REPAIR MANUAL

FOR

HALLICRAFTERS

SR-160 AND SR-500

TRANSCEIVERS

The little radios that could

STUFF NOT IN THE BOOK

By WDØGOF **April 2020 update**

HALLICRAFTERS, HAM RADIO, & WDØGOF

I was working for Wilcox Avionics in the 60's & 70's when Hallicrafters became part of Northrop/Wilcox. I was taken by the Hallicrafters gear so much so that I went and took the test and got my call sign. I opened a hobby business on a limited scale repairing Hallicrafters SR series and the FPM 300 radios. I left Wilcox in 79 and due to business travel requirements, I became a dormant ham. On a very limited scale I continued servicing radios and kept the call sign active. In '95 I retired (at 54) and spent 5 years RV'ing the USA. With that out of our systems my wife and I settled down to retired life with church and family. I became an active ham again. I had a bunch of old "H" stuff around. I sold all the old tube junk. This funded the purchase of top of the line MODERN equipment. I still have **nightmares** over that act of stupidity. It only took me a year to realize, that was a mistake. I sold all the Taiwan and Japanese gear and started re-collecting Hallicrafters SR series "tech units" and "parts units". To date I have not purchased a single working rig although I have bought several ***"it worked fine the last time I used it***" rigs. I have a complete collection of the full production SR series HF transceivers in operation in the shack. There are 7 full production rigs in this series and I have restored many of each from the 100watt SR-150 to the 1000watt SR-2000. I have one of each in the shack. In 2015 I closed my repair shop. In the interim I repaired and sold off all the shelfed rigs I had. I have to admit that I enjoy repair and restoration more than operation. Of the series, my favorites are the SR-500 and the SR-2000. The 500 has only two "bells or whistles" xtal cal and RIT so it is truly nostalgic operation. It is quick to tune, very stable (now) and enough punch to get through the noise. I don't contest and if I ever make a DX contact, well that's nice. I'll have to admit that it is not a CW rig, no narrow filter, no VOX (unless you add the HA16 VOX unit) and no break-in keying. But then I have a hearing condition that runs the dots and dashes together at about 9 wpm so that makes me a **nuisance** on cw.

Why a paper on the SR-160 and SR-500? Well I like the little guys. Any time I would bring them up in conversation I would hear "Oh that's the little tri-bander that drifts all over the place." I have to admit if they haven't been cleaned up that is exactly what they do. But with a little TLC they are great communicators. So, after many years of working on them I thought I would share what I have learned.

73's Walt WDØGOF

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I-1. SR-160 OVERVIEW

This SR-160 dressed up with a VFO tuning knob from the SR-150

Contrary to many reviews of the SR-160 Transceiver it is not a scaled down SR-150. It was designed specifically to fill a perceived market niche. The frequency synthesis is totally different and it is a single conversion receiver. The xtal filter in the 150 is 1650 KHz and 5200 KHz in the 160. It is a tri-bander covering the complete 80, 40, and 20-meter ham bands. Power input of 150 watts for SSB and 125 watts for CW. The receiver section has a sensitivity of 1 microvolt for 20 dB signal-to-noise ratio (That is the spec. but most 160's will achieve that at 0.5 to 0.7uv). It uses a 5200 KHz IF, and a crystal lattice filter for selectivity. It has a 100 KHz crystal calibrator and RIT. RIT, RECEIVER INCREMENTAL TUNING was a new feature and the Hallicrafters SR series were the first full production radios to offer this as a standard feature. The power requirements are: 12V ac at 4.5 amps, -125V dc at 6.5 ma, 150V DC at 175 ma, and 575V DC at 200 ma. All of which are provided by the PS-150 AC and DC series power supplies. Production year 1961-63.

I-2. SR-500 OVERVIEW

The Hallicrafters SR-500 Tornado is a radio transceiver designed for 500 watts input PEP on SSB and 300 watts input for CW on 20, 40 and 80 meters. Introduced in 1965 at a price of $395 plus $119.95 for the AC power supply. It is in fact a beefed-up SR-160 using a matched pair of 8236 power output tubes in place of the 12DQ6B pair in the SR-160. The 8236 is a heavy-duty carbon-plate tube and is not that common. The PS-500AC power supply (on the left) is specifically designed for the greater power requirements of the SR-500. A matching mobile supply, PS-500DC, was available at $149.95. The 12AU6 tube and the 100 KHz crystal for the crystal calibrator were extra-cost options (installed in this set).

I-3. 160/500 basics

The SR-160 and 500 are basically the same radio. The biggest change was in the transmitter PA section. They went with stronger tubes in the finals and made a few bias changes. The 500 uses the PS-500 series of power supplies where the 160 uses the PS-150 series power supplies. We will discuss the tubes later. The RX, although being single conversion does a remarkable job. It manages to provide ½ watt audio out with 0.6 to 0.9 uv input and s+n:n of around 20db at 1.0 uv. The AGC flattens out at about 3 to 8uv and provides about 3 to 3.5 watts of audio up to around 8 or 10 thousand uv before the audio out starts to rise again. The air tests are surprising. People report "clean, clear, good sounding audio". Some are actually amazed that an old 60's vintage rig sounds so good. Aside from the lack of features the most offensive problem with the little guys is they tended to be drifty. This too will be covered later.

I-4. SR-160 TO SR 500 EVOLUTION

The following is based on a little fact, some conjecture and rumors. By its third year of production, sales of the 160 had dropped significantly. The reasons were many. It was drifty. In mobile operation the drift problems were even more noticeable and mobile operation was a major marketing hook. The power output, watts per $ was low. However, the marketing people at Hallicrafters believed the niche was there. So, the engineers set about to clean up and power up the 160. They stabilized the VOX/Cal circuitry. They added a voltage regulator for the VFO tube filament for DC mobile operation. Most significant, they gave it a PA that would put out a true 250 to 300 watts of power to the antenna. Of course, the marketing ploy of **"500 watts of input power"** was used. Unfortunately, they did nothing to the VFO and as the little tri-bander accumulated hours it became drifty again. Later in this document "**we gonna fix that**".

I-5. SR-500 FINALS

Hallicrafters selected the 8236 for the final amps. This is a truly remarkable tube. As long as it is not gassy or shorted it's good. The solid carbon block plates are indestructible. With a plate dissipation of 50 watts each they will take a lot of misuse and a very heavy-duty cycle. The prime user of this tube was the Navy and Coast Guard. When they did away with the equipment that used the tube all production of the tubes halted. When I checked with my Navy contacts, I found that the Navy cleared all their stock of 8236's around 1985. You can still find NOS tubes. I suspect that someone bought the navy stock and is slowly selling them to keep the price up. You can find them on ham classified sites and eBay. I buy "cheap" singles and pairs and very seldom get duds. I seldom resort to eBay. I plug a single tube in the rig with no RF drive. Then I record the bias voltage for 35ma and 150ma of plate current. Then I match tubes with similar readings.

There is an alternative. The 8236 is a beefed-up direct replacement for the 6DQ5. The 6DQ5 has a plate dissipation of 24 watts. So, you have to be cautious of the duty cycle. I also use a muffin fan with stick-on felt pads, placed on top of the rig over the finals sucking hot air out. The power output with a good matched pair of 6DQ5 tubes is equal to the 8236. Some of the 6DQ5 tubes are taller than the 8236 so you may have to dimple the PA cover for clearance. Careful, dimple too high and the case will not go back on.

I would expect the life to be shorter for the 6DQ5 but have no verification of that. There is an $80.00 difference in the rig price between the rig with the 8236 and 6DQ5 finals. I have sold several 500's, at the buyer's choice, with the 6DQ5 finals and have not received any negative comments. But then, once the deal is done you seldom hear from them again.

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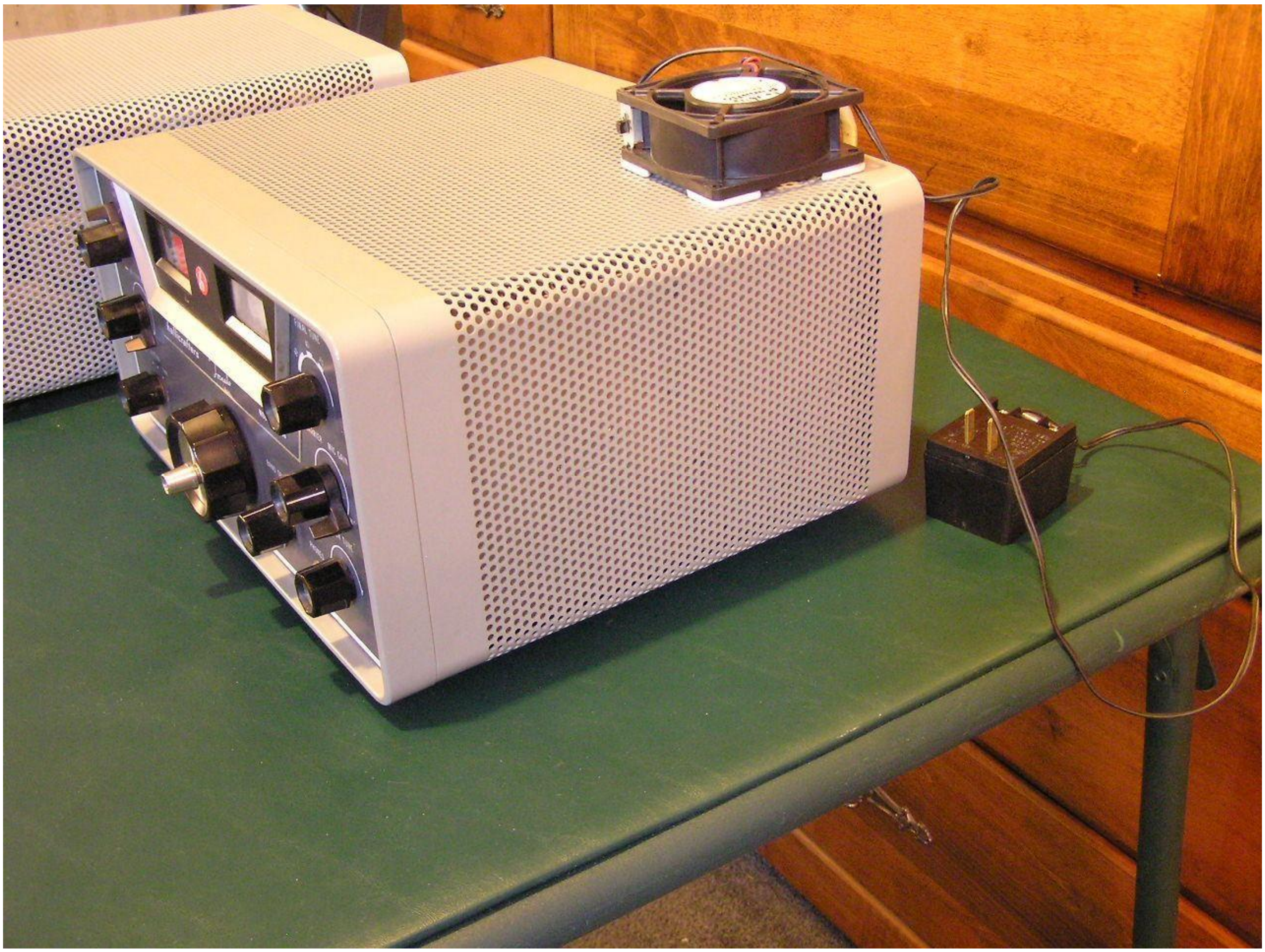


This one was rescued from the loft of a barn. Restored, striped and painted.

II. REPAIR AND REFURBISHING PROCESS

Whether I am repairing or doing a total refurbishment of a rig I take a "nothing works" approach. Over the years I have evolved a uniform approach that serves me well regardless of what kind of transceiver I am working on.

First, get the power supply working properly.
Second, get the oscillators working properly.
Third, get the receiver working properly.
Fourth, get the transmitter working properly.
And finally, perform a full alignment.

The following processes assume a fair understanding of circuit and tube theory.

II-1. TEST EQUIPMENT CONSIDERATIONS.

No exotic test equipment is required for repair and alignment of the SR160 and the SR500. The following test equipment is the minimum requirement.

1, Signal generator: URM25 or spec similar RF generator.

2, O'scope: At least 100MHZ bandwidth. 1X, 10X and 100X probes.

3, Audio output meter: The General Radio Model 1840A is perfect. The meter is calibrated for power and DB measurements.

4, Audio oscillator: It must cover 500HZ to 4KHZ with a **600 ohm output Z_o** and provide .005 to 15v output. Function generators are not a good substitute.

5, RF wattmeter: A 500 watt full scale wattmeter is recommended.

6, VOM, DVM: Don't spend too much money hear. The Harbor Freight $4 seven function meter is good.

7, RF RMS voltmeter: This is optional, I use the scope and mentally convert from pp to rms. If you like the meter, you will need ranges from 5mv to 300v.

II-2. POWER SUPPLY REHAB

II-2-1 POWER SUPPLY LINE CORD

The following applies to both the PS-500 and the PS-150.

When recapping power supplies there seems to be an uncontrollable erg for most people to install a three-wire power cord. **Don't do it**. The PS-150 and the PS-500 power supplies do not like three wire power cords. The system will have a 60/120 HZ hum. Chassis gnd should be connected to the station (antenna system) ground. A keyed 2 wire cord should be used. The wide pin (the neutral wire) of the plug will connect to C202. The narrow pin connects to the fuse. Capacitors C201 and C202 ***are safety*** capacitors. "Line-to-ground" line filter capacitors should be replaced with Y2 or X1/Y2 safety capacitors. (Do not use X2 type). All caps should be replaced with modern caps not NOS parts.

II-2-2. POWER SUPPLY RECAPPING AND COMPONENT UPDATING

All of the electrolytics should be removed and replaced with modern components. Do not skimp here. Search out low ESR capacitors. One ohm or less cap are available and if you search diligently ESR's of 0.5 ohm and less can be found. I prefer to replace C204A & B with two caps mounted under the chassis. Removal of the original C204 is optional. Resistor R207 should be replaced with 10 ohm 10 watt resistor. Improper tuning, bad antennas and or a bad tube will take out R207 before the fuse blows. Resistors R201 and R202 should be changed to 20K 10 watt resistors.
I replace all the diodes with 1N4007. They will handle 1KV and 30amps surges. They can be found for as low as $0.20 each.

II-3. R/T UNIT RECEIVER REFURBISHMENT

It is essential that the power supply is known to be fully in spec before any work on the R/T unit is started.

II-3-1. R/T UNIT POWER DISTRIBUTION

There are three capacitors in the R/T unit that should be replaced. They are, C39, C41 and C137. Once they are replaced you are ready for your first power on test.

II-3-1-1. POWER ON TEST

Set the RF GAIN, AF GAIN, MIC GAIN, and CARRIER controls all to minimum. (**This is the standard settings for these controls every time you power up the system always**.) For bench tests set the rear antenna switch to SEPARATE. The dummy load will be connected to the COMMON connector for TX testing. The signal generator will be connected to the REC. ONLY connector for RX testing.

Locate R83 and R82. (**Caution you are about to expose yourself to voltages that will stop your heart. Observe the FREE HAND IN THE HIP POCKET RULE.**)
Remove the PA cover. Connect the power supply to the R/T unit and set the OPERATION switch to REC. ONLY. The panel lamp should come on and the meter should move to the right. Measure the voltage on the lead of R83 that does NOT connect to R82, it should be approximately +275vdc. Measure the voltage at the tie point of R82 and R83. It should be approximately 35vdc lower than the +275vdc measurement. Measure the voltage on the opposite end of R82. It should be 150vdc + or – 1.0vdc. Measure the voltage on one of the PA final plate caps. These voltages may be + or – 30 vdc from schematic notations of 575 for the PS-150 and 800vdc for the PS-500. If any of these voltages are not correct then you have a fault that must be corrected before you can continue. If they are correct you are ready to proceed to the oscillator test and adjustment section.

