The Making of a TV Repairman, 1950 - 1960

By: Stanley Pitman 20 August 2014

This article is a summary of knowledge and experience gained in over eight years in the repair of radios and TVs, augmented by later insights derived from many years in electronic engineering. I'll explain first about how I came to be in the business, followed by a short history of my employment. Then I'll cover some of the TV technology of that era, along with related repair issues, and close with some anecdotes you might find interesting or amusing. Because of my limited experience with color sets, they are not covered here.

PART 1 : THE EARLY YEARS

My earliest memories of involvement with the wonders of technology were at the age of three, during pre-TV days in World War 2. We had a tall table-top radio that sat on a sideboard, and I was very curious about how those little tiny people inside the radio could talk and play music so loud. When I almost pulled the radio off onto the floor seeking to see them in there, I was very disappointed to see mostly only round glass tubes, and I was barked at severely by my wicked stepfather.

When I was nine, we moved to a shack in "the boonies", with no electricity. For a while we had entertainment via a "farm radio" powered by monster battery packs (including A, B and C batteries), but they were very expensive and were later cut from the budget

In the 6th grade I was introduced to SCIENCE, including the real magic of magnetism and electricity. We wound wire around nails to make electromagnets, and built telegraph keys and sounders. Then a neighbor kid and I strung wires between our houses and exchanged secret Morse code messages. All this was done with 1.5 volt carbon-zinc cells --- big honkers the size of a salt box.

My first direct experience with AC power came in 6th grade when, egged on by several of my cronies, I wired up a 6 volt DC doorbell with a 110 volt plug and plugged it into a classroom wall socket during recess. The resultant 3-second flash and clamoring bell cleared the room in about 11 seconds. When we cautiously sneaked back in and retrieved our experiment, we found that the bell contacts had vaporized and the magnetic coils were charred. So went my first lesson in higher voltages and power.

About this time, I heard rumors about old-time radios that didn't need batteries or other power and someone explained to me about "crystal set" receivers. These were simple tuned circuits with a rectifier to turn radio frequencies into audio signals to feed a pair of earphones. From a mail order site, I bought a crystal detector assembly and instructions for making a radio. A friend of my uncle gave me a slider-adjustable coil that he had wound on a round Quaker Oats box when he was a kid. After cadging a few more parts here and there, I put it together on a piece of wood and had my first radio. We strung a long antenna wire in the yard, and pounded a 6-foot ground rod into the earth outside my window.

My first detector was a chunk of galena potted in a small cup of lead. This was mounted with a sharp-pointed pivoting wire (sometimes called a cat's whisker) to contact the detector surface. To get reception, you had to listen on the earphones while probing around the detector surface to find a spot that gave the best signal.   If you bumped the board or yanked on the earphone cord, you lost contact and had to start over.   Later on, my uncle told me about a fixed germanium diode (1N34) which solved that problem. Performance left a lot to be desired, as the selectivity was very bad. The "Q" of the tuning circuit was very low, dragged down by the low impedance of the detector, and a local 50 kilowatt station swamped lower-powered stations in the area.

In the 8th grade I got a job in a radio and TV repair shop. Mostly I kept the place clean, tested radio and TV tubes, and answered the phone when the boss was out. In return, he taught me a lot about radios and how to solder and replace components, while paying me a minuscule wage

PART 2 : HIGH SCHOOL YEARS

I worked a series of paper routes to support my tinkering habit, and I bought and fixed up several TVs and radios to resell.   I built a series of simple one tube portable radios in cigar boxes, which I carried around school to listen to during breaks. I probably would have been designated as Geek of the Week, but the word hadn't been coined yet. The single tube was a 1U4 pentode in a reflex circuit with controlled positive feedback for high sensitivity.   Because power needs were so modest, I was able to run on used batteries that didn't have enough juice left for regular radios, and several repair shops saved their customers' old batteries for me.

At some point I started listening to short wave stations on an old Zenith console radio, but trying to read Morse code messages (which are on-off clicks with no audio modulation) was very frustrating. So I built an add-on tube-powered beat frequency oscillator (BFO) to get a audible BEEP BEEP. I got to be fairly proficient at the code if it was slow enough, while studying radio theory and operation so I could pass exams for my Novice radio amateur (ham) license, and I became KN6GGL.

