



# The Wireless

March 2023

The Garden City

Amateur Radio Club



### Next Meeting:

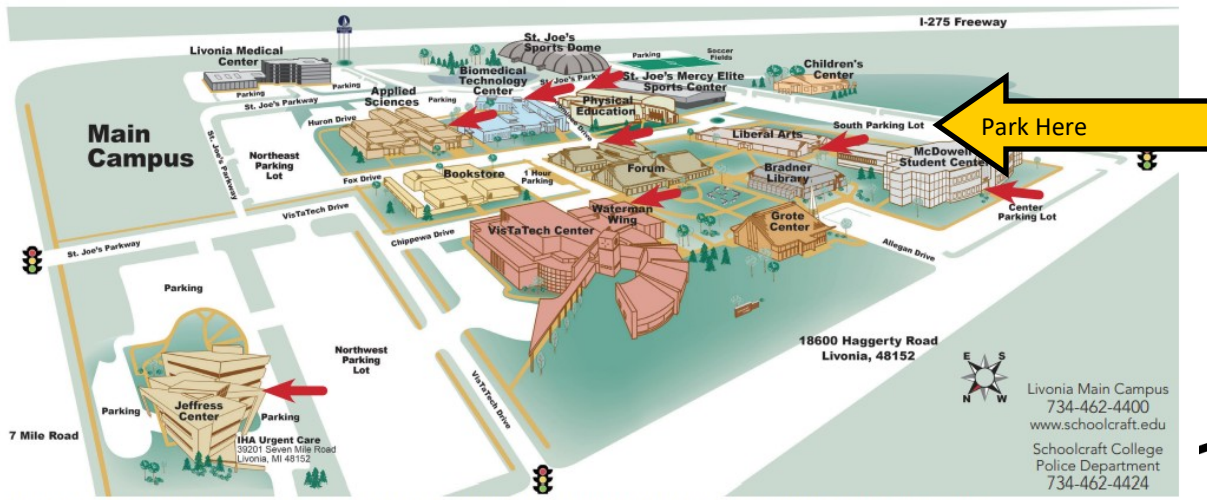
Tuesday, March 21, 2023, 7:00pm  
Garden City Presbyterian Church  
1841 Middlebelt Rd.  
Garden City, MI 48135

PO Box 482 • Garden City, MI 48135-9998

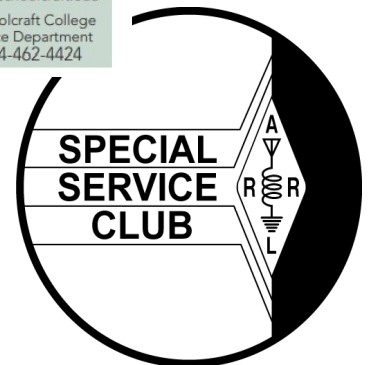
### Notes for all VE's:

Last November, I renewed my Amateur License. It was a pretty straightforward process, and I was able to print my new license within about 24 hours. I expected my VE credentials to arrive in the mail soon thereafter, but they didn't come. I checked my VE manual, and it said that they could take up to 24 days, so I waited. In January, I called the ARRL, and was told that they didn't send them out automatically anymore, and that I needed to call to request the renewal sticker, which I did during that same call. Within a few days, my stickers arrived in the mail. Now, I've been told that some other VE's did get their stickers automatically; I'm just relating my own experience here. My advice is that when you do renew your license, it won't hurt to make a quick call to ARRL at 1-860-594-0300 just to make sure. They're very friendly when you call.

Our next VE session will be Thursday, April 13. Testing will begin at 7:00, so please plan to be there by about 6:30. It will be in the Liberal Arts Building, so use the South Parking Lot unless you want to do a lot of walking.



