THE HOLLOW STATE NEWSLETTER

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Editor's And Publisher's Corner

First, please note Ralph's new address above.

Next, and I know this will please many of you, we have a new editor, Reid C. Wheeler. I am delighted too, of course, that <u>HSN</u> will not cease with this issue. I asked Reid to write a short paragraph to introduce himself, and have included his introduction below. I hope that many of you who have been thinking of sending a short (or long) contribution to <u>HSN</u> will take a few minutes from your busy schedule and sent that contribution to Reid. There may be enough material on hand for two or three more issues, but Reid will surely need your help if <u>HSN</u> is to continue.

Finally, let me say what a pleasure it has been to edit <u>HSN</u> these last eight years for issues 11 - 30, and especially to have met so many fine people.

Welcome To Our New Editor: Reid C. Wheeler

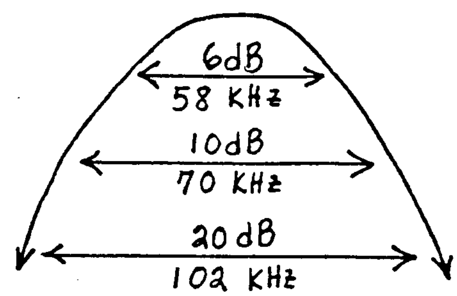
It is my pleasure to soon be assuming the editorship of HSN beginning with #31 later this fall. I certainly hope, with all of your help and contributions, I can do as good a job as Dallas has. Gratefully, Ralph Sanserino will continue to handle the publishing. My primary goal is to make HSN address <u>your</u> needs, interests and desires; suggestions are always welcome. Background: I'm a 50-year old, married civil engineer working for a small state agency. My work is all administrative which has permitted me to keep up fairly well with computer technology. My combination shack/workshop is well filled with hollow state equipment including two R-390A's (a Stewart-Warner and an EAC), a National NC-183T, and my first multi-band receiver, a Hallicrafters S-38E. All my test equipment (scope, signal generators, VTVM, etc. are tube-type as well. Electronics and radio have been hobbies since high school and I never seem to get tired of building, repairing or modifying most anything electronic. My main love is BCB DXing and I am presently the Western DX Forum editor for IRCA's <u>DX Monitor</u>. I hope to hear from many of you soon - we'll talk again in HSN #31. My address is 5910 Boulevard Lp SE, Olympia, WA 98501-8408. If calling, your best chance is between 6 pm and 9 pm PLT most any evening at (206) 786-1375. Reid

Collins Torsion Mechanical Filter For The R-390A

Dallas Lankford

Recently while studying the feasibility of adding a noise blanker to the R-390A, I made a surprising (to me) discovery. For the non-crystal filter bandwidths, i.e., for the 2, 4, 8, and 16 KHz mechanical filter bandwidths, the 3rd order intercept (ICP3) and hence the 3rd order dynamic range (DR3) of an R-390A is determined mainly by the 1st IF amp, not by the front end as it should be.

The non-crystal filter bandwidth of an R-390A at pin 1 of V501, the grid of the 1st IF amp, is shown at right. When the front end selectivity is included, at lower frequencies (say, below 5 MHz) the non-crystal filter bandwidth at pin 1 of V501 is somewhat narrower. But in any case, for non-crystal filter bandwidths, the R-390A is quite broad up to the mechanical filters following the 1st IF amp. In other words, the R-390A was designed as a CW receiver, and AM was added as an afterthought.



