The Wireless

May 2023

The Garden City Amateur Radio Club

PO Box 482 • Garden City, MI 48135-9998

Next Meeting:
Tuesday, May 16, 2023, 7:00pm
Garden City Presbyterian Church
1841 Middlebelt Rd.
Garden City, MI 48135

Are you ready for the two biggest events of the year? We're only two weeks away from the **Dayton Hamvention**. This is the best opportunity all year to see all the latest in Ham gear, pick up some good deals on used gear, and make a lot of new friends.

Then, in just over a month, it will be time for **Field Day**. If we can get enough people, we'll be going for 24 hours trying to make as many contact as possible, not to mention working with our local **Scout Troops** to help them earn their **Radio Merit Badge** and maybe start some of them on their path to becoming licensed operators themselves. If you'd like more information, contact Hank, AB2XG or Scott, WT8S.

Photographers needed: If anyone is planning to go to either Dayton and/or Field Day, please take pictures, and send me copies to use in upcoming editions of *The Wireless*. You can send them to me at GCARC.Wireless@gmail.com. Thanks.

Congratulations to those that tested at our April Exam session:

KE8YDD	KE8YDL
KE8YDE	KD8YDM
KE8YDF	KD8YDN
KE8YDG	KD8YDO
KE8YDI	KD8YAN/AG

SPECIAL SERVICE CLUB

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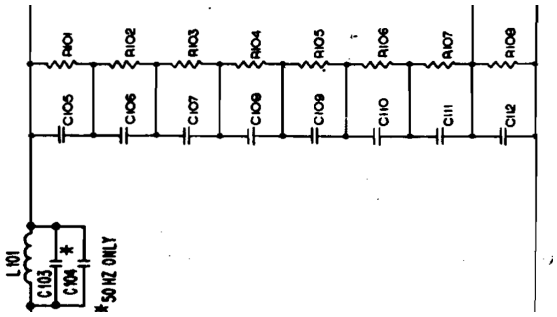
Mat-Matics # 116
Henry 2K-Classic Valve Operation
Part 3 – Filament & Plate Voltages

-Mat Breton, N8TW

This is the third of five articles in a series on my studies into the behavior of my linear amplifier with respect to proper operation of the Eimac 3-500Z power tubes.

Although the specs I will work with are for the Eimac 3-500Z tubes and the Henry 2K Classic Amplifier, and the diagrams and descriptions below are for the Henry 2K Classic, the concepts and general information should extend to move amateur radio tube-based linear amplifiers and tubes/manufacturers (just redo the calculations as necessary for the specifications).

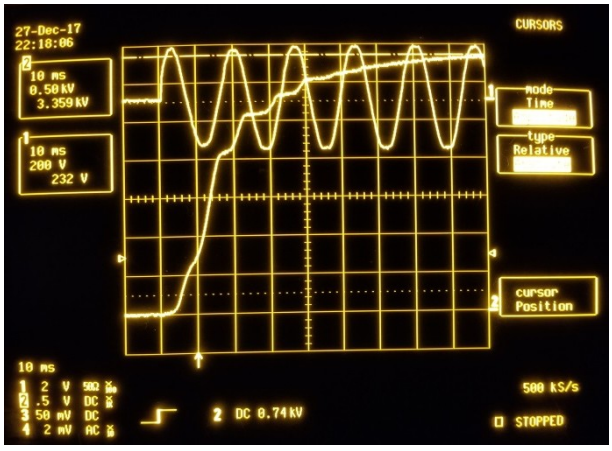
Anode Voltage: The limitation on the anode voltage is the HV capacitor bank. The 2K Classic uses a series string of eight 450V capacitors, balanced by a series string of resistors (see schematic below). In an ideal world the capacity of the bank would be 8*450V = 3600Vdc. However, the resistors have an initial mfg tolerance of 5% associated with them, this means one capacitor could potentially see a higher voltage than all the others … and this limits the maximum anode voltage to 3300Vdc. Note that I did not apply aging and temperature variance because all the resistors should shift similarly in my amp. If we apply a 5% worst case figure then max allowable input voltage drops to 242Vrms into the linear amp: Nominal voltage at my house is routinely over that year-round. Even if we cheat and we use a 1% resistor tol figure (assuming all the resistors came the same lot and fit within a tight variance) we can just barely make the 260Vrms surge figure (which we have already measured at my house, see previous article). We would have no margin on the capacitors.



