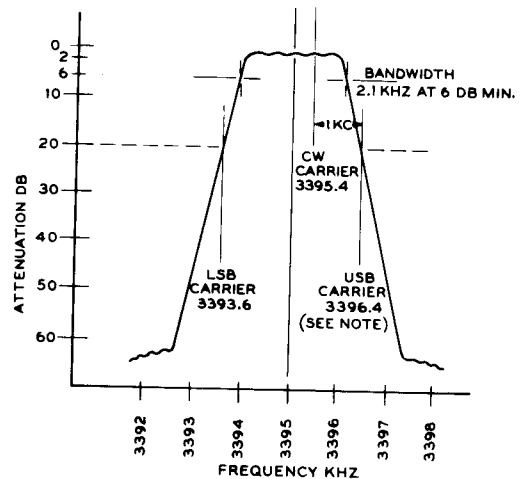


Figure 6-7

**SYMMETRICAL CRYSTAL BANDPASS FILTER (Figure 6-8)**

The crystal filter is a 2.1 kHz lattice type, designed to pass the usable LSB (3393.6 kHz) and USB (3396.4 kHz) modulated signals, and a carrier (3395.4 kHz) frequency. The carrier frequency is used in the CW and Tune Modes. The resulting low impedance signal is coupled through capacitor C118 to the grid of LMO (linear master oscillator) mixer V4. NOTE: Resistance measurements on the crystal filter are not meaningful due to differences in manufacturers.



NOTE: From the Figure, it appears that the USB CARRIER FREQUENCY would pass the lower sideband frequencies. Due to further conversion, the signal is inverted in later stages and the output frequencies are those of the upper sideband.

**LINEAR MASTER OSCILLATOR**

The LMO, consisting of tube V6 with its associated circuit, is a very stable linear oscillator that operates over a frequency range of 5 to 5.5 megahertz. The tuning capacitor changes the LMO frequency and thus changes the operating frequency of the Transmitter. The output signal of the LMO is coupled to the cathode of LMO mixer tube V4.

In this instance (using 3.895 mHz as an operating frequency), it can be seen from the Frequency Chart that an 8.5 megahertz signal is required at the LMO mixer. Because the LMO mixer frequency is the sum of the carrier generator and LMO signals, the LMO output will be 5.105 megahertz.

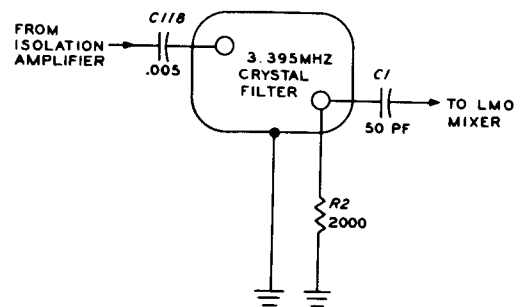


Figure 6-8



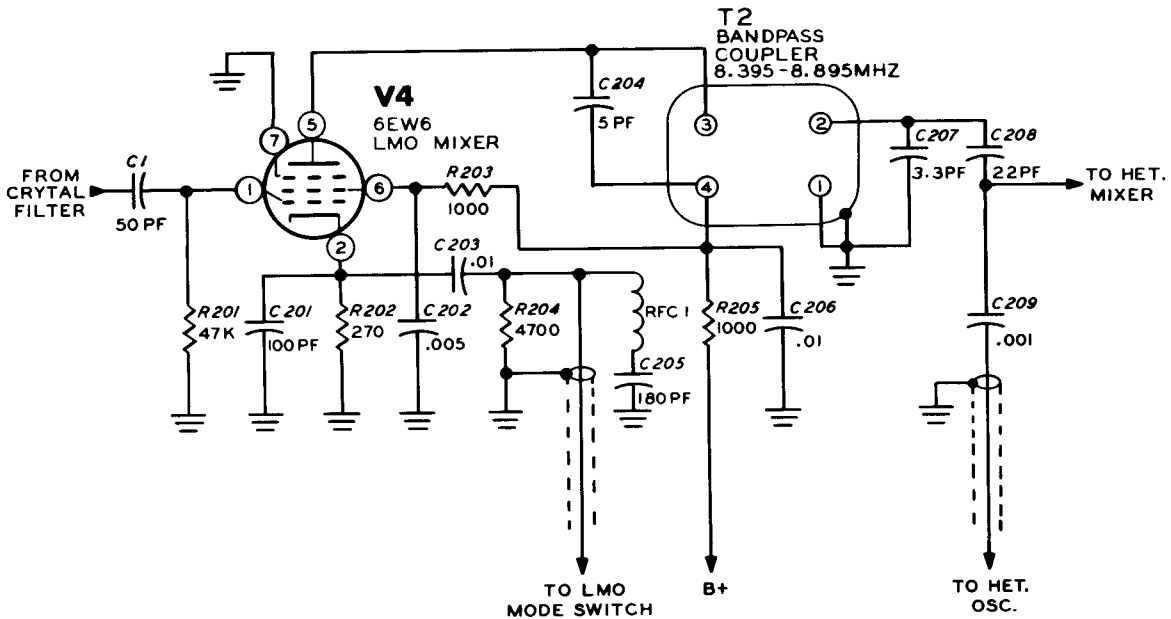


Figure 6-9

### LMO MIXER (Figure 6-9)

The carrier generator signal (3,395 megahertz) at the grid and the LMO signal (5,105 megahertz) at the cathode of LMO mixer V4 are mixed in the tube to produce the sum and difference of these two frequencies. The LMO signal is obtained from either the internal LMO (Transmit operation) or from the external receiver LMO (transceiver operation), depending on the position of the Freq Control switch.

The output sideband signal from V4 is coupled through the bandpass coupler to heterodyne mixer tube V5. The bandpass coupler transformer is tuned to pass only signals with a frequency between 8,395 and 8,895 megahertz. Only the sum of the carrier generator and LMO signal frequencies fall within this frequency range. In all cases, it is only the sum of the frequencies from V4 that is passed through the bandpass filter, as the different frequencies always fall outside its frequency range.

### HETERODYNE OSCILLATOR AND HETERODYNE-OSCILLATOR AMPLIFIER (Figure 6-10, fold-out Page 133)

Heterodyne oscillator V8A has regulated B+ voltage applied only when the Function switch is in the Standby, Transmit, and Spot positions.

V8A operates as a tuned-plate crystal-controlled oscillator. Band switch wafer 1F selects the proper crystal and band switch wafer 2F selects the proper plate coil (L1 through L8) for the desired frequency of operation. The output of V8A is coupled through capacitors C49 and C209 to the grid of heterodyne mixer tube V5.

In the Transceive mode, B+ voltage is removed from V8A and applied to V8B, the heterodyne oscillator amplifier. V8B amplifies a heterodyne oscillator signal from the receiver, and uses the same coils (L1 through L8) as did V8A for proper plate tuning. The output signal is coupled through capacitors C49 and C209 to the grid of heterodyne mixer V5.

### HETERODYNE MIXER (Figure 6-11)

The sideband signal from the bandpass coupler and the RF signal from the heterodyne oscillator are coupled to the grid of heterodyne mixer V5. These signals are mixed to produce their sum and difference frequencies in tube V5. The plate of V5 is tuned by capacitors C4A and C4B with the proper tuned circuit (L9 through L14) selected by the Band switch.

The plate frequency-selected circuits are such that only the difference frequencies are permitted to pass through, and all other frequencies

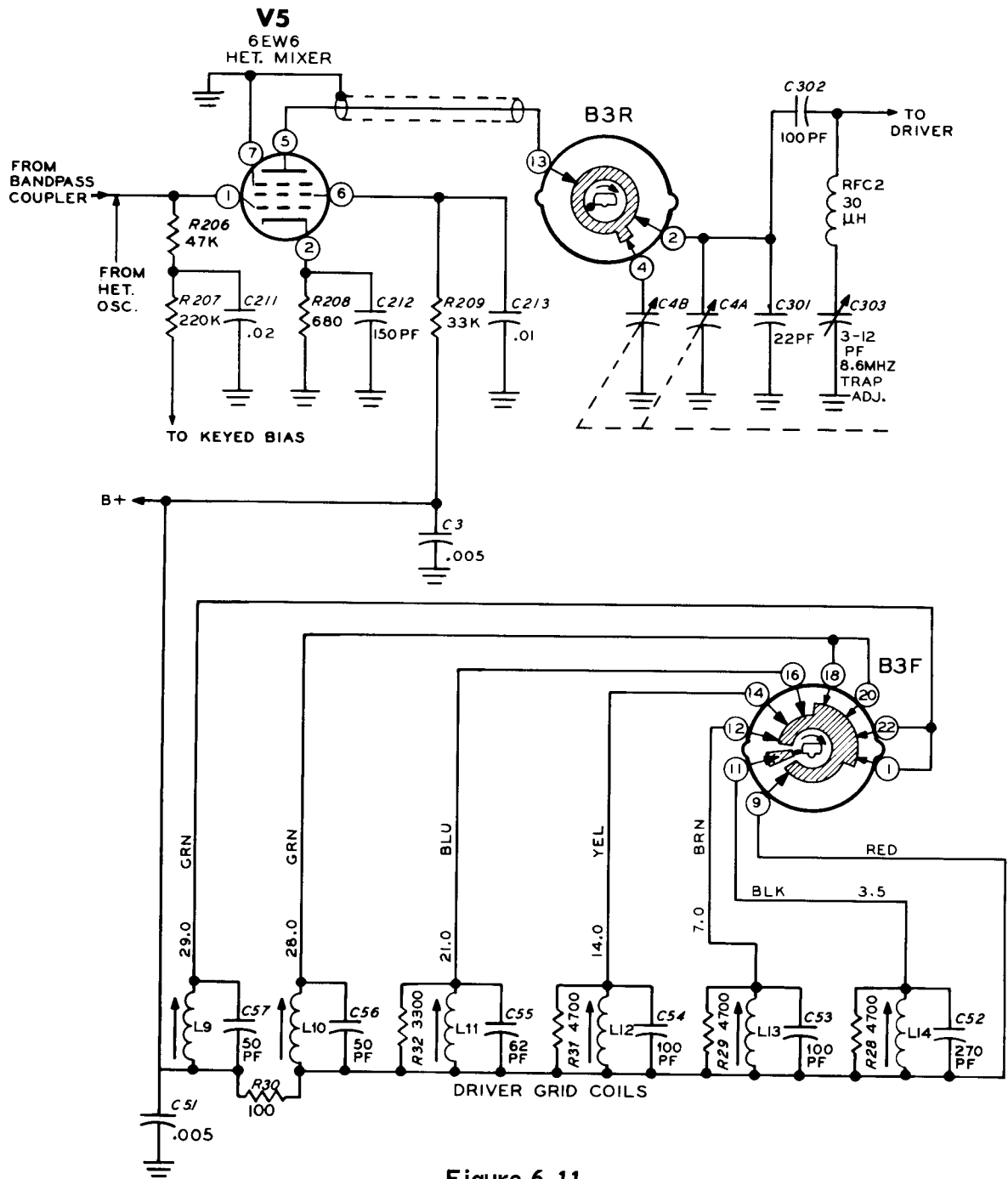
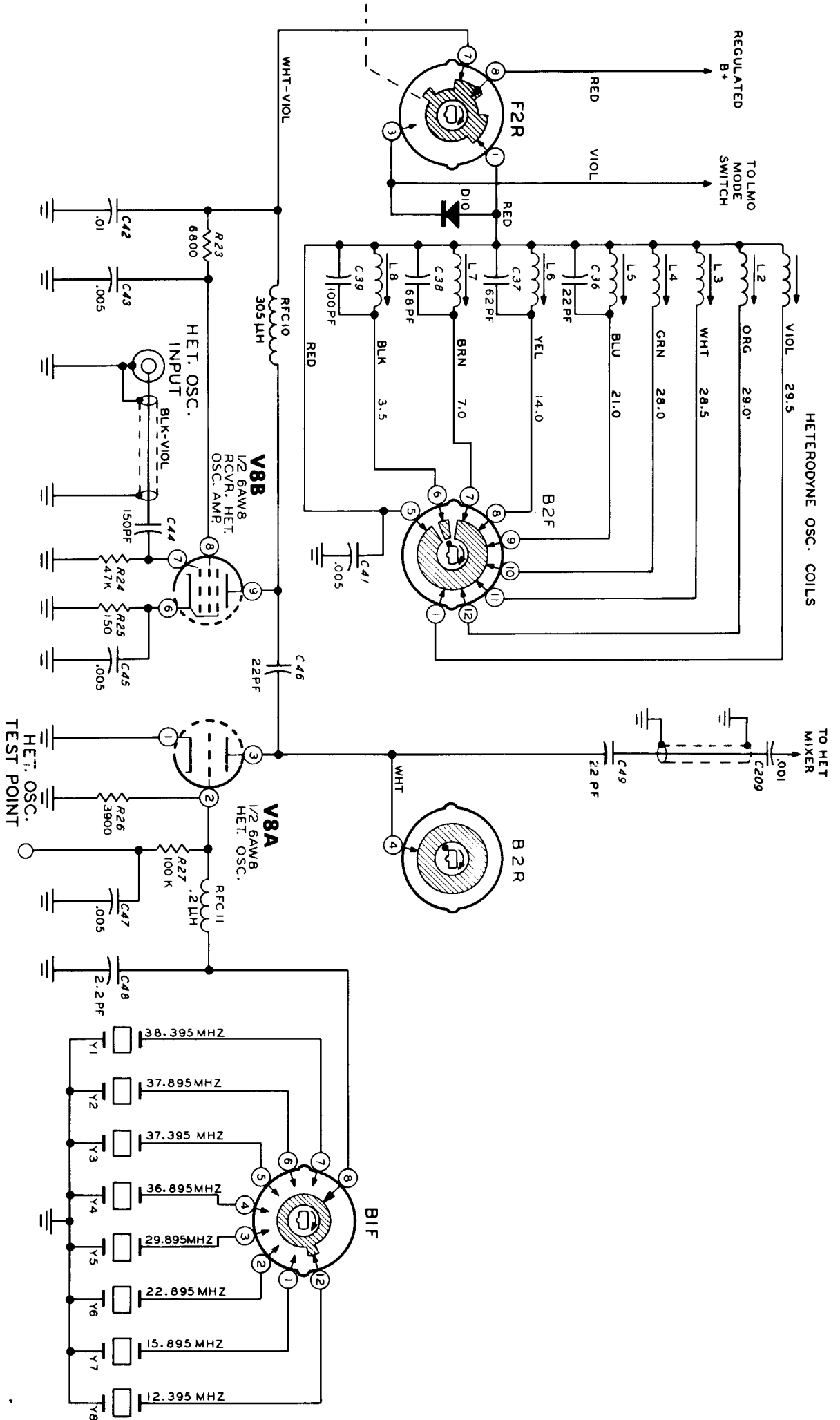


Figure 6-11

are passed to ground. In this instance, the difference between the sideband frequency of 8.5 megahertz and the heterodyne oscillator frequency of 12.395 megahertz results in a heterodyne mixer output frequency of 3.895 megahertz.