I saved up enough to buy a used Hallicrafters S38-C receiver with ham band coverage, and built my own CW (keyed continuous wave) transmitter from info in a ham reference manual. It was mounted on a plank, breadboard style, with a type 6L6 tube. Because the voltage from my makeshift power supply was too high, the transmitter tube ran way too hot, so I inverted the whole shebang over a bucket of cool water. I was the probably the only novice ham in L.A. with a water-cooled transmitter. I'm pretty sure I was running over my legal limit of 75 watts, but had no meters or other test gear to check power or anything else. My unit was at least crystal-controlled, so I think the frequency was probably OK.

PART 3 : THE WORLD OF WORK

My first job after high school was at a TV repair shop in Hollywood, working at fixing radios and as general flunky and TV repair trainee. In addition to the work in the shop, I sometimes got to go with the outside repairman on TV service calls or to help put up antennas. I even met a few film and TV celebrities when we went to their sumptuous homes for repairs.

Two years of apprenticeship and study taught me enough to get journeyman TV repair positions at several shops over the next few years. The changing technology of consumer electronics offered a lot to learn, as semiconductors made their way further into radios and TVs. There were plenty of amazing or amusing or harrowing experiences along the way --- enough to fill another report this size.

In 1960, after a disagreement with an employer over ethical treatment of customers, I bailed out of TV work to do test and repair of aerospace instrumentation. I really enjoyed working with professionals after the hurly-burly of the TV repair business.

PART 4 : TV TECHNOLOGY

TV broadcast signals:

The VHF TV channel range was 54-72 MHz, 76-88 MHz and 174-216 MHz. Each TV channel was allotted a 6 MHz bandwidth, with the main video carrier 1.25 MHz from the lower end and the FM sound carrier 4.5 MHz above that. Vestigial sideband video modulation was used, in which the transmitter suppresses the lower sideband. At the TV station I visited, RF feed to the antenna was by oversized copper pipe waveguides, rather than coaxial cable. Brute-force sideband suppression was by an impressive tangle of tuned pipe stubs on the ceiling.

Antennas:

Most of the outdoor antennas in my area were a “Yagi” design, with a line-up of different length elements for broadband coverage of channels 2 to 13. Most of the elements were passive reflectors or directors, along with one or two “active” elements feeding signals to the TV via 300-Ohm flat cable. The cable was twisted to cancel pickup, both of the TV signal and any interference noise. Some installations used mast-mounted pre-amplifiers and coaxial cable, for less attenuation and better noise immunity. A few used open “ladder lines” for long distance runs.

Yagi antennas had good signal gain, but were not good at rejecting unwanted signals from the sides, such as happen with reflections from hills or man-made structures. These show up as a “ghost” picture to the right of the screen images. Using a “Radarray” antenna, with its large screen behind the receiving elements, usually fixed the problem. In some cases, the reflected signal was stronger than the original, and antennas were aimed away from the transmitter.

Tuners:

Most tuners had a dual-triode amplifier, such as a 6BK7 or the later 6BQ7, connected in a “cascode” circuit for increased gain and bandwidth. This was followed by a dual-triode 6J6 used as oscillator and mixer. The 6BQ7 was “hot” in several senses of the word. It had higher gain, but drew more power than its predecessor, and was more prone to shorting after long use, often burning up the tuner’s internal power feed resistor. Some later model sets moved the resistor to a terminal strip outside the tuner, for ease of repair in the home.

Most of the early tuners had a stack of rotary switch wafers for changing channels. When the contacts inevitably got contaminated, it was hard to get contact cleaner into the right spots. After a few years, most makers used a “Standard Coil” barrel-type tuner. The 12 barrel “staves”, each tuned for a TV channel, had button nubs that rotated against contact springs. This truly ingenious device was more reliable and easier to clean.

Several TV brands, notably Dumont and Crossly, used an unusual continuous tuner with a hand crank knob. The tuning was by a ganged Mallory “Inductuner”.

UHF tuners, added later, had an oscillator tube and a passive diode mixer, and output passed through the VHF tuner for gain and selectivity.

<u>I-F amplifiers and video detectors</u>:

In most cases, the tuners converted the broadcast carriers to 45.75 MHz (video) and 41.25 MHZ (audio), which fed through the intermediate frequency amplifier chain of 2 to 4 stages. An RF sweep generator was used for stagger-tuning IF stages to get the desired broad bandpass alignment. Automatic gain control was applied to IF and tuner stages to maintain optimal signal voltage levels.

Most sets used the intercarrier method for demodulation, in which a silicon diode detector produced the AM video signal. It also mixed the video and sound carriers to generate a new 4.5 MHz sound carrier signal that fed to a sound IF amplifier and an FM detector. The sound carrier was blocked from the video amplifier with a tuned trap. Some better models (and all later color sets) used a separate sound mixer diode, bypassing the video detector. Some high-end sets used a completely separate sound IF chain, at about 21 MHz.

