THE HOLLOW STATE NEWSLETTER

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P. O. Box 6145
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Number 27

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Publisher's And Editor's Corner

First, a BIG THANK YOU to everyone who donated any amount of cash to The Hollow State Newsletter. Both smaller and larger amounts were greatly needed and greatly appreciated. Ralph and I are happy to report that The Hollow State newsletter is now solvent again.

Although I had intended to finish our discussion of the 51J-4 with this issue by including an excellent product detector mod which makes the 51J-4 maybe the best all band, all mode receiver of all time, instead I have decided to make this an all R-390A issue and return to the 51J-4 product detector mod in the winter. Several reasons motivated this decision, not the least of which was the receipt of some good new R-390A information from Shaun Merrigan. I believe you will find Shaun's discovery that Maynard's ILO is not compatible with my latest SSB/AGC mod quite interesting, and his solution for this problem equally interesting. Shaun also gives us another way to add a Q-multiplier to the R-390A, one which appears quite easy to do. But the one I liked best was Shaun's discovery of the cause and cure of "thunderstorms" in the R-390A audio output with no antenna connected. I have encountered this problem before, but was never able to identify and cure the problem. Congratulations Shaun!

Let me add a few remarks about the R-390A AGC and BFO mods which are included in this issue. When I finished my first version of the mod and showed it to Wally Chambers, K5OP, it turned out that Wally was already doing something similar. After that, we worked together so closely on the project that I don't even remember who is responsible for what parts of the mod. I would suggest that if names are to be attached to the mod, then it should be referred to as the Chambers-Lankford AGC/BFO mod. Of course, I am entierly responsible for the contents of the article and any inaccuracies or errors. We hope that the article is free of typos, and we believe that the mod can be done with superb results to any IF deck. If you have an EAC IF deck, be sure to read the note at the end of the article. In fact, you may want to do the EAC variant to your IF deck (even if it is not an EAC) because it is simpler.

MAYNARD'S ILO INCOMPATIBLE WITH LANKFORD'S LATEST SSB/AGC MOD: Upon modifying an IF subchassis and AGC switch according to Lankford's latest SSB/AGC mod (this issue, Ed.) which works extremely well, it was found that (because my R-390A includes Maynard's ILO mod, Ed.) the strong SSB signal handling performance of the R-390A was severely degraded. Very noticeable audio distortion was noted on strong SSB signals, especially the 80m ham band, and as a result, I had to "ride" the RF gain control.

The solution was to add a switch (in my case mounted on a small L-shaped piece of aluminum, held down by the carrier meter pot adjustment nut) so that I could switch the ILO in and out. I might add that this mod is useful in any case because it permits the ILO to be switched in and out for alignment and calibration purposes. For example, with the ILO switched in, the BFO will lock to the xtal calibrator and you could be 300 Hz or more off frequency. Of course, the main purpose of the switch is to have available both Maynard's ILO feature for AM synchronous detection, and Lankford's mod for superb SSB performance. (Shaun Merrigan)

Q-MULTIPLIER FOR R-390A: January 1965 CQ magazine, pages 37-38, suggests connecting a Q-multiplier as follows: inner conductor to pin 5 of V502 (the plate of the second IF amp) and shield to nearest ground. I tried this and found it to work well. If you use miniature coax, you can route the coax through the access hole in the top of the IF subchassis (the hole which passes the wires to the carrier meter zero adjust pot and IF gain adjust pot), so no drilling is required. (Shaun Merrigan)

R-390A THUNDERSTORM NOISE: One of the R-390As I worked on had a bad noise problem which sounded like a nearby thunderstorm was raging with no antenna connected. I traced it to the IF subchassis by disconnecting the output of the RF deck (P213 and P218) and by switching AF decks. Within the IF deck I used "Freeze-it" and found the culprit, an intermittent mica capacitor, after about 10 minutes work. I replaced the mica cap with an identical one from my "parts unit", and all was well. (Shaun Merrigan)

This is a wonderful discovery which Shaun has made. I had an intermittent "thunderstorm" problem in an IF deck which I never was able to isolate. For a while I suspected a bad tube, but repeated efforts to isolate the bad tube failed. It never occurred to me that I might have a bad or intermittent mica capacitor. Now I know what to do if I ever encounter the problem again. However, let me add that some of these "thunderstorm" problems are bad tubes, so you should check for bad tubes first before you proceed to try to isolate a bad or intermittent mica cap. (Ed.)

