R-390/R-390A AGC - Ending The Moment Of Silence
The Way They Should Have Done It
By David Wise

Ending The Moment Of Silence Easy front-panel wiring change involving a new terminal strip, a couple caps and resistors, and a new AGC switch.

- No more silence or blasting.
- No side effects.
- Compatible with all IF decks, no deck changes needed.
- Can be done on the R-390 but not quite as neat mechanically.

PRINCIPLES

Collins designed three AGC rates into the R-390, and carried the circuit forward to the R-390A with no change. FAST is a couple of 0.1uF caps, for a time constant of about 0.015 second. MED is a 2uF cap, which gives you about 0.5 second. SLOW multiplies the 2uF cap by about 15* by stringing it across a triode, from plate to grid. Any time the grid moves, the plate moves in the opposite direction about 14 times as much. With 15 times as much charge moving through the cap, to the AGC bus it looks 15 times as big.

* Please understand that due to the nonlinear transfer characteristic of V506, this number is approximate.

This is the next-cheapest possible way to get the SLOW time constant. Since the R-390 IF and RF amplifiers do not load the AGC bus, they could have simply switched in a big series resistor. Either grid current was a concern, the Carrier meter created a compelling argument for the time constant tube, or they anticipated the R-390A's RF deck voltage divider, R201 and R234.

ORIGINAL DESIGN (Figure 1)

Refer to Figure 1, an IF deck schematic excerpt from the Y2K Manual. The cap, C551, has one end connected to V506A's grid, which is also the AGC bus. The other end goes out to S107's rotor on the front panel. There, the MED position grounds it while the SLOW position routes it back to V506A's plate. The plate goes to B+ 205V through R549 (82k).

When the grid is at 0V (no signal), V506A conducts about 2mA of plate current, pulling the plate down to about 27V. At -20V AGC, the tube is cut off and the plate is at +205.

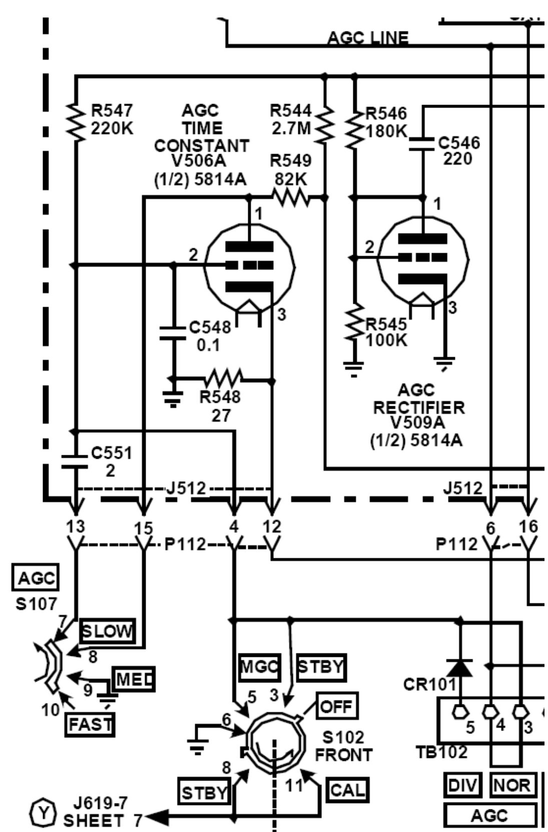


Figure 1

THE PROBLEM

The grid end of C551 is on the AGC bus. At MEDium speed, the other end is grounded. In SLOW, however, the other end is anywhere from +27 to +205. Obviously the cap has to charge up to get there, by dumping [conventional] current onto the AGC bus, which forces it positive and causes a huge signal overload. I call this the "Blast".

If not for two ameliorating factors*, it would last 15 times as long as the MOS because of the multiplication effect.

* First, until V506A gets out of saturation, its grid is driven positive, draws current, and charges the cap more quickly. Second, R545 is bypassed by the AGC rectifier. (IF decks with the Lankford AGC mod will be even faster, limited by the rectifier's effective impedance of around 7k.)

Now switch back to MED. The non-grid end of C551 instantly goes from a large positive voltage (+27 to +205) to ground, which forces the AGC bus negative by the same amount. We're talking up to -200V or ten times max. Every tube cuts off hard until this charge drains away. This is the well-known "Moment of Silence".

These effects are intrinsic to the dual use of C551. In MED, it has X volts, while SLOW gives it 10*X. While switching circuitry could force the cap to the correct charge level as the switch moved between detents, it would be quite complex and utterly out of the question.

