Antique Radios

Bringing them back to life

There is a tremendous amount of interest and a reasonable profit in restoring old radios. This article tells you what radio restoration is all about and how you can become actively involved.

JACK DARR
SERVICE EDITOR

THERE HAS BEEN A TREMENDOUS RISE IN INTEREST IN ANTIQUE radios lately. (The price of the old sets has gone up, too!) Most of these radios are not very hard to fix; in fact, they provide a good place to use logical troubleshooting methods.

The only difficulty you will have will be in a few circuits that were common in the early days but haven't been used for a long time. They are not too hard to handle; you just probably haven't run across them. If you know about them ahead of time, it'll make repairing them a lot easier. (I can speak with authority, because I've worked on 'em when they weren't antiques but the current models!)

Tubes and circuits

The early battery-type vacuum tubes were triodes—'01A, '12, '10, 71A, etc., and the filaments were 5 volts DC. The original filament power source was a 6-volt automobile battery with a small dropping resistor in series. It was a variable resistor (called a rheostat) so you could turn the voltage up as the battery went down. In some very old sets, it was also the *volume control*! I use the term filament instead of heater because these devices were of the "red-hot hairpin in a bottle" type, and the filament was the source of the electrons.

This setup led to an unusual circuit. When these tubes were used with an AC power supply, they developed hum problems. So, the filaments were fed from a center-tapped winding on the power transformer. This equalized the AC voltage from either side of the filament to ground. Since the cathode must have a ground-return to complete both plate and grid circuits, the center tap of the filament winding was grounded. If a high bias voltage was needed, which was usual in older power tubes (the 71A tube needed −40 volts on the grid), a resistor could be connected from the center tap of the winding to ground. Or a positive voltage could be applied to this point. The grid circuits returned directly to ground; therefore, making the filament positive made the grid that much more negative with respect to it. Figure 1 shows these two circuits.

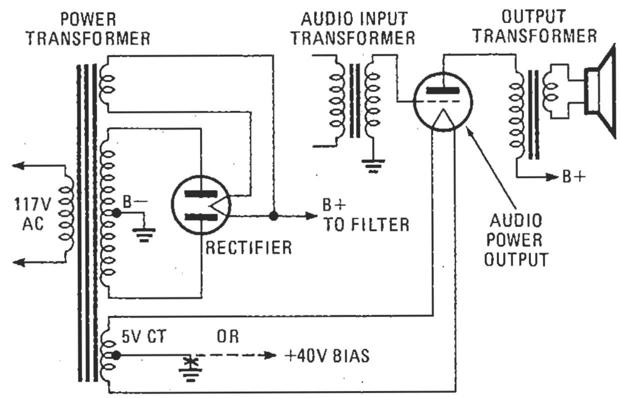


FIG. 1—FILAMENT CENTER TAP is the ground return for the "cathode" circuit. Bias may be applied at this point.

If manufacturers didn't want to use a center-tap filament winding, they connected a small variable resistor across the winding with its slider grounded. In stages like audio drivers that were more sensitive to AC hum, this could be varied for the

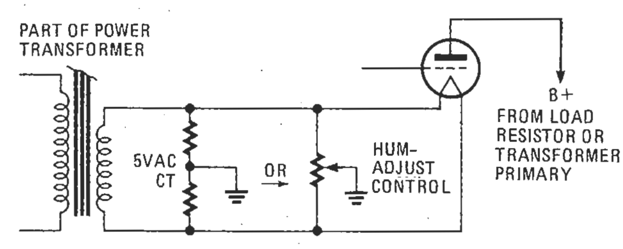
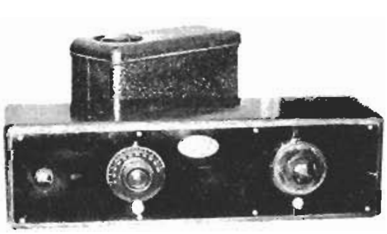
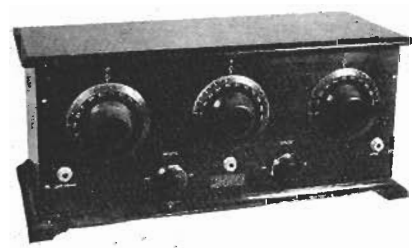


FIG. 2—LOW-OHM FIXED RESISTOR was often used instead of center tap. If adjustable, it could reduce hum. (Later ones on AC tubes were commonly called "humdingers.")