R-390A WON'T TURN OFF?: When you turn your R-390A FUNCTION switch to the OFF position, do your dial lights remain on? If so, then you have a worn micro-switch (which is part of the S102 function switch assembly). The only permanent cure is to drop the front panel, unsolder the two wires to the microswitch, remove the microswitch, gently pry the side plate off the microswitch (held on by 4 small screw-like, but unthreaded and unslotted, pieces of metal), and refinish the microswitch contacts. This is akin to refinishing the points of an automobile. GC makes a burnishing tool which can be used, or you may use different grits of wet-dry sandpaper, starting with #400, then #600, then finer grits (which you can make by sanding a piece of metal with #600 until it is "well used"). The idea is to make the contact surfaces of the switch flat and smooth again. After years of use, repeated arcing has roughed up the surfaces so much that finally one arc causes the surfaces to literally weld together. An 8X lupe is probably essential for inspection of your work. (Shaun Merrigan & Dallas Lankford)

CHAMBERS-LANKFORD AGC/BFO MOD: This AGC/BFO mod is not perfect. The SLOW attack time is 6 mS, which causes some distortion, pops, and clicks on the initial syllables of SSB transmissions. These are not eliminated even with a product detector. Some additional distortion is contributed by the BFO mod, which is not a product detector. But it is a relatively simple mod, and gives excellent results for the amount of effort involved. For CW it is outstanding. In any case, it is better by far than any other SSB mod which has been done before. Wally and I have some ideas about how to speed up the slow attack, and I have an excellent product detector waiting in the wings, so we hope to eventually arrive at the outstanding SSB performance which the R-390A is capable of. (Wally Chambers & Dallas Lankford)

R-390A AGC And BFO Mods

For Improved SSB And CW

Dallas Lankford

Two things prevent an R–390A from performing well on SSB and CW signals – unsuitable attack and release times for SSB and CW, and low BFO amplitude at the diode detector.

The usual way to demodulate SSB or CW is with a product detector. There are two ways to add a product detector to an R–390A. The BFO circuit can be converted to a product detector as described by Capt. Paul Lee in his 1968 *CQ* article, "Modifying the R–390A receiver for SSB," pages 55-58; see also a variation using relay switching which includes the R–390A noise limiter function with the product detector as described by Eugene Hubbell in his 1974 *Ham Radio* article, "Improving the R–390A product detector," pages 12-15. Or an external product detector can be connected to the R–390A 455 KHz IF output, such as one of the military sideband converters, a Hammarlund HC–10 converter, or a home built product detector like the one described by Alan Nusbaum in his November 1985 *Ham Radio* article, "External product detector improves receiver performance," pages 107-111.

However, there are disadvantages to these approaches. Lee's product detector requires that an R–390A mainframe be rewired, which means that you cannot use that mainframe without a specially modified IF subchassis. In addition, the noise limiter is bypassed, and Hubbell reported that there was a regenerative effect which occurred at the BFO frequency, resulting in a peak in the audio response. Hubbell implemented Lee's mod with a relay, which eliminated the regenerative effect. He also expanded Lee's mod by making the noise limiter operational with the product detector. But Hubbell's mod requires a special Potter and Brumfield relay (type PW5LS, 2 mA, 10K ohm coil) which now costs about $100 retail, and the relay must be mounted in a 7 pin miniature socket added to the IF subchassis. Hubbell's approach can be implemented with an ordinary low voltage relay, but then you will have to provide additional low voltage, high current, DC for the relay coil, and use a BJT to switch the relay on and off with the switched 200 volt B+ line. There is hardly enough space to mount the necessary additional components. The military SSB converters are almost always large and heavy, and generally use many tubes (CV-157: 44 tubes, 125 lbs.; CV-1982: 23 tubes, mostly nuvistor, 30 lbs.). I have been told that there is a small solid state SSB converter made by McGee Industries, but I have never seen one. The Hammarlund HC–10 converter (only 10 tubes) requires precise frerquency alignment for whichever sideband you want to use, or a wider than necessary R–390A bandwidth if you want to switch sidebands quickly. If you use a wider than necessary R–390A bandwidth, then adjacent QRM activates the R–390A AGC and degrades the performance of the HC–10. Finally, none of these product detector mods or add-ons does anything about the unsuitable R–390A attack times and release times for SSB and CW.

For SSB an attack time of 2 milliseconds (mS) is often stated as optimal, while release times of 500 mS for fast SSB release and 2 seconds (S) for slow SSB release are considered suitable. My goal was to modify the R–390A AGC in such a way that attack times for all three AGC speeds (FAST, MED, and SLOW) were about 2 mS, and the MED and SLOW release times were about 780 mS and 2 S respectively.

