

Classic Receiver Circuits Part 2 - The TRF Receiver

At the conclusion of the last installment, we made the point that one tube operating in a regenerative circuit actually does the work of three: functioning as a highly sensitive radio frequency (r.f.) amplifier, a detector and an audio frequency (a.f.) amplifier. Indeed, the rule of thumb is that it would take two tubes connected as r.f. amplifiers (without regeneration) and a separate detector/amplifier tube to provide the same performance as a single tube in a regenerative hookup.

Yet, looking for radios from the battery-operated era at any large antique radio swap meet, you are apt to find that the sets without regeneration (known as Tuned Radio Frequency, or TRF sets) far outnumber the simpler, smaller and (originally) much less expensive one-tube regen sets. Made in huge numbers, the TRF set, with its distinctive array of three large tuning dials, dominated America's living rooms throughout most of the 1920's.

Why such a marked preference for a much more expensive and (seemingly) more complicated radio receiver? There were a couple of very good reasons. For one thing, though the TRF receiver certainly had more tubes and controls, it was much easier to tune.

The regeneration control on a "regen" set required a very critical adjustment; too little regeneration and the set would be insensitive, too much and it would howl and squeal. The howls and squeals were not only annoying, but could also be picked up on neighbors' sets, interfering with their reception. Furthermore, the adjustment had to be changed each time a new station was tuned in.

It's true that *three* tuning dials had

to be manipulated to pick up a station on a TRF. But the dials tuned in and out smoothly, with no howling or instability, and the index settings on each of the three dials were usually quite similar for any given station. This was a much easier set for the



Detail from Gilfillan ad of 1925 shows Style GN-1, a handsome 3-dialer with doors to conceal controls.

non-technically-minded to operate--an important factor as radio began to evolve into a major medium for family entertainment. As an extra bonus, the three tuned circuits (contrasted with the single one used in most small regenerative receivers) enhanced the selectivity of these radios, making it easier to separate the growing number of radio stations that were beginning to appear on the dials.

Equally important was the fact that, after Westinghouse purchased the regeneration patent from inventor Armstrong towards the middle of the

1920's, licenses to use the circuit became difficult and expensive to obtain. Manufacturers who were not already licensed through Armstrong usually offered TRF designs.

A typical "three dial" TRF usually had five tubes: these included two stages of r.f. amplification, a grid-leak detector, and two stages of audio amplification. Though it was possible to obtain headphone volume directly from the detector, the extra audio amplifiers made it possible for the set to drive the horn-type loudspeakers of the day. The thinking obviously was that, if it was necessary to use three tubes to provide adequate headphone performance, one might as well add two more to operate a loudspeaker--something a one-tube regen wasn't able to do.

The tubes used were classically the ubiquitous type 01-A's. Plate voltage typically came from a couple of dry "B" batteries; filament voltage from a rechargeable automobile-style lead-acid storage battery. Sometimes, plug-in "battery eliminators" were substituted for one or both of these. These power sources were usually placed under the radio table, connected to the set above by a multi-conductor umbilical cord.

There was a problem associated with the design of TRF amplifiers, a problem that different manufacturers solved in different ways. An R.F. amplifier whose input and output is tuned to the same frequency (as is the case with TRF's) tends to be unstable, breaking into oscillation similar to that of a regenerative receiver--but not under operator control. This problem was aggravated by the high internal capacitance of the vacuum tubes of the day. Two of the better-known methods for dealing with the problem

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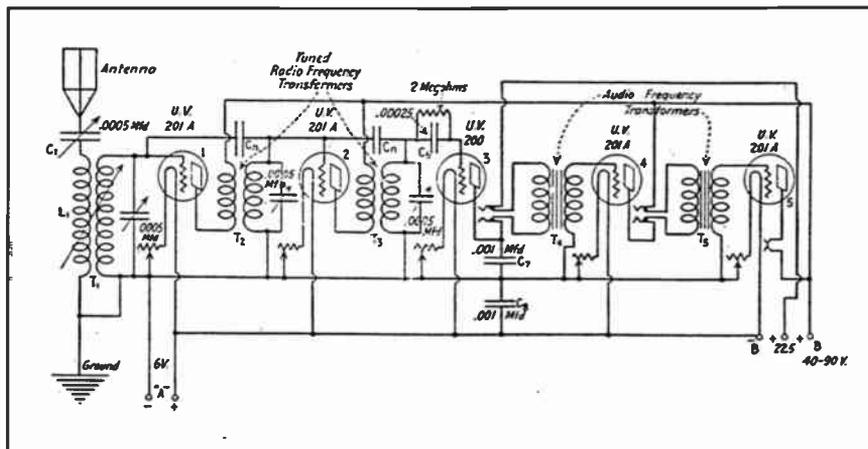
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Circuit of typical 5-tube Neutrodyne "3-dialer." Neutralizing condensers, located above r.f. transformers T2 and T3, are labeled "Cn."

were (1) through the use of neutralization and (2) through the use of "losser" circuitry.

The neutralization approach was introduced by the prominent radio inventor Hazeltine, who called his circuit the "Neutrodyne." Through coupling some of the energy from the tube's output circuit back into the grid through a small, precisely adjusted capacitor, the tube's internal capacity could be effectively canceled out—quelling the tendency to oscillate. A typical neutralizing capacitor, such as was used in the Freed Eisemann Neutrodyne sets, consisted of a pair of insulated wires inside a metal tube. The tube could be slid back and forth over the wires to achieve the precise capacitance required.

The "losser" principle simply involved making the r.f. amplifiers less sensitive through making them less efficient. By sacrificing some sensitivity, the tendency to oscillate could be eliminated without noticeably affecting the signals from broadcast stations. An inelegant solution to be sure, but it did work, making it unnecessary for the manufacturer to purchase a Hazeltine license.

There were several methods for introducing losses, and one of these was simply to avoid using the most efficient parameters in the design of the tuned circuits. Many manufacturers, Atwater Kent being among the most notable, also placed resistors in the grid circuits of the r.f. amplifier tubes to throttle down their gain.

In his book *Behind the Front Panel* (Wren Publishers, Philomath, Oregon, 1994, ISBN 1-885391-00-5), David Rutland tells us that in the Freshman "Mastepiece," a well-known TRF set of the 1920's, the tuning coils were mounted directly on the metal tuning capacitor

frames. That not only simplified the installation of the coils, but also resulted in eddy currents being induced from the coils into the steel frames, loading down the circuitry in the manner of a grid resistor without the expense of purchasing and installing the latter.

Also worth mentioning in any discussion of TRF receivers are the methods that were used to avoid unwanted coupling and interactions between the three tuning coils. Being large and bulky, these coils were difficult to keep physically separate. One was to mount the coils with their axes at right angles to each other. A more elegant solution worked out by Hazeltine (as described in the Rutland book), was to mount the coils in line, but with each one tilted at 57 degrees from horizontal. This angle was mathematically calculated to keep interactions to a minimum.