II-3-2. VFO AND XTAL OSCILLATOR test and adjustment.

Before starting the oscillator tests and adjustments go to section III-10 and complete all the tests and adjustments described therein.

Before starting any receiver or transmitter RF or I.F. repair or alignment it is **imperative** that the xtal oscillators and the VFO are **precisely** on frequency. If you will devote the time to these considerations you will be rewarded with a rig that performs as well as any modern rig. A frequency counter is a must. The procedure in the book will work ok, but will compound errors. If you get all the oscillators “on freq” individually then all else will fall into place. Do not make any adjustments until the rig has been on for at least 30 minutes.

II-3-2-1. HETERODYNE OSCILLATOR

The heterodyne oscillator functions only on the 40-meter band and does not affect the operation of the 80- and 20-meter bands. **There is no frequency adjustment for this oscillator.** The spec is + or – 1KHZ. If it is off frequency then you will have to live with it and “CAL” any time you go the 40-meter band. **Or,** there are a few things you can do to shift the frequency.

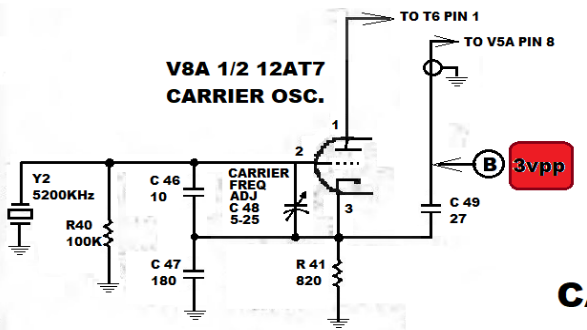
First check the alignment of T8. Connect the scope to test point A. On 80- and 20-meters test point “A” is the VFO signal and should be 3.5 Vpp. On 40 meters test point A is the VFO plus the Heterodyne oscillator and should be 4 Vpp. On 40 meters adjust T8 for peat voltage at test point A.

Connect your frequency counter to test point A. On the 80-meter band set the dial to 3.8MHZ and fine tune the frequency to exactly 9.000MHZ on the counter. Then switch to 40 meters. The counter should now read exactly 12.400 MHZ. If it is not, then try the following:

1) You can hand select the tube V11, this can shift as much as 500HZ.
2) T8 will shift the frequency of the oscillator, but care must be taken to insure you do not detune too far off peak. No more than 15% off peak.
3) In my personal rig I replaced C79 with a 9-35pf variable cap. (T8 and C79 adjustments will interact)
4) The crystal is the last resort. If the oscillator is way out of spec or won’t oscillate, and you can find no other part at fault, then try to find another xtal. After replacing the xtal you may still need to correct the frequency.

II-3-2-2. CARRIER OSCILLATOR

This oscillator has a trimmer adjustment, C48. Simply connect the frequency counter to test point B and adjust C48 for exactly 5.200MHZ. The adjustment of C48 and T6 do interact. So anytime you change the tuning of T6, recheck the oscillator frequency. The voltage at test point B should be 3 Vpp.



CARRIER OSC

VFO and HETRODYNE OSC's

TEST POINT Ⓐ
80/20 METERS 3.5vpp
40 METERS 4.5vpp

TEST POINT Ⓐ
FREQUENCY SYNTHESIS

80 METER = VFO
LOW = 8.7 MHz
HIGH = 9.2 MHz

40 METER = VFO + HET
LOW = 8.7 + 3.4 = 12.1MHz
HIGH = 9.2 +3.4 = 12.6MHz

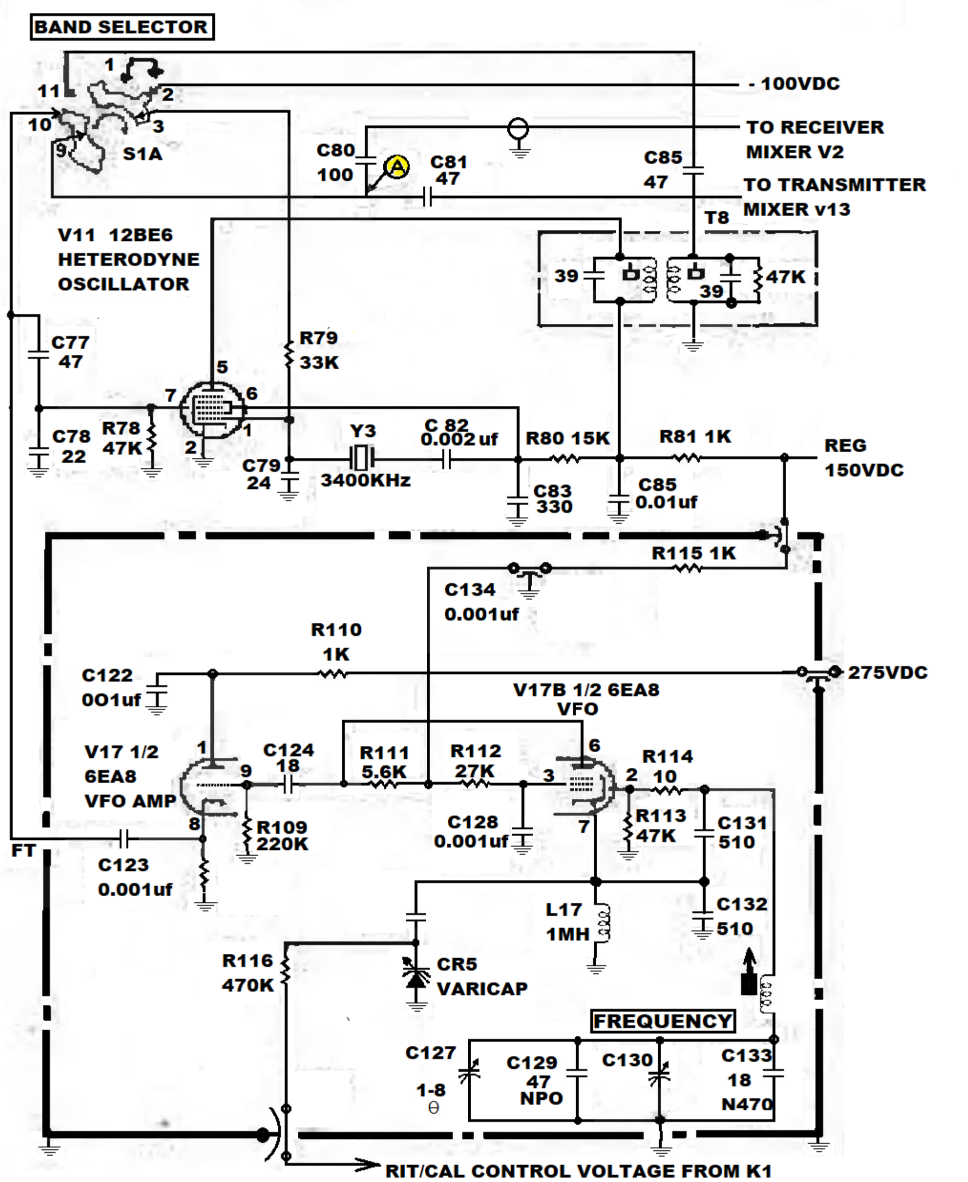
20 METER = VFO
LOW = 8.7 MHz
HIGH = 9.2 MHz

V13 XMTR MIXER
FREQUENCY SYNTHESES

80 METER = VFO - CARRIER
LOW = 8.7 - 5.2 = 3.5 MHz
HIGH = 9.2 - 5.2 = 4.0 MHz

40 METER = VFO + HET - CARRIER
LOW = 8.7 + 3.4 - 5.2 = 6.9 MHz
HIGH = 9.2 + 3.4 - 5.2 = 7.4 MHz

20 METER = VFO + CARRIER
LOW = 8.7 + 5.2 = 13.9 MHz
HIGH = 9.2 + 5.2 = 14.4 MHz



II-3-2-3. ALTERNATE VFO ALIGNMENT

Do the mechanical index adjustment first (section 8-8 in the manual). Now read sections 8-9 and 8-10. Once you have read these sections and have an understanding of what is going on you can start. These adjustments are simple but **critical.** If you don't understand them, find an Elmer. I prefer a freq. counter to align the VFO. Using X10 scope probe connected to the freq. counter and test point A. Set the band switch to 80 meters. At 4.00 on the dial the VFO is 9.200 MHz. At 3.500 on the dial The VFO is 8.700 Mhz. At 3.800 on the dial the VFO is 9.000 Mhz. **When aligning the VFO ensure that the RIT is OFF and the CAL control is in the center of its rotation.** The adjustment of C127 and L18 interact and a *feel* for rocking the two adjustments in for the band ends will need to be developed. Use the procedure as described in the manual. With the frequency counter method, the calibrator will remain off. Make the following changes to steps in section 8-10 of the manual.

Step 2. Set the BAND SELECTOR at 80M, the OPERATION control to REC ONLY, and the RIT control OFF.

Step 4. Set the dial at 4000 KC and adjust C127 for exactly 9.200 MH on the counter.

Step 5. Set the dial at 3500 KC and adjust L18 for exactly 8.700 MHZ on the counter.

Let me say again. The adjustment of C127 and L18 interact and a *feel* for rocking the two adjustments in for the band ends will need to be developed

NEVER DO STEP 7 IN THE MANUAL UNLESS YOU ARE VERY SKILLED IN THE KNIFING PROCEDURES. C130 IS VERY FRAGILE AND THE UTMOST CARE IS REQUIRED TO PREVENT THE CAPACITOR BLADES FROM FALLING OUT…!!

Last check; measure the voltage at test point A on 80 meters it should be 3.5 Vpp.

II-3-3. RECEIVER TEST AND FAULT ISOLATION

II-3-3-1. EQUIPMENT REQUIRED:

- HF RF signal generator capable of .5 microvolts to 200 millivolts.
- Audio output meter (similar to General Radio 1840A).
- Scope 100 MHZ or better. 1:1 and 10:1 probes or switchable probe.
- Audio oscillator.

II-3-3-2. PRETEST CONDITIONS*:*

This procedure ASSUMES that you have successfully completed all the tests and adjustment is section II-3-2. There is not anything inherently clever about this process. What it does offer is signal injection levels and output results gathered from dozens of tests performed on both the 160 and the 500.

The receiver functions as a closed loop. What this means is that by virtue of the AGC circuits the overall gain is dependent on the level of AGC action and the AGC action is dependent upon the signal level at the input and the overall gain. **For the primary tests we will disable the AGC. Locate the junction of R65 (220K) and R66 (100K) and place clip-lead from that point to ground.**

Connect the audio output meter to J1, the front panel PHONES jack. Set the meter load to 3.12 ohms and the meter scale to the 2 watt/30db range. If you do not have an audio power meter you can use a 3 to 4 ohm 5 watt resistor and monitor the voltage across the resistor. You will then need to do calculations to arrive at the proper power levels and db shifts. You may want to make a chart of these levels in advance. You will soon see why the audio output meter is such a valuable tool.

II-3-3-3 STANDARD CONTROL SETTINGS

RIT-off

RF GAIN, AF GAIN, CARRIER and MIC GAIN set to minimum.

DIAL CAL to center of rotation.

BAND SELECTOR to 80M.

DRIVER TUNE to center of rotation.

(DRIVER TUNE is a misnomer it actually functions as the preselector for the receiver rf amp and the driver grid and plate tune.)

FREQUENCY set to 7.900MHz.

FINAL TUNE set to approximate section on selected band.

OPERATION set to REC ONLY.

Allow 2 minutes and then advance the RF GAIN and AF GAIN controls to max.

II-3-3-4 RECEIVER FAULT ISOLATION

STEP	PROBE	INJECTION POINT	FREQ.	SIG. LEVEL	OUTPUT	RESULTS
1	1:1	Pin 1 V6	1000HZ	12Vpp	.5 wt.	Good go to step 2. Incorrect; fault in V6 stage.
2	1:1	Pin 2 V5	1000HZ	0.3 Vpp	.5 wt.	Good go to step 3 Incorrect; fault in V5B
3	1:1	Pin 7 V5	1000HZ	0.1 Vpp	.5 wt.	Good go to step 4 Incorrect; fault in V5A or AF GAIN control
4	1:1	Pin 2 V4	*5200KHZ Adjust T4 for audio peak	0.004 vrms	.5 wt.	Good go to step 5 Incorrect; fault in V4A or T4
5	10:1	Pin 2 T2	*5200KHZ Adjust T2 &T3 for audio peak	200uv	.5 wt.	Good go to step 6 Incorrect; fault in V3,T2 or T3
6	1:1	Pin 7 V2	3.900MHZ Tune for peak audio out	150uv	.5 wt.	Good go to step 7 Incorrect: fault in V2, T1 or FL1
7	1:1	Pin 1 V1	3.900MHZ	7.5uv	.5 wt.	Good go to step 8. Incorrect; fault in V1
8	Coax	J6	3.900MHZ Adjust L1 and L5 for max audio	1uv	.5 wt.	Good go to step 9 Incorrect; fault in band switch S1B and associated circuitry or K2.
9	Coax	J6	3.900MHZ	1uv	.5 wt.	Remove ground jumper from AGC. Audio output should drop 1 to 2 db. If audio drops more than 2db or increases go to step 10
10	Coax	J6	3.900MHZ	#	1.5wt	Adjust T7 for minimum audio output. This should coincide with a peak on the S-METER. Rerun step 9 if it is still incorrect there is a fault in V10A or B.
This concludes the receiver fault isolation process. Check the receiver operation on 7.23MHZ and 14.28MHZ. If the receiver fails to function then there is a band switching fault. Some adjustment of L2 and L6 on 40 meters and L3 and L7 on 20 meters may be required.						

* Frequency must be precise. If using vintage test equipment use a frequency counter to insure proper frequency.

Increase signal generator output until you get 1.5 watts of audio output.

Proceed to section III-5 and complete AGC test and evaluations and then return to this point.

If you have followed the procedure from the beginning you have proven the proper operation of the following: The power supply, oscillators, the heterodyne mixer, the receiver and the agc circuits. You are now ready to process the transmitter.

II-4. TRANSMITTER FAULT ISOLATION

UNLESS OTHERWISE NOTED ALL TX TESTS ARE PERFORMED AT 3.900MHz.

Caution you are about to expose yourself to voltages that will stop your heart. Observe the FREE HAND IN THE HIP POCKET RULE.

II-4-1 BIAS ADJUSTMENT

The bias adjustment sets the idle current of the PA tubes.
A. Go to section 8-3 of the Hallicrafters OPERATING AND SERVICE INSTRUCTIONS and complete the instructions for the bias adjustment. If the adjustment is unsuccessful replace the PA tubes with a new matched pair.
B. Measure the voltage at the junction of R95 and L11 (Grid ckt PA tubes).
For the SR-160 it should be approximately -55 volts + or – 5volts.
For the SR-500 it should be approximately -85volts + or – 8volts.
If the voltage is not within the stated range the PA tubes should be replaced.

II-4-2 NO SSB POWER OUT

If you have normal power output in CW/TUNE but no power out in SSB mode you most likely have a fault in the mic amp train or the balanced modulator.

II-4-2-1 MIC AMP FAULT

The microphone amplifier train is composed of V9A, V9B and V8B. V9A & B are active in receive (rx) and transmit (tx) modes. V8B is biased OFF in receive mode. V9B has a gain of 20X (not db). V9A has a gain of 10. V8B is a cathode follower with unity gain. With the V9's being active in rx and tx these two stages can be analyzed in rx mode without having to key up the transmitter.

Read the following procedure and follow the flow on the schematic once or twice before you start analyzing the ckt performance.