My starting point was Cornelius' AGC mod, which speeded up attack times for FAST and MED. The original Cornelius AGC mod removed R545, replaced R546 with a back pointing diode, and replaced R547 with a 10K ohm resistor. I developed a better variant of Cornelius' AGC mod by leaving R545, R546, and R547 unchanged, and adding two back pointing diodes, one across R546, the other across R547.

To improve the SLOW attack time, it was necessary to redesign the SLOW AGC circuit. In the SLOW AGC position, C551 is connected across the plate and grid of V506A. By unsoldering the wire at pin 1 of V506A (which connects lug 8 of S107 and pin 1 of V506A) and resoldering it to a convenient nearby ground lug (pin 8 of V506), the SLOW attack time problem was mostly solved. But with this change the SLOW and MED attack and release times are identical. So a new capacitor C1 was inserted from lug 9 of S107 to ground (after removing the original ground connection). Now in the MED position C1 is in series with C551, which permits the MED release time to be adjusted to a smaller value than the SLOW release time.

I don't like modifying an R–390A mainframe as a matter of general principle. However, the addition of C1 does not prevent using an unmodified IF subchassis. The MED release time with an unmodified IF subchassis will not be as slow as with an unmodified mainframe, but that is hardly noticeable.

At this point in my experiments the SLOW release time was about 500 mS, but a slow release time of 2 S was desired. I tried adding additional capacitance in parallel with C551, but that caused a slower SLOW attack time (and the SLOW attack time was already too slow at about 10 mS). To make the SLOW release time slower without increasing the SLOW attack time, R547 was removed (leaving only the back pointing diode in place of R547). I learned the hard way that this diode <u>must</u> have a very high back resistance, and that 1N34A and 1N270 germanium diodes are not suitable. A 1N4148 or 1N914 is suitable because they have a reverse leakage current rating of 0.025 microamps at the maximum rated voltage of 75 volts, which works out to a back resistance of about 3000M ohms. Thus, the AGC capacitors are forced to discharge through the 1.77M ohm combined resistance of R201 and R234 (a voltage divider for the 6DC6 RF amplifier grid AGC voltage).

After R547 was removed the SLOW release time was too slow, about 3.7 S. To adjust the SLOW release time to about 2 S, C551 was replaced with C2. My final AGC mod is shown on the following simplified schematic. I used a scope to measure the release times, and confirmed that the release times can be calculated from the conventional $T = R \cdot C$ time constant formula (when R is in megohms and C is in μF, T is in seconds). So it is easy to select the values of C1, C2, and even C548 for whatever release times you desire. The time constant formulas are as follows: $T_{FAST} = 1.77 \cdot C548$, $T_{MED} = 1.77 \cdot \left(C548 + \frac{C1 \cdot C2}{C1 + C2}\right)$, and $T_{SLOW} = 1.77 \cdot (C548 + C2)$.

For unchanged C548 (= 0.1 μF), C1 = 0.47 μF, and C2 = 1.22 μF, the measured and computed release times were about 180 mS, 780 mS, and 2.3 S for FAST, MED, and SLOW respectively.

Replacing C551 by the smaller capacitance (1.22 μF) had the beneficial effect of speeding up the SLOW attack time to about 6 mS. The MED and FAST attack times were about 3 mS and 1 mS respectively. The SLOW attack time is not quite as fast as I wanted, but it is the best that can be done without more substantial modifications.

Like the Cornelius mod, my AGC mod increases AGC line voltage, which causes higher carrier level meter readings and reduces the signal levels at the diode detector, thus reducing audio output. The reduced audio output is not a problem because an R–390A has plenty of reserve audio gain. The increased carrier level meter readings should not be a problem for most R–390As. But if the meter pins on strong signals, there are two cures. Unsolder one of the meter leads and add one ohm resistors one at a time until the meter no longer pins on strong signals. The carrier level meter has a very low internal resistance, about 17.4 ohms nominal, so a small additional resistance will cause a large change in meter readings. The other cure is to replace R524 (680 ohms nominal) by a larger resistor. The best solution here is to add a 500 ohm, 2 watt, ten turn, wire wound resistor in series with R524. In effect, this adds a meter sensitivity adjustment. The reduced signal levels at the diode detector has the beneficial effect of reducing distortion on SSB and CW.

