FROM THE STAFF

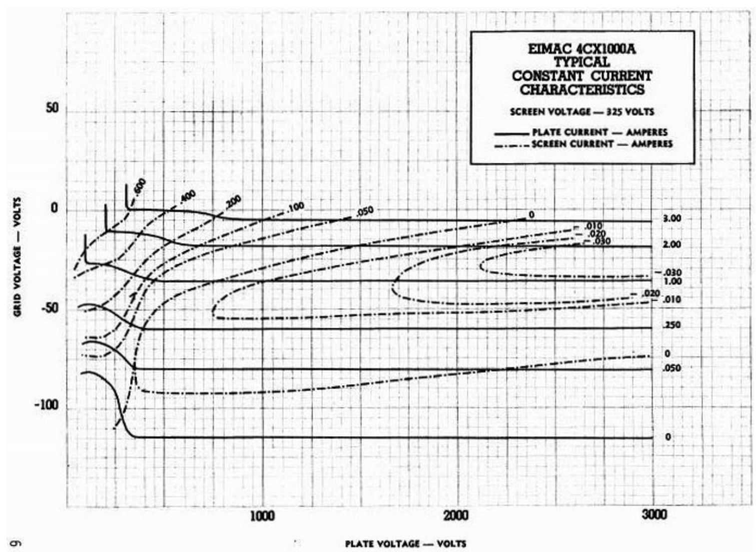
by Bill Carns, N7OTQ & Don Jackson, W5QN

From the Desk of N7OTQ

You could not ask for a better source of information about the 30S-1 amplifier than one Warren Bruene. It was Warren of course that did the fundamental first PA design with the then new 4CX1000 tetrode and gave us the big amp that we love so much. Just as a reminder, it was Warren Bruene who first patented the then novel way of neutralizing a large tetrode. This was only one of his many key patents that contributed to his, and Collins Radio's, success.

Several months ago, there was a flurry of activity on the CCA reflector about the 30S-1 and its operation, and more to the point, how to tune it properly – and why. There was a lot of good info put out on the reflector in response to that thread, but there were also some marginal comments and some that left things a little cloudy.

This led me, having had several cherished personal discussions with Warren over the years, to write an article on how to properly tune the amplifier and also cover some of its novel characteristics. We promised that this article would be placed immediately on the website – somewhat unusual – and then also published in the next (this) issue of the *Signal Magazine*. At this time, the article has been uploaded to the website and here it is here in better detail for you to enjoy.



In this framework, the Gods smiled upon us and two members almost simultaneously provided me with copies of letters that Warren himself had written to them in response to questions about the operation of the amplifier. These are previously unpublished.

When this material became available, I could not resist zeroing in on the 30S-1 as a theme for this issue and printing those two letters here for you to read. Together they provide a unique picture of how and why that amplifier was designed the way it was and why Warren felt you should and should not do certain things with it. These letters also give us more perspective on Warren, his professionalism and his pride in his work.

I suggest reading Warren's letters first and then reading the 30S-1 article on how to use it along with some of the whys contained therein. It is not often we get the story right from the "horse's mouth".

de Bill, N7OTQ

email: wcarns@austin.rr.com

From the Desk of W5QN

In the last issue of *The Signal*, there was an article on spectrum analyzers. During the creation of that article, I purchased a Rigol DSA815-TG. Although not a killer problem, I noticed that it had an issue with internal leakage that degraded its sensitivity when in Tracking Generator mode. Thanks to several folks who frequent the Reflector, I was able to gather enough data on a number of DSA815-TG units to come to some conclusions concerning this problem. If you would like to see some of the results and hear the whole story, drop me an email at w5qn@verizon.net and I'll fill you in. This is also of value to anyone considering purchase of this unit. I will say that, for the price, this spectrum analyzer is a great value.

As usual, I'd like to ask the members to contact me if you have something you think might be worthy of an article for The Signal. It can be technical in nature, historical, or anything else you believe might be of interest to the CCA membership. As well, if you would like to submit information for our "In the Shack" feature, please contact me. Don't be shy. Give me a shout!

73s - Don, W5QN

email:w5qn@verizon.net

Warren Bruene "Talks to us" regarding the 30S-1 Linear Amplifier

Warren B. Bruene, W5OLY
7805 Chattington Dr.
Dallas, Texas 75248
214-239-2492

March 2, 1994

R. Charles Rippel, WA4HHG
1272 Parkside Place
Virginia Beach, Virginia 23454

Dear Chuck,

Yes, I would be happy to discuss the 30S-1 with you. I am retired so am home most of the time. Usually not home Wed and Fri evenings. Generally any time from 8:00 AM to 10:00PM is OK except for lunch from 12:00 to 12:30 and dinner from about 5:30 to 7:00 PM Central time.

I am a member of the Collins Collectors Association also and spoke to the group at the Dayton Hamvention 2 years ago. The Rockwell/Collins Ham club have a 30S-1 in the shack in the plant.

I built a working model of the it and even got a patent on the circuit, which I am sure has long since expired. Others did the detail design to put it into production. Fred Johnson was the mechanical engineer. He lives here in the Dallas area. The cooling system was designed for minimum fan noise while keeping tube temperature rise within limits. I still have some of my original engineering notes but they are not very comprehensive. Unfortunately, I don't remember many of the details but maybe I can resurrect some of the thinking.

