Understanding the Craft of Soldering

By Mark Palmquist

Soldering may become a lost art for young people growing up today. Most electronic gadgets, computers and radios are built with sophisticated but "non repairable" technology. Your DVD player dies, you throw it away and buy another for $29. The cost of taking it to a repair shop is out of the question since a replacement is so cheap. Something similar happened to tube radios just before transistor radios took over. The All-American Five radios got so cheap that tossing it and getting a new one was a reasonable alternative to repair when the radio stopped working. Growing up in a hardware store/radio repair shop in the '50's I had plenty of chances to learn how to solder. Every Heathkit, Eico or Knight kit I built had a manual with a good explanation of how to make a reliable solder joint. There were lots of experienced folks who could show you how to make a good solder joint and inspect for a bad one. These assembly manuals are still very good references.

As a college student, I got a job as an electronics technician for Physicists at the University of Iowa who were building experiments that would eventually fly into orbit and measure various kinds of natural electric and magnetic fields. All of the flight-qualified electronics were built by young women who had been extensively trained at the NASA soldering school. Their job was to assemble and inspect ultra-high reliability circuit packs that could withstand long exposure to heat, cold, vacuum and the vibration associated with a orbital launch vehicles. Any assemblies that failed during pre-launch qualification testing at Langley in Maryland were scrutinized for the quality of the solder joints on the cable harnesses and circuit boards. Each joint was carefully inspected under high magnification and marked and photographed for archival purposes.

I have seen my share of old radios: very few in their original condition and most which have been repaired by technicians with skills from novice to expert. I can always tell the expert repairs by the quality of the soldering at the terminals where components or wires have been replaced. The expert repairs have wires with good mechanical connections for a start, then covered by a smooth and shiny fillet of solder. In contrast, the novice repairs generally have poor mechanical connections, anywhere from zero to 10 times as much solder as required. Sometimes I see evidence that the solder was melted by the soldering iron and allowed to drip onto a cold connection. Since many of the club members are learning how to repair the radios they find at swap meets, Ebay and estate sale expeditions, the rest of this article will explain the chemistry, physics and general craft of making good solder joints.

What is Solder?

Solder sold for use in most electronic applications is an alloy of lead and tin, extruded into a tube that is filled with "rosin". The proportion of tin to lead is typically 60/40. The combination of these two ingredients has a melting point that is lower than either of the components taken separately. When heated, the rosin works to de-oxidize the surfaces of the components and promotes wetting and adhesion of the molten solder alloy. The diameter of the solder can be very fine, say 0.020" in diameter, up to 0.125" diameter. The small stuff is used for delicate circuit

board repairs and the larger stuff is used to sweat copper pipe joints. A good size for general radio repair is 0.031".

What kind of Soldering Equipment Do I need?

A high quality soldering station with a thermostat or variable temperature control will allow you to work quickly and get consistent results. I have a Weller TC-202 60-watt unit. This unit has solder tips that can be selected for a given temperature, typically 700 to 800 degrees. I also like the EDSYN 951 SX. It has a variable temperature control that I set at around 750 degrees for most bench work. Each has a place to store a wet sponge to clean the crud off the tip of the iron before soldering a new joint. You can find cheaper equipment, but I have yet to regret buying the best tool I could afford if it is a tool that I will use often.

The first thing to do with a new iron or new tip is to melt some solder on the tip so that the entire surface is "tinned". I'm not sure why this is done, but my guess would be that it protects the tip from corrosion and also improves heat transfer from the soldering tip to the solder joint and aids in the wetting of the solder to the tip and the joint.

One of the most useful gadgets on my repair bench is a spring-loaded windup timer that shuts off the soldering iron after 5 to 60 minutes of operation. I call it my "Alzheimers timer". These are hard to find now but other alternatives probably can be found.

What About Soldering "Guns".

Sometimes you have to make a connection directly to the chassis of a radio. The chassis is a giant heat sink so a 60-watt iron isn't big enough to get the job done. The is where you need a 200/275 watt "gun". On the high setting, with the trigger pulled all the way back, the tip will in time transfer enough heat to a local point on the chassis that a good joint can be made. Many times I have seen under-heated joints where the only adhesion is the "glue" action of the rosin. There is no metal-to-metal bonding if there is not enough heat. I am currently using a Snap-On tools gun made by Weller that I found in a basement cleanout sale a couple of years ago.

