Notes on the R-441/SRR-13

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Following are a few notes from my experience getting my R-441 working.

General

Like most complex radios, the R-441 (and its brothers, R-439/SRR-11, R-440/SRR-12, R-441A/SRR-13A and the corresponding shore versions, R-501/FRR-21, R-502/FRR-22, and R-503/FRR-23) are almost certain to need work when you get them. In fact, the R-441 (at least most of them) needed work when it was brand new, due to what seem to be last minute design 'bloopers' by RCA. When you add to that the usual wear-and-tear of even a short military career and in many cases, a problem sufficient to cause the Navy to consider the set disabled, you can be sure it will need some work.

When these things are taken care of, the R-441 joins its relatives as one of the finest general coverage communications receivers of its class. The only receivers it can really be compared to are the Collins R-390 and relatives; the R-441 is not quite as stable or precisely calibrated as the R-390 but is probably equal in most other departments. It is, on the other hand, lighter, more compact, and easier to work on.

If RCA and the Navy had finished what they started out to do -- a first quality communications receiver with post-war technology -- the R-441 would be highly prized and would sell for several times today's usual (fleamarket) price of $50. However, if you have patience and twenty or thirty hours of time, you can finish the job and have not only a fine receiver but one which is relatively rare, as well.

By all means get a 'parts' set if you can; not only is troubleshooting by module swapping much faster, but there are many unique parts which can neither be repaired nor replaced with a standard item.

The manual for the SRR-sets is one of the worst postwar manuals I have seen. Confusing, incomplete (but bulky -- RCA must have been paid by the pound for this one!), hard to use, full of errors (especially the early edition) -- this book has it all. Unfortunately, you need it anyway -- for the specs, diagrams, and a few detailed procedures without which it is near-impossible to get a radio this complicated to work right. I have not seen the FRR manual; it could be either essentially identical or much different and (probably) better.

Because the manual is so bad, some topics you would normally get there will be covered in these notes. The discussion will center on the R-441/SRR-13 but much of it also applies to the related sets.

All the sets of this family are basically sound and show great attention to detail. The SRR-13, however, has several serious problems:

(1) Severe audio distortion - a fully modulated AM signal may be almost unreadable, even if it is clear on another receiver.

(2) Inadequate AGC - as we will see, this problem contributes to the preceding one but it is also a nuisance in its own right requiring (in the worst cases) that you 'ride' the audio gain control when listening to a round table.

(3) Inaccurate calibration - even with correct alignment of the set and use of the CAL ADJUST control at the nearest checkpoint, the dial may be off by 10 kcs or more at 80 meters and a corresponding distance on the dial on other bands. Errors of this size occur near the ends of each band where the error is changing rapidly enough that it isn't 'almost constant' between two checkpoints.

Cures for all of these will be discussed below.

In addition, these sets originally had vacuum diodes for all rectifier and switch functions; replacing these with solid state diodes will reduce power consumption while improving performance. Most of the set runs from unregulated high voltage; performance can be further improved by adding a regulator circuit.

Panel Controls

The manual does a very poor job describing what the controls do; following are the functions of those which aren't completely obvious.

GAIN -- This is an RF and IF gain control. It is in the circuit only on the A1 and A2 modes.

ANT COMP -- Operates a trimmer to resonate the antenna coil.

CAL ADJUST -- Moves the lens which focuses the dial image on the ground glass. Since the index mark is scribed on the glass, this has the effect of moving the index relative to the dial. Most unmodified SRR-13's (See 'CALIBRATION', below) will take nearly the full range of the control. The other sets require much less if properly aligned. The manual says a set may be considered satisfactory if the error on a calibration marker is less than 1/3 of the way to the next mark.

FREQ VERNIER -- This is the BFO frequency. The BFO operates in A1 and FSK modes. The knob turns an air trimmer located in the module right behind the panel. In A1 modes with the knob in the center position the BFO frequency should be exactly 200 kcs. The rightmost of the two trimmers on the top of the module sets this. Before adjusting, make sure the variable cap is mechanically centered when the knob is centered.