-Inject 1000Hz into pin 1 of the mic jack while monitoring the signal at pin 2 of V9B with an oscilloscope. Adjust the level of the audio until you get 20 millivolts peak to peak on pin 2.
-Move the scope to pin 7 of V9A. Ensure the mic gain is at max. You should have 400millivolts peak to peak on pin 7 with 20 millivolts into pin 2.
-Move the scope to pin 7 of V8B. You should have 4 volts peak to peak.
-Move the scope to pin 8 of V8B. V8B should be cut off in rx mode and there should be no signal on pin 8 at this time.
-While observing pin 8 of V8B temporarily ground pin 2 of the mic jack. The signal should rise to 4 volts peak to peak. Once you have proper audio to this point the mic amp train is good. Go on to analysis of the balanced modulator.

II-4-2-2 BALANCED MODULATOR FAULT

The basic components of the balanced modulator are; T6, R45, CR2 and CR3.

The first thing is to ensure the carrier oscillator is functioning properly.

Connect a 10x scope probe to test point B (top of C49 connected to pin 3 of V8A. The other end of the scope probe will be alternately connected to a scope or a frequency counter.

In the REC ONLY mode you will use C48 to adjust the frequency and T6 to adjust the amplitude. *NOTE: As little as 300Hz low and you will be out of the bandpass of FL1. In CW mode the carrier frequency is fed straight to FL1. This frequency is actually out of the passband of the filter, normally there is enough signal there to function properly in CW mode. In some cases, you may want to set the carrier frequency* ***100 to 200Hz high*** *to get full power in CW mode.*

With the probe connected to the counter adjust C48 for exactly 5.200MHz.

Adjustment of T6 is a little more involved. With the probe connected to the scope adjust T6 for max signal output. Now carefully tune each way from peak. You should note that the signal falls off more slowly in one direction than it does in the other direction. Now retune for peak, and in the direction of the slow fall off, tune for a signal equal to 90% of the peak value.

The minimum voltage will be 3vpp (1vrms)

The adjustments of C48 and T6 do interact somewhat so repeat the adjustments until you are satisfied you have a stable condition.

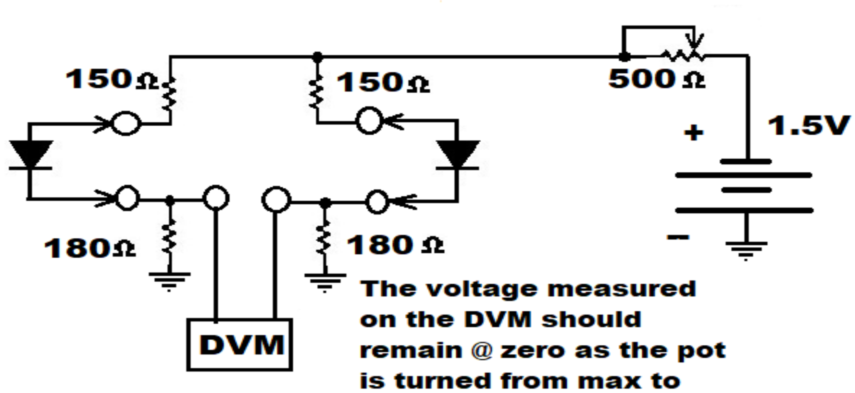
In the procedures above we have proven the operation of the mic audio and carrier osc circuits.

In the SSB receive mode check the signal levels on pins 3 and 4 of T6. They should be between 3.5 to 4.5 volts peak to peak. Too little and you will have low power. Too high and you will have poor carrier rejection. If there is a large difference between the signal on pins 3 and 4 then most likely C51 or C52 is bad.

If you reach this point and have no power in SSB mode and have normal power out in CW/TUNE mode only a few parts remain unproven. Check the following individually; R44, R43, R45, CR2, CR3, C51.

II-4-2-2-1 1N87 DIODES

CR2 and CR3 need to be a matched pair. Great quantities of these diodes are still available and can be found for around $0.50 ea. Matched pairs go for around $30.00 a set. I purchase 10 to 15 at a time and match them myself. If you do not have a curve tracer a simple matching circuit can be made.



II-4-2-3 OPERATION SWITCH FAULT

If you did not find a fault in section II-4-2-1 or II-4-2-2 above then perform a continuity test of the operation switch S2A.

II-4-3 NO POWER CW/TUNE, SSB POWER NORMAL

Under normal operating conditions there is a negative voltage on the anode of CR2 and the cathode of CR3 via R49. The cathode of CR2 and the anode of CR3 are tied together and are dc floating via R46, R47 and open contact of S2A. In this condition the circuit operates normally as a balanced mixer. When the unit is switched to the CW/TUNE mode a ground is applied to the wiper of R47. This turns CR2 OFF. CR3 is biased on at approximately 0.01ma with R47 fully ccw. When R47 is fully clockwise CR3 is biased to conduct at 3.5ma. Essentially CR3 becomes a variable resistor ranging from 35K to 100ohms passing the carrier freq straight through to the xtal lattice filter.

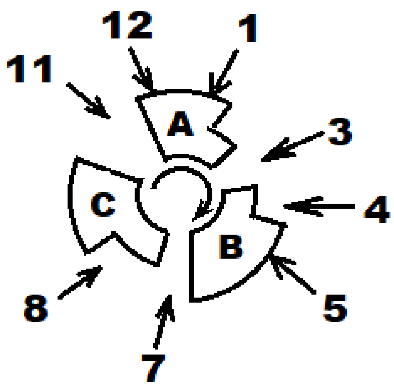
Only 2 things will cause loss of power in the CW/TUNE mode and **normal** operation in the **SSB** mode.

First; the carrier oscillator frequency is too low. Go back to section II-4-2-2, read the oscillator discussion and test the oscillator.

Second; the junction of CR2 and CR3 is not receiving a ground in CW/TUNE function. Measure the voltage on the wiper of R47. It should be near -100v in REC ONLY and SSB operation (The actual voltage measured is determined by the quality of the test meter you use to take the measurement). In CW/TUNE is should drop to zero. If this is not true then R46, R47 S2A or the wiring to it is bad.

II-4-4 S2A FUNCTION GUIDE

SR-160/500 S2A



S2A	A	B	C
OFF	1-12	5-NC	NC-NC
RX	1-NC	NC-7	NC-11
TUNE	NC-3	7-8	11-12
SSB	3-4	8-NC	12-1
CAL	4-5	NC-NC	1-NC

12 TX KEY
1 MIC KEY SWITCH
3 3rd MIC AMP PLATE
4 B+
5 CAL OSC PLATE V
7 CARRIER LEVEL
8 TX GND/RX-100
11 GND

II-4-5 NO POWER OUT ANY MODE

The following is predicated on the FACT that the receiver is working properly and to spec. If not go to II-3-2 and start at the beginning.

II-4-5-1 TX MIXER DRIVER TRAIN TROUBLESHOOTING

The following measurements are taken with a 100x scope probe. Tune the unit to 3.900MHz and tune up the receiver for max signal. Some adjustment of L5 and L8 may be required for max signal.

TEST POINT	SIGNAL		RECOMMENDATION
V13 PIN 1	3Vpp		This is the output from the VFO. With all the preconditions met if this signal is not present then C81, R85 or V13 is bad. If ok continue.
V13 PIN 7	5Vpp		If this signal is not present the balanced modulator and the primary of T1 are the prime suspects. If ok continue
V14 PIN 2	3Vpp		If not then V13 and its plate loading ckts are suspect. If ok continue
V15 PIN 5	100Vpp (Should produce approx. 100 watts)		If not then V14 and its plate loading ckts are suspect. Move the probe from the scope to a frequency counter and ensure the signal is 3.900MHZ. If ok go to II-4-5-2

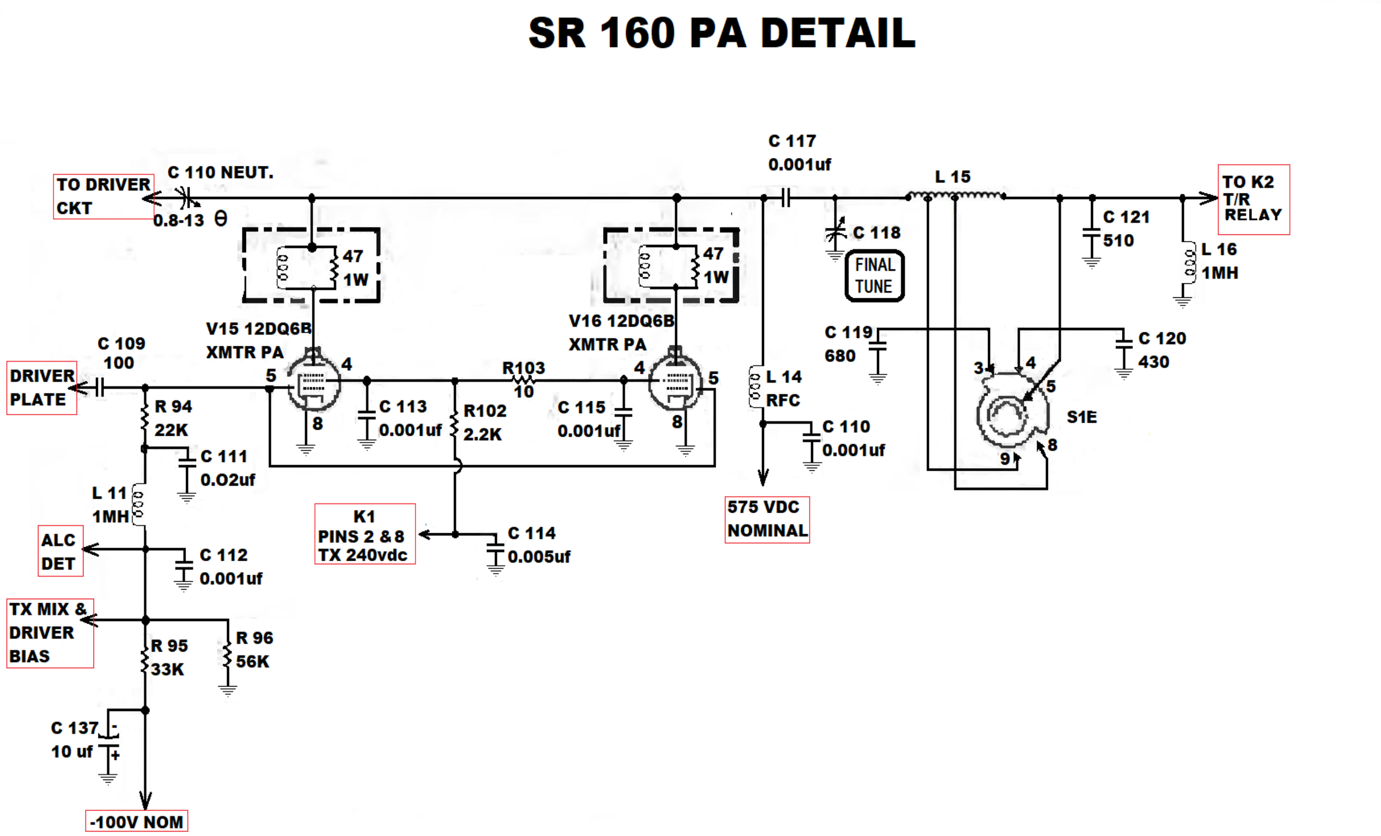
II-4-5-2 PA FAULT ANALYSIS

Caution you are about to expose yourself to voltages that will stop your heart. Observe the FREE HAND IN THE HIP POCKET RULE.

You have reached this point because the receiver and all the transmitter front end ckts have tested good. First, we will assess the conditions of the 12DQ6B's. Double check the no-drive idle current of the PA's and adjust to spec. Measure the bias voltage on pin1 or 5 of V15 it should be; For the SR-160 approximately -60 volts + or – 5volts.
For the SR-500 approximately -85volts + or – 8volts.

II-5. SUBSYSTEM SCHEMATICS AND VOLTAGE CHARTS

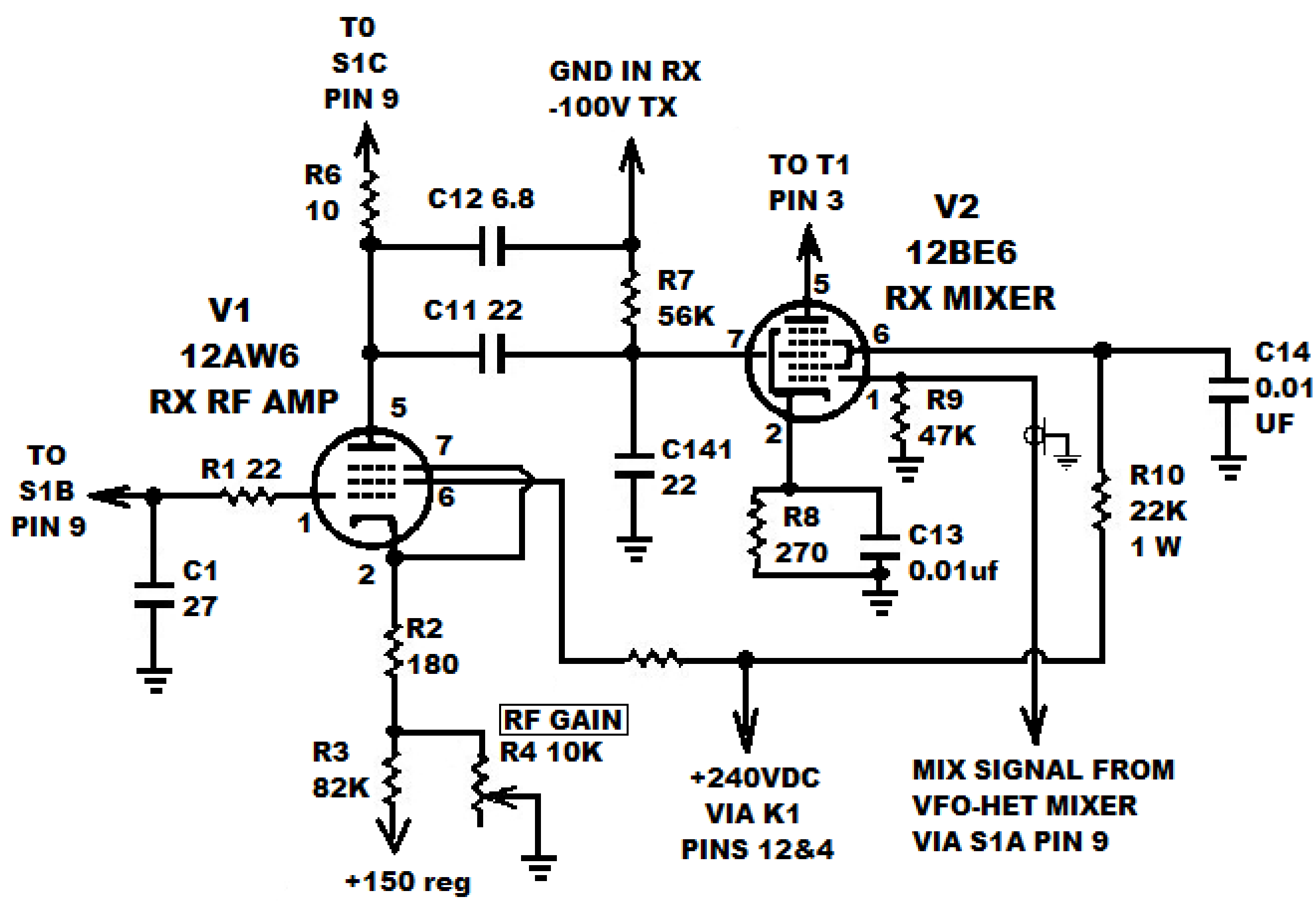
II-5-1. FINAL PA



II-5-1-2 PA BIAS CONSIDERATIONS

The -100v supply is adjusted to produce an idle current in the final amp tubes of 60 mills in the SR-160. As tubes age and get weak you have to keep reducing the bias supply to keep the idle current up to standard. On the surface that seems ok. However, as you reduce the bias on the finals you are also reducing the bias on the tx mixer and the driver. The system was designed this way so, as the finals get weak the drive from the mixer and driver will increase to some small degree. But this also puts more stress on the 12BY7A driver tube and shortens its life. Ideally for the SR-160 with no drive to the finals, and the idle current set for 60 mills you should measure -55 to -65 volts on either grid of the finals. For the SR-500 idle current is set for 100 mills and the bias on pins 1 or 5 should measure -77 to -93v. Generally speaking; Less voltage indicates weak finals; more voltage indicates gassy tubes. This could also be an indication of screen or plate voltage problems.