At the time the 30S-1 was designed, the FCC limited the DC plate power input plus driver plate power input to 1000 watts as read on the peaks of the plate current meter "kicks" with voice modulation. Art Collins insisted that the power output be kept "legal". We did a little fudging by having the plate current meter built with a little extra damping so it wouldn't kick quite as high to keep it "legal".

The 4CX1000A was a hot new tube and it had to be operated Class AB1 because the tube data sheet says that the grid dissipation limit is zero. Later, Eimac came out with the 4CX1500B which could tolerate 1 watt of grid dissipation. The 30S-1 should not be operated without the ALC connected since ALC limits drive to avoid excessive grid current.

From the tube curves, I estimate that the grid bias for 200 ma idling current for SSB with 200 DC screen voltage is approximately -37 volts DC. Based upon the feedback circuit capacitor values and the tube interelement capacitances, I estimate that the RF feedback voltage is approximately 45 volts peak. The total RF voltage on the cathode then has to be 45 + 37 = 83 volts peak to get grid current for ALC.

The screen voltage consists of the 200 volts DC screen to cathode voltage plus the 83 volts peak of cathode drive for a total of approximately 283 volts at the instant of maximum plate current. This achieves the benefit of being able to use an optimum value of idling current for low distortion and have enough peak screen voltage for the desired peak plate current at zero grid voltage (bias plus RF). Enclosed are copies of plate current transfer curves for screen voltages of 225 and 325 volts DC. Note that the extention of the straight line portion (on the 225 volt curves) gives the optimum bias voltage and above it the idling current of 250 ma. The optimum current will vary approx as the 3/2 power of screen voltage so that with 200 volts screen voltage the 200 ma of idling current is close to optimum.

Now look at the curves for 325 VDC screen voltage. The optimum idling current for low distortion is approximately 400 ma. This would increase zero-signal plate dissipation to 1200 watts! Using only 200 ma idling current with 325 volts on the screen raises IM distortion. The bias would be increased to about -65 volts. The peak screen voltage then will be 325 + 65 + 45 = 435 volts if there is enough drive to produce grid current pulses for ALC! PEP output would be well above the legal limit of 1500 watts.

The advantage of a 325 volt screen supply is a substantial increase in PEP output (perhaps 2 dB) to more than 1500 watts PEP. One of the disadvantages discussed above is higher IM distortion - although it may be no worse than other linears on the air. Driving it with a rice box instead of an S-Line would probably increase distortion substantially also.

The other big disadvantage is that it increases plate dissipation and would overheat the tube unless a larger cooling fan was used. Some hams have done this but it causes more air noise.

The original design was highly optimized and raising the screen/cathode voltage affects many things. I suggest that if raising the PEP output to 1500 watts is important to the owner that this could be accomplished with a much smaller increase in screen voltage.

CW power output can be increased by just operating in the SSB mode. I haven't looked at what might be done to optimize CW operation for 1500 watts output.

Your scheme of using the trapezoid looks like an excellent way to set the loading indicator. On larger transmitters, we usually calculated the value of DC screen current and plate current at PEP and then adjusted loading and drive to get those values. Then we set the automatic tuning system to tune for the ratio of RF plate voltage to RF grid voltage existing in that PEP condition.

The 4CX1000A tube has a large negative screen current region and apparently just gets back to zero at the desired peak plate swing limit. More swing would produce a rapidly rising screen current and rapidly rising distortion. Screen current loads the input circuit like grid current does in triode GG linears.