When in FSK mode, the BFO frequency is offset; with the knob centered the frequency is 2550 cps above 200 kcs for use with the military teletype systems of the 1950's. This frequency is set by the left trimmer of the two on top of the BFO module.

Turning the knob to the right increases the BFO frequency, corresponding to higher channel frequencies. Thus to receive LSB signals you turn the knob to the right to the first major index mark, that is, about 1/4 revolution. For USB, turn to the left. These relationships hold on all bands.

The range of the knob is about +/- 1500 cps.

FUNCTION -- Controls IF bandwidth, BFO ON/OFF (and offset), RF/IF GAIN control enabled/disabled, AGC ON/OFF, SILENCER ON/OFF and AF bandwidth. Table 2-19 in the manual explains everything. On the SRR-13A there's an AGC NORMAL/OFF switch; on all the other sets the AGC is controlled only by the function switch.

In A1 NARROW, an audio filter with 350 cps bandwidth centered at 1000 cps is switched into the circuit. This is only useful for CW; you can't hear enough of an SSB signal in NARROW to understand anything.

The easiest way to use A1 NARROW is to zero beat the CW signal in A1 BROAD with the BFO at zero. Then switch to A1 NARROW and turn the BFO knob until you can hear the beat note. After you have done this once or twice you will know about where to set the knob for best results.

SILENCER This is a squelch circuit, enabled on the A3 modes only. It lets you cut off the audio when no carrier is being received. When not in use, the control should be set fully CCW.

LEVEL -- This controls a potentiometer to adjust the volume at the panel phone jacks. It has no effect on signal levels elsewhere inside the set nor on the audio level at the rear connector.

OUTPUT -- On the A3 modes this is an audio gain control, located at the input to the audio module. Accordingly it affects both phone jacks and the rear connector.

On the A1 modes, the OUTPUT control is not an audio gain control (the audio gain is fixed at the maximum level). Instead, it adjusts a double diode series audio limiter which will clip both positive and negative going peaks. The regular single diode series noise limiter remains in the circuit.

When using only the panel jack output, the best way to use the OUTPUT control is to set it to maximum. Leave it there for A3 and when copying SSB using A1 BROAD mode. When copying CW, tune the signal in the usual manner, then reduce the OUTPUT control until the signal begins to drop in volume as the limiter takes effect. If the signal is fading, you can reduce the OUTPUT setting (and thus the limiting level) to reduce the effect of the fading.

If you try to copy SSB with the OUTPUT control below about '9', the distortion will reduce intelligibility; since the series noise limiter is still in the circuit, it won't cut the noise significantly.

CALIBRATE ON/OFF -- This turns on the internal calibration oscillator and removes the plate voltage from the two RF stages.

The calibration oscillator of the SRR-13 operates at 200 kcs. The 200 kcs fundamental is fed into the 200 kcs IF; a second signal taken from a different point in the circuit where there are more harmonics is fed into the first mixer. At a calibration frequency you can hear the beat between the harmonic signal coming through the mixers and the 200 kcs fundamental signal.

Signals coming from the antenna are greatly reduced by removing plate voltage from the RF stages but strong signals will still get through; you can use CALIBRATE to zero beat your own transmitter or another very strong signal. This is simpler and more accurate than turning the function switch to A1 BROAD and setting the BFO to zero.

Preliminary Checks

A jumper cable to go from the back of the set to the inside of the case is the 'standard' way to service these sets but in fact you need only the antenna and power connections. Instead of the jumper, I made a 'cheater' cord from the connector in a 'parts set' cabinet.

After necessary cleaning and mechanical check-out, you can 'fire up' (hopefully not too literally) for a smoke test. With the receiver upright on the bench, remove the lid on the power supply and check the 120 VDC and 95 VDC (regulated) outputs. If the 120 volts is off by more than five volts or so, you can move the link on the terminal board at the end of the power supply to correct for your higher or lower than normal line voltage.

