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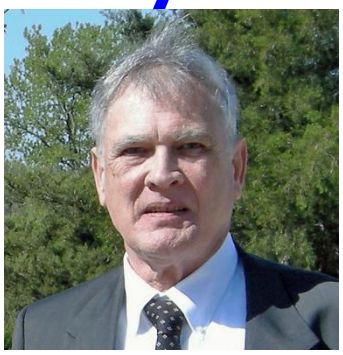
High Powered History

Eimac Comes to the Aid of An Aging Military Radar - Twice!



By Reid Brandon

[July 2017] In the past century or so, the advance of technology has changed the way countries relate to one another, especially during wartime, both hot and cold. Reid Brandon offers some insight in one area of how tech changed things..

As we approach Independence Day 2017, let us remember a time when America came dangerously close to being a subject of the USSR.

It was during the Cuban Missile Crisis in October 1962. President John F Kennedy carefully, in non-negotiable terms (except for what was supposed to be a secret agreement for the US to remove its missiles from Turkey) created a better world for both nations.

The Cuba missile incident led to the U.S. building the FPS-85 radar to maintain vigil on the area South of Florida in case such a thing might be attempted a second time. The radar has operated continuously, except for minor maintenance and a fire I describe below, and today it is an important asset for watching space debris.

If Eimac had been unable to supply a couple of special tubes in the past few years, this radar site would have either been shut down or it would have to be converted to solid state.

Either of those paths would have required a lot of down time and that just was not in the cards.

LIMITED OPTION

There is an interesting story connected to Eimac behind the tubes used in the FPS-85 radar at Eglin AFB in Florida.

Not one, but three Eimac tubes are necessary to keep the radar operating.

The FPS-85 is a well-known phased-array radar system built during the 60's and was intended to be a significant tool to be used as a threat deterrent after the US discovered Russian missiles on the island of Cuba. Today it is one of several sites serving the important function of tracking space debris - the stuff left in orbit after the launch of a satellite or other rockets.

MAJOR DAMAGE

The phased-array was built around a large wood structure that holds the array of antennas with an rf amplifier at each antenna (I believe they are individual dipoles).

Unfortunately, the structure caught fire shortly after it was completed and it burned to the ground because there were no means of putting out the fire. Perhaps the fabric that covers the face of the array caught on fire – after all high voltage is routed across the entire antenna and either that or a lightning strike from the frequent electrical storms that occur at the South end of the Floridian peninsula may have been responsible.

Today, there is a beautiful fire house located on the site now, located near the entrance to the radar, the side away from the antenna array. I imagine a story about life as a fireman there would not be very interesting as hardly any tourists even venture this far South besides the armed guards at the entrance make it less than a friendly vacation spot.

5184 MODULES

The electronic system at Eglin consists of a pulser in the basement feeding pulses of current at high voltage to the array of 5184 (!) individual UHF amplifier modules placed across the face of the array, each antenna is fed by an Eimac 4CPX250K and the rf radiated energy is combined in space.

The specs for 4CPX250K are quite impressive for a tube of its small size (2.8 inches long and weighing only 4 ounces). Tubes are tested at Eimac and must deliver to the load a minimum output of 10 kW at 442MHz for 250 microsecond pulses at 0.005 duty.

At an NAB show one year I met an individual who was involved with a special series of tests on samples provided for consideration when the radar was in a development phase. I believe he indicated the first radar at the site used a GE triode that was designed into the radar but could not deliver the power necessary to meet performance objectives.

THE ORIGINAL TUBE SET

Basically, he said both RCA and Eimac tubes had been submitted for evaluation to determine which would ultimately be used in the rf modules for the FPS-85.

It was said that RCA tubes sparked during the peak power test. I also learned that Eimac had considered this so they had processed the samples using a special high voltage processing – called de-barnacling in the industry – which allowed 4CPX250K's to reliably hold-off over 5000Vdc. Ultimately Eimac was awarded a contract for thousands of the 4CPX250K, and many more have been delivered over the decades the radar has been in operation.

Now, enter the Westinghouse WX-4778. This is a unique tube having a small oxide cathode triode with a Mu (amplification factor) of 20. It is also designated 5960-00-892-9475. Westinghouse made glass special purpose and receiving tubes at their Red Bank, NJ factory and the WX-4778 may have been made at that facility.

I believe the WX-4778 is the highest power tube having an external anode with an oxide cathode that Westinghouse ever made. It uses a small glass bulb below the anode and the base appears unique with two pins extended for supplying heater power. In the samples I have seen the base is made from fused glass, a material Eimac used in early 4X250 tetrodes and discontinued after it was found to be susceptible to vacuum leaks.

IMPRESSIVE ENGINEERING

The grid flange on the WX-4778 is part of a cup that terminates in the glass base insulator and there is a heliarc weld around the relatively thick rim which constitutes the grid terminal.
Looking at the overall system one sees there are 16 banks of pulse modulators for the over 5000

4CPX250K's. The first tube in each pulse modulator is a type 5687, a low power glass dual triode (think audio!) which drives the WX-4778 and that drives four 4PR60C tetrodes in parallel, these tubes remove bias momentarily from the final tube in the chain, a big F8147A triode which drives a pulse forming network and that then supplies pulsed plate current to groups of 4CPX250K's.

The total combined rf output from the array is 32 MW peak. The F-8147A was designed by ITT in the 1960's and is a whopper, weighing in at 22 pounds, it has a 7.5kV max anode rating and can deliver up to 150 Amperes peak current but to do that requires the grid be pulsed up to approximately 2000 Volts.

The anode cooling fins on the WX-4778 have a series of dimples to increase air turbulence, a simple technique but not as effective as the louvers on Eimac air-cooled tubes which provide increased cooling efficiency.

The rated dissipation for the WX-4778 as indicated on the Westinghouse data sheet is 600 Watts – which is pretty impressive considering the fact its anode is not much larger than that on a 4CX250B! Westinghouse states this dissipation requires air flow at 30 CFM with a modest pressure drop of 0.5 inches of water.

SUPPLY DISRUPTION

Now, the first "Bail-Out."

Suddenly, at some point around 1999, Eglin's stock of spