THE SIGNAL

Collins Collectors Association

Issue Fifty Two OFFICIAL JOURNAL of the COLLINS COLLECTOR ASSOCIATION Fourth Qtr , 2008

The CCA Board of Directors

And Signal Staff

Wish All of Our Members

A Happy Holiday

And

A Prosperous New Year

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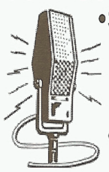
OFFICIAL JOURNAL of the COLLINS COLLECTOR ASSOCIATION

Issue Number Fifty Two

Fourth Quarter 2008

Join Us on the Air!



•Sunday 14.263 mHz at 2000Z
•Tuesday 3805 kHz at 8pm CST
•Thursday 3805 kHz at 8pm CST
•Friday (West Coast) 3895 kHz at 10pm CST
•Sunday 10m AM 29.050 mHz at Noon CST
•1st Wednesday AM 3880 kHz at 8pm CST

Sunday for Technical, Buy, Sell & Swap
Tues., Thurs., Fri., & Sunday for Ragchew

Inside This Issue

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In the News

- Election Uncontested
- L1 Mystery Solved
- Santa Heard on 20 Meters

Cover - Collins 32F Manufactured 1935

Converting the 20V Broadcast Transmitters to 75 Meters - Second Installment

by Bill Carns, N7OTQ

The first part of this article that appeared in the Q2 issue of ***The Signal*** started the process in general and took you through bringing the transmitter up on the broadcast band. The following information will walk you through the process of converting the transmitter to the 75 meter ham band and setting the cutback power out to the legal AM limit of 375 watts carrier. Lowering the output power to 375 watts carrier uses the standard nighttime cutback feature on the 20V and leaves the transmitter completely stock and capable of 1 kW carrier operation. In addition, I will give you some reference operating data not found in the Collins manual for the transmitter.

<u>75 Meter Conversion</u>

Now that you have it running (Beautiful, isn't it?), it is time to address the conversion...And, if you have not done it before this, it is time to plan how you are going to interface your audio and the various control, drive (if you are using a VFO) and monitor functions.

A monitoring output for modulation, and perhaps frequency, is taken from the modulation sampling coil output at the PL-259 connector on the top of the cabinet. The correct level for your modulation monitor or scope can be set using the roller inductor in the RF tuning compartment. The procedure in the manual will guide you, along with knowledge of the requirements of your particular instruments. The frequency sampling output (BNC on the 20V-3) on the bottom of the RF amplifier chassis is just for that! Do not attempt to use this for anything else. It is a very harmonic rich test point due to it being also the drive point for the nonlinear grids of the 4-400s. It will major confuse the issue on a spectrum analyzer for instance. If you want to pick off a spectrum analyzer monitoring point, do it after the antenna output insulator. The modulation monitor output is better, but not good enough.

Do not be tempted to try and just overwind new coils on the plug-in coil forms for the buffer and driver plate coils. This has been done, by others and by me, but the result is reduced grid drive and unpredictable mutual coupling and tuning effects. You can try to short them out or open them up, but it does not help. Start with clean forms. I am a purist and badly wanted to save my original coils, but finally gave in to good design practice. The result was great grid drive and easy tuning. The plug-ins, as well as the output network, are broad enough that you will not need to retune much, if at all, when you make frequency changes inside the normal 75 meter AM window. Oscillator and exciter plug-in and RF output network components were chosen so that the resultant network loaded Qs were maintained to Collins original design parameters. These were reverse engineered from the broadcast components using Spice simulations.

A word here about the RF output network design. There are as many ways to design and tune a Pi-L network as there are ways to skin a cat. In my mind, staying with the Collins guide-

Cont'd Pg. 4

From the Editor's Desk

by Bill Carns, N7OTQ and Co-Editor Joe Nyberg, WILJN

What a quarter. It was very short (Hi!) due to the late issue in Q3. I do appreciate everyone's patience as we went to press last quarter. I did not get one complaint and that says a lot about what folks think of the new format and size/content of the magazine. Worth waiting for, I hope.

The fiscal quarter flew by for me as it was, since I was in major crash mode to get the building done for my shack and get a life, other than construction worker. I am happy to relate that, less a few small touch-up jobs, it is finished and I started moving in during the second week of December. I have gotten one room completely furnished and even a couple of radios physically in their places and THAT MAKES ME VERY HAPPY. It took me a year and seven months to build my shack/shop and I am real glad to see that phase basically over……On to playing radio. K0CXX will be on the air very soon.

I am trying real hard to get this issue to press in time for it to reach you all by Christmas, but know that, if it does not, you are all wished a very happy holidays and a great new year.

Speaking of the new year, it should be another great one for the Collins Collectors Association. We are looking forward to several new, or renewed, board members, and I know that there are great things in store this coming year. There will be some more nice enhancements on the website, Dayton plans are already percolating, Butch Schartau, CCA board member, is organizing a great Caribbean cruise for the group and I would not miss it for the world. You will see a complete write-up on the trip in the Q1 issue and find out how to sign up. I hope that many of you can come.

The Signal will continue to mature and we will be moving to at least one international focus issue each year and hopefully putting on at least one more international correspondent from Asia. The technical data sheet inserts will continue, thanks to the effort of the board and I promise you more great ***Signal*** Magazines.

I do need more writers. I keep asking, and there have been some more volunteers, but I am still waiting for those of you that have the really rare and interesting pieces to share them with the group. Just a hint.

Joe Nyberg, W1LJN and our Co-Editor, will be writing his first article for us. Joe has had a number of careers, including Lawyer, Historian/Author and for many years, an airline pilot. Joe first article will be on Collins Radio's focus on the airline industry, it's product line evolution and particularly their contribution of the Flight Director and VOR system to Instrument Flying. Who is better qualified?

A word on the nets is in order. The low band and AM nets are doing very well and propagation has been decent. The 20 Meter SSB net is still struggling with very poor and erratic propagation. In spite of this check-ins are still hanging in there. I sure hope this sunspot cycle gets with it pretty soon. In the mean time, keep trying and we will keep the net organization focused on trying to pick up all that come to check in.

Finally, I hope you enjoy the next series of Service Line columns. Dale Svetanoff will be doing a series of three columns on trouble shooting your rigs. There have been so many questions on the reflector (paraphrased: My rig is dead, where do I start?) regarding how to trouble shoot equipment that Dale and I thought a thorough series on this was in order. They will start with the VERY basics for those who need this, and there a many, and then they will go into more in depth techniques. For those of you who are more advanced in doing your own maintenance, I encourage you to "start at the beginning" with Dale and read on. You may just find some nuggets in the basics. I know I did.

Have a great quarter. I am setting up my equipment and will talk to you all soon on the air.

de Bill Carns, N7OTQ/K0CXX
wcarns@austin.rr.com

Seasons Greetings to all of our readers. Now that the historical writing has settled down a bit, I am looking forward to writing more for ***The Signal.*** The first article on Collins' involvement in avionics should appear in the first or second quarter of this coming year.

Best 73s, Joe W1LJN
nyberg1@roadrunner.com

Converting the 20V Series to 75 Meters II (Cont'd)

lines (where there is not only an emphasis on plate efficiency and harmonic content, but on good audio bandwidth and minimal network I-V losses) fits the bill. The important thing is that you not stray too far from the recommended parameters, but they are not sacred. The resulting harmonic suppression is better than 57 db for the 1st harmonic - which is outstanding. I have seen folks get way off the mark with the loading L and essentially turn the output network into a straight Pi and say it was working fine. The resulting harmonic content was much worse and they were not capitalizing on the capabilities of the Pi-L.

The modulation ground fix on the 20V-3 (Discussed in the first installment), and any other ground "grooming" that can be done, is extremely important. You have a big box on your hands and very long harness runs and very long lead lengths for the interior components. This gets more critical as you go up in frequency, but even on 160 meters, you will find the need for covering your bases.

You probably will need to use an input "H" RF network filter on the audio balanced pair, as well as torroidal isolators. With a typical amateur installation where the microphone and the processing are very close to the transmitter, not to mention the antenna, RF feedback will be a constant issue.

A good RF ground to the chassis is very important. It should be short, low inductance and low resistance. RF impedance is what counts. A very short run of wide copper sheeting running to a very good earth ground is what you are looking for. Do not depend on the antenna cable and AC power line ground.

Another note here about the interface. The AC power required by the box is two pole (no neutral) 240 Vac and a safety ground. If you wind up needing 120 volts inside the box, do not be tempted to get it from one 240 volt leg and ground. This will result in a non-code install and will also put AC currents in your power line ground run which, in turn, will play hell with your audio.

I wanted to install lights (120 volt) on my meters on the 20V-3 as well as use 120 volts for some internal control. A small 50 V-A 240/120 volt step down transformer solved the problem.

PTT operation is extremely easy to come by. In the front contactor area of the 20V-3, next to the arc suppression relay K-105, there is a barrier strip (TB 102) with a jumper installed. Remove the jumper and replace this with an external PTT controlled n/o relay contact and you have it. This requires manually setting the front panel high voltage turn on relay prior to each operating session. In the case of remote operation, you will also then have to run remote high voltage turn on lines from the TB 105 area. PTT control is straightforward this way. If you try and use the push on/push off remote lines, it is more difficult but could also be done this way. For the 20V, 20V-2 and derivatives, you will have to add this barrier strip and rewire the arc suppression area a bit to implement PTT. This can be done nondestructively.

In summary, the 75 meter conversion itself will involve: Modifing the plug-in coils, Bringing up the Grid Drive, Changing the Plate Choke, Converting the RF tuning network and adding the PTT circuitry. Then, off you go! The only new parts required will be the reworked plug-in coils and a new home-brew plate choke. This assumes you got it real healthy on the BC band. Right?

Note: If you are ordering a crystal for the 20V series, you should spec a 30 pf load.

To add a helpful hint, in the process of debugging the plug-in coils and bringing up the grid drive, I removed the 4-400s and replaced the grid load with a linear equivalent load of about 20K ohms in parallel with 30 pf so that I could look at the drive chain with a spectrum analyzer. I was rewarded with a great 60 mc parasitic that turned out to originate in the 807 driver. This was eliminated by adding a .005 mfd short lead length screen bypass in parallel with the longer lead length (not so effective) .05 mfd bypass. I thought at the time of conversion that this whole parasitic thing would probably have washed out in the following tuned circuits, but I did not like it so I fixed it. Since then, I have heard of 20V-3s operating on 75 meters that burned up the front end of the owner's closely located FM stereo receiver. I suspect he did not do this bypass fix.

Cont'd Pg. 5

THE SIGNAL

Collins Collectors Association

Converting the 20V Series to 75 Meters - II (Cont'd)

Summary of Instructions for Initial BC Run

Updating your PA screen circuitry if converting a 20V -2 or a 20V-3 with < ser. # 119.

- Two 20 k ohm series Rs into a 7.5 k ohm internal R.
- This will set up the 4-400s at about 3.1 kV plate and 500 V screen operation – textbook Eimac.

Checking strapping on the filament transformer.

- A lot of units were on 208 V. * Set for 240 V.

Decide on audio input attenuation level methodology for cutback.

- Use internal relay.
- or Outboard audio board manipulation.

Rework all RF grounds including finger stock on RF and modulator chassis.

Cutback (Rcb = 4.25K Ohms for 375 Watts) and screen resistors updated to 225 watts.

AC and RF grounding.

Contactor and relay cleaning.

Lubrication – yes, the manual is wrong 45 years later.

Check List for Conversion to 75 Meters – Here we go

Plug-in Coil Modification

Disassemble can, stand-offs and ground to expose coil form. NOTE: Be careful of 6 small washers !!

Remove at least top winding to reduce mutual coupling.

Modified Plug-in Coil

Wind on 22 turns of #24 silk covered coil wire (Available at Antique Electronics) same direction as original coil.

Use existing solder lugs shown.

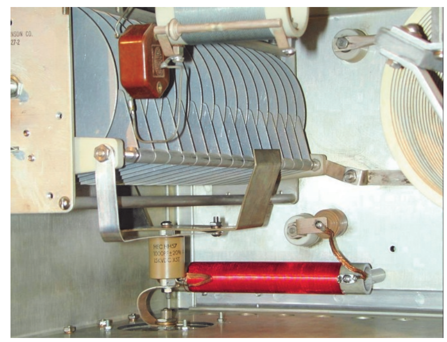
Set "inside" variable carefully to min capacitance.

Add ~ 20 pf of stray capacitance and grid dip adjust to 3860 kc

Then remove temp 20 pf.

Replacement RF Plate Choke Construction

Standard broadcast band RF plate choke has a self-resonance in the 75 meter band. Note: It will burn up!

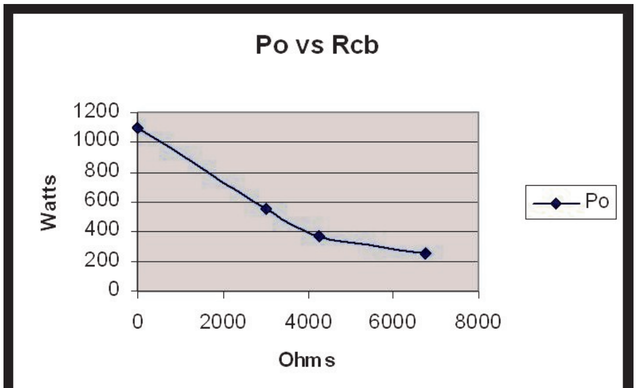


New 75 Meter Plate Choke

The correct reactance choke can be solenoid wound on a 1 inch fiberglass or Delryn form.