Though the "three-dialer" battery sets became obsolete in the late 1920's, when radios switched to a.c.-power and single-knob tuning, the TRF circuit lived on. Shafts now belted together within the cabinet, the three tuning capacitors and their associated coils were still present, and the circuitry was virtually identical. A little later, the three capacitors would be ganged together on a single shaft, resulting in much more compact construction.

The TRF was able to hold its own (for a while), even against the powerful new superheterodyne circuitry, because of the late-1920's introduction of the type 24 (later 24A) screen-grid tubes. The new tetrode (4-element) tube could amplify r.f. signals at very high gain without instability or oscillation. In fact, long after the superhet had become the dominant receiver design (as late as the 1940's and 1940's), TRF circuitry was still sometimes used in low-end sets.--MFE

PLAY IT AGAIN!

A No-Nonsense Course in Radio History, Evolution and Repair

THE EMERGENCE OF THE AC/DC SET OVERVIEW OF RADIO ALIGNMENT

Audio Transformers Disappear

The audio amplifiers we have studied coupled stages together with transformers. Early tubes had such low amplification factors that the additional voltage gain of transformers was necessary to get enough total voltage to drive the output tube. Fig. 1 shows another way to couple stages together using resistors and capacitors. It is called R-C coupling.

An audio signal on the grid of V1 varies the current through V1 correspondingly. This current flowing through the plate

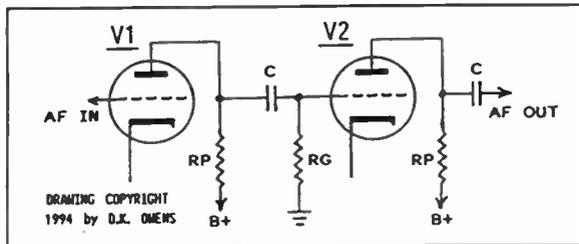


Fig. 1. Example of stages coupled by an R-C network.

resistor, RP, varies the voltage drop across RP causing the voltage at the plate of V1 to vary. The amplitude of the voltage at the grid of V1 is multiplied at the plate by V1's amplification factor. Coupling capacitor C passes the amplified audio to the grid of V2, but blocks the DC plate voltage from the grid. Old coupling capacitors are often leaky causing severe distortion. I always replace them.

Resistor RG returns the grid to ground. Control grids must always have a DC path to ground. The action of V2 is identical to V1. The network of RP, C and RG is passive and doesn't amplify. If the tubes are type 27's, the signal at the output will be amplified 8X in V1 and 8X in V2 for a total of 64X. The same amplifier using 1:3 ratio coupling transformers has a total gain of 576. Since two R-C coupled tubes only amplify 64X, a third tube is needed for the additional 8X to bring the total gain to an acceptable value of 512.

Although R-C coupling was well-known in the 1920's, designers were fixated on transformers despite their cost, poor fidelity and hum pickup. The development of the Type 47 output pentode in 1931 greatly reduced the amount of audio amplification needed. The voltage required to drive a tube to full output equals the grid bias. A Type 71A triode needs 40V of drive to get 0.8 watts out to the speaker, and a Type 45 needs 56V for 2 watts output. The 47 can deliver 2.7 watts output with only 16V of drive. The output

pentode made it possible to eliminate the audio transformers without using additional tubes.

Getting Along Without The Power Transformer

The next step was to get rid of the power transformer. In 1932-33, tube makers came out with the Type 43 output pentode and 25Z5 rectifier. Both used a heater-cathode operating at 25V, 300mA. The 25Z5 had 2 independent plates and cathodes so it could be used as a voltage doubler, though few used it that way. A 5-tube superhet was developed using existing 6V/300mA converter, IF and detector-

first audio tubes to go with the 25Z5 and 43. The filaments, wired in series, added up to 68V. With a resistor in the series to get rid of the other 42V, the filaments could be operated directly from the 110V AC line. The 25Z5 rectified the 110V AC to furnish the B+.

The filament (ballast) resistor took various forms: a big wirewound unit on the chassis, part of the line cord or packaged like a tube with its own socket. By 1939, tubes like the 12SA7, 12SK7, 12SQ7, 50L6 and 35Z5 had been developed. Their filament voltages add up to 121, eliminating the ballast. Filament current was reduced to 150mA for cooler operation.

This tube lineup was so commonly used that it was called the "All American Five". The tubes (and later their miniature equivalents) were used in tens of millions of radios until replaced by transistors.

In the 1930's there were still places where the residential power was DC. The fact that transformerless radios worked equally well on AC or DC was used as a selling point, and the radios came to be called AC/DC sets. The only difference between AC/DC superhets and those we have studied was in the power supply.

The development of cheap, high-capacity electrolytic filter capacitors allowed designers to substitute power resistors for the much more expensive filter chokes; the development of powerful permanent magnets for use in speakers meant that

speaker field coils could be eliminated.

The AC/DC Power Supply

Figure 2 shows the series filament wiring and power supply of a typical AC/DC set. Voltage for the 6V/150mA pilot lamp, PL, is obtained from a tap on the rectifier filament. The rectifier plate is fed through the tap and lamp. When first turned on, the lower resistance of the cold filaments makes the lamp flare up. It dims while the filaments warm up and then brightens again as B+ starts flowing through it. The lamp is an essential part of the circuit; operating the set without it will quickly burn out the rectifier filament.

R1 is a 20-50Ω resistor to absorb surges. V5 is a standard half-wave rectifier. Because of half-wave rectification and the absence of a filter choke, the filter capacitors, CF must be large (30-80μF). R2 (1-2KΩ) has little filtering action; it separates the 2 filter capacitors so they can act independently. This is called a "brute force" filter.

AC/DC Safety

Because of the power supply design, AC/DC radios can be killers. Notice that one side of the power line is the B- bus. In residential wiring, one wire is hot (115V) and the other is grounded (cold). Some makers actually used the chassis as the B- bus. Others floated the B- and connected it to the chassis through a capacitor for RF grounding. If the set is plugged in wrong, 115V will appear on the chassis, capacitor or not (capacitors conduct AC, but limit the current that can flow). If you touch the chassis while touching a grounded metal object or standing on a damp floor, you will get a nasty

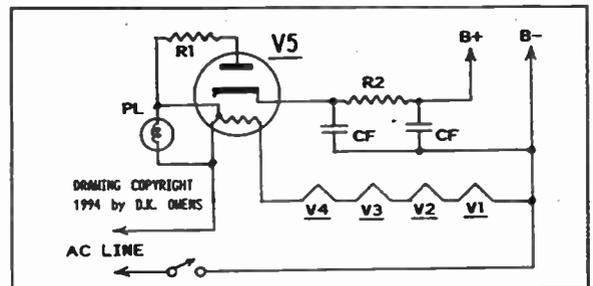


Fig. 2. Typical AC/DC power supply wiring.

shock or worse.