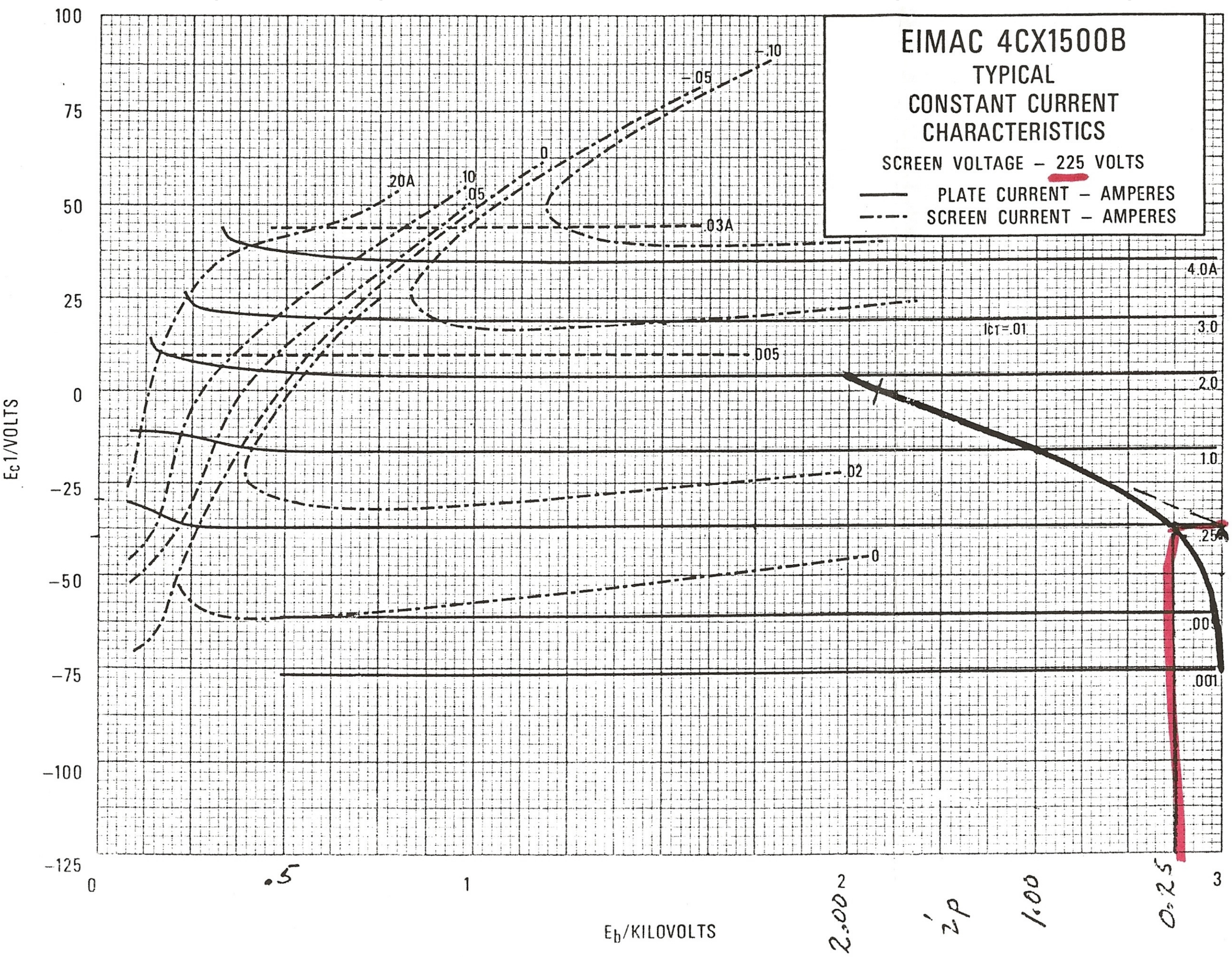
Well, Chuck, I have rambled on and on and perhaps have answered most of your questions. Please call if I can be af any further help. I will be looking forward to your article. It makes me proud that the 30S-1 is still considered to be one of the best.

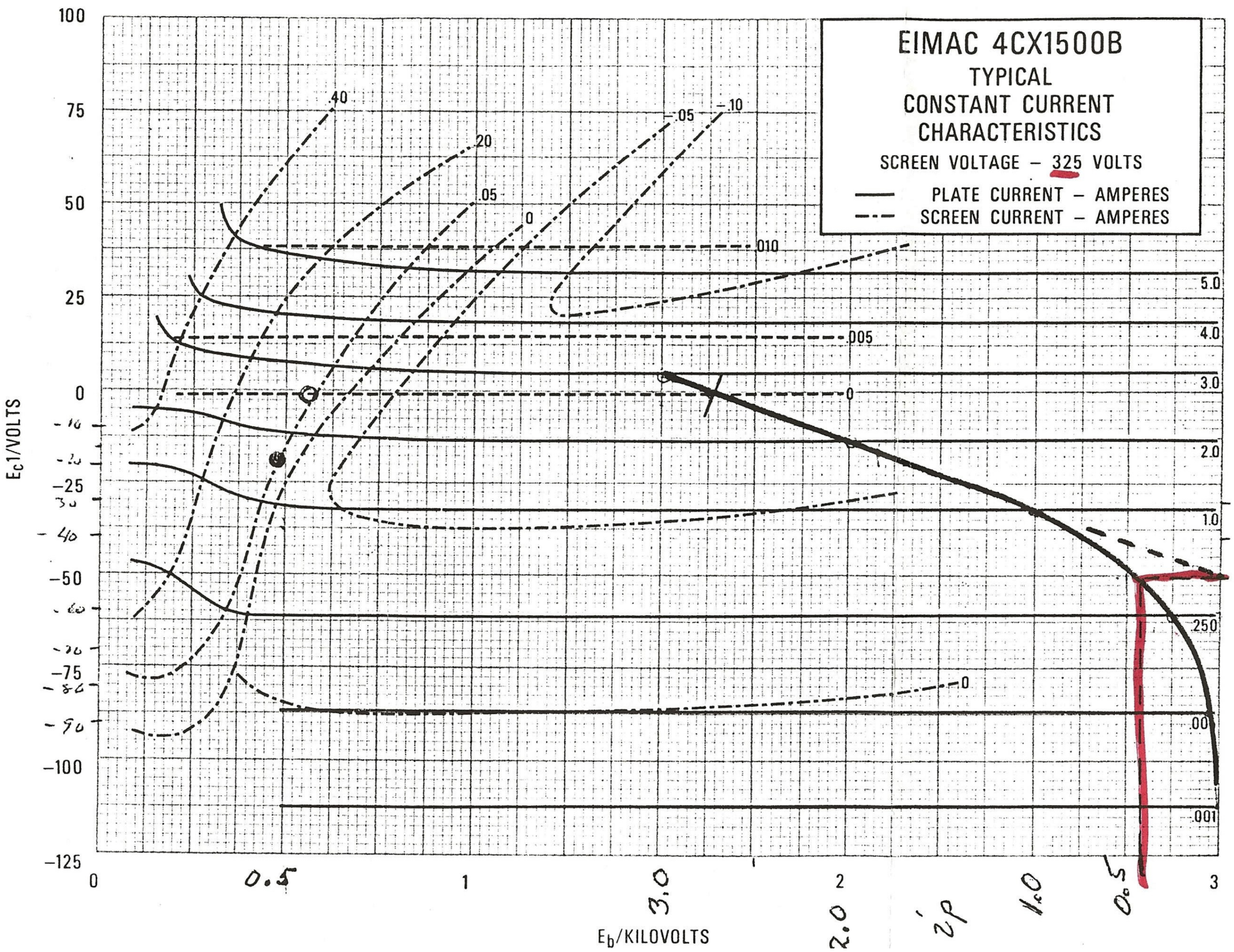
In case you missed it, Harry Snyder, W0RN, had an article "The Collins 30S-1 - Restoration and History" in July 1991 Electric Radio.