330 microhenry at 0.5 amps with # 24 # 8052 Belden Formvar wire.

Cont'd Pg. 6



Rcb Ohms	Po Watts	Ip mA	Vp Volts
0	1100	500	3150.00
3000	550	350	2100.00
4250	375	300	1875.00
6750	250	245	1496.25

Cutback Resistor Selection Table for Setting Pout in the Cutback (Night) Position

Converting the 20V Series to 75 Meters - II

300 turns at 50 TPI Tight wound – Then check for self resonances in band by shorting choke and grid-dipping.

Pi-L Modifications for 75 Meters

Set the Pi-L up as follows:

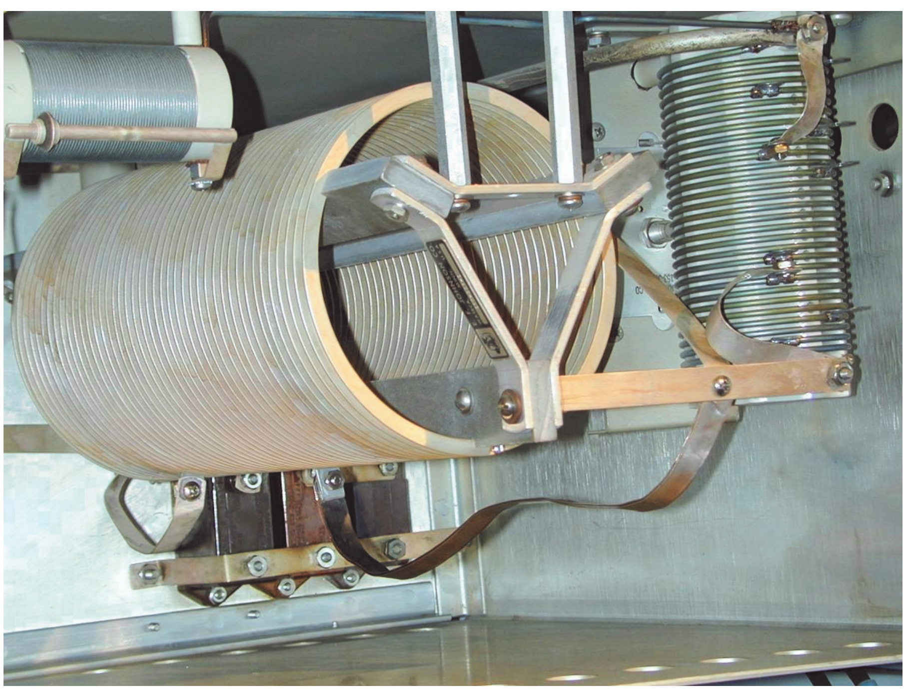
After completing the steps above, you are ready to test the unit on 75 Meters into a dummy load. I would, if possible, check the unit with a spectrum analyzer as well as making the normal Pout and frequency checks.

Tune up is per the owner's manual and you should find that you have very nominal readings and plenty of grid drive. If not, there is something wrong.

In the process of trouble shooting and doing the conversions I have made, the following table of DC and RF voltages was compiled. This should be of help when making measurements.

20V-3 and 20V-2 Set up for 75 Meters						
freq	**Z i**	**R L**	**C141/142**	**L108**	**C143-147**	**L109**
3860 kc	406	3300	125	18 microhy	614	5.5 microhy
			58-185	**13 T**	**430 pf shunt**	**9-10 T**
				= 18.8	+	
			No Shunt		184 pf Var.	
Remove C141, 200 pf fixed air shunt in factory Pi						
Change L107, Plate Choke must be modified						

Pi L Output Section Set-up Table (Above)



Modified Pi L Taps shown set-up for 75 Meters
The Pi Inductor, L108 on the left, L109 on right.
Note the very small setting on the modulation coil.

That should get you on the air. In the final short installment, I will discuss some RF switching and control issues and techniques that I used to solve issues I was concerned about. When you get your rig on the air, send me an email. I like to keep track of units being brought up and, hopefully, by the time you are on the air, I will be finished with my building and have my 20Vs back in operation. A schedule is in order.

Good luck, be safe and enjoy. See you in the next issue.

de Bill, N7OTQ/K0CXX

I can be contacted at wcarns@austin.rr.com

	Volts (dc)
High Voltage	3150
Low Voltage	640
Bias Voltage	-140
PA Plate Screen Voltage	~ 500
	Volts (rms)
Carrier freq out	1
Modulation Monitor out	3.55
VFO input	~ 2 watts
Audio Input (600 ohms)	+10-12 dbm
(100% Mod. @ 1 kW*)	2.45 V (rms)

Typical Performance Data

The Service Line

Troubleshooting Basics
- or -
Just How Do I Fix This Danged Thing Anyway?

by Dale Svetanoff, WA9ENA

I am sure that those of you with 32S-3s found the "Service Line" article in the 3rd Quarter issue of *The Signal* to be very interesting and informative. I am guessing that those of you who do not own 32S-3s, or who have no interest in doing your own repair work, either skipped the article completely or maybe just glanced at it. The fact is that there were several good "hints and kinks" within that article that are useful for troubleshooting most electronic equipment, including our beloved Collins gear. Those of you who have been slinging solder for decades can probably stand by for installment II or III. The rest of you should sit back, relax and follow along a path designed to help *you* save time and money. Sound good? OK, here we go.

Let's consider the three most likely states into which you may find one of your radios: 1) Dead - no filaments or pilot lamps light, no output or other signs of operation; 2) Works, but only partially - may not work on all bands or modes, may receive but not transmit, or vice-versa, has low output; 3) Intermittent - the set alternates between periods of perfect or near-perfect operation and a serious malfunction. We'll discuss each of these three states as the article progresses, but next it is important to know what basic "tools of troubleshooting" you really should have before tackling that "dream rig" which isn't quite up to specs.

Most of us come equipped with three basic tools to do the job: eyes, ears, and olfactory sensors. It is incredible what you can learn about a piece of equipment just by looking at it very thoroughly and thinking about what you see. Similarly, if a set is making sounds that it should not (or vice-versa), those are clues that could help to define the problem. Finally, if a set should emit that "magic" smoke that makes all electronic devices operate, your nose and sense of smell can, with training, tell you if the toasted victim is a large inductor (like a transformer), an old carbon composition resistor, or something made with Bakelite or phenolic. Notice that I did not include fingers in the list of body "tools". There is a reason for that - *safety*. In tube equipment, there are hazardous (and potentially fatal) voltages present, plus the heat generated can create some very high temperatures in some components, or on some tube envelope, that can cause serious burns if touched directly. In general, do not place your hands or fingers into operating electronic equipment without first studying the manual (or other documentation) and applicable safety documents. NEVER by-pass or jumper out interlocks - they exist to protect YOU!

Situation #1: The set is dead - stone dead!

