Thank you for any support you can give.

hy-range I

by hy-gain

MODEL 670B
CITIZENS TWO-WAY RADIO
mobile

Manufactured and Distributed by
Hy-Gain de Puerto Rico, Inc.
P.O. Box 68 State Hwy 31, Km. 4.0
Naguabo, Puerto Rico 00718

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CHAPTER 1 — GENERAL INFORMATION

Introduction

This service manual contains all the information needed to service and repair the Hy-Gain, Hy-Range I transceiver (Model 670B). It does not cover models 670 and 670A; they are covered in a separate manual. This manual includes an explanation of the theory of operation and alignment procedures. Revision, addendum, and errata sheets will be published as needed. Insert them as required in the manual.

The Hy-Range I is a full 23-channel transceiver designed and type accepted for Class D Citizens Radio Service, as designated by the Federal Communications Commission (FCC).

It is a compact mobile unit, completely solid-state, and highly reliable with low power consumption. Its crystal matrix frequency synthesizer provides immediate operation on all 23 channels. A built-in automatic noise limiter (ANL) is included to help reduce atmospheric noise. Output jacks for an optional telephone-style handset and an external speaker are also included. Use the unit with 12 VDC (nominal), either negative or positive ground.

Warranty Service Department

For help with technical problems, for parts information, and information on local and factory repair facilities, contact the National Service Manager. When you write, please include all pertinent information that may be helpful in solving your problem. Address your letter to:

Hy-Gain Warranty Service Department
4900 Superior Street
Lincoln, Nebraska 68504
attn: National Service Manager

The Warranty Service Department can repair any unit. But before you ship a unit to us, contact the National Service Manager first. Often a problem is field solvable with just a little extra help. This can save you lost time and shipping costs. Factory returns should be limited to the difficult problems.

How to Ship Returns

To return a unit, get a return authorization first. This is important. You will only delay the handling of your unit if you ship without it. If you must ship immediately, telephone or telex the National Service Manager to have him expedite the matter.

When you request return authorization, you may also request notification of completion of repairs. The notification will include a copy of the bill. If you pay the bill before we return your unit, you can save yourself the cost of a COD fee.

For warranty repair, prepare a letter in duplicate containing the following information (for out-of-warranty repair, delete items 2 and 3):

1. your name and address
2. purchaser's name and address
3. proof of purchase
4. serial number
5. a complete description of the problem
6. the return authorization

Then check the unit to see that all parts and screws are in place, and attach an envelope containing a copy of your letter directly to it so that we do not overlook this important information. Wrap the unit and envelope in heavy paper or put them in a plastic bag. If the original carton is not available, place the unit in a strong carton that is at least *six* inches larger in all three dimensions than the unit. Fill the carton equally around the unit with resilient packing material (shredded paper, excelsior, bubble pack, etc.). Seal it with gummed paper tape, tie it with a strong cord, and ship it by prepaid express, United Parcel Service, or insured parcel post to the address given previously. Mail the original of the letter in a second envelope to that same address.

It is very important that the shipment be well-packed and fully insured. Damage claims must be settled between you and the carrier and this can delay repair and return of the unit to you.

All shipments to us must be set PREPAID . We ***do not accept*** collect shipments. After the unit has been repaired, we will send it back to you COD unless you have prepaid the bill. Unclaimed or refused COD shipments will not be reshipped until payment in full is received. Otherwise, these items become the property of Hy-Gain 60 days after refusal or return and will be sold for payment of charges due.

Units with unauthorized field modifications cannot be accepted for repair.

Purchase of Parts

Parts can be purchased from any Hy-Gain Service Center or from the factory Warranty Service Department. When ordering, please supply the following information:

1. model number of the unit
2. serial number of the unit
3. description of the part
4. part number

Specifications

General

Channels	all 23 channels in the Citizens Band (26.965 MHz - 27.255 MHz)
Antenna impedance	50 ohms, nominal
Dimensions (HWD)	2¼" x 6⅜" x 9¼"
Net weight	4 lbs. 0 oz.
Shipping weight	4 lbs. 11 oz.
Power requirement	11.5 VDC - 14.5 VDC, negative or positive ground
Compliance	Type Accepted under FCC Rules, Part 95 Type Approved, under DOC Specification, RSS-136 (Canada)

Receiver section

Circuitry	dual conversion superheterodyne with rf amplifier stage and 455 kHz ceramic filter
Sensitivity	0.7 *u*V for 10 dB (S + N)/N ratio
Intermediate frequencies	1st IF — 11.275 MHz 2nd IF — 455 kHz
Audio output	3 watts, maximum
Current drain, receive	about 100 mA (no signal)

Transmitter section

RF power output	4 watts
Emission	AM, type 8A3
Spurious response rejection	all harmonic and spurious suppression better than FCC and DOC requirements
Modulation	AM, 90% typical
Current drain, transmit	less than 1 amp @ 13.8 VDC

CHAPTER 2 — THEORY OF OPERATION

General

The theory of operation of the Hy-Range I is divided into three sections: the Crystal Matrix Frequency Synthesizer, the Receiver, and the Transmitter. The material presented here covers the functioning of the transceiver with a minimum of technical involvement. Although it is intended to be informative, we have not attempted to explain the engineering techniques and approaches that arrived at these circuit designs.

Crystal Matrix Frequency Synthesizer

The Crystal Matrix Frequency Synthesizer is a heterodyne oscillator that generates synthesizer frequencies for use in both the transmitter and receiver sections. Its output determines the channel on which the transceiver is operating.

The output of the synthesizer is determined by the particular pair of crystals from the crystal matrix that are selected by the channel selector switch, S2. This switch is set-up so that S2b switches to the next crystal each step, while S2a switches to the next crystal every fourth step. There are twenty-four pairs possible from this. However, the twenty-fourth position of the switch, located between channels 22 and 23 is blank.