<u>FM audio detectors and amplifiers</u>:

The sound IF amp contained a limiter stage that clipped the carrier wave to eliminate any amplitude modulation. Most detectors were dual-diode Foster-Seeley discriminators, including ratio detectors. Later models often used a 6BN6 quadrature detector, which was much easier to align. Audio amp stages were pretty standard, with single-ended transformer coupled output.

<u>Video amplifier and CRT / picture tube</u>:

Video amps typically included a simple DC restorer circuit, to maintain displayed black levels. Contrast was controlled by a pot in the amplifier’s cathode leg that varied the gain. The amp usually drove the cathode of the CRT, while brightness knobs usually controlled the CRT grid voltage, although some sets did the reverse. Video screen trace was blanked during horizontal retrace, usually by a screen grid on the CRT. Early CRTs had adjustable magnetic focus coils, but later sets used electrostatic elements in the CRT.

As CRTs aged, their cathode emission would drop, dimming the picture. This could usually be alleviated temporarily by using a “picture tube booster” attachment to supply higher filament voltage.

Noise suppression:

Video quality and sync stability suffered when noise sources polluted the video signal. There were many types of designs for noise limiting, variously called blanking, clipping, rejection, or cancellation circuits. These were sometimes part of video amps or sync circuits, and sometimes stand-alone stages.

Sync generation:

The heavily biased sync separator stage only passes the peak voltage, which comprises the transmitted sync information, and a low pass filter forms a vertical integrator. This filter was often in a flat ceramic package made by Centralab.

Vertical deflection:

Vertical sync pulses from the integrator lock in a directly-triggered vertical relaxation oscillator, which feeds the vertical power amplifier that drives the output sweep current to the magnetic yoke winding. A vertical size pot controlled oscillator output voltage, and a pot and capacitor in the power amp cathode circuit controlled linearity.

Horizontal deflection:

Horizontal scan circuitry performed more functions and had more variations between various makes and models than any other section. Deriving a high-powered very linear ramp current took a lot of add-on fixes and patches to the basic drive circuits.

Direct keying of the horizontal oscillator by the sync separator in early sets was later dropped in favor of more stable automatic phase control circuits, which used a tube or diode phase detector stage to keep sync locked in the oscillator.

The horizontal output tube powered a flyback transformer that fed the yoke and high voltage section. At the end of each scanning line, the drive current was turned off, and the energy stored in the combined inductance of the yoke and transformer generated a reverse voltage pulse. This kick-back (or flyback) energy was rectified by the damper tube, and used to supply “boost” power to the horizontal output tube (which supplied the power in the first place) and to some other circuitry. This energy-harvesting “bootstrap” circuit was named for the concept of lifting yourself up by your own bootstraps. The peak energy stored in the yoke windings could be as much as 50 watts, and generate over 300 volts of added boost voltage. Shorted turns in yoke or transformers were very hard to diagnose by most conventional means.

Note: Be very cautious if using a regular scope around horizontal deflection circuits, as it could be damaged by voltage spikes, especially if the TV is malfunctioning.

High voltage:

High-voltage AC at about 15 kHz was developed by a winding on the flyback transformer. This usually fed a 1B3 or 1AX2A rectifier tube to give 12 kV to 15 kV to feed the CRT anode. The rectifier filament voltage was supplied by a couple of turns of wire around the flyback transformer core. Filtering was by a 500 picofarad ceramic “doorknob” capacitor, plus the CRT’s anode-to-ground capacitance. Some sets used a lower-voltage flyback transformer with two or three rectifier tubes in a voltage doubler arrangement.

Most sets used glass CRTs, with a snap-in anode connector, and an outside “Aquadag” conductive ground coating with a sprung wire connection. RCA and several other makers used a metal shell CRT with exposed high voltage DC, which required careful attention when servicing.

Power supplies:

With few exceptions, most early TVs I encountered were transformer powered, usually with a type 5U4 full-wave rectifier tube to supply B+ voltage. Sometimes the tube socket was embedded atop the transformer. Most of the tube filaments used 6 volts AC, including 12 volt tubes with center tapped filaments.