In several aspects, this is the best kind of failure. It is often due to simple problems:

- Bad power cord
- Bad fuse(s)
- Tripped circuit breaker
- Bad connection or power switch
- Defective AC mains circuit

Test equipment most likely to be useful for checking out a "dead" set:

- Modern DMM (Digital Multi-Meter) or VOM (Volt-Ohmmeter)
- AC line voltage meter
- Voltage detector/sensor - used by electricians to check for "live" circuits
- Small lamp or test light
- Variable line voltage autotransformer

With a dead set, first, consider that the fault may not be with the set at all. For safety, I suggest checking to see if the power outlets that feed the operating position or test bench are, in fact, working. Plug in either an AC line voltage meter or a small lamp to see if the outlet is working. If you get no power at the outlet, take the time now to learn why that is and fix the problem. It may be just a tripped circuit breaker at the power panel or a loose connection.

You now have AC line power, but the set still will not "fire up". With the rig's power switch turned to the "ON" position, wiggle the power cord at the plug end and at the point at which it enters the radio set chassis. These are areas at

Cont'd Pg. 8

Service Line (Cont'd)

which cord conductors can fatigue and break. Next, check the AC fuse, usually found in a holder with screw-on cap on the rear of the chassis. Remember, for S-Line transmitters, and KWM-1 / KWM-2/2A transceivers, the AC power fuse is on the chassis of the accompanying power supply. If you know nothing about the particular set, and you have several spare fuses, my suggestion is to replace a blown fuse and see if the set will now operate. Fuses can develop fatigue, a condition frequently visible in glass body fuses. Long hours of operating at what might be close to the fuse rating can cause a fuse to simply break or go open without there being an accompanying electrical problem. In any event, fuses can look good, but may be open circuit. Use a DMM or VOM to check continuity of any and all fuses on the equipment of interest.

Hint: One of the more common and difficult to find problems can be a defective fuse holder. If the fuse itself tests good, place it back into the fuse holder. Make sure that AC power is disconnected from the set and then take a DMM or VOM in the "Ohms" function and verify that you do have continuity across the fuse holder. Over time, the contacts within the fuse holder body can either develop corrosion - producing a high resistance contact - or they get deformed and no longer make contact at all. Check carefully!

CAUTION! Sets that have not operated for many years should not just be plugged into a wall outlet and left to chance when throwing the power switch. If you have a non-functioning set with a blown fuse and you know that the set has been idle for many years, now is the time to go find one more test equipment item: a variable line voltage transformer or auto-transformer. Known most commonly as a Variac, these devices allow you to slowly bring up line voltage from zero to full level. It is true that most receivers are not that big of a deal if not operated for several years, but keep in mind that receivers with solid state rectifiers (such as the 75S-series) will still have a very substantial line current surge on the first half-cycle if the electrolytic caps have been flat for many years. That current surge is not only stressful on the rectifiers, power transformer, and electrolytic caps, but it also makes for a possible welding job on the contacts of the power switch. One advantage of tube rectifiers is that their conduction "ramps up" as the filament heats, thus reducing that initial turn-on surge into the filter capacitor.

Summary: All troubleshooting to this point has concentrated on possible causes of a non-operating set. Except for fuses or AC power cords, all of these causes have been external to the set itself. Now, it is time to go inside the radio set.

Before diving into the "guts", consider the AC power switch itself. Is it working? With the power cord unplugged from an outlet, connect one lead of your DMM, or VOM, to the NARROW blade of the power cord (if the set has a polarized plug). Assuming that you have already checked out the fuse and its holder, connect the other lead of the test meter to the WIDE blade of the power plug and operate the power switch. You should see a fairly low resistance (a few ohms to maybe a few hundred ohms) across the power plug blades. If you see an open circuit, locate the power switch's contacts or connections and see if you can find continuity across the switch when thrown.

Most communications equipment that is powered by AC mains uses a power transformer to provide the various voltages required for the set. With vintage gear, this is usually an iron core device with two or more windings. You probably know that the primary winding is connected to the AC power source, and that secondary windings are those required for actual set operation. Common secondary voltages are 5.0 and 6.3 volts for filament and indicator light power, and then anywhere from maybe 150 volts to over 1000 volts for plate supplies as needed, with the higher voltages used in transmitters and transceivers. There is not a lot to fail in a power transformer, but when they do, you can end up with anything from a very dead set to a spectacular fireworks display just prior to having a very dead set.

It is important to determine if the lack of power in the set is due to a defective power transformer or problems in the other parts of the power supply. First, let's say that you apply

Cont'd Pg. 9

Service Line (Cont'd)

AC line power and NOTHING happens within the radio - no pilot lamps, no tube filaments glowing. If your test meter confirms that normal line voltage is being applied to the ends of the primary transformer winding, when there is no output, there is the strong possibility that the transformer has an open primary winding. Use a DMM or VOM in the "Ohms" position to check for continuity of the transformer primary. Typical readings will be a few ohms (on large transformers) to perhaps a few hundred ohms on smaller ones. Remember, the meter is using DC for this test and the DC resistance of any of the transformer windings will be much lower than the actual impedance when AC is flowing through the winding.

When a transformer is fully sealed or potted, you are usually out of luck in trying to make repairs at the home work bench. However, if the transformer is not potted and has either flying leads or solder lug terminals extending from underneath insulating "fish paper", you might have a chance. I have had some success with transformers in which a winding was broken just inside the stack, usually within an inch or so of the terminal. If you work carefully with an Xactoä knife, or similar tool, you may be able to cut back the paper insulation and find the broken off end of the winding. It is then a rather simple job of tacking on a short piece of bare wire to make an extension, and you are back in business. Be sure to restore the insulating paper with appropriate durable material so that you do not get arcing to the chassis or transformer core or frame. Olde fashioned Corona Dope can be of help here.

Now, for a trickier issue, the pilot lamps and tube filaments are all warming up, but the set makes no sound or shows no other signs of operation. For a receiver, this usually means that either the main B+ winding is open, the rectifier(s) are open, or that there is a problem in some other part of the power supply section. The 75S- and 51S- receivers all employ solid state diodes under the chassis. Earlier vintage sets used tube-type rectifiers. There are also filter capacitors, filter chokes (in some cases), and dropping or bleeder resistors included as part of the power supply system. Issues for transmitters or transceivers are similar, but there may be more complexity in those power supplies because of bias circuits, high and low B+ supplies, and high voltage on-off switching.

<u>Here are a few specific issues for S-Line equipment:</u>

* Remember that even the receivers (75S-1 and so forth) have jumper wires within the power connector on the rear of the unit. For normal AC line operation, those jumpers are set such that the tubes are running as 6.3V strings. If some filaments in a 75S-receiver fail to light, check the wiring within the power plug first. If that is OK, then check the wiring on the receiver chassis at the mating power connector. A wire may have broken.