The outputs of the 23 MHz Oscillator, Q1, and of the 14 MHz Oscillator, Q3, are applied to the Synthesizer Mixer, Q2, to produce the 23 required synthesizer frequencies. Mathematically, this is expressed in the following formula:

$$f_S = f_{SO1} + f_{SO2}$$

where: f_S = synthesizer frequency, in MHz
f_{SO1} = first synthesizer oscillator frequency, in MHz
f_{SO2} = second synthesizer oscillator frequency, in MHz

example:

given that — f_{SO1} = 23.290 MHz (X1)
f_{SO2} = 14.950 MHz (X7)

f_S = 23.290 MHz + 14.950 MHz
f_S = 38.240 MHz

This frequency will yield Channel 1 at the antenna jack after the appropriate intermediate stage mixing.

The synthesizer frequency from the Synthesizer Mixer is applied to both the Transmit Mixer and the First Receiver Mixer.

Receiver

The receiver is a dual-conversion superheterodyne, receiving AM signals from 26.965 MHz to 27.255 MHz. The operating channel is determined by the crystal matrix frequency synthesizer, which provides the first local oscillator frequency. A variable squelch circuit is included to quiet the receiver between transmissions.

In the receive mode, 13.8 VDC is supplied to IC1, Q12, Q13, Q14, Q15, and to Q10 (the AVR). The AVR supplies regulated voltage to the synthesizer stages, Q1, Q2, and Q3, and to the Second Local Oscillator, Q16. A bias voltage is also applied to the base of the Transmit Switch, Q11. This bias holds the Transmit Switch open, so that the transceiver circuits remain in receive.

AM signals are received by the antenna and enter the ratio at the antenna jack. The π-filter formed by L8, L9, C33, and C1 of the rear panel acts to match the antenna impedance to the RF Amplifier, Q12. Signals in the 26.965 MHz - 27.255 MHz range are filtered out and amplified by the RF Amplifier and the tank circuit of C37/L10 that precedes it.

The output of the RF Amplifier and the synthesizer frequency, which in this case could be called the "first local oscillator frequency," are applied to the First Receive Mixer, Q13.

This first set of two signals is mixed in the First Receive Mixer for an output of 11.275 MHz, which is the first i-f. Mathematically, this is expressed in the following formula:

$$f_{IF1} = f_S - f_R$$

where: f_{IF1} = first i-f, (11.275 MHz)
f_S = synthesizer frequency, in MHz
f_R = receive frequency, in MHz

The first i-f passes through the i-f tuned circuit of L12 and L13. This circuit helps obtain the desired selectivity. The first i-f is then applied to the Second Receive Mixer, D11, along with the output of the Second Local Oscillator, Q16 with X12. The second local oscillator frequency is 11.730 MHz.

These two signals are mixed in the Second Receive Mixer for an output of 455 kHz, which is the second i-f. Mathematically, this is expressed in the following formula:

$$f_{IF2} = f_{LO2} - f_{IF1}$$

where: f_{IF2} = second i-f, (455 kHz)
f_{LO2} = second local oscillator frequency, (11.730 MHz)
f_{IF1} = first i-f, (11.275 MHz)

or

$$f_{IF2} = 11.730 \text{ MHz} - 11.275 \text{ MHz}$$
$$= .455 \text{ MHz}$$
$$= 455 \text{ kHz}$$

The second i-f is fed to the Ceramic Filter, CF. It is then amplified by Q14 and Q15. They are the Second IF, First Stage and Second Stage Amplifiers, respectively. The amplified signal is then fed to the Detector, D8. (D5 is a signal overload protector.) The Detector recovers the audio from the modulation signal to yield an af output. The output is applied to Automatic Noise Limiter (ANL), D6, and the Squelch Switch, Q19.

The squelch functions in the following manner. In the receive mode, a bias voltage from Q10 is applied to the base of Q19, as determined by VR2. In the absence of a signal, the base of Q19 is positive biased and it turns on. This biases the squelch transistor inside IC1, which turns off the Audio Amplifier and results in squelching of the receiver.

The output of the ANL goes through the volume control, VR1, and is RC-coupled to the Audio Amplifier, IC1. The amplified af output from IC1 goes through the audio transformer, T1, to be applied to the speaker jacks and the speaker.

Transmitter

The operating channel is determined by the crystal matrix frequency synthesizer. The synthesizer frequency is heterodyned with the offset oscillator frequency to yield the transmit frequency. This frequency is then amplified by a three-stage power amplifier.

T/R switching to the transmit mode is done in the following manner. When the PTT switch is closed, the base of the Transmit Switch, Q11, is grounded via that switch. This prevents biasing of Q11, and therefore it is closed. Regulated voltage from the Automatic Voltage Regulator (AVR), Q10, can then be supplied through Q11 to Q4, Q5, Q6, and Q7. Since the RF Power Amplifier is a class C type, it will conduct only when rf is applied to the bases of Q8 and Q9. Therefore, it is not necessary to provide switching for the 13.8 VDC that is supplied to it at all times. Thus, with the PTT switch closed and rf applied to Q8 and Q9, the transceiver is in the transmit mode.

The synthesizer frequency is applied to the Transmit Mixer, Q5, along with the 11.275 MHz output of the Offset Oscillator, Q4 with X11. The synthesizer frequency is determined by the channel selector switch, S2, as explained in the synthesizer section of this chapter. These two frequencies are mixed to yield the transmit frequency. Mathematically, this is expressed in the following formula:

$$f_T = f_S - f_O$$

where: f_T = transmit frequency, in MHz
f_S = synthesizer frequency, in MHz
f_O = offset oscillator frequency, (11.275 MHz)

The transmit frequency from this mixer passes through the filter circuit of L4 and L5 and is then applied to the Pre-drivers, Q6 and Q7. This filter circuit removes part of the undesirable spurious signals from the transmit frequency.

The Pre-drivers of Q6 and Q7 and the Driver, Q8, form two stages of voltage amplification leading to the final stage. The filter circuit of L6 follows Q6, and L7 follows Q7. These two circuits filter out the rest of the undesirable spurious signals to be removed from the transmit frequency.

From the Driver, the signal is applied to the third stage of amplification, the RF Power Amplifier, Q9. This is a current amplifier that raises the transmit signal to an output of four watts. Its output is applied to the π-filter of L8, L9, C1 of the rear panel, and C3, and then to the antenna jack. The π-filter constitutes an antenna impedance-matching circuit.