Henry Radio Schematic Showing the Capacitor/Resistor Ladder

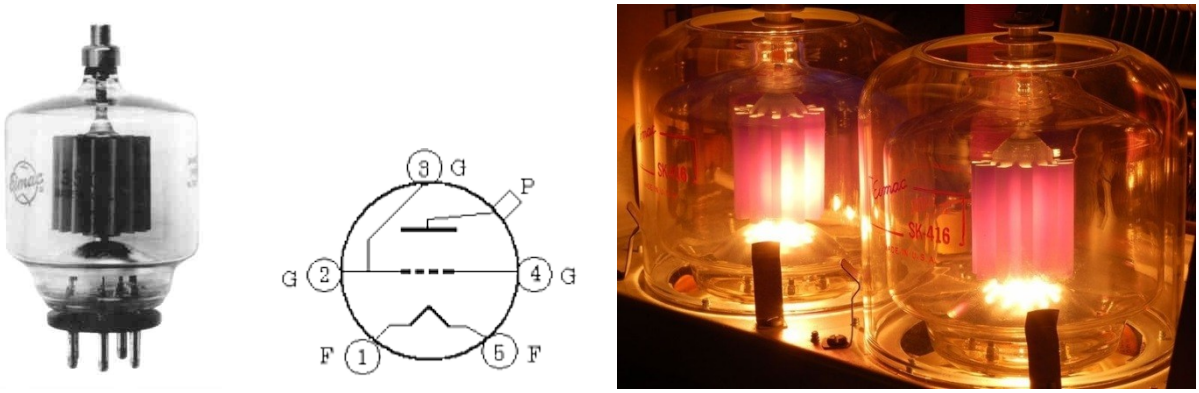
Anode Voltage Measurements & Calculations								
	Voltage Spec			Unloaded			Worst-Case High	
Line Voltage				244.8	Vrms		260.0	Vrms
Transformer In				244.3	Vrms		259.5	Vrms
Anode Voltage	3300	Vdc		**3338.5**	**Vdc**		**3545.79**	**Vdc**

I also checked for overshoot when the amplifier is turned on, just in case. I did not expect to see any and as can be seen below the anode voltage ramp up is well behaved:



Top Trace is Transformer Input Voltage, Bottom is Anode Voltage

Filament Voltage: As previously mentioned (in the first article) the tubes are rated for a set amount of operating filament voltage (not current). The acceptable range for each of the two genuine Eimac 3-500z tubes in my amp is 5.0Vrms +/- 5% (or 4.75Vrms to 5.25Vrms). The 3-500Z is a power-triode tube, and consumes a lot of current in the filament (it is rated at 14.2 or 14.6A nominal).



Eimac 3-500Z Tube (left), an electrical representation (middle), and two tubes loaded and glowing (right, from Pinterest®).

Why is the tube filament spec given in voltage rather than current? It would seem that since filament emissivity (the rate electrons are given off) is directly related to heat, and the heat is directly related to the current, that a min/max current spec would better fit the application. The most probable reason is that most tube filaments are driven with unregulated supplies that come directly from a transformer winding: since the primary side is voltage "controlled" by the line voltage, the secondary will appear to be a voltage source (as long as the current is within the transformer capability). Complicating the use of voltage versus current is the fact that filament resistance varies with its temperature (by a lot), and this creates a very non-linear relationship between filament voltage and current.