* When selecting an external power supply for the S-Line, be sure that it can supply the required filament, bias, and B+ voltages. There has been much controversy over the years about using those popular and inexpensive Heathkit HP-23 series power supplies if you don't have a 516F-2 for your S-Line. Purist issues aside, note that ALL of the HP-23s can supply 12 VAC @ 5.5 amps for filament power. The HP-23 and HP-23A can alternatively provide 6.3 VAC @ 11 amps for filaments. The specs for a 32S-1 call for either 6.3 VAC @ 6 amps or 12.6 VAC @ 3 amps, 800 VDC @ 200 mA high B+, 275 VDC @ 175 mA, and -60 to -80 VDC bias at very low current. All of those requirements are met by the HP-23 and HP-23A power supplies. A problem with the HP-23B is that it does not have an adjustable bias supply, as required by the 32S- transmitters. The 32S-3 transmitter is specified at 800 VDC at 230 mA and 275 VDC at 190 mA. These are higher current draws, but they are within non-continuous load limits for the HP-23 series. Note that Heath's specs on the HP-23 series allow high B+ to drop to 700 VDC at rated load. Note also that I make no claims for the HP-23 series with respect to the KWM-2/2A transceivers.

* If you can not determine whether the problem is within the power supply or the rig, separate the two pieces of equipment and operate the power supply as a stand-alone unit. NOTE! Operating the 516F-2 power supply as a stand-alone unit and taking voltage readings is not difficult, but it

Cont'd Pg. 10

Service Line (Cont'd)

can be VERY hazardous. Use of a Variac, or equivalent, on the AC power input of the 516F-2 is highly recommended. Remember that you must jumper pins 5 and 7 at the 11 pin connector in order to activate the power supply. Do that with a short piece of insulated #14 AWG (or similar) house wire pushed fully into the pin sockets. Set up the leads of your voltmeter prior to applying power and do not touch those leads as you bring up the AC line voltage! If your 516F-2 still has the tube rectifiers installed, you will not get low level B+ and high B+ output until you have somewhere between 60 and 70 VAC applied to the input.

* If you can get the 516F-2 to full rated voltage output without problems, you now know that the problem is in your transmitter or transceiver. If the 516F-2 blows a fuse or develops arcing when tested alone, check for the following:
 -Arcing at the 5R4 tube socket - usually across the surface
 -Arcing within the bleeder resistor cage (likely due to a pinched wire or broken resistor)
 -Shorted electrolytic capacitors on any of the DC outputs

 -Short within any of the filter chokes (either within a winding or between the winding and case of the choke). A "Megger" is useful here.

 -Poor or broken solder connection within the cover cap of the 11 pin socket or at the chassis end of the cable.
 -Arcing between any winding of the main power transformer and its case or the chassis

Repair any noted problem before attempting to use the power supply to operate a radio set. After the power supply tests good by itself, then connect the transmitter or transceiver and verify proper operation.

At this point in the troubleshooting process, I hope that your 'Work of Art" is now fully functional and providing you the enjoyment you deserve. If not, it is time to move on. Before you do that, observe the operation of your radio carefully and ask yourself these questions:

* Does the problem ALWAYS happen at the same (select as necessary) time/frequency/band/mode of operation?

* Is the problem constant (always present) or does it come and go?

* Are there any abnormal symptoms present when the set fails to operate properly? These might include, but not be limited to: giving off an odor or wisps of smoke, making unusual sounds inside the chassis - such as arcing, one or more tubes exhibiting red plates, one or more tubes with "dead" filaments, inability to dip or peak a circuit according to the manual, excessive frequency drift, signals going up and down in strength (receiver) when there is actually very little QSB, lack of drive during transmitter tune-up, lack of adequate audio drive from the mic.

At this point, it is really productive to then sit down and study the manual schematic and block diagrams to see what the observations are telling you. This will also help you, in the long run, enjoy your rig to its fullest potential.

In the next installment, we'll be discussing the use of "divide and conquer" techniques to address these symptoms.. In addition, the list of desirable test equipment will grow and we'll move into more advanced troubleshooting techniques. Until next time, PLEASE be careful when working around any type of electrically energized equipment. Follow all shop safety practices and use these repair opportunities as learning experiences. Share your knowledge via the reflector or *Signal*. This is how the Collins Collectors community grows and serves as such a valuable resource to so many.

de Dale Svetanoff, WA9ENA
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Author Information:

Dale has written for ***The Signal*** previously in the Q2, 2008 issue. He is currently employed by Rockwell Collins in Cedar Rapids as a EMC Engineer working on RF shielding and interference issues. Please see the past Q2 issue for more detailed information.

The 516F-2 Resonant Choke: What is Going on Here ?

A Technical Analysis by Don Jackson, W5QN

In mid-November of 2008, Martin Sole, HS0ZED, posted an email to the Collins Reflector questioning the values of L1 and C1 in the 516F-2 schematic diagram. It started a thread with a lot of interest. The reason for the question is that the Circuit Description in Section 3 of the manual states: "Under no-load conditions, the L1-C1 combination resonates at a frequency of 120 Hz, presenting a relatively large impedance to the 120 Hz ripple voltage." However, the values shown on the schematic are 8 H for L1 and .05 uF for C1. The calculated resonant frequency for these values is 251.6 Hz, which disagrees with the 120 Hz that everyone agrees it should be.

So what is going on here? A number of suggestions arose, including possible confusion over the "dual reactor" description for L1 in the parts lists, the possibility that L1 was a "swinging choke", or there was simply a typographical error. The first useful information came from Bob Jefferis, KF6BC, who has some historical and technical knowledge of L1. Bob said that he had seen the specification for L1 in the past, and its inductance was specified as 8 H +50% -15% @ 150mA, with no other inductance spec. Further, he said the 516F-2 parts lists are misleading. Collins part number 668-0300-00 refers to a complete "dual reactor" assembly consisting of L1, L2, and the hardware necessary to bolt them together. The supply contains only one of these assemblies, not 2, and the individual chokes do not have dual 8 H windings inside. So Bob put that problem to bed.

What about the 8 H value? In order to resonate at 120 Hz with .05 uF, L1 should have an inductance of 35.2 H. It was conceivable, if L1 were designed as a "swinging choke", the choke could have a value of 8 H at 150 mA and 35 H at the no-load current of 19 mA. (Note: Though somewhat misleading, throughout this article I will refer to the "no-load" current as the approximate 19 mA drawn by the bleeder resistors, since this is the terminology used in the Collins Circuit Description.) However, several folks (Martin, Jim W8ZR, Bob, and myself) measured the zero-current value of L1 (using a simple circuit resonance method), and the results were between 9 H and 11 H. So, a swinging choke was not the answer. We were left with a conundrum since everyone I spoke with, as well as myself, believed that the maximum value of an inductor was the zero-current value. This inductance would decrease due to core saturation affects as DC current through the inductor increased to a high value. But increasing inductance? Nahhh!!