If you plug the set in correctly so the cold wire goes to B-, the chassis is cold,

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POWERING UP THOSE OLD FARM RADIOS (REVISITED)

An "A" and "B" Power Pack You Can Build From Scratch - Part 1

By Anthony P. Jacobi

In our previous article, we discussed powering up battery-pack type radios using a rebuilt commercial power pack to replace the 1.5-90V battery. Since these power packs are not always readily available, we will present some ideas for building your own "from the ground up."

The first item to find is a suitable power transformer. In the past, there were a few types available for smaller projects that had 6.3V and 125V secondaries. The most common were the Stancor PS-8415 and the heavier duty PA-8421. Either of these would be suitable for this project, and often can be found at antique parts dealers.

A modern version now available has 12.6V and 125V secondaries. Antique Electronic Supply lists one of these as part #PT-442. Fair Radio Sales has an equivalent unit listed as Stancor P-8624. Both of these are rated at 12.6V @ 300MA and 125V @ 15MA. They are for light duty use, but are adequate for the most common 4 or 5 tube sets if the filament current total is not over 300 MA. I have used two of these in parallel for heavier duty requirements. (Fair Radio Sales' price is reasonable enough to warrant this.)

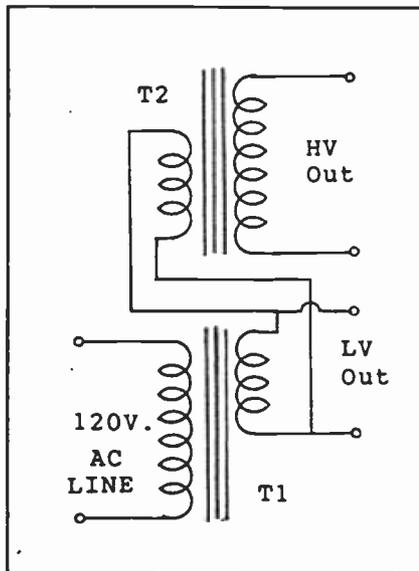


Fig. 1. Method of wiring two filament transformers back-to-back to provide required low and high voltage.

There are also still plenty of filament transformers available with 6.3 or 12.6 volt outputs at various current ratings. Using two of them back-to-back (Fig. 1) makes a good substitute for the dual second-

dary types. With this method the low voltage windings are connected to each other. It is best that the low voltage winding of each transformer be of the same value. With windings having a center-tap, more combinations are possible.

When using this system, the line transformer (T1) must supply the current for both the low voltage and the high voltage of the power pack. Therefore, its secondary requires a higher current rating than that of the HV transformer T2. For our use here, T1 should be at least a 1.0 A unit, and T-2 could be a 500 MA unit.

Our goal is to have a pack with outputs of 90 to 95 Volts DC for the 'B' supply, and 1.4 to 1.5 Volts DC for the 'A' supply—preferably about 1.45 V. The 1.4V tubes used in farm sets (and portables) are very critical as to overvoltage, and can be burned out with just a few tenths too much voltage. So, to insure good control of that, use of a regulator at the 1.4V output is recommended. The solid state LM317T is an inexpensive unit, and works very well for this.

Since there are several transformer and voltage combinations available, some experimentation is needed to get the correct values of dropping resistors for a particular set-up. Light duty (low current capacity) transformers will drop more voltage internally and therefore heat up more, resulting in lower voltages out under load. Heavier duty types have larger wire and less internal resistance, so the output voltages are less affected by normal loads.

Generally, with a 6.3V transformer, I use a full-wave bridge rectifier so as to have enough extra voltage for the regulator to function properly. With a 12.6V type, I use a single diode half-wave. This helps cut down the excess voltage slightly, with a power resistor dropping the rest. For the HV section, a half-wave rectifier works well, using a control resistor to adjust the voltage under load.

Many farm sets used the standard tube line-up of 1A7, 1N5, 1H5, and 1C5, or similar, drawing 250 ma for the filaments and about 10 ma for the high voltage. So, we will build our power pack for this type set using the Fair Radio Sales transformer P-8624. If your set uses more tubes, a heavier current transformer will be needed, or you can wire two of the P-8624 in parallel.

Fig. 2 shows the circuit we will be using.

Part two of this article, which will run in the next issue, contains additional circuit details and construction hints. See you then!

PLAY IT AGAIN

(continued from P. 3)

but only while the set is turned on. When you turn it off, the chassis is disconnected from ground. 115V will then flow through the filament string (150mA) and appear on the chassis. Even if the chassis is isolated from B- with a capacitor, I refuse to trust the cheap paper capacitor usually used. The only safe AC/DC set is an unplugged one!

Most sets made after World War II are well insulated against accidental contact with the chassis when the cabinet, knobs and back are intact. They are safe in the bedroom, but are not to be trusted in the bathroom or kitchen where the user can easily be grounded through the plumbing.

How do we safely work on AC/DC sets when they are out of the cabinet? We use an isolation transformer. This transformer has 2 separate 115V windings. The input winding is plugged into the AC line. The floating 115V output has no hot and cold wire, therefore no voltage exists between it and ground.

The average AC/DC set draws ~30 watts. You can get isolation transformers rated at 1A (100W) for less than \$15 from Fair Radio Sales, P.O. Box 1105, Lima, OH 45802 or Hosfelt Electronics, 2700 Sunset Blvd., Steubenville, OH 43952. Don't work on any AC/DC set without an isolation transformer!

Aligning Sets From Different Eras

Alignment is the process of synchronizing the various tuned circuits in a radio so that they track (maintain the correct frequency relationships) over the entire tuning range. There are small, screw-adjustable capacitors called "trimmers" in parallel with the main tuning capacitors to "trim" out variations in coils and capacitors resulting from manufacturing tolerances. Superhets also have trimmers in the IF transformers for precise tuning.

Early TRF sets like the Radiola 17 and AK 40 had no trimmers of any kind. Tuning was non-critical, and manufacturing tolerances were good enough for satisfactory tracking. Neutrodyne had neutralizing capacitors, but once adjusted correctly, they need never be touched, again unless somebody tampered with them.

If your Neutrodyne whistles, the neutralizing capacitors need adjusting. Remember that the Neutrodyne works by

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CORRESPONDENCE FROM OUR READERS

letters may be paraphrased, shortened, or otherwise edited so that everyone gets a chance at the floor!

Kudos for Rybak and Kryzhanovsky

Please publish my congratulations to Rybak and Kryzhanovsky for their fair and accurate series on early wireless, especially the contributions of Aleksandr Popov. Their use of sources not generally available makes it especially valuable. We tend to focus on the British and American pioneers forgetting that important work was done in France, Russia, Germany and Holland also. Braun shared the Nobel Prize with Marconi, but how many people know what Braun did?—Ken Owens, Circleville, OH

Re: Volume 3, Numbers 1 & 2 -- another first rate issue(s).

I've been following *The Early Development of Wireless Communication* by Rybak and Kryzhanovsky -- very, very interesting.