The improvement in SSB quality caused by reduced signal levels at the diode detector, the difficulty of converting an R–390A BFO circuit to a product detector, and the defects of add-on converters motivated me to examine the possibility of further improving the diode detector for SSB and CW. In his May 1956 *QST* article, "Reception with product detectors," Murray Crosby, W2CSY remarked that proper reception of SSB may be obtained with a diode detector provided the signal amplitude entering the diode detector is less than or equal to the BFO amplitude.

I added a 47 pF 500 volt mica capacitor in parallel with the 12 pF BFO injection capacitor C535, and was pleased that most of the residual SSB distortion was eliminated. But when I measured the signal and BFO amplitudes I was surprised that a 50 dB unmodulated RF signal produced a 4 volt peak signal at the diode detector, and that the BFO was already 12 volts peak with the 12 pF injection capacitor alone.

Wally Chambers, K5OP provided the answer to this perplexing situation. In the 49th (1972) and 54th (1977) editions of *The Radio Amateur's Handbook*, page 239, it is said that the BFO signal amplitude should be 5 to 20 times greater than the strongest SSB or CW signal at a diode detector if distortion is to be minimized. The addition of a 47 pF capacitor across C535 increased the BFO amplitude at the diode detector to about 25 volts peak, which makes the BFO amplitude about 6 times greater than a 50 dB unmodulated RF signal. There is apparently some room for additional improvement. Wally suggested that replacing R530, the 22K ohm BFO plate resistor, with a 12 mH choke might further increase the BFO output, but I have not tried that. The 22K ohm BFO plate resistor is a large 1 watt resistor which is difficult to remove, and there is not much space underneath or beside the BFO bellows coupler for a 12 mH choke.

For Capacitors C1 and C2 I used 250 volt mylar, radial leads. For a 1.22 μF capacitor I used a 1 μF capacitor and a 0.22 μF capacitor in parallel. I used 1N4148 diodes from a Radio Shack package marked 1N914.

To add C1 you will need to remove the R–390A front panel. Unsolder and remove the end of the insulated stranded wire, nominally white insulation, at pin 9 of S107. Clip one or more loops of cable lacing which secure the white wire to determine if the other end is connected to lug 1 of the LIMITER potentiometer R120. If so, the white wire may be removed completely. Tie the loose end(s) of the cable lacing. If desired or necessary, use new cable lacing to tie new loops where the old loops were removed. If the white wire does not terminate at pin 1 of R120, or if you do not want to remove the white wire, you can add a small insulated 4-40 standoff to the top screw of S107. If there are not enough screw threads to mount the insulated standoff securely, you will have to remove the nut and/or lock washer. And if the nut and screw threads are painted with varnish, you may have to remove S107 from the front panel to access the screw head. A hot soldering iron tip can be used to soften the varnish so that the nut can be removed without stripping the screw head or rounding off the nut (they are small and nominally brass).

R546 is usually connected to pin 1 or 2 of socket XV509 and to an insulated standoff. It is easy to add a diode across R546. The cathode lead of the diode can go to either pin 1 or pin 2 of XV509, and the anode lead of the diode goes to the insulated standoff.

R547 is usually connected to pin 2 of socket XV506 and to an insulated standoff. How easy it is to remove R547 depends on the order in which the other wires are mounted on the insulated standoff. You may have to temporarily remove other wires to access the R547 lead. Be careful uncrimping the lead of R547 at pin 2 of XV506. It is easy to break a tube socket lug. The cathode lead of the diode goes to the insulated standoff, the anode lead to pin 2 of XV506.

C551 is not removed from the IF subchassis, and one lug of C551 is used as a tie point. Remove C548. One end is usually connected to a ground lug beside XV509, the other end to one of the C551 lugs. Save C548 in case you want to undo my mod. Unsolder and remove the end of the insulated stranded wire, noninally white with blue and black tracers, attached to the same lug of C551 to which C548 was attached. Take a 4.5 inch length of insulated, stranded, tinned, #22 wire, strip 0.5 inch of insulation from one end, strip 1 inch of insulation from the other end, remove the solder from the lug of C551 to which C548 was <u>not</u> attached (this lug of C551 should have attached to it an insulated stranded wire which is nominally white with blue and red tracers), run the short stripped end of the stranded wire through this lug of C551, crimp it, and solder it. On the metal panel beside C551 there are two Phillips head screws which mount ground lugs in adjacent compartments. Remove the screws and reverse them. Mount two small insulated 4-40 standoffs on the screw ends. If there are not enough threads to securely mount the insulated standoffs, you will have to use longer screws. Mount C2 on the two insulated standoffs, attach the free end of the wire removed from C551 (white with blue and black tracers) to one standoff, add a 0.1 μF, 250 volt, mylar capacitor running from that same standoff to the ground lug from which C548 was removed (this 0.1 μF capacitor replaces C548), attach the free end of the new stranded wire added to the other lug of C551 to the other insulated standoff, and resolder or solder all remaining added or changed lugs.