II-5-2. SR-16-/500 RF AMP & MIXER



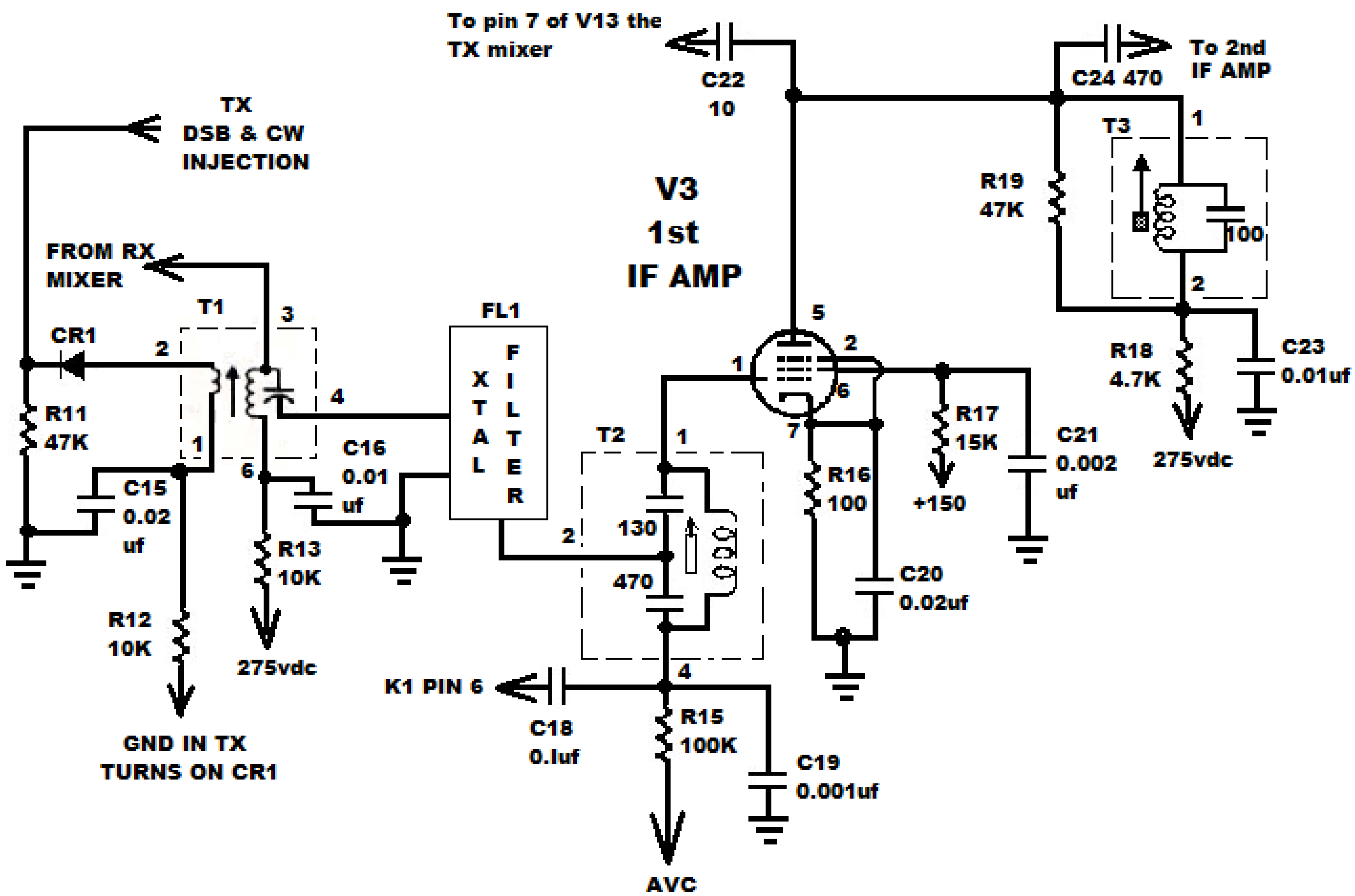
The band switching and **grid** tuning for V1 is provided by S1B and coils L1, 2 and 3. The band switching and **plate** tuning for V1 is provided by S1C and coils L5, 6 and 7. S1C and coils L5, 6 and 7 also provide the grid tuning for V14 the PA driver. The RX mixer grid is provided a gnd for the bias resister R7 by K1 pin 3 and 11. In the transmit mode the gnd is removed and the grid receives a negative bias which cuts off the mixer and mutes the receiver.

RX = No signal in RF GAIN set to max. TX = MIC and CARRIER set to minimum in tune.

TUBE PIN#		1	2	5	6	7
V1	RX	0	1.4v to 17.0v *	258	116	XXXX
	TX	XX	XXXXX	XXXXX	XXXXX	XXXXX
V2	RX	0	3.1	260	99	0
	TX	1.6	0	288	0	-89

*RF GAIN at max = 1.4v. RF GAIN at min = 17.0v

II-5-3. 160 500 1st IF AMP

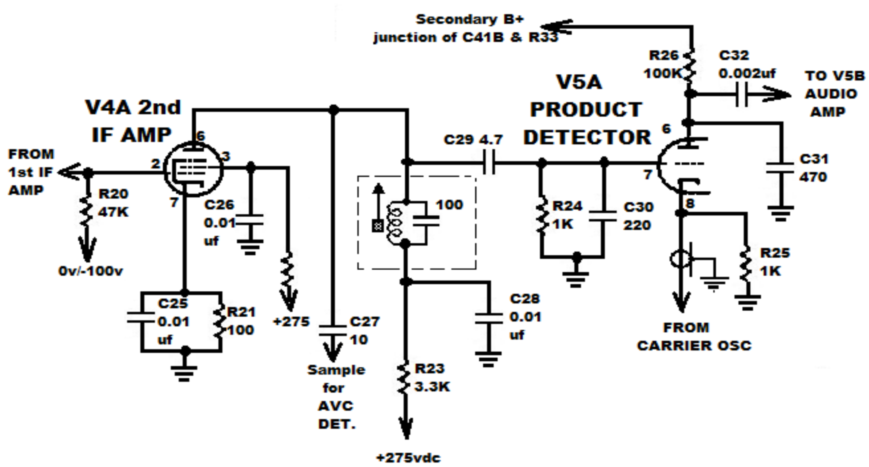


In receive mode, signal from the receiver mixer is feed through T1, FL1 and T2 to the first if amp. In SSB transmit mode the double sideband suppressed carrier signal from the balanced modulator is fed through FL1 stripping away the unwanted sideband. In CW transmit mode the carrier oscillator signal is fed directly to and through FL1. In both cases the transmit signal is amplified by V3 and passed on to the transmit mixer.

Measurements made in receive mode with RF GAIN at minimum. (+275 MEASURED 300)

PIN	1	5	6	7
VOLTAGE	0	245	125	1.0

II-5-4. SECOND IF AMP & PRODUCT DETECTOR

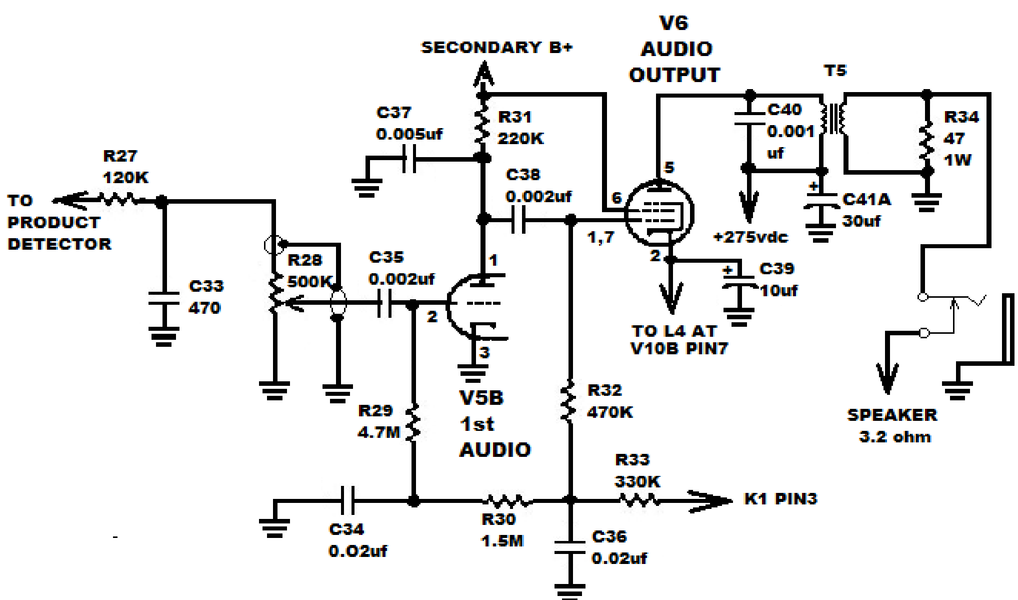


The voltage at the bottom of R20 is 0v in receive mode via pins 3 and 11 of K1. In transmit mode the gnd at K1 is removed and -100 volts is delivered via R105.

Measurement taken with no signal in, receive mode with RF GAIN at minimum. (+275 measured +300)

PIN#	2	3	6	7	8
V4A	-0.2	68	283	0.65	///////////
V5A	/////////////	////////////	126	0	1.3

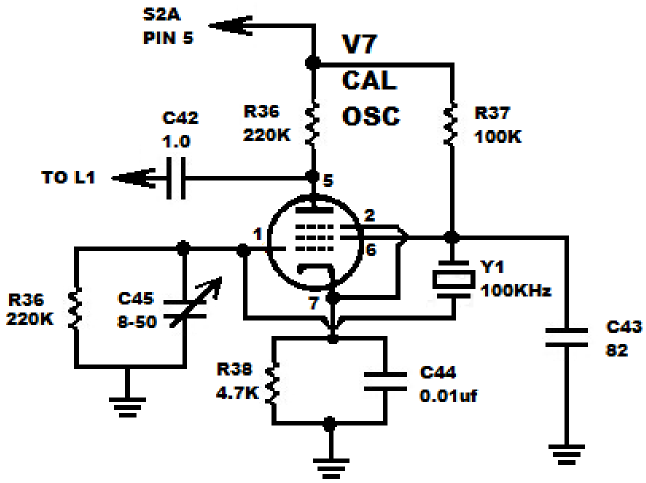
II-5-5. AUDIO AMP AND OUTPUT



Measurement taken in receive mode, no signal in RF GAIN at minimum.

PIN #	1	2	3	5	6
V5B	99	-1.55	GND	//////////	///////////
V6	-0.15	17.4	///////////	300	258

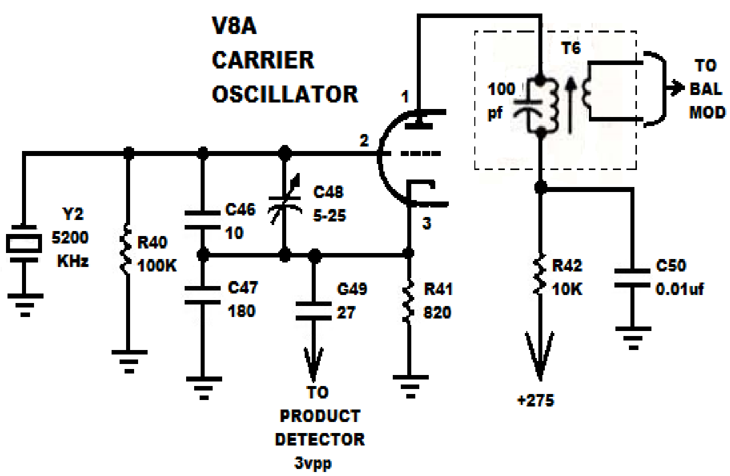
II-5-6. CALIBRATION OSCILLATOR



Measurements taken in receive mode, SSB and CAL functions.

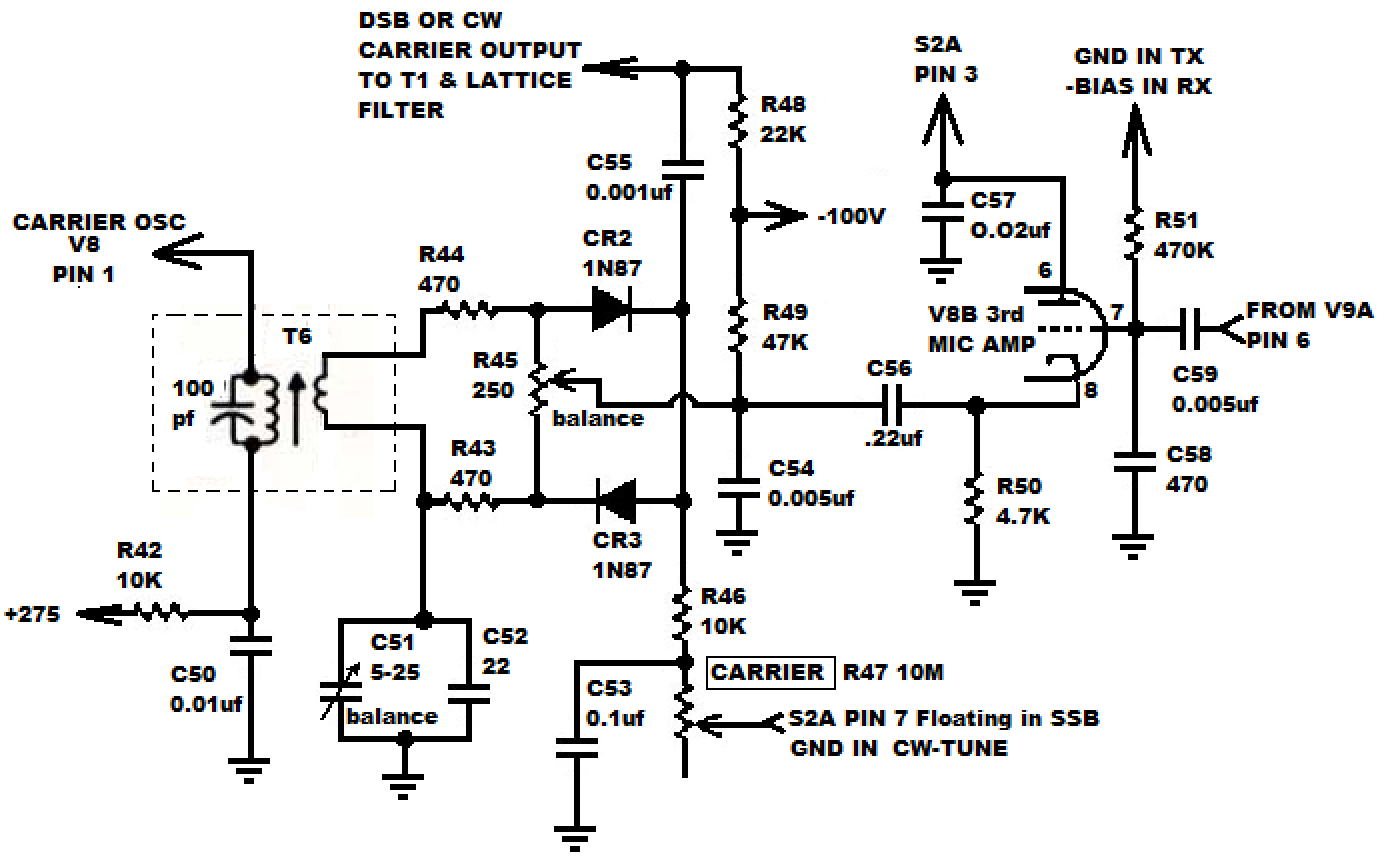
PIN 3	1	5	6	7
SSB	-0.86	-0.62	-0.71	0.03
CAL	-35	72	115	10.75

II-5-7. CARRIER OSCILLATOR



PIN	1	2	3
VOLTAGE	222	-55	3.8

II-5-8. BALANCED MIXER



In SSB mode Carrier signal is mixed with audio signal. The balanced mixer produced a double sideband suppressed carrier signal which is fed to the lattice filter. In CW mode S2A applies a ground to R47. This cuts off CR2 and turns CR3 into a variable resistor. As you adjust R47 you increase or decrease the level of carrier signal passed through CR3.