Livonia Main Campus  
734-462-4400  
www.schoolcraft.edu  
Schoolcraft College  
Police Department  
734-462-4424



# Mat-Matics # 115

## Henry 2K-Classic Valve Operation

### Part 1 – Series Overview

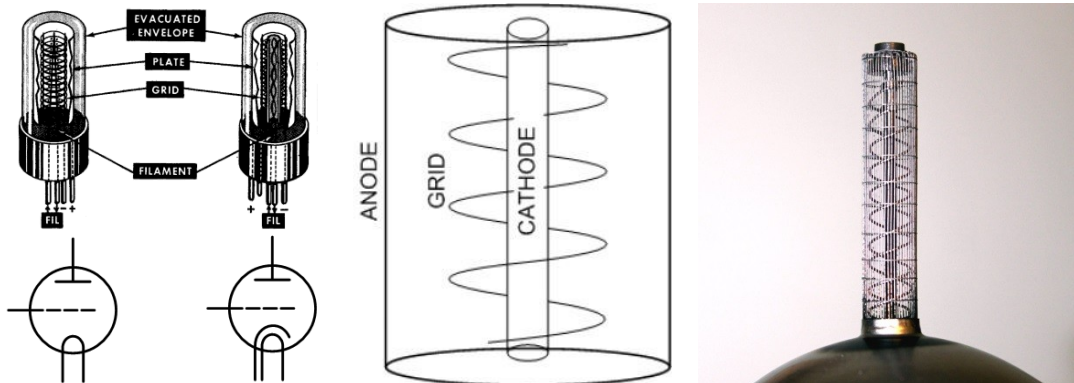
*-Mat Breton, N8TW*

This is the first 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:

- Article 1: Series Overview (this article)
- Article 2: Henry 2K-Classic 3-500Z Filament Inrush Current
- Article 2: Henry 2K-Classic 3-500Z Plate & Filament Voltages
- Article 4: Henry 2K-Classic 3-500Z Seal Temperatures

If everyone remembers, I found a NIB (New-In-Box) Henry Radio 2K-Classic® linear amplifier (hereafter referred to as the “Henry”) on Craigslist® still wrapped in plastic in an unopened box. It came with two NIB Eimac® 3-500Z tubes also sealed in boxes. Because Eimac no longer makes these tubes (not for a long time), the only current sources are copies from Chinese manufacturers. Although quality has been recently improving, cost has not: prices currently range from \$180 to \$220 each for Chinese replacements. You can still buy tested NOS (New Old Stock) Eimac and Phillips/Amperex® tubes at a severe premium. Because I would like these original NOS (New Old Stock) Eimac tubes to last a long time I started this study to see how the Henry Classic-2K amplifier “treats” them by comparing measured results to Eimac’s original manufacturer’s specifications. Some items like grid current are actively measured by meters, and I can regulate them as I use the amplifier. Other items like the filament voltages are not easily found during use, and it is these items that I’ll be concentrating on. I’m making my own measurements and conclusions as I don’t believe in blindly putting faith in everything I read on the web ... and there is a lot of conflicting information regarding tube amplifiers available on the web.

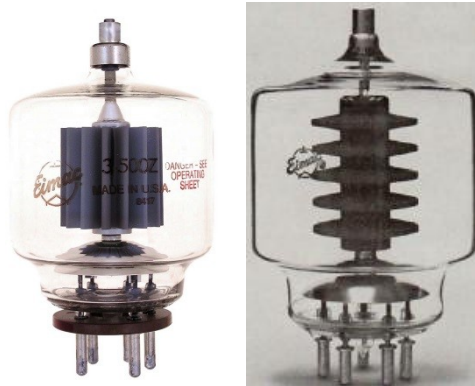
The 3-500Z (3=triode, -=glass, 500=anode dissipation, Z=pins), originally designed by the Eimac Corporation, is a power triode: the triode having three elements (anode, cathode, and a single grid), and the power meaning it is built to handle some amount of power (up to 1400W of input power). It was an upgrade over the earlier 3-400Z product (the first triode designed for grounded-grid operation). As with most power tubes, it uses a “directly heated cathode” meaning that the filament and cathode are the same element: the filament, a thoriated-tungsten alloy, emits the electrons directly. Low-power tubes usually use an indirectly heated cathode, separate from the filament.



