

Safety Issues Attendant to Restoration and Use of Radios Using Series String Filaments

This document does not provide any troubleshooting advice; it is limited to issues of safety.

Brief History

In the early days of radio, most vacuum tubes were intended to be operated using battery power. By the 1920s, many radios were AC operated using transformers and tubes that had 1.5, 2.5 or 5V filaments. In 1933, many new tubes with 6.3V 0.3A filaments were released as well as the types 25Z5 and 43. Each of these tubes had 25V filaments and also required 0.3A of current. In 1931, the first large scale production of electrolytic capacitors began by Cornell-Dubilier. The availability of those tubes and electrolytic capacitors made possible the first small inexpensive radios without power transformers; the tube filaments could be connected in series. Many such radios were manufactured during the depression and survive today.

However, the typical complement of tube filament voltages required did not add up to the line voltage; this required a series dropping resistor. Many radios used ballast tubes to dissipate the necessary energy, but they were bulky and were a major heat source. It was also common practice to include the necessary series resistance distributed in the line cord in order to dissipate the heat over its length. With age and mishandling, these cords could become a fire and shock hazard. Many of these radios had one side of the line connected to the chassis, creating a serious shock hazard depending on which way the power cord plug was inserted in the receptacle. Polarized plugs and receptacles were not in use.

“This changed with RCA’s introduction in 1939 of a 150 mA complement, familiar today as the ‘All American Five’; 12SA7 converter, 12SK7 IF, 12SQ7 detector-audio, 50L6GT output and 35Z5GT rectifier. Sylvania’s 1940 loktal answer was the 14Q7-14A7-14B6-50A5-35Y4. Development of RCA’s miniature AC-DC lineup was delayed by war, but was complete in 1945: 12BE6-12BA6-12AT6-35W4-50B5.”¹ Series string connection of the filaments of these tubes did not require a dropping resistor. The 35/50B5 was supplanted by the 35/50C5 to satisfy UL listing requirements.

During the long time of manufacture of series string filament radios, many of them continued to use the chassis as a ground return, connected to one side of the power line. Such a radio is commonly termed a “hot chassis”. Radios were not generally equipped with polarized plugs and receptacles were not polarized; depending on the orientation of the plug, the chassis could be connected to the “hot” side of the AC line. Many of these radios were well insulated to avoid user contact. However, any contact with the chassis, control shafts, unprotected screw heads, etc., could expose a person to a serious shock hazard. In many later radios, an often used

¹ Tube Lore, Ludwell Sibley 1996, pg 4.

improvement was to employ an insulated negative bus, connected to the chassis through a capacitor, often in parallel with a high value resistor.

Underwriters Laboratories (now UL LLC) was created in 1894 to study and certify many types of equipment for safety from shock and fire hazard. UL's scope of evaluation has expanded dramatically since its formation. Detailed evaluation of shock hazards for radios began in 1945. "In 1945, all radios were two-wire products as grounding had not yet been implemented in the National Electrical Code"². It is extremely important that in servicing radios, original manufacturer design elements that enhance safety not be compromised. If possible, more recent practices in the pursuit of greater safety should be implemented.

Since these radios were produced, consumer electronics and the requirements for items connected to AC power have evolved dramatically. We now live in an environment of low voltage consumer electronics using solid state devices, often with "wall warts" to power them, double insulated appliances, Ground Fault Interrupters with three wire and polarized AC plugs. By comparison, series filament string AC/DC radios manufactured and widely sold since the implementation of transformerless design continue to pose shock and fire hazards, especially when reawakened after being dormant for many years. These radios were widely produced and are currently collected, restored and utilized. Appropriate caution should be exercised in repairing and using these radios.

Servicing and Restoring Radios

Presumably, persons who are restoring old radios will be conversant with the hazards and issues associated with working on them. Many of us who work on these radios are of advanced years; the effects of shock may be more life threatening than they would have been at an earlier age. In the case of transformer operated radios, a good power transformer should serve to isolate the AC mains from everything in the radio, with the exception of the switching and wiring associated with connecting and interrupting power application to the transformer primary. Even with transformer operated radios, a new line cord should be installed, preferably a three-wire type with the ground lead connected to the chassis. If that is not possible, a cord with a polarized plug should be installed, correctly connected in the radio.

After extended times of unpowered storage, power should not be applied to any series string radio without use of an isolation transformer and a Variac. This is even more important if test equipment is to be connected to the radio which is likely to have its own grounding connection.