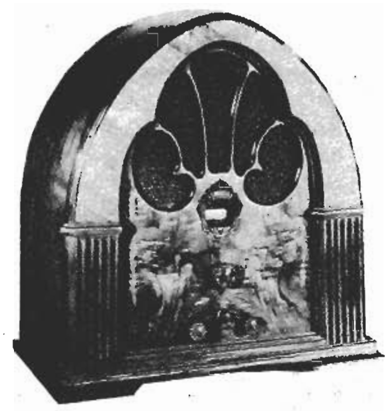
ATWATER KENT model 36, 1927

FRESHMAN MATERPIECE, 1925



FRESHMAN MASTERPIECE, 1925

RADIOLA 60 by RCA



PHILCO CORP. model 90B, 1931

ZENITH model 75 Radio Phonograph, 1930

least hum; therefore, you'll find this marked HUM CONTROL in some of the sets. (See Fig. 2.)

Around 1926, the first tube with a separate cathode sleeve was developed; and, as far as I know, it was the type '27 triode. (Now, we have to use the term heater again!) A year or so later, the first tetrode tube was developed. That was the type '24, the famous "screen-grid" tube with higher gain. (This tube and I went into the radio business in the same year. It's done better than I have!) These tubes got rid of a problem that had bugged designers since the beginning—neutralization!

Other tubes soon followed: the 35/51 and the first 6-volt 0.33-amp tubes, the 36-to-39 group. (The '38 was the first AC-operated pentode with a suppressor grid.) Then along came the '40 tubes, including the famous '47 power-output pentode, that could be found in about half the sets sold in the middle 1930's. We also had the 56/57/58 series, with 2.5-volt heaters. However, all this comes from my fallible memory, so, don't pin me down on it.)

Power supplies

The first radios used batteries. The filament battery was called the "A" battery, and the plate battery was called the "B" battery. If separate batteries were used for grid bias, they were called "C" batteries. These terms hung on when the first AC-power radios were built. (To this day, most of us old-timers use "B+" when we refer to the high voltage DC supply of a radio—even in TV applications, where the proper term is "low voltage DC supply.")

There were some odd components in these circuits that were eliminated in later radios. The stock circuit always had a power transformer. The B+ voltage was fed from the secondary winding, which was always center-tapped, and was the negative return. A full-wave rectifier tube was used, generally a type '80.

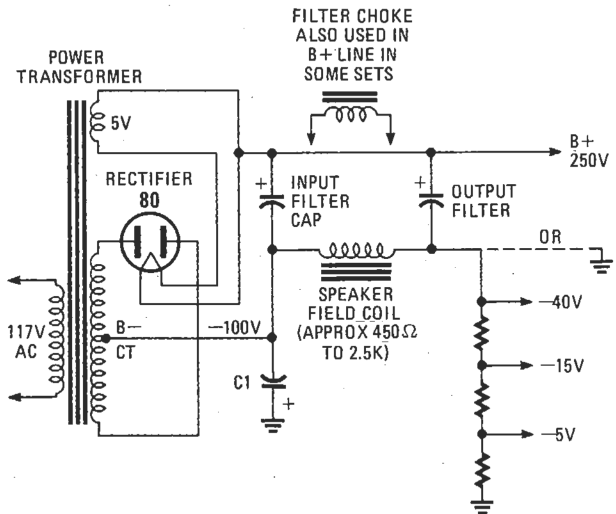
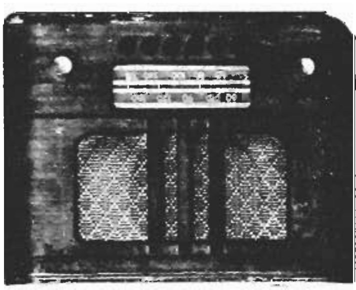


