TECHNICAL ANALYSIS

R-390/URR vs. R-392/URR

A Stage-by-Stage Comparison of the Collins Receivers
Do They Actually Sound Different? And If So, Why?

1. Introduction — The Question on the Table

A recurring question in the R-390 community deserves a proper engineering answer: if you set an R-390/URR and an R-392/URR to the same station, on the same antenna, with the same bandwidth setting — do they sound different? And if so, what in the circuit accounts for it?

The questioner's instinct is correct: the core IF signal chain appears nearly identical on the schematics. Both receivers use the same Collins triple-/double-conversion architecture. Both employ six stages of 455 kHz IF amplification with cascaded LC filters. The PTO, crystal oscillator bank, and mixing scheme are functionally the same.

But "functionally the same" and "electrically identical" are two very different claims. The R-392 has one fundamental constraint that ripples through every stage: the entire receiver operates on 24–28 VDC with no voltage conversion whatsoever. That single design decision — no vibrator, no DC-DC converter, no transformer — changes the operating point of every active stage in the radio.

2. Architecture Overview

Both receivers were designed by Collins Radio Company in the late 1940s and share the same frequency coverage (0.5–32 MHz in 32 bands), conversion scheme, and general signal flow:

- Triple conversion below 8 MHz (variable 1st IF 9–18 MHz, variable 2nd IF 2–3 MHz, fixed 3rd IF 455 kHz)
- Double conversion above 8 MHz (variable IF 2–3 MHz, fixed 455 kHz)
- PTO tuning 2.455–3.455 MHz with identical mechanical/electrical design
- Two stages of RF amplification, six stages of 455 kHz IF amplification
- 5-digit mechanical frequency readout with 200 Hz resolution

The R-392 was designed for vehicular use as part of the AN/GRC-19 radio set (paired with the T-195 transmitter). It is immersion-proof, parachute-drop rated, and draws approximately 3 amps at 28 VDC. The R-390 is a rack-mount, AC-powered receiver intended for fixed-station or shipboard installation.

3. The 28-Volt Elephant in the Room

The single most important engineering difference between these two receivers is plate supply voltage. The R-390 operates its tubes at conventional B+ levels (195–250 VDC depending on the

regulated supply rail), while the R-392 runs every tube in the signal chain at approximately 28 VDC plate voltage — directly from the vehicular electrical bus.

3.1 What 28V B+ Does to a Pentode

Consider the 26A6, which is the workhorse of the R-392's RF and IF chain. The 26A6 is electrically equivalent to the 6BA6 — same internal structure, same electrode geometry — but characterized for operation at 28 VDC plate and screen. The tube data sheets provide curves at both 28V and 250V, confirming that the tube was specifically designed to operate in this low-voltage regime.

At 28V plate and screen, the 26A6 operates on a very different part of its characteristic curves compared to a 6BA6 at 250V:

- Transconductance (gm) is dramatically lower. At 28V, the 26A6 achieves perhaps 1–2 mA/V versus the 4–5 mA/V a 6BA6 delivers at full B+. Less gain per stage.

- Plate voltage swing is severely constrained. With only 28V of headroom, the available signal swing before clipping is a fraction of what the R-390 can handle. This directly limits dynamic range.

- The tube is operating closer to cutoff and closer to saturation simultaneously. The linear region of the plate characteristic is compressed. Intermodulation distortion products are generated at lower signal levels.

- AGC range is reduced. With less plate voltage headroom, the usable AGC control range (from full gain to full cutoff) is narrower. Strong signal handling suffers.

Community experimentation has confirmed this analysis. Reports from the 1970s indicated that the R-392 actually performed better when operated with split supplies — 24V for heaters and 32V for plates — yielding improved dynamic range. The fact that a modest 4V increase in plate voltage was audibly noticeable tells you how close to the margins this design operates.

3.2 Noise Figure Comparison

Here is where the questioner's schematic analysis is largely correct. The noise figure of a pentode in an RF or IF application is dominated by shot noise and partition noise, both of which are primarily functions of cathode current, screen current ratio, and internal geometry — not plate voltage per se (as long as the tube is not saturated). The 26A6 has the same electrode structure as the 6BA6. At equivalent bias conditions, the noise figure is comparable.