The output signal from tube V5 is coupled to drive V9 through capacitor C302. Any RF energy that may be fed through the bandpass filter at approximately 8.6 megahertz present at the plate of V5, is passed to ground by a trap, consisting of RFC2 and capacitor C303.



**FIGURE 6-10**



## DRIVER (Figure 6-12)

Driver stage V9 functions as a voltage amplifier to increase the low level heterodyne mixer output signal to a level sufficient to drive the final amplifier tubes. Since the grid and plate are tuned to the same frequency, the tube socket is shielded to prevent self-oscillation.

The plate of V9 is tuned by capacitor C4C (Driver Tune) with the proper tuned circuit (L15 through L19) selected by the Band switch. On the 3.5 megahertz band, capacitor C4D is added to increase the tuning capacitance.

Neutralizing energy is coupled from the final amplifier plates through capacitor C24 and is adjusted by capacitor C23 to neutralize the final amplifier grid-to-plate capacitance.

The output signal of the driver stage is coupled through capacitor C9 to the grids of the final amplifiers. In this instance, at a frequency of 3.895 megahertz.

## FINAL AMPLIFIERS (Figure 6-13)

Final amplifiers V10 and V11 are parallel connected and function as class AB1 linear amplifiers. A fixed operating bias of approximately -50 volts is maintained on the grids of these tubes, limiting zero signal plate current to 50 milliamperes. Under Standby conditions, the B+ voltage is removed from the screen grids to reduce the plate current to zero, thus cutting the tubes off. RF driving voltage is developed across RFC6.

Peak driving voltage is continuously variable in CW, and is set by Level control R16. In the LSB and USB Modes, the peak driving voltage is controlled by Microphone Level control R1 and the limiting action of the ALC. Plate voltage is shunt fed through RFC9 and bypassed for RF by feedthrough capacitor C67.

The output of V10 and V11 is coupled through capacitor C25 to the pi-section plate tank. RF parasitic chokes RFC7 and RFC8 in the plate leads eliminate any tendency toward parasitic oscillation. The proper tap of the plate tank coils (L20 and L21) is selected by the Band switch. Capacitors C27, C28, C31, and C32 (depending on the Band switch setting), with capacitors C29A, B, and C (Final Loading),

provide a 50  $\Omega$  impedance point on each band. Loading is variable from 40  $\Omega$  to approximately 150  $\Omega$  on any band. Plate tuning resonance points are marked on the front panel of the Transmitter.

## AUTOMATIC LEVEL CONTROL (Figure 6-14)

When operating in the LSB or USB modes, the ALC circuit is connected to the grid of isolation amplifier V3. A normal fixed bias condition exists at the grid of V3, providing maximum gain. When the final amplifier grids begin to draw current, a voltage occurs at the junction of resistor R33 and capacitor C308. This voltage follows the audio voltage peaks and is coupled through capacitor C308 to diodes D301 and D302. A portion of this fluctuating voltage is rectified by the diodes and appears as a bias voltage at the junction of resistors R303 and R304.

This bias voltage is fed to the grid of V3, effectively limiting its output and thereby reducing the drive available to the final amplifiers.

The resistance and capacitance network consisting of resistors R303 and R304, and capacitors C306 and C307 is a fast-attack, slow-decay network which effectively prevents overdrive in all but extreme settings of the Level control.

The ALC Adjust control is used to provide a zero meter setting when the Meter switch is in the ALC position.

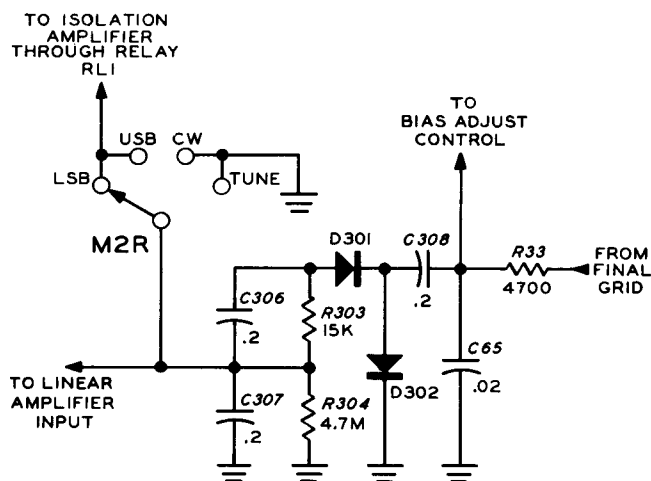


Figure 6-14

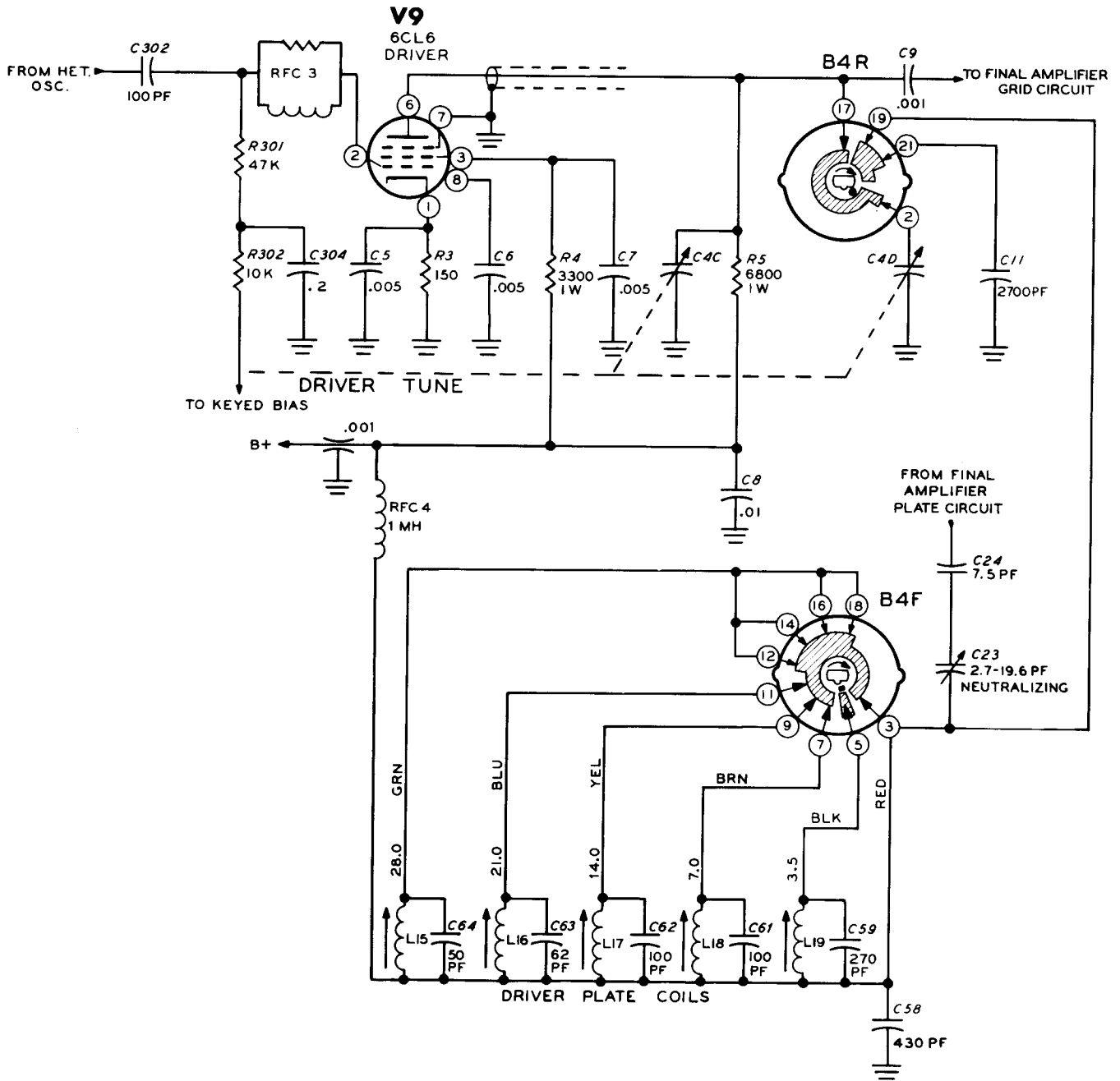


Figure 6-12

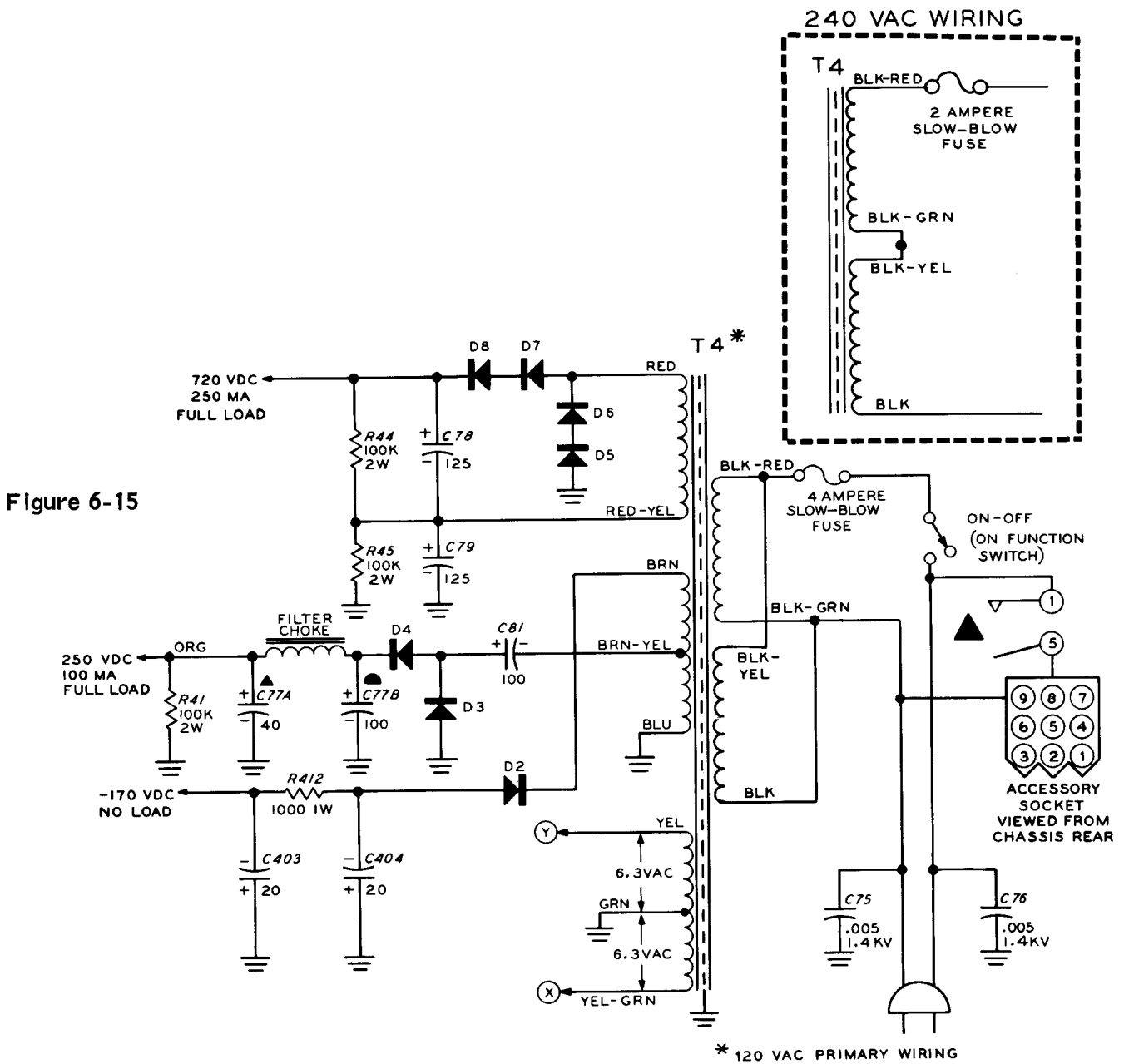


Figure 6-15

**POWER SUPPLY (Figure 6-15)**

Four silicon diodes are used to rectify the AC voltage developed across the high voltage secondary winding (red and red-yellow leads) of the power transformer. These diodes, D5 through D8, are connected in a full-wave voltage-doubler circuit.