*Direct vs Indirect Heated Cathodes (left), Structure (middle), 3-500Z Cathode/Grid (right)  
 {right picture from QRZ Forum, W8JI, fair use}*

The 3-500Z was designed for use in a grounded grid (cathode-driven) configuration although other designs are permitted and used. In the grounded-grid configuration, the tube displays a high  $\mu$  (a high voltage gain), with an associated power gain of up to 20 times the input power. With a Class-AB2 grounded-grid amplifier, a mere 46W of input (exciter) RF signal power can give you up to 890W of output power (with a total input power usage of ~1450W).

The original 3-500Z uses a molybdenum anode with a zirconium out coating (the getter). A later version (the 3-500ZG) uses a graphite anode. The graphite anode is rated at 600W dissipation (versus 500W with the 3-500Z), and it was/is advertised as “more rugged”.



3-500Z (left), 3-500ZG (middle), Glowing (right)  
 {right photo credit: flickr 585836949, fair use}

Eimac was originally started as Eitel-McCullough Company by two amateur radio operators Jack McCullough (W6CHE) and Bill Eitel (W6UF), who wanted power tubes that required lower plate voltages. When WWII came along, the US Military became a big customer, and the company (later renamed Eimac), expanded quickly. Eimac was later merged with Varian (the Varian brothers). Finally, the Eimac division and other assets were sold to CPI (Communications & Power Industries). CPI-Eimac still makes very high power vacuum tubes (up to a million watts) although they exited the internal-anode/glass-envelope tubes in the 1980’s. 3-500Z manufacturing has since shifted to other companies and countries, first in France, then Russia, and now in China. With each new company and plant there has been a learning curve in manufacturing these tubes correctly, often resulting in poor tube quality. The first step was identifying what Eimac tube characteristics were “critical” to measure and control. A look at the original Eimac 3-550Z datasheet shows the following limitations:

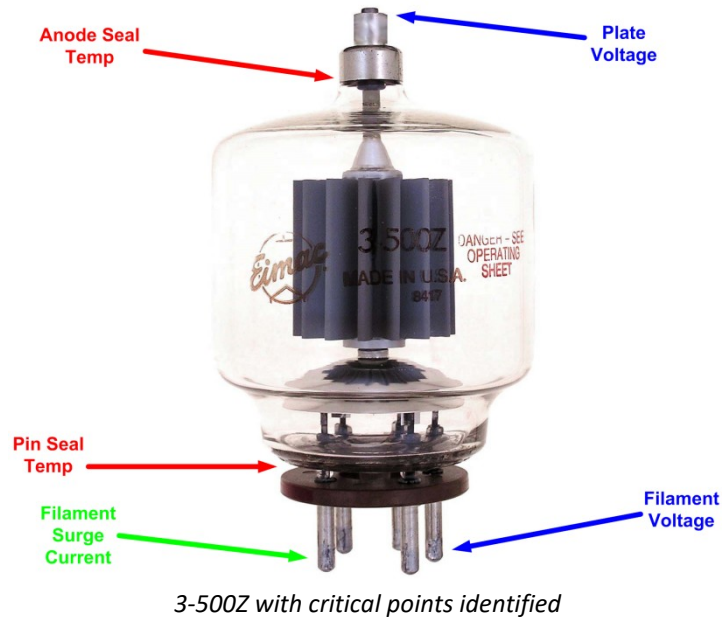
- ◆ Plate Voltage:  $\leq 4000\text{Vdc}$  (Cathode Driven Configuration)
- ◆ Filament Voltage:  $5.0\text{Vdc} \pm 0.25\text{V}$  (4.75 – 5.25Vdc)
- ◆ Filament Inrush Current:  $2x$  “normal current”. Nominal current is listed as 14.6A at 5.0Vdc, so max inrush  $\leq 29.2\text{A}$
- ◆ Plate Seal Temperature:  $\leq 225 \text{ degC}$
- ◆ Base Seal Temperatures:  $\leq 200 \text{ degC}$

Please note that the USECA Swap Meet scheduled for March 26 has been cancelled.