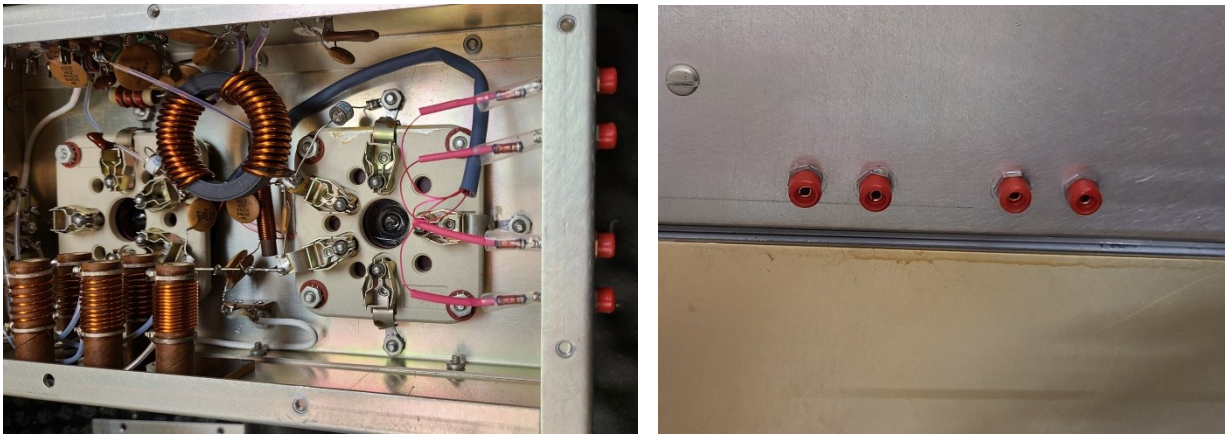
Commercial (very-high-power) installations often have a filament voltage management process, where-by the filament voltage is periodically adjusted for optimal life/performance. In these cases, the filament voltage is slowly lowered until output power begins to drop, or spurious emissions appear. It is then raised slightly above that level. To do this, you need to have very accurate measurements of output power, filament voltage, output spectrum, and a method to adjust the filament voltage in fine increments. This must be periodically re-done as the amount of current (and therefore voltage) required to maintain full power output increases as the tube ages. Since the transmit duty-cycle of an amateur station doesn't approach that of a commercial radio station, this sort of balancing act may not add any sort of real value, while actually increasing risk of damage to the tube as well as creation of spurious emissions.

The first step was to actually measure what my filament was for a given voltage (both under load, and unloaded). I could then add the known Point-of-Use line voltage variance that I previously measured (in the first article) and understand where my tube filament were operating during (hopefully) all operating conditions. If I'm lucky, they are operating within spec (or closely enough); if I'm unlucky they may be severely enough out of spec that I have to do some mitigation (either contact the local electric company about variance, and/or modify my linear amplifier).

As a quick test, I measured the idle filament voltage at the transformer (points Ma and Mb in the picture below). I would expect this voltage to be relatively high: first the amplifier (and therefore transformer and input wiring) was idling (not transmitting), and secondly there should be several tenths-of-volts drop in the wiring and connectors to the tube filaments. If the specified maximum for each tube is 5.25 volts RMS (Vrms), and there is perhaps 200mV of additional I*R drops in the circuitry, I would expect the transformer taps to be putting out somewhere between 10.2 and 10.7Vrms (+/- depending on line voltage and the actual I*R drops).