To add a 47 pF capacitor across C535 you must remove the BFO PTO bellows coupler. The spline set screws in the bellows coupler are painted with varnish. To remove them without stripping the splines, use a 45 watt 900 degree soldering iron to soften the varnish. Apply the hot iron tip directly to a set screw for about 30 seconds, and then apply reasonable pressure with a spline wrench. If the set screw does not release with reasonable pressure, apply the hot iron tip again for about 30 seconds.

You may wonder why Collins did not design the R-390A AGC this way and save us all the trouble of modifying the AGC for fast attack and slow release. And why did they use the Miller effect circuit for the SLOW AGC circuit? After all, the Miller effect SLOW release circuit in an R-390A has the disadvantage of being slow (200 mS) attack. I learned what I believe is the answer quite by accident: reliable SLOW release.

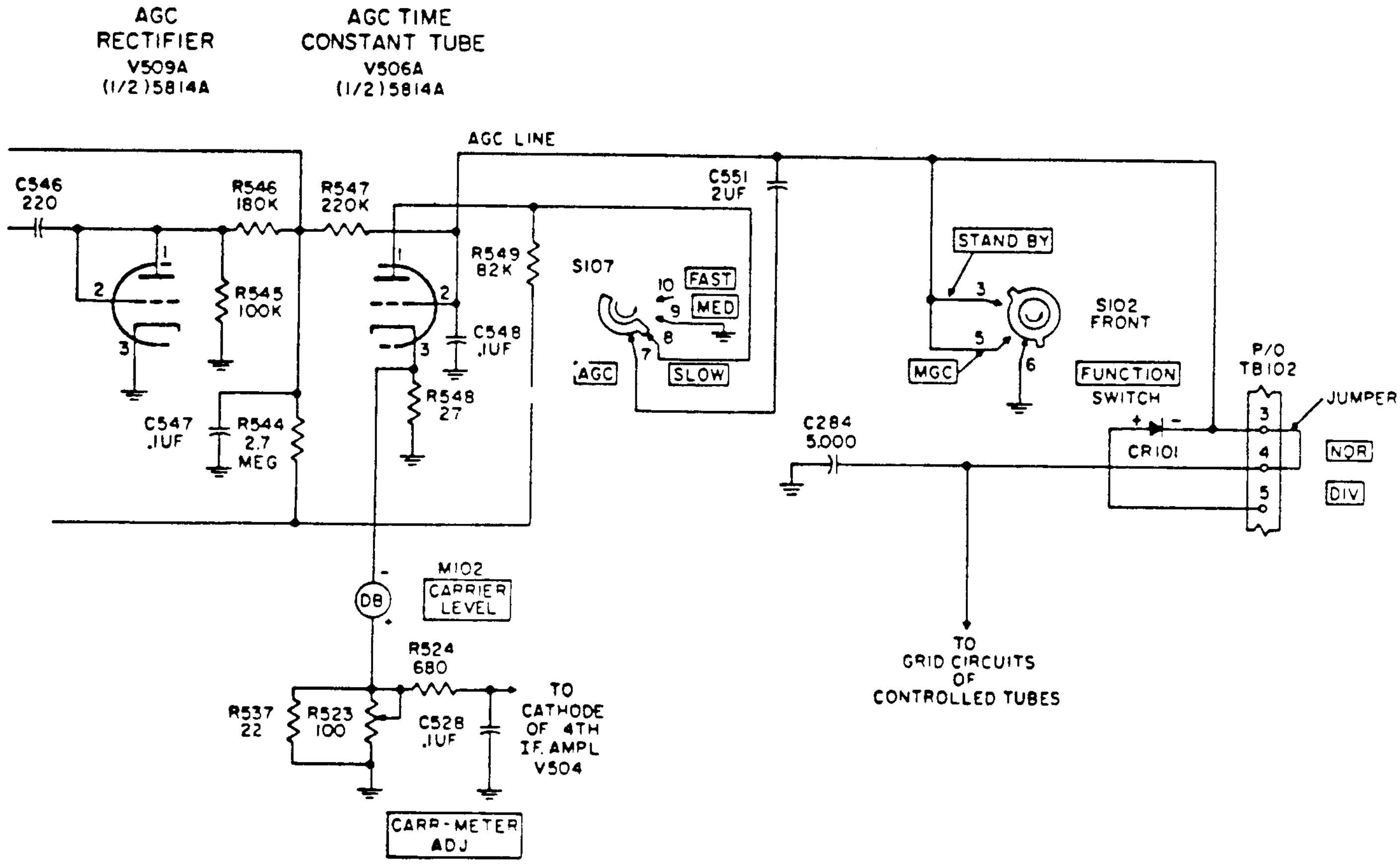
As I was developing my AGC mod, I discovered to my amazement that the SLOW release time got faster as the R-390A warmed up. I first noticed this effect by observing the carrier level meter. Did I imagine it? No. Scope measurements confirmed that the SLOW release time gradually decreased from about 2 S shortly after turn on from a cold start to about 500 milliseconds after 30 minutes. The cause was traced to a gassy 1st IF amplifier tube. It appears that Collins used the Miller effect SLOW AGC circuit because it is not effected significantly by gassy AGC controlled tubes.

