Colorado Radio Collectors Antique Radio Club

The FLASH!

Dedicated to the Preservation and Education of Wireless, Radio, Television and Associated Equipment

Volume 27, Issue 4 | The July 10th meeting is at the Bemis Library in Littleton | July/August 2016

Thoughts & Ramblings About Repairing Post War FM Radios

By David Boyle, CRC Member

I Introduction

This article in intended for those of us who may want to understand a little background information regarding frequency modulation (FM) radio and the repair thereof. FM receivers have several unique circuits that require some functional knowledge of their design and operation. In order to repair FM circuitry the reader should be first quite familiar and skilled with analyzing and repairing AM radios. Only the significant differences between AM and FM, both in FM circuits and repair hints, will be presented in this article. Figure 1 presents typical block diagrams for each type of receiver.

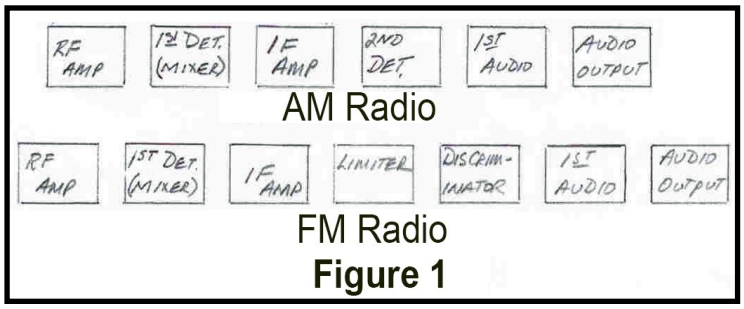

Figure 1 Block Diagrams, AM and FM Radios

As can be seen from Figure 1 there are two significant differences, both after the IF amplifier stage; the Limiter stage and the Discriminator stage.

II Why FM Radio (Advantages Over AM Radio)

Most of us older guys think and equate FM broadcasting to High Fidelity from our early days in this hobby. Actually that is only one of the advantageous features of FM broadcasting... and receiving the FM signal and listening to it.

Keeping in mind the term “amplitude modulation (AM) there is a key word in that terminology. That is amplitude. The FM signal is generally immune to sources of noise, static, interference from adjoining stations, and (somewhat) fading. Noise, static, and other signal disturbances are basically a signal of amplitude modulation, therefore, are eliminated in the processing of the incoming signal through the unique FM circuits. Regarding the audio sound of “hi-fi”; if the FM receiver has adequate audio design and construction including the speaker(s) then it will be capable of receiving and reproducing higher, and “purer' audio frequencies up to the limit of our ears! AM radio, at best, is good to 5,000 Hz.

III Uniqueness of the Limiter and Discriminator Stages

Purposely getting ahead of myself for a moment I wish to explain one of the most important aspects of the discriminator stage. First of all, it is analogist to the Detector stage in a AM radio...and oftentimes in discussing FM circuits it is referred to as the demodulator stage. Anyway, the discriminator stage is frequency-sensitive and not amplitude sensitive.

Amplitude variations present in the signal coming from the IF amplifier stage are eliminated in the limiter stage (hence the term “limiter”). Refer to Figure 2 for a typical limiter schematic of the era of radios we are discussing.