The diodes are connected so that during one-half of the AC cycle, capacitor C78 becomes charged; and during the next one-half of the AC cycle, capacitor C79 is charged, resistors R44 and R45 provide a discharge path for these capacitors. The capacitors are charged individ-

ually but discharge in series to produce a DC voltage equal to approximately twice the applied peak AC voltage. Because of the large capacitance of C78 and C79, the output of the voltage doubler has low ripple and excellent dynamic regulation.

The low voltage secondary winding (brown-yellow and blue leads) applies 95 volts AC (rms) to a half-wave voltage-doubler circuit, consisting of diodes D3 and D4, capacitors C81, C77A and C77B, and the filter choke. The use of a high capacitance input pi-filter network provides a well filtered DC output with a low percentage of ripple.

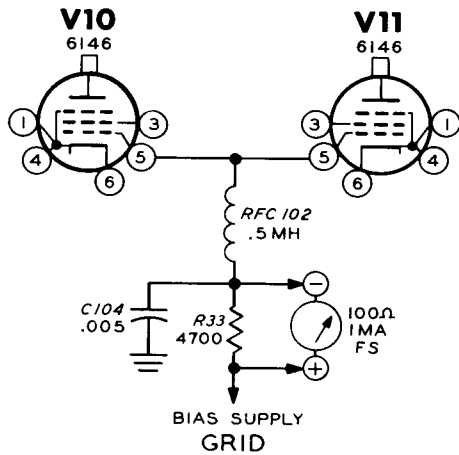


Figure 6-16

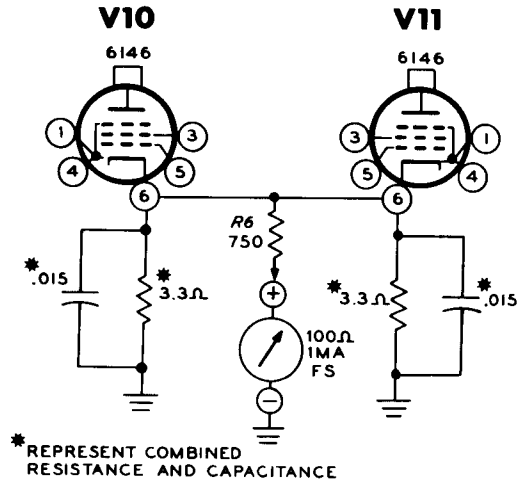


Figure 6-17

The AC voltage obtained from the low voltage secondary winding (brown lead) is approximately 125 volts (rms). A half-wave rectifier circuit consisting of diode D2, capacitors C404 and C405, and resistor R412, removes the 60 Hz ripple from the bias voltage. With suitable divider networks (see the Schematic Diagram), variable bias (-45 to -70 volts) and various fixed bias levels are obtained.

All tube filaments receive voltage from a separate power transformer filament winding (yellow, green, and yellow-green leads).

The primary winding of the power transformer is fused and a TV type quick-disconnect line cord is used.

**METERING CIRCUITS**

**Grid (Figure 6-16)**

Current in the grid circuits of final amplifiers V10 and V11 is shunted through the meter, which has a 1 milliampere full-scale, 100 Ω movement. This provides a 0-1 ma range in this position of the Meter switch.

**Plate (Figure 6-17)**

Plate current is indicated by measuring the amount of current in the cathode circuit of the final amplifiers. For 500 milliamperes of cathode current in the cathode circuit (combined resistance-capacitance cathode circuits), there will be 1 milliampere of current in the meter.

**Automatic Level Control (Figure 6-18)**

The meter is balanced for no-signal conditions (zero current) in the cathode circuit of isolation amplifier V3 by ALC Adjust control R120. When a sideband signal is transmitted and ALC (negative) voltage is applied to the grid of V3, the tube draws less current, causing the cathode to become less positive and the screen to become more positive. The voltage difference developed across the meter causes a current through the meter, which indicates ALC action in the Transmitter.

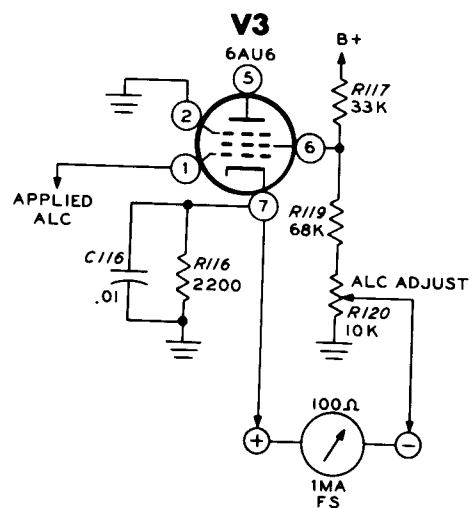


Figure 6-18



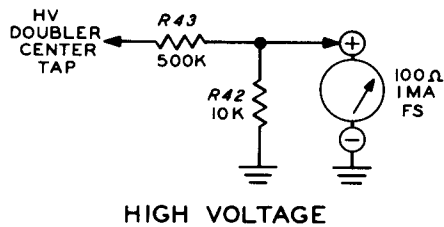


Figure 6-19

### High Voltage (Figure 6-19)

With the meter connected in parallel with resistor R42 and in series with R43, and with 500 volts from the power supply impressed across this resistor combination, there will be 1 milliampere of current through the meter. A current of 1 milliampere through the meter will cause full-scale deflection. Resistor R42 limits the voltage on the Meter switch when it is not in the HV position.

Since the voltage source is the center tap of the high voltage doubler circuit, the meter indicates 1000 volts, full scale, or the voltage that should be present at the high voltage tap of the voltage doubler.

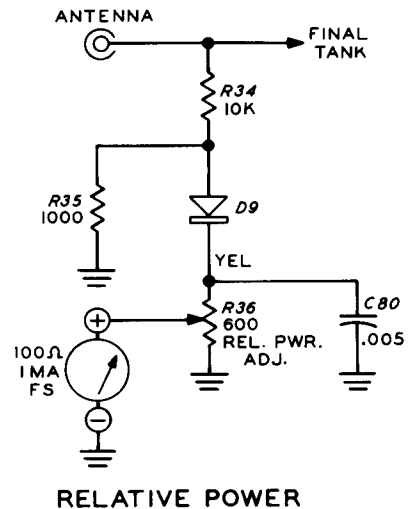
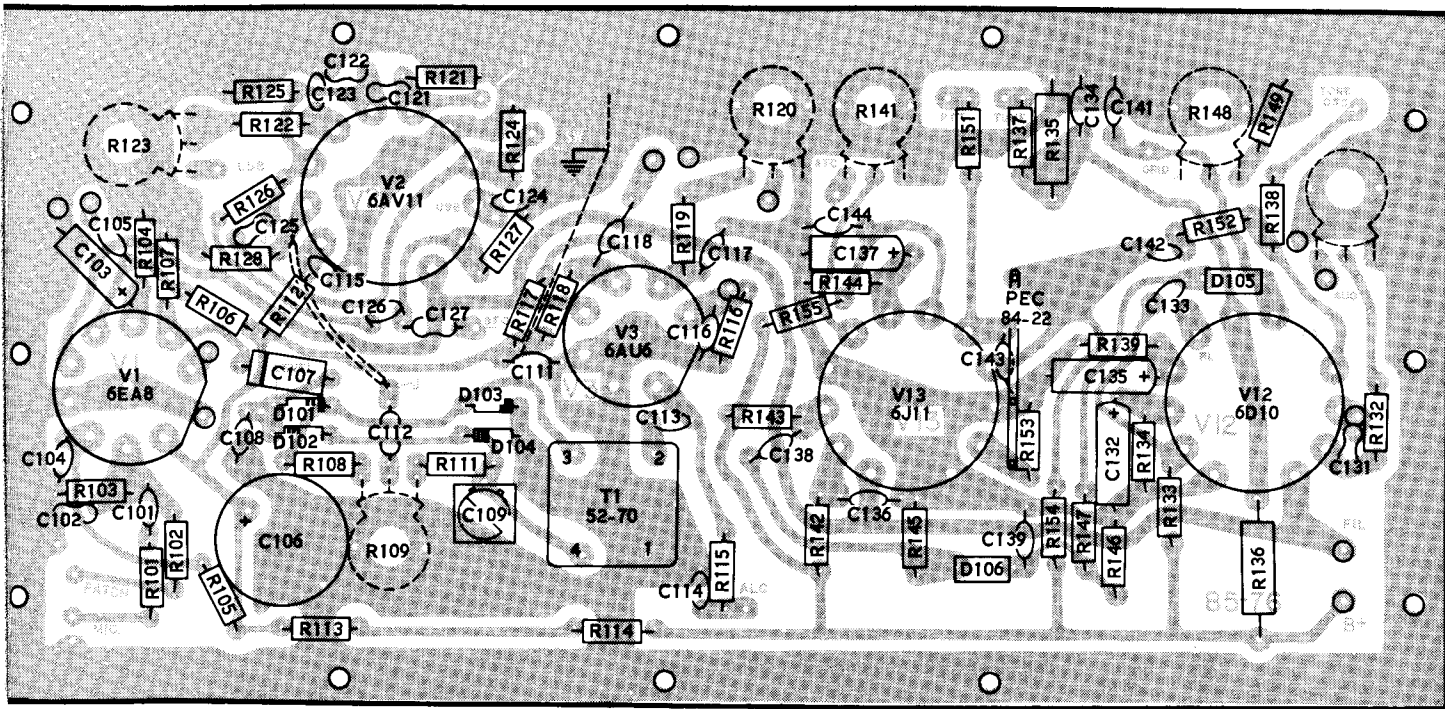


Figure 6-20

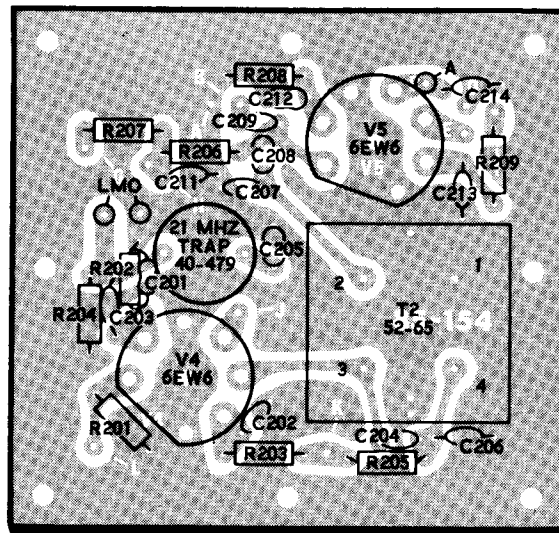
### Relative Power (Figure 6-20)

Relative power readings are obtained by rectifying a small amount of the RF output with diode D9. This rectified (DC) voltage is applied across the meter, and is adjusted by relative power adjust control R36 for full-scale deflection on the 3.5 megahertz band.