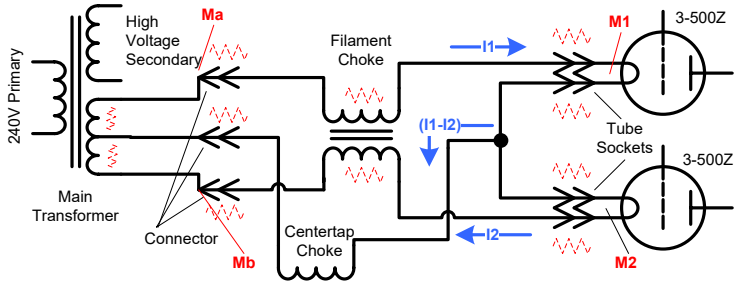
- Unlike most other linear amplifiers, the Henry 2K Classic uses the center tap of the filament transformer to attempt to "balance" the voltage (not current) of two tube filaments (this design introduces a bad failure mode with a single-tube filament open, and will allow current differences between the tube filaments). This means that I actually need to measure both sides of the winding with regards to the center tap and not just the difference between the two transformer terminals.
- Between Ma and Mb (in the picture below) I actually measured 11.30Vrms with a line voltage of 245.8Vrms. The voltage split between the two sides of the winding was 5.80Vrms versus 5.83 Vrms, a difference less than 1%. In the diagram below, these measurement points are shown at points Ma and Mb.

For the real filament voltage measurements I needed to get right on the 3-500Z tube pins. This is because of all the parasitic resistances in the elements between the transformer and the filament itself. The intermediate connectors, wiring, choke and sockets all add small amounts of resistances … but at 15Amps of current even small resistances can result in significant voltage drops. I've shown some of these resistances in the diagram below as red dotted resistors. The more accurate filament voltage measurements are shown at points M1 and M2. I attached sense leads directly on the pins and ran them to a LPF (low pass filter), and out to some special jacks I added to the back of the Henry. Note the high-temp protective covering on the wiring.



Filament Taps and LPFs (left), and Jacks (right)

Filament Current Path



The results were not great: I was running the 3-500Z tubes over-voltage. If the Henry was being run at 230Vrms input it is likely the filament voltage would be on the high-side but within spec. However any voltage variation coming in would put them overvoltage … this is likely a design issue with the transformer.

Sunday Night Net:

We still need more people to help with the net. Serving as a net control operator is a great way to get more involved in the club and to get to know more of our members. If you'd be willing to help, please contact any of the Net Control Operators or Club Officers for more details.
Join us on Sundays at 9:00pm, 146.86 MHz, -600Hz offset, 100Hz PL tone
This is a purely social net, all licensed hams are welcome to join in.

Upcoming Sunday Night Net Control Operator Schedule:

May 14 N8TW
May 21 W8ROY
May 28 KC8VCX
June 04 N8TW
June 11 W8ROY
June 18 KC8VCX
June 25 N8TW
*Can we add **your** name to the schedule?*

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Mitigation: To reduce the filament voltage there are a couple of options available (some of which are not really an option due to technical issues)

Bad: Place additional resistance in the primary side of the transformer: a bad idea on this design, as this would introduce load-related non-linearities into both the filament supply, and the plate supply (same transformer), creating a "non-linear amplifier".

Expensive: Replace the 10.2V unregulated supply with a regulated supply. This would be a very big supply, and would need to float to make the grounded-grid amplifier concept work.

Expensive: The ideal option would require a transformer with multiple primary taps to adjust for natural variations in line voltage. Some linear amplifiers already come equipped like this. For the Henry I would have to replace the main transformer … making this a very expensive proposition.

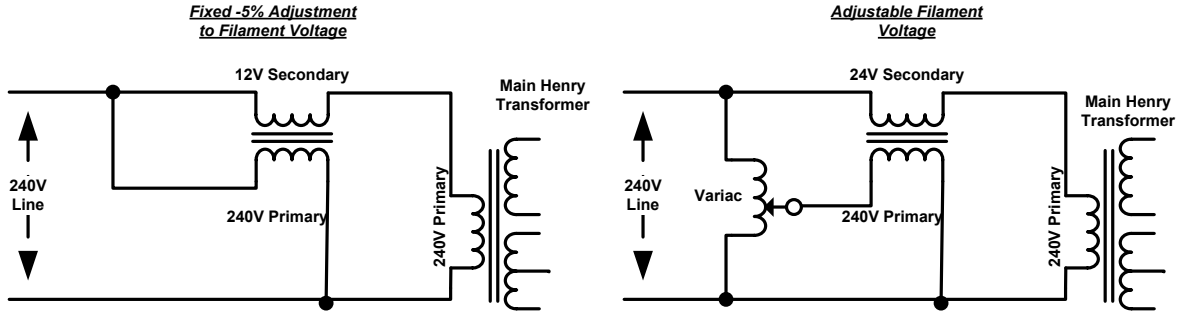
Expensive: Put a variac on the line to adjust the line voltage: a 3KW 240V variacs do not grow on trees, and would be an expensive way to get the job done (although it would do a great job I'm sure).