The transmit signal is modulated in the following manner. Microphone output is applied to the Audio Amplifier. The resulting af is applied to the collectors of Q8 and Q9 through the secondary coil of the audio output transformer, T1.

Control voltages for the Transmit Audio ALC, Q17, and the Range Boost, Q18, are obtained from detector diode D10. The Transmit Audio ALC boosts, or lowers, the amplifier gain in response to line voltage fluctuations. This insures full modulation of the carrier despite any changes in line voltage. The Range Boost rolls off af peaks so that a higher average af level is supplied to the Audio Amplifier. This achieves the high average modulation desired at the output of Q9 without an attendant overmodulation of the peaks.

CHAPTER 3 — ALIGNMENT

General

The following procedures must be followed in order to properly align the Hy-Range I transceiver. Alignment should not be undertaken unless the technician has adequate test equipment and a full understanding of the circuitry of the transceiver.

IMPORTANT: Tuning adjustment of this transceiver "shall be made by or under the immediate supervision and responsibility of a person holding a first- or second-class commercial radio operator license," as stipulated in Part 95.97(b) of the FCC Rules and Regulations.

The procedures are divided into two main sections: Receiver Alignment, and Transmitter Alignment. Beginning each procedure is a list of equipment needed for that procedure. See *Tools and Equipment* below for a complete list of recommended equipment.

These procedures assume that voltages are present at all points of the unit. If not, troubleshoot it before continuing.

NOTE: The ferrite cores in the tuning coils are rather easily chipped or broken. Therefore, always use care when inserting an alignment tool in the tuning coil; insert it straight into the core.

Tools and Equipment

The following tools and equipment (or their equivalents or better) are recommended for use in aligning the Hy-Range I (all instruments must be correctly calibrated):

GC 8728-A — alignment tool
GC 9304 — alignment tool
GC 9440 — alignment tool
Heathkit IP-2720 power supply
Simpson 260 VOM
Heathkit IM-28 VTVM with PK-3 RF probe
Heathkit IB-1101 frequency counter
Tektronix 465 oscilloscope
Waters 334-A dummy load wattmeter
Zodiac U-2 signal generator

Receiver Alignment Procedures

Refer to Figure 3-1 or Figure 3-2 for the location of receiver alignment procedures adjustment components.

Sensitivity Adjustment

test equipment needed:
Heathkit IP-2720 power supply
Zodiac U-2 signal generator

1. Turn the transceiver off.
2. Adjust the power supply output for 13.8 VDC. Then connect the transceiver power wires to it. Unplug the microphone from the transceiver.
3. Set the signal generator frequency for 27.115 MHz with 1 kHz, 30% modulation and the attenuator set at minimum. Then connect the generator to the transceiver antenna jack.

4. Turn the transceiver on. Set the channel selector on channel 13 (27.115 MHz).

5. Raise the signal generator attenuator output to at least 10 uV (or as much as 100 uV, if needed).

6. Adjust coils L10, L11, L12, L13, L14, L15, and L16 for maximum reading on the transceiver meter.

CAUTION

If you begin adjustment with more than 10 uV input, reduce the output level of the signal generator as the receiver cans are peaked to prevent readings from exceeding full scale.