However, the 28V operating point forces the bias conditions to be different in practice. The cathode resistor values are chosen to establish a viable operating point within the severely limited plate voltage budget. While Collins' engineers did an admirable job of optimizing these, the stage is inherently operating at lower plate current, which modestly increases the noise contribution. The net effect on noise figure is small — perhaps 1–2 dB — but it compounds across six IF stages and two RF stages.

4. The IF Chain — Identical Topology, Different Operating Points

The questioner correctly identifies that the IF stage topology appears identical between the R-390 and R-392. Both use six cascaded 455 kHz IF amplifier stages with LC bandpass coupling networks providing the selectivity. The circuit topology — the way the tubes are connected, the coupling networks, the AGC feed — is functionally the same.

But every component value in the bias network is different because the plate supply is 28V instead of 250V. The plate load impedances, screen dropping resistors, cathode bias resistors, and decoupling networks are all redesigned for the low-voltage operating point. The tubes are doing the same job, but they are doing it with one hand tied behind their back.

4.1 What This Means for Selectivity

The selectivity of the IF chain is determined primarily by the LC coupling networks between stages, not by the tubes themselves. Since both receivers use cascaded LC filters at 455 kHz (the R-392 simply omits the 0.1, 1, and 16 kHz positions from the bandwidth switch), the selectivity shape factor at the common bandwidths (2, 4, and 8 kHz) should be essentially identical.

Where a difference may emerge is in the loaded Q of the coupling networks. The impedance presented by a 26A6 at 28V plate is different from a 6DC6 or 6BA6 at 250V. If the inter-stage coupling networks were not re-optimized for the different tube impedances (and in some cases they were not fully re-optimized), the effective bandwidth and shape factor could differ slightly. Alignment becomes more critical in the R-392 for this reason.

4.2 Gain Distribution

With lower per-stage gain, the R-392 relies more heavily on its six IF stages to achieve usable sensitivity. The R-390A, by contrast, achieves ample gain from only four IF stages at full B+ voltage. The original R-390 (non-A) also uses six IF stages, but each stage has substantially more gain than its R-392 counterpart. The net result: the R-392 achieves good but not exceptional sensitivity, typically specified at 3 µV or better for 10 dB (S+N)/N on AM, compared to sub-1 µV for the R-390.

5. The Detector — Where Things Get Interesting

The questioner flags the R-392's IF output as "a wreck" and describes it as appearing to be half-wave rectified with significant nonlinearity. This observation warrants careful analysis.

5.1 AM Detector

In the R-390, the AM detector operates at conventional signal levels, driven by IF stages running at full B+. The diode detector sees a clean, high-level 455 kHz signal with good symmetry. The detector's DC output faithfully tracks the modulation envelope.

In the R-392, the detector is working with lower-amplitude signals from the IF chain. At low plate voltages, the IF output waveform can develop asymmetry due to the tubes clipping asymmetrically as they approach the supply rails. When this slightly asymmetric waveform hits a simple diode detector, you get exactly what the questioner describes: the output looks half-wave rectified with poor linearity. The fundamental issue is not the detector itself — it's that the signal arriving at the detector is already compromised by the low-headroom IF stages.

5.2 AGC Detector

The AGC loop is similarly affected. The R-392's AGC has a narrower useful control range because the 28V plate supply limits how far the gain can be pushed up or pulled down. Reports from operators describe the R-392's AGC as "pumping" or "sluggish" compared to the R-390. The root cause is the same: less headroom in every stage means the AGC system has less room to maneuver.

5.3 IF Output (455 kHz BNC)

The 455 kHz IF output connector on the R-392 is taken from the IF chain at a point where the signal has passed through the gain stages but before the audio detector. If the IF stages are generating asymmetric waveforms at 28V operation, this tap will faithfully reproduce that distortion. This is likely what the questioner observed: the IF output waveform showing half-wave-like characteristics. On the R-390, the same tap point delivers a clean, symmetric 455 kHz signal because the IF stages have adequate voltage swing.