Sincerely and 73,

Warren

Warren enclosed the two following diagrams. The first indicating the design target operating area and then the second with the higher screen voltage





September 30, 1995

Richard Baldwin, KD6VK
2720 Twin Palms Circle
Las Vegas, NV 89117

Dear Richard,

It looks like you have a nice collection of Collins equipment. Hope that you are getting a lot of enjoyment out of it.

Yes, I invented the 30S-1 circuit using the new Eimac 4CX1000A tube back in about 1957. Art Collins had placed a requirement that all SSB equipment would have distortion products down at least 35 dB - and that was one IM product to one of the two tones. Now most ham manufacturers list IM products relative to PEP - which gives a 6 dB better sounding spec - so the 30S-1 when driven with the S-Line met 41 Db specified that way! I built and tested an engineering model to prove the circuit but others did the detail design for putting it into production.

I had to use several "tricks" to meet that requirement. One was to use a low screen voltage, another was to use some RF feedback and another was to use some multiple of 180 degrees electrical length from the driver plates to the 4CX1000A cathode. (That is the reason for the special length of coax from the driver to the 30S-1.)

In those days, the FCC power limit for SSB was 1000 watts input as read on the plate voltage and plate current meters - and if grounded grid - you were to include the driver plate power input also. The plate current meter has some damping so that the instantaneous peaks on voice were higher. Some have said that they get about 1100 to 1200 watts instantaneous PEP output in the original configuration. The FCC limit now is of course 1500 watts PEP output.

I agree that the grid in the 4XC1500B is much less subject to damage from overdrive - although the ALC should prevent that. The 4CX1500B has a much denser cooling fin structure on the anode. You have to use a much higher pressure cooling fan or blower to get 1500 watts dissipation. My estimate from looking at the properties of the two tubes and the blower is that - with the installed cooling fan - the 4CX1000A can dissipate 1000 watts but the 4CX1500B probably only about 850 watts. Therefore, if you choose to use the 4CX1500B, you should use a higher pressure blower.

Eimac lists 325 volts for the typical grid-driven operating condition on the data sheet. (The absolute max is 400 Volts DC.) When you drive the cathode, the peak RF voltage on the cathode ADDS to the DC screen-to-cathode voltage. The RF feedback to the control grid increases the cathode RF voltage by an equal amount. The peak RF voltage on the cathode is probably on the order of 70 to 90 volts. **THAT IS WHY YOU DO NOT NEED AND SHOULD NOT USE 325 V DC (OR HIGHER) ON THE SCREEN FOR 1500 WATTS PEP OUTPUT!**

The DC regulation of the cathode DC supply is rather poor - mostly because of the 40 ohms resistance in the DC filter choke. A 10 ohm choke would be much better but would have to be designed to resonate at 120 Hz with the 0.5 UF capacitor across it with just bleeder and tube idling current flowing through it. It probably would be about 4 times as big. I suggest that it be left as is but that the 10 ohm resistor R232 be removed or shorted. To get up to 1500 watts PEP output, you would probably have to add a boost voltage of about 50 V AC in series with terminal 10 on transformer T201.

Before all of the above I suggest that a good stiff 240 V AC power source be provided. The rig is rated for 230 V AC input but the transformers are rated for 50/60 Hz, therefore they can handle 240 V AC, 60 Hz OK.

Boosting the power is probably not worth it because it stresses the components more. Increasing power output 20% causes 44% more heating of some components. I could go on but I have already probably said more than you cared to hear.

Hope I have been of some help.

Sincerely and 73,

Warren

Tuning the 30S-1 Amplifier – How & Why

A Preface

For the uninitiated, tuning a higher power amplifier can be a bit intimidating. On one hand, they do deserve a bit more "respect", but on the other hand, a 30S-1 is no different than a 30L-1 or your driver PA for that matter. The noises just get louder, and the repair bill higher, when those "events" happen.

The following is meant to be a primer for those so intimidated, or new to the game. Tuning is actually pretty straight forward and, if you follow the basic steps, the results gratifying and easy to achieve.

Some of you may know most of this. However, reading through this you may find a new perspective or a tidbit or two that you did not know – or that will help your perspective on what is happening inside and outside the amp during its operation. Enjoy.