Also check the voltage going to the oscillator filament; this is regulated (in most sets) by a 1HT4 ballast tube and should be around 6.3 VAC. See below for further discussion of oscillator filament regulation.

You can't test tubes in this radio because they are soldered in. In a darkened room you should be able to see the filaments of all the tubes by removing the appropriate shield covers -- note, however, that in some sets the 5647 diodes were replaced with solid state diodes. If all the tubes light, then check the DC cathode voltages on each of the stages. There's a table in the manual with the expected values; if you find an abnormal one make further checks on that stage to isolate the problem. 'New' subminiature tubes are rare at flea markets (I suspect the government is holding on to them because some such sets are still in service) but if you have spare modules you should be able to find a good tube.

If you get 1/4 scale or more deflection on the 'TUNING' meter when you turn CALIBRATE on, then the 2nd IF assembly is okay -- except perhaps the detector circuit -- and the calibrator oscillator is also working. A 'rushing' noise from phones means that the detector and audio circuits are working. (It doesn't matter where the set is tuned for this test)

If your set is 'dead' due to a failure in the IF assembly, check plate and screen voltages on the IF stages; screen voltage but no plate voltage on a tube means a bad IF transformer.

If you can hear strong beat notes on the low bands when tuning with CALIBRATE on, then everything from the first mixer stage on is working. If the set is 'dead', the trouble must be in one of the two RF stages and is most likely only present on some bands.

If 'dead' on a band (or some bands but not others), check plate and screen voltages on the RF stages; screen but no plate voltage means an open RF stage plate coil on the band to which the switch is set. (The SRR-11 has shunting resistors on these coils.) If 'dead' on all bands but you heard beat notes then you are looking for a more general problem in one of the RF stages -- something like a burned out tube, broken wire, or bad connector.

Open IF and RF coils are frequent problems with these sets; they may show up first as distorted signals, then progress to only being able to hear very strong signals (like static crashes) and those only with distortion, and then end with a set which is effectively dead. There may be signs of corrosion elsewhere in the bad assembly.

Note that both IF and RF coils interchange to a degree -- you don't necessarily have to find the same coil or transformer from the same type of receiver as a replacement. You can figure out the choices by studying the schematic and parts list in the manual.

Oscillator Filament Regulation

There are several alternatives to the 1HT4 filamentary regulator used in the SRR-series sets. Since these tubes are very rare in dealers' stocks and they frequently go bad, you may have to face the issue whether you want to or not.

If your line voltage regulation is good (you don't really need regulation), you can replace a dead ballast tube with a 50 ohm 2-watt resistor connected between pins 1 and 7 of the regulator tube socket.

If you need regulation, you can install a simple solid state regulator circuit by using a 31 ohm resistor feeding a pair of 6-volt 1-watt zeners in series (back to back) to ground. I wired this circuit on a 7-pin tube base plug; the zeners go from pin 7 to pin 4, and I grounded pin 4 of the tube socket in the supply by placing a solder lug under the adjacent mounting screw.

This solid state regulator circuit is the way the Navy eventually dealt with this problem except that they removed the regulator tube socket and wired the parts right into the circuit. If you have the SRR-13A, you may already have this circuit; the change was also made to some earlier sets.

The zener diode approach only regulates the voltage peaks; the power supplied still varies (somewhat) as the supply voltage changes. In addition, shunt regulation like this takes extra power. A better approach would be to rectify the heater supply (14.4 VAC), and use a 7806 regulator fed through a 27 ohm 2-watt resistor to supply current limited regulated DC to the oscillator heater. I haven't done this yet.