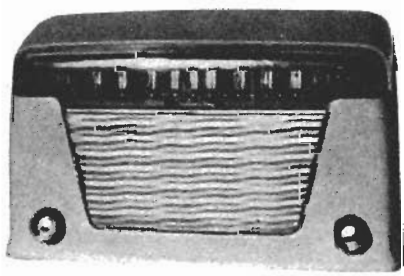
FIG. 3—THE SPEAKER FIELD COIL could be in the positive or negative leg of the power supply. Note that filter capacitors may go to negative terminal.

This negative return was a "B−" supply.

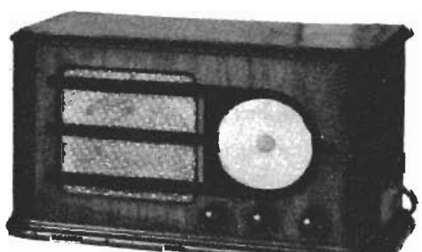
Figure 3 shows one of the old power-supply circuits. Many sets isolated the negative return of the B+ supply at the center tap and ran it through the field coil of an electrodynamic speaker to ground. (An electrodynamic speaker resembles modern dynamic speakers but it had a good-sized field coil to develop the magnetic field and needed a fairly heavy current.) All current drawn by the circuits in the set passed through the field coil, which also acted as the filter choke. In quite a few sets, the field coil was in the positive leg of the B+ supply. It works



RCA model 95T5, 1938



SILVERTONE model 8005, 1941



MODEL 6050 Sears Silvertone

exactly the same since the same current flows on both sides of the power supply circuit.

With the field in the negative leg of the B+ supply, the current developed a negative voltage drop. This drop was taken off and used as bias on stages that needed it. In many radios, some small resistors were used between the field coil and ground to develop lower bias voltages. The unusual feature in this circuit lies in the connection of the *input* filter capacitor. Note that the negative connection does not go to ground but to the B− line. Connecting this capacitor to ground when you replace it results in a terrific hum. In quite a few of these old radios, another capacitor (C1) was added, as shown in Fig. 3. This capacitor was connected with its negative lead to the center tap, and positive lead to ground.

Bleeders

Voltage regulation wasn't so great in most antique sets. To improve this situation somewhat, many sets used a long string of resistors connected from the B+ voltage to ground. This type of resistor was called a bleeder resistor. Its function was to draw a certain constant "bleeder" current, placing a partial load on the power supply. As a result, variations in the load currents of the various stages did not cause so much change in the voltage. Atwater-Kent was one manufacturer who used this circuit extensively.

Figure 4-a shows a typical bleeder circuit. This bleeder was connected directly to ground. Figure 4-b shows another type