Understand & Correctly Tuning your Collins 30S-1 Amplifier

The Collins Radio 30S-1 linear amplifier is well known and well understood to be one of the best linear amplifiers ever produced. It was introduced late in 1960 and stood the test of time, remaining in production well into the 70s. It has become the subject of much discussion due, not only to its popularity, but also to the tantalizingly higher dissipation rating of the follow on 4CX1500B tube that was not available when the amplifier was first developed.

It was developed by a man considered to be the guru of high power RF amplifier and transmitter design – one Warren Bruene. Warren's contributions to the field included significant patents regarding Tetrode Neutralization, RF Feedback techniques, RF Directional Couplers, ALC and Gain Control and included patents on AM Digital Modulation, a significant contribution to the future of AM. He worked for Collins Radio for 44 years and lived to be 95 years young.

The 30S-1 employed the then newly developed 4CX1000 ceramic "lighthouse" tetrode and a novel and effective power supply and biasing circuit in which the Control Grid was at RF ground, and the Screen Grid was at hard ground. This allowed the amplifier to be Cathode driven in class AB_1 service while keeping the screen effectively grounded.

Understanding Your 30S-1

First, let's examine the power supply and biasing employed in the amplifier. The effective plate voltage on the tube is the sum of the applied plate voltage (in this case 2800 Vdc – above ground) and the minus 200 volts (200 volts below ground) on the cathode for a total effective plate voltage of 3000 volts Plate to Cathode.

The implications of this bias scheme at BOTH quiescent and RF dynamic conditions are very relevant if you are going to understand and not abuse your amplifier. While the Eimac 4CX1000A tube data shows a recommended typical Screen Voltage (bias) of 325 Vdc, the 30S-1 employs a more conservative static 200 Vdc bias. Warren was always quick to point out that, under the conditions specified at the time (1 KW stage input power and, as tuned, 300 mA of plate current) the typical additional screen RF voltage developed at the point of instantaneous peak plate current is approximately 83 volts, resulting in a screen instantaneous voltage of about 283 volts. Remember that the absolute maximum screen voltage rating for the tube is 400 volts.

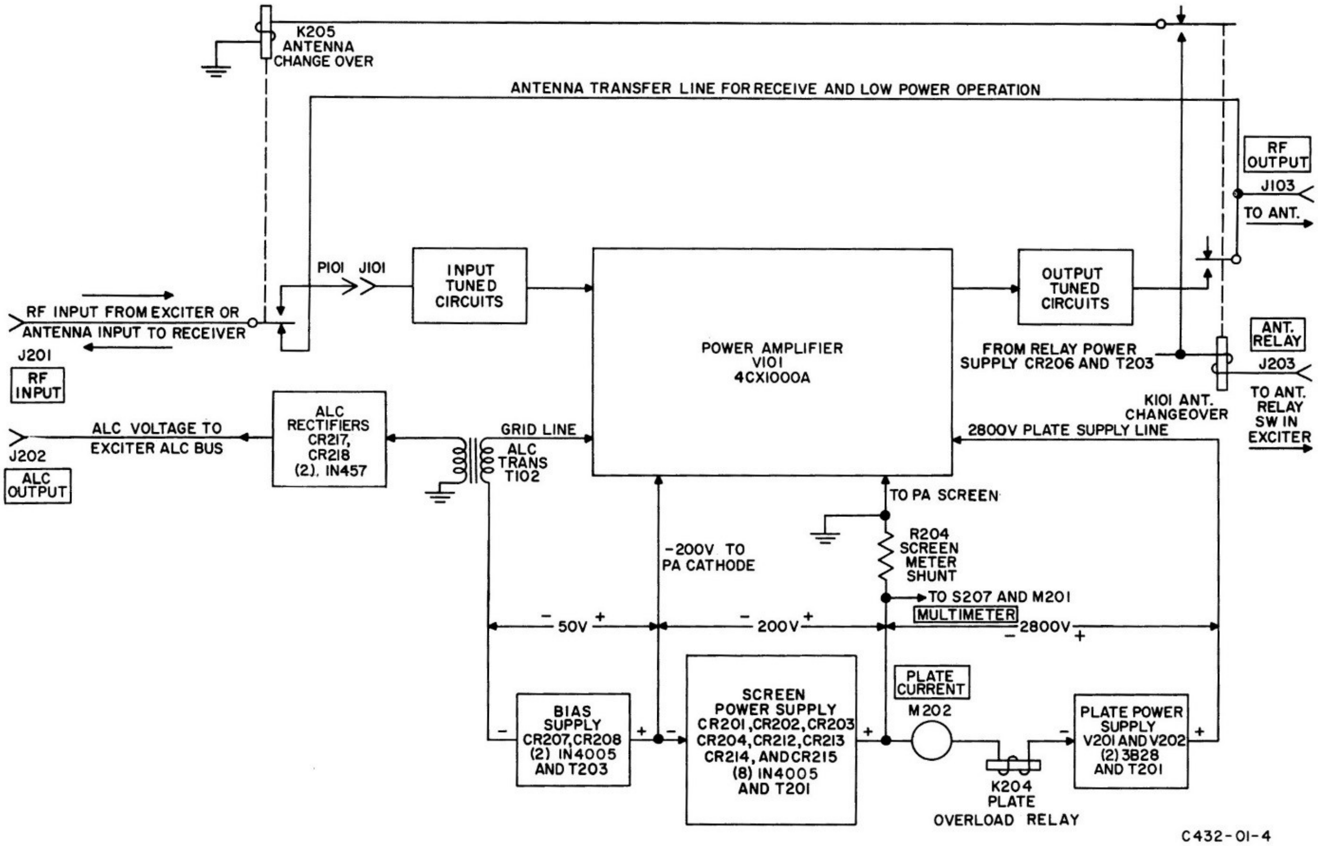
There is a commonly held thought that raising the screen DC bias to 325 Vdc will give higher performance. Here follows a caution, and also a smidgeon of understanding of the trade-offs that Warren made in the interest of overall amplifier performance.