Calibration Oscillator

You may notice a 'chuffing' sound or low volume audio tone when tuned away from a checkpoint with the CAL switch on. When tuning in a checkpoint this signal appears as modulation on the beat note; either as a variation in volume or as a distorted note. The cause is leakage of the 1400 kcs harmonic of the 200 kcs calibration oscillator from where the RF signal is injected (second RF stage plate) through to the second mixer where it beats with the 1400 kc second oscillator. I did not find a good way to attack this directly; a 1400 kc trap in series with the 'harmonics' path affected the multivibrator enough to cause the crystal to lose control and a shunt trap (though it eliminated the effect) caused considerable reduction of calibration signal strength on the high band. The problem doesn't interfere with use of the calibrator, so I have learned to live with it.

The SRR-13 calibrator has far too much output at 200 kcs; the resulting large AGC voltage reduces the gain so much (particularly after you install the amplified AGC circuit) that the markers are very weak on the highest band. A correction is to connect a .001 mf cap from pin 'B' to pin 'E' of the socket for Z-1201 in the calibrator unit. This reduces the 200 kcs signal by 10-20 db; it is still ample but no longer overpowers the harmonic signal on the high bands.

Audio Distortion

On most older receivers badly distorted audio output means a leaky coupling cap. Not so the R-441; it has glass-metal sealed paper caps and I have never seen a bad one. However, it has other sources of audio distortion.

I found the 5902 audio output tube in my set was weak and a source of considerable distortion; if you made the checks suggested above you have eliminated problems of this sort.

Now correct the one problem all the SRR-13's (and 12's) have: the always 'ON' series noise limiter. This unit is Z-1101, it is the front-most tube in the audio assembly. Because it is a vacuum diode, it is biased to begin clipping at about 40% modulation; that probably wasn't too bad on the typical military AM signal (which was usually undermodulated) but on a ham signal with 80 to 100% modulation, the distortion is severe. You can check that you have the problem by tuning in a heavily modulated signal and connecting a .01 mf cap from the pin with the blue dot to the pin with the yellow dot on Z-1101 to bypass the noise limiter. If the audio improves, you have the problem.

This is easy to fix. Remove the audio assembly, pull Z-1101, and remove the 5647 tube. Replace it with a 1N914 or 1N4148 diode -- these are available from Radio Shack and many other sources. Connect the cathode of the diode to the pin with the yellow dot and the other end to the pin with the blue dot.

This change alone will improve the audio quality but considerable further improvement can be had by changing the bias so clipping doesn't start until about 100% positive modulation. To do this, replace the 82k resistor with 120k. Take care not to build up solder on the sides of the terminals next to the outer edges of the module as there isn't much clearance.

This change will give a big improvement in the audio quality; the clipping will be the same or better than it was. A modern solid state diode is just a much better switch than a vacuum diode...

If your Z-1101 is stamped '1N458' on top, you already have a solid state diode. Check the forward and back resistance with an ohmmeter; if it is okay then just change the 82k resistor as above to fix the bias.

A slight additional improvement in the audio can be obtained by replacing any other 5647's on the audio assembly with solid state diodes. While these are supposed to be biased 'on' in normal use, in fact the bias isn't great enough to eliminate them as a source of distortion.

The final source of distortion (and in my set, the third most important one, behind the bad 5902 and the noise limiter) is overloading due to excessive signal levels. This probably occurs in the mechanical filter; if so the problem doesn't exist in sets with L-C filter units. In general, SRR-13's have L-C filter units and -13A's have mechanical filters but since the IF assemblies are interchangeable this is not a hard-and-fast rule. You can tell which you have by looking for Z-1003 at the back end of the IF assembly; if it is there, then your set doesn't have mechanical filters. (I am indebted to Todd Roberts, WD4NGG, for pointing out the use of mechanical filters in some of these sets.)

Overloading is best corrected by adding amplified AGC; this will be discussed below.

Mechanical Alignment of the Dial

The instructions in the book are adequate but be sure you do this before turning any screws in the front end. It must of course be repeated whenever the tuning cap is replaced. If the index line on the ground glass does not align with the index at the left end of the dial on all bands then the support bracket at the left of the lens carrier is probably bent or worn; it can be replaced with a spare or repaired.