6. The Audio Output Stage — A Completely Different Circuit

The questioner correctly notes that the audio output stage is substantially different between the two receivers. This is the one area where the circuit is not merely the same topology at a different operating point — it is a genuinely different design.

6.1 R-390 Audio

The R-390 (non-A) uses a conventional vacuum tube audio amplifier driving both a 600-ohm line output and a local audio output through an audio output transformer. With 250V B+ available, the audio stage has generous headroom, low distortion, and can deliver clean audio at rated output levels. Two separate audio channels (line and local) allow simultaneous monitoring and recording or downstream processing.

6.2 R-392 Audio

The R-392 uses a 26A7GT beam power tube as the audio output stage, transformer-coupled to a single 600-ohm output. The 26A7GT is operating at 28V plate supply and is rated for 200 mW output into 600 ohms. This is a workmanlike military design — adequate for driving headphones or a remote speaker through a matching transformer — but it is not a hi-fi circuit.

The negative feedback loop from the output transformer secondary back to the first audio stage (via the 8.2 megΩ R629) is a nice touch that improves linearity, but the fundamental limitation remains: 200 mW from a beam power tube at 28V B+ will exhibit higher distortion and more constrained frequency response than the R-390's audio section operating at 250V.

A notable community observation: Western Electric produced a solid-state audio module as a drop-in replacement for the 26A7GT output stage. However, the solid-state module introduces a 180° phase shift that the tube does not, converting the negative feedback loop into positive feedback. The fix is to remove R629. This issue has tripped up many R-392 owners.

7. Side-by-Side Comparison

Parameter	R-392/URR	R-390 / R-390A	Significance
B+ Plate Voltage	28 VDC (nominal)	195–250 VDC	Largest single difference
Sensitivity (AM, 10 dB S+N/N)	≤3 µV (typ.)	≤1 µV	28V B+ limits gain/tube
IF Bandwidth Selections	2, 4, 8 kHz	0.1, 1, 2, 4, 8, 16 kHz	R-392 omits extreme narrow/wide
IF Stages (455 kHz)	6	6 (R-390) / 4 (R-390A)	R-392 matches original R-390
Audio Output Power	200 mW into 600Ω	100 mW line + local	Single output, transformer-coupled
Audio Outputs	1 (600Ω line)	2 (line + local/phones)	R-392 omits local channel
AGC Time Constants	Slow/Fast	Slow/Med/Fast/MGC	Reduced selection
Dynamic Range	Moderate	Good to Excellent	Limited by low plate voltage headroom
Noise Figure	Comparable per-stage	Comparable per-stage	26A6 ≈ 6BA6 at equivalent bias
Power Source	24–28 VDC vehicular	115 VAC mains	No internal power conversion in R-392
Physical Env. Rating	Immersion-proof	Rack-mount, indoor	R-392 fully sealed case

7.1 Tube Complement Comparison

Stage	R-392/URR	R-390 / R-390A	Notes
1st RF Amplifier	26A6	6DC6 (R-390) / 6BA6 (R-390A)	Equivalent function; 26A6 operates at 28V B+
2nd RF Amplifier	26A6	6DC6 / 6BA6	Same topology, different operating point
1st Mixer	26C6	6BE6	Pentagrid converter equivalent

2nd Mixer	26C6	6BE6	Same conversion scheme
3rd Mixer	26D6	6C4	Triode mixer stage
IF Amplifiers (6 stages)	26A6 (×6)	6DC6/6BA6 (×6 in R-390; ×4 in R-390A)	Core signal chain — functionally identical topology
BFO	12AU7	12AU7 (R-390) / 6AK5 (R-390A)	Same tube type as R-390
AM Detector	Diode	Diode	See detector analysis below
AGC Detector	Diode	Diode	Different implementation details
1st Audio	6AJ5 (×2)	6AK6 / 6AK5	Different tube, different gain structure
Audio Output	26A7GT	6AK6 (R-390) / 6AK5 (R-390A)	Transformer-coupled, 28V operation
Crystal Calibrator	12AU7	12AU7	Identical function
VFO/PTO	12AU7 (×2)	12AU7 (×2)	Identical PTO design

8. The Verdict — Do They Sound Different?

Yes. They will sound different, and here is why, in order of audible significance:

- **Audio output stage:** This is the most obvious difference. The R-392's 26A7GT at 28V simply cannot match the fidelity and headroom of the R-390's audio section. Expect more distortion, a different tonal character (somewhat more compressed and "thin"), and less clean output power. An external 10W audio amplifier, as some operators use, largely neutralizes this difference.