Feasible (but unlikely): Contact the electrical company to reduce the service voltage: since my voltage was technically within spec I expect this would have been unlikely to happen.

Feasible: Place a "bucking" transformer on the primary: a 12V transformer would reduce voltage by fixed 5% (see the schematic on the left below).

Feasible: Place a variac-driven bucking transformer on the primary. A 200W variac driving a 24V transformer would allow for a 0 to -10% adjustment (see the schematic on the right below). This is sometimes done on continuous-use commercial applications where "optimization" provides real value.

Feasible: Place additional resistance in the filament secondary path: not as bad an idea as putting resistance in the primary side, but adding a fixed resistance would require high-power precision resistors, or measured coils of wire. But there are other ways around this (read below) J



Bucking Transformers: Fixed (left), Adjustable (right)

Since I was already adding NTC's for the 3-500Z filament inrush current limiters (previous article), I also measured to filament voltage before and after they were installed. These NTCs have a rating at 15Amps of current to be 0.02 Ohms +/- 0.005Ohms. I would therefore expect a total voltage drop between 0.225V and 0.375V per tube (0.3V nominal). The actual measured results are shown in the table below:

Filament Voltage Measurements & Calculations					
	Eimac Spec	Before - Unloaded	After - Unloaded	After - 90% Load	Worse-Case Low	Worst-Case High
Line Voltage		242.9 Vrms	241.7 Vrms	241.0 Vrms	232.0 Vrms	250.0 Vrms
Transformer In		242.5 Vrms	241.2 Vrms	240.3 Vrms	231.3 Vrms	249.5 Vrms
Tube 1 Filament V	5.25 Vrms	**5.56 Vrms**	**5.15 Vrms**	**5.02 Vrms**	**4.83 Vrms**	**5.33 Vrms**
Tube 2 Filament V	5.25 Vrms	**5.49 Vrms**	**5.07 Vrms**	**4.95 Vrms**	**4.77 Vrms**	**5.24 Vrms**

We can see that the total voltage drop from adding each NTC element was about 0.4Ohms. This is slightly higher than the NTC's by themselves should have added, but we need to remember that I also added in some additional lengths of cable and also connections with the modification … so we are OK.

It is true that the worst-case high calculation shows one tube theoretically operating slightly overvoltage. I'm OK with this, as this should be very infrequent, and it is far worse to operate the tubes under-voltage than over-voltage.

Summary: The anode voltage was debatable as to be in range of the high-voltage capacitor bank, but the filament voltages at the tube pins were certainly out of spec. Both are mostly due to my house voltage averaging around 242Vrms while the amplifier was originally designed to operate at 230Vrms, as well as the Henry filament voltage being slightly high to start with. Fortunately the NTC's I added to limit inrush current dropped the filament voltage enough to be in range … two birds with one stone. I've kept the filament voltage taps installed so that I can re-measure anytime I want without disassembling the Henry.