Typical R-390A Selectivity At Pin 1 Of V501, 2 KHz BW Or Greater

Suddenly in a flash, a number of published statements which had seemed incorrect to me were explained. How had Sherwood gotten such uniform dynamic range measurements for the R-390A at 20, 10, and even 5 KHz tone spacings? My measurements using mechanical filter bandwidths were not nearly as uniform as his. Apparently he used the 0.1 or 1.0 KHz crystal filter bandwidths! And how did Rohde get a -4 dBm ICP3 for the R-390A? I never got better than aboput -12 dBm in the MW band using mechanical filter bandwidths. And in the SW bands I got much worse, typically about -24 dBm. Again, apparently he used one of the crystal filter bandwidths. To confirm my suspicions, I made extensive ICP3 measurements using the 0.1 crystal filter BW and got quite uniform ICP3 values at all frequencies and at various tone spacings, from 5 to 20 KHz. With the 1.0 KHz crystal filter BW, the 5 KHz tone spacing ICP3 drops off quite a lot to as low as -22 dBm for a Motorola I measured. That still translates into a DR3 of 74 dB. By contrast, with the 2 KHz BW the Motorola measured -52 dBm ICP3 and 54 dB DR3 for 5 KHz tone spacing. It appears that I made a mistake in a earlier HSN where I gave much higher values as typical. Or perhaps there is substantial variation from one R-390A to another. When some of the values I quoted in a draft of this article were questioned by Denzil Wraight, I could not reproduce my earlier measurements on an EAC of mine because I had modified it with a mechanical filter as described below. And when I measured the ICP3 and DR3 of a Motorola R-390A, I got lower values than I thought I got with my previously unmodified EAC. The most accurate statement I can make at present is that there is some variation from one R-390A to another, and perhaps substantial variation in ICP3 and DR3. In any case, the general trend is clear. The R-390A has significantly better 3rd order IMD performance in the 0.1 and 1.0 BW's than the 2, 4, 8, and 16 BW's, and the R-390A 3rd order IMD performance declines as frequency increases for the 2, 4, 8, and 16 BW's.

Further measurements revealed that RF voltages as high as 20 volts RMS can be present at the input to the R-390A mechanical filters when a weak signal is tuned near a strong signal. The maximum rated input of an R-390A mechanical filter is 5 volts RMS. It is remarkable that the R-390A mechanical filters routinely withstand 4 times their maximum rating. However, this may account for some of the occasional mechanical filter failures in R-390A's.

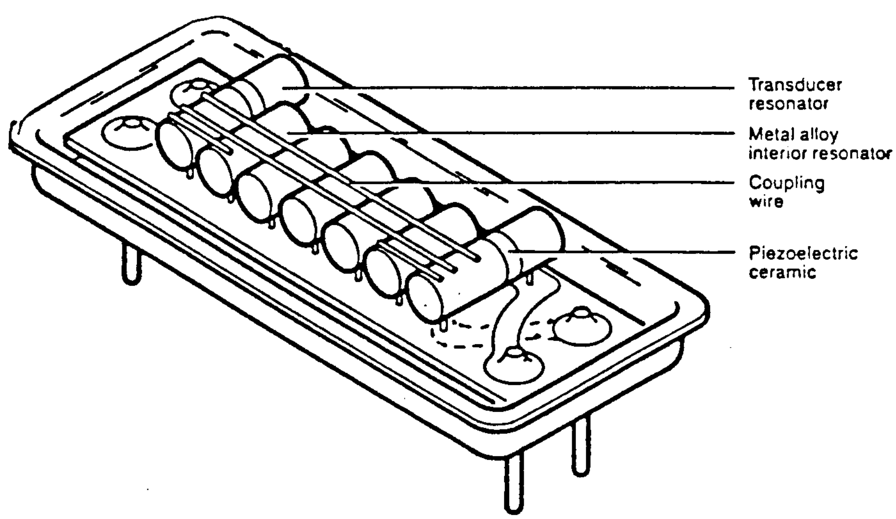
I have often wished for a 6 KHz BW filter for the R-390A, so this seemed like an ideal opportunity to kill 3 birds with one stone: add a mechanical filter immediately after the 3rd mixer which would provide (1) a 6 KHz BW while retaining the 4, 2, 1.0, and 0.1 BW's, (2) improve the non-crystal filter ICP3 and 3rd order dynamic range within about 50 KHz of the tuned frequency, and (3) protect the R-390A mechanical filters from excessive signal levels.

Of course, this is easier said than done. I am sure I am not the first person to contemplate adding a filter after the 3rd mixer. The problem is space. There is not much spare room in the small compartment where such a filter would naturally be installed. An R-390A N-type filter is too large to fit. An FA type Collins filter would barely fit, but try finding an F455FA60 at a reasonable price. Six years ago Collins priced them at $290 for one. An FD filter is the same size as an FA filter, but an FD filter requires other components for impedance matching because the FD filters are 2000 ohms source and load.