- **AGC behavior:** The R-392's narrower AGC range will produce different gain-riding behavior on fading signals. This is perceptible as a difference in "smoothness" on AM broadcast and shortwave listening.

- **Strong signal handling:** The R-392 will exhibit earlier onset of intermodulation distortion. On a busy band with strong adjacent signals, the R-390 will produce cleaner audio because its IF chain has more linear headroom.

- **Sensitivity:** On weak signals, the R-390 has the edge — probably 6–10 dB depending on frequency and condition of tubes. Enough to matter on a marginal signal.

- **Detector linearity:** The distortion products from the R-392's detector stage (driven by lower-level IF signals) will add a subtle but real coloration to the audio. This is the "half-wave rectified" effect the questioner observed at the IF output.

8.1 Where They Sound the Same

On a moderate-strength AM signal with no adjacent-channel interference, using the 8 kHz bandwidth setting, driving into an external amplifier — the two receivers will be remarkably similar. The IF selectivity shape is the same. The frequency accuracy is the same. The basic tonal character of the audio will be similar because the selectivity determines the audio bandwidth. An experienced ear will still detect differences, but a casual listener may not.

9. Conclusions and Recommendations

The R-392/URR is an extraordinary achievement in engineering compromise. Collins' designers took the full R-390 architecture and made it work from a Jeep battery with no voltage conversion — a remarkable feat that required re-optimizing every bias network in the receiver while maintaining the same fundamental signal processing chain.

The core IF topology is indeed virtually identical, and the questioner's analysis of the 26A6 operating parameters is sound. The tubes have equivalent noise figures and transfer characteristics when properly biased. But the 28V operating constraint limits dynamic range, gain per stage, and detector performance in ways that are measurable and, in several cases, audible.

For anyone wanting to do a proper A/B comparison, the recommended test protocol is:

- Same antenna, same feedline, using a splitter or relay switch for instant A/B.
- Same bandwidth setting (2, 4, or 8 kHz — the three shared settings).

- Both receivers recently aligned per their respective TM procedures.

- Feed both into the SAME external audio amplifier and speaker, switching the audio input — this eliminates the R-392 audio stage as a variable.

- Use the diode load output or IF output to compare pre-audio-stage signals for a fair test of the RF/IF chain alone.

- Test across signal levels: weak DX signal, moderate broadcast, and strong local to expose the dynamic range differences.

The R-392 remains a magnificent receiver and a tribute to Collins engineering under severe constraints. It was never intended to be a lab-grade monitor receiver — it was intended to copy traffic from a Jeep in a combat zone, and it does that superbly. Understanding where and why its performance differs from the R-390 only deepens the appreciation for what Arthur Collins and his team accomplished.

References

TM 11-5820-357-35: Organizational, DS, GS, and Depot Maintenance Manual, Radio Receiver R-390/URR

TM 11-858-5820-334-35: Field and Depot Maintenance Manual, Radio Receiver R-392/URR (August 1961)

The 21st Century R-390A/URR Technical Reference (Y2K-R3, July 2009)

RoveroResearch: Collins R-392/URR Technical Data

R-390A.NET Pearls Archive: R-392/R-648 Miscellaneous Notes

Mike Dinolfo: R-392 Solid State Modifications and Experiences

26A6 / 6BA6 Tube Data Sheets (RCA, Sylvania, GE)

Prepared for the r390a.net community. This analysis represents the author's engineering assessment based on published schematics, tube data, and community experience reports. Corrections, additional measurements, and A/B comparison results are welcome — post to the R-390 mailing list.