I am particularly interested in the references to Russian activities in the development of wireless. The authors may wish to know that Popov delivered a lecture before the All Russian Technical Congress in 1900. It was during that lecture that Popov confirmed that Nikola Tesla had unselfishly disclosed to the world in 1893 (three years before Popov) his pioneer work on wireless telegraphy.

Thanks for a fine publication.—Harry Goldman, Tesla Coil Builders Association, Queensbury, NY.

Filament Safeguards

I very much enjoyed Mr. Jacobi's article on the old battery eliminators in the March/April issue. He is painfully correct in his statement that 1.4V filament tubes can be easily terminated by over-voltage.

Here are a couple of circuits that will safeguard filaments not only from a regulator failure, but also from an internal plate/screen/filament short (rare, but it can happen), or much more likely a slipped test probe shorting a B+ connection to the filament string

The circuit of Fig. 1 protects 1.4-volt filament tubes. D1 and D2 are any silicon diodes, 1N4001 or equivalent. F1 should be rated at about 50% greater than the filament current of the set and should be a fast-blow type. In this setup, the diodes act as .7V Zeners and will

start conducting hard at slightly better than 1.4V (2 X .7V).

The circuit of Fig. 2 protects 6V filaments. F1 should be as specified for

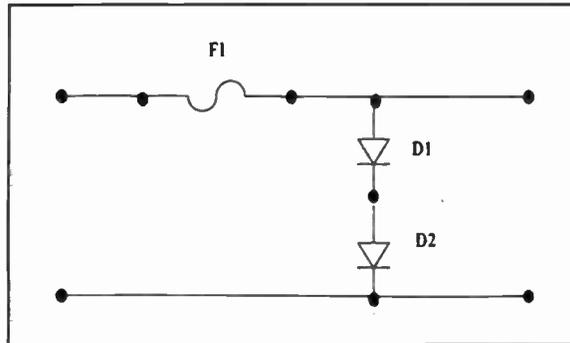


Fig. 1. Protection circuit for 1.4V tubes. D.c. input at left; d.c. output at right.

the 1.4V circuit. Use any garden variety unit for the SCR. R1 is about 250 ohms; R2 is 10 ohms; C1 is 1 mfd. The Zener is 6.8V, 1/2 watt. The regulator should be an adjustable one capable of handling the filament current.

If the output voltage exceeds 6.8V, the Zener conducts and triggers the SCR which will blow the fuse. It is very fast-acting.

I used this circuit on a power supply for a set whose filament current measured 1.4 amps, so I installed a 2-amp fuse and an NTE935 regulator.

Impressed With Henney

Recently a radio friend gave me a copy of *Radio Engineering Handbook* Edited by Keith Henney (Fourth Edition, McGraw-

Hill, 1950). Though I do own a Second Edition (1932), which is very average by comparison, I had never seen this book before and was very impressed by it. Each of the chapters was written by someone tops in the field at the time. The chapter on TV was written by Don Fink, who was on first standards committee in the late 1930's. I have his television engineering book of 1952. Alas, Don died on May 23, 1996 at age 84.

The Henney volume is very thoroughly written and, though I haven't finished it yet, I've already discovered numerous details I was unaware of. The closest books to Henney's in my possession are Don Fink's *Electronics Engineering Handbook* of 1975 (being quite a bit later, it contains lots of semiconductor data) and *The Standard handbook For Electrical Engineers* by Fink and Beatty (1978). These are both big heavy-duty books and, while a bit much for old radio buffs, are certainly books to keep an eye open for.

Find the Henney first, though! I checked on its availability before writing this recommendation and discovered it was not easy to locate. One technical book dealer at a swap meet I recently attended did have a copy in very good condition for \$18.00. The things I don't like about this book are purely physical, the covers are of the "limp" type and a little flimsy, also it is printed on very thin paper (1185 pages).—Ray Larson, W. Los Angeles, CA.

Answers to Info Exchange Questions

In the last issue's "Information Exchange," Gary Van Santen mentioned that his tube tester had neither sockets nor charts for testing older tubes such as the 42, 77 or 80. He wondered if it might be possible to build an adapter to handle these tubes. If Gary would let us know the make and model of his tester, I may be able to help. In a nutshell, an adapter might be practical if the instrument is a modern G_m tester such as the Hickock 6000A. But it wouldn't be

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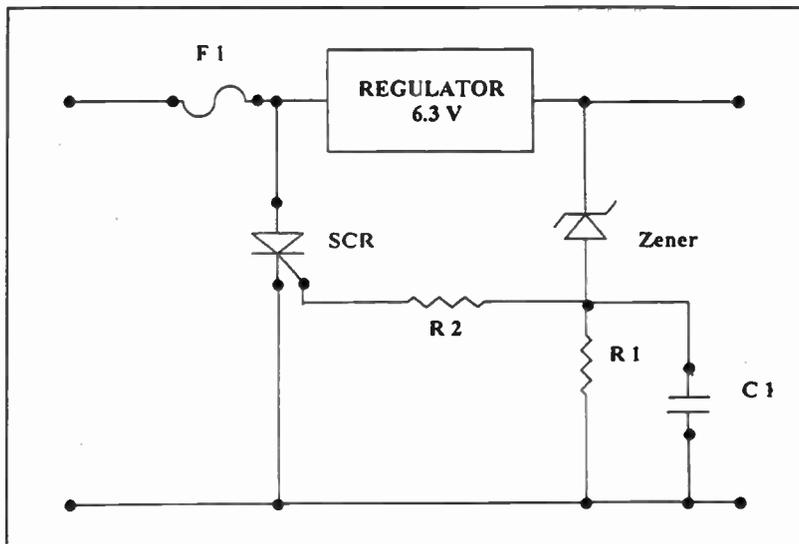


Fig. 2. Protection circuit for 6V tubes. D.c. input at left; d.c. output at right.

PLAY IT AGAIN

(continued from p. 4)

feeding back an equal amount of signal opposite in phase to that leaking through the grid-plate capacitance of the tube. To neutralize one of these sets, you need a dummy tube. Years ago we cut one of the filament pins off a good tube to make a dummy. Today we wrap the filament pin with tape. We don't want the tube to work. It merely provides grid-plate capacitance. Do not use a burned-out tube. The broken filament may be shorted to other tube elements.

Tune in a station. Turn off the set, put the dummy tube in the neutralized stage nearest the detector and turn the set back on. *Never change tubes in an operating set.* Any signal you hear is leaking through the g-p capacitance of the dummy tube. Balance out this leakage by adjusting the neutralizing capacitor for *minimum* volume. Repeat with any other neutralized stages. The adjustment of neutralization is not an alignment process according to the definition I gave you earlier but—like alignment—is a critical adjustment that must sometimes be made.

The alignment of superhets is much more critical than TRF's. The difference between the oscillator and station frequencies must be precisely maintained at the IF over the entire tuning range. Also, the IF transformers must be tuned exactly to the intermediate frequency. Early set manufacturers took great pains to calibrate the tuning dial so that stations came in exactly where they were supposed to.