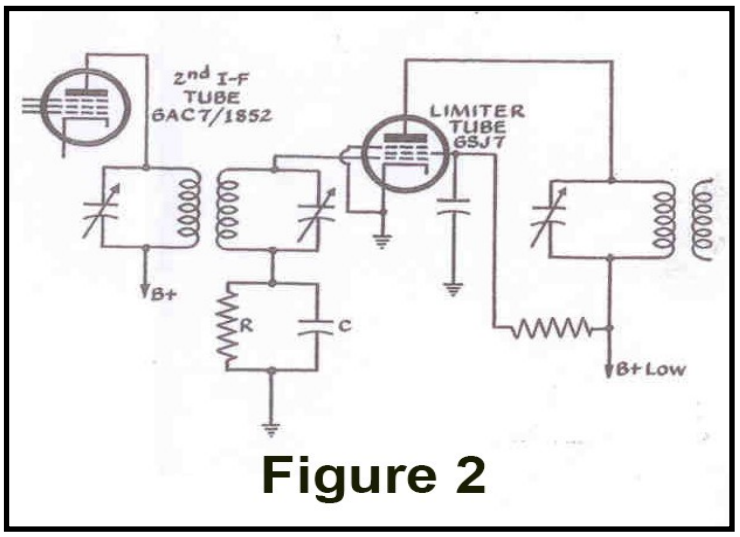

Figure 2 Simplified Limiter Schematic

The limiter stage is essentially another IF amplifier stage modified so that it provides an output of constant amplitude regardless of the signal input. In a general fashion the limiter circuit consists of a sharp cutoff pentode (reference the ubiquitous RCA Tube Manual) operating on low plate and screen voltages. Thus the tube 'saturates' easily on the positive half

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COLORADO RADIO COLLECTORS ANTIQUE RADIO CLUB
Founded October 1988

Message from the President

Here we are in the good ole' summertime, and for me that means I can now do some of the more messy radio restoration work in the garage. I tend to start into a few wooden cabinets at this time of the year, where I can work in the open air a bit and do the sanding and spraying of lacquers.

It's also that time of the year to make sure you are paid up on your club membership, so be sure and get square with Merrill.

We had a great turnout for the last meeting in May, with lots of good discussion about the March show and lots of other topics. One thing that came out is that I will take the action to review our show entry categories before next year, to provide some more and clarify some others. Also we are rescheduling the meeting that we normally have the week after Labor Day weekend back to August 28th. We are doing this to avoid the art show conflict at the Castle Rock Library.

The Barbeque/Auction date is September 18th, and we have a new Auctioneer -in –training, Cliff Shelby, to help out Tom this year. Thanks Cliff for stepping up! We had a few items that were brought to the meeting, including an AK-82Q Cathedral and some ARC-5 receivers, and Tom and Cliff did a fine job of auctioning them off. Portions of the proceeds went to the club, so thanks to everyone that brought those items. I think it's a good idea that we get a few auction items every meeting; it allows people to bring home something a little more interesting than the normal raffle material, and it brings in some funds to the clubs.

The raffle was fairly decent with lots of unique items there and as a result we filled the treasury a bit. So "bring it" as they say.

The show and tells were very impressive as you can see from the photo spread in this issue. Thanks to all who participated. A particular recognition goes out to Larry Snyder, who's restored Zenith Tombstone and accompanying slide show were awesome. You may recall that Larry picked up this "basket case" of a radio at a meeting raffle. At the 2015 show he had a display of this radio in pieces, pre-restoration, showing how bad it was, with the plan that at the next show he would have the finished radio. The sad part of the story is that the morning of the 2016 show, Larry's car wouldn't start, and that prevented him from getting to the show on time. I'm real glad we had the chance to see it at the meeting and have a good discussion. Nice work Larry!

Tom Pouliot shared with us the use of water soluble stains and clear finishes that can be sprayed without harmful vapors. Very nice looking results. He says he can do this in his basement… now I won't have to wait until summer to work on those wooden cabinets, I guess.

After the meeting Mike McCutcheon provided help for folks who were interested in getting on the e-group as well as other computer tips. Mike is a great resource for us. Thanks Mike!

We are still looking for a new *Flash* Editor. In the meantime, continued and extended thanks to Rich for continuing to do this. And as far as *Flash* articles, we have a few but will need some more. So think about an article or even just a small "restorer's tip" with a photo!

I look forward to seeing you all at the July 10th, 2016 meeting in Littleton.