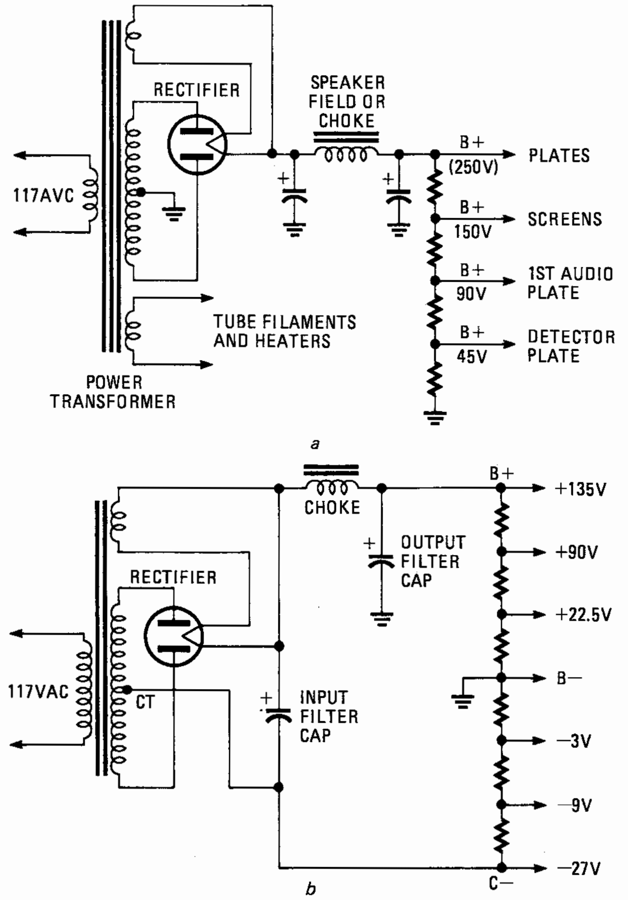


FIG. 4—BLEEDER DROPS THE B+ voltage for different stages of the receiver, while stabilizing the power-supply output(*a*); and (*b*) bleeder with negative end for bias.

that had a tap connected to ground and more resistors going to B− at the transformer center tap, so that they could tap off negative voltages for biasing.

Signal circuits

The oldest radios are all TRF (*T*uned *R*adio *F*requency) types. This means there was a string of RF amplifier stages, one after the other (cascaded) with a detector and audio amplifiers. There were two reasons why: First, this was the first radio receiver circuit, and second, RCA held a patent on the superheterodyne circuit! That circuit was invented during World War I by Major Edwin Armstrong. (Yes, "FM Armstrong" himself.) So, for quite a while, if you owned a superhet radio, it was an RCA model. Eventually all radios became superhets.

The TRF's comprise a string of up to three amplifier stages. More than three stages resulted in stability problems, to say nothing of tuning problems. The first sets had three separate tuning capacitors. Dials were calibrated from 0 to 100. (This resulted in your having to log the settings, with entries like "KDKA: 47-51-42"!)

Then a three-gang capacitor was developed that would track, and then the ad men had a field day selling "one-dial tuning"! Before then, however, some wild and wonderful schemes were used. The Atwater-Kent units drove all three tuning capacitors from the middle shaft, with the outboard capacitors driven by small belts made of thin brass on metal drums. (If you need a replacement for these, cut some thin strips of brass shim stock, and solder the ends together.) To prevent slippage, a tiny hole in the belt slipped over a pin on the drum.

The superheterodyne radios generally used separate triode oscillators with a tetrode mixer. The most popular (but not universal) intermediate frequency was 175 kHz. The IF transformers were generally tuned by a pair of mica compression trimmers, accessible through holes in the top of the shield cans. Some later transformers used powdered-iron cores, with a long, thin brass screw coming out the top and bottom. Since the ends of these screws were split (they broke off very easily, which caused problems) we soldered a nut on the end of the screw and used a *Bakelite* hex-tool to tune them). Some manufacturers used fixed-tuned IF transformers (the early Majestics, for instance) tuned them up at the factory and then ran the shield can full of hot tar. This is what I call an early example of encapsulation!

Several manufacturers followed the same procedure with the DC power supplies. The filter capacitors and chokes were mounted in a big square tin can and filled with tar. This is where the term filter block came from! You replaced the whole thing if any single part blew.

Servicing—parts substitution

Servicing the old sets can be fairly easy, especially if you have a schematic. Even though it was common practice then to omit DC voltage readings from the diagram, it's not difficult to check them. In early TRF sets with triodes, the B+ voltage is about +180—the voltage of four 45-volt B-batteries in series. This voltage will be used as plate voltage on the RF amplifiers and audio output stage, with about +90 volts on the first audio stage and still less on the detector stage—from +22.5 volts to +45 volts. These voltages are tapped-off the bleeder resistor, and negative bias is picked up as discussed earlier.