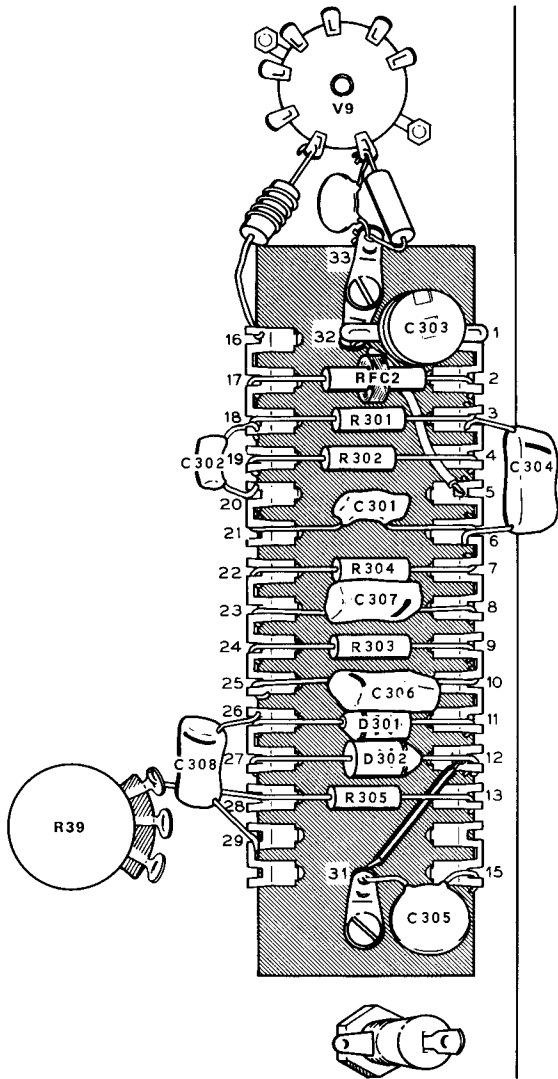
# CIRCUIT BOARD X-RAY VIEWS (VIEWED FROM FOIL SIDE)