The selection of screen voltage within the limitations of the tube's characteristics is not particularly critical, but there are recognized effects. The screen voltage is the most significant accelerating voltage that an electron sees when it leaves the cathode and starts its journey to the plate. If you choose, for instance, to increase the screen voltage of the 30S-1 design, this then provides a more intense "screen bias field" and makes it easier for the Control Grid to drive the plate current to a given positive value during dynamic operation. The result is higher dynamic RF gain for the amplifier. In other words, you need less drive from your KWM-2 or your 32S-3 to achieve a given power output of the amplifier.

Here is where there was some "system" thinking going on. Remember, in 1960, the power output of the 30S-1 amplifier in amateur service was limited by the legal Input Power limit of 1 KW total stage input which was the total of the DC plate input power and the RF drive applied to the stage.

This resulted in a 30S-1/ S-Line transmitter drive system where the driver had to be adjusted to an idle current of 50 mA and the loaded plate current reduced to 200 mA in order to optimize the IMD products produced by the combined driver/amplifier system. Drive levels were then typically 60 - 80 watts at the then legal limit of 1KW input power.

If Warren had elected to use a higher Screen Bias Voltage, the basic RF gain of the amplifier would have increased, the required S-Line drive power (already low) would have gone down and it would have resulted in a "system" where it would have been much easier for an operator to over-drive the amplifier and to risk getting up against the Screen Voltage absolute maximum rating. Let's say you raise the Screen Grid bias to 325 Vdc. Perhaps you are doing that to get more gain but for sure you are doing that to get more power out. So, the



instantaneous Screen Grid voltage is now north of 390 (RF + DC) volts peak (you pick your poison) and the tube is getting right up there against the screen limit. There is no margin there for error.

In other words, it would have been a lot easier for the average amateur radio operator to produce a less than stellar signal and/or damage the tube. Notice here that we are talking about total system considerations. This is always a good perspective to think about when you are choosing to monkey with one parameter of a known quality "system" in order to get a "better" result.

Well, you say, we are going to substitute in a 4CX1500B.

Hmmmm This tube indeed is a bit more rugged. The Control Grid rating is now 1 Watt max dissipation, so you can now get away with running a little Control Grid current without disaster, but notice something else. The Screen Grid ratings are the same (400 Volts Max and 12 Watts dissipation). Now look at the data sheet and the typical class AB1 operating recommendations for both tubes.

Some years had gone by since Eimac designed the 4CX1000A, and they had gotten more experience with this tube family. The Screen Grid Typical Operating condition for Class AB_1 operation now shows not 325 V on the screen, but 225 V, and the "Useful" output power has actually been reduced from the 1600 plus Watts shown for the 4CX1000A to 1100 watts for the 4CX1500B.

OK, let's park that thought for a while and look at another aspect of Warren's system design. He was also VERY quick to point out that the 30S-1 was designed (as a system) to provide very low fan noise. He talked about the fact that since the legal limit was 1 KW PA stage DC input power, Collins had reduced the airflow from the Eimac spec'd (sea level) airflow of 25 CFM for max rating (1 KW to start with) to a lower flow in order to use both a smaller fan, and to produce less air impact noise in the ductwork. (For reference, at 25 CFM, the pressure drop across the 4CX1000A is just 0.2 inches of water column)

Note: Therefore, your 30S-1 4CX1000A is NOT rated at 1 KW dissipation. Unfortunately, until we get some good actual airflow data, we do not know what the rating is. Operating the amplifier at greater than the manual recommended plate currents (higher Pout) therefore puts you in *no man's land.*

OK, but we can substitute a 4CX1500B. You get better Control Grid dissipation and higher plate dissipation. But, wait! Looking at the data sheet for the 1500B, we see that the specified airflow for its rating of 1500 watts is not 25 CFM (Sea Level), but rather 34 CFM with a pressure drop of 0.6 inches of water column. Looking carefully at the tube, we also see that the fin density of the 4CX1500B is denser than the 4CX1000 - and thus the airflow as used in the 30S-1 will be even lower than it was with the original tube.

More *no man's land* - and it gets worse. When you sub a 4CX1500B for the designed 4CX1000A, as we said, the airflow though the tube is lower. How much, we do not know. Sitting on top of the tube, and serving as a last ditch protector of your tube and amplifier, is a bimetallic strip thermal interlock sensor. If the air temperature of the cooling air reached the point where the bimetallic strip opens the interlock, the amp drops off line (HV kicks out) and gives you a moment to think about things.