Be extremely careful when working near the engraved glass dial; it is really glass (not plastic) and can be broken quite easily.

Oscillator Alignment Technique

When tracking the local oscillator to the dial, you have to go back and forth between the high and low ends of each band alternately adjusting the trimmer capacitor and coil. You can greatly reduce the number of trips by using the following procedure which involves overshooting the adjustments by the right amount to come to the final answer in two or three rather than ten or more passes.

Make sure the set is adequately warmed up; a really complete warmup takes about eight hours. Center the 'CAL ADJUST' control and lock it. Tune to the high end of the band and adjust the trimmer cap for that band until the crystal checkpoint is on the mark. Then tune to the low end, note the amount of error, and turn the dial <u>past</u> the mark by 1/3 of the error on the three low bands, 2/3 of the error on band four, and 90% of the error on band 5. Now adjust the oscillator coil for the band for zero beat.

(If, for example, you found that the dial read about 1970 kcs -- 30 kcs low -- at the low end of the 2 - 4 Mcs band, you would turn the dial to 2010 kcs and adjust the coil for zero beat.)

Return to the high end and adjust the trimmer until the checkpoint is on the mark again. Back to the low end again, and readjust the coil, overshooting as before.

Repeat these steps until you are satisfied; that should rarely be more than three iterations. Note that you always start by adjusting the high end and that you only overshoot when adjusting the coil at the low end.

This procedure will also save time when doing RF alignment but since great precision isn't needed, one or two passes is plenty.

When adjusting the oscillator coils, be aware that the screws are ceramic. They are very easy to break (can you guess how I know this?) if you turn too forcefully at the end of the range or if your screwdriver slips down beside the screw and you twist against the side. Always look at the slot when inserting a screwdriver; even if you have a spare, these coils aren't too easy to change.

I found it helpful to replace the standard tuning knob with a spinner type knob while doing the calibration and other procedures requiring frequent end-to-end retuning.

Panel Handles

To paint the panel or even do a good cleaning, you may want to take the handles off. Each is held by two 10-32 philips head machine screws which go in from behind the panel. Loosen the lower one a few turns first, then raise the locking lever until it starts to lift the hook latch; you will be able to see the head of the other screw behind the gears in line with the threaded hole which is visible from the front.

Before removing a handle, make a sketch showing the angular position of the various parts. Mark in particular the location of the pin which lifts the hook latch just before the latch starts up as you lift the locking lever. Also note where the uncut portion is on the top of the gear visible from above just behind the panel. These locations are critical; if you don't get things back in the same angular position when reassembling, the latch may not work.

When reassembling, make a final check before you put the set in the case. It must be possible to lift the hook latch (using the latch handle from the front of the panel) until the latch hits the stop. If you can't do this, puting the set in the case may be permanent. (You may have to drill out the screws holding the lugs in the case to get the set out again.)

Brush-on oven cleaner is excellent for cleaning these or similar nickel plated parts of green corrosion, and official U.S. Navy sweat, and cigar and cigarette smoke. Give it about an hour, rinse, and scrub with a toothbrush.

Dial Calibration

This section applies to the R-441/SRR-13 and at least some SRR-13A's; it may or may not apply to the FRR-23. The lower frequency sets don't have the problem.

One distressing feature of the R-441 is that the dial can be read much more accurately than it can be calibrated with the normal procedure. If (for example) you align the oscillator on the low band (2-4 Mcs) following the directions in the book so that the dial reads correctly at the ends of the band with the CAL ADJUST knob centered, and then calibrate at 3800 kcs, a frequency near 3885 may be off by ten to 15 kcs -- even though you can read the dial to about one kc. The maximum error with CAL ADJUST centered (after proper oscillator alignment) may be 30 to 40 kcs at 3000 to 3500 kcs. That's about an inch -- many times what you'd expect of a receiver of this quality.