Tom Zaczek

CRC CONTACTS

President	Tom Zaczek 303-665-3743 zacfam at comcast.net
Vice President	Wayne Russert 303-660-3799 Deartrail at wans.net
Treasurer	Merrill Campbell 719-596-3482 Campbell321 at juno.com
Egroup Manager	Mike McCutcheon (303) 343-2956 ugea07 at denvercommons.net
Egroup message posting address:	colradcol at yahoogroups.com
Flash! Publisher	Steve Touzalin (303) 988-5394 Stevetou at comcast.net
Flash Graphic Editor	Rich Kuberski ROKuberski at msn.com
Webmaster	Bill Grimm
Website	www.radioace.com

NOTE: at = @ in email addresses

Upcoming Events

7/4	Independence Day
7/15	1945 First Atom Bomb test
7/20	1969 Apollo 11 lands on moon
8/3	1492 Columbus sets sail
8/6	1945 Hiroshima
8/15	1969 Rich K. leaves VietNam
8/28	CRC Meeting in Castle Rock
9/1	1939 Hitler invades Poland
9/2	1945 Victory in Japan Day

Meeting Locations

(Unless noted otherwise)

Littleton	Castle Rock
March	January
July	May
November	September

CRC MEETINGS

Meetings are held on the 2nd Sunday of every other month starting in January (except May is 3rd Sunday) at 1:00 pm. The meetings consist of business, "show & tell", raffles, auctions, swap meets, technical discussions and other subjects of interest

CRC MEMBERSHIP

Annual membership in the CRC runs from July to June. Dues entitle members to attend meetings, "The Flash!" our newsletter, discount book prices, participation in our spring show and Fall auction. Current annual dues are $20. New memberships will be prorated to the following June.

(Continued from page 1)
cycle of the incoming signal and quickly reaches cutoff on the negative half cycle. This action provides a constant amplitude signal. Limiter stages can be one or two in series.

IV Discriminator Stage

In a FM radio, demodulation (where the audio signal is "detected") takes place in the discriminator stage. There are two types of circuits that will be discussed in this article. The Foster-Seeley and the ratio detector. My experience and most literature concerns the Foster-Seeley circuit as the most popular in post war (1946-1950's) FM radios.
*Foster-Seeley type:

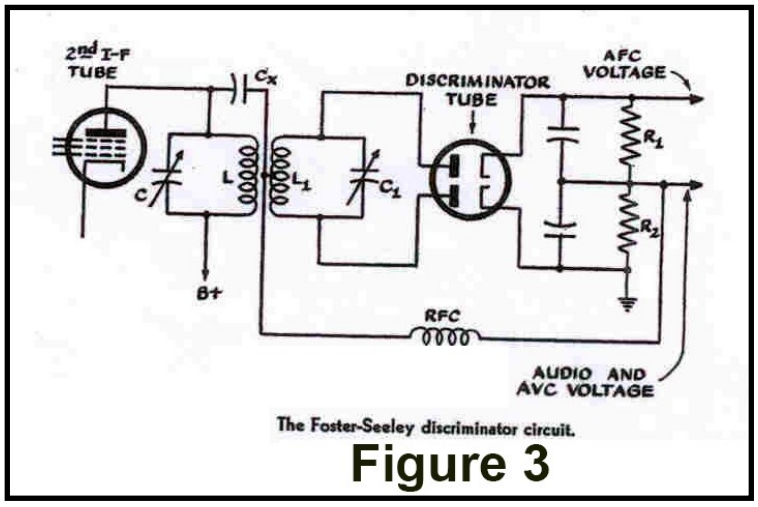

Figure 3 Schematic of Foster-Seeley Discriminator

An explanation how the circuit operates in-depth is too complicated to discuss here. But I'll try to describe how it works using the schematic in Figure 3, above.

L and L1 are primary and secondary windings , respectively, of a loose coupled IF transformer. Both pri. and sec. circuits are tuned to the nominal IF frequency (usually 10.7 MHz). Additional coupling is produced through the capacitor Cx which is large enough so that its reactance at the nominal IF frequencies is quite low. Capacitor Cx is connected to a center tap on the secondary winding. Thus, there are two voltages that cause the current to flow through resistors R1 and R2. One voltage is due to the capacitive coupling of Cx and the other due to the induced voltage.. Those two voltages are out of phase with each other and that phase difference between them depends upon the frequency of the IF voltage.

As a result of all this, when the frequency of the IF voltage of the carrier frequency is normal , equal and opposite voltages appear across R1 and R2. These cancel each other out and the control voltage is zero. If the frequency of the IF voltage becomes high, a negative control voltage is produced. Similarly, when it becomes low, a positive control voltage is produced These voltage differences make up the audio signal voltage passed on to the first audio amplifier stage.