Nevertheless, I began prototyping with an FD58 to verify the feasibility of such a mod. Those results are related in my hand written notes "Collins FD mechanical filter for the R-390A." The FD58 circuit never progressed beyond breadboard form, with the filter and impedance matching components sitting on a small piece of wood on top of the RF deck, with connections made via wires running through a spring hole and via a tube test socket. However, the FD58 breadboard circuit permitted me to confirm the feasibility and desirability of such a mod.

Meanwhile, the search continued for a suitably small filter. Ceramic filters were considered, but rejected because of the difficulty of obtaining ceramic filters with uniform specs. I could get high quality, tightly speced ceramic filters directly form Murata of NTKK, but I would have to order about 100 filters for about $2000. I could not see myself going into the filter peddling business just to get a few small, tightly speced, 6 KHz BW filters. And what good is a mod if others can not easily reproduce it?

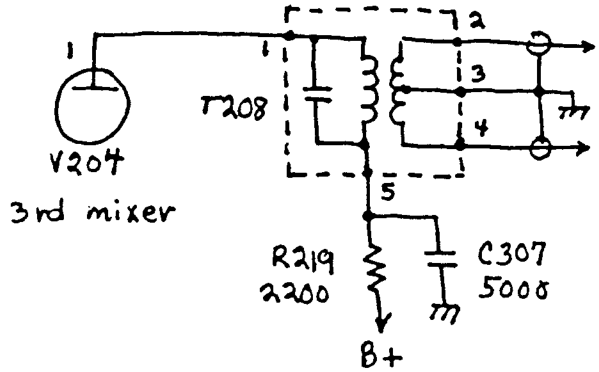
Fortunately, Collins came to the rescue with their low cost series of torsion mechanical filters. I did not know much about Collins torsion mechanical filters when I ordered them; only that they were small, about the size of a 16 pin IC, that they cost $76.81 each, and that the 6 dB and 60 dB specs were good, namely 5.5 KHz min. and 11 KHz max. respectively. for the AM filter.



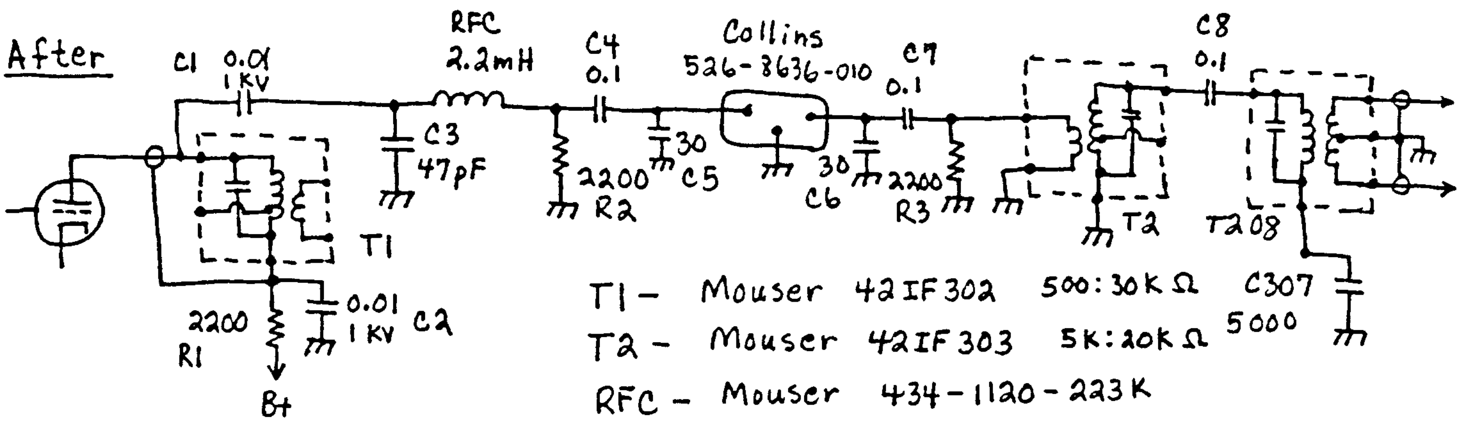
I also knew that the Collins torsion mechanical filters were 2000 ohms source and load, so that impedance matching would be required. I guessed correctly that the same impedance matching circuit I used for the FD58 would work for the torsion filter, and because the torsion filter was much smaller than an FD filter, that everything would fit inside the 3rd mixer compartment.

Before and after schematics of the mod are shown below. A PC board layout is also given below.