7. Repeat step 6 until no further improvement is obtained.

Tight Squelch Adjustment

test equipment needed:
Heathkit IP-2720 power supply
Zodiac U-2 signal generator

1. Set the signal generator frequency for 27.115 MHz with 1 kHz, 30% modulation and the attenuator set at minimum.

2. Set the channel selector on channel 13 (27.115 MHz). Set the squelch control on tight (fully clockwise).

3. Raise the signal generator attenuator output to 100 uV.

4. Adjust RV1 so that tight squelch just breaks with the 100 uV input.

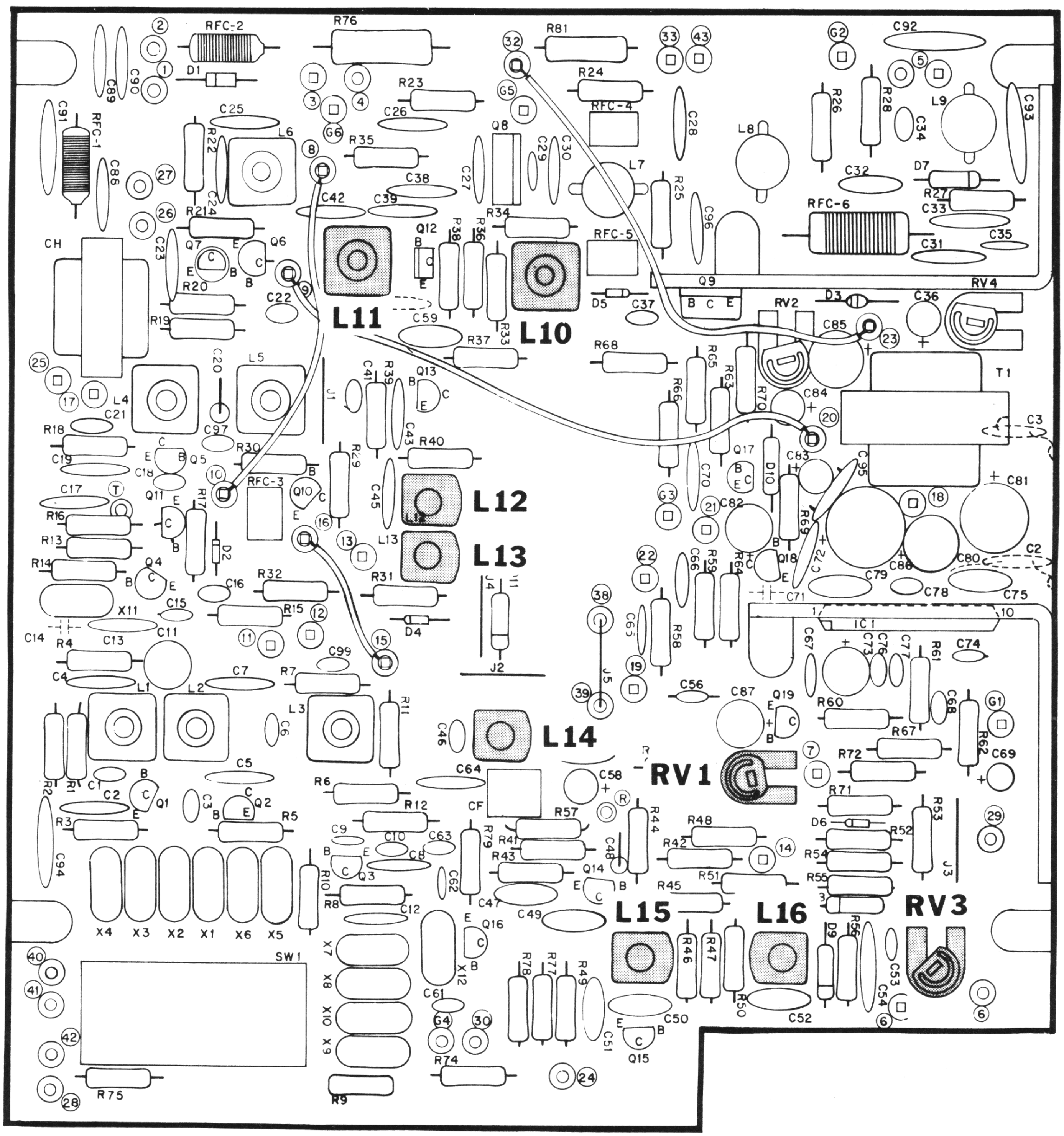
S Meter Adjustment

test equipment needed:
Heathkit IP-2720 power supply
Zodiac U-2 signal generator

1. Set the signal generator attenuator output at 100 uV.

2. Adjust the RV3 for a meter reading of 9 on the upper scale.

3. Turn the transceiver off and disconnect the test equipment. This completes the receiver alignment.



(FRONT PANEL)

Figure 3-1. Components to be Adjusted for Complete Receiver Alignment, Stages 1 & 2

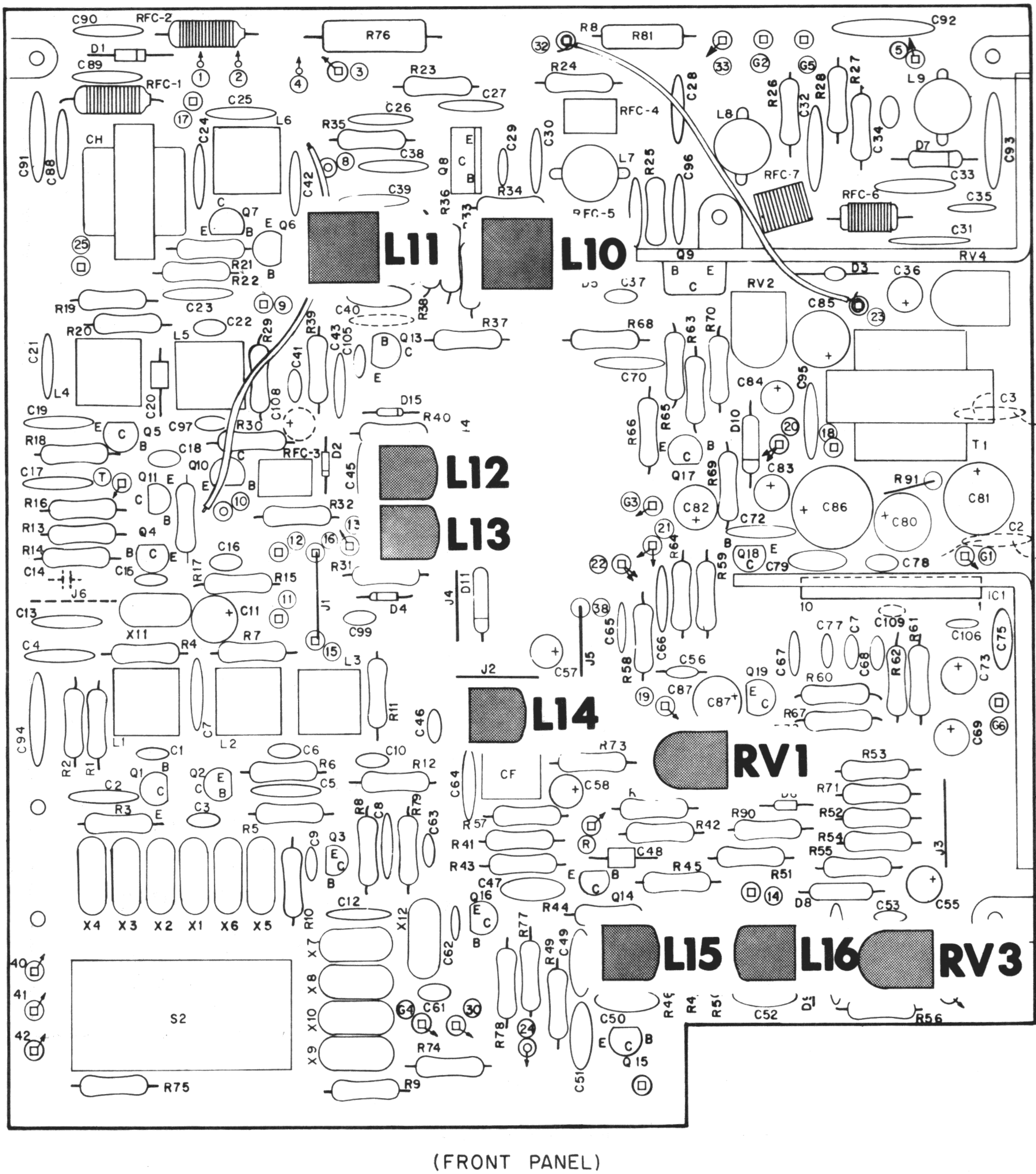
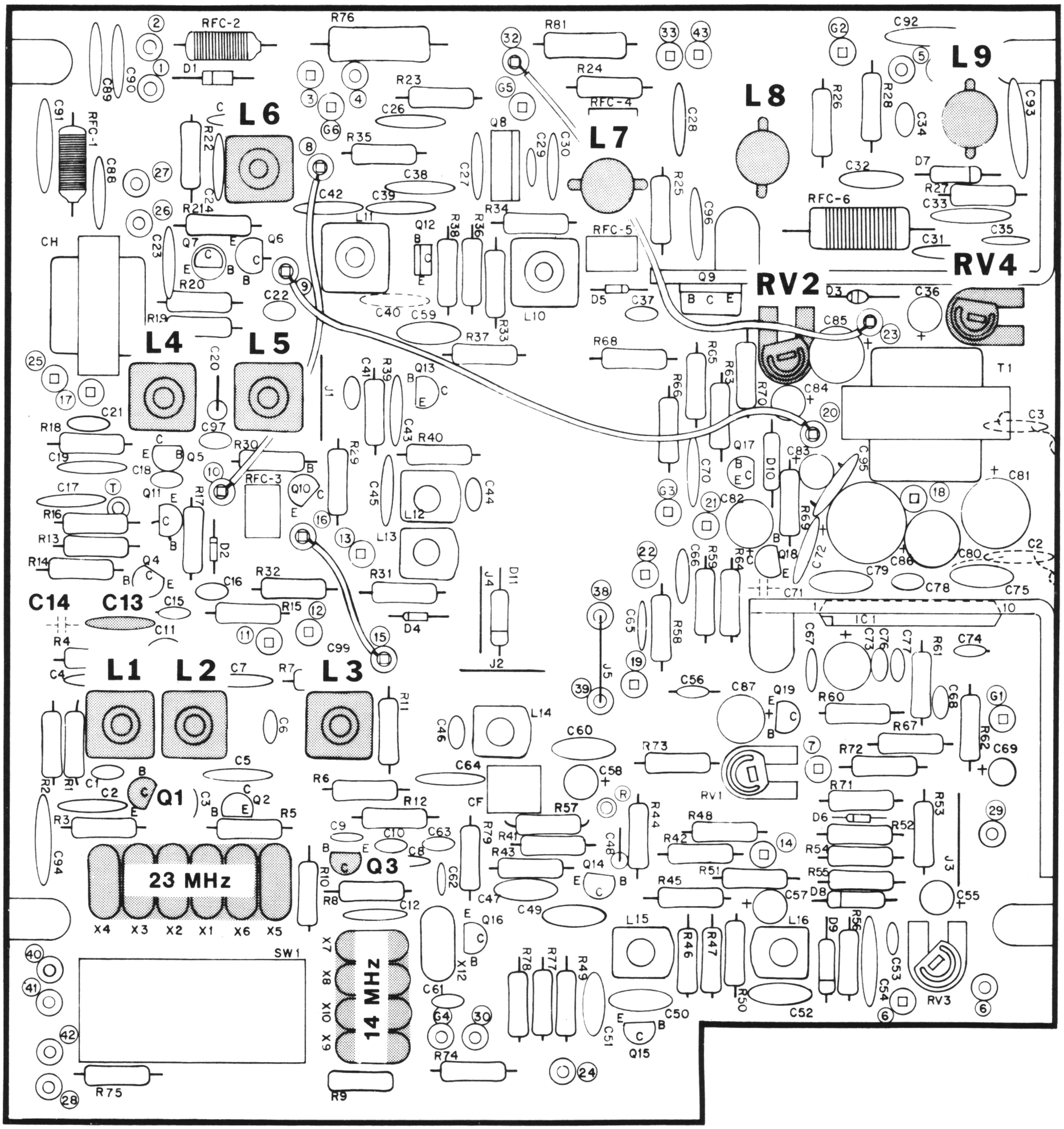