I realize this description maybe somewhat lacking...so I have included a brief but elegant description of a Foster-Seeley discriminator circuit plagiarized from, and now, given credit to Wikipedia:

"The Foster–Seeley discriminator is a common type of FM detector circuit, invented in 1936 by Dudley E. Foster and Stuart William Seeley. The circuit was envisioned for automatic frequency control of receivers, but also found application in demodulating an FM signal. It uses a tuned RF transformer to convert frequency changes into amplitude changes. A transformer, tuned to the carrier frequency, is connected to two rectifier diodes The circuit resembles a full-wave bridge rectifier. If the input equals the carrier frequency, the two halves of the tuned transformer circuit produce the same rectified voltage and the output is zero. As the frequency of the carrier changes, the balance between the two halves of the transformer secondary changes, and the result is a voltage proportional to the frequency deviation of the carrier."

***Ratio Detector type:**

Is the other style of discriminator circuit somewhat utilized in receivers. I have found more commonly used in older TV's. I have not provided a schematic because it is still founded on the Foster-Seeley approach. The main difference is that one of the diodes is reversed placing that portion of the circuit in series. The output voltage is developed a little differently too. The one advantage is that it is mostly immune to incoming amplitude variations, therefore, a preceding limiter circuit is not required. There are limitations on it's ability to attenuate noise, fading, and static. I guess that is why the Foster Seeley circuit combined with one or two stages of limiters are quite common!

V.(a) Repairing/Servicing FM Receivers

Please note; before proceeding with any analysis or servicing of the limiter and discriminator stages make sure all other circuits are to optimum condition; power supply voltages, the entire "front end" from the antenna through the RF amplifier (if used), and the entire converter circuit including the local oscillator.
****

As we have discussed thus far the main differences between AM and FM broadcast receivers is the type of transmission modulation and the way the incoming signal is detected into a audio frequency voltage. The radio circuits involved with that

(Continued on page 4)

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detection are the limiter and discriminator stages. Since the limiter eliminates any amplitude modulation which may be present in the incoming signal, any defect of this stage's circuitry components may cause noise to appear on the output. Such defects may result from weak tube(s) or low operating voltages. The defects are not limited to the limiters stage itself. Since this stage requires a certain minimum input level to function properly any defect in the preceding stages causing a low IF signal could be the problem. In the "old days" it might even have been an inadequate FM antenna as a contributor. Remembering that we only repair quite old radios we have to suspect many causes; weak tubes, leaking or shorted capacitors, resistors out of tolerance, and even the windings in the discriminator transformer. The B+ to the limiter tube conducts through the primary winding. That can be stressful to those little 'ol wires. Perform a resistance check on that transformer ...both windings. In later paragraphs, alignment procedures will be described for the discriminator circuit. At that step it will become clear if a part defect exists in the discriminator circuit components.

FM broadcast receivers use a higher intermediate frequency of approx.10.7 MHz to produce a relatively low "Q", broadly tuned 200 MHz bandwidth. See Figure 4 below:

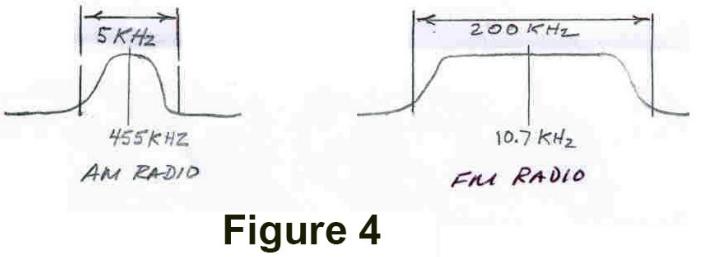


Figure 4

Figure 4; showing both AM and FM IF bandwidths

Some early FM IF transformers designed to peak around 10.7 MHz were tuned by the addition of resistors across the windings, either the pri. or sec. or both. This lowered the "Q" of the windings and, hence, broadened the response curve (bandwidth). Ultimately, to ensure the reproduction of high fidelity sound; should these resistors age out of tolerance the bandwidth would be affected. Remember that when you start the servicing/repair/alignment of the limiter and discriminator stages addressed later on in this article