IDEA THE FIRST

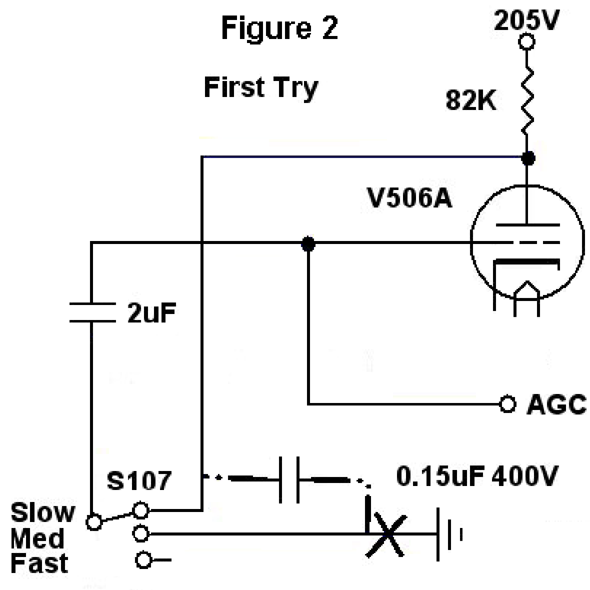
The only feasible solution is to use separate caps for MED and SLOW.

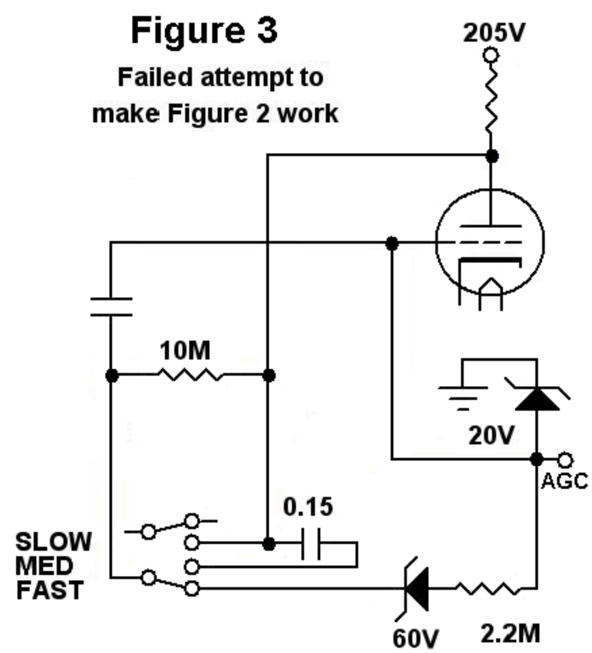
The brute-force approach is to add a second 2uF cap, and use one for MED and the other for SLOW. However, C551 is a big, expensive cap, and Collins would not have sprung for a second one, even on a Government contract.

IDEA THE SECOND

And rightly so, it's not necessary. We could use V506A for MED as well as SLOW, multiplying a small cap to get the old 2uF time constant.

My first try was beautifully simple. In MED, instead of grounding C551, hook a small cap in series, which requires nothing more than that you remove the ground wire from S107, and substitute a cap. The other end goes to the SLOW contact, and ground is not used. In SLOW, there is no change. In MED, we go from plate, through a small cap, then through C551, to grid. The small cap is sized to give medium speed when closed-loop. Since it's much smaller than C551, the latter won't affect the total much, so we just divide 2uF by 15 and round to the nearest standard value: 0.15uF. I scoped AGC attack and decay during step changes of signal level, and they are indistinguishable from the stock arrangement. This mod is documented in Figure 2.





I should mention that when you switch to MED, you may get a small dip or surge, a Blast or MOS in miniature, at most 7% (1/15) of the real thing. This is the only thing that went right.

NOT SO FAST

This works as advertised - until you meet the real world. There is a huge bug lurking. Let's say you've been listening to BBC at +60dB. Your "favourite programme" ends, and you go hunting, switching to FAST so as not to miss anything while you scan. Down in the mud you hear something, but it's fluttery. You switch back to SLOW to smooth it out --- and all goes silent. It's the Moment all over again, but it goes on and on. Finally, after maybe ten seconds you can hear again, and your quarry's gone off the air. What happened? When you were on BBC, C551 was sitting at about -10 on the grid and about +100 on the plate. When you went FAST, it was disconnected. Since you have conscientiously installed a nice new cap, it holds its charge. Your new signal is very weak. You go back to SLOW, and Pow! the stored charge slams the AGC bus right back to -10. Not only that, you're on the SLOW time constant, so it takes 15 times as long to get back to equilibrium.