Trimmers and Padders

We have already covered IF tuning, but not RF and oscillator alignment. Early superhets used the tuning circuit shown in Fig. 3. L is the oscillator tank coil and CV is the main variable capacitor. CT is a small (10-50pF) mica compression trimmer capacitor in parallel with CV. CV is usually an integral part of CV. CP, in series with CV-CT, is called a "padder" capacitor. It is a separate compression capacitor having a value of several hundred pF.

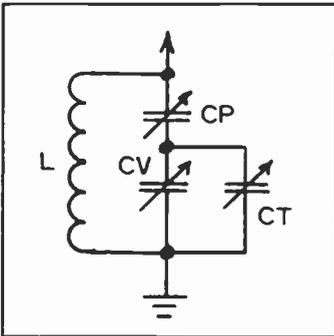


Fig. 3. Generalized r.f. alignment circuit as used in older superhets.

When CV is near minimum capacity

(high end of the band), CT is a significant fraction of the total capacity and has a large effect on the tuning. At low frequency, CT is a small fraction of the total with minimal effect. Because it is in series with CV, the action of CP is the opposite. This circuit allows independent calibration of the high and low ends of the tuning range. RF tuning is more critical at the high end, so RF sections of the main variable capacitor also have trimmers, but padders are not used.

In the mid-1930's, makers realized that the public didn't really care about accurate dial calibration so they quit using padders on most sets.

Next time we will present a complete 5-tube superhet, take a look at its circuit, and give detailed alignment instructions. We'll also begin a discussion of the power supply circuits used in a.c. sets (sets with power transformers).

CORRESPONDENCE

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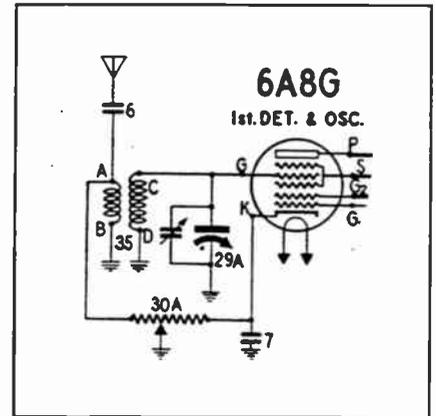
worthwhile to go to that kind of trouble if the tester is an emission "cheapo."

Gary also had questions about which tolerance to use when replacing resistors and how much variance in value was acceptable in replacing capacitors. On the resistor question, I'd suggest just using 5% for everything. You can hardly buy anything else now, anyway, and the things are dirt cheap. In actuality, no radio uses circuitry that requires better than 20% tolerance (with the exception of heater voltage-droppers), so usually any old thing will do.

Regarding the capacitor question, those in frequency determining circuits obviously must be replaced with an exact match. But since these are usually micas or ceramics, they'll rarely need changing. When it comes to paper capacitors, bypasses can be larger; coupling capacitors can usually be larger (though this may lead to an undesirable increase in bass response); tone control caps should be roughly the same (+/- 50%). Line bypasses should be replaced with ceramic units. (I'm out of touch, but I think paper capacitors can catch fire in this application and even mylars may be unsafe.)

Depression Radio Volume Control

Many collectors have never encountered an unusual and ingenious volume control circuit that was frequently used in small, inexpensive TRF (and some superhet) receivers of the 1930's. In the accompanying schematic, which is for a Firestone 4-tube superhet—Models S7425-7426—the volume control is labeled 30A. Notice that the resistance element of the pot is connected between the antenna (!) and the cathode of the first r.f. stage and the wiper arm is grounded. Actually, back then, wiper arms were usually grounded to the body of the pot (and hence to the chassis) because it was easier to make pots that way.



Quite often these sets had a fixed 400-ohm bias resistor in the cathode return, and it wasn't unusual for this resistance section to be included in the volume control pot in order to keep the parts count down. I once found such a pot in an Emerson Model 20 (an early AC/DC set). It was defective, so I had to replace it with a standard pot and a separate 400-ohm resistor. It worked fine.—Ray Larson, West Los Angeles, CA

Latest Xtal Set Society book

CRYSTAL RADIO: HISTORY, FUNDAMENTALS, AND DESIGN, by P.A. Kinzie. Published by the Xtal Set Society, P.O. Box 3026, St. Louis, MO 63130. 119 pages. 5 1/4" x 8 1/4". softcover. \$10.95 plus \$2.50 s&h.

This latest addition to the books published by the Xtal set society neatly bridges a gap in the literature of the crystal set. The volume is the product of the author's life-long interest in crystal radios. P.A. (Phil) Kinzie built his first crystal set at the age of ten. He went on to win a Master's degree in Engineering and worked on aircraft and space test instrumentation projects.

The reign of the crystal set was brief—perhaps 30 years or so—but the crystal opened up the key to a whole world of point-to-point and broadcast communications as we know it. *Crystal Radio* provides the radio collector with some concise but comprehensive information about the development of crystal radios and what they need to make them work.

In the book's three major sections, Kinzie covers the historical development of the crystal detector; the fundamentals of receivers; and crystal set design. A fourth section deals with the crystal material itself. Each section includes a bibliography or related current and historical books and articles for further reference.

In all, *Crystal Radios* is a book well worth having in your library. Another recent publication of the Xtal Set Society is also worthy of note: *Crystal Sets: Volume V* includes the six issues of the Society's newsletter ending November, 1995. (85 pages. 5 1/4" x 8 1/4". softcover. \$9.95. \$2.50 s&h if ordered alone, but no additional s&h charge if ordered along with *Crystal Radios*.)—Julian Jablin, Skokie, IL

VINTAGE BOOK REVIEWS

Books from the era when vintage radios were new! Look for them at swap meets, flea markets and used book stores.

PRACTICAL RADIO SERVICING by William Marcus and Alex Levy. Published by McGraw-Hill Book Co, 1955. 565 pages. Hardbound.

For many radio collectors, bringing an old set back to life is one of the most pleasant parts of the hobby. To repair radios safely and properly, expertise must be gathered from many sources. Courses and workshops in antique radio repair are rare, so most of us pick up the knowledge we need from friends and through self-study.

There are some very fine books on the repair of vintage radios currently in print, but older texts offer the reader a different slant and often have a better approach. One group of such books is the so-called "Marcus" series. Co-written by William Marcus and other authors, they were meant to be used as radio servicing textbooks by high and vocational schools.

Since they were originally sold in fairly large quantities, these volumes are readily and inexpensively available at swap meets and used book stores. The next group of books to be reviewed in this column will be from the "Marcus Series."

Practical Radio Servicing was written as an entry-level text. It is quite basic and practical in its "building-block" approach. The authors suggest that the student acquire an "old" AC/DC set on which to practice while studying. This is also an excellent way for a radio collector to gain experience—while ending up with a restored set at the end of the process!