The first glimmer of an explanation came from Bob, who recalled something about inductance increasing with AC level. This was news to me. He checked the L1/C1 resonant frequency at low AC excitation voltage, and then at the maximum voltage his audio generator would produce, about 2VRMS. He saw a slight decrease in resonant frequency at the 2VRMS level, indicating an increase in the inductance of L1. Although I still wasn't really buying this, I repeated his test on my 516F-2. Sure enough, I saw the same thing. How far would this affect go with increasing AC voltage, I wondered? I fed my audio generator to an old stereo amp, and then applied the amp's output to a 6V/120V transformer in a voltage step-up configuration. This arrangement gave me about 165VRMS to drive L1/C1 with. A series resistor was inserted to isolate the generator and L1/C1. For low AC voltages, I could use a resistor of 1Meg or so, but in order to maximize the voltage delivered to L1/C1, this value needed to drop. A value of 33k was a decent compromise that enabled measuring the resonant peak with satisfactory accuracy, while delivering 100VRMS to L1/C1. The results of this test were startling to me. Above about 3VRMS drive level, the calculated inductance of L1 consistently increased about 18% every time the voltage was doubled. Although I could only reach about 100VRMS, this convinced me that L1 was acting exactly like the designer expected it to. Making the assumptions that the curve could be extrapolated to the actual operating condition of about 450VRMS, and that the small bleeder current had little affect on the inductance, the inductance of L1 could be estimated to be about 40 H in the no-load condition. Since 40 H and .05uF were resonant near 120 Hz, this appeared to be the answer we were looking for. Wrong!

Bob performed a "tuning" test with one of his 516F-2 supplies in which he varied C1 while moni-

Cont'd Pg. 12

516F-2 Resonant Choke (Cont'd)

toring the AC ripple at the supply output. This tuning experiment has been done by a number of Collins experts in the past. The idea is to adjust C1 for minimum AC output ripple, which occurs when L1 and C1 are resonant at 120 Hz. From this data, the inductance of L1 can be estimated. His result indicated that L1 was in the 17-19 H range, far from the 40 H estimated from our previous curve extrapolation. I then performed the no-load tuning process on my own 516F-2. The results are shown in Figure 1. Included is the result of a Spice simulation, a tool I often use to confirm my understanding (or lack of) of circuit and component function. Such a circuit model also makes "what if" experiments very easy.

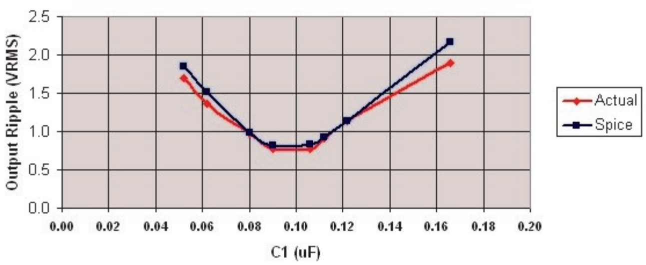

Figure 1 – C1 "Tuning" Results – Ripple vs. C1

While I was at it, I took data on the DC output voltage as C1 was varied, shown in Figure 2 with the corresponding Spice simulation.

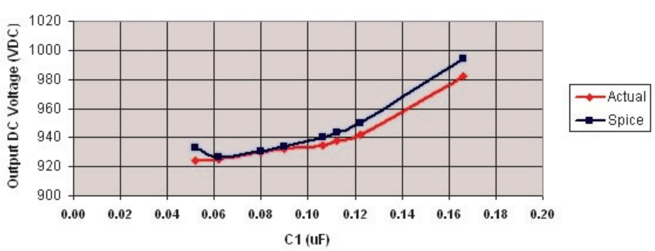

Figure 2 – C1 "Tuning" Results – DC Output vs. C1

My tuning experiment, using series/parallel combinations of three fixed capacitors, showed that L1 is resonant at 120 Hz under no-load conditions when C1 is approximately .098 uF. L1 may then be calculated to be approximately 18 H, which agreed with Bob's findings. So, why was this 18 H number so different from the original inductance of 40 H that was determined by extrapolating the L1 inductance from the L1 vs. AC voltage curve?

Going back to the bench, I rigged up a new test setup that would allow me to inject DC current simultaneously with the AC applied voltage from my signal generator. A schematic of the setup is in Figure 3.

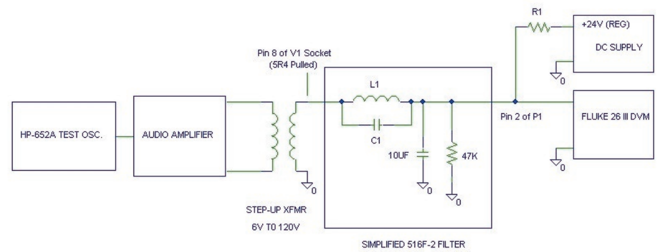

Figure 3 – Test Setup

As well as injecting DC current, the setup enabled me to increase the AC voltage across L1 to 168 VRMS. With this setup, I looked for a minimum reading on my Fluke true RMS voltmeter to determine resonance. I set about taking data for L1 as a function of AC and DC excitation. A sampling of the resulting data is shown in Figure 4.

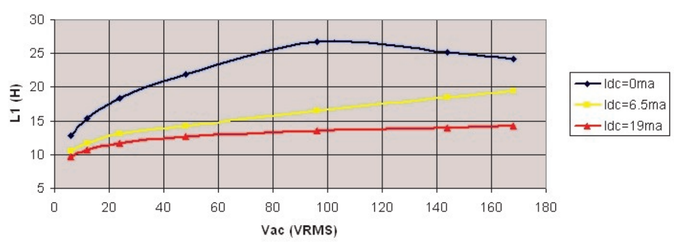

Figure 4 – L1 vs. AC & DC Excitation of L1/C1

To my surprise, I found that even a small DC current of a few milliamperes resulted in a significant reduction in L1 inductance, when combined with large AC voltage. The data also showed that the zero current inductance did not continue to increase beyond approximately 100VRMS, but "turned over" and began to decrease. So, it was now obvious that both my assumptions in making the original 40 H inductance estimate were erroneous.

Additional data taken by resonating L1 with a large enough capacitor to produce resonance at 120 Hz indicated that the value of L1 was approximately 15 H with a DC current of 19 mA and an AC voltage of 168 VRMS, which was the highest my test setup could produce. However, what we

Cont'd Pg. 13

516F-2 Resonant Choke (Cont'd)

really want to know is the value of L1 with the AC voltage that is actually present across it under typical no-load conditions.

Measuring the AC voltage across L1 under no-load conditions with my voltmeter indicated approximately 454 VRMS. The resulting Spice simulation of this voltage predicts 452 VRMS under no-load conditions. The waveform of the voltage produced by the simulation is shown in Figure 5.