Many later sets deleted transformers to save money, using selenium rectifiers in a 1/2-wave voltage doubler circuit to get B+ of about 260 volts. This created servicing problems, as described in the servicing section below. In these sets, tube filaments of various voltages but matching currents were strung in series to add up to 117 volts, just like in cheap AC-DC radio sets. Series filaments make it impossible to diagnose problems by unplugging tubes, because the whole string of tubes shuts down. Some of these sets had a separate 6-volt filament transformer for audio and tuner sections.

Since B+ voltage was so high, some later sets routed B+ power through the audio section to feed several other sections at a lower voltage. In effect, the audio tubes acted as a voltage-dropping resistor in this “stacked” arrangement, which made voltage measurement a little more complicated.

System design notes:

There was a wide range of electronic design quality in the sets I encountered. Some high-end sets made for custom cabinets or wall installations, like those from Radio Craftsman and Conrac, had lots of refinements like more IF tubes for better bandpass quality, improved noise rejection, and better video definition. Most brands were mid-range, with some innovations. At the bottom of the pile were makers like “Mad Man” Muntz, which were the bane of repairmen.

Early sets were hand-wired, with parts connecting to and between tube sockets and terminal strips. GE later introduced strips of hollow terminals, into which part leads and wiring were stuffed, with subsequent dip-soldering in a molten bath. Alleged benefits were more reliable connections and easier troubleshooting, but cheaper manufacturing was certainly a factor.

RCA then started using primitive printed circuit boards, which lowered costs (and selling prices) significantly. Unfortunately, it also caused a lot of servicing headaches. No longer was it possible to disconnect a wire or a part lead when troubleshooting, and the boards were often burned by hot tubes. Several shops I worked for refused to sell RCA sets, because of their service difficulties, recommending Zenith or Packard-Bell instead.

GE's tube division later introduced "Compactron" tubes, with combinations of three or more stages in one envelope. This again reduced maker costs, while making servicing more difficult.

The CRT on most early sets had the CRT mounted on the chassis, but later sets mostly mounted it to the cabinet. Their propaganda alleged plausible sounding reasons, but it was messy if shop repairs were needed. Without the rest of the set functional, it was hard to tell if the CRT was OK. The yoke was removed along with the problem chassis; then jury-rigged on the shop bench with a small test CRT. After we fixed the main problem, there was no guarantee that all would work well on reinstallation.

PART 5 : REPAIR ISSUES

Running a service shop was an expensive investment. Required equipment included tube testers, meters, oscilloscopes, a variety of special tools, and a well stocked tube caddie for house calls (plus backup shelf stocks). Better shops also invested in sweep generators, specialty testers (for CRTs, yokes and flybacks), and a file cabinet full of service literature.

Business ethics of technicians and shop owners varied enormously. I quit two jobs after I was chastised by owners for not "pulling" enough sets for shop repairs, whether they needed it or not. One technician's specialty was selling people unneeded picture tubes whenever there was no picture, no matter the real cause. If they declined the shop repair, he made sure the tube had a blown out filament by using his "cheater" AC cord on it.

Legit shops of that era usually charged $5 for service calls, plus the cost of any parts used, and only put in what was necessary. We would charge extra for lengthier procedures like tuner cleaning, which some shops wouldn't do in the home. But there were some shops that got a lot more business because they only charged $2 for service calls, but sold the customers a lot of unneeded tubes to make a profit. Customer prices were double wholesale costs, so the total added up fast. All this doesn't sound like much now, but this was when I was making $2 per hour, and gas cost 30 cents per gallon.

Many customers had very convenient memories when it came to service calls. I often heard the refrain of "You were just out here recently, and it's doing the same thing again." Fortunately we kept pretty good records, and were able to ferret out that it was often at least six months ago and for an entirely different problem, or sometimes even for a different set !

Most TV problems were caused by tubes going bad, and could be fixed in the home. The most common cause was internal shorts, especially in horizontal scan and tuner circuits. These were often intermittent, and seemed normal after blowing a fuse and cooling down. Moderate tapping with a plastic-handled driver was usually enough to reveal the problem.

Some outside service techs were referred to as “tube jockeys” because they did fairly well at swapping out tubes, but couldn’t find a defective capacitor if it jumped out and bit them.

Shop repairs:

Beyond tube failures, the most frequent problems were caused by capacitors, especially aluminum electrolytic units used for power supplies and bypassing. These polarized devices sometimes shorted, but most often developed high internal resistance due to loss of conducting liquid. In power supply filtering, this caused excessive 120 Hz ripple and lowered B+ voltage. Those used in other TV sections for bypassing can cause many symptoms, including lower audio or video gain, vertical sweep non-linearity, or signals in one section interfering with other sections. When TVs or radios have been unpowered for a very long time, these capacitors tend to lose their voltage rating. They may destroy themselves when re-powered, unless slow-start techniques are used to renew their functioning.