If you look carefully at the circuitry surrounding this interlock, you will see that the trip point is adjustable. This adjustment is accomplished by running a AC bias current through the strip to heat it up (or bias it up thermally) so that it is closer to tripping. Interesting is the fact that, if you consider the static (no drive applied - so no thermal rise of the tube air above the idle temperature) bias temperature of this thermal interlock, this temperature is a function of airflow over the sensor. Reduce the airflow (by substituting a 4CX1500B into the equation) and the bias temperature of the thermal interlock, K102, will rise, making it more sensitive and causing it to trip at a lower air temperature. Ha…more systems considerations.

Continued on Page 23

The practical result of all of this involves both tube configurations. If you are tempted to just run a little (maybe a lot) higher Pout with the 4CX1000A and the amp otherwise stock, but push it above the 1 KW input power operating limit, that sensor will get you at some point.

If you run a 4CX1500B and maybe the higher screen voltage with a boost mod, then the airflow will be reduced and the sensor will get you, unless you adjust it of course.

What we see in many actual cases is that the sensor is moved, or removed, from the airflow and tube protection is lost. Now, fan failure = Tube destruction. Or, some folks figure out the adjustment, and "tweak" it using Kentucky windage. This is not a good plan. This lands you deep in *no man's land again*. In the manual, the adjustment of K102 is listed as a factory adjustment and "Do Not Tamper".

I have seen the factory adjustment spec, and it is not for the faint of heart. You need to drive the amp above limits VERY CAREFULLY. Then quickly – after it stabilizes – adjust R106 that controls the AC bias current through T103 and K102. Someone who is not experienced in this adjustment may well damage the tube in the process.

What is the take away from all of this? Each of you must reach your own conclusions. We all know that the 30S-1 (as unmodified and with a 4CX1000A installed) is capable of running better than 1000 Watts Pout. Many do it regularly with no apparent damage done. Stay within tube limits, suffer the occasional thermal sensor trip and all is well in amplifier land.

I happen to use a 4CX1500B in my amplifier and like the fact that it is a bit more robust on average. I do not drive it hard. The fact is that the small difference between 1000 Watts output and 1500 Watts output is a mere 1.76 dB increase in power into your antenna, which equates to less than a half S-Unit at the other end of the path.. Now, do I do the full legal power enchilada when running my 204H (which is rated conservatively at 2.5 KW) – of course I do. I like full power as much as the next guy when it is useful. In many case it is not necessary at all.

Draw your own conclusions, but base them on a system approach. That system, when you are on the air, not only consists of the amp box with all of its nuances, but your antenna, your neighbors and the propagation path. Who am I to judge.

What do those two big knobs do – anyway?

There is one last tidbit of confusion that I see about tuning. Without going into a lot of technical detail, the Tuning knob sets the resonant frequency of the tuned circuit in the output of the PA. Setting this circuit to resonance allows maximum transfer of power from the amplifier to the load - for a given loading condition. The tube in your 30S-1 has two different Current vs. Voltage (I-V) characteristics. The first underlying I-V characteristic is the DC load line. This is the DC current that will flow when you just adjust the Grid Bias and set idle current under "no drive" conditions. This load line has a very low resistance and the DC current is controlled only by the DC Grid Bias. There is very little actual resistance in the High Voltage path. The more relevant load line, or I-V characteristic, is the dynamic load line and, for the 4CX1000A, this amounts to about 3700 ohms real at resonance and under typical as-designed conditions.

The output matching network (typically a PI configuration) converts the impedance of the antenna to the proper load impedance for the tube. To do this, the network must be tuned to resonance, meaning the load presented to the tube is purely resistive. The job of the Loading control (the loading capacitor) is to transform the - hopefully close to 50 ohm real - antenna impedance into something that looks close to 3700 ohms at the tube plate. The combination of the correctly set Loading control, inductor and the Tuning control does this. And, as you know from tuning, this is an interactive process. This is because resonance of the matching network is affected by both the Load and Tune controls.

(As an example, let's assume we have a properly adjusted PI network that is resonant and converts 50 to 3700 ohms. If the Load control is "increased" (its capacitance is reduced) and the network re-resonated with the Tune control, the resistive load presented to the tube decreases. So, the tube "loading" is indeed increased. Note that in this example, the inductor remains the same value, so the Q of the circuit is different from the original. By varying the inductor value, the Q could be made to be the same.)

When you are increasing loading (note this because some are confused here), you are actually reducing loading shunt capacitance, and you are shifting the dynamic load line impedance up on the Y-axis (current). This equates to a lower impedance dynamic load line. Remember: Lower capacitance equals increased loading.

More system perspective

Also note that the amplifier ALC circuit detects the RF grid drive level and makes proportional ALC available to the driving transmitter such that there is about 3 db of override authority. This circuit has been factory set – if it has not been monkeyed with – using the (as designed) legal limit derived power output and required drive. If you elect to tune the amplifier above this level, regardless of what other changes have been made, the ALC compression will be more severe and onset too early. This ALC alignment should be changed if you elect to go to higher power output. It should also be noted that changes in screen bias and the subsequent change in amplifier gain will also change the relationship between desired output level and ALC authority. I think you are starting to get the point about making changes without understanding, and taking into account the balance of the "system".

Some other Considerations

Control Yourself

While this may seem a bit unrelated to tuning, the following comments are very relevant and an area where we commonly see confusion and mistakes being made. When you define "Tuning" as the process where you make sure that the amplifier is operating properly, putting out its cleanest signal and not hurting itself, then the following is VERY relevant.