The first section covers the general operation of a radio receiver and reviews the tools and equipment necessary for radio service work. The most common problems encountered in radio servicing are also discussed.

The next part of the book discusses the operation and servicing of the radio power supply. This is quite logical since the power supply must be functioning properly before other key tests can be made. It is also one of the most failure-prone areas of the set. Only AC/DC (transformerless) power supplies are covered.

The section that follows deals with the operation and repair of the audio stages. This follows the logical order of radio servicing. Normally, after the power supply is found to be functioning properly, the repair person starts troubleshooting at the speaker and works back to the antenna. Record player servicing is also included in this section.

Following the same logic, the intermediate frequency, second detector and AVC circuits are covered next. In addition to the operation and troubleshooting of these circuits, alignment techniques and the use of the signal generator are explained. A treatment of the converter circuit completes the in-depth study of the operation and repair of AC/DC sets.

What follows are two chapters devoted to specific problems with battery portables and three way (AC/DC/battery) sets. The final chapter is a summary of service procedures and is symptom-based. A good index concludes the book.

Within its limitations, Practical Radio Servicing is a good book for the beginning repairman/restorer. Since it was written as a textbook, it follows a logical and progressive order that is easy to read and follow. There are questions at the end of many chapters, and at the conclusion of each section there is an "Experience Gaining Plan" with practical, work-related exercises. Throughout the book there are handy diagnostic charts as well as many drawings and pictures of good quality. There is very little radio theory and practically no mathematics.

The downside of this book is that it is oriented almost exclusively to the AC/DC radio with little coverage of transformer type sets.

ELEMENTS OF RADIO SERVICING by William Marcus and Alex Levy. Published by McGraw-Hill Book Company, 1955. 566 pages. Hardbound.

Elements of Radio Servicing is another book in the "Marcus" series of textbooks designed for the high and vocational school training of radio servicemen. While it was published in the same

year as Practical Radio Servicing and written by the same authoring team, it is not the same book. *Elements of Radio Servicing* is a more advanced book, covering a broader range of consumer electronic items. But a study of *Practical Radio Servicing* is not a prerequisite. *Elements* stands just fine on its own.

The beginning chapters cover the superheterodyne receiver, various servicing procedures, and the use of test equipment. Emphasis is on the multimeter and signal generator, especially the latter. The authors also expect the reader to be familiar with the basics of electricity.

The strong emphasis on the signal generator is continued throughout the book. Circuits had become so complicated by the mid-fifties that signal tracing was about the only way many problems could be found. With the advent of FM and TV, this was especially true. However, the authors emphasized that a balance of different servicing procedures was the best for rapid and efficient servicing. Time was money, so rapid and accurate work was essential. Adhering to strict procedural dogma was unrealistic.

The next chapter is on the understanding and servicing of power supplies, with emphasis on transformer designs. For the radio collector/restorer, this is important. Transformer type power supplies are commonly encountered and more complex than AC/DC supplies.

The following series of chapters discusses the operation, problems and repair of all of the circuits and components of a radio starting with the loudspeaker and going back to the antenna. Included are discussions of loudspeakers and RF amplifiers not found in *Practical Radio Servicing*. A thorough study of these chapters will give the reader a good understanding of all of the circuits found in AC superheterodyne sets.

Next come chapters dealing with other types of sets that the repairman was likely to encounter: AC/DC radios, auto radios, portable sets, FM and AM/FM sets are covered, as are AM and FM alignment. Much of this information, not found in *Practical Radio Servicing*, is very useful to antique radio restorers.

The concluding chapters suggest service procedures based upon the complaints reported by the owner and discuss the construction of a radio service bench. The service procedure chapter is quite useful, sometimes making it possible to sidestep the formal troubleshooting process and go directly to the route of the trouble. The chapter on service bench construction will be valuable to those who want to get into serious radio work.

The appendix contains color codes, common abbreviations, pin diagrams and schematic symbols. There is also a list of film strips that apparently were available as training aids for instructors. The film strips went hand in hand with the material in the book. It would be interesting to find a set of them. The index is fairly extensive.

Elements of Radio Servicing, while more detailed than *Practical Radio Servicing*, is not more difficult to study. Since it contains much material useful to the general radio collector, *Elements* is highly recommended. The book is as easy to use as a text can be and has almost no math. One gets the impression that the authors are interested in your learning how to fix radios, not in pontificating from on high. The pictures and drawings are high both in quality and quantity. Especially useful are the service charts placed throughout the book.

This is a fairly common and inexpensive book that should be in the library of anyone who wants to bring old radios back to life.

If you have any questions concerning vintage radio books, please feel free to contact me at any time.

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COMPANY CHRONICLES

Brief Biographies of Classic Radio Manufacturers



Zenith Radio had its beginnings right after World War I when two radio ham buddies, in anticipation of radio amateur privileges being restored, organized the Chicago Radio Laboratory to manufacture equipment for the radio amateur trade. Working out of a prefab two-car garage erected for the purpose, R.H.G. Mathews and Karl Hassel set up first to build amplifier modules and eventually (after receiving a regenerative license from inventor Armstrong) complete receivers. The building also housed Mathews' ham station, 9ZN.

For their first receivers, which were essentially copies of the paragon RA-6, the pair cavalierly appropriated the Paragon name. However, under pressure from the Adams-Morgan Company, owners of the marque, CRL had to choose a different brand name—the "ZNith Regenerator."

In 1921, the company was moved to the third floor of a factory building and upped its production from one to ten sets per week. About that time, CRL built a radio for Commander Eugene F. McDonald, Jr. The Commander was a wealthy man who had liquidated his business interests prior to a wartime stint with Naval Intelligence. He had become interested in radio and was looking for a new business to enter. Impressed with CRL, he was soon supplying both capital and business guidance.

McDonald brokered a deal with the QRS Music Company (the well-known manufacturers of piano rolls) to become manufacturing and sales agent for a line of broadcast radios developed by CRL. But the arrangement was not permanent. In 1923 the Zenith Radio Corp., under the firm control of Commander McDonald, was formed to replace QRS. (Legally, Zenith could not manufacture in its own right because the Armstrong regenerative license was not transferable).

In 1924, Westinghouse (which now owned the Armstrong patents) filed suit against Zenith for overstepping the conditions of CRL's regenerative license by selling to other than radio amateurs. However, for some reason the suit was never tried and seems to have been dropped in 1927. About the same time, apparently emboldened by the disappearance of the suit, Zenith absorbed CRL and formally took over the manufacturing role.

Zenith made headlines by supplying the radio equipment for explorer Donald MacMillan's 1923-1924 and 1925 Arctic expeditions. Commander McDonald actually participated in the 1925 expedition as captain of the second ship. A master of sales promotion, McDonald also kept Zenith in the public eye through its broadcasting activities. Station WJAZ opened for business in 1923 with studios in Chicago's Edgewater Beach Hotel.