Before



After



T1 - Mouser 42IF302 500:30K Ω

T2 - Mouser 42IF303 5K:20K Ω

RFC - Mouser 434-1120-223K

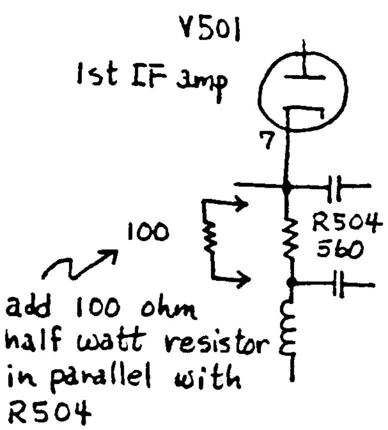
R1 - half watt } Radio Shack
R2, R3 - 1/4 watt }

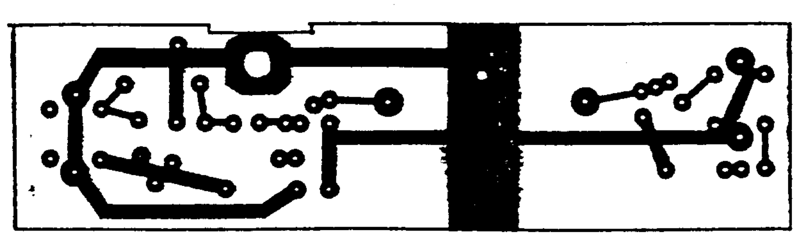
C4, C7, C8 - 0.1, 50V monolithic (RS 272-109)

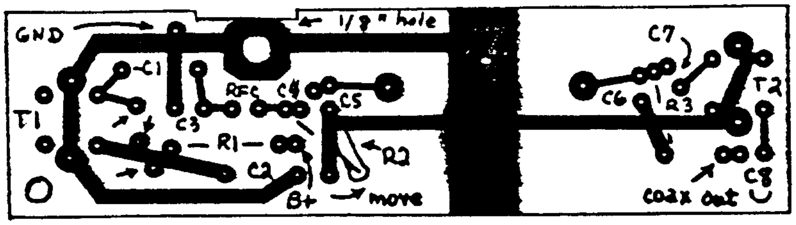
C3, C5, C6 - small 50V ceramics

C1, C2 - 0.01, 1KV (see text)

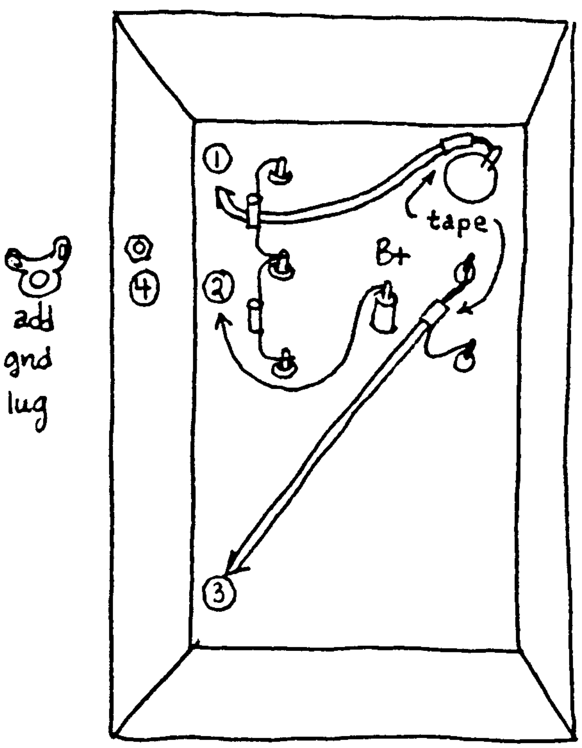
Note that R219 has been removed from the R-390A.