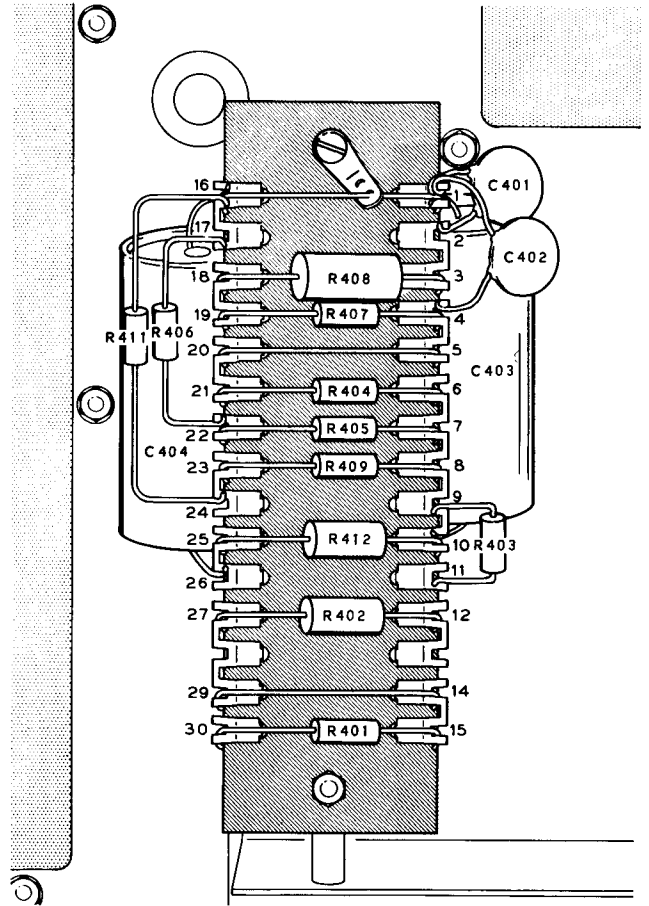
CARRIER GENERATOR CIRCUIT BOARD



MIXER-BANDPASS CIRCUIT BOARD



TERMINAL BOARD #1



TERMINAL BOARD #2

# CHASSIS PHOTOGRAPHS

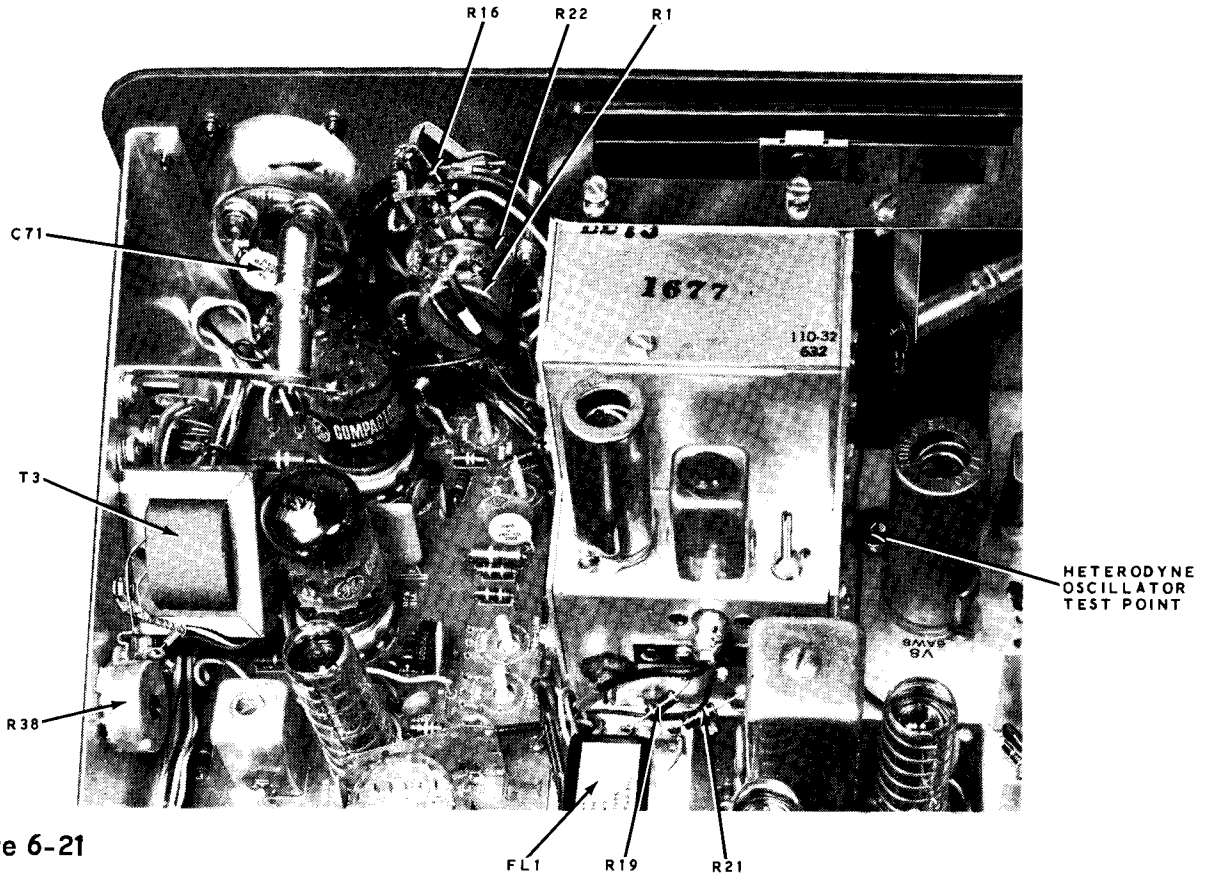


Figure 6-21

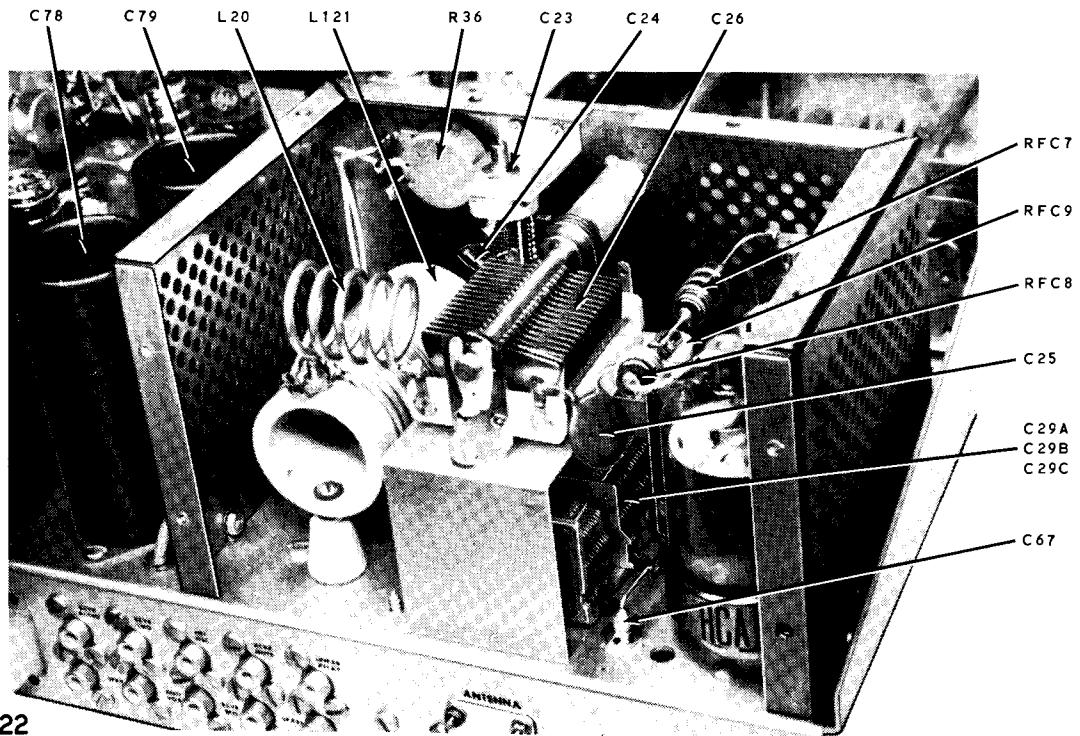


Figure 6-22

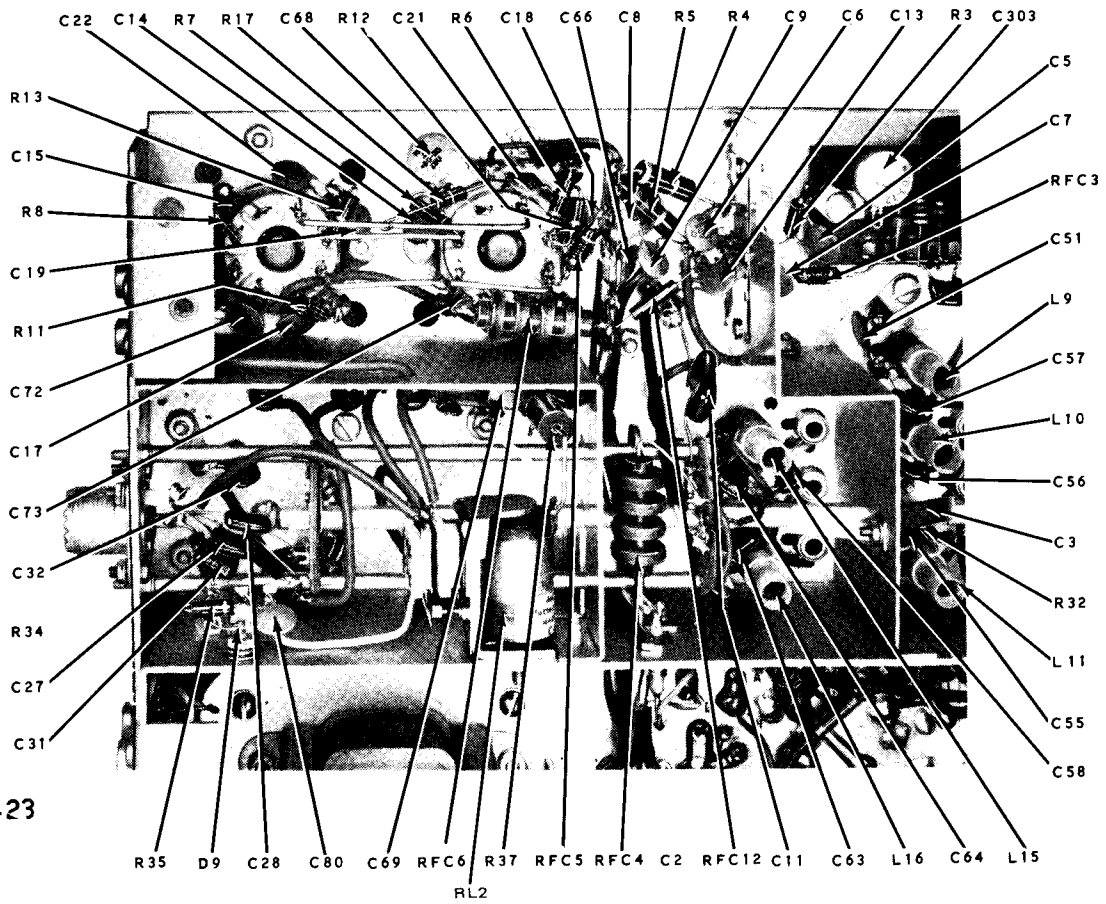


Figure 6-23

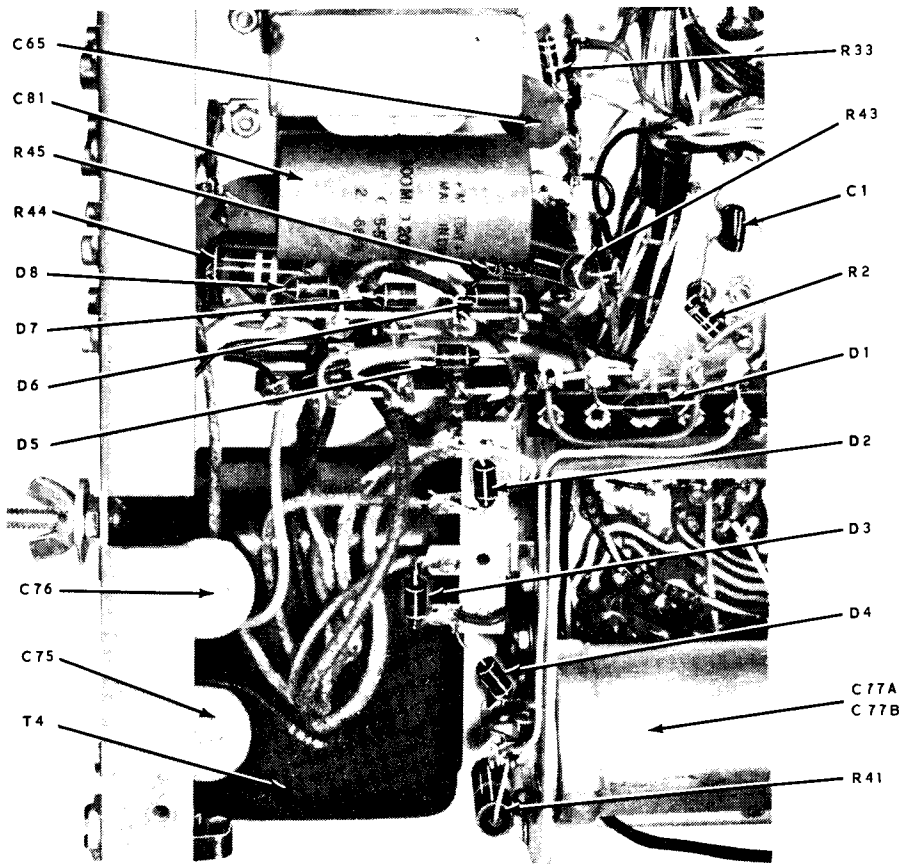


Figure 6-24

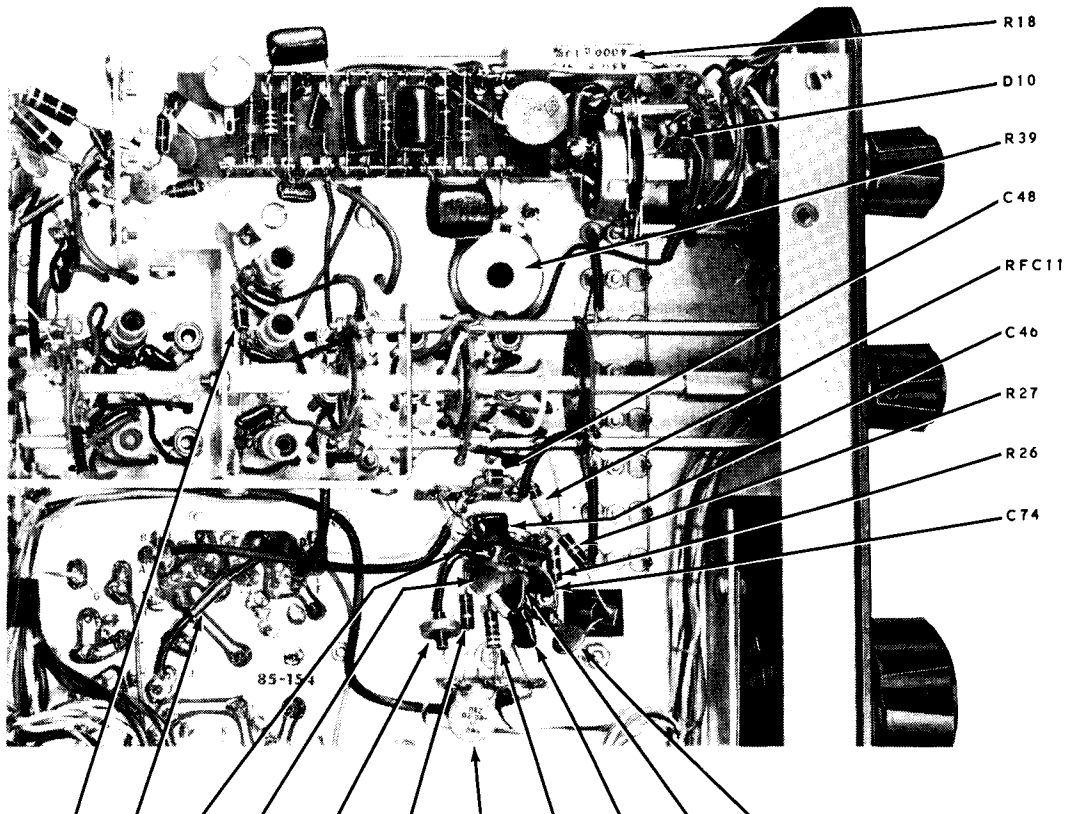


Figure 6-25 R30 RFC13 C49 C43 RFC10 R23 C42 R24 C44 C45 C47

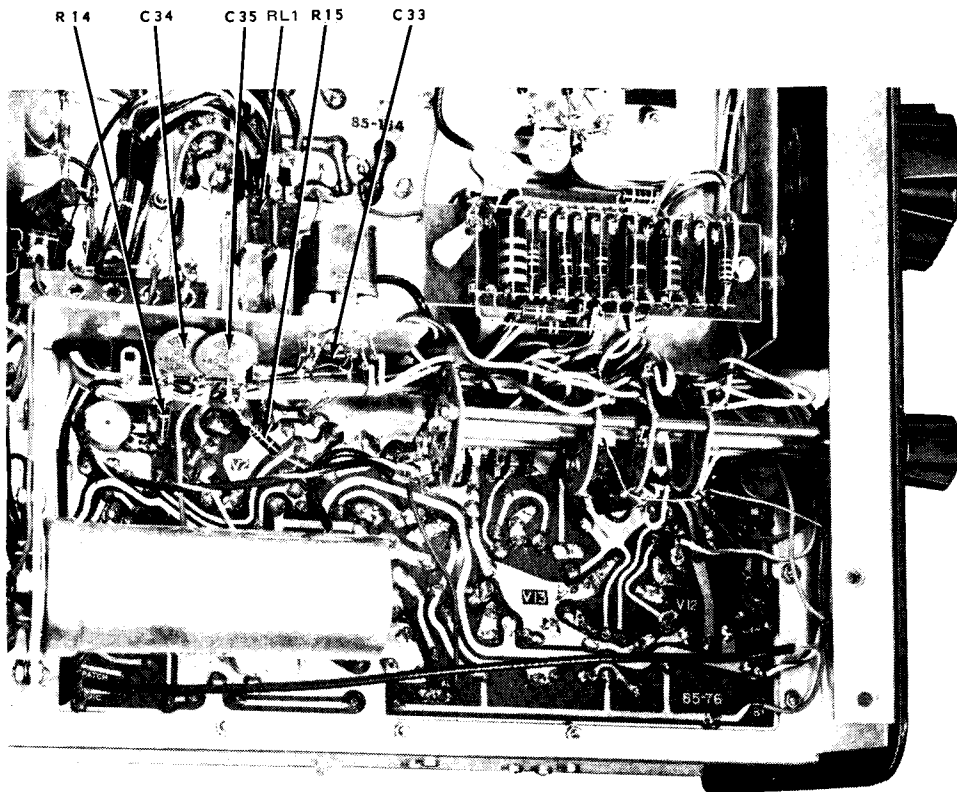


Figure 6-26

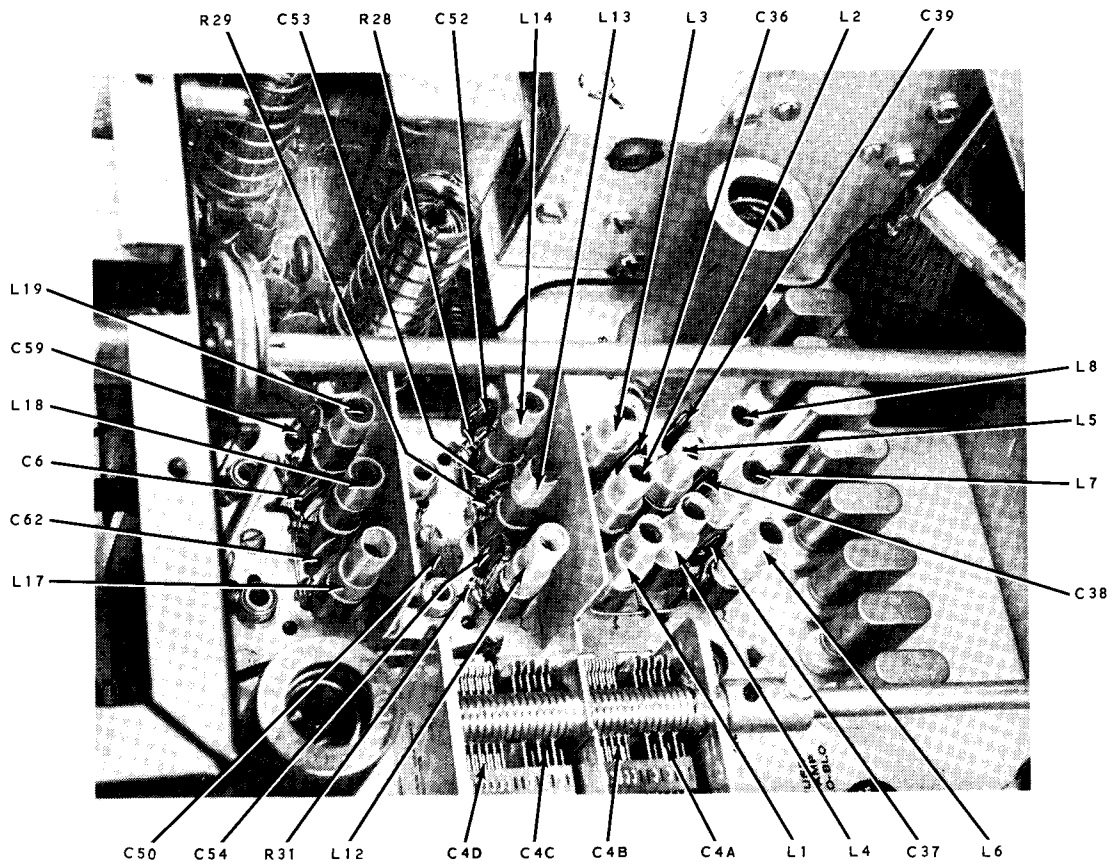






Figure 6-27

**VOLTAGE AND RESISTANCE CHART NOTES**

SWITCH AND CONTROL POSITIONS	MEASUREMENTS CONDITIONS			
				
FUNCTION	STBY	SPOT	TRCV	OFF
BAND	3.5			
MODE	CW			CW
DRIVER	Full counter-clockwise dial marking	Tuned		
FINAL LOAD	50 $\Omega$			
FINAL	80			
LEVEL	Fully clockwise	Fully clockwise		
METER	REL PWR			REL PWR
LMO	0			
KEY	OPEN			OPEN