In the superheterodyne sets and in later sets using tetrodes, the B+ voltage is about +250 for plates, with about +100 to +150 on the screen grids.

Many sets used grid-leak detectors (see Fig. 5). The grid-leak resistor and grid capacitor were often unmarked. The resistor

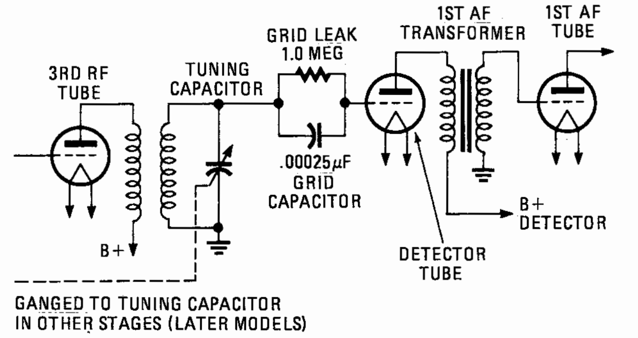
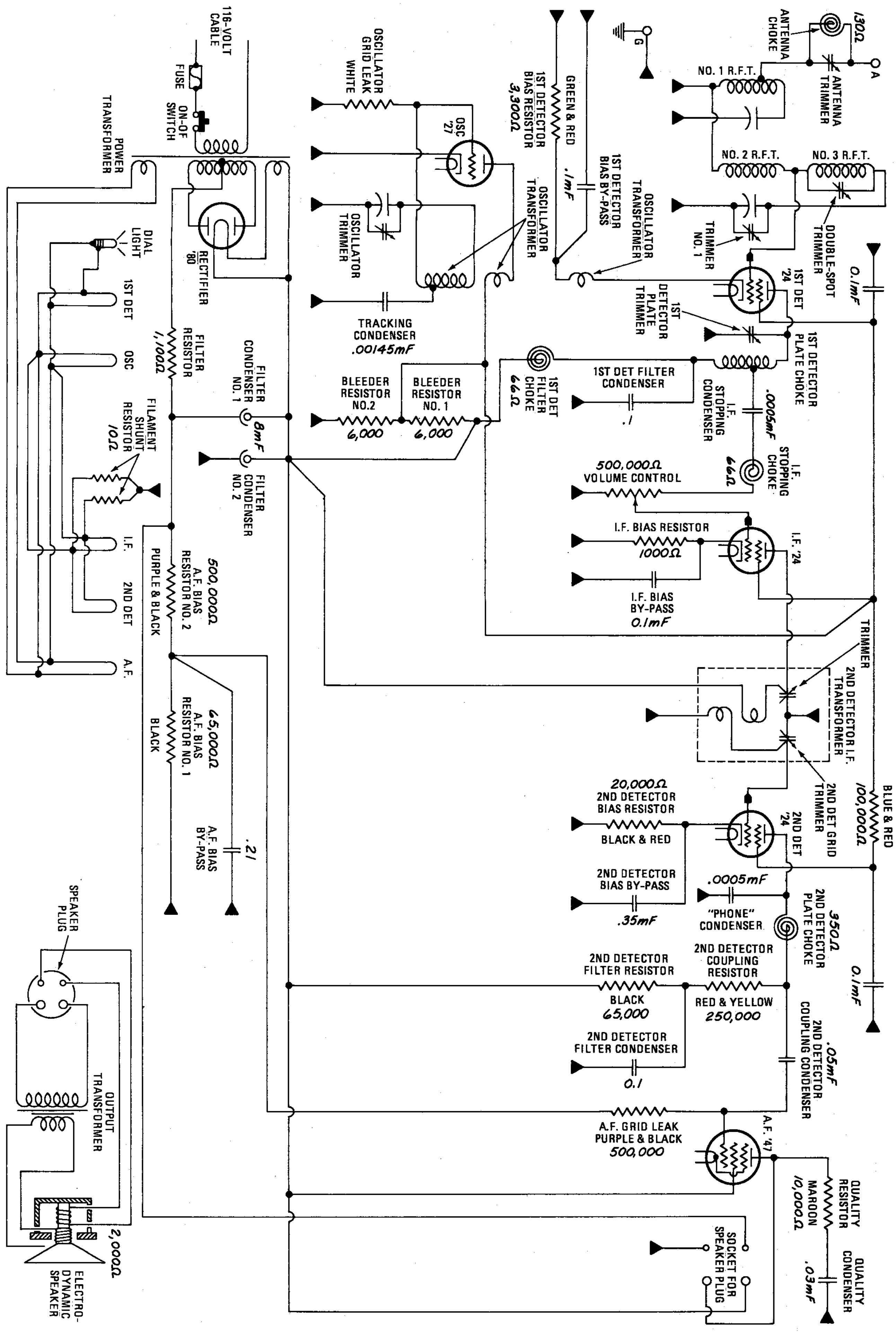