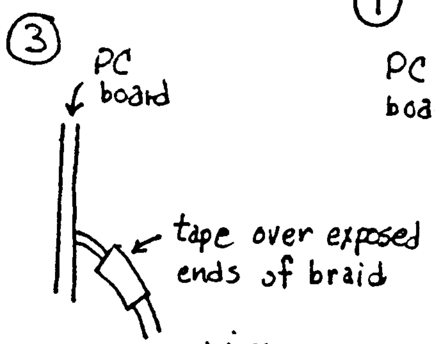


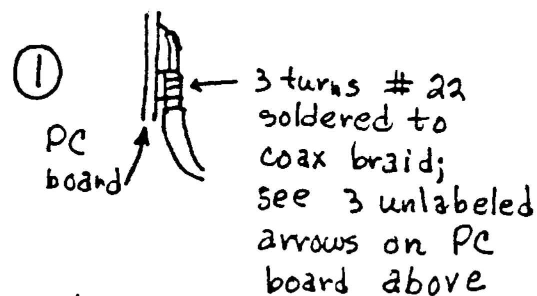


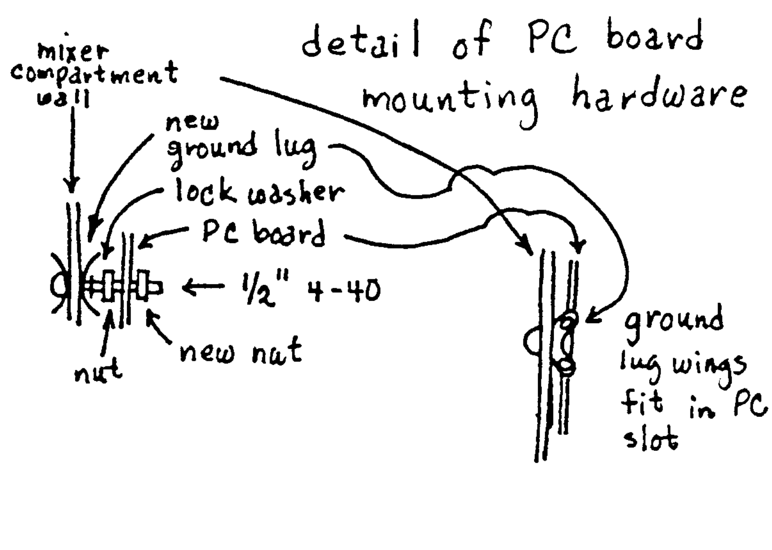
Another view of the PC board with information on the parts layout is given above. The 1/8 inch hole in the ground trace at the top is for mounting the PC board with a 4-40 screw in the side of the mixer compartment; see (4) in the simplified mixer compartment diagram below. The shallow notch in the PC board above the mounting hole is to clear the ground lug which is part of the mounting arrangement; see below. The two holes in the bottom corners of the PC board are for nylon bolts and nuts which are used as standoffs to prevent the bottom of the PC board from accidentally shorting to the metal side of the mixer compartment. For mounting, the existing 4-40 screw is removed and replaced by a 1/2 inch long 4-40 screw. Also, an R-390A type ground lug is added. An exploded detail of the PC board mounting arrangement is given below. The miniature ccax from mixer tube to PC board (1), the stranded insulated wire from standoff (B+) to PC board (2), and the miniature coax from T208 to PC board (3) are shown in simplified form below. Most of the R-390A parts have been omitted from the sketch for clarity. The miniature coax and wire run underneath all R-390A parts and connecting wires. Some details for attaching the miniature coax to the PC board are also given below. The PC board layout can be improved by moving the trace and pad for one end of R2 as shown above.