The Company went through a tough period in 1926, when not only were business conditions poor but also the product line was high-priced and contained little that was new. Zenith weathered this crisis with the release of the Model 27, a pioneering a.c.-operated set that incorporated many components from the company's large stockpile of materials for earlier battery models.

After 1927, when the company purchased a license to use RCA patents, the Zenith models lost some of their distinctiveness—becoming similar to those of other manufacturers. But, through clever advertising, consummate marketer McDonald was able to create a product differentiation that did not actually exist. The company remained among the half-dozen industry leaders until the Depression, when it added low-cost models to its line and emulated Philco's aggressive sales tactics. By the end of the 1930's Zenith was in the number two spot among radio manufacturers and the company has remained successful to this day.

The information for this company biography was obtained from Alan Douglas' three-volume encyclopedia "Radio Manufacturers of the 1920's," published by Sonoran Publishing, 116 N. Roosevelt, Suite 121, Chandler, AZ 85226, and copyrighted 1988, 1989 and 1991 by Alan Douglas.

DICK'S CORNER

Tips and Tidbits from the World of Antique Radio Collecting and Restoring

Troubleshooting Crystal Sets

Many radio collectors wish to experience radio receiving as it was in the very early days. They will purchase a vintage crystal radio, or perhaps replicate an early set. More than one collector who has gone to this trouble has been very disappointed to find that the newly purchased or constructed set receives nothing at all! In this article, I'll try to cover the most common problems encountered by the beginning crystal set enthusiast.

First and foremost, you will need a good *outdoor* antenna. Fifty feet long is acceptable, 100 feet is better! Keep the antenna away from power lines and high enough not to be dangerous to children at play. Solder the lead-in connection to the antenna wire. Next, ensure a good earth ground for your set via a connection to a *metal* cold water pipe or an eight foot copper rod driven fully into the soil.

If the set is a vintage unit that tunes via a sliding contact, use a magnifying glass to examine the coil where the slider has contacted it. If too much pressure has been applied to this slider over time, the turns of the coil may have flattened, shorting against each other and destroying the inductance. At this point there are only two choices: (1) place the set on the shelf for display only, or (2) obtain the best available replacement wire and re-wind the coil. (Very close attention must be paid to wire size, insulation type, even the correct shade of insulation color.)

Let's assume the coil is good, no tuning capacitor plates are touching, all connections are well soldered or screwed together, and a check of early literature shows the circuit is correct. The next likely problem is a faulty crystal. If the set uses an early *fixed* detector, it probably won't work. These were little more than adjustable detectors with fixed adjustments. And the ad-

justments simply didn't last. Disassembling one of these detectors will usually ruin it; substitute a small (hidden) 1N34A diode, leaving the fixed detector in place for appearance.

If the set has an adjustable detector with a replaceable crystal, it's a good idea to try a new crystal. Never use a sharp pointed cat's whisker except with a carborundum crystal. A sharp point will ruin a new galena crystal. The catwhisker wire, no matter how small in diameter, should always have a blunt point.

The last major source of potential problems is the headset. Forget the cheap crystal units often supplied with small kits etc. Use a good pair of electromagnetic phones with a d.c. resistance of at least 1500 ohms. Keep the tips on the ends of the phone cord clean and shiny with a bit of fine steel wool. Dirty, oxidized tips will really detract from headphone performance.

If you still have no reception, hook an r.f. signal generator to a coil a few inches in diameter, made with three or four turns of hookup wire. Place this close to the set. Tune the generator to a spot near the middle of the broadcast band. Temporarily substitute a good 1N34A diode for the adjustable crystal.

Adjust sliders, tap switches, variable capacitors, etc. for best reception, lowering the generator output or moving the signal coil away from the set, as necessary, to avoid overloading the phones. When everything is adjusted for best reception with minimum output from the generator, remove the 1N34A and re-connect your adjustable detector. When the cat's whisker is properly adjusted on a good crystal, the output should be almost identical to that obtained with 1N34A.

After some experience with adjusting the cat's whisker and tuning your set, you'll find that the generator will no longer be necessary. Happy DXing!--Conducted by Dick Mackiewicz

THE INTERNET CONNECTION

Information From and About Antique Radio in Cyberspace

Paper Capacitor Question

This month I thought we'd take a different tack and explore more of the "meat" that can be found by "surfing" the Internet and newsgroups for antique-radio-related items and message threads.

This is a message thread from the Boatanchors Mailing List regarding the life expectancy of wax-paper dielectric capacitors. One person had seen data on this type of capacitor and had asked if most wax-paper caps "died" not from use, but just from old age effects, as the data he had seen indicated.

The first reply. . .

"(From "Reference Data for Radio Engineers," 1949) Capacitors - paper-dielectric Life - voltage and ambient temperature: Normal paper-dielectric-capacitor voltage ratings are for an ambient temperature of 40 degrees Centigrade, and provide a life expectancy of approximately 1 year of continuous service. I guess most of them die not from use (1 year = 8,700 hours) but from old age...Comments?"

. . . and a follow-up reply.

"Good question. Alfred Ghirardi, in 'Radio Physics Course' (1931-33) gives a detailed explanation of how wax-paper condensers were made, and states that they are designed to have an operating life of 10,000 hours. He mentions a failure mode involving dielectric breakdown of the paper dielectric. At the time he was writing, the type of wax-paper condenser that we talk about changing out in an old box [i.e. radio] was fairly new.

To make some estimate of usage of home entertainment radios in the 1930 period, assume that the set was operated four hours per day, five days per week. That gives about 1,000 hours per year of operation, and 10,000 hours would be about ten years of service. The 10,000 operating hour figure is a fairly common one, both for commercial and consumer electronics design.

The question arises, how do you prove that these components will last for ten years, operated at 1,000 hours per year, without using up ten years in a 'real life' test? Here, you get into attempts to devise 'accelerated life tests' that will induce failures fairly quickly, and great statistical studies that supposedly extrapolate out to something that more-or-less represents real-world use of something. A sociologist friend of mine, who gets hired to set up statistical research studies is rather blunt in saying that all such studies are 'demonstrably flawed.' I say this to point out that accelerated testing requires a lot of assumptions, and that not all factors relating to failure modes get included in accelerated tests. Almost any device has aging mechanism that accumulate some sort of 'service life' or deterioration while sitting unused in storage. The stuff we are collecting has been around for somewhere between forty and seventy years, and it is well to remember that most of the manufacturing processes used to make this stuff were only a few years old when it was made. It's easy to find a 1935 capacitor in 1995. But there were no 1875 capacitors to study in 1835 that used anything like a similar technology to that used in 1935. Current capacitor manufacturing technology is much closer to that of the thirties and forties.

I think we have to remember that before the 1970's space programs, genuinely high reliability electronics didn't exist. By the end of WWII, it was very evident that wax-paper condensers were prone to a steady flow of failures throughout their service life, and that they were close behind vacuum faults as a failure mechanism. The total recapping we talk about today was being practiced in 1950. I'm not sure whether the failure mechanism we see today are greatly different from those seen 45 or so years ago. Moisture contamination and mechanical breakage seem to me to be at the head of the list in both instances, but I have some "high quality" wax-papers in a 1944 box that show high leakage and appear to be built and mounted so that mechanical problems

shouldn't be an issue. The molded paper capacitors of the fifties seem to have problems of their own, even though they are made with solid jackets to keep the leads from wiggling, and so forth.