The oscillator circuit contains three components for each band which when adjusted in the proper combinations are capable of making the dial read exactly right at three frequencies within the band. Two of the three (the oscillator coil inductance and shunt capacitor) are screwdriver adjustments; the third (the capacitor in series with the tuning cap) is fixed, and in the SRR-13, it is far from the right value. By replacing this cap (on each band) you can bring the worst error to about 5 kcs on the low band and 10 or 15 kcs on the high band.

I did this by trial and error; later I discovered that the upper two bands of my (250 kcs to 8 Mcs) FRR-22 have the same coverage, coils, and tuning capacitor as the first two bands of the SRR-13 -- but near perfect calibration. The main difference is the values of these series capacitors -- the FRR-22 has almost the same values as I 'discovered' for the SRR-13. This suggests that changing the series caps to the values in the table below would fix things up with little or no trial and error, however I haven't tried this.

Before making any changes, be sure that you have the problem. Do the normal oscillator alignment so the dial reads correctly at the ends of each band for one or two of the low bands. Then tabulate the errors at the check points in between the ends. If after doing this the errors near mid-band are amazingly large, you do have the problem.

The table shows the original and final values of the capacitors I changed. In addition to the five series caps, I had to change the padding caps to bring the required shunt capacitance into range of the trimmers. The notation '400+15 = 415' (for example) means I used 400 and 15 mmf in parallel to get 415 mmf. <u>NPO capacitors are best here, but adequate stability can be achieved with</u> standard silver micas.

Symbol	Original Value	Final Value
C-606	458	400+15 = 415
C-609	820	390+270+50= 710
C-612	1400	390+750+33= 1173
C-617	288	270
C-620	120	82 + 30 + 3 = 115

When you change the series caps you must also change the fixed caps which parallel the trimmers to bring the right value within range. Except as noted, <u>these capacitors must be NPO types</u>. The values which worked in my set are:

Symbol	Original Value	Final Value
C-607 & 608	33+7	26 (20+6N470)
C-610	33	22 (10+12N470)
C-613	27	26 (20+6N470)
C-615 & 631	10+15	21 (15+6N470)
C-618	22	13 (N330)
C-619	33	25

"20+6N470" means a 20 mmf NPO cap in parallel with a 6 mmf cap having an N-470 temperature coefficient. The values shown were chosen to place the trimmers near the center of their range so they should be okay for all sets.

The capacitors I used were a mixture of 1% and 5% values; the values in the tables above are the marked values and accordingly could be 'off' by up to 5% Even so, they'll be much better than the original values.

When aligning after making these capacitor changes, set all the trimmers to center position, then use the respective coils to set the correct frequency at the bottom of the band. Then go to the top of each band and adjust the trimmers for the correct frequency and procede as in a normal alignment.

To change a cap you must remove the bottom covers from the oscillator and mixer assemblies, disconnect the oscillator to mixer link, remove the tuning cap connection screws for the oscillator, remove the oscillator assembly by taking out its three mounting screws, and then remove the shield from the assembly. Most of this is somewhat harder than it sounds. Reassembly is the reverse procedure and you must finish up by realigning the oscillator before doing any testing.

To reduce the number of times you must pull the oscillator assembly and bend those oscillator to tuning capacitor straps, change all the capacitors at one time. Then recalibrate all bands and take new data. The results will be better. If the error passes through zero near the center of a band then that band cannot be improved. If that is not the case, the following info will help you adjust the capacitors. It is probably obvious that this is so much work that it is only worthwhile if you plan to make considerable use of your R-441.

If the error (with CAL ADJUST centered and the band ends correct) is positive near the center of the band (for example, if the dial reads 3010 when the 3000 kcs checkpoint is zero beat) then the series capacitor must be increased; if the error is negative then the series cap must be reduced.