FIG. 5—GRID-LEAK DETECTOR USED in most old TRF radios. In many cases the "leak" resistor went direct from grid to ground.



EARLY SUPERHETERODYNE, the Atwater-Kent models 84 and 84-F.

was a glass-body type with metal end caps and was clip-mounted on the mica capacitor. The resistor value was usually 1.0 megohm, and the capacitor was 250 mmf—now called pF (or 0.00025 μF).

Servicing the B+ line

The first step in servicing the B+ line is to take all the tubes out. Now turn the set on and check the B+ voltages. (To know what reading to expect, check the AC voltage from either plate of the rectifier tube to ground. If it reads about 160 volts RMS, the B+ voltage will be +180. If it reads 220 volts RMS, then the B+ voltage will be about +250.)

The '80 rectifier tube will have to be left in, of course, to read the B+ voltage. If its plate becomes red-hot, turn it off *quickly*, you've got a short. If you check from the B+ voltage to ground, the cause of the short should be easy to find. For an easier test, lift up one end of the bleeder-resistor network. For a ballpark figure, these bleeders averaged about 25,000 to 50,000 ohms total in most sets.

Many older sets used paper filter capacitors with a range from 2 μF to 4 μF. This range was as much as these capacitors could have and still be small enough to fit into the cabinet. They can be replaced by 4 μF–8 μF, 450-working-volt, electrolytic tubular capacitors (noncritical). If the filter is encapsulated, find the shorted capacitor and clip off the lead. Fit the replacement capacitor under the chassis, if any. Make sure to connect the negative terminal to the right place.

The next step was the use of wet electrolytic filter capacitors. The first such type was a huge 3-inch brass or copper can with an insulating disc on top. This type was succeeded by the more familiar-looking aluminum can, which was about 1 inch in diameter. The advantage of the wet electrolytic capacitor was that it was truly self-healing. The can was one electrode, and an aluminum corkscrew was the other electrode; the electrolyte was really a liquid. If the capacitor arced over, it would heal up instantly and be as good as new! The disadvantage was that if you turned the chassis upside down to service it and forgot to tape over the *vents* on top of the filters, all the liquid leaked out and you had to replace all the filter capacitors! These electrolytic types ran about 8 μF at 450 working volts. They can also be replaced by tubular capacitors with the same capacitance or greater and the same working voltage.

Checking bleeders

If you discover that several B+ voltages are off-value, one of the bleeder resistors is probably open, and you'll need the schematic to find the value. If a diagram isn't available, you can determine the approximate resistance by connecting a 25K-50K potentiometer in the place of the open. Turn on the set and adjust the potentiometer until the B+ voltage at that point returns to normal. Use the ballpark voltages previously given as a guide. Then take the potentiometer out and read its value; replace it with a 5-watt wirewound resistor.