How Do You Clean Off the Old Solder?

Another essential item to have on your bench is a **De-Soldering** pump. This is a spring-loaded manual device that sucks up molten solder and helps you clean the old solder off a joint so you can neatly remove the old component wires and connect the new one in the same manner as originally done at the factory. These are plentiful at Hamfests and can also be found at commercial electronics houses such as Austin Electronics or RS Electronics, both in Norcross, GA.

Another useful item to have is called desoldering braid or **"solder wick"** . It is a braid of finely woven copper that will wick up molten solder and remove it in places where it's not possible to reach with a desoldering pump. It comes in small to large rolls with names like "pro-wick".

Another essential tool is a **solder brush**. This is a small wire brush with a pencil-sized handle. Use the brush to clean off old rosin and oxide from terminals where repairs are to be made.

Good lighting is also essential. You can't do good work if you can't see. A high intensity lamp or a fluorescent ring light with a magnifying glass on an articulated arm are good items to keep handy. I found mine at a garage sale for a buck.

How Do I Make A Good Solder Joint?

First, make sure the old solder is cleaned off the original joint and that the component lead or wire to be soldered is clean and has a good mechanical connection. Most components such as resistors or capacitors have leads that are "tinned", meaning that they have a thin coating of solder already melted onto the copper conductor of the component. If I am working with a vintage component, I often use a piece of Scotch-Brite™ abrasive pad to remove any oxide coating on the component lead before attaching it to the joint.

When making a joint using stranded wire, always heat the end of the stripped wire with the tip of your iron and apply enough solder to bond the ends of the stranded wire together. Tinning stranded wire makes the end of the wire act like a solid wire and makes it easier to make a tight loop at the end of the wire when connecting to the terminal.

1. If working with insulated wire, typically strip off about ½" of insulation.
2. Tin the wire if necessary.
3. Put a tight bend in the end of the wire and crimp it to the terminal.
4. Heat the wire and terminal with the tip of the iron
5. Apply solder to the joint when the joint is hot enough to melt the solder
6. Try to make a smooth, shiny fillet.
7. Don't move the wire until the solder sets, or you will get a "cold solder joint" that will have a grainy appearance rather than a smooth and shiny appearance.

Some soldering tools on my bench. My bench is never this clean. Alzheimers timer top center. Soldering Iron should always be stored in its holder. Never leave it on the bench!

Restoring Radio Cabinets with Shellac

By Mark Palmquist

Les Cane and I took advantage of an opportunity to spend a weekend with wood finishing Guru Bob Flexner at a recent seminar held at Highland Hardware in Atlanta. Bob is the author of *Understanding Wood Finishing* , a book that helps the reader get a better understanding of the solvents and solids that go into finishes such as oil, varnish, lacquer and shellac. Prior to this seminar, I had never tried shellac as a finish on radios, since I somehow got the impression that modern finishes had made shellac obsolete because of their better application qualities, clarity and durability. After watching some demonstrations with shellac, and after learning that many '30's radios were probably finished with shellac or a close relative, I decided to give it a try and learn how to use it.

What is Shellac?

Natural shellac is made from a hard, brown secretion that the *Lac* Bug leaves on twigs in trees, Found primarily in the orient, the material is harvested and processed into flakes that vary in color from very light blond to orange to garnet in color. The flakes will dissolve in alcohol, and the result in an evaporative finish that leaves a very hard, sealed surface that can be rubbed out to a high gloss. *Evaporative* finishes simply leave behind the solids after the solvent evaporates, and the solids bond to the surface below. An important attribute of evaporative finishes is that they can be easily repaired by putting more of the same finish on top. The solvent immediately softens and dissolves to some extent the previous layer, resulting in a strong and homogeneous film build. In contrast, a finish such as polyurethane varnish is *reactive,* implying that it forms a new compound when the solvent evaporates and the remaining solids react with oxygen in the air. Shellac may be purchased already mixed or mixed fresh from flakes at the time of application. Pre-mixed shellac has a shorter shelf life than other finishes, so use it while it's fresh.