Before conducting any work functions on a radio, you should familiarize yourself with the circuitry. You should determine whether it has a "hot chassis" or insulated chassis and review the circuit to determine which side of the line is interrupted by the on-off switch. Some radios have the on-off switch wired in the cold side of the line. If this is not changed, when the radio is

² In Compliance Magazine, Electric Shock from Radios, Jan. 29, 2016

turned off, most of the internal circuitry will rise to the level of the “hot” side of the line. If a dropping resistor is required for the filaments, you should know where it is and determine its condition. If a filament string resistor is contained in the line cord, make sure the cord and resistance element are new; better yet, substitute a power diode for the series resistor. Always install a modern polarized line cord or if possible, a three wire cord with the ground lead connected to the chassis.

In working on these radios, you should be familiar with the risks associated with conducting repairs and restoration and utilize the most effective means at your disposal to render the process as safe as possible. An important component of these practices is to be mindful of the way the radio may be used in the future.

Routine Operation of a Restored Radio

Once a radio has been restored to normal operation, presumably it may be used or demonstrated from time to time. For the collector who understands the characteristics of these radios, it is certain that their idiosyncrasies will be understood and appropriate cautions observed. However, some of these radios may be taken into possession and operated by others who do not have a full appreciation of the possible hazards involved. These radios should not be operated in kitchens or bathrooms or in any location where contact paths are available between the radio and appliances (which are almost certain to be securely grounded) or metallic plumbing. They should not be operated in areas that might be subject to moisture. These radios commonly radiate considerable heat; if one is accidentally left on for extended periods, it could become very hot. Long term heat exposure could melt a plastic cabinet or otherwise constitute a fire hazard.

Conclusion

Collection and restoration of old radios can be an interesting, instructive and rewarding activity. Your practices and procedures should be carefully considered to ensure your safety while doing service work and result in a radio that will be safe to operate into the future.

In response to an inquiry for permission to use the Tube Lore quote, Ludwell Sibley, President of the Tube Collectors Association, author of “Tube Lore” and editor of the “Tube Collector” responded as follows. He also granted permission to append his comments to the document.

Well, you've got the idea!

It might be good to point out that Fada and Emerson were the top-schlockers regarding hot chassis. I don't remember an RCA, Philco, or Zenith set with the problem. Sadly, the Fada Bullet and Emerson Patriot are high-value sets with this problem. The hot-chassis radios seem to have faded out after UL put on shock limits ca. 1949. However, Emerson put out a TV set ca. 1952 that had a power transformer AND a hot chassis.

I restored a Fada Bullet one time for a local antiques dealer. It turns out that the loop antenna is held in place by a screw in a bracket that's attached to the chassis. Sure enough, the screw head is exposed to anyone moving the set. I took a photo of a 60-watt light bulb glowing full when connected between ground and that screw.

I have feared for a long time that, if one restores a hot-chassis set and sells it, the restorer – who knows the problem - is legally liable if the buyer gets zapped or has a fire.

For the same dealer, I fixed a Fada 1948-vintage AM-FM set with hot chassis. Its rubber feet had crumbled away, leaving the mounting screws exposed. "Don't put that set on a metal table." I put on new feet using nylon screws.

There are a couple of communication sets that have a hot chassis inside a metal cabinet. The National SW-54 and a '40s Hallicrafters, are this way. One had better make sure that the cabinet insulation is OK!

I also once fixed a set made with the proper isolated return bus. However, someone had added an RCA jack for a phono input . . . and it tied the chassis to the return bus. I took that out.

(Incidentally, I once figured out why the typical capacitor from return bus to chassis always has a resistor (usually 220K) across it. Never saw a reason in print, but it would be possible to, with a ground or leak to ground on the chassis, and unplugging the radio at the right moment in the AC cycle, the user might get 154 volts off the capacitor if touching the chassis and the line plug. Not a likely event, but the resistor insures against it.)

Your mention of using an isolation transformer is wholly proper policy. If one does not have an isolation transformer on hand, one may come across a small Sola voltage-regulator unit that also provides isolation. (A quick ohmmeter check will verify that.) There were also a few small surge-isolation units to protect home computers from nasty voltages coming down the line. (I got one at a flea market once). It is simply a 120-to-120 transformer, good for 100 watts or so, that breaks the neutral lead. It could easily be rewired for pure isolation like we need.

The use of a Variac to give slow heating-up is also good policy. However, a simpler way is to use an old-fashioned light bulb (100 watts or so) in series with the radio. This will limit the current if, say, the filter cap is leaky.

I don't remember seeing any guidance on any of this other than in "Radio Age." For example, John Sideli's book "Classic Plastic Radios of the 1930s and 1940s," which came out during the Catalin Craze in 1990, talks about restoration of Catalin sets without mentioning the hot-chassis problem.

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