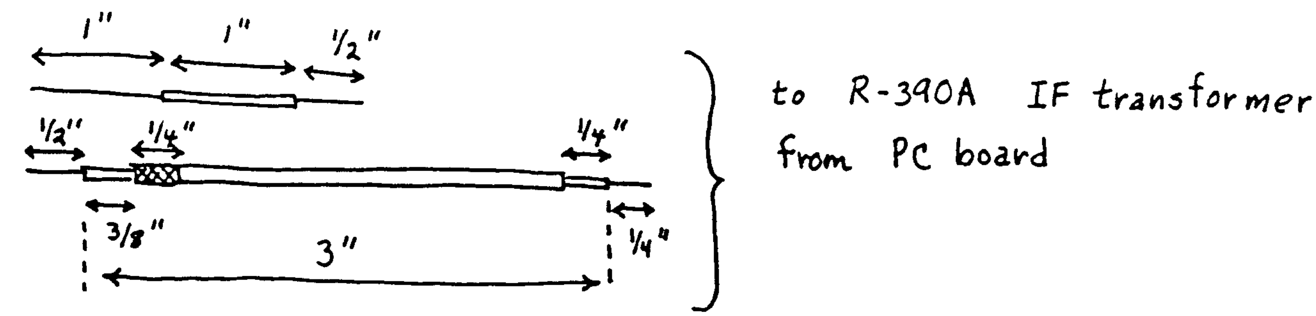


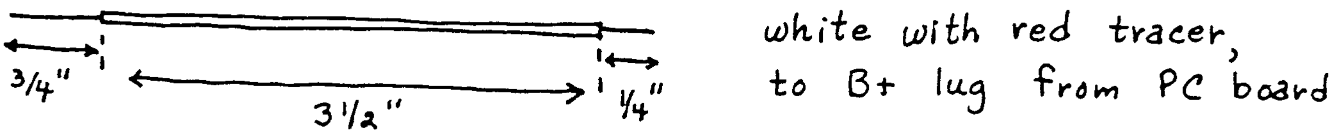
simplified mixer compartment

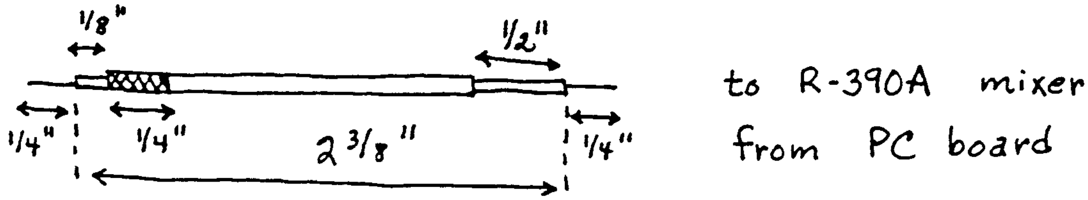












Lengths of the miniature coax and lead dressing are given above. Actually, I used Teflon insulated shielded hookup wire which is sturdier than miniature coax. Exposed edges of braid were taped with Scotch 27 Glass Cloth Electrical Tape, 1/2 inch wide, available from Amidon. It is important not to introduce shorts, especially around the mixer tube socket where high voltages are present.

The transformers T1 and T2 are standard (SUMDA) miniature 455 KHz IF transformers. T1 is a 500:30K ohm, 22:1 turns ratio, while T2 is a 5K:20K ohm, 6:1 turns ratio. I did not know if T1 would safely carry 200 - 300 VDC, so I tore one apart and examined the internal construction. It looks like it would carry 1000 VDC. I also did not know if the current rating of T1 was adequate for the mixer current. So after 20 hours of use I removed T1, tore it apart, and inspected the coil. There was no evidence of internal heating. However, I cannot guarantee the safety or reliability of this transformer, only that it appears to be safe and reliable. Consequently, I assume no responsibility or liability for this mod. The primaries of both transformers are tapped, and the pin-out on one side of each consists of three pins. The middle pin was cut off with miniature diagonal cutters to simplify mounting the transformers. This pin should not be cut off too close to the insulated base; otherwise the transformer primary may open.

C1 and C2 must be 0.01, 1000 volt disc ceramics, and C2 must be small enough to clear internal R-390A parts. With a different PC board layout, C2 could be placed at the end of the PC board beside T1, and then the size of C2 would not be critical. Naturally I discovered this after the PC board was etched as I attempted to install the PC board.

The trace for mounting R2 should be moved slightly as shown, or the leads of R2 can be curved slightly so that R2 does not cover the B+ wire hole.

R2 and R3 may be omitted for a slight increase in signal throughput. They are artifacts of the breadboard version where I tried different circuit variations to minimize passband ripple. They are also the preliminary steps in developing a diode switched multi-filter board.

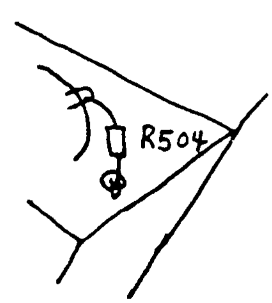
RFC and C3 form an L matching network to match the high impedance of the mixer and T1 to the 2000 ohm source required by the filter. You may use 2000 ohm resistors for R2 and R3 if they are handy, but don't expect any noticable improvement.