The early bleeders varied in type. Atwater-Kent used an odd variety—a large strand of asbestos that had resistance wire wound around it and then was insulated. The wire ends were made of blobs of molded solder, some up to 12 inches long, and they might use eight or ten taps. The underside of the chassis looked like a nest of snakes.

Another common and unpopular type of bleeder was called a *Candohm* (canned ohms). These resistors were flat and wirewound with taps connected to metal tabs. The entire resistor was insulated with empire cloth, a fabric soaked in fish oil, then covered with a tin shield that served as the mounting; hence the name, *Candohm*. This type of bleeder would break down to the grounded tin case, and was prone to developing intermittents. (One stock cure was to run a sharp-pointed knife down the wirewound resistor to make sure it stayed open, and then tack a 5-watt wirewound resistor to the terminals.)

Replacing IF transformers

If one of the IF transformers in an old set is open (a common occurrence) you can often substitute a modern-type IF transformer. Take the old transformer out of the shield can. Now select a replacement transformer and mount it on the chassis in the original hole. For the sake of appearance, you can put the original shield can back, and the set will look just like it did. I used this trick on a beautiful old Scott All-Wave radio that I was overhauling, and the set worked just as well as ever. You can obtain 175-kHz IF transformers in small cans from the J. W. Miller Company, as well as 262-kHz, 455-kHz and even 132-kHz types. Many sets then were supposed to be tuned to 450 kHz or 460 kHz, but any 455-kHz transformer will cover that range.

You may also find open RF coils. In many very old sets, these coils are often single-layer solenoids, wound on forms that are up to 2 to 3 inches in diameter. If those are bad, they can be completely rewound without too much trouble. (Most of the open circuits are at the coil ends and can be repaired by unwinding one turn and resoldering.) If the whole RF coil must be rewound, count the turns as you unwind the original and use the same size wire and the same winding direction. Even oscillator coils can be rewound if they're single-layer coils. If they are multiple-layer or honeycomb coils, a replacement can probably be found in an RF coil catalogue.

Checking tubes

If your tube tester won't check the old tubes, just plug the tubes into the set; if they light up, they may be good. The best tube test is signal-tracing. Feed a signal to the grid and read the signal on the plate. In the RF or IF stages, read the signal voltage at the detector output as you move the signal generator through the IF stages toward the antenna.

Many older tubes had such heavy filaments (to avoid hum; the heavy filaments had a much longer thermal lag between AC cycles) that they can be rejuvenated in the same way as picture tubes. Just raise the filament voltage about 10%, let it heat for a while, then try it.

You may have noticed that I've referred to tubes as " '01A," " '71A," etc. The apostrophe indicates that the last two numbers are the only ones that are really significant. At first, the tubes were designated "201A," "301A," etc. The first digit indicated the brand name—RCA tubes were all marked "2," Cunningham tubes were all marked "3," and so forth. (This description may not be precisely correct, but it gives you the general idea.)

Speakers

The oldest radios used horn speakers. They were driven by what amounted to a big earphone. Next came electromagnetic speakers, or just "magnetic" for short. These speakers had a pair of coils, driven by the output stage, which moved an iron vane or armature connected to a paper cone with an iron rod. Next came electrodynamic or moving-coil speakers, which were similar to those used today.

The big difference is that these old speakers had a "field coil," as I mentioned earlier. Current had to flow through it to provide the magnetic field. Some of the first speakers had their own separate field supply—a transformer, rectifier and filter that energized the field directly from the AC line. The next versions were used in series with the B+ line of the DC power supply. The field coil served as the filter choke.

Any of these dynamic speakers can be replaced by a modern PM dynamic speaker of the same size. Just connect the voice coil directly to the original output transformer, matching impedances, of course. Most speakers were 8-ohm voice-coil types. If the field was used as the filter choke, replace it with a suitable iron-core choke with an inductance around 8–10 henries at 250 mA.