**UPCOMING SWAPS:**

- 04/01/2023 - [AC8RC April Fools Day Mini-Swap](#)  
 Burnips, MI 49314 (Salem Twp.)
- 04/22/2023 - [St. Joseph County Michigan Amateur Radio Club Ham Fest](#)  
 Centreville, MI
- 05/06/2023 - [Wexaukee ARC Swap & Shop](#)  
 Cadillac, MI
- 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





While there are other items such as grid current and plate current, these are operator controlled during operation, and do not require the same approach.

Three of the items are relatively straightforward.

- ◆ Base Seal Temperatures: 200 degC: The base seal temperatures (there are five seals for the five pins) can be accurately measured with thermocouples. As a grounded-grid 3-500Z application typically only produces 20W of grid heat dissipation, I'll measure these three pins but don't expect any grid pin issues. The bigger risk comes from the filament pin seals: the filament is producing up to 79W (plus anything picked up from radiated anode heat).
- ◆ Filament Voltage: this can be measured with an accurate true-RMS voltmeter.
- ◆ Filament inrush current: this can be measured with an AC current probe.

The two remaining items require special care due to the very high (lethal) voltages involved:

- ◆ Plate Seal Temperature: using a common contact thermocouple on the plate is not safe due to the extremely high voltages. Using an IR thermometer is not effective due to the small area of the plate, the low emissivity of the aluminum, and the surrounding items. We will instead use temperature-sensitive materials to indirectly check if thresholds are exceeded.
- ◆ Plate Voltage: using a common multimeter to directly measure the plate voltage (> 3000Vdc) is not safe (even with a high-voltage probe). We will instead use another indirect method to measure a reduced voltage amount.

In addition, several of these items may be affected by the line-voltage of the amplifier. Line voltages (from the power company) can vary over time, or with household or neighborhood loads. The output voltages of "unregulated" supplies (such as the Henry uses) will vary with the line voltage. In this case, we will pay extra attention to the effect varying line voltages will have on the filament voltage, and the plate voltage. We will also extrapolate this into some other measured results, such as a potential increase in seal temperatures at maximum line voltages.



A previous article (related) showed how I measured the variability of the line voltage at the Henry, and obtained worst-case low and high operational voltages. In part 2 I'll cover filament inrush currents. In part 3 these will then be applied to further measurements on the 3-500Z filament (direct) and plate voltages (indirect) to obtain their true operating conditions at my QTH. In Article 4 we will take measurements of the pin seal temperatures, and we will see if we cross the 225 degC boundary for the plate seal temperature. This will require pushing the Henry to operational limits (power, transmit time). In each of the following articles I will be describing the theory and results, as well as the measurements. If we do find problems (if we find we are operating the 3-500Z tubes outside of their design window), we will apply corrective actions.



Henry Advertisement Picture (left) and My Henry 2 K-Classic (right)



**A Word from our Treasurer:**

I am still collecting yearly 2023 dues from our membership at large. The current fee is \$17.00 and please provide exact change if payment is by cash. Checks to GCARC also will be accepted. Dues can be paid in person during meetings or by mail to our P.O. Box listed on the newsletter letterhead. Please mention our club to prospective new members who may be interested in joining.

*-Richard Zarczynski / AC8FJ  
GCARC Treasurer*

**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:**

**Schedule:**

- Mar. 26 KC8VCX
- Apr. 02 N8TW
- Apr. 09 W8ROY
- APR. 16 KC8VCX
- Apr. 23 N8TW
- Apr. 30 W8ROY
- May 07 KC8VCX