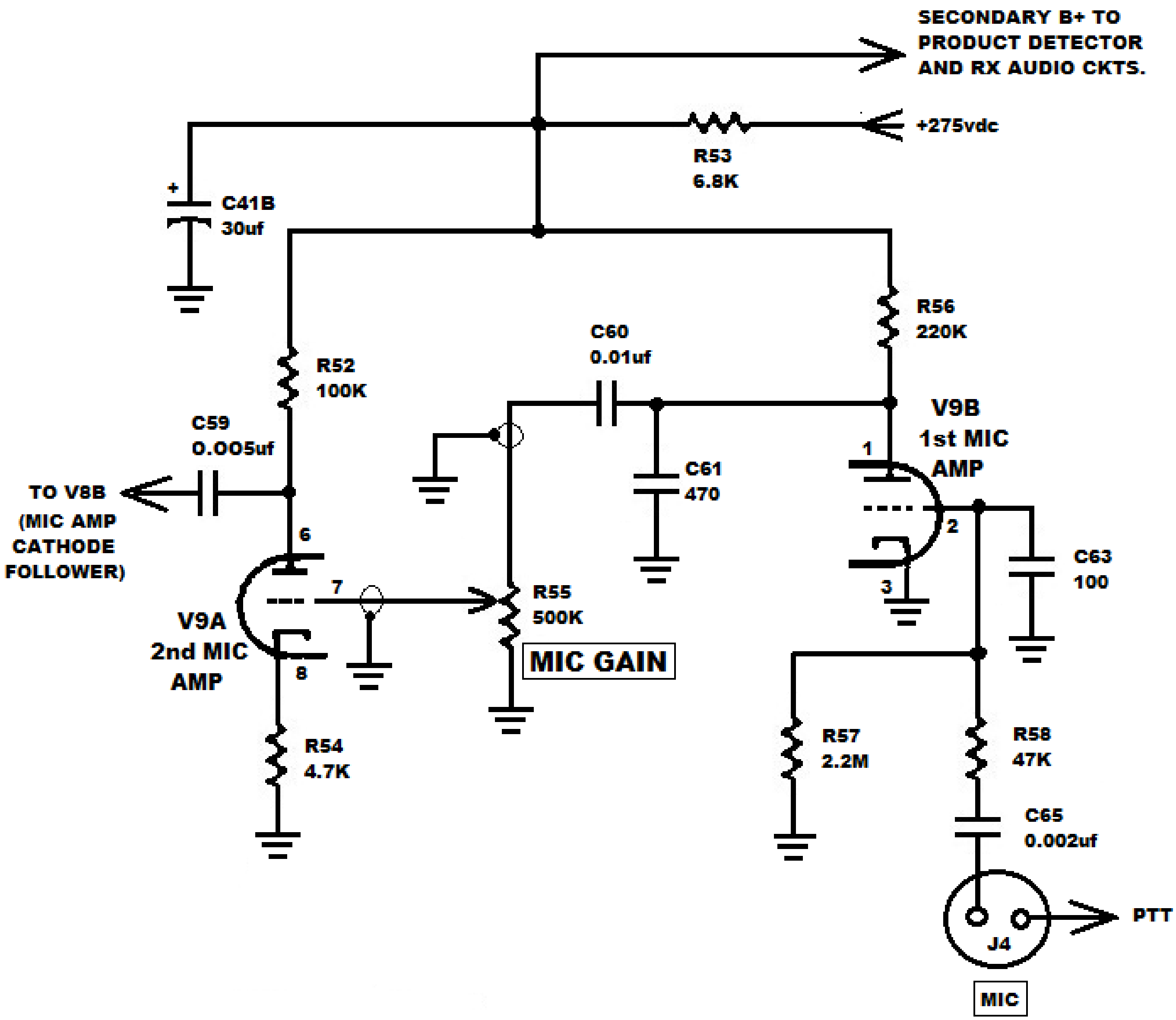
Note: V8B the 3rd MIC AMP is not an amplifier. It is a cathode follower. The audio signal on the grid and cathode should be nearly equal at 4.0 vpp. Loading by a sampling probe may cause a slight difference.

Adjust mic gain and carrier to minimum.

(+275v measured +300)

PIN #	6	7	8
SSB	300	-60	0
CW/TUNE	0	0	0

II-5-9. MIC AMP

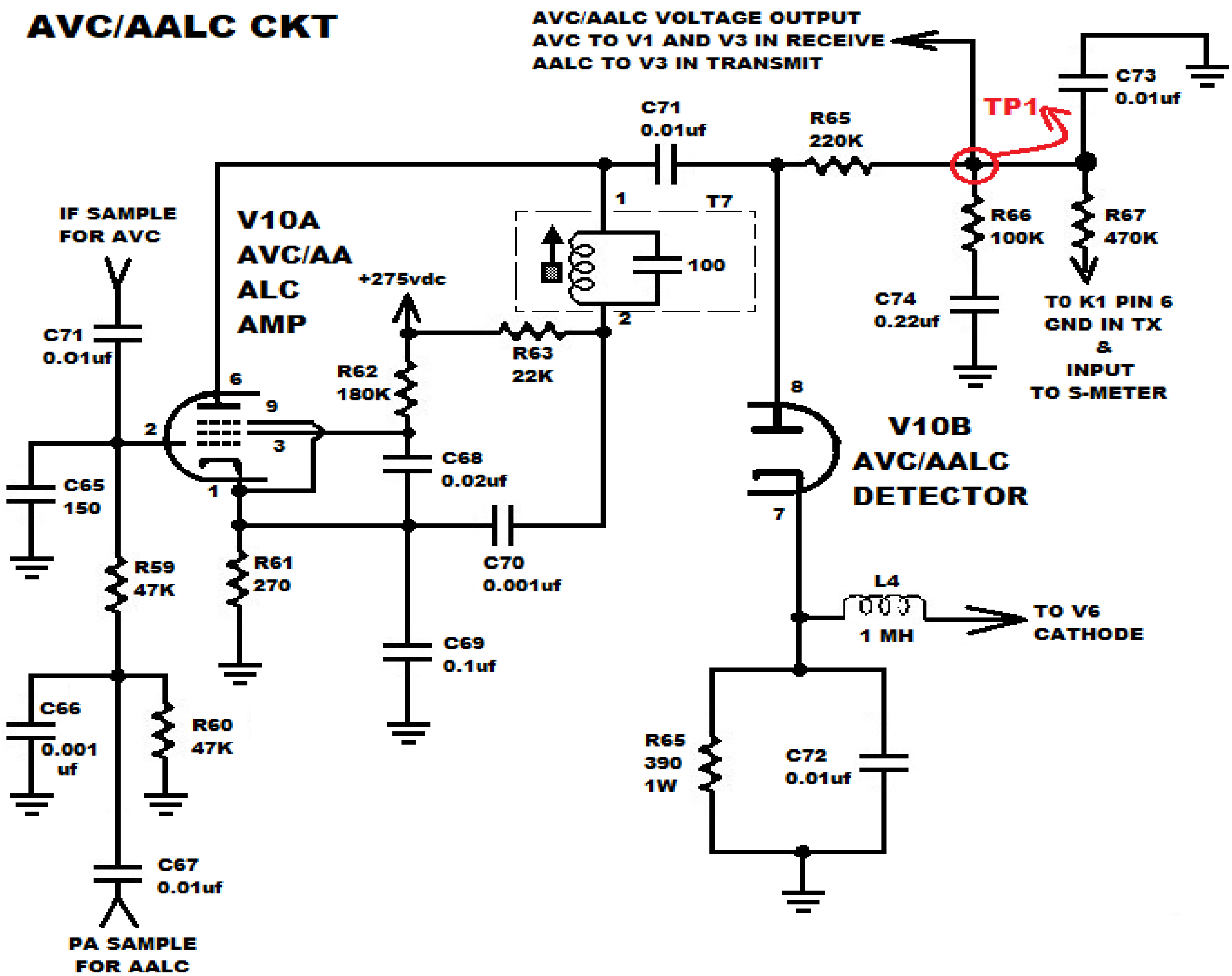


The standard input signal for the microphone amplifier ckt is 0.005v (0.014vpp) from a 600 ohm source. This portion of the mic amp ckt is hot in all modes. This allows for the preliminary testing to be done in receive mode.

(+275 measured +300)

PIN #	1	2	3	6	7	8
VOLTAGE	49	-0.774	gnd	174	0	3.1

II-5-10. AVC/AALC



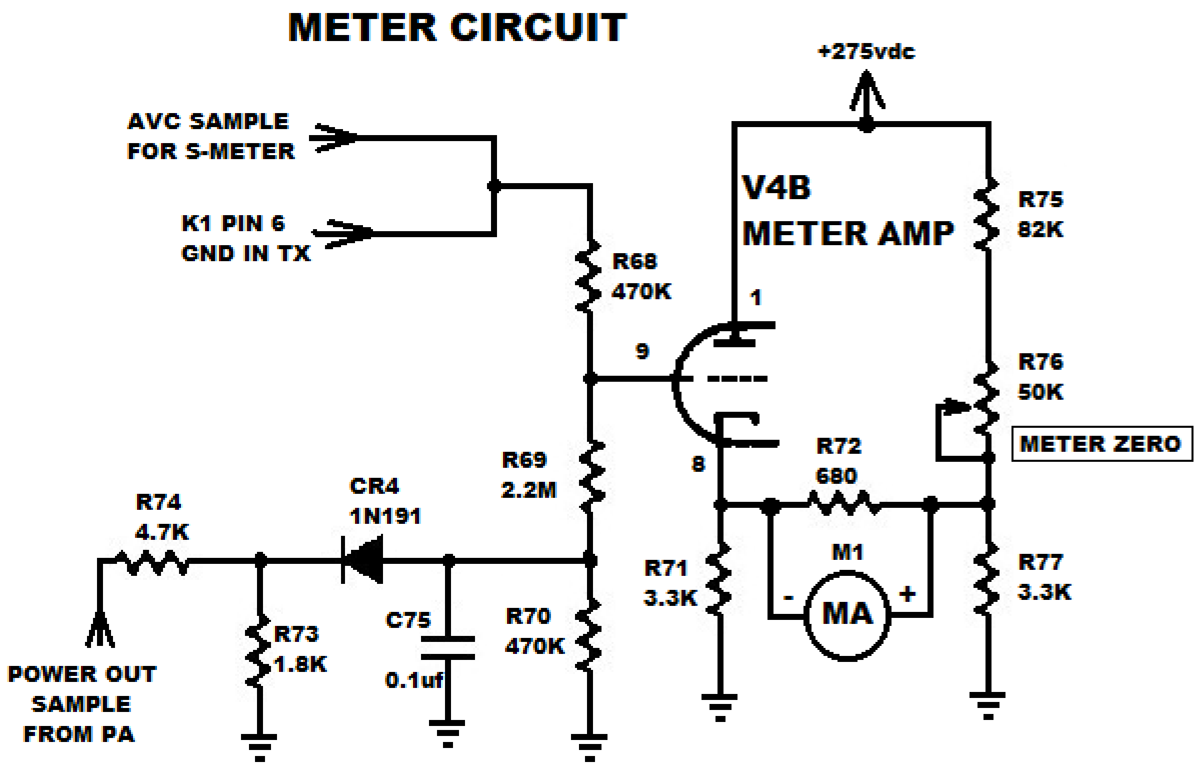
In receive mode the voltage passed by R67 is applied to the meter amp grid. This voltage is then presented as S units by the meter. In transmit mode a ground is applied to R67 by K1. This allows the PA rectified sample voltage to drive the meter amp. See the METER AMPLIFIER discussion for more details.

Tune in receiver on frequency of your choice. Set RF GAIN to max. Adjust signal input to 50uv. Set AF GAIN to comfortable level. Adjust T7 for max S-METER reading. Remove signal for first set of measurements. Input 10uv signal for second set of measurements. Ensure signal is peaked.

PIN #	1	2	3	6	7	TP1
0 SIG IN	1.7	0	105	188	17	-1.00
10 uv IN	1.7	0	105	188	17	-3.5

BE AWARE this is a high impedance, closed loop circuit. No two radios will react in an identical manner. Some variation in signal levels are expected. Overall similar results are expected.

II-5-11. METER CIRCUIT



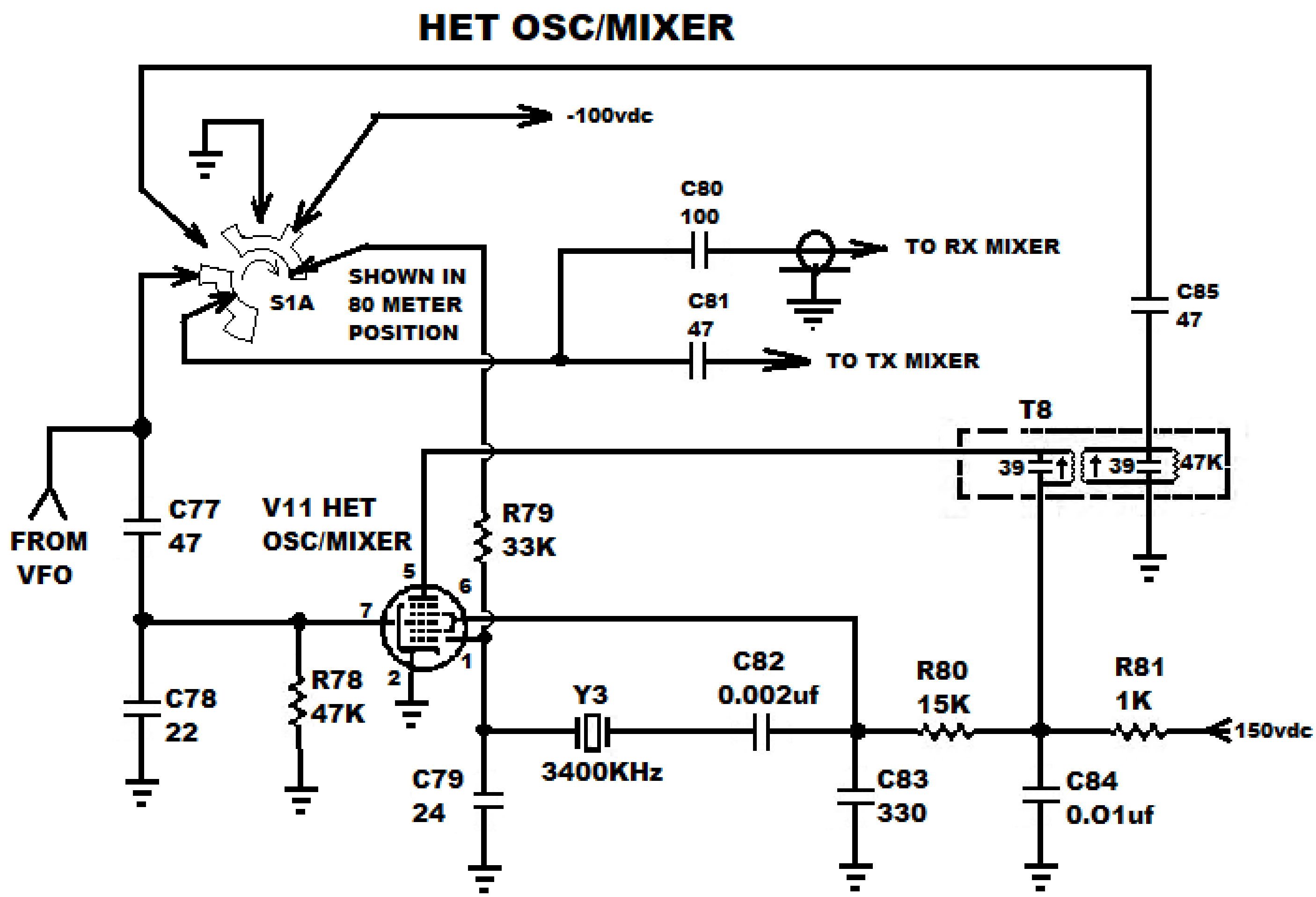
The meter ckt presents an indication of signal strength in receive mode and relative RF power out in transmit mode. The meter amp is one leg of a bridge ckt that feeds the meter M1. The meter zero pot and R75 form another leg. R71 and R77 form the balanced legs of the bridge.
In receive mode a sample voltage relative to the AVC level is presented to the meter amp V4B which drives the meter to indicate relative S units.
In the transmit mode a ground is applied to R68 which isolates the meter amp ckt from the AVC ckt. A sample of the RF power out is presented to CR4, rectified and presented to the meter amp as a voltage relative to the RF power out.