Try about a 1% change in the series capacitor on each band in error, measure the effect, and then extrapolate to get the right answer. For example if you have a 15 kcs error at the center of a band, and a 1% change affects the error by 5 kcs, then you need a total of 3% change to fix the problem. It helps a lot to write down what you do and the result at each step.

In making adjustments, you can do the first three bands at one time and you need not replace any of the shields to get valid data. When these are finished, do the two high bands; here you must replace the oscillator assembly top and bottom covers and (on the high band) the mixer bottom cover as well to get meaningful results.

I recommend using a 2 mcs oscillator or (very accurate) signal generator set to 2 mcs instead of the internal 200 kcs calibrator to do all but the final testing; with signals at closer intervals it is easy to get disoriented and really mess things up. If you get 'lost', a frequency counter connected to the osc-mixer link bar will help; the oscillator should be 1.6 Mcs above the channel frequency. Use a 2 mmf (or so) coupling cap and check the amount this connection lowers the oscillator frequency before you actually need to use this trick.

Removing and replacing the oscillator assembly will change the calibration of all bands slightly.

Oscillator Temperature Compensation.

The temperature compensation of the SRR-13 is based on a unique scheme. First, the tuning capacitor and coils are designed to be as stable as possible. Then, the screws which hold the coil slugs move in threaded plastic sleeves which are themselves adjustable to give a controllable negative temperature coefficient -- these don't have a very wide range of adjustment.

Next, the series capacitors (which have greatest effect at the low end of each band) are specified as having a small positive coefficient: (0 to +40 ppm/degree F) their effect and that of the coils cancels at the low end.

Finally, the 'stray' capacitances in a circuit like this invariably (I haven't seen an exception) have a positive coefficient. At the high end of the band (where 'strays' are important) their effect is cancelled by the negative coefficient of the inductance.

When I finished correcting the calibration, my SRR-13 had what I considered excessive drift, ranging from 5 kcs to 10 kcs over eight hours at the high end of the low bands and 15 kcs or more on the higher bands. I had used ordinary silver mica caps (positive temperature coefficient) for the parallel caps and that was a mistake. When I replaced these with NPO ceramics, things got much better. Then I replaced part of the NPO capacitance with negative temperature coefficient capacitance; that brought the results down to what I expected -- no more than 1 kcs at any point within the two low bands in eight hours and less than 10 kcs everywhere else.

Bending Plates in the Tuning Capacitor

This applies only to sets on which series capacitor changes have been made.

When you have gotten the best possible calibration with the procedure above (i.e., when you have zero error at a point near the center of all bands as well as at the ends) you can further reduce errors by bending capacitor plates.

Don't try to do it unless you have really gotten minimum error with the series caps because there isn't enough adjustment available to correct larger errors. Moreover, plate bending can only correct one band exactly; if the others aren't at minimum error they may not be much improved.

I would not try this unless you have bent plates on some other set as the procedure is tricky, some parts are quite fragile, and mistakes are hard to correct in the limited space. A command receiver is an excellent practice piece and you will be amazed at how accurate those dials can be with a couple of hours work.

Get a new blade in a small hacksaw -- the type with about a six-inch blade is ideal. Remove the tuning capacitor. The ceramic insulators on the bottom are just as fragile as they appear; take appropriate care during the following work.

Hold the capacitor firmly but not too tightly between blocks of wood in a bench vise. Saw a slot almost (but not quite) through the top of capacitor can perpendicular to the shaft and about 1/2 inch from the front of the can. Saw a second slot about 1-1/4 inch further back. Make the cuts slowly and without too much pressure so as to avoid cutting more deeply at the edges than at the center; the new blade also helps with this.

The reason for not cutting through is that you want to avoid getting metal filings inside the can.

Use a hand grinder with a cut-off wheel to connect the slots along the rounded corners, again taking care to cut not quite through.