I will eventually be "upgrading" the electrolytic capacitor bank to a higher-voltage oil-filled capacitor. This is a project in itself as I will have to also change the HV and anode current measurement circuits. In the meantime I will hope we don't get a high surge event at my house while I have the linear amplifier on J **The measurements for this article required working with lethal voltages: do NOT attempt this if you don't have the proper equipment and experience.**

UPCOMING SWAPS:

06/03/2023 - IRA Hudsonville Hamfest
Hudsonville, MI
06/04/2023 - Chelsea Amateur Radio Club Swap Meet Partnering w/Michigan Electronics Expo
Chelsea, MI
06/17/2023 - Midland Amateur Radio Club Hamfest
Midland, MI
06/18/2023 - Monroe Hamfest
Monroe, MI

In less than a month, the Dayton Hamvention **kicks off!** It's by far the biggest Ham Radio Show of the year, and I'm sure looking forward to seeing so many friends there. We're working hard to get as much as possible ready to go, and you can expect to see our usual huge display packed full of Ham Radio goodies and gadgets. And yes, you can expect to see our **"special staff members"** there as always.

It's a big show, and if you want to see as much as possible, it takes some planning. Here are my **top 10 tips for getting the most out of Hamvention**. In fact, most of them apply to just about any large Hamfest.

1. **Make a list** of companies and forums you want to visit. My good friends at PC Board have a complete listing of both indoor and outdoor booths **here**. Note that booth numbers correspond to buildings or flea market areas. For example, we'll be in booths 3503, etc. in Building #3, also called the Marconi Building. **Split your list** in three categories -- (a) must see, (b) really want to see, and (c) would like to see. Knock off the must see first, then tackle the others.
2. If a booth is just too crowded, **don't spend a lot of time waiting** to talk to someone. Move on to your next stop. Booth traffic starts to drop off after about 2-3PM and you'll have an easier time then. Of course, remember it's ***ALWAYS*** worth waiting at the **Quicksilver Radio Booth** ;-)
3. Noon 'til 1:30 or so is peak time for lunch. **Eat a bit earlier, or later,** and you're likely to encounter much shorter lines at the food trucks. Don't forget to **pack water and snacks,** or be prepared to pay typical concession stand prices for them. If you need medication during the day, have that with you. No sense hiking back to your car to get it. And pack a bottle of your favorite **pain reliever**, too. A headache or sore feet can really kill your enjoyment of the show. There are just a very few real restrooms on site, but last time there were plenty of Porta-Potties that seemed to be well maintained throughout the show. A small pack of baby wipes or similar might be handy to have.
4. **Be prepared for the weather**. It might pour rain. It might be blazing hot and sunny. It might be damp and chilly. It might even hail. And all of them might occur over just a few hours! A hat, sunscreen, umbrella, and light jacket should be in your pack.
5. You're going to be on your feet -- a lot. Unless you're used to standing for long periods, your "dogs will be barking". One of the best tips I've ever heard is to **bring a second pair of shoes and socks**, and switch them halfway through the day. Believe me, it will almost feel like you have a new pair of feet.
6. **Bring plenty of cash.** While the larger commercial dealers probably accept credit cards, many in the flea market will not. Try to get used bills. If you have to get crisp new ones out of the ATM, take a minute to give each one a "crumple". That makes them much less likely to stick together. Especially early in the day, it may not be easy for a dealer to make change for a small purchase with a large bill. And most (like me) always appreciate small bills to make change for others.
7. If you plan to use a credit or debit card, **let your bank know in advance.** Banks have ever more stringent anti-fraud practices in place, protecting both you and them. You may typically use your card for a tank of gas and a trip to the grocery store once a week at home. If you suddenly make a flurry of purchases in a short period of time, far from home, your bank may well flag and suspend the card. There should be a customer service number on the back of your card. **Make sure you can read it!** Even so, cell phone service at the Fairgrounds was less than ideal last year and I'm unaware of any change in that regard.
8. **Take advantage of the opportunity to learn**. There are forums galore, covering just about every aspect of our great hobby. They'll be presented by experts in the field, and you'll get the chance to meet fellow enthusiasts as well. The same is true for shack accessories -- in many cases, you can speak directly with the folks who designed and manufacture it.
9. Take a minute to **thank the hundreds of volunteers** who make the Hamvention possible. I can't imagine how many hours of their time it takes to put on a show like this. At the very least, they deserve a big round of thanks. Similarly, most vendors put a huge effort into their Dayton booths. Without them, there's no show. Let them know you're glad to see them. And (I know it sounds a bit self-serving) keep them in mind year-round as you plan your purchases. **I don't see either Amazon or E-Bay on the vendor list!**
10. Whether you go expecting to have a great time, or you expect to find a lot of shortcomings, you're probably right! So **ignore that very small minority of Negative Ninnies**. Yep, there will be a few glitches. If you let that ruin your Hamvention, shame on you. With Ringling Brothers' Circus now closed, this is the Greatest Show on Earth. Enjoy all it has to offer, and take home some wonderful memories along with some new toys.
11. Bonus tip -- stop by my booth, #3503 etc in the Marconi Building, for a **free "73" sticker** or two. And please do say hello. I always enjoy seeing you in person and hearing what's on your mind.