It works the other way too. Let's say, instead of going to a program you don't like, BBC went off the air. You sit mulling over what you've heard, until the static comes up. You go to FAST, hit another good powerhouse, and go back to SLOW so the Debussy doesn't get clobbered by the fades. *Blast* goes the audio as you endure seconds of overload. It's shorter than usual (C551 starts at +27V instead of 0), but still -- we were trying to eradicate this nonsense, weren't we? We've just made it better some ways, worse others, and unpredictable to boot.

IT'S SUPPOSED TO BE AUTOMATIC BUT ACTUALLY YOU HAVE TO PRESS THIS BUTTON

I tried a couple of embellishments on this mod. I was reluctant to give it up outright, because as far as I can see it is very much the simplest possible mod. The problem is charge storage on C551. First I tried to gradually leak it off to the right value with a bleed resistor. This was doomed, because if you make the R-C551 time constant less than about 20 seconds (and you must, if it's to be useful), there is a noticeable AGC offset until the cap reaches equilibrium.

Then I added a zener diode to limit the stored charge (connected to the FAST terminal so it wouldn't disturb MED or SLOW operation), but it only works in certain ranges of signal level and sometimes only if you switch speeds at certain narrowly-defined intervals, and also was getting to be a kluge, see Figure 3. I even entertained a "Dump AGC" button. I was out of the sweet spot, to put it mildly.

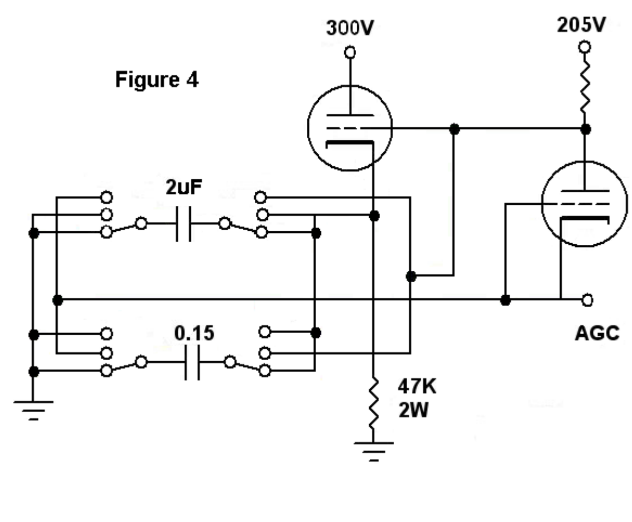
EXODUS

At this point I concluded that I had exhausted the possibilities of the existing C551. It's that darn grid connection in the IF deck. As long as C551 is shackled to the AGC bus, you can't manage its charge without also distorting the AGC. I mentally threw out all constraints and started sketching, just to see where it would take me.

A NEW HOPE

The first sketch is reproduced in Figure 4. It uses a 4-pole switch for maximum flexibility. The big idea here is that when a cap is not being used for AGC, we hold it at the same potential it would have if it were.

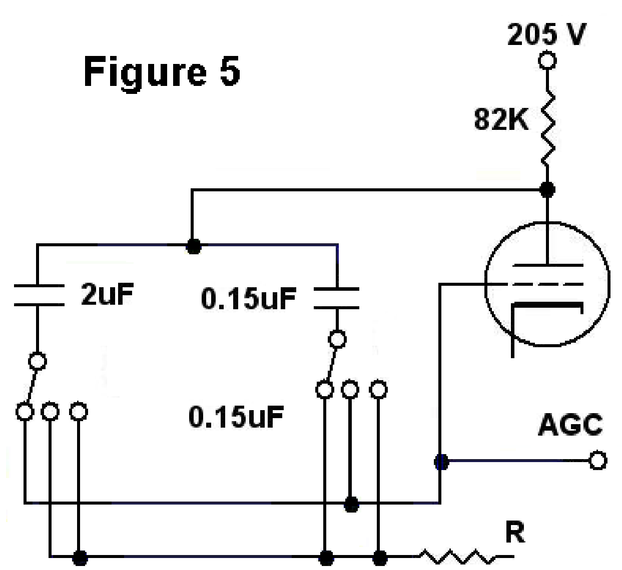
That way, when we switch it in, there's no bump. A new cathode follower (don't panic, this is a gedankenexperiment) isolates the unused cap from the V506A plate to eliminate all chance of interaction.