V.(b) Servicing Procedure for Early FM Radios

Figure 5 Simplified & Partial IF, Limiter, and Discriminator Schematic

Useful in the Analysis and Alignment of these Circuits

Servicing the FM receiver should not present too difficult a problem if you keep in mind the theory upon which the receiver operates. As we have somewhat discussed, the audio frequency modulation causes variations up to 75 KHz above and below the carrier frequency (10.7 MHz). Thus, all the circuits must be tuned broad enough to pass this 150 Khz band.
The partial schematic shown above is of a typical FM radio. Only the essential circuits to this servicing procedure are shown in Figure 5.

The instruments needed are an unmodulated signal from a Signal Generator and a VTVM or good digital VOM. Preferably a center scale VTVM ...you usually can use the "zero adjustment" to bring the needle to the center of the DC scale. Attach the "ground leads" to chassis, warm up the instruments and radio for 15-20 minutes to stabilize to an operating condition. Short circuit the local oscillator by placing a jumper across the oscillator portion of the tuning condenser (points (9 & 10) to prevent it from interfering with the following tests.

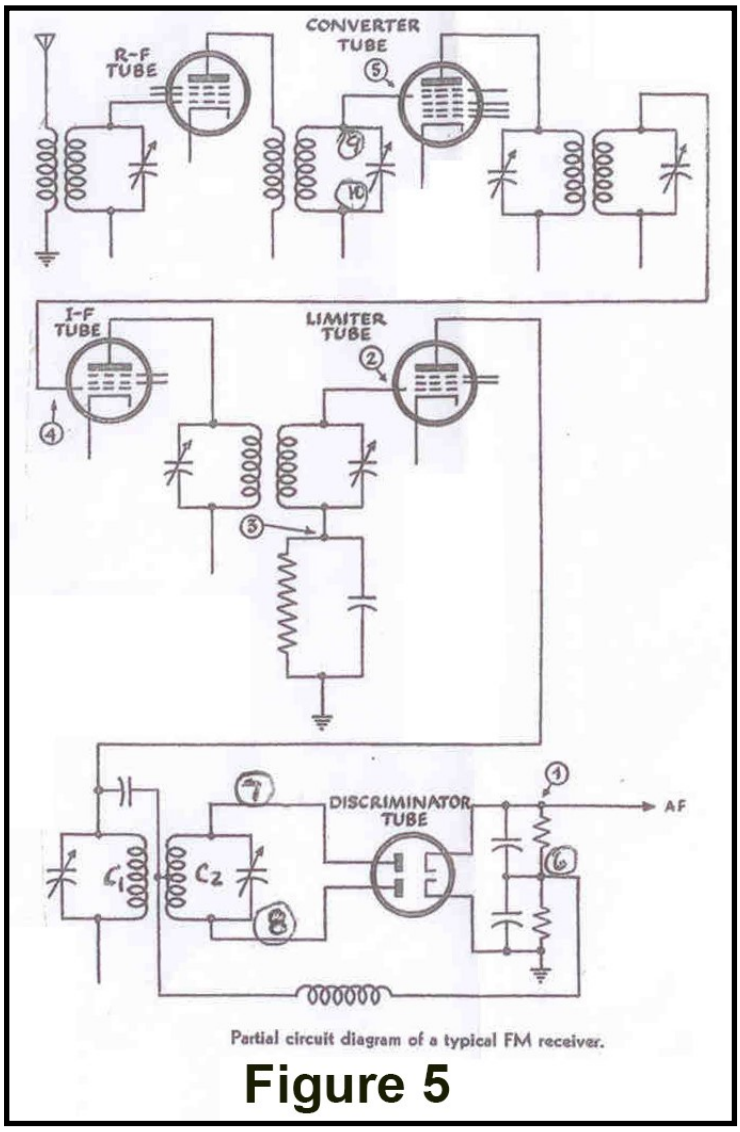


Figure 5

Connect the probe of the voltmeter to the high side of the discriminator (point 1) on the schematic. Set the signal generator to the IF (10.7 MHz. most likely) and connect its probe to the grid of the limiter tube (point 2).
If the discriminator stage is working properly, no voltage indication should appear on the voltmeter. Now tune the signal

generator to a value of 75 Khz. above the IF. A negative voltage should be now indicated. Note its value. Now tune the signal generator to a value 75KHz below the IF. A positive voltage should be indicated. Both values should be the same. If the voltages are equal skip the following discussion on the alignment of the discriminator:

Discriminator Alignment (the easy way!)
If the voltages are "off "a defect in the discriminator stage is indicated. Most commonly, this is due to misalignment of the IF transformer. If all the associated components in the discriminator are found to be in spec. then alignment of the discriminator transformer is indicated.

Here again, refer to Figure 5 for the hook ups and adjustments required by the following: Using the same test instruments used to diagnose the discriminator, including both instruments and the radio warmed up and properly grounded to the chassis; connect jumpers as follows: Short circuit the local oscillator (points 9 & 10) as before, and then place another jumper across the diode plates of the discriminator tube (points 7 & 8).

Set the generator to the IF and connect the probe through a 0.01mfd cap to the grid of the last limiter tube (point 4). Now connect the voltmeter probe to the junction of the two load resistors in the discriminator stage (point 6). Adjust the output of the signal generator to just give a substantial indication of voltage on the meter. Adjust the primary trimmer (C1) to give the maximum reading obtainable. Now remove the jumper across the plates of the discriminator tube. Shift the voltmeter probe to point 1, which is the output. This places the meter across the load resistors. Adjust trimmer C2 on the secondary of the discriminator transformer for "zero" indicated voltage.

Now repeat the original "servicing" procedure to verify proper alignment.

Alignment of the Limiter and IF Stages (also the easy way!)

Connect the probe of the generator to the control grid of the of the IF tube preceding the last limiter stage (point 4) Note; this may be the first limiter stage if two limiter stages are used. Connect the voltmeter to the control grid of the limiter tube (point 2). Set the generator to the IF.

A negative voltage should be indicated on the meter, resulting from the voltage drop across the grid leak resistor of the limiter tube. If this voltage does not appear, turn up the generator output attenuator until a voltage does appear. In aligning FM radios, it is desired that the generator produce a signal strong enough for the limiter stage(s) to operate normally.
Now, adjust the trimmer of the secondary winding of the last limiter transformer for the maximum negative reading on the meter. Do the same for the primary winding. Then tune the generator 75 Khz. Below the IF and note the reading. Then do the same procedure above the IF and note the reading. The readings should be the same. If not, redo the alignment ...or perhaps throw the radio away. I know this is tedious. Remember these old radios may not come into precise alignment due to a number of factors especially gradual deterioration and shifting of tolerances of all components. Another important factor is the changing of transformer winding "Q"...not much to do about that. Ask yourself if the radio sounds OK when tuned to a strong station...are you pleased? I have mostly given up accepting FM radios from customers...too much brain damage can occur.

Anyway, continue to work the same alignment procedure on any other IF stage, if more than one, as you head towards the front end converter tube. Remove any jumpers after IF stage alignment. Alignment of the antenna, RF, and local oscillator stages is the same as for AM radios...just the frequencies different.

Some thoughts:

Nothing better that making sure your signal generator is as calibrated as possible. One of the ways to do that is to check it against local radio stations at the upper middle and lower dial settings. Both Am and FM. Assume that the generator has somewhat a linear output across the bands.

Some AM-FM radios of the 1950's used the same IF transformer "can" for both AM and FM. ...just two different windings inside...so beware. If burned out or otherwise no good...about impossible to replace. On a customer radio a number of years ago I ran across this situation: I just replaced the IF transformer with a AM variety of 455 KHz. IF, (a little circuitry change required) then performed the entire alignment for the AM position and told the customer that was best possible outcome. No more FM reception...problem solved.