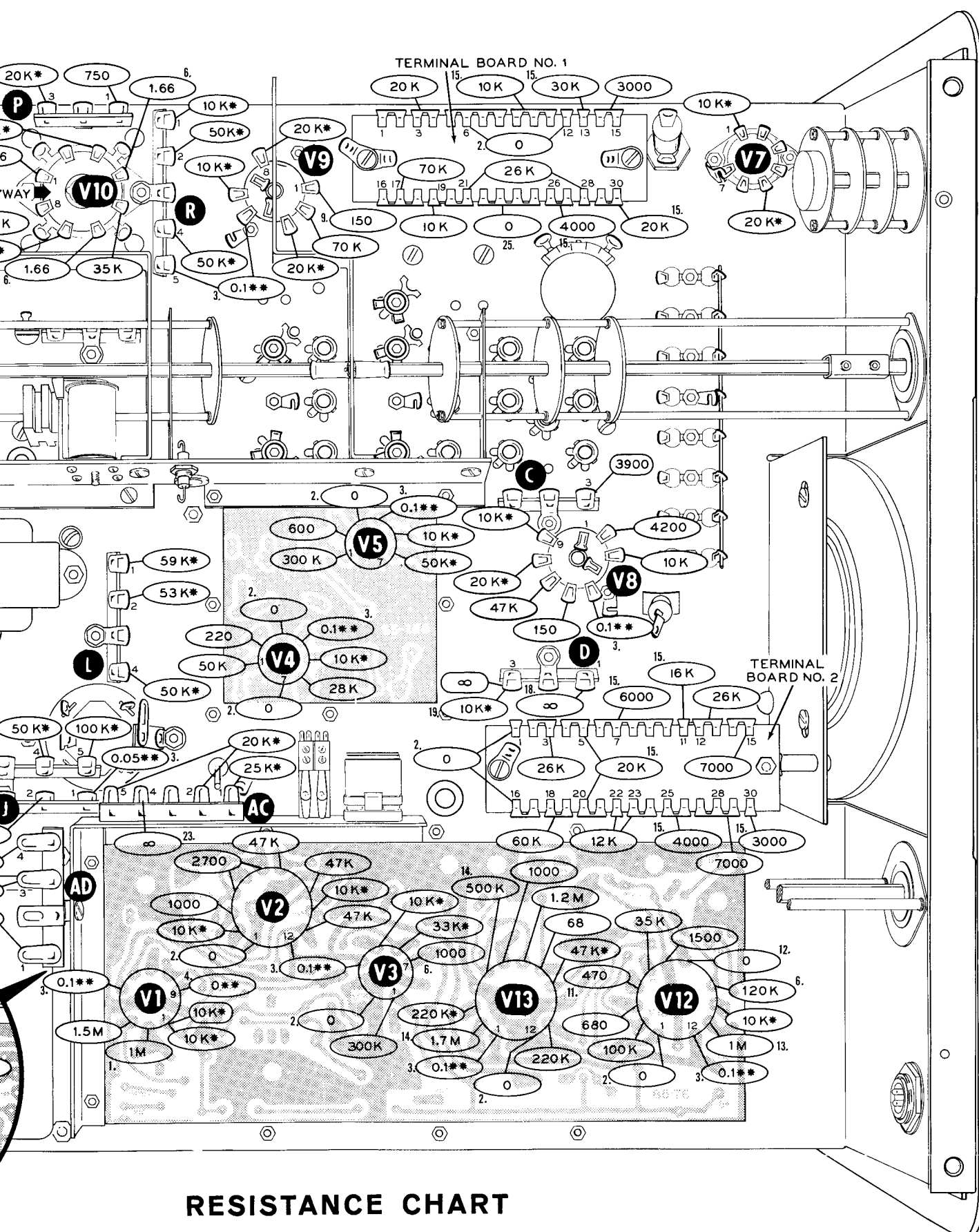
\* MINIMUM AFTER 5 SECONDS

\*\* APPROXIMATELY

1. MAY VARY.
2. CHASSIS GROUND.
3. FILAMENT.
4. VARIES WITH SETTING OF LEVEL CONTROL.
5. VOLTAGE PRESENT ONLY ON LSB.
6. TUBE IS CUT OFF.
7. VOLTAGE DEPENDS ON AMPLITUDE OF HETERODYNE MIXER INJECTION.
8. VARIES WITH CRYSTAL ACTIVITY AND HETERODYNE OSCILLATOR COIL SETTING.
9. PENTODE SECTION OPERATES ONLY IN TRANSCEIVE.
10. RELAY NOT CLOSED.
11. OPERATES ONLY WITH KEY DOWN IN CW MODE.
12. GROUNDED BY THE FUNCTION SWITCH.
13. VARIES WITH SETTING OF VOX CONTROL.
14. VARIES WITH SETTING OF ANTI-VOX CONTROL.
15. VARIES WITH VOLTAGE IMPRESSED ACROSS DIODE.
16. GROUNDED BY MODE SWITCH.
17. VARIES WITH SETTING OF BIAS ADJUST CONTROL.
18. HETERODYNE OSCILLATOR INPUT FROM RECEIVER IN TRANSCEIVE ONLY.
19. VOLTAGE IN TRANSCEIVE ONLY.
20. VARIES BETWEEN LSB, USB, CW, AND TUNE.
21. PROVIDES BIAS VOLTAGE TO UNBALANCE BALANCED MODULATOR.
22. TO CHASSIS.
23. INFINITY IN USB OR LSB.
24. APPROXIMATELY 50 K AFTER A FEW SECONDS IN LSB OR USB.
25. GROUND IN CW AND TUNE.











**RESISTANCE CHART**



## VOLTAGE AND RESISTANCE CHART NOTES

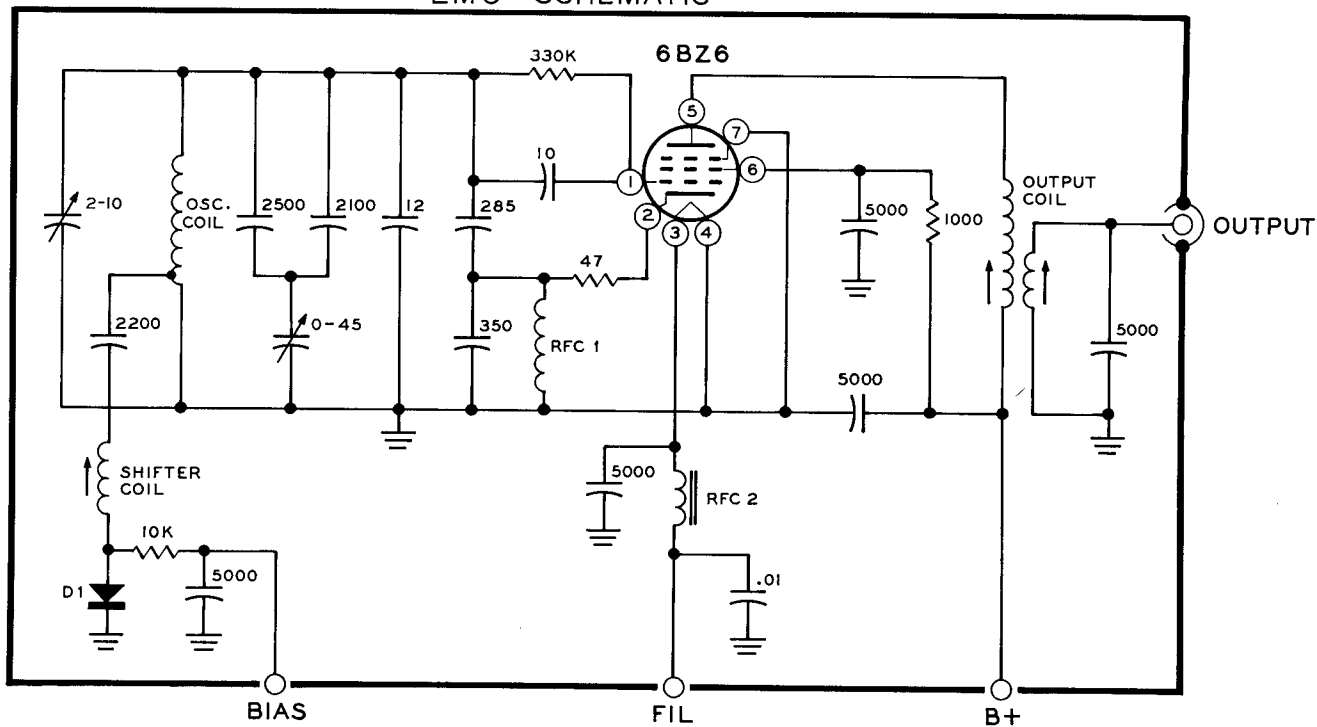
SWITCH AND CONTROL POSITIONS	MEASUREMENTS CONDITIONS			
				
FUNCTION	STBY	SPOT	TRCV	OFF
BAND	3.5			
MODE	CW			CW
DRIVER	Full counter-clockwise dial marking	Tuned		
FINAL LOAD	50 $\Omega$			
FINAL	80			
LEVEL	Fully clockwise	Fully clockwise		
METER	REL PWR			REL PWR
LMO	0			
KEY	OPEN			OPEN

\* MINIMUM AFTER 5 SECONDS

\*\* APPROXIMATELY

1. MAY VARY.
2. CHASSIS GROUND.
3. FILAMENT.
4. VARIES WITH SETTING OF LEVEL CONTROL.
5. VOLTAGE PRESENT ONLY ON LSB.
6. TUBE IS CUT OFF.
7. VOLTAGE DEPENDS ON AMPLITUDE OF HETERODYNE MIXER INJECTION.
8. VARIES WITH CRYSTAL ACTIVITY AND HETERODYNE OSCILLATOR COIL SETTING.
9. PENTODE SECTION OPERATES ONLY IN TRANSCEIVE.
10. RELAY NOT CLOSED.
11. OPERATES ONLY WITH KEY DOWN IN CW MODE.
12. GROUNDED BY THE FUNCTION SWITCH.
13. VARIES WITH SETTING OF VOX CONTROL.
14. VARIES WITH SETTING OF ANTI-VOX CONTROL.
15. VARIES WITH VOLTAGE IMPRESSED ACROSS DIODE.
16. GROUNDED BY MODE SWITCH.
17. VARIES WITH SETTING OF BIAS ADJUST CONTROL.
18. HETERODYNE OSCILLATOR INPUT FROM RECEIVER IN TRANSCEIVE ONLY.
19. VOLTAGE IN TRANSCEIVE ONLY.
20. VARIES BETWEEN LSB, USB, CW, AND TUNE.
21. PROVIDES BIAS VOLTAGE TO UNBALANCE BALANCED MODULATOR.
22. TO CHASSIS.
23. INFINITY IN USB OR LSB.
24. APPROXIMATELY 50 K AFTER A FEW SECONDS IN LSB OR USB.
25. GROUND IN CW AND TUNE.

LMO SCHEMATIC



# REPLACEMENT PARTS PRICE LIST

To order parts, use the Parts Order Form furnished with this kit. If Parts Order Form is not

available, refer to Replacement Parts in the Kit Builders Guide.

## MIXER-BANDPASS CIRCUIT BOARD

### PARTS LIST #1

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

#### RESISTORS - 1/2 Watt

1-42	.10	270 $\Omega$
1-7	.10	680 $\Omega$
1-9	.10	1000 $\Omega$
1-16	.10	4700 $\Omega$
1-24	.10	33 K $\Omega$
1-25	.10	47 K $\Omega$
1-29	.10	220 K $\Omega$

#### CAPACITORS

##### Mica

20-99	.15	22 pf
20-102	.15	100 pf
20-103	.15	150 pf
20-105	.20	180 pf

##### Disc

21-33	.10	3.3 pf
21-78	.10	5 pf

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

#### Disc (cont'd.)

21-14	.10	.001 $\mu$ fd
21-27	.10	.005 $\mu$ fd
21-16	.10	.01 $\mu$ fd
21-31	.10	.02 $\mu$ fd

#### GENERAL

40-479	.25	3.5 $\mu$ H coil
52-65	5.00	Bandpass coupler transformer
434-129	.15	7-pin tube socket
331-6	.15	Solder
85-154-1	1.05	Mixer-bandpass circuit board

#### ITEMS FROM PACK #5

2.00	Manual (See front cover for Part Number.)
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## CARRIER GENERATOR CIRCUIT BOARD

### PARTS LIST #2

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

#### RESISTORS

##### 1/2 Watt

1-41	.10	10 $\Omega$
1-2	.10	68 $\Omega$
1-45	.10	220 $\Omega$
1-6	.10	470 $\Omega$
1-7	.10	680 $\Omega$
1-9	.10	1000 $\Omega$
1-11	.10	1500 $\Omega$
1-90	.10	2000 $\Omega$
1-13	.10	2700 $\Omega$
1-21	.10	15 K $\Omega$

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

#### 1/2 Watt (cont'd.)

1-24	.10	33 K $\Omega$
1-25	.10	47 K $\Omega$
1-50	.10	68 K $\Omega$
1-26	.10	100 K $\Omega$
1-29	.10	220 K $\Omega$
1-33	.10	470 K $\Omega$
1-35	.10	1 megohm
1-36	.10	1.5 megohm

#### 1 Watt

1-22-1	.10	1500 $\Omega$
1-30-1	.10	220 K $\Omega$

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

**CAPACITORS**
**Mica**

20-52	.15	7.5 pf
20-100	.15	30 pf
20-97	.15	50 pf
20-114	.20	270 pf
20-107	.40	680 pf

**Disc**

21-14	.10	.001 $\mu$ fd
21-27	.10	.005 $\mu$ fd
21-16	.10	.01 $\mu$ fd
21-48	.15	.05 $\mu$ fd

**Other**

27-34	.25	.2 $\mu$ fd resin
25-54	.40	10 $\mu$ fd electrolytic
25-135	.75	20 $\mu$ fd electrolytic
26-93	2.85	2-19 pf variable

PART No.	PRICE Each	DESCRIPTION
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**CONTROLS**

10-147	.75	200 $\Omega$ linear
10-150	.65	5000 $\Omega$ linear
10-148	.60	10 K $\Omega$ linear
10-149	.60	500 K $\Omega$ linear
10-151	.80	10 megohm linear

**GENERAL**

52-70	.75	Balanced modulator transformer
57-27	.60	Silicon diode
56-26-1	.35	Crystal diode (one to be used in Section 5)
84-22	.60	P.E.C. network
85-76-3	2.60	Carrier generator circuit board
205-87	.10	Bottom tube shield
434-129	.15	7-pin tube socket
434-130	.15	9-pin tube socket
434-140	.20	12-pin tube socket
259-20	.05	Terminal pin

## CHASSIS PARTS

### PARTS LIST #3

PART No.	PRICE Each	DESCRIPTION
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**CAPACITORS**
**Mica**

20-99	.15	22 pf
20-109	.15	62 pf
20-76	.15	68 pf
20-102	.15	100 pf
20-114	.20	270 pf

**Other**

21-27	.10	.005 $\mu$ fd disc
21-59	1.20	1000 pf (brown-black-red)
25-34	2.10	125 $\mu$ fd electrolytic
26-24	2.20	20 pf variable
26-74	3.75	20-200-20-200 pf, 4-section variable
26-77	5.50	250 pf variable
26-92	2.85	245-245-354 pf, 3-section variable

**CONTROLS**

10-61	.35	200 $\Omega$ linear, tab mount
10-34	.60	600 $\Omega$ linear
10-57	.35	10 K $\Omega$ linear, tab mount

PART No.	PRICE Each	DESCRIPTION
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**COILS**

40-529	.35	15-meter RF amplifier
40-528	.35	20-meter RF amplifier
40-602	.40	40-meter RF amplifier
40-601	.40	80-meter RF amplifier
40-552	.40	20-meter heterodyne oscillator
40-551	.40	40-meter heterodyne oscillator
40-550	.40	80-meter heterodyne oscillator
40-548	4.00	15-20-40-80 meter final tank

**TERMINAL STRIPS**

431-25	.10	1-lug vertical
431-14	.10	2-lug
431-10	.10	3-lug
431-38	.10	3-lug miniature
431-40	.10	4-lug
431-11	.10	5-lug
431-42	.10	5-lug wide space