If the output transformer is open, you can find replacements for them. The '12A tube has a load impedance of 10,000 ohms; the '71A's load is 5000 ohms, and so on. You can find the right load impedance for any transformer in supplements at the back

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of some receiving tube manuals. For example, GE's *Essential Characteristics* manual lists a great many older tubes.

Interstage audio transformers

The old sets all shared a common problem even when they were new—open interstage audio transformers. Winding impregnation hadn't reached its peak at that time. For some reason, the primary windings, with a fairly high positive voltage on them, would corrode at any pinhole in the insulation and then open. You can detect this by the presence of a bright green spot. (This also happened to IF and RF coils with positive voltages.)

If the primary of an interstage transformer is open, you can shunt it with a resistor of about the same value (from 25K–50K) and then connect a coupling capacitor from the plate to the grid of the next stage (see Fig. 6). You may even be able to find

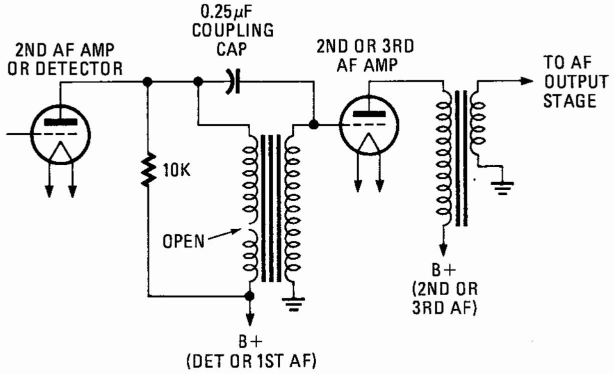

FIG. 6—"QUICK-AND-DIRTY" fix for an open AF transformer.

suitable replacement interstage audio transformers. They are not too critical—a ratio of about 10,000-ohm plate to a 30–50,000-ohm secondary, or a *step-up* of 3:1 or so.

Many old sets had these transformers potted; Atwater-Kent, for example. You might be able to melt the tar, get the old transformer out, then slip a new transformer inside and put the can back! The work—and dirt—is worthwhile only if you wish to maintain the antique appearance of the old set.

Service data

Service data is very helpful on all sets. For reliable data on very old radios, Gernsback's *Official Radio Service Manuals* and John F. Rider's *Perpetual Radio Troubleshooter's Manuals* are invaluable. Volume I of either manual contains most of the real oldies and quite a few more are in Volumes II through V. Another and readily available source of data on antique radios is Volume I of *Most-Often-Wanted 1926-1938 Radio Diagrams*. Mr. M. N. Beitman, at Supreme Publications, Box 46, Highland Park, IL 60035, is the publisher of the *Most-Often-Needed* series of service manuals. He also collects individual volumes and complete sets of Gernsback and Rider service manuals for resale.

One of the annoying things about service data in the early days was the manufacturers' reluctance to give anything but the bare schematic! (Does this sound familiar? There's nothing really new under the sun!) In fact, the Atwater-Kent Company forbade their distributors to inform service technicians about parts values! You asked for a black-and-white resistor and that's what you got.

(We found a way around this situation. Whenever any of us got his hands on a new model Atwater-Kent, he fixed it, then used his ohmmeter to measure all the resistance values! He kept a log of these values and, at the next Radio Trades Association meeting, made copies of everyone else's list. Finally, Atwater-Kent wrote down these values on the schematics, which you can find on many of the early models. **R-E**

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LETTER TO JACK DARR

I was reading your item in R-E August '73 and on page 69 you were wondering aloud why the Philco 39-45 had that weird 1st i.f. transformer with the third winding connected to the suppressor of the 78. I think this circuit was one of the wondrous variable selectivity ideas that were used in