Figure 3-2. Components to be Adjusted for Complete Receiver Alignment, Stages 3 & 4

EO-0670-C-020



(FRONT PANEL)

Figure 3-3. Components to be Adjusted for Complete Transmitter Alignment, Stages 1 & 2

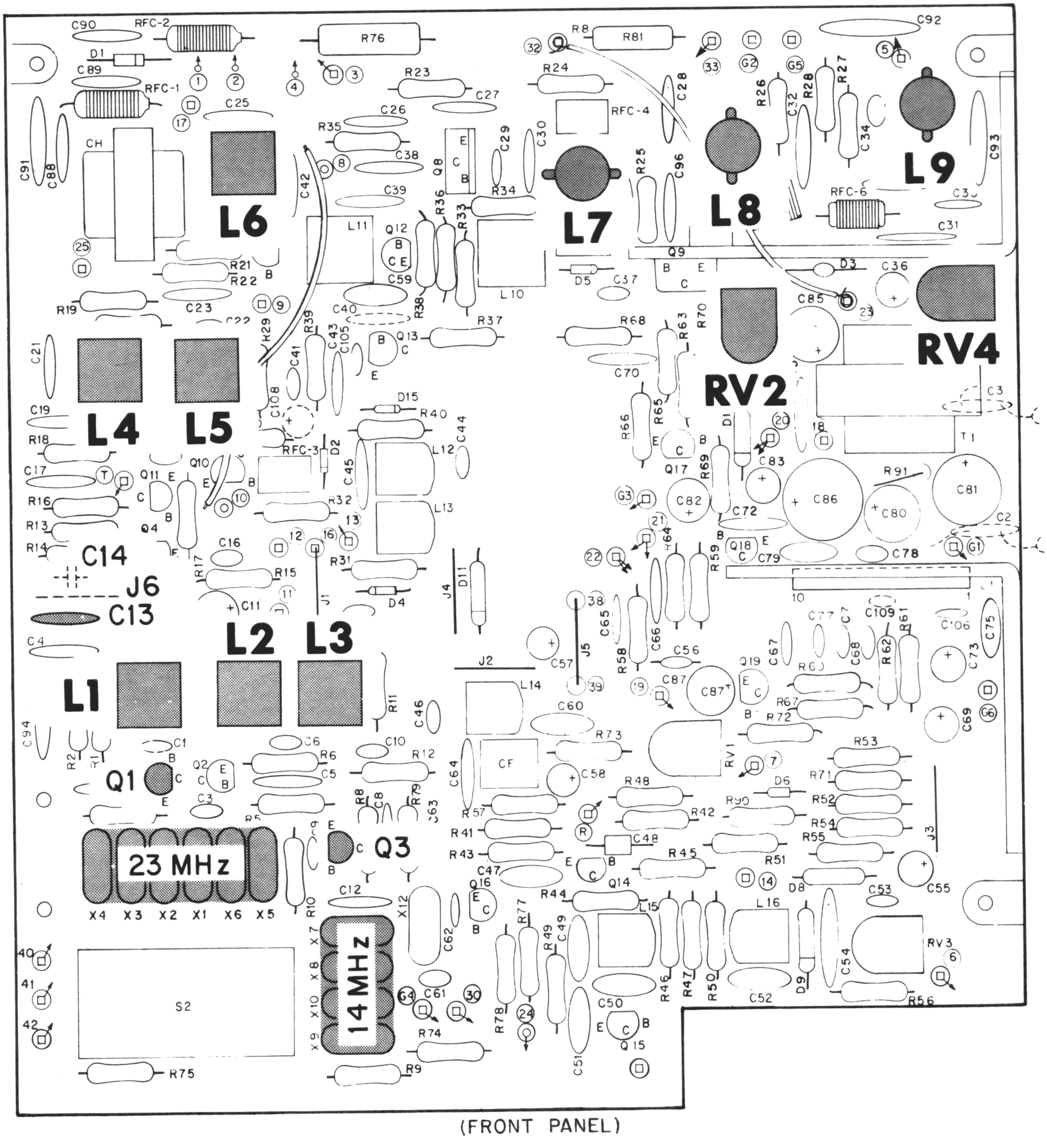


Figure 3-4. Components to be Adjusted for Complete Transmitter Alignment, Stages 3 & 4

Transmitter Alignment Procedures

Refer to Figure 3-3 or Figure 3-4 for the location of transmitter procedures alignment components.

NOTE: Be sure to perform any indicated prerequisite procedures first, before continuing with the desired procedure.

Aligning and Checking the 23 MHz and 14 MHz Oscillators

test equipment needed:
- Heathkit IP-2720 power supply
- Waters 334-A dummy load wattmeter
- Simpson 260 VOM
- Heathkit IB-1101 frequency counter

1. Turn the transceiver off.
2. Connect the dummy load to the antenna jack.
3. Adjust the power supply output for 13.8 VDC. Then connect the transceiver power wires to it.
4. Turn the transceiver on. Set the channel selector on channel 13.
5. Key the transmitter with the microphone PTT button.
6. Adjust L1 so that its core is flush with the top of the can.
7. Touch the VOM probe to the emitter of Q1. Turn the core of L1 clockwise until a jump in emitter voltage is observed. This is the oscillation starting point. Turn the core of L1 one-half turn further clockwise beyond that point.

NOTE: To insure accurate readings, be sure to connect the VOM ground lead to a p.c. board ground, not the chassis frame; because the unit has a floating ground.

8. If desired, the frequency may be checked by touching the frequency counter probe to the emitter of Q1. There should be a reading of 23.440 MHz ±300 Hz.
9. The 14 MHz Oscillator may also be checked at this time, if desired. Touch the frequency counter probe to the collector of Q3. There should be a reading of 14.950 MHz ±300 Hz.

NOTE: Use a low capacity probe when measuring these frequencies. A high capacity probe can cause the oscillators to go off-frequency.

10. Unkey the transmitter.

Output Frequency Check and Adjustments

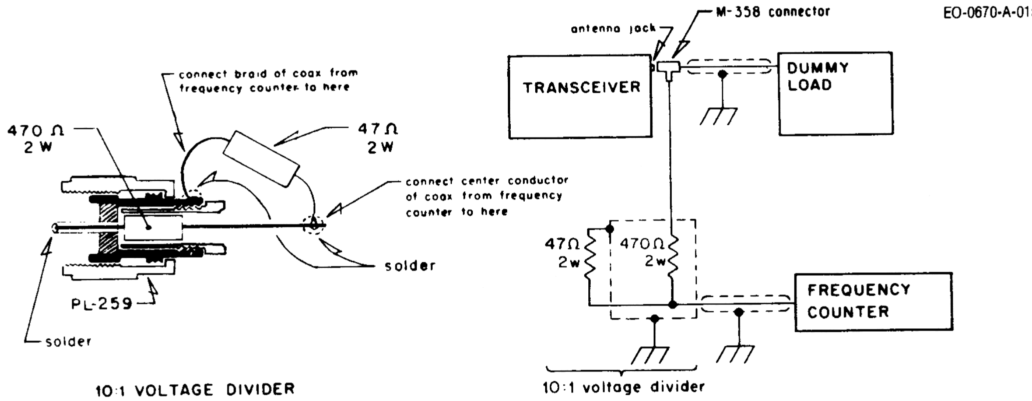
test equipment needed:
- Heathkit IP-2720 power supply
- Waters 334-A dummy load wattmeter
- Heathkit IB-1101 frequency counter

All transmit channel frequencies should be within ±800 Hz of the specified channel frequencies at the antenna jack per FCC requirements. There are two ways to correct deviations in excess of this. If all the frequencies are off in the same direction — all high or low — they can be corrected by adjustments made to the Offset Oscillator. If a multiple of four channels or of six channels is off, the Crystal Matrix has one or more crystals that must be replaced.

A. Frequency Check

1. Turn the transceiver off.

2. Connect the dummy load and frequency counter of the antenna jack as shown below:



3. Key the transmitter with the microphone PTT button.

4. Check the frequency of each channel per the chart below:

CHANNEL FREQUENCY

Channel	MHz	Channel	MHz
1	26.965	13	27.115
2	26.975	14	27.125
3	26.985	15	27.135
4	27.005	16	27.155
5	27.015	17	27.165
6	27.025	18	27.175
7	27.035	19	27.185
8	27.055	20	27.205
9	27.065	21	27.215
10	27.075	22	27.225
11	27.085	23	27.255
12	27.105		

5. If all the frequencies tend to be off in the same direction, follow B below. If a multiple of four or six channels are off, follow C below.