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
<b>INSULATORS-GROMMETS</b>			<b>Other Hardware</b>		
71-4	.45	Ceramic insulator	250-93	.05	8-32 x 1/4" setscrew
73-3	.10	1/2" rubber grommet	250-105	.10	8-32 x 1/8" setscrew
73-43	.10	3/8" plastic grommet	252-7	.05	Control nut
73-46	.10	5/16" plastic grommet	253-10	.05	Control flat washer
<b>CONNECTORS-SOCKETS-JACKS</b>			254-5	.05	Control lockwasher
432-4	.10	Male line cord connector	259-10	.05	Control solder lug
434-34	.15	7-pin tube socket	253-49	.10	Nylon flat washer
434-36	.30	9-pin tube socket	75-18	.10	Nylon shoulder washer
434-53	.70	8-pin octal tube socket	252-32	.05	Push-on speednut
434-42	.10	Phono socket	255-11	.15	5/16" x 1" tapped spacer
434-74	.15	Crystal socket	255-23	.10	5/16" x 15/32" tapped spacer
434-90	.20	Pilot lamp socket	255-49	.30	7/32" x 5/16" spacer
436-3	.10	Banana jack	455-11	.10	1/4" split bushing
436-20	.45	Phone jack	<b>GENERAL</b>		
<b>HARDWARE</b>			1-16	.10	4700 $\Omega$ 1/2 watt resistor
<b>#10 Hardware</b>			45-41	.95	425 $\mu$ H RF choke
250-191	.05	10-24 x 1-1/8" screw	46-43	1.65	4.5 H filter choke
252-30	.05	10-24 nut	100-19	.20	Dial pulley assembly
252-31	.10	10-24 wingnut	204-9	.10	Angle bracket
253-19	.05	#10 flat washer	423-1	.55	Fuseholder
254-3	.05	#10 lockwasher	437-1	.10	Banana jack insert
<b>#6 Hardware</b>			456-4	.70	Phenolic shaft coupling
250-27	.05	6-32 x 2" screw	481-1	.10	Capacitor mounting wafer, metal
250-26	.05	6-32 x 5/8" screw	481-3	.10	Capacitor mounting wafer, insulated
250-89	.05	6-32 x 3/8" screw	490-85	.15	#8 allen wrench
250-56	.05	6-32 x 1/4" screw	490-5	.10	Nut starter
251-1	.05	6-32 spade bolt	489-1	.15	Sandpaper
252-3	.05	6-32 nut	<b>METAL PARTS</b>		
253-25	.05	#6 flat washer	204-573	.25	Large tuning capacitor mounting bracket
254-1	.05	#6 lockwasher	204-316	.10	Small tuning capacitor mounting bracket
259-1	.05	#6 large solder lug	206-223	.55	Coil partition shield
259-6	.05	#6 small solder lug	100-593	2.30	Final amplifier enclosure
253-2	.05	#6 fiber shoulder washer	<b>WIRE</b>		
<b>#4 Hardware</b>			340-2	.05/ft	#20 bare wire
250-213	.05	4-40 x 5/16" screw	344-21	.05/ft	Red stranded wire
252-15	.05	4-40 nut	344-50	.05/ft	Black hookup wire
254-9	.05	#4 lockwasher	344-51	.05/ft	Brown hookup wire
<b>#3 Hardware</b>			344-52	.05/ft	Red hookup wire
250-172	.05	3-48 x 3/8" screw	344-53	.05/ft	Orange hookup wire
250-49	.05	3-48 x 1/4" screw			
252-1	.05	3-48 nut			
254-7	.05	#3 lockwasher			



PART No.	PRICE Each	DESCRIPTION
<b>Wire (cont'd.)</b>		
344-54	.05/ft	Yellow hookup wire
344-55	.05/ft	Green hookup wire
344-56	.05/ft	Blue hookup wire
344-57	.05/ft	Violet hookup wire
344-59	.05/ft	White hookup wire
346-1	.05/ft	Sleeving

**Items from Pack #5**

100-40	63.30	Linear master oscillator*
200-469-1	5.40	Chassis

PART No.	PRICE Each	DESCRIPTION
<b>#100-450 Packaged Dial Drive Assembly,</b>		
	6.00	
Consisting of:		
204-553	.55	Dial mounting bracket
100-443	1.00	Dial pointer assembly
464-30-1	.25	Plastic dial window
100-447	.50	Dial pointer drive arm
250-63	.05	3-48 x 1/8" screw
266-74	.10	Nylon spiral follower
100-445	.45	Zero set drive pulley (small)
100-449	2.50	Circular dial
100-444	1.65	Dial drive pulley (large)
455-42	.90	Drive shaft bushing assembly

**CHASSIS WIRING**

**PARTS LIST #4**

PART No.	PRICE Each	DESCRIPTION
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**RESISTORS**

**1/2 Watt**

1-41	.10	10 Ω
1-3	.10	100 Ω
1-66	.10	150 Ω
1-6	.10	470 Ω
1-96	.10	750 Ω
1-9	.10	1000 Ω
1-90	.10	2000 Ω
1-14	.10	3300 Ω
1-46	.10	3900 Ω
1-16	.10	4700 Ω
1-19	.10	6800 Ω
1-73	.10	8200 Ω
1-20	.10	10 KΩ
1-21	.10	15 KΩ
1-25	.10	47 KΩ
1-26	.10	100 KΩ
1-27	.10	150 KΩ
1-29	.10	220 KΩ
1-34	.10	680 KΩ
1-35	.10	1 megohm
1-39	.10	4.7 megohm

**1 Watt**

1-2-1	.10	1000 Ω
1-3-1	.10	3300 Ω
1-25-1	.10	6800 Ω
1-8-1	.10	68 KΩ
2-45-1	.30	500 KΩ precision

\*Tuners are available at half-price plus postage on an exchange basis; the defective unit returnable after replacement is received. Tuner returned must be in repairable condition.

PART No.	PRICE Each	DESCRIPTION
----------	------------	-------------

**2 Watt**

1-3-2	.20	10 KΩ
1-18-2	.20	33 KΩ
1-24-2	.20	100 KΩ

**7 Watt**

3-8-7	.15	4000 Ω wire-wound
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**CAPACITORS**

**Mica**

20-52	.15	7.5 pf
20-99	.15	22 pf
20-97	.15	50 pf
20-109	.15	62 pf
20-102	.15	100 pf
20-103	.15	150 pf
20-108	.20	200 pf
20-133	.35	430 pf
20-129	.85	2700 pf

**Disc**

21-14	.10	.001 μfd
21-27	.10	.005 μfd 500 V
21-72	.20	.005 μfd 1.4 KV
21-35	.15	.005 μfd 1.6 KV
21-16	.10	.01 μfd
21-31	.10	.02 μfd

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
<b>Other</b>			<b>#6 Hardware (cont'd.)</b>		
28-1	.10	2.2 pf tubular	251-1	.05	6-32 spade bolt
21-53	.65	1000 pf (brown-black-red) 500 V feedthrough	252-3	.05	6-32 nut
27-34	.25	.2 $\mu$ fd resin	254-1	.05	#6 lockwasher
25-16	.80	20 $\mu$ fd electrolytic	259-1	.05	#6 solder lug
25-57	.95	100 $\mu$ fd electrolytic	259-6	.05	#6 small solder lug
25-59	1.80	100-40 $\mu$ fd electrolytic	<b>#4 Hardware</b>		
31-13	.90	3-12 pf trimmer	250-34	.05	4-40 x 1/2" screw
<b>COILS-CHOKES</b>			250-213	.05	4-40 x 5/16" screw
40-549	.45	10-meter final tank coil	252-15	.05	4-40 nut
40-768	.40	10-meter RF amplifier coil	254-9	.05	#4 lockwasher
40-529	.35	15-meter RF amplifier coil	<b>#3 Hardware</b>		
45-38	.20	.2 $\mu$ H choke	250-172	.05	3-48 x 3/8" screw
45-51	.25	15 $\mu$ H choke	250-49	.05	3-48 x 1/4" screw
45-33	.30	305 $\mu$ H choke	250-63	.05	3-48 x 1/8" screw
45-30	.40	.5 mH choke	252-1	.05	3-48 nut
45-4	.40	1.1 mH choke	254-7	.05	#3 lockwasher
45-27	.20	30 $\mu$ H RF choke	<b>Other Hardware</b>		
45-53	.40	RF parasitic choke	252-7	.05	Control nut
45-43	.25	RF parasitic choke	254-4	.05	Control lockwasher
<b>SWITCHES-RELAYS</b>			259-10	.05	Control solder lug
63-341	5.40	Band switch 5-section, 8-position	260-29	.25	Crystal clip
63-342	5.00	Mode switch 4-section, 4-position	260-39	.05	Anode clip (Appearance may vary)
63-343	3.40	Function switch 2-section, 5-position	258-5	.10	Small spring clip
69-17	5.00	SPDT relay	258-6	.05	Large spring clip
69-40	9.70	5-pole DT relay	<b>METAL SHIELDS</b>		
<b>CABLE ASSEMBLIES</b>			205-87	.10	Bottom tube shield
134-135	2.50	4-conductor cable	206-233	.50	Driver shield
134-92	1.90	5-conductor cable	206-234	.35	Final shield
134-91	3.10	16-conductor cable	206-235	.80	Switch support shield
134-136	5.00	56-conductor cable	206-236	.55	Carrier generator shield
<b>HARDWARE</b>			<b>GENERAL</b>		
<b>#8 Hardware</b>			54-198	12.40	Power transformer
252-4	.05	8-32 nut	57-27	.60	Silicon diode, 750 ma, 500 PIV
254-2	.05	#8 lockwasher	73-1	.10	3/8" rubber grommet
<b>#6 Hardware</b>			73-3	.10	1/2" rubber grommet
250-143	.05	6-32 x 1/2" stud screw	73-4	.10	5/16" rubber grommet
250-8	.05	#6 x 3/8" sheet metal screw	74-4	.35	Plastic tape
250-56	.05	6-32 x 1/4" screw	207-4	.10	Plastic cable clamp
250-230	.20	6-32 x 3/16" setscrew	431-38	.10	3-lug miniature terminal strip
			340-3	.05	#16 bare wire
			343-7	.05	RG-174 coaxial cable

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
<b>General (cont'd.)</b>			<b>General (cont'd.)</b>		
431-12	.10	4-lug terminal strip	432-73	.10	Female terminal pin
431-42	.10	5-lug wide-spaced terminal strip	434-74	.15	Crystal socket
431-11	.10	5-lug terminal strip	436-5	.85	Coaxial jack
431-69	.55	30-lug terminal strip	438-4	.10	Phono plug
404-283	35.50	Crystal filter	456-16	.20	Switch shaft coupling
432-70	.30	Accessory plug	481-1	.10	Metal capacitor mounting wafer
432-71	.30	Accessory socket	411-75	4.35	6146 tube
432-72	.10	Male terminal pin (not used in assembly)	490-14	.10	#6 allen wrench

## FINAL WIRING

### PARTS LIST #5

PART No.	PRICE Each	DESCRIPTION	PART No.	PRICE Each	DESCRIPTION
<b>SHIELDS</b>			<b>TUBES</b>		
206-54	.30	2-3/8" for 9-pin tube socket	411-11	1.00	6AU6
206-68	.10	1-3/4" for 9-pin tube socket	411-59	1.35	OA2
206-77	.15	1-3/4" for 7-pin tube socket	411-63	1.90	6CL6
206-86	.10	Pilot lamp shield	411-96	1.80	6AW8
<b>HARDWARE</b>			411-124	1.50	6EA8
<b>#6 Hardware</b>			411-168	2.40	6J11
250-40	.05	6-32 x 1-1/2" screw	411-170	1.20	6EW6
250-29	.05	6-32 x 3/4" screw	411-186	1.95	6D10
250-8	.05	#6 x 3/8" sheet metal screw	411-199	2.20	6AV11
250-218	.05	6-32 x 3/8" oval (phillips) head screw	<b>KNOBS</b>		
250-32	.05	6-32 x 3/8" flat head screw	462-175	.15	Aluminum
250-56	.05	6-32 x 1/4" screw	462-191	.70	1-1/8" plastic
250-230	.20	6-32 x 3/16" setscrew	462-193	1.05	2-1/2" plastic
252-3	.05	6-32 nut	462-195	.50	Lever
252-23	.05	6-32 thumbnut	<b>GENERAL</b>		
254-1	.05	#6 lockwasher	1-3	.10	100 Ω resistor
253-25	.05	#6 flat washer	1-7	.10	680 Ω resistor
<b>Other Hardware</b>			21-16	.10	.01 μfd disc capacitor
250-260	.15	8-32 x 1/4" oval head screw	51-3	1.35	Output transformer
250-93	.05	8-32 x 1/4" setscrew	63-94	1.10	5-position Meter switch
250-156	.10	4-40 x 1/8" setscrew	63-424	4.95	2-position switch with 10 KΩ/1 megohm control
250-251	.20	3-48 x 3/8" flat head screw	89-3	.45	Line cord
252-1	.05	3-48 nut	204-560	.25	Angle bracket
252-7	.05	Control nut	90-341	20.80	Cabinet
253-10	.05	Control flat washer	203-367-2	1.70	Front panel
254-5	.05	Control lockwasher	206-221-3	1.10	Coil enclosure
259-10	.05	Control solder lug			
254-7	.05	#3 lockwasher			