Tune up the receiver on a frequency of your choice. Turn the RF GAIN minimum, adjust R76 for zero on the S-meter. Record the voltage readings. Turn the RF GAIN to max, set the signal in at 10uv. Ensure the receiver is peaked, record the voltage readings.

(+275 measured +300)

PIN #	1	8	9
RF GAIN min.	300	8.7	-0.41
RF GAIN max 10uv input	300	8.2	-0.73

II-5-12. HETERODYNE OSCILLATOR



The HET OSCILLATOR is active only for the 40-meter band. On the 80- and 20-meter bands the VFO signal is sent directly to the receive and transmit mixers via the switch S1A. When S1A is turned to the 40-meter band the inhibit signal is remove from R79 and a ground is applied thus turning on V11. The VFO is mixed with the 3400KHz and passed to the transmitter and receiver mixers.

PIN #	1	2	5	6	7
80 METER BAND	-100	GND	150	147	0.0
40 METER BAND	-23	GND	144	71	-0.7

Connect scope using a 10X scope probe to pin6 of v11. Remove V17 power up in REC. You should measure 2.6vpp. Move the probe from the scope to the frequency counter. You should measure 3.4MHz.

III. GENERAL TECHNICAL TIPS

III-1. RX ANTENNA & DRIVER INPUT & OUTPUT

The alignment procedure in the factory manual is good. I offer the following suggestions for your consideration. Sections 8-14 and 8-15 are good procedurally but some clarification is needed. **NOTE**: The DRIVER TUNE control (C8A, B, C) is a bit of a misnomer , it also functions as the receiver RF preselector tuning. C8A is the grid tuning for the RF amp V1. C8B tunes the plate of the RF amp V1 and the grid of the driver V14. C8C tunes the plate of the driver V14. Start by setting the DRIVER TUNE to the center of its rotation and **LEAVE IT THERE.** Do not readjust it at any time during the entire alignment process. On each band set the VFO Main Tuning to the center of the band you're tuning. If you are a General class doing 80 meter band set the VFO to 3.900 MHz, ok, get my drift. Then do not move the VFO until you finish that band. Always tune the driver input and output coils first. Then tune the receiver antenna coils. When aligning the antenna coils tune your signal generator to your VFO setting, don't tune the VFO to the generator the procedure in the manual has you tune all bands on TX first and then tune the RX. However, in order to get the TX peak and the RX peak to coincide they both need to be done without changing the settings of the VFO or the DRIVER TUNE. Align all three bands WITHOUT moving the DRIVER TUNE knob, keep it in the center of its rotation (I seem to be repeating myself but this is important). On each band you will have to tune the VFO to the center of that ham band, but once you start on a band the VFO should not be moved. If you cannot get the RX and TX to track you have a circuit problem and a part has failed. Read the procedure, look at the schematic and think about it a little before you start.

III-2. BAND ALIGNMENT INTERACTIONS.

The 80 meter coils, L1, L5 and L8 are in the circuit on all three bands. Therefore, you must start the alignment on the 80 meter band first. The 20 meter band driver grid coil L7 and plate coil L10 are greatly affected by the alignment of the 80 meter coils. The process should be: align 80 meters RX L1, TX L5 and L8; align 40 meters RX L2, TX L6 and L9; align 20 meters RX L3, TX L7 and L10. If the power is low on 20 meters then, while transmitting on 20 meters adjust the 80 meter coils L5 and L8 to see if the power will come up. If it does and takes less than ½ turn on either 80 meter coil go back to 80 meters and check power out. If 80 meters has **not** dropped off too much you are good to go.

If, however it takes more than ½ turn on the 80 meter coils or 80 meter power has been significantly reduced then you have a component failure or degradation. It is time for some ***intuitive logic reasoning.*** Go back and realign 80 meter L5 and L8 for max. On 40 meters recheck alignment of L6 and L9 then test the effect of L5 and L8 on the 40 meter power out. If there is little or no effect then suspect C94, 95, 103, 106 L7, or L10.

If the 40 meter test shows significant interaction then C8B, C8C, C107, C91, L5, L8, L19 and neutralization may all be considered as possible causes along with V14.

Also note that the driver grid coils also act as the RX RF amp (V1) plate tuning. So, some ***intuitive logic reasoning*** needs to be applied when aligning the RX.

III-2-1 RX RF AMP AND TX DRIVER TRACKING

Getting the receiver front end and the transmitter driver to track can sometimes be a challenge. The challenge comes from the DRIVER TUNE control. This control functions as the receiver preselector tune as well as the driver tune. It is a three-section capacitor. The first section C8A is the RF amp V1, grid tuning. Section 2 C8B is the RF amp plate tuning AND the driver V14 grid tuning. Section 3 C8C is the driver plate tuning. The center section in the train is where the challenge comes from. As components age the tracking of the receiver and transmitter will shift.

The coils, L5, L6, L7, L8, L9 and L10 are aligned in the transmit mode for max power out. The coils, L1, L2, and L3 are aligned in the receive mode for max s-meter deflection.
In some cases, L5, L6, and L7 do not track in receive and transmit modes. To test for this, you complete the normal alignment procedure. That is: align L5 through L10 in transmit mode on each band. Then align L1, L2 and L3 in receive mode on each respective band. Then test each band. Start with 80meters. Set the main tuning to 3.900MHz, Adjust DRIVER TUNE for max power output. Connect and adjust the signal generator for max s-meter with 3uv signal in. Now tune the slug of L5 ¼ turn in each direction, if the s-meter reading does not increase more than ½ of 1 s unit it is good. Repeat the test on 40 meters, 7.237MHz, testing L6 and on 20 meters 14.287 testing L7.

There are two solutions to the problem. One solution is to test and optimize all the components associated with C8B and S1C. (L5, 6, 7, C89, C90, C93, C94 and C96).

Another approach is an off-set alignment. Normally when aligning the receiver front end and the driver circuits the DRIVER TUNE control is set in the center of its rotation. If you have a tracking problem rotate the DRIVER TUNE control 15^{o} to 20^{o} counter-clockwise and realign the front end and driver coils. If the tracking gets worse readjust the DRIVER TUNE control 15^{o} to 20^{o} clockwise from the center of its rotation and realign. If one of these two methods produce satisfactory results then check each end of each band to see is you can still get minimum power out and minimum receiver sensitivity. It is normal to have some drop off on the ends of the bands but, it should still meet min spec.

If neither of these two approaches works then more analysis is needed.
Are all bands not tracking?
Is one band significantly worse than the others?
Is tracking worse on one end of the band than the other.
Remove the mounting screws of C8, apply De-Oxit to holes and screws, replace screws.
Individually test all components listed above.
Send me an email and we will both curse it.

III-3. T7 AGC AMP

Be careful here, read section 8-17-4 closely. A common error is the tune T7 for a peak in audio output from the receiver. T7 should be tuned for peak AGC action (most negative AGC voltage) which will cause the audio output to drop several dB from peak. The AGC is monitored by the S meter or it can be measured at the junction of R65 and R67. I prefer to hang an X10 probe on the junction of the resistors and observe the AGC action on the scope. Mistuning of T7 will also cause the AALC to malfunction. Proper alignment of T7 and T4 is essential to successful alignment of the radio. Once again read the entire alignment procedure carefully before starting.

III-4. T3 RX/TX INTERACTION

T3 is the plate loading coil for V3 the receiver First IF Amp. V3 also functions as the RF amp for the carrier osc after passing through the lattice filter in the transmit mode. Prior to performing T3 alignment (8-16 in the manual) **ensure** that the 5200KC oscillator is **exactly** on frequency. After aligning the T3 and T4 - T7 (8-17 in the manual) and performing the lattice filter checks and alignment in paragraph 8-18 in the manual check and record the receiver sensitivity at 3800KC.

NOTE: The procedure in 8-18-2 is precise and sweeping the filter is not necessary. If you encounter problems then you have a failed component

To properly check the sensitivity, tune the signal generator and the rig to 3800KC. Then adjust the generator level for 0.5 watts audio output with the RF and AF gain at max. The signal level should be around 1/2uv (Spec states 1.0uv but most receivers will provide 0.5 watts output at between 0.5 and 0.7uv). Now readjust T3 for max audio output. If you get more than 3db increase in audio output when T3 is readjusted then there is a problem. Go back and realign steps 8-15 thru 8-18 again. If this does not help then, most likely, one of the following is bad: V3, T3, C23, R19, R23, C21 or C20.

III-5. THE S-METER

III-5A. The S Meter Scale

S-reading	HF uv (50Ω)	Dbm	Signal Generator emf dB above 1uV
S9+10dB	160.0	-63	44
S9	***50.2***	***-73***	***34<***
S8	25.1	-79	28
S7	12.6	-85	22
S6	6.3	-91	16
S5	***3.2***	***-97***	***10 <***
S4	1.6	-103	4
S3	0.8	-109	-2
S2	0.4	-115	-8
S1	0.2	-121	-14

III-5-1. 160/500 S METER OPERATION

The S unit is a reflection of signal level at the antenna. So, what in the typical receiver has a direct relationship to the input signal? Simple, the AGC, right, well almost. There is a hole in this concept. In almost all receivers AGC threshold is about .1 to .3uv and doesn't reach linearity until around 3 to 5 uv. This has become a de-facto standard, as is the case with the SR-160/500. The most linear area of SR160/500 AGC circuits is from 3 to 200 uv. So, we try to get S-5 at 3 uv in and S-9 with 50 uv in. Ok, this should be easy; all we need to do is develop the algorithm to match the AGC curve to the current curve of a meter circuit. The designers accomplish this with resistor networks and the characteristics of a tube. As these rigs age components change in value and the algorithm is no longer true. So, we have to select tubes to match the curves and correct the algorithm. However, in the 160/500 half the tube is the meter amp the other half of the tube is the 2nd IF amp. This is characteristic for most of the SR line of transceivers. The best tube for the meter is not always the best for RX gain. To get it right you need a bunch of tubes and a few minutes to sit and hand select the tube that makes both work. Since gain is most important, we usually shoot for good gain and S-9 close to 50 uv. I think this was Hallicrafters attitude when they wrote the spec. (“**A signal at the antenna of between 25 uv and 50 uv will produce a meter reading of S9**” pretty broad spec.)

III-5-2. S METER AMP TUBE SELECTION

V4B is the Meter amp. Unfortunately, as stated above, the other half of the tube is the second IF amp. The meter amp ckt is extremely sensitive to the tube characteristics. If you have a double handful of 6EA8's you can select for one that will give you S5 at 3 uv and S9 at 50 uv. You need to allow 5 minutes for warm up with each tube. You will need to re-zero the meter with each tube. You will find some tubes that flat won't work even though they are perfectly good. I have three tube testers so I set them up to preheat the tubes. That speeds up the process. I try to find several tubes that will work because next I'll have to find one that also works well in the second IF slot. If it just won't come in then get a hand full of 2% carbon film resistors and replace R68, 69, 70, 71,72, and R77. Or forget the S meter pick a good tube for the second IF and have fun with your radio.

III-6. AGC CONSIDERATIONS

The AGC measured at the junction of R65 and R67 should be around +0.1 to +0.3 volts with no signal in. This is a high impedance line so I prefer to use a scope with an X10 probe to make this measurement. At 0.1 to 0.3 uv of signal at the antenna jack you should start to see movement in the negative direction this is the AGC threshold. At 1 to 3 uv the AGC should be around -1 volt. At about 10,000 uv the AGC will saturate at about 14 to 15 negative volts. The factory spec for the AGC figure of merit is**:** With a signal at the antenna terminal from 5uv to 1500uv no more than a 10 dB variation in audio output shall occur. The actual figure of merit for the 160 and 500 for a 10 dB change commonly runs from 5 uv to 50,000 uv. Due to the high impedance of the circuit the component tolerance drift due to age will cause the threshold and figure of merit to vary greatly from rig to rig but they will very rarely fail to meet spec. Seen below is a chart of the agc action of properly functioning SR-160 receiver.

SR-160
AGC FIGURE OF MERIT
TABLE

INPUT	AGC	AUDIO
0	+0.2v	-4db
1uv	0v	-2db
5uv	-2.5v	0db ref
10uv	-3.0v	0db
50uv	-5.3v	+0.5db
100uv	-6.5v	+0.8db
500uv	-9.0v	+1.5db
1,000uv	-10.0v	+2.7db
5,000uv	-11.5v	+3.8db
10,000uv	-12.0v	+4.5db
100,000uv	-14.0v	+7.5db

III-7. TUNING FOR PLATE I DIP

In order to operate the finals in the most efficient manner the plate loading should be adjusted for plate current dip. When the rig is properly neutralized the power out **peak** and the plate I **dip** will occur concurrently. The only way to monitor the plate dip is to use an external meter connected to TP-201 and TP-202 in the power supply. *See paragraph 8-3 in the manual.* I keep a meter attached to the power supply whenever operating an SR-150, SR-160 or an SR-500. **Also, I always tune for the plate I dip, regardless of the peak power point.** When the plate dip and power peak differ by more than 15 or so watts I re-neutralize. Be very suspicious any time the plate I dip exceeds 450 mills on the SR-500 and 300 mills on the SR-160. This is of extreme importance when using 6DQ5's in place of the 8236's in the SR-500. To keep plate dissipation at a minimum you must be tuned to the plate dip.

III-8. RX RF AMP MOD

The receiver gain on the 160 and 500 is ok, but does not quite match the gain of the rest of the SR series. This is a simple fix. Simply replace V1 the 12AW6 with a 12DK6, it's a direct replacement. This will provide from 3 to 6 dB more gain. The AGC tracking normally runs in the order of 5 to 8 times wider than spec. So even with the additional gain in the front end it will still meet the AGC figure of merit spec

III-9. RIT/CAL

The RIT/CAL ckt is virtually the same for the SR series gear from the SR-150 thru the SR-2000. The advertised purpose of the RIT was to allow you correct for contacted station RX/TX off set of up to 3 KHz.