By now, some of you may be wondering how the FM broadcast signal accommodates the variations/intensity of the audio. (?) Well, here goes the explanation: "...in the FM system of broadcast communication, the intensity of the sound determines the amount of frequency deviation of the carrier current from its normal value and the pitch determines the number of such frequency deviations per second." Hopes that helps.

Wanted: Someone to take over as Newsletter Editor.

What does it take to do this job? You must have email, a computer and the skill to use it. I use Microsoft Publisher to put the Newsletter together—It's not the only way to do this, just the way I do it. You also have to be willing to expend some of your time and energy every other month on behalf of the club. I've been doing the Newsletter for about 7 years and I see no reason why I should be allowed to monopolize this position. Are you one of the club members that has yet to be a significant participant in the operation of the club? Well, here is a chance to do your part. Don't meet the qualifications or have already done your duty—Okay. What about the rest of you?

Photos from the CRC May 15th Meeting.

Larry Weide talks about Show categories

Cliff Shelby to assist with auction duties

Wayne gives update on Tiny Town Radio

Tom Pouliot describes ARC-5 radios

Mark Kuligowski describes his 1946 Stewart Warner 9001B radio

Merrill Campbell with another great restoration on plastic radios

Tom Zaczek shows off his before & after finish work

YuriyYedidovich with his G.E. Clock timer

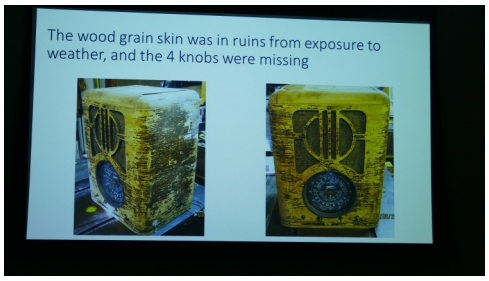
Dave Laude describes what he uses to polish radios.

Wendy Kuligowski with her new crystal radio.

Brian with his Zenith 7J045T he is restoring

Tom Pouliot with his beautiful home built "vintage" transmitter.

Wayne Russert with vintage collectable paper items.



Larry Snyder restores "basket case" radio.

Larry's finished radio. BEAUTIFUL

The Open Trunk

Member submitted advertisements

REPAIR SERVICE:
Radio repairs for club members. Reasonable rates. Good references.
Call David Boyle
303-681-3258 11/09

For Sale: by Dave Boyle
Most of the following instruments have been completely refurbished, repaired as needed, and calibrated. Most have manuals and test leads.
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1) Eico 5 inch oscilloscope. Model 425. Perfect for old radio repair work. Completely electronically rebuilt with **new CRT**! $68.00
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Radio Chassis For Sale:
1) RCA Radiola Model, 80,82, 86 complete dual chassis and mounted speaker. VG condition, with tubes including 2ea VG 45 tubes. Make offer.
2) Philco Model 91. Complete *working chassis* with 12" good speaker. Working tuning meter too!
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3) Philco Model 37-610 complete chassis with tubes, good condition complete with bezel and glass.
Make offer.

Call David Boyle,
303-681-3258 09/15

Wanted: 1920's Wooden Horn Speakers and a Crosley Musicone Speaker.
Also 1920's battery sets, especially Neutrodyne sets, Pre 1930 AC Radios and a Crosley Widget Console Radio
Michael O'Leary 602-354-7011
moleary9@cox.net.
WANTED: To buy: 1948 Motorola 5A9B portable radio, Maroon color. Good condition only.
Dewey Reinhard 719-596-5516
deweyfly30@gmail.com

WANTED: Broadcast or recording mics, especially from 20's to 1950's.
Crosley Pup Info
NBC chimes, all eras.
Tom Keeton **303-797-8073**

For Sale: Patterson PR-10, 1933 Amateur Radio Receiver.
10 tubes, fully electronically restored.
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Please call me for an appointment to see if any of them would fit in your collection.

I have tube radios including Tombstone, Cathedral, and Novelty etc.

I also have a large collection of transistor radios both shirt pocket and Novelty type.