*Can we add **your** name to the schedule?*



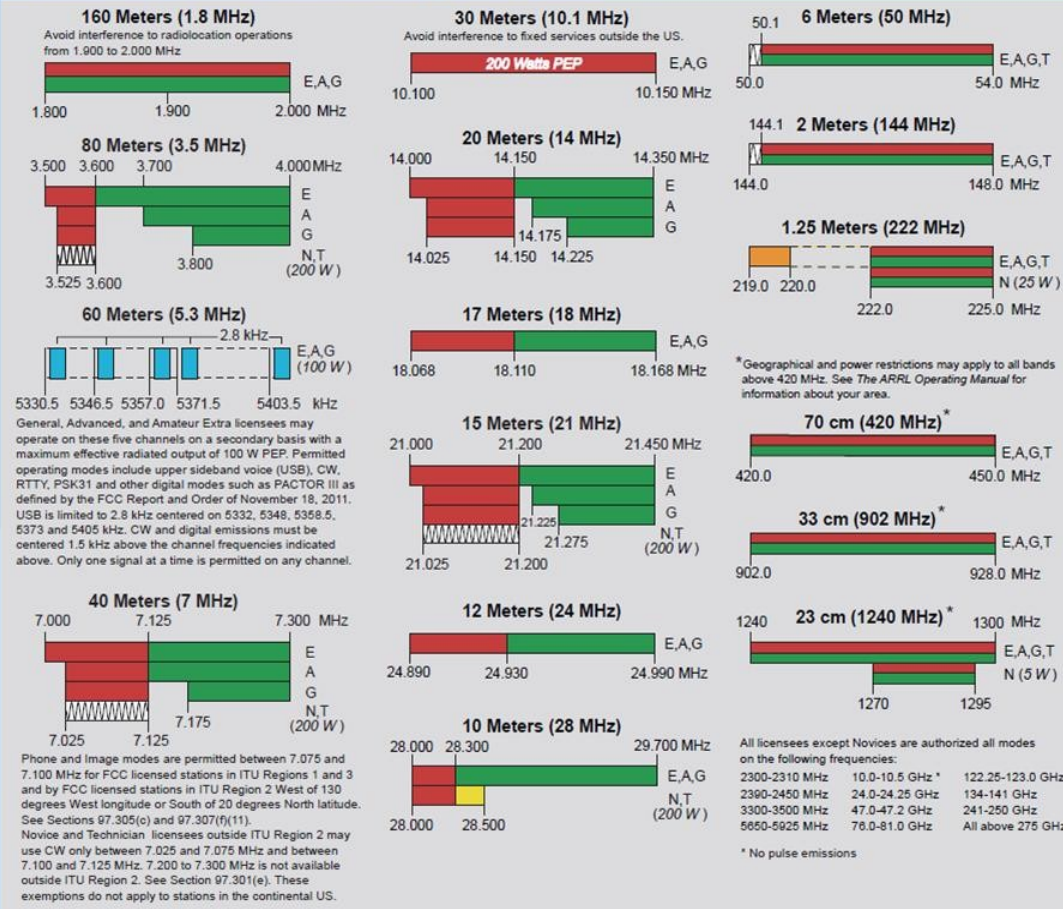
# US Amateur Radio Bands

## US AMATEUR POWER LIMITS

FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

Effective Date  
March 5, 2012

Published by:  
**ARRL** The national association for  
**AMATEUR RADIO®**  
www.arrl.org  
225 Main Street, Newington, CT USA 06111-1494



**KEY**

Note:  
CW operation is permitted throughout all amateur bands.  
MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 210-220 MHz.  
Test transmissions are authorized above 51 MHz, except for 210-220 MHz.

- = RTTY and data
- = phone and image
- = CW only
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems only

E = Amateur Extra  
A = Advanced  
G = General  
T = Technician  
N = Novice

See [ARRLWeb](http://ARRLWeb) at [www.arrl.org](http://www.arrl.org) for detailed band plans.

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Exams: 860-594-0300 email: [vec@arrl.org](mailto:vec@arrl.org)

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Thanks to W8ROY for the image.

**Severe Weather Spotter Training**

**SKYWARN**

**Saturday, April 15, 2023**  
**10:00 am - 12:00 noon**  
**Garden City Presbyterian Church**  
**1841 Middlebelt**  
**Garden City**  
Bring a friend

- ◆ All are welcome
- ◆ You do NOT need an Amateur Radio License to take this training.