Now use a small screwdriver or similar tool to poke through at one corner of the area you cut. The best approach is to 'chisel' horizontally from one end of one of the grinder cuts; the frame of the capacitor is below this cut and if you try to go down, it will be in the way. When you have a corner loose, pry up to expand the tear until you can catch hold of the flap with a pair of stout pliers. Peel away the rectangular piece with the pliers as you would the top of a sardine can; if your cut is of fairly uniform depth it should come off easily. Don't bend the flap unnecessarily or discard it as you will want to flatten and reinstall it when you are done.

Take great care in this part of the job as anything broken inside the capacitor can may not be fixable with such limited access. The spring fingers at the front of the rotor are particularly delicate; if overstressed you cannot get the right pressure without total disassembly, that is, removing the capacitor from the soldered-on can.

Reinstall the capacitor and do the mechanical realignment. Warm the set up fully (say 8 hours), correct the calibration oscillator and do the electrical realignment at the end of each band.

Start on the 4-8 Mcs band with the capacitor fully open. Tune toward lower frequencies recording the error at each checkpoint and marking down which checkpoints occur at the point where a slot on the capacitor end rotor plates is about to mesh with the stator.

Study the data and decide your strategy. Depending on the existing shape of the plates (they are already bent slightly, probably by the capacitor supplier to meet a specification) it is generally easier to move a dial reading lower (i.e., dial reads 5005 when at 5000 kcs checkpoint) than to move one up; this is because when the plates are straight you can safely reduce the capacitance (by bending a plate out) by more than you can increase it.

Thus it may be better to move the entire band up a bit (make the average reading high) with the coil so that most points can be moved down by bending plates.

Start at the top of the band and correct the dial reading with the trimmer cap. Tabulate the errors at each checkpoint until you reach the first slot, then bend the plate nearest the front of the cap in the direction to reduce the error -- 'in' (toward the stator) for greater capacitance if the dial reading is too low, 'out' if the dial reads too high.

These plates must be bent with great care as they seem to be of copper -- just a little more than the right force will really make a mess of things. I found it best to use one small tool (say a screwdriver) to push on the section I wanted to bend while supporting the adjacent section with another tool so the net force on the plate was zero.

The reason for looking at the errors at each checkpoint rather than just the one at the slot is that in some cases the error will not build up in a linear fashion so bending the whole section of the plate between slots won't fix it perfectly. You will have to either put a crimp in the plate or pick the best compromise between errors in one direction and those in the other.

On the first pass, look for a compromise. Also, don't try to correct the entire error on the first pass -- just get half of it or so.

When you are satisfied with the behavior of the first plate segment, continue down to the checkpoint at the second slot. Except on the final pass, if you left an error at the previous slot, that error becomes the 'zero error' condition for the next segment. For example if you have a slot at 7200 and wind up with a dial reading of 7202 at that point, you will be looking for a dial reading of 6202 (not 6200) at the next slot checkpoint. When you are satisfied with the second slot checkpoint, go back and recheck the top of the band and the first slot checkpoint. It is hard to avoid bending previous segments and you don't want to go on until everything up to the current point is really as you intend it to be.

Continue with the third and subsequent slots, returning to check the high end and all previous slot checkpoints after each new slot. When you reach the low end of the band, return to the top end and make another complete pass, reducing the error further.

As you see how much bending is required, you will probably want to do some of it on the rear plate of the oscillator rotor section. Since the access there is not as good it is better to use these for 'roughing in' and make the final adjustments on the front plate. (The cutout is the size it is because you don't want to weaken the mirror mounting too much.)

On this band you can get within a kc or so at every checkpoint. If you do, and if the series capacitors have been chosen correctly then the other bands will be in error by only slightly more than the same amount of space on the dial. It isn't worth trying to get the error below a kc or so because the other errors -- drift, mechanical looseness in the coil slugs, etc. -- are of that size. The SRR-13 can be made into a very well calibrated receiver by the standards of 1950 but it will never be a frequency meter.