There is some signal leakage past the filter with the Mouser radial lead choke specified. To eliminate all signal leakage, you should use an Amidon FT-50-43 ferrite toroid core (mu = 850, A_L = 0.52 microHenrys per turns squarred, L = 0.52 t^2 microHenrys) with 62 turns of #30 enameled copper wire. The signal leakage was discovered after the PC board was etched. A different PC board layout is required for correct toroid mounting.

When the R-390A 8 KHz BW filter is used, the 80 dB BW with the Mouser choke is 10.5 KHz, so there is really no need for the toroid choke when the AM torsion filter is used. It might be worthwhile to use the toroid choke if the 2.5 KHz BW SSB torsion filter is used for this mod.

The Collins low-cost torsion filters are truly remarkable. Low cost does not mean cheap, either in appearance or performance. The torsion filters are small, about the size of a 16 pin dual in-line IC. The case is metal, while the bottom is epoxy fiberglass PC board construction, apparently plated through, with press-fitted pins. I can attest to the fact that the pins are well-attached because I have removed and reinstalled some of them several times. Some torsion filters are assembled with standard low-temperature solder. In that case, the solder around the bases of the pins will flow up inside the case if the filter is soldered or unsoldered upside down. You can fix that by holding the case rightside up, applying the hot iron tip to the pin for a moment, and the solder will flow back out. Then desoldering braid can be used to restore the pins to original. As I have said many times before, ChemWik Lite 0.100 desoldering braid is the only desoldering braid which really works well.

My original PC board had a small copper foil barrier fitted into a slot cut across the center of the PC board and soldered to the ground plane. My current PC board has no such barrier because careful measurement revealed it was unnecessary, at least for the AM filter.



The torsion filters are low loss, but the L matching network adds additional loss, enough loss to slightly desensitize the 390A. Fortunately, this loss can be mostly recovered by adding a 100 ohm half watt resistor in parallel with R504, the 1st IF amp cathode resistor. One end of R504 is attached to a lug on the end of the bandswitch waffer, the other end to an insulated feedthrough; see the sketch at right. Use desoldering braid to remove excess solder from the lug and feedthrough, form a small loop in one end of the 100 ohm resistor lead (Radio Shack half watt works well), push the loop onto the feedthrough using the tip of a screwdriver blade (the loop should be tight enough to hold the resistor in place as you solder it), solder the feedthrough connection, and connect and solder the other end of the 100 ohm resistor at the bandswitch waffer lug.

To install and tune the filter, first remove the 390A RF deck, remove R219, and remove the insulated wire (white with blue tracer) from pin 1 of V204 to T208. Next install a long length of insulated wire at the B+ insulated standoff, and a long length of mini-coax at T208, and bring these two wires through the rack spring hole in the mixer compartment. Reinstall the RF deck. Use a tube test socket to extend V204. Place a 6 inch by 6 inch piece of 1 inch thick wood on top of the RF deck. Attach the completed PC board. Turn on the R-390A, inject a signal generator signal (or tune a CAL marker) and peak T208, T2, and T1 in that order. Disconnect the PC board, remove the RF deck, and reinstall the PC board in the mixer compartment (remove the temporary mini coax from T208 and install the final mini coax, and trim the stranded insulated wire from the B+ insulated standoff to an appropriate length, about 3 1/2 inches long). The mini coax at the input side of the PC board should be the same as was used for the outboard tuneup. The PC board ground connection is a short length of #24 tinned solid copper wire from the PC board ground pad to the ground lug. Reinstall the RF deck, and repeak T208.

The low-cost torsion filters are available in AM, 6 KHz BW, part no. 526-8636-010, SSB, BW 2.5 KHz, part no. 526-8635-010, and CW, BW 0.5 KHz, part no. 526-8634-010. Shape factors are typically slightly under 1:2, and the filters are capable of ultimate attenuation in excess of 100 dB. You should contack Bob Johnson, Principal Engineer, Filter Products, Rockwell International, 2990 Airway Avenue, Costa Mesa, CA 92626, phone (714) 641-5311 for prices and availability of these filters. The attenuation characteristics of a similar low-cost, 8 resonator, torsion filter are shown below. The spurs between 370 KHz and 390 KHz, at about 480 KHz, and about 530 KHz are normal for mechanical filters. Even the spur at about 480 KHz will be attenuated to below 100 dB by an ordinary 455 KHz IF transformer, so these spurs are of no consequence unless the torsion filter is the only selectivity in your IF. This is, of course, not the case with an R-390A.