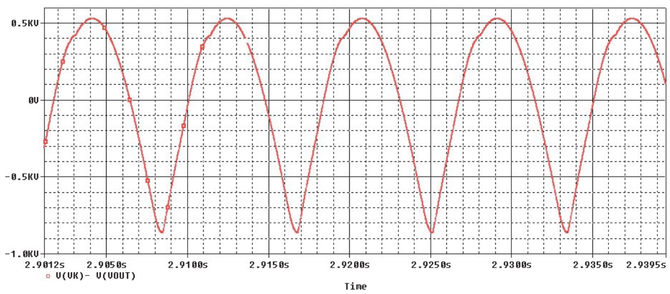

Figure 5 – Voltage Across L1/C1 - Spice Simulation

Referring to Figure 4, the percent inductance increase of L1 by extrapolating the "19 mA" curve to the 454 VRMS level is in the neighborhood of 12%. Applying this increase to the 15 H measurement at 120 Hz indicates that L1 could approach the 18 H inductance found with the tuning method. Yes, we are again depending on a curve extrapolation, but it's the best I can do without the ability to produce a test voltage of 454 VRMS.

Nevertheless, at this point we have two test results indicating the inductance of L1 to be approximately 18 H. The next task was to find a published description of the phenomenon that causes inductance to vary with both AC and DC excitation. I started calling engineers who might be able fill me in on this, but everyone I initially spoke to was unaware of the phenomenon. My friend and Collins-ex Bob Kellow W5LT, suggested I call Forrest Cummings, W5LQU. Forrest mentioned that Warren Bruene, W5OLY, might have the answer. At this point I asked if Forrest was referring to *THE* Warren Bruene, whose name I ran across numerous times on the web while looking for info on resonant power supply filters. Yes, it was that Warren, and even more amazing, I found that Warren lives just a few miles from me. I called Warren on the phone and he graciously invited me over to visit him. I felt fortunate to meet one of the legends of Collins Radio and listen to him describe the highlights of his career. What a privilege that was for me. To make a long story short, Warren mentioned the "increasing inductance" phenomenon in the book "SSB Principles and Circuits", which he co-authored, but didn't recall all the answers as far as the theory was concerned. I borrowed a couple of books from him, including his 2nd Edition of Terman's "Electronic and Radio Engineering". At home, I was studying Terman, and noticed a reference in the power supply section back to the section on Circuit Elements very early in the book. The section on inductance contained what I had been looking for. I then found a very similar paragraph in my own 4th Edition of Terman. It states:

"The value of permeability thus defined has two important characteristics. First, for a given alternating current the incremental permeability (and hence the inductance) to the superimposed alternating current will be less the greater the direct current. Second, with a given direct current the incremental permeability, and hence the inductance to the alternating current, will increase as the superimposed alternating current becomes larger. These characteristics hold until the flux density becomes so high that the core is saturated."[1]

This was the confirmation I was looking for. Clearly it is old knowledge, but perhaps is not well known to those of us who are not magnetics experts. In addition to the text, Terman includes a figure which shows typical plots of permeability vs. AC flux density at different DC current levels. It clearly shows the affect of DC current in the presence of the AC excitation, and is similar to the test results of Figure 4. Although the phenomenon of increasing inductance may occur to a small degree in other core materials, the affect is apparently much stronger in steel cores.

Having found direct confirmation of the legitimacy of this phenomenon, the question remained as to why it occurs. What is it about a steel core that causes this behavior to be as significant as it is? Warren recommended that I find a copy of Reuben Lee's book, "Transformers and Circuits" [2], which is an introductory textbook. It

Cont'd Pg. 14

516F-2 Resonant Choke (Cont'd)

is now in the public domain and a web version can be found at www.vias.org/eltransformers/. The chapter of most interest for this discussion is entitled Transformers, Construction and Materials. It contains a section on Core Materials that addresses the phenomenon of interest. Lee's publication explains it in reasonably simple terms. Figure 6 is a graph from Lee's textbook similar to the one found in Terman. It shows permeability increasing with increasing AC flux density for two different types of steel cores. Certainly there are many different core structures and materials that result in different absolute results, but for the purposes of this discussion, the specifics are not as important as the general behavior.

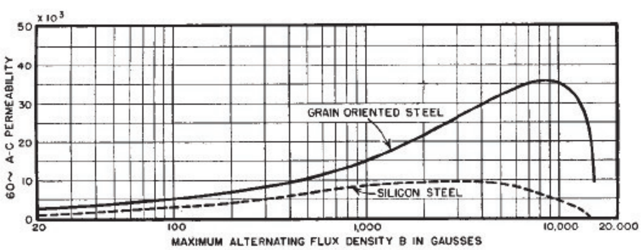

Figure 6 – Permeability vs. AC Flux

The first thing to understand is the basic definition of inductance, which is directly proportional to permeability. There are a number of subtly different permeability definitions, but let's consider "normal permeability" which is equal to Bm/Hm, where Bm is the maximum flux density, and Hm is the maximum magnetizing force for a given AC excitation. By this definition, permeability is the slope of a line drawn from the origin of a B-H curve to the point defined by Bm and Hm. Figure 7 from Lee's textbook illustrates the concept.

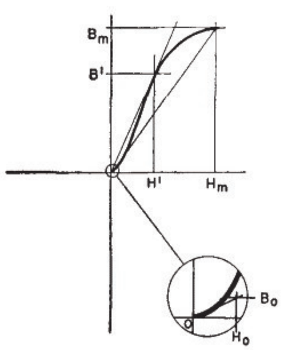

Figure 7 – Typical B-H Curve for Steel

The magnified portion of the curve shows how the slope of the B-H curve, and therefore the permeability and inductance, increases as the AC magnetizing force increases. This significant change in the slope of the B-H curve close to the origin is the characteristic that causes the inductance change with applied AC voltage to be so prominent in steel cores.

Another question is whether there is a significant advantage to modifying your 516F-2 by creating resonance at 120 Hz at no-load condition, as is stated in the circuit description. To help answer this question, I plotted the DC and ripple outputs vs. DC load current of my own 516F-2, both with the original C1 and with C1 increased to produce no-load resonance at 120 Hz. The results are in Figures 8 and 9.