Even so, we only partly achieve the ideal. To go all the way, we'd need a second cathode follower plus a regulated negative supply, to isolate the grid end of the caps from the AGC bus. As it is, we get a compromise. The cathode follower output is maybe five volts above its grid, so when the AGC is around five volts, we're perfect. We're never more than 15 volts off, which causes a short, mild, fairly innocuous correction because it's divided by 15.

THE REAL DEAL

Of course, adding a cathode follower is out of the question. In fact, any kind of follower, because we don't have a supply higher than +205. Yes, there is one on the audio deck, but I wasn't about to route it to where I would use it. Too much of a kluge, again. I took another leap of faith and erased it. Since the high ends of the caps were now permanently connected to V506A's plate, I could throw out two switch poles. Getting warm, but what about interaction?



The worst case is MED, where my 0.15uF cap is active and C551 is on standby. Picture a step change in signal. At V506, the grid and plate voltages, formerly steady, would abruptly start to rise or fall. At medium speed, the design time constant is about 0.5 second. Hang a 2uF cap off the plate, it will try to hold the plate steady, which reduces the feedback effect and therefore the effective capacitance. Add capacitor, it speeds up: not exactly intuitive.

Could I use a resistor to isolate the standby cap, and still get what I wanted? I wired it up as in Figure 5. As expected, R=0 threw the medium time constant way off. As I increased it the TC came back to normal. At 470k, I couldn't see any effect, so I sat back and took stock. The V506A plate load is 82k, but the impedance seen by C551 is 82k in parallel with the tube's plate resistance, which is only about 20k. The 470k isolation resistor is more than 20 times that, confirming my observation of no significant interference. What about the standby cap? If it's 2uF, it's on about a one-second time constant, in other words, if the signal holds constant for five seconds, we're right on. That's perfectly reasonable. Any time C551 is out of equilibrium, the charge or discharge current offsets the plate voltage, but the effect on the grid is tiny. The plate offset was small (15/485), and it's divided further by the tube gain. The 0.5-second MED time constant cuts it even further. By George, I think we've got it!

REVIEW

In SLOW, we have C551 from plate to grid same as usual, plus a 470k - 0.15uF series combo to ground. The latter keeps up handily without causing trouble.

In MED, we have the 0.15 from plate to grid, plus a 470k - 2uF series combo to ground. The latter is an acceptable five seconds behind, and adds less than 0.3% AGC offset which decays over a period of about five seconds, in other words, you can't see it outside the lab. Heck, I couldn't see it *inside* the lab, I'm predicting it mathematically. It also affects the meter ballistics slightly, eyeballed at about 5% overshoot on a step change. Again, it's undetectable against a real-world signal.

In FAST, both caps are on standby. V506A is open-loop, so this only affects the meter ballistics. When we go back to MED, the 0.15uF cap goes active, highlighting a small problem.

It was directly in parallel with C551 and therefore five seconds behind. If we rearrange the 470k resistor slightly, FAST will connect the 0.15uF cap straight to ground. This also allows you to use one of the switch terminals as a tie point. The incremental ballistic effect is small and in my opinion quite worth the convenience. You could also use two separate resistors, but you need a tie point.