B. Adjusting the Offset Oscillator

1. To *raise* all the channel frequencies — first check for a jumper installed at C13 or C14, either above or below the p.c. board. If present, remove it, install a 270 pF capacitor at C13, and recheck all channel frequencies. If they still need to go higher, replace C13 with a lower value capacitor and then check all frequencies again.

2. To *lower* all the channel frequencies — first check for a jumper installed at C14, either above or below the p.c. board. If present, the frequency cannot be lowered because it is already as low as it can go. In this case, replace X11 and then go back to Part A, Step 6. If there is no jumper, replace C13 with a higher value capacitor and recheck all channel frequencies. If the frequencies are not low enough, install an additional capacitor at C14 and recheck all frequencies. If the frequencies are still not low enough, replace C13 and C14 with a jumper and recheck all channel frequencies again.

3. Unkey the transmitter.

C. Correcting Synthesizer Frequencies

1. Determine which channels are off-frequency and replace the appropriate crystal with a good crystal as indicated in the chart below:

Off-frequency or Defective	Replace Crystal
CH 1 - 4	X1 — 23.290 MHz
CH 5 - 8	X2 — 23.340 MHz
CH 9 - 12	X3 — 23.390 MHz
CH 13 - 16	X4 — 23.440 MHz
CH 17 - 20	X5 — 23.490 MHz
CH 21 - 23	X6 — 23.540 MHz
CH 1, 5, 9, 13, 17, 21	X7 — 14.950 MHz
CH 2, 6, 10, 14, 18, 22	X8 — 14.960 MHz
CH 3, 7, 11, 15, 19	X9 — 14.970 MHz
CH 4, 8, 12, 16, 20	X10 — 14.990 MHz

2. Recheck all channel frequencies.

3. Unkey the transmitter.

RF Output Adjustment

test equipment needed:
Heathkit IP-2720 power supply
Waters 334-A dummy load wattmeter

1. Set the channel selector on channel 13.

2. Key the transmitter with the PTT button.

3. Reduce the power supply voltage for a wattmeter reading of exactly 0.5 watt. This unsaturates the cans to get the sharp peaks needed to adjust them.

4. Adjust L2, L3, L4, L5, L6 and L7 for maximum readings on the wattmeter.

5. Repeat step 4 until no further improvement is observed.

6. Change the channel selector to channel 23 and raise the power supply voltage to 13.8 VDC.

7. Adjust L8 and L9 for maximum radings on the wattmeter.

8. Repeat step 7 until no further improvement is observed.

9. Back off L9 (counterclockwise) for a reading of 4.0 watts. Maximum total current at this setting must not exceed 950 mA. Readjust L8 also if necessary to meet this specification.

10. Unkey the transmitter.

Modulation Adjustment

test equipment needed:
Heathkit IP-2720 power supply
Waters 334-A dummy load wattmeter
Tektronix 465 oscilloscope

prerequisite procedure:
RF Output Adjustment

1. Connect the oscilloscope probe to the center lead of the backside of the antenna jack. Connect the ground lead to the chassis wrap-around.

2. Key the transmitter with the PTT switch and whistle into the microphone. Note the oscilloscope display and adjust RV2 for 90% modulation (valleys are 90% of peaks).

3. Unkey the transmitter.

Spurious Frequency Check

test equipment needed:
Heathkit IP-2720 power supply
Waters 334-A dummy load wattmeter
Tektronix 465 oscilloscope

prerequisite procedures:
RF Output Adjustment
Modulation Adjustment

1. Key the transmitter with the PTT switch and whistle into the microphone. Note the oscilloscope display. There should be no irregularities on any portion of the wave pattern.

2. Re-do the RF Output Adjustment procedure if any irregularities are noted. The output signal should be a clean, smooth pattern.

3. Unkey the transmitter.

Meter Adjustment, Power Scale

test equipment needed:
Heathkit IP-2720 power supply
Waters 334-A dummy load wattmeter

prerequisite procedure:
RF Output Adjustment

1. Key the transmitter with the PTT switch. Adjust RV4 for the same reading on the transceiver meter power scale as is shown on the wattmeter (calibrated instrument).

2. Unkey the trasmitter, turn the transceiver off, and disconnect the test equipment. This completes the transmitter alignment.

APPENDIX

Description of the Different Models of the 670

There are three models of the 670 transceiver. In addition, one model has a separate marketing designation and four stages of engineering development. The first model is called simply the 670. It was followed by the 670A. The only difference between the first two models is the fact that the 670A does not have a VFO jack.

The third model is the 670B. However, the differences between it and the first two models are substantial. Therefore, service information for this third model has been provided in this manual rather than including it in a revision of the earlier manual.

The marketing designation is a black-on-silver label on the back of some of the 670B units that reads "670B-PR." For the purposes of this manual, this designation can be ignored.

There are four engineering stages of the 670B. The basic circuitry of all four, however, is unchanged. Here are the key differences between these four stages. Stages 1 and 2 share the same p.c. board. Stages 3 and 4 share a different p.c. board. Stage 1 used a TA7205P for the audio IC. Limited supply caused a change to BA511A's for Stages 2 and 3 and finally to BA521's for Stage 4. The rest of the component changes are related to the audio IC, except for certain ones relating to the rf power output stage and a few incidental changes.

Detailed Information on the Four Stages of the 670B

To differentiate quickly between the four stages, check the bottom of the unit's transceiver board for its part number and the audio IC for its type number and compare them against this listing:

Stage 1	EPO-0646-01	TA7205P
Stage 2		BA511A
Stage 3	EPO-0646C-01	BA511A
Stage 4		BA521

The chart below lists the components that differ from one stage to the next, and what those differences are. The component location drawings should be referred to along with this list to aid in differentiating the stages. Finally, at the back of the manual, there is a separate schematic for each of the four stages.