Accelerated testing may predict a 10,000 operating hour service life, and testing for 10,000 continuous hours of operating may confirm that prediction. But many of the caps we see to day have accumulated as little as 1,000 hours of operation in periods on the order of fifty years. The high frequency of failures we observe today simply proves that whatever predictions were made, and whatever tests were devised, that they didn't simulate the effects of decades of sitting on the shelf in a variety of environments.

This reply then brought up a related question. . .

"If it was known around 1950 that wax-papers weren't all that great, when did the industry stop using wax-paper capacitors? Or to better phrase the question, when did a capacitor superior to wax-papers come out? Was there a better replacement available around 1950, or were recap jobs then just done with new wax-papers?"

...and its reply.

"I'm not sure I've accurate answers to these questions, but do have some recollections from the 1945-60 period. There were always 'better' capacitors than the wax-papers. They cost more money. My Hallicrafters S-36A has zero wax-paper caps and zero electrolytics in it. Someone like Dave Stinson, who collects WW II era military electronics can comment on the details of what's in that equipment, but my recollection is that 'JAN spec.' (Joint Army-Navy---'MIL' is from the 1948 realignment of the armed services) equipment used 'postage stamp' and 'bathtub' caps. The smaller values of 'postage stamp' caps are mica, the larger ones use 'paper, although I suspect the dielectric material was higher quality than used in the wax-impregnated jobs. The bathtub caps are in hermetically sealed cans, with a variety of dielectrics. Also, there were grades of wax-paper caps, which can be viewed as 'cheap' and 'expensive.' The S-36A uses a number of ceramic dielectric caps. The early ones were made on ceramic tubes.

My recollection of repair parts inventories used by service shops after 1946 is that they had molded paper caps for replacement of the wax-papers. These had a much better track record in the short term, although, as many of the postings here indicate, after 30-50 years, they are just as troublesome as the old wax-papers. Disc ceramics, as I recall, were a feature of the early fifties. My HQ-150, which was built in 1956, uses disc ceramics, and has had 100% survival of the originals. I have no real 'handle' on the later users of wax-paper caps. I have heard tales of wholesale recapping of late prewar radios, and it appears that this was related to original manufacturing quality as well as operating temperature. The real volume in service shop business was in vacuum tube replacement and replacement of early electrolytics, and if the faults went beyond this, the radio was considered a 'dog.' You'll see wax-papers in mid-fifties boxes. There are several factors here. Cost is a big item--as long as wax-papers were the cheapest that would do the job, they were used in low-priced stuff that was sold in 'price-first' markets (the equivalent of K-mart and Wal-mart today). Also, if the manufacturer was primarily an assembler, light on in-house engineering capability, and they weren't dealing with a lot of warranty repairs, they would have stuck with the old technology until price clearly favored using the new. There is a good deal of wisdom in the 'if it is working, don't fix it' adage. Remember that electronics of the early postwar period were generally built with the idea that five years was an adequate service life."

(continued on p. 10)

CLASSIFIED ADVERTISING

Subscribers may place one free classified ad, up to 30 words long, in each issue. Count your name, ham call (if desired), complete address and one phone number as six words. Do not count the words in the boldface heading. Additional words are 15 cents each per issue. Non-subscribers pay 30 cents each per issue for all words. Free ads will be automatically run in two issues, but expire after their second insertion unless renewed by mail or phone. Those wishing to run the same ad for extended periods of time may want to use a "business card" space (see Display Advertising Dimensions and Prices table elsewhere in this issue). This is a boxed area in which we can print your business card or any advertising message that will reasonably fit (no charge for setting type). We reserve the right to make editorial adjustments in classified ads without advance notification and to refuse advertising at our discretion. We will reprint, without charge, any ad containing typographic errors, but assume no other financial responsibility.

Wanted any and all information on Radio Receiver R-366/URR manufactured by Espy Mfg. Co., NY, for Navy Dep't Bureau of Ships; need operating manual, etc. Barney Wooters, W5KSO, 8303 E. Mansfield Ave., Denver, CO 80237-1723. (303) 770-5314.

Wanted Working chassis (or repairable one) for a Crosley Model 305, 315, 335 or 345. Tom Zenisek, Lucky Awards, Inc., 3300 1st Ave. NE, Cedar Rapids, IA 52402 (319) 366-3686. e-mail TomJonZee@aol.com.

Wanted Zenith S4419 antenna coil, S4420 detector coil for 10S130; tube shields for AK145, Zenith 6S229, Arvin 617 (has tabs for chassis slots), Goat 4.0" tall; Emerson 107 in excellent cond. John Pelham, W1JA, 1185 Bend Creek Trail, Suwanee, GA 30174-2041. (770)476-0473. e-mail John_Pelham@msn.com.

Wanted Old headphones, headphone parts, plugs, adapters, junction boxes, paper. I will purchase any amount, or trade for phones not in my collection. Dick Mackiewicz 1549 N. River Rd., Coventry, CT 06238. (203) 742-8552.

For Sale Reproduction crystal detectors, replacement Philmore domes, new loop antenna wire, grille cloth - more! SASE for details. Do you need some oddball part or information? Drop me a note. I'll try! Dick Mackiewicz, 1549 N. River Rd., Coventry, CT 06238. (203) 742-8552.

For Sale Crystal Radio Kits, complete with face panel, base board, variable capacitor, prewound coil and many parts for old style radio. Remit \$22.50, Carl & Grace Ent., 5636 Romeyn, Detroit, MI 48209.

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MONTHLY MINI QUIZ

Match wits with our quiz editor! See next month's issue for the answer, as well as the names of all readers who responded correctly.

A Catholic priest and native of Central Europe who settled in Wilkes Barre, PA, this 1890's experimenter successfully transmitted information at a distance. Slovakia honored him with a commemorative stamp in 1939 and a WWII Liberty Ship was named after him in 1944.

Answer to Jan/Feb quiz: Robert Watson-Watt; Answer to Mar/Apr quiz: Roy Weagant. Correct answers sent in by Alan Douglas.

THE INTERNET CONNECTION

(continued from p. 9)

Finally the original person asks. . .

"And now the really scary question. Will I have to redo my recap jobs of today 15 or 20 years down the road?"

And the answer. . .

"Good question. In truth, no one knows. But remember that the stuff we are discussing on the boatanchors list was not built in 1980 or 1975, which are your '15 or 20 years.' We are talking about stuff that is two or three times that age, and that has been 'stored' for periods like 15-20 years. I put 'stored' in quotes, because the item may have sat in a barn with a leaky roof and been rained on for 20 years."

Conducted by Chuck Schwark
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