73, John Bee N1GNV
www.qsradio.com

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Someone told me that Hamvention was like Mecca and you MUST go at least once in your lifetime. I got mixed up and thought they said that you can only MISS Hamvention ONCE in your lifetime I've been to all of them since 1977 and have a few tips on how you can make the most out of attending Hamvention.

- **WALK!** Weeks in advance you should get out and walk a mile or two or three every day to beef yourself up for all the walking you'll be doing. Get used to being on your feet for several hours.
- Over the weeks leading up to Hamvention, **break larger bills** into $10, $5, and $1 dollar bills. Don't make the sellers burn through all their small bills.
- **Make a wish list**. List the items you need for ongoing projects, and any future projects you hope to do over the next year.
- Write down the specifications/details of any products you want.
- Make an estimate of how many you'll need and how much they'll cost. Don't forget to include spares!
- **Stock up on supplies.** I used to hit Mendelson's first thing Friday morning, with my folding hand cart. I'd purchase 40 or 50 POUNDS of hardware of all sizes ($1.25 per pound). Then haul that heavy load back to my car well before I'd burn out walking all of Hamvention. This assured a life-long supply of hardware in my workshop. Did the same with rolls of resistors and capacitors, and filled my parts bin drawers back home.
- **Write down the phone numbers**, flea market space numbers, motel name and room numbers, of any friends you hope to hook up with.
- **Put together a list of eateries** near your motel that you'd like to try. Include their reservation phone number and address. Maybe make a plan for which place to eat on which night, and share that with your friends and buddies you would like to spend more time with.
- Make a list of any **evening events or dinners** you'd like to attend.
- **Make a list of seminars** you plan to attend. Note the day, time, and room number. This will help to keep you on schedule and not miss an important seminar you wanted to see.
- **Carry a "goodie bag"** to collect all your small items and even some big ones. Picture one of those heavy cloth bags newspaper boys used to use on their routes. Sometimes I even carry smaller bags inside my Goodie Bag, just in case!
- **Carry a DMM and a multitool.** Sometimes making a resistance check or popping the cover off a case, will confirm if that "deal" is a good one, or a boat anchor.
- **Be prepared** for intense sunshine, rain, and even sleet! Carry a hat and a plastic rain poncho. If you don't use the poncho to cover yourself from rain, you may be glad you have it to cover that $1000 radio you just bought.
- **Keep track of your purchases.** Log every purchase on a small pad or on your wish list. Hamvention is long and tiring and your memory will evade you when trying to figure out where that last $300 went that you can't account for.
- **Don't keep all your cash in one pocket or wallet.** Place your money in multiple pockets just in case you drop or misplace it!!! Use money clips if you have them. I account for all my cash-on-hand each day before I start out, and reconcile my funds back at the motel in the evening.

By having a plan and a shopping list you are likely to have a much better experience at Hamvention

—Jay, WB8TKL

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