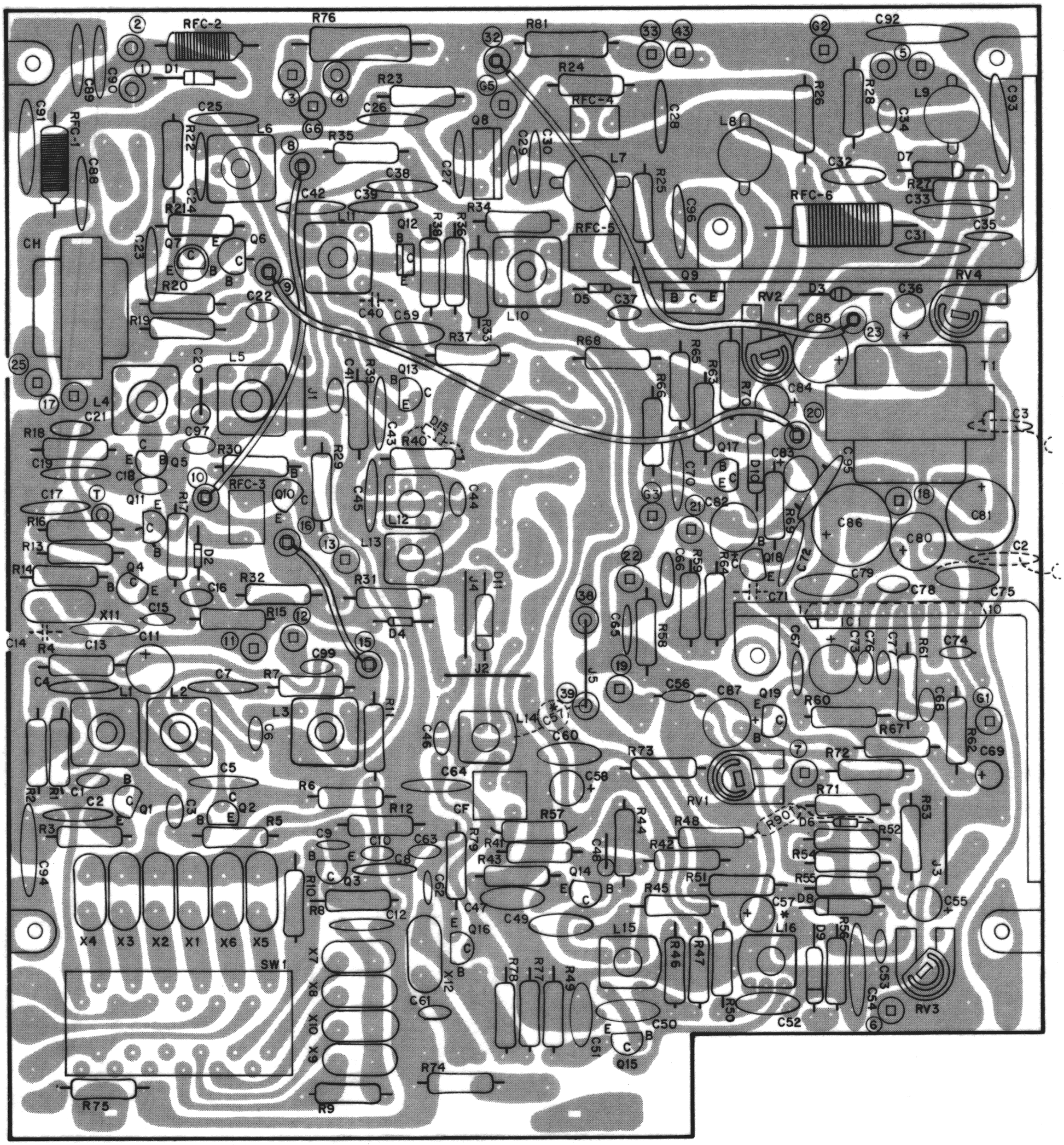
ENGINEERING CHANGES CHART

Component	1st Stage	2nd Stage	3rd Stage	4th Stage
p.c. board	EPO-0646-01	EPO-0646-01	EPO-0646C-01	EPO-0646C-01
IC1	TA7205P	BA511A with extender p.c. board	BA511A	BA521
T1	ETA-0066	TBG25B004W	TBG25B004W	TBG25B004W
C27	330 pF	330 pF	390 pF	390 pF
C56	2200 pF	.047 uF	.047 uF	2200 pF
C57	3.3 uF, 25 V (under p.c. board)	3.3 uF, 25 V (under p.c. board)	3.3 uF, 25 V	3.3 uF, 25 V
C69	3.9 uF	5.6 uF	5.6 uF	5.6 uF
C74	100 pF	—	—	—
C78	100 pF	390 pF	390 pF	390 pF
C105	—	—	39 pF	39 pF
C106	—	—	.01 uF	.01 uF
C107	—	—	100 pF	100 pF

ENGINEERING CHANGES CHART (cont'd)

Component	1st Stage	2nd Stage	3rd Stage	4th Stage
C108	—	—	10 *u*F, 16 V (under p.c. board)	10 *u*F, 16 V
C109	—	—	390 pF (under p.c. board)	390 pF (under p.c. boards)
C110	—	—	—	0.1 *u*F (under p.c. board)
D15	1S1555 (under p.c. board)	1S1555 (under p.c. board)	1S1555	1S1555
R44	33 k	33 k	47 k	47 k
R46	4.7 k	4.7 k	3.3 k	3.3 k
R49	330	330	220	220
R50	470	470	47	47
R58	5.6 k	3.3 k	3.3 k	3.3 k
R62	12 k	12 k	15 k	15 k
R73	12 k	12 k	15 k	15 k
R90	330 (under p.c. board)	330 (under p.c. board)	220	220
R91	—	100 (under p.c. board)	100	100
RFC4	15 *u*H	15 *u*H	2.2 *u*H	2.2 *u*H
RFC7	—	—	0.55 *u*H	0.55 *u*H

P.C. Board Drawings, Stage 1



NOTES:

1. P.C. board shown as viewed from component side.
2. Dashed outline component — mounted on foil side.
   Dashed schematic symbol — selectable component and/or value.
3. †R90 was not used on early units.
4. *C57 may be mounted either above or below the p.c. board.

Figure 4-1. P.C. Board, Component Outline, Stage 1