Please call 303-238-1384
Thanks in advance,
Ron Smith

RADIOS4US@aol.com

WANTED to buy: 1980s Atari 520 or 1040 ST computer components (keyboard, monitor, etc.). I still need it for several specialized programs I wrote including a simulator for transistor and tube circuits. **Dave Laude** dlaude1@msn.com

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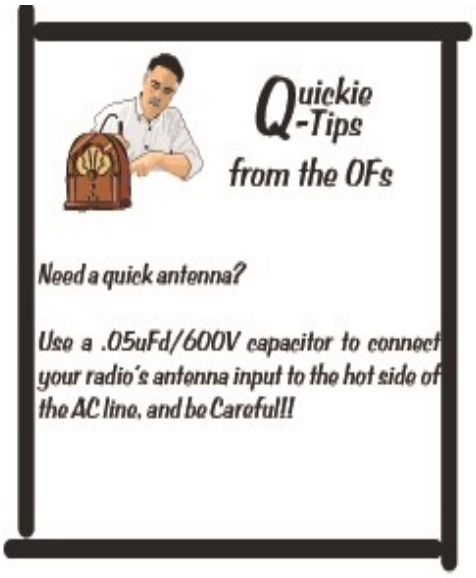
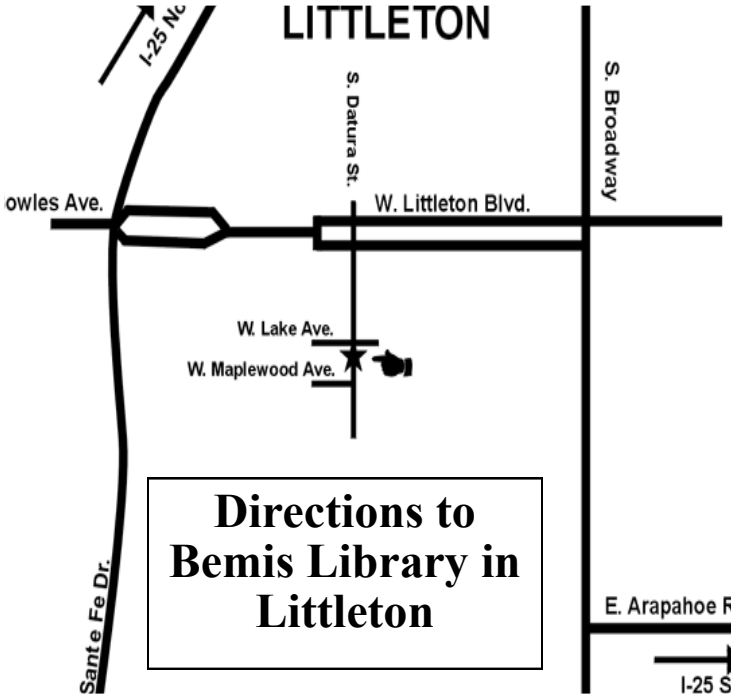


SUBMISSION OF ARTICLES &AND ADVERTISEMENTS

Classified Ads for The Open Trunk and articles of any radio/electronic or historical related subject to be published in the Flash are encouraged and welcomed. The article(s) should be submitted in Microsoft Word, RTF, or as text cut/paste into your email. Submit to Steve Touzalin by email at: stevetou@comcast.net or by postal mail to 417 So. Queen Circle, Lakewood CO 80226.

Formatting isn't necessary, but if you do, set the font to Times New Roman, size 10, left justified. If you have graphics (.jpg files) to be inserted, please name them and be specific about how you would like them placed. We will do our best based on space limitations.

The July 10th 1:00 meeting will be at the Bemis Library in Littleton



Directions to Bemis Library in Littleton

Directions to Miller Library in Castle Rock

From I-25: Take the Plum Creek Parkway, exit #181.

Turn East onto Plum Creek Parkway. Turn Left (North) onto S. Wilcox Street and continue north 2 tenths of a mile.

The Philip S. Miller Library is on the east side of the street at 100 S. Wilcox St.

The building is towards the back of the parking lot, past the Dairy Queen.

Prepare for the Auction

Colorado Radio Collectors
Antique Radio Club
417 S. Queen Cir.
Lakewood CO 80226

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