That's the bad news. The good news is that it is relatively easy to determine if a gassy tube is degrading the SLOW release. Merely observe the carrier meter descent rate when you tune quickly away from a calibrator marker shortly after you turn on the R-390A from a cold start, and then observe the descent rate about 30 minutes later. If the descent rate is noticably faster, then one or more gassy tubes may be the cause. The most likely candidates are the 1st, 2nd, and 3rd IF amplifier tubes. One of these three tubes was gassy in two out of three IF subchassis I have modified. Naturally, these bad tubes tested good on a tube tester. The RF amplifier and three mixer tubes are also candidates, as well as the 4th IF amplifier, AGC amplifier, and perhaps the AGC time constant tubes.

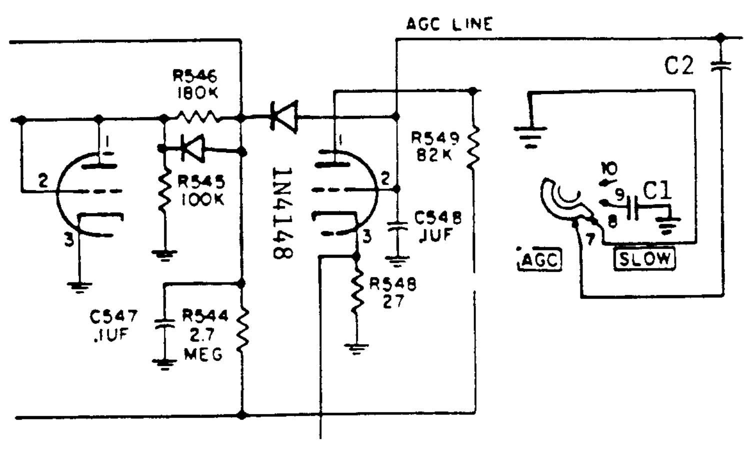
I was concerned that my AGC mod should not degrade the excellent AM performance of an unmodified R-390A. It does not. In two modified IF subchassis I included a 330K ohm resistor in series with the diode which replaced R547 and a switch across the resistor. In effect, this provided switched attack times, slow attack for AM and fast attack for SSB and CW. After considerable listening I have concluded that there is little benefit to switched attack times. A few listeners, like me, may hear a small amount of very low frequency (below 50 Hz) audio distortion on AM signals using the FAST AGC speed with fast attack with the 455 KHz IF output feeding an AM synchronous detector followed by a hi fi amplifier. But most listeners will not notice any difference between fast and slow attack. If you have no interest in SSB or CW, there is hardly any reason for you to do my mod because it does not improve AM performance. Of course, with the original R-390A AGC it is annoying that the carrier meter pins for several seconds when switching between SLOW and MED. That does not happen with my mod.

I would like to express my appreciation to Wally Chambers, K5OP for sharing his experiences modifying R-390A AGCs, and for discussing many of the ideas in these mods.

R–390A AGC Circuit Before Modification



After Modification



NOTE: In some IFs, especially EACs, it will be virtually impossible to do this mod beacuse of wiring layout. In that case, leave C551 as is, and insert a 2 mF or 2.2 mF, 250 volt mylar capacitor between pin 8 of S107 and ground (instead of grounding pin 8). The attack and release times are almost exactly as with the more complex nod.