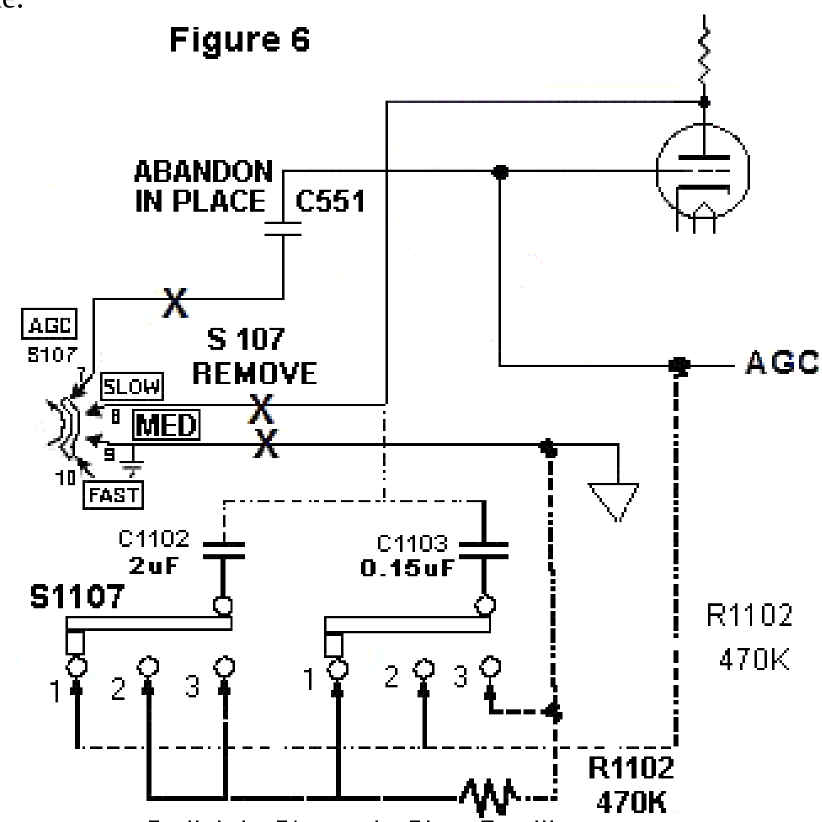
On switching FAST-MED, MED-SLOW, and SLOW-MED, the cap being brought online has a potential equal to V506A's plate voltage. If there is enough signal to generate AGC voltage, it is not part of the cap's potential, and the AGC bus will experience a positive step. It's very small, because the error is inside the feedback loop and gets divided by the tube gain. For example, with a 16V error, the grid (i.e., the AGC bus) goes up 1V and the plate goes down 15.

ONE LAST THING

This is how Collins should have done it. The cost delta would have been: one resistor, 2-pole vs 1-pole switch and one additional 0.15uF 400V Vitamin Q cap

I am not a genius. All I can figure is, the engineer assigned this task was mediocre, inexperienced, unimaginative, or just pressed for time.

Figure 6



Switch Is Shown In Slow Position

I changed S107 on the front panel. I was loath to also modify the IF deck, but the only way to avoid it is to abandon C551 and add my own 2uF cap on the front panel.

In Figure 6 I call it C1102 (C551, version 2). Provided we can find a place for it, we have a viable mod.

FITTING IT IN

Where to put our new caps? Since we're already replacing S107, the open space between it and the ANT TRIM shaft is a prime candidate. How much space do we need? The DigiKey catalog lists six different 2.0 or 2.2/400 caps. They're all less than 2" x 1-1/4" x 1-1/4".

If we elevate a cap this size to where it doesn't quite graze the tallest nearby gear, it squeezes in under the top cover (if used). Let's mount it on a terminal strip. Then C1103 can go on the back side and hang upside-down in front of the gear. To avoid gluing or drilling the panel, we can mount the terminal strip to a flat sheet-metal bracket anchored under the terminal board mounting bracket.

PARTS LIST

Piece of 22ga sheet steel, 1" by 2-1/4".

Terminal strip, Radio Shack #274-688 (5-lug) or similar

470k resistor

0.15uF/400V capacitor, NTE MLR154K630 or similar*

2.0uF/400V capacitor, NTE MLR205K400 or similar**

2-pole 3-position rotary switch

A couple feet of wire

* It only needs to be 400V, but with NTE, the 630V model has more convenient lead spacing.
** 2.2uF is fine too; there are six available from DigiKey, they're all small enough, and several are cheaper.

TOOLS

Vise & hacksaw	Sandpaper	Drill
#1 Philips	#2 Philips	Dikes, stripper, soldering iron

ASSEMBLY (Figures 7 and 8)

Take your sheet metal, drill a 1/8" hole 1/2" from one end, and sand the other half bright. This is our mounting bracket.

Solder the terminal strip mounting lug to the bracket, exactly 1-1/2" from the hole, with the strip facing away from it. See Figure 7.

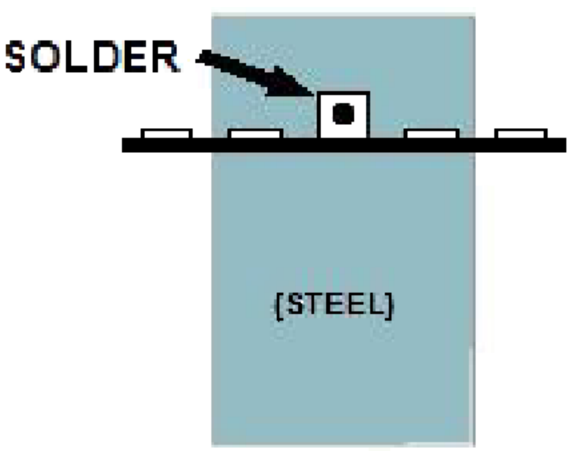
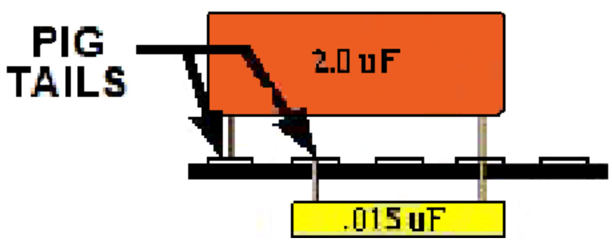