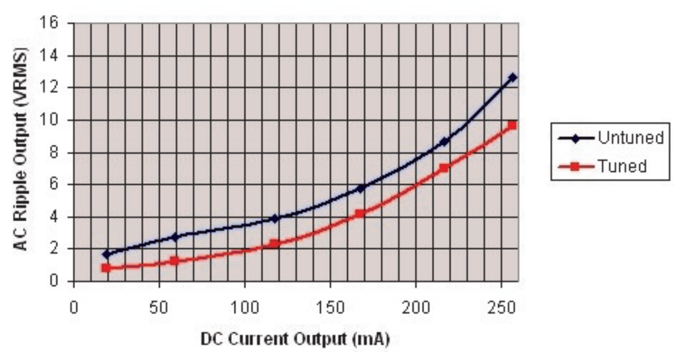

Figure 8 – AC Ripple vs. Load Current, Tuned & Un-Tuned

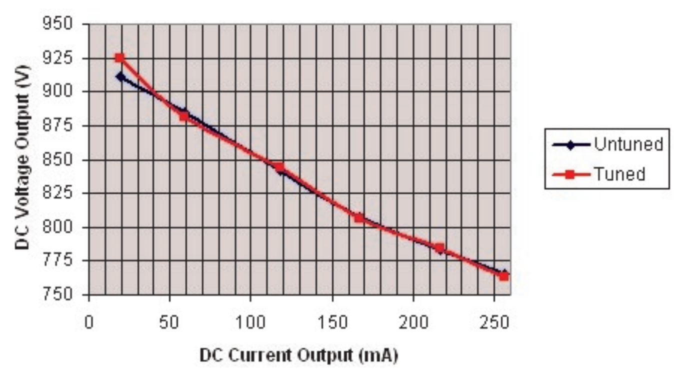

Figure 9 – DC Output vs. Load Current, Tuned & Un-Tuned

Cont'd Pg. 15

516F-2 Resonant Choke (Cont'd)

From these graphs it can be seen that resonating L1 at 120 Hz does produce an improvement in ripple performance, while having little affect on the DC output regulation. Whether this ripple improvement is worth the trouble of modification is a matter of conjecture. The easy answer is that if you are hearing no on-the-air complaints about hum, don't bother. If you have time on your hands and really want to optimize your 516F-2, you might want to perform the modification. Before considering modification, it is important to understand that the tolerance on L1, as we understand it, is wide: 8 H +50% -15% at 150 mA. Because of this, it is not recommended to simply add an additional .05uF across C1. The easiest way for most of us to determine the correct value is to use the "tuning" method, varying C1 with external capacitors while monitoring the AC output ripple. When a capacitor is found that minimizes the ripple, you have found the correct value to install across the existing C1. Or, you can replace C1 with a new capacitor that is the sum of the original C1 and the external value determined in the test. Needless to say, exercise extreme caution if you choose to perform this "tuning" process, as the voltages present may be hazardous to your health. In my case, the correct value was about .05 uF, which would be placed in parallel with the existing .05 uF capacitor.

To this point, we have determined the no-load value of L1, and what causes it to vary from its "advertised" value of 8 H. Unfortunately, there remains the original question of why the Collins Circuit Description states that L1 and C1 are resonant at 120 Hz under no-load conditions. Clearly 18 H and .05 uF do not resonate at 120 Hz. Although I don't have a good explanation, Bob Jefferis suggested that it may have to do with component tolerances. If you do the analysis, which Bob did, you find that in order to guarantee the resonant frequency of L1/C1 will not fall to less than 120 Hz, you must use a value for C1 no greater than .05 uF. This is primarily due to the "+50%" inductance tolerance of L1. We may never know the real answer to this question unless someone can contact one of the original Collins designers of the supply.

So, what should we take away from this investigation? Perhaps the most important is a reminder that an inductor value on a schematic may not always represent the value of that component under the actual circuit operating conditions. In particular, for inductors with steel cores, both the AC and DC excitations must be taken into account when attempting to understand the behavior of the inductor. One last thought is a quote that William Culpepper, W4BZ sent me from the "Iron-cored inductors in resonant circuits" section of the Radiotron Designer's Handbook:

"The performance of iron-cored inductors in resonant circuits cannot be calculated mathematically owing to the immense complexity."

This project has made me truly appreciate that sentiment! By the way, the Radiotron Designer's Handbook appears to be an excellent source of design data and methods for iron core devices, as well as many other topics.

Once again I would like to thank everyone who helped out with ideas and measurements during this investigation, with special thanks to Bob Jefferis for his technical input and editing efforts.

I don't know about everyone else, but I learned something new, and had a lot of fun doing it!

73s, Don W5QN, w5qn@verizon.net

[1] F.E. Terman, "Electronic and Radio Engineering" 4th Edition, p.14, McGraw Hill 1955
[2] R.Lee, "Electronic Transformers and Circuits" 1955

Author Information:

Don Jackson, W5QN, of Garland, Texas is writing for us for the first time. It is a pleasure to have him on board and, after reading this article, we look forward to many more.

Don is retired from a 40 plus year career as an electrical engineer, where he specialized in HF and Micro-

Cont'd Pg. 16

From the President
by Paul Kluwe, W8ZO

I love my Collins S-Line.

Yes, I mean those radios with the front panel of a fine camera. They have held a very high standard - with a very low noise floor - all these years. I know it didn't start out that way: I have a copy of a 1958 Collins letter calling the 75S-1 a "cost-reduced" 75A-4. But nearly 20 years after that, and after many visits to see Roy at Purchase Radio Supply, it was a new S-Line that ended up on the bill of sale. Anyhow, thirty years after that purchase, the trusty S-line still holds its own on the HF bands in the main operating position of my shack. There are not many examples in the history of electronic products that can match that record of reliable longevity!

Recently, I had fun scouting out an internet site called "MyHamShack.com" that is operated by our very own CCA webmaster Brian Sokol. The user interface at this site makes it easy to share ham shack information and photos. You can even view a picture of the above-mentioned S-Line at: http://www.myhamshack.com/W8ZO/

Regarding CCA election news, there were exactly three nominees for the three positions that were open. Jim Stitzinger and Mac McCullough were the incumbents nominated, with the third spot being filled by our ***Signal*** Editor, Bill Carns. Going off the board is Pete Zilliox, though we are grateful he is remaining as CCA Membership Chairman. I want to thank all of the board members for their service this last term. We appreciate your efforts.

Best wishes to all of the CCA membership for 2009, and we hope to see you all at the CCA Events/Dinner at Dayton, Ohio in May!

de Paul, W8ZO
paul@kluwe.com

Election Update Notice:

Since there are three seats up for election, and there have only been 3 nominations, there will not be a ballot mailed. The three nominees were Jim Stitzinger, Mac McCullough and Bill Carns. Pete Zilliox was nominated, but declined due to work load. The above 3 nominees that accepted will join the Board as of March 1, 2009. Pete will remain as Membership Chairman.

Don Jackson, W5QN
Author Information (cont'd)

wave Receiver design. He graduated in 1966 with a BSEE from the University of Florida and started his career with Texas Instruments.

He is fairly new to Collins collecting and has a 75S-3B, 32S-3, 30L-1, 312B-4 line-up which he uses as his main station. Don was first licensed in 1960 while in high school and started ham life with an Allied R-100 kit receiver and a Heathkit DX-40. When asked what his favorite piece of Collins gear was, he named off the 75A-4, but he has yet to find one. I am sure you can find some room Don. Keep trying.

Don's other hobbies include fly fishing, volley ball, bridge and photography. Welcome Don to ***The Signal.***

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