Shorting or leakage in other capacitor types can allow current to flow where it shouldn’t. Bad coupling capacitors can cause a following stage to draw excessive current. When repairing any set, it’s a good idea to check for proper circuit voltages in their vicinity. Older tubular capacitors usually had a dielectric of wax-impregnated paper, and any parts showing wax leakage should also be replaced.

Note: In some older literature capacitors were called condensers, and the ones in simple car ignition systems still are.

Regular carbon composition resistors seldom went bad, unless burned by other failures, but power resistors were a bit more prone to opening up. Some of these were “fusibles”, acting like fuses to protect other circuitry.

Transformer-less sets:

Using cost-cutting selenium rectifiers brought several problems. Unlike a tube rectifier, which can be easily replaced, the selenium units were soldered in. Their interior resistance increased with age, causing B+ to drop and picture to shrink. The higher resistance made them run hotter, causing a disagreeable odor. If a short caused the seleniums to blow up, the stench was very like a skunk, and required stringent cleaning with a variety of solvents. Newer silicon rectifiers for replacement use didn’t age, but had problems of their own. They raised the B+ voltage enough to blow filter capacitors that weren’t conservatively voltage rated.

On these sets, TV circuit ground was connected to one side of the AC line via an unpolarized line cord, and could be “live”. Connecting AC-powered test equipment called for use of an isolating transformer.

Dealing with the DIY crowd:

As in most repair businesses, we dealt with our share of do-it-yourselfers. They would often use the tube tester at the corner drugstore, buy a bunch of tubes that measured “weak”, then call us when that didn’t fix the problem. When servicing sets, we didn’t usually replace tubes that were marginally weak, unless symptoms dictated otherwise. My favorites were the guys who would come in to buy a high voltage rectifier tube because they looked in there and it wasn’t glowing like the others. We usually kept a straight face without a snicker, and didn’t tell them it ain’t supposed to.

We also used to get radios where the DIY guy had helpfully tightened down the loose screws on those little square cans (IF transformer trimmers).

PART 6 : SERVICE STORIES

On one service call, the woman’s cat had knocked over a vase of flowers atop the TV, causing everything to go belly up. When I opened the back, the glass 5U4 rectifier tube looked normal except for the two inches of water in the bottom. Apparently it had split, then resealed itself when it cooled.

Once I brought a woman’s console radio into the shop to replace defective filter capacitors. After I fixed that, the set sounded a little shrill, and I discovered and replaced an open tone-shaping capacitor. When I returned her set and told her how I’d improved the tone, she listened intently for a moment. Then she asked “What have you done with my treble ? I want you to march right back down to the shop and put my treble back in.” She remained adamant, so I opened up the set and snipped out the shaping capacitor, restoring her smile in the process.

Once when I was helping install a large antenna, the service tech fell off the ladder into some bushes, probably saving his neck. He recovered enough to finish the job, but came back severely scratched and bloody. When the boss heard what happened, his first question was “How’s the ladder” ?”

The exposed high voltage on metal CRTs, was very low amperage and wouldn’t do much bodily harm. But bodily reactions to the shock were a bigger hazard. On one service call, the set had no sound, and I could see that the audio amp tube just under the CRT wasn’t lit. Without turning off the set, I gingerly reached in to ease the tube from its socket. It suddenly came up, with my knuckles hitting the live CRT. In jerking my arm back, I severely scratched it on a protruding adjustment screw on an IF transformer.

High voltage ionizes impurities in the air and attracts them to exposed surfaces. I was used to some smudge deposits, but one set had a 1/4” thick fur coat around the metal CRT, apparently due to three 2-pack-a-day smokers in the house. They also had to have their tuner cleaned about once a year.

One service call to a nearby college frat house was a real puzzler, as their TV picture seemed normal at first glance. But any lettering read backwards. I pondered possible causes of this as I removed the set back, but closer look at some suspiciously sloppy wiring revealed that some prankster had reversed the horizontal yoke wires. I should have suspected as much, because this was an engineering fraternity, and most engineers never learned to solder properly.

While in high school, I would sometimes amuse friends by holding the base of a large light bulb to the high voltage rectifier tube cap. The high frequency AC would ionize the trace gases in the bulb, with the serpentine arc splattering against my fingers. They were also impressed when I would make contact with the tube cap and light up a fluorescent tube held in the other hand.