Mixing Shellac

You may have heard terms like "three pound cut" in reference to shellac. This refers to the number of pounds of shellac mixed with one gallon of denatured alcohol. Finishing a radio normally requires only a cup or so of shellac. I use a two-pound cut for brushing on the finish, which amounts to two ounces of shellac by weight in 8 fluid ounces of denatured alcohol. Scaling this up to a gallon works out to two pounds of shellac per gallon. Mix the shellac in a glass jar. Just put in the flakes, add the alcohol and stir. It takes a while to fully dissolve so be patient. After it is fully mixed, I pour the mixture through a coffee filter into a clean glass jar. Denatured alcohol is both poisonous and flammable, so work in a well-ventilated area away from sparks or flame. Read all safety precautions on the label of the alcohol container and observe them.

Preparing the Surface

Open-grained woods such as oak, walnut and mahogany should be filled and sanded smooth prior to application of shellac. I like to use *Bartley* paste wood filler. Follow the directions on the can. The most important thing is to sand the excess filler off so that the filler is in the pores of the wood and not on the surface. I use orange or garnet shellac on dark woods. This type of shellac warms

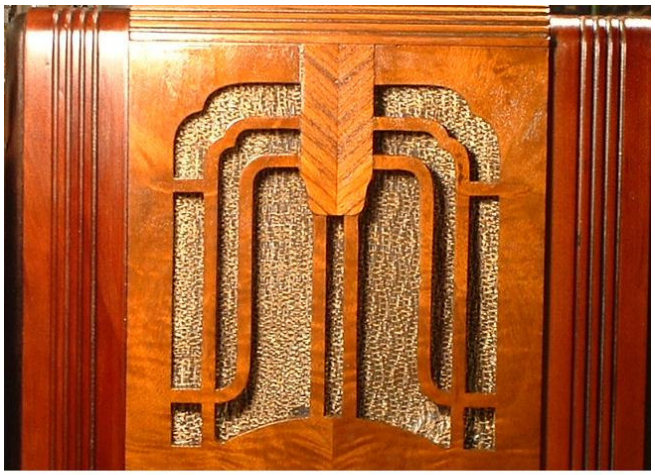
up the wood grain without sacrificing clarity. Lighter woods such as maple should be finished with blonde shellac to reduce the yellowing that might result from darker shellac. If you don't fill an open grained wood, the pores will telegraph through and it will be harder to get a smooth finish.

Applying the Finish

Shellac may be applied by brush or with spraying. The first time I used a 2-inch natural bristle brush with the 2 pound cut mixture. Clean off all dust with a vacuum cleaner or tack cloth before starting. Shellac is applied in a single, long smooth stroke along the grain of the piece. The next stroke is lapped slightly with the wet edge of the previous stroke. Do not "work" the brush or try to brush out a defect or a missed spot. Leave the glitch until the next coat because the next coat will dissolve and mix with the previous coat. Sand the first coat lightly with 320 grit or finer sandpaper after a couple hours of drying time and apply the next coat. I would recommend practicing on some scrap pieces before diving into that priceless zenith your grandfather left you.

Rubbing Out the Finish

The really cool thing about shellac is that it can be sanded and polished to a mirror finish using very fine abrasives (600 to 1500 grit sandpaper) and rubbing compounds such as pumice and rottenstone. Automotive rubbing compound can also be used to buff out the finish. Be careful on corners and curved surfaces that you don't sand through the finish. Flexner recommended that the finish should harden for at least a month before rubbing it out. Rubbing will remove all the ridges, puddles and other defects that result from brushing. I haven't tried spraying it yet, but a thinner mixture and more coats are generally called for to get a satisfactory film build. My goal is to put a "Steinway Piano Finish" on a radio someday. I doubt if any radios from the '30s started out life this way, but I can't resist the urge to give it a try. The Grunow tombstone and Emerson table model below represent a start in this direction. Each was finished with three coats of orange shellac after stripping, filling and sanding the surface to 320. Neither radio was stained prior to application of the finish. The shellac preserved the clarity and color of the burl on the front of the Grunow at the left. Rubbing out the Emerson on the right with 1500 grit wet or dry paper followed by 8-micron silicon carbide film lubricated with mineral spirits produced something akin to a mirror gloss finish in a very short time. I then applied a coat of paste wax as the last step.



Caution: Performing repairs on radios could be dangerous. SARS assumes no responsibility for accidents resulting from any information contained in this web site.