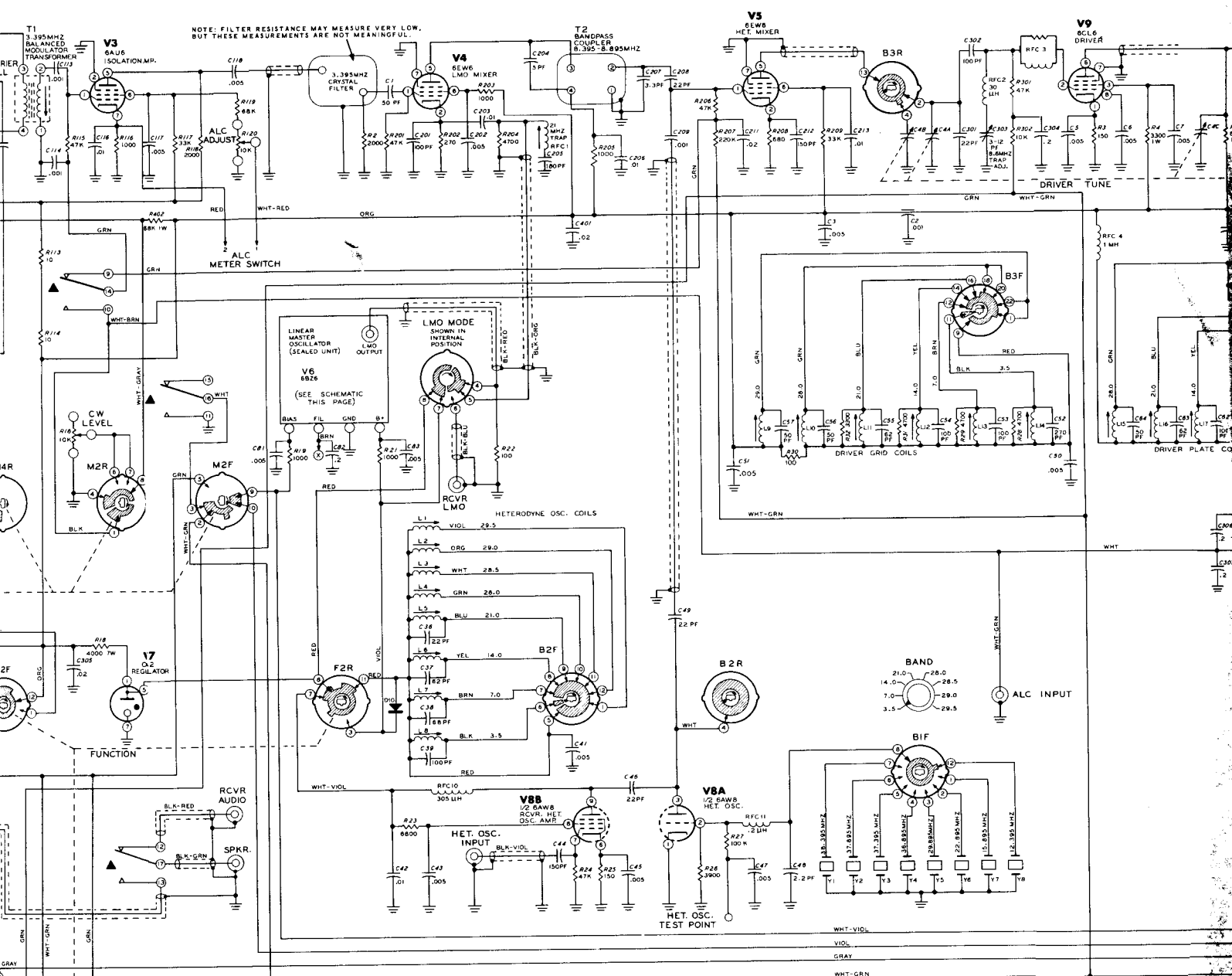


<u>PART No.</u>	<u>PRICE Each</u>	<u>DESCRIPTION</u>
<b>General (cont'd.)</b>		
255-59	.15	Foot spacer
258-1	.05	Dial cord spring
261-9	.05	Rubber foot
349-3	.05/ft	Dial cord
391-46	.30	Nameplate "SB-401"
404-215	4.50	3395.4 kilohertz crystal
407-102	8.30	Meter
412-20	.20	#47 pilot lamp
421-5	.25	4 ampere slow-blow fuse
432-38	1.10	Male microphone connector
432-39	1.10	Female microphone connector
434-90	.20	Pilot lamp socket
438-4	.10	Phono plug
100-458	.25	Dial pulley
453-36	.15	3-7/8" long shaft
453-125	.25	9-3/8" long shaft
453-108	.60	8-1/4" long tubular shaft
455-10	.10	15/32" long bushing

<u>PART No.</u>	<u>PRICE Each</u>	<u>DESCRIPTION</u>
<b>General (cont'd.)</b>		
455-13	.10	1/4" long bushing
455-11	.10	Split bushing
456-7	.25	Metal shaft coupling
352-13	.15	Silicone grease
490-1	.10	Alignment tool
446-40	.70	Dial escutcheon
490-168	.15	Open end wrench
490-23	.10	#4 allen wrench

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.





NOTE: FILTER RESISTANCE MAY MEASURE VERY LOW. BUT THESE MEASUREMENTS ARE NOT MEANINGFUL.

### SCHEMATIC OF THE HEATHKIT® SSB TRANSMITTER MODEL SB-401

#### NOTES:

1. RESISTOR AND CAPACITOR NUMBERS ARE IN THE FOLLOWING GROUPS:

- 0-99 PARTS MOUNTED ON THE CHASSIS
- 100-199 PARTS ON THE CARRIER GENERATOR CIRCUIT BOARD
- 200-299 PARTS ON THE MIXER BANDPASS CIRCUIT BOARD
- 300-399 PARTS MOUNTED ON TERMINAL BOARD #1
- 400-499 PARTS MOUNTED ON TERMINAL BOARD #2

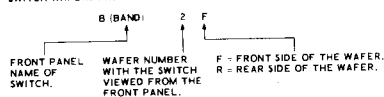
2. ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K = 1000, M = 1,000,000).

3. ALL CAPACITOR VALUES ARE IN  $\mu$ F UNLESS MARKED OTHERWISE.

4. ALL SWITCH WAFERS SHOWN IN FULL COUNTERCLOCKWISE POSITION, AS VIEWED FROM THE SHAFT.

5. THE DOT LOCATED IN THE CENTER OF SOME SWITCHES INDICATES A TIE PIN WHICH CONNECTS A CONTACT ON ONE SIDE OF THE ROTOR TO CONTACTS ON THE OTHER SIDE OF THE SAME ROTOR.

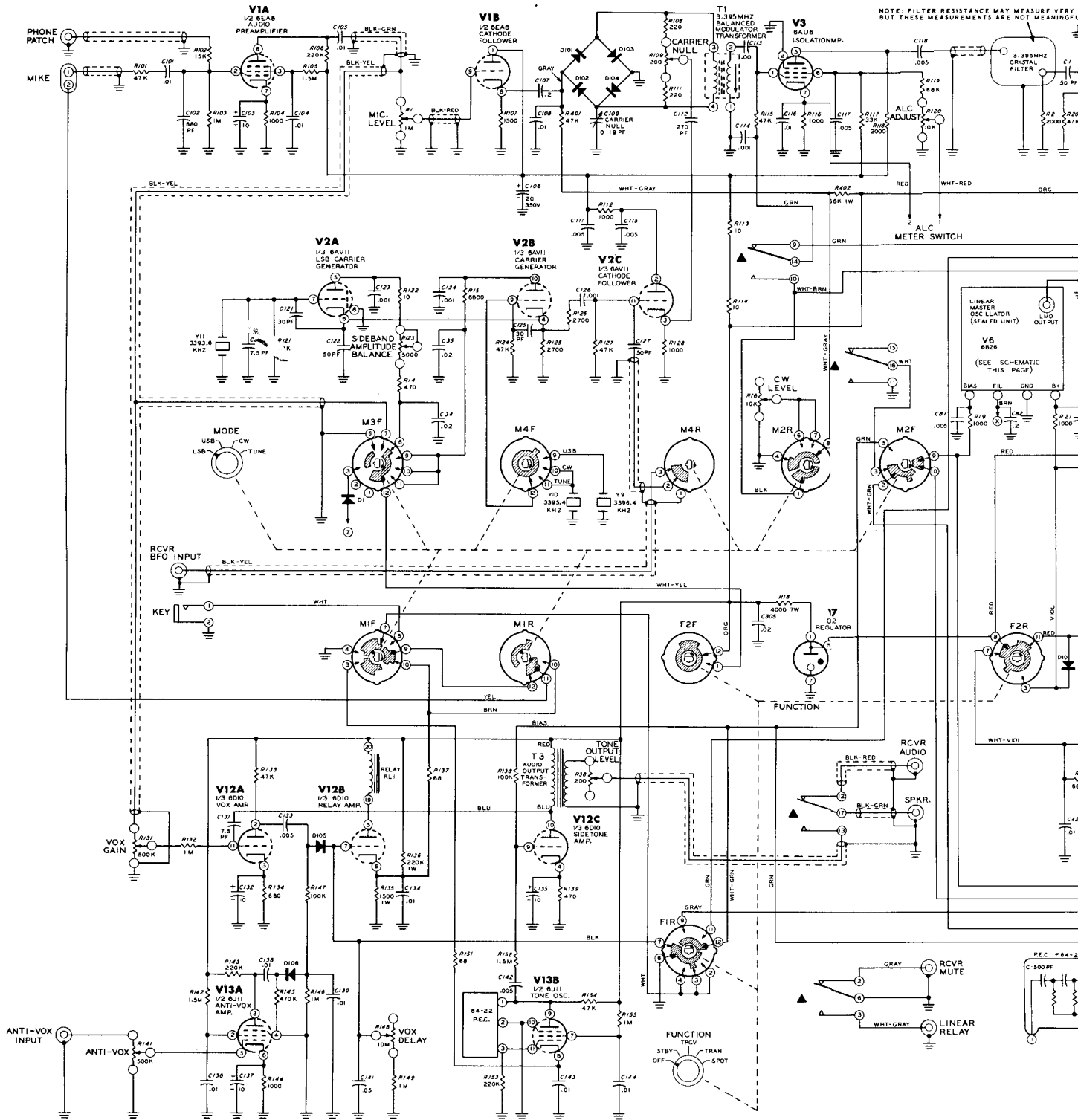
6. SWITCH WAFERS ARE IDENTIFIED AS IN THE FOLLOWING EXAMPLE:



7. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.

8. RELAYS ARE SHOWN IN STANDBY POSITION.  
- IDENTIFIES SECTIONS OF RELAY

9. VOLTAGES AND RESISTANCE MEASUREMENTS LISTED ON CHARTS BEGINNING ON PAGE 145 OF MANUAL.



## TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations

should prove helpful in identifying most parts and reading the schematic diagrams.

<p style="text-align: center;"><b>RESISTOR</b></p>	<p style="text-align: center;"><b>CAPACITOR</b></p>	<p style="text-align: center;"><b>TUBE</b></p>
<p style="text-align: center;"><b>POTENTIOMETER (CONTROL)</b></p>	<p style="text-align: center;"><b>ELECTROLYTIC CAPACITOR</b></p>	<p style="text-align: center;"><b>TRANSISTOR</b></p>
<p style="text-align: center;"><b>TRANSFORMER (IRON CORE)</b></p>	<p style="text-align: center;"><b>VARIABLE CAPACITOR</b></p>	<p style="text-align: center;"><b>RECTIFIER (DIODE)</b></p>
<p style="text-align: center;"><b>TRANSFORMER (ADJUSTABLE POWDERED IRON CORE) ARROW INDICATES DIRECTION OF CORE MOVEMENT TO INCREASE INDUCTANCE</b></p>	<p style="text-align: center;"><b>BATTERY</b></p>	<p style="text-align: center;"><b>NEON BULB</b></p>
<p style="text-align: center;"><b>TRANSFORMER (ADJUSTABLE CORE)</b></p>	<p style="text-align: center;"><b>PHONO JACK</b></p>	<p style="text-align: center;"><b>ILLUMINATING BULB</b></p>
<p style="text-align: center;"><b>POWER TRANSFORMER</b></p>	<p style="text-align: center;"><b>PHONE JACK</b></p>	<p style="text-align: center;"><b>METER</b></p>
<p style="text-align: center;"><b>INDUCTOR (COIL)</b></p>	<p style="text-align: center;"><b>RECEPTACLE</b></p>	<p style="text-align: center;"><b>SWITCH (TOGGLE)</b></p>
<p style="text-align: center;"><b>PIEZOELECTRIC CRYSTAL</b></p>	<p style="text-align: center;"><b>SPEAKER</b></p>	<p style="text-align: center;"><b>SWITCH (ROTARY)</b></p>
<p style="text-align: center;"><b>BINDING POST</b></p>	<p style="text-align: center;"><b>MICROPHONE</b></p>	<p style="text-align: center;"><b>FUSE</b></p>
<p style="text-align: center;"><b>ANTENNA</b></p>	<p style="text-align: center;"><b>EARTH GROUND</b></p> <p style="text-align: center;"><b>CHASSIS GROUND</b></p>	<p style="text-align: center;"><b>CONDUCTORS</b></p>