The RIT (receiver incremental tuning) function is used to offset the transmitter and receiver frequencies. Even if your rig is perfectly tuned and on frequency those you operate with may not be. A difference of just a few cycles can cause you to walk up or down the band. When the RIT function is turned on the transmitter is still controlled by the CAL control but the receiver frequency is varied by the RIT CONTROL. This allows you to fine tune your receiver without moving your transmitter.

The CAL function in the SR-160 and 500 is needed to correct any slight error in the HET osc or small errors in the alignment of the VFO. The 3400 KHz heterodyne oscillator is switched on when the 40-meter band is selected. This xtals has no trim adjustment. During assembly and test, at the factory, xtals were hand selected for minimum error. However, any error of a few cycles or more can be detected by the ear. If everything is aligned and tracked correctly the CAL operation corrects for the entire band. The CAL operation must be performed each time you change bands and should hold until the band is changed again. As long as the carrier oscillator (the 5200 KHz) is on frequency, then once either the 80 meter or 20-meter band is calibrated the other will be calibrated. If you calibrate on the 80-meter band and the 20-meter band is off frequency you have a circuit failure.

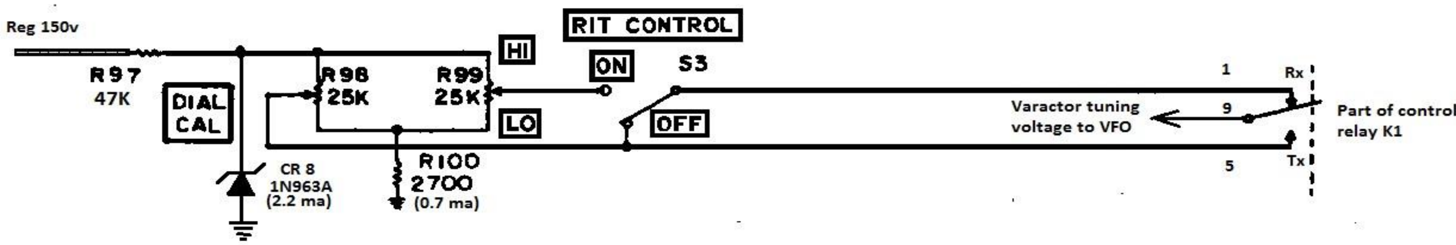
NOTE: The specs are a little vague on the tolerance for the oscillators in the SR series. The overall spec for maximum band to band shift is ***2 kHz*** which seems like a lot. However, I did find one spec sheet that stated that the minimum swing on the CAL and RIT controls is +/- 3 kHz another stated +/- 4.5 kHz. This is more than ample to off-set any osc differences if they are within these specs.

The CAL ADJ and the RIT CONTROL are both used to fine tune the bias voltage on the vari-cap (also referred to as a veractor diode) in the VFO. With the RIT off both the TX and RX are fine-tuned by the CAL ADJ pot. With the RIT ON the RIT CONTROL fine tunes the RX and the CAL ADJ controls the TX. These two pots are in parallel in the vari-cap voltage divider network and are switched by K1. On a perfectly aligned band when the CAL ADJ pot is in its electrical center position then the RIT CONTROL will also be in the center of its rotation.

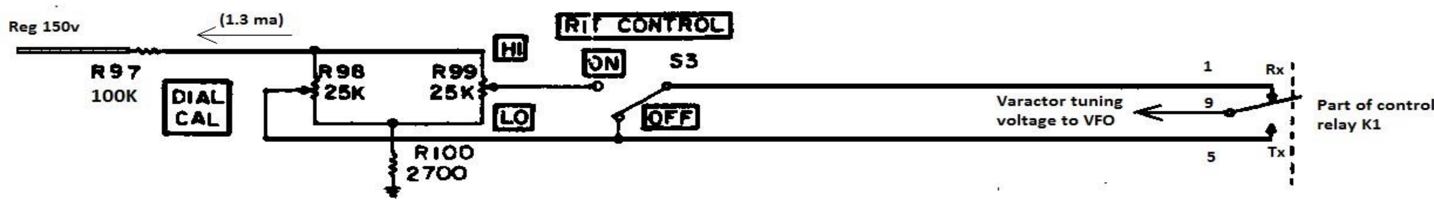
III-10. SR-160/500 DRIFT

III-*10*-1. CAL/RIT CIRCUIT CONSIDERATIONS

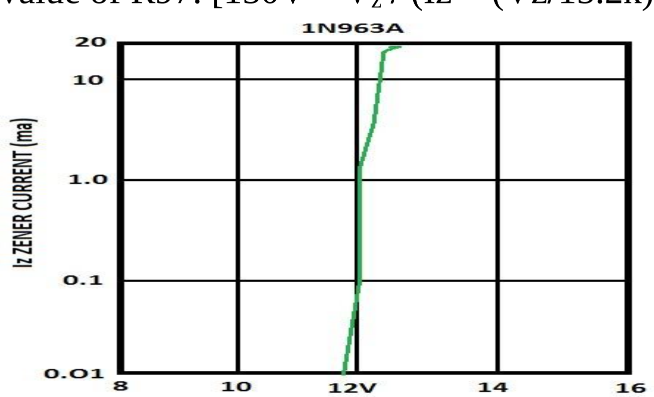
The SR-160 and the SR-500 have been plagued with drift problems as they have aged. The 160 had minor drift problems from its inception. When the 500 came along an attempt was made to correct part of the problem with the inclusion of a zener diode in the RIT/CAL circuitry. I have found two problem areas contributing to the drift problem. The first is ageing of critical parts in the VFO and second is DC instability in the RIT circuitry. SR-500 RIT



SR-160 RIT



The linear range for the 1N963A is from 0.1 ma to 2 ma. The original design of the zener ckt has the zener drawing 2.2 ma. That puts the zener just above the knee of the flattest part of the curve. Under normal circumstances this would still function properly. But this does explain why it takes longer for the 500 to stabilize after turn on. If you operate in an uncontrolled environment such as field day in the fall, chances are, it'll never stabilize. If you stick with the 1N963A then R97 should be a 75K 1% or 2% resistor. If you go with a different zener diode pick a current level between ½ and 2/3 up the flattest part of the curve. The zener current + resistor network current (0.7ma @ 12vzv) will be used to calculate the value of R97. [150V – V_z / (Iz + (Vz/15.2k)] or for 12 v zener ~ [138v/ (I_z +0.7ma)]



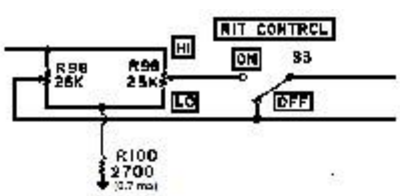
There is nothing magical about 12v, that's just what they used on the SR-500. On the SR-160 the voltage at the top of the resistor network is 19v. There are two things to be concerned about when changing the voltage at the top of the network. First, the higher the voltage the wider the tuning range of the CAL and RIT controls. At first that sounds like a good thing. However, the wider the range the more unstable the VFO and the more difficult it is to track the Rx and TX. Note also any change in the voltage will require re-tracking and alignment of the VFO.

Use metal or carbon film 1% or 2% for R97. There is not much you can do to improve the resistor network, R98, R99 and R100. There is not much point in replacing R100 with a more stable type. The pots R98 and R99 with an equivalent resistance of 12.5K swamp out any effect caused by R100. The pots should be cleaned and lubed with a suitable control lubricating/cleaning spray. If R98 and, or R99 have been replaced you should check to insure they are of equal value and have the same taper. Differences in these two pots will affect the operation of the RIT. Cleaning of the relay contacts and S3 is also important.

The addition of a zener and replacement of R97 is highly recommended for improving the operation of the SR-160. The same process is used to determine the value of components on the 160 as used on the 500.

III-10-1-1. RIT OFFSET AND RANGE TEST

To test the range of the Cal/RIT circuit turn the RIT off. Set the CAL control to the center of its rotation. Set the band switch to 80 meters and the frequency dial to 3.8 MHz Connect a frequency counter to pin 1 of V2. Fine tune the frequency dial for 9.000 MHz on the frequency counter (If the dial is off do not be concerned at this time, tracking and alignment of the VFO later will correct for any error). Now rotate the CAL control and note the frequency shift in both directions. It should shift a total of at least 6 KHz.



If the total shift is more than 8 KHz then the voltage at the top of R98 and R99 is too high. If you do not get enough shift the voltage is too low. Nominally the voltage should be from 9 to 11 volts. If the frequency shift is not equal in both directions from the mechanical center of rotation then R98 is at fault.

Now return the CAL control to the mechanical center and readjust the main tuning for 9.000 MHz. Turn the RIT control ON. Adjust RIT HI/LO control for 9.000 MHz. The index line on the HI/LO knob should be within 15^{o} of top dead center. If not then you may have a problem with R99.

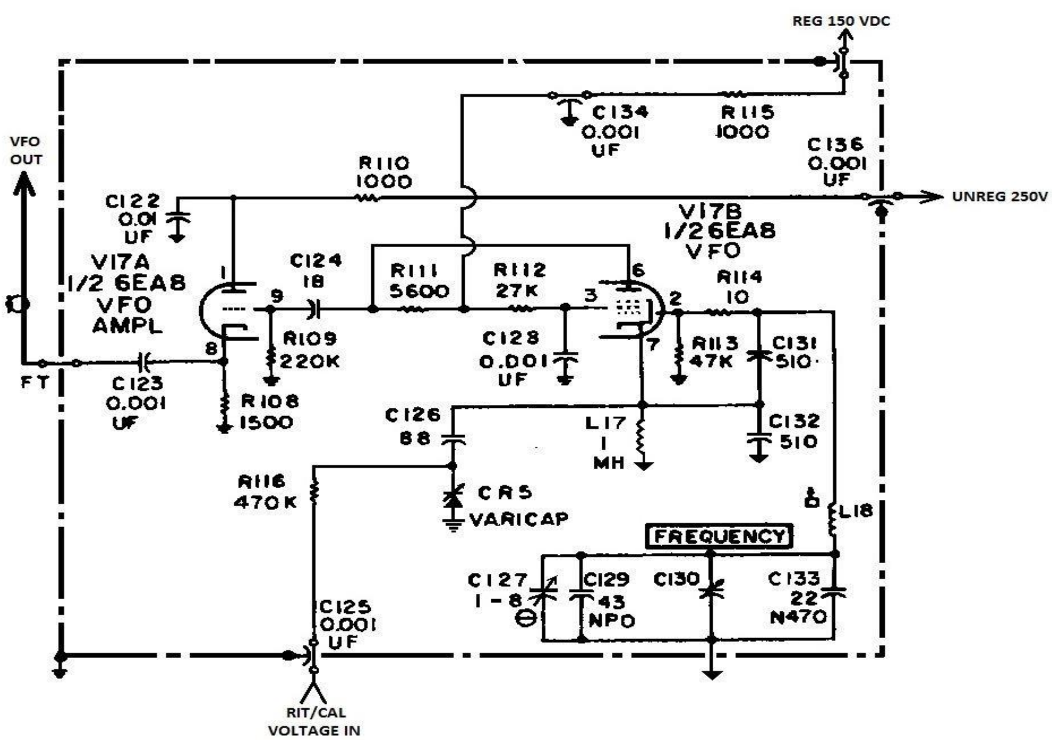
NOTE: R98 and R99 are not linear taper pots. I do not know why Hallicrafters used audio taper pots in this application. The result is that the shift is not centered. You will see about 3Khz to the low side and 5 KHz shift to the high side. (This will vary depending upon the level of voltage at the top of R98 and R99.)

To test the divider network, disconnect the wire to the wiper of each pot. Disconnect the wire to the top of R99. Set both pots to the mechanical center of their rotations. Measure the resistance from the top of each pot to the top of R100 to insure they are both 25k pots. Measure the resistance from the wiper of both pots to the top of R100, you should read very close to 9K. If they are not within a couple hundred ohms of each other than that will explain the offset between the CAL and the RIT controls. At this point you must determine if the offset is offensive enough to warrant the trouble finding matched pots that will fit and the work involved in making the repair.

III-*10*-2. VFO STABILITY CONSIDERATIONS

The VFO in the SR-160 and the SR-500 are identical.

IMPORTANT NOTE for alignment of the VF0. The CAL control shifts the VFO for TX and RX when the RIT is off. The CAL control shifts the TX only when the RIT is on. With the RIT on the RIT control shifts the RX. ***It is important*** to ensure that the CAL and RIT pots are in the center of their rotation during all alignment and tracking operations. You can test proper alignment by setting both controls to center. Then tune in a signal and switch the RIT on and off. There should be no change in the receiver tone.



III-10-2-1. THE PROBLEM

Over the last 5 years every single SR-160 and SR-500 I have had in the shop has suffered from freq. drift. I reviewed the repair files and eliminated the obvious random component failures. I found that a combination of at least two of 4 specific components was involved in all restorations. These components are R113, R114, C129, and C133. The exact nature of the failure mode is unknown. Whether it was crystallization of the carbon resistors causing noise or dielectric breakdown generating drift really doesn't matter at this point.

III-10-2-1-1. THE TEST

For this test I collected three rigs two SR-500's and one SR-160 all of which demonstrated the drift problems. I cleaned, lubed, aligned and cleared all other problems. When I pre-tested the three units I found roughly the same for all three:

> After 30 minutes of warm up the drift was about 150 Hz per minute and random in direction.

> After another 30 minutes the drift trend was upward about 900 Hz per ½ Hr. with the short-term drift of about 100 Hz per minute.

> After three hours it was +2200Hz and still going up, still had short term drift. All three rigs displayed similar characteristics.

III-10-2-1-2. FIRST CORRECTION

I performed the RIT/CAL ckt changes on all three rigs. I went with 12 v zener and 75K metal film 1% resistors. Following the changes, I re-ran the test. The short-term random drift was gone. All three rigs were then drifting in the upward direction from 10 to 30 HZ per minute and around 800 Hz to 1100HZ per hr.

III-10-2-1-3. SECOND CORRECTION

I replaced the 4 suspect components in all three rigs. CAUTION stay away from NOS parts. If you use NOS parts you are getting old technology and outdated manufacturing processes and materials which were the root of the problems. Better materials, technology and processes are available today therefore producing better products. Be sure the C129 is an NPO cap and that C133 is N470.

Re-test proved that the continual upward drift had been eliminated. The specs on the radio states that after 30 minutes of warm-up no more than 300 Hz drift should occur. The spec is vague and no further time limits are stated. I'm assuming that the intent is that once warm-up is achieved then the drift total +/- should not ever exceed 300 Hz.

One 500 and the 160 took 45 minutes to stabilize but from that point on the drift was from -20 Hz to +130 Hz for the 500. The 160 drift was from 0 Hz to +230 Hz. Both rigs remained within that range for 2 hrs. at which time I terminated the test. The other 500 stabilized in 15 minutes and the drift went from -110 Hz to +90 Hz.

III-10-2-1-4. SUMMATION

Due to the small population of the units tested this cannot be considered a definitive test with irrefutable results. However due to the consistency of the results and the repairs made over the last 5 years I believe that it does warrant a look here first approach when you encounter similar problems.