Analog meter movements are essentially an averaging measurement system. They react to waveforms in a way that tends to make them an averaging device. They are made of mechanical parts that have mass, and so they do not give you a real time version of a time varying current or voltage, but rather a delayed (and "squashed") version. This phenomena is related to the "meter ballistics".

In other words, whether you are looking at plate current on your driving rig, on the amp, or at the resulting power output of either, after you tune up in Lock Key and note the resulting drive and amplifier output power, do not expect to ever see those readings again in normal operation.

To the unknowledgeable, or un-indoctrinated, this can result in creeping mic gain – or carrier level – and then over-driving the amplifier with the resulting compromise (sometimes quite severe) of IMD performance and splatter.

If you feel like you are not getting what you expect, go back to Lock Key quickly, or get yourself a peak-reading wattmeter. Saying "Ahhhhhhhhhhhh" into the microphone can often get you to the correct (or close) reading but it just does not sound that great on the air.

About tuning in general

Rule number one when tuning an amplifier – any amplifier: Start at reduced drive and STAY DIPPED, which means the network is adjusted to resonance and the plate current is at minimum.

Sneaking up on the tuning is good. It adds some time to the tuning – maybe, but it helps protect the amplifier and the tube. Always read the manual and follow the directions contained. A 30L-1 for instance has some duty cycle tuning considerations that must be considered when tuning, or you will overheat the tubes.

Then, RESONANCE is next to Godliness.

Consider: The 30S-1 as shipped used the 4CX1000A rated at 1 KW dissipation under optimum cooling conditions. At rated output, and about 300 mA amplifier plate current in Lock Key mode (constant Carrier), the output power will be about 850-900 watts.

Under these conditions, dissipation in the tube is a mere 150 watts. Now consider letting the amplifier get out of resonance (undipped). We all know that the plate current will rise and the power output will fall. Suddenly, power input can be 1200 watts and Pout falls to say 500 watts and the dissipation soars (just as quick as you can turn that knob) to 700 watts. Stay out of dip too long, get the drive a little too high, and that dissipation number can get right up to the limit.

That is why you stay dipped. And, by the way, all of the above assumes you have a 50 ohm antenna being presented to the amp. A quick look at a VSWR table will tell you that, if you are say at 2:1 VSWR (not all that bad), add another about 80 watts into the dissipation result.

Rule number two for a Tetrode amplifier: Tune the amplifier to a tad over-loaded condition. Then, operate at a slightly lower level. This will improve IMD and reduce grid current. That means operating it at a point below where you loaded it to. The 30S-1 manual (read that Warren Bruene) recommends loading to 350 MA in Lock Key and then backing off on the drive in Lock Key until 300 MA plate current is read. Then you leave the driver carrier gain adjust set right there for SSB operation.

The actual tuning

Now that you have some better understanding of what is going on, let's talk turkey.

Tuning is not an overly complicated or difficult process. It should start with reading the manual. I can't emphasize enough how important this is and basically just follow the instructions. But, tuning is summarized here for completeness of this article.

Start by preparing your driver transmitter. Because less than full output power is required to drive the 30S-1 (and the 30L-1), the driver should be set up for lower power output. This involves more than just turning down the mic gain and Pout.

Set the idle current of the 32S-X transmitter, or the KWM-1 or 2, to 50 mA and tune the driver into a dummy load or directly into a good antenna, but load it only to 200 mA in place of the normal 230 mA. The driver is now ready to use with the 30S-1.

Make sure you are using ALC if at all possible as this improves the IMD and protects you from accidental overdrive (and Grid Current).

Bring the amplifier on line and let it warm up until the HV lamp and HV will come on.

Start with the mic gain turned all the way down
Select the band of interest on the 30S-1
Preset the tuning control to the center of the band segment indicated on the lower (difficult to see) part of the dial disk below the logging scale
Set the 30S-1 load control almost all the way to the left (CCW – low numbers)
Place the multimeter switch in the Control Grid Position (Grid Current) & monitor closely during tuning
Go back and forth between Grid Current and Screen Current.
Allow no Grid Current – Ever
Try to keep Screen Current under 10 mA – I usually see almost none.
Select Lock Key with the driving rig (You can start with the Tune position, but this is not necessary if the driver is already tuned and you are careful).
Increase the mic gain (carrier control) until you get some indication of 30S-1 plate current rise.
Immediately dip the 30S-1 Plate Tuning.
Increase the amp loading. The plate current should rise and then quickly redip the plate current. You should be seeing some power output.
Repeat steps 8 thru 10 until you reach 350-400 mA of plate current dipped on the 30S-1.
Reduce the drive to get 300-350 mA of plate current. Leave the Loading & Tuning where they were.
Give the amp a break and let it cool taking the driver out of Lock Key. Leave the Mic Gain set where it is. Select the correct sideband on the driver.
You should have seen over 6 dB of ALC indication on the driving rig meter with it set to ALC position. Now, in normal SSB operation, you should see about 6 dB (32S series) or S6 reading on the KWM-1/2 series on voice peaks. You should increase the mic gain slightly (only if you need to) to get these ALC readings.

Note that if you are driving the amplifier to higher than "book" power output, the ALC will be out of calibration. Just leave the mic gain/ carrier control alone.

You are now ready to operate. See the above comments about average readings and meter ballistics.

Enjoy!

de Bill, N7OTQ

In Memory of Warren

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