Figure 7



Solder C1102 (2uF) on the "normal" side, and C1103 (0.15uF) on the back. Lug 1 is C1102, 2 is C1103, 3 is unused, 4 is common to both caps. Also wire 4 to 5.

Figure 8

Solder 4" pigtails to lugs 1 and 2. They will go to the A and B rotors on S1107. The wire from the S107 SLOW contact (V506A plate, white with green and orange traces in my radio) will go to lug 5

Drop the front panel and solder a 6" pigtail to the MGC/STBY contacts on the S102 FUNCTION switch (front wafer, two adjacent contacts wired together). Route this wire, AGC, up near S107 and temporarily tape it down. Replace the front panel.

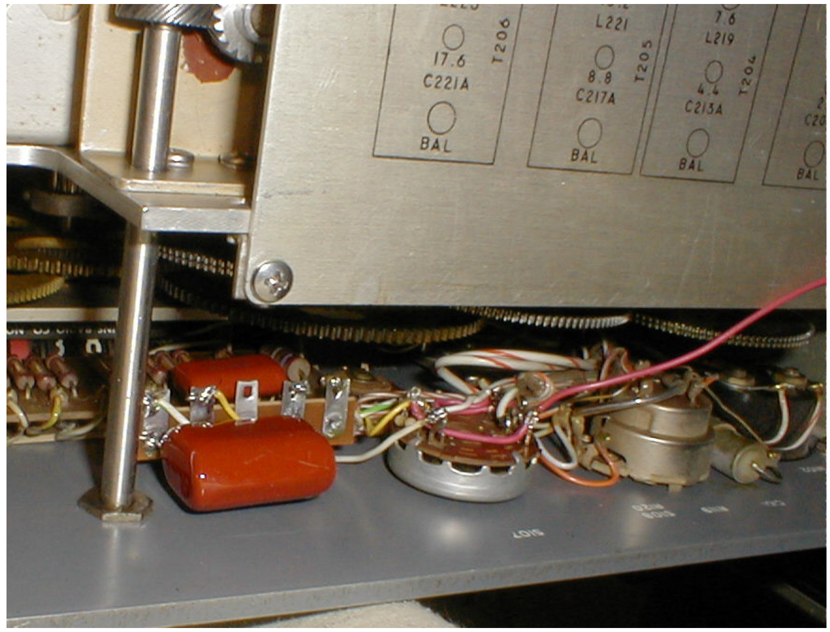
Remove the nameplate, exposing the Terminal Board screws. Loosen the left-hand one, remove the right, slide our bracket under the TB bracket, and replace the screw, through our bracket. Tighten them up, and replace the nameplate.

Disconnect the wires on S107.

The one on the rotor is C551. Tape it off, you won't use it.

The one on the SLOW contact is Plate, solder it to terminal strip lug 5.

The MED contact is Ground, it will go to S1107. Remove and archive S107.



With S1107 on the bench, connect together contacts A1 and B2. Connect together A2, A3, and B1. Solder R1107 (470k) between B1 and B3.

With S1107 behind the front panel, solder the terminal strip #1 pigtail to the A rotor, the #2 pigtail to the B rotor, the AGC pigtail to A1/B2, and the Ground wire to B3. Slip it into the mounting hole, bolt it down, and you're done.

THE R-390

Electrically, the mod can be applied with no value changes. Since the time constant tube has a smaller plate load (56k vs 82k), the meter overshoot will be slightly less. The main issue is where to fit the terminal strip. Not having an R-390, I can't try it myself. It can't go to the left of the AGC switch, the terminal board is there. It would be convenient if it could go below the TB, between it and the frequency readout. There are probably other nooks it could be fit into, although the wires would be longer.

Note: I didn't drop the front panel; the red wire snakes back to the rear panel to the AGC terminal.