III-11. LOW LEVEL AUDIO OSCILLATIONS IN RECEIVER

CASE 1 BACKGROUND

Over the years I have seen and added comments to a lot of posts concerning gain in the mic amp of the SR150, 160 and 500. Some of these have involved placing a cathode bypass capacitor on the 2nd mic amp. I'll have to admit that I to thought this was a good idea, but not anymore. This **is not** a good idea. Recent discoveries indicate it should not be done. The problem is there in all three rigs but was noticed first in the SR-150. In the RX mode with the audio gain turned fully CCW there will be a faint 2500 Hz to 4500 Hz tone in the speaker. When measured, it will run from 10 to 150mw. I have had four 150's recently with this problem. Needless to say, the first time I noted the problem it was quite puzzling. When I pulled the 2nd 1650 I.F. tube which killed all the Rx noise I found that the level of the objectionable tone was not changed by the setting of the AF Gain control. Now how exactly I ended up in the VOX circuit I can't quite remember. But I noted that if I turned the VOX gain control all the way down the tone went away. I connected the scope to the plate of V18B the second mic amp, and to my surprise I found a 75v peak to peak audio oscillation. I also noted at that time a 10uf/50v capacitor had been added from the cathode of V18B to gnd. When I removed the capacitor, the oscillation stopped. I have run into oscillation problems on 4 rigs in recent months and in each case a bypass capacitor has been added to the cathode of the second mic amp. In one case I did not have a tone in the RX but was unable to properly set up the VOX gain and delay. The oscillation, on this one turned out to be about 18 kHz, which is outside the range of my old ears and the response of T5. So, the tone did not appear in the speaker.

Why was it noticed in the 150-receiver audio and not the 160 and 500? Well the 150 has VOX and the VOX ckt provided the feedback path to the audio output. Due to low level of the signal in the speaker I believe the feedback path is from the mic amp to the VOX ckt then thru cr5, r98, c117 and directly into the secondary of T5.

The oscillation is there in the SR-160 and SR-500 rigs. The only indication you get is the carrier balance does not quite meet spec and receivers on the other end report a low-level squeal or tone in your audio.

I have come to the conclusion that the un-bypassed cathode resistors in the mic amp ckts do serve the intended purpose of the original design. That is, to degenerate the high frequency response of the mic gain train, and that's a good thing. The original design is good and if all the "parts" are good it will work well. One of the most miss-matched parts is the microphone. The 150, 160 and the 500 all want to see a **high Z dynamic** mic with an output in the range of 5 to 10 millivolts. High Z dynamic microphones in 1963, in the published words of Hallicrafters were in the order of 600-1200 ohms. Ceramic and xtal mics have far too much output in the 3 KHz to 4 KHz range with the level at 500 Hz usually 3 to 8db lower. Since the audio response of the SSB circuitry is from around 500 to 2700 HZ, depending on the rig, putting a mic on the radio that over drives the system in the 3 KHz to 4 KHz range does nothing but screw up the spectrum.

So, in conclusion if you cannot drive SSB to full power check your mic or fix your broken radio. But don't compromise the design by adding bypass caps.

CASE 2, With the RF GAIN at min and AF GAIN at max you get a 60 or 120 Hz hum.

Of course, the first guess is ripple on the DC voltage supplies. But if you find that the DC ripple is in spec there are three tubes that may be the cause. A filament cathode short in V5, V6 or V10 may be the fault.

CASE 3, With no signal at the antenna you get a 900 to 2000 Hz tone in the receiver, all bands, across the dial.

There are three common causes.
1, Injection levels from the oscillators are too high.
2, Fault in the AGC detector or amp.
3. Placement of C24. C24 is the coupling cap from the plate of V3 to the grid of V4B. The area between V3 and V4 is a rat's nest and coupling between components is a problem. First shorten the lead from the capacitor body to pin 2 of V4. Then move other capacitors away and orient them by 45 or 90 degrees.

CASE 4, This one comes from comments from others who have experienced a problem concerning V10. I have not experienced this fault in my shop but it has been reported several times over the years. Most recently Bob, AB1MN stated "An oscillation occurred while aligning the IF stages. It may be associated with V10 filament ckt. The addition of a 0.01 capacitor to pin 4 of V10 eliminated the oscillation."

Should I ever see this fault I would like to test C139. The filament of V10 (aalc/avc amp/detector) is in series with the filament of V17 (VFO). The filaments are decoupled by C139. Even if C139 is the cause adding a shunt cap is the easiest solution to the problem

III-12. CONVERSION OF THE SR-160 TO A SR-500

The SR-160 is the predecessor of the SR-500. They took the SR160 made a few ckt changes to improve the overall performance and used different final tubes. They then replaced the PS-150 with the PS-500 family of power supplies. The factory change uses the 8236, carbon block plate tube. However, the 6DQ5 is a direct replacement for the rare and expensive 8236. The 8236 is preferable. If you use the 6DQ5 then a cooling fan should be added. Tubes need to be matched. The mod will require rewiring of the PA tube sockets.
You will need both the 160 and the 500 schematics.

PARTS CHANGES REQUIRED FOR 160 TO 500 MODIFICATION		
REF DESIGNATOR	ORIGINAL PART	MODIFICATION PART
C11*	47uuf	22uuf
C12*	8.2uuf	6.8uuf
R53	47K	6.8K
C65	47uuf	150uuf
R92	180K	220K
C100	1000uuf	750uuf
C104	470uuf	220uuf
C107	1000uuf	750uuf
R96**	56K	Delete
C119	680uuf	620uuf
C120	430uuf	250uuf
C121	510uuf	300uuf

*These changes did not have anything to do with the PA mod. They were Factory directed changes to improve the receiver operation.

**Resistor R96 was removed for proper bias of the new PA tubes.

IV, SR-160/500 NEUTRALIZATION PROCESS

PROPER NEUTRALIZATION WILL ENHANCE THE PROPER OPERATION, EFFICIENCY AND LIFE OF YOUR FINAL TUBES. THEORY AND OPINIONS ON THE EFFECTS OF INTERELECTRODE CAPACITANCE ARE AS NUMEROUS AS THE WRITERS OF SUCH ARTICLES. SO, TO BE VERY BASIC, WE ARE ATTEMPTING TO NEUTRALIZE THE EFFECTS OF THE INTERELECTRODE CAPACITANCE OF THE PA FINAL TUBES.

HERE IS A GOOD SITE FOR A DISCUSSION ON NEUTRALIZATION.
HTTP://WWW.W8JI.COM/NEUTRALIZING__AMPLIFIER.HTM

THE NEUTRALIZING PROCESS IN THE BOOK IS OK, BUT NOT VERY PRECISE. IT WILL WORK, BUT I PREFER A MORE PRECISE PROCESS. THERE IS NOTHING NEW OR REVOLUTIONARY ABOUT THIS PROCESS. IT IS A PROVEN PROCESS THAT HAS BEEN IN USE FOR OVER 50 YEARS. ALL I HAVE DONE IS SPECIFICALLY ADAPTED IT TO THE SR-160/500. BEFORE STARTING THE PROCESS, YOU NEED TO TUNE THE TX AS BEST AS YOU CAN AT 21.3 MHZ. AFTER TUNE UP TURN THE POWER OFF AND DO NOT RE-ADJUST THE DRIVER TUNE OR FINAL TUNE THROUGHOUT THIS PROCESS. POWER DOWN AND REMOVE UNIT FROM IT'S CASE AND REMOVE THE PA COVER.

1, DISCONNECT THE PLATE VOLTAGE AT THE BOTTOM OF L14 BE SURE THE LEAD IS OUT OF HARMS WAY.

2, DISCONNECT THE SCREEN VOLTAGE AT THE BOTTOM OF R102 BE SURE THE LEAD IS OUT OF HARMS WAY

3, TURN THE CARRIER FULLY CCW.

4, CONNECT THE TRANSMITTER OUTPUT TO THE SCOPE OR TO AN RF VOLTMETER (I PREFER A SCOPE).

5, WITH THE CASE REMOVED AND THE COVER REINSTALLED ON THE FINAL AMP ENCLOSURE TURN ON THE RIG AND LET IT HEAT UP FOR AT LEAST 20 MINUTES.

6, IN THE CW-TUNE POSITION KEY THE TX.

7, ADVANCE THE CARRIER CONTROL UNTIL YOU GET ANY WHERE FROM 1 TO 5 VOLTS PP ON THE SCOPE.

8, ADJUST C110 FOR MINIMUM SIG ON THE SCOPE. ADJUST SCOPE SENSITIVITY AND CARRIER LEVEL UNTIL YOU GET A REAL GOOD PRESENTATION OF THE MINIMUM POINT.

THIS PROCESS OF NEUTRALIZATION HAS SERVED ME WELL. THIS PROCESS CAN BE ADAPTED TO MOST ANY TRANSMITTER. THIS IS THE MOST PRECISE METHOD OF NEUTRALIZATION I HAVE FOUND. IF IT DOESN'T WORK THEN YOU HAVE SOMETHING ELSE WRONG.

V, CLEANING

<u>Step 1</u>. I have found all forms of foreign matter in rigs emerging from long term storage. My favorite of cleaning method is the bathtub, Scrubbing Bubbles bathroom cleaner, and the shower hand wand. I set the rig in the tub, back side down, front panel up. With the rig leaning against the side of the tub I spray it full of Scrubbing Bubbles and let it set 3 to 5 minutes. Then I spray it full again and after 5 minutes I rinse it using the shower hand wand. I do this on the top and bottom side of the chassis. I keep the Scrubbing Bubbles away from the front panel, dials and meters, just use common sense. All the brown residue, smoke odor and filth literally run down the drain. Very seldom is any scrubbing needed if it is I do it with a ¾" wide paint brush with half the length of the bristles cut off. I rinse it a second time then it sets in front of a fan for a day.

<u>Step 2</u>. Now that it is squeaky clean the potentiometers need the application of a suitable control cleaner/lubricant.

<u>Step 3.</u> Some mechanical drive trains to tuning devices require special lube so don't forget them.

<u>Step 4</u>. The relays are next. I use thin strips of card paper, about 3" long and 3/16" wide. Place a drop of DeOxit on the paper and slide it back and forth between the contacts. Manually energize the relay and clean the normally open contacts as well. A pair of hemostats simplifies this step. NEVER USE SANDPAPER.

<u>Step 5</u>. Now for the controversy, The Wafer Switches! Every three months or so on one of the ham forums a wafer switch cleaning war breaks out. No minds are changed, no territory is conquered. Hostilities subside only to be resurrected a few months later when the "new be" asks How do I clean my wafers. There are at least 3 regulars out there that vehemently oppose my method and that is ok. It works for me and I have not to date suffered any loss due to it. First, I take a cotton swab and cut a little cotton off the tip. I spray a little DeOxit in a small glass bowl. I dip the swab in the DeOxit and clean the switch. It's pretty simple and no over spray. I ***NEVER*** spray DeOxit into a rig.

<u>Step 6</u>. Now we have to clean the tube sockets. Somewhere around the tooth brushes at your local store you will find very small round brushes used to clean between teeth. There are usually 10 or 20 to a package. Once again, I use DeOxit in the glass bowl. Dip the brush, insert the brush, spin the brush, repeat 150 times or so and you're done.

VI, PERFORMANCE DATA SHEETS

VI-1, SR-160 PERFORMANCE DATA

VI-1-1, RECEIVER PERFORMANCE:

Overall Sensitivity (gain)
The receiver will produce 500 mw audio out with 1.5 uv RF signal at the antenna terminal.
Tests performed at center of General Class bands

BAND	TEST FREQ	SIG REQ FOR 500mw
80		
40		
20		

Overall Sensitivity (S+N:N)
A 1.0uv signal at the antenna terminal will produce a minimum 20db s+n:n.

BAND	TEST FREQ	SIGNAL LEVEL	S+N:N MEASURED
80			
40			
20			

AGC Figure of merit
With a signal at the antenna terminal from 5uv to 1500uv no more than a 10 dB variation shall occur.

MEASURED CHANGE	

"S" METER CAL
The S meter will read S-9 when between 25 and 100uv are injected at the antenna terminal.

LEVEL FOR S-9	

SR-160 PERFORMANCE DATA

VI-1-2TRANSMITTER PERFORMANCE

Tests performed with 50ohm resistive load. Measurements made with BIRD avg power and PEP power meter.
Bench power _______ VAC

Final amplifier bias set to 100 ma SSB mode zero drive. _____

Neutralization performed @ 14.150 MHZ. _____

Carrier balance null _____ dB below full power output level.

Microphone input sensitivity at 1000HZ. A signal level not more than 8 mv RMS shall produce the minimum specified SSB output at specified freq. with the mic gain set between 50 and 75% of full rotation.

Minimum power achieved at ______% of mic gain rotation with 8 mv audio input.

CW power output with RF level set just to saturation level.

FREQ	**MIN SPEC**	**AVG POWER**
3.9mhz	60 W min	
7.23mhz	65 W min	
14.28mhz	60 W min	

SSB PEP power output mic gain set just at saturation.

FREQ	**MIN SPEC**	**PEP**
3.9mhz	65 W min	
7.23mhz	70 W min	
14.28mhz	65 W min	

SSB TX AUDIO RESPONSE.
From 600 Hz thru 2700 Hz there will be no more than 3 dB change in output power.
Tune transmitter at 3.900 MHz do not exceed the duty cycle of the TX.
Mic audio input set for 8 millivolts at 1000Hz, LSB, set mic gain for 50 watts output.
Set audio freq to 600Hz, 8 mv. TX PEP not less than 25 or greater than 65 watts ___________watts
Set audio freq to 2700Hz 8 mv. TX PEP not less than 25 or greater than 65 watts ___________watts
Manually sweep audio osc from 600 HZ to 2700 HZ if multiple peaks occur within the pass band there will be no more than 2db from the peak to valley between. _______ Db.

VI-2, SR-500 PERFORMANCE DATA

VI-2-1, RECEIVER PERFORMANCE:

Overall Sensitivity (gain)
The receiver will produce 500 mw audio out with 1.5 uv RF signal at the antenna terminal.
Tests performed at center of General Class bands

BAND	TEST FREQ	SIG REQ FOR 500mw
80		
40		
20		

Overall Sensitivity (S+N:N)
A 1.0uv signal at the antenna terminal will produce a minimum 20db s+n:n.

BAND	TEST FREQ	SIGNAL LEVEL	S+N:N MEASURED
80			
40			
20			

AGC Figure of merit
With a signal at the antenna terminal from 5uv to 1500uv no more than a 10 dB variation shall occur.

MEASURED CHANGE	

“S” METER CAL
The S meter will read S-9 when between 25 and 100uv are injected at the antenna terminal.

LEVEL FOR S-9	

SR-500 PERFORMANCE DATA

VI-2-2, TRANSMITTER PERFORMANCE

Tests performed with 50ohm resistive load. Measurements made with BIRD avg power and PEP power meter.
Bench power __ VAC

Final amplifier bias set to 100 ma SSB mode zero drive. _____

Neutralization performed @ 14.150 MHZ. _____

Carrier balance null _____ dB below full power output level.

Microphone input sensitivity at 1000HZ. A signal level not more than 8 mv RMS shall produce the minimum specified SSB output at specified frequency with the mic gain set between 50% and 75% of rotation.

Minimum power achieved _______% of mic gain rotation with 8 mv audio input.

CW power output with RF level set just to saturation level.

FREQ	MIN SPEC	AVG POWER
3.9mhz	190 W min	
7.23mhz	220 W min	
14.28mhz	200 W min	

SSB PEP power output mic gain set just at saturation.

FREQ	MIN SPEC	PEP
3.9mhz	190 W min	
7.23mhz	220 W min	
14.28mhz	200 W min	

SSB TX AUDIO RESPONSE.
From 600 Hz thru 2700 Hz there will be no more than 3 dB change in output power.
Tune transmitter at 3.900 MHz do not exceed the duty cycle of the TX.
Mic audio input set for 8 millivolts at 1000Hz, LSB, set mic gain for 100 watts output.
Set audio freq to 600Hz, 8 mv. TX PEP not less than 50 or greater than 65 watts __________watts
Set audio freq to 2700Hz 8 mv. TX PEP not less than 50 or greater than 65 watts __________watts
Manually sweep audio osc from 600 HZ to 2700 HZ if multiple peaks occur within the pass band there will be no more than 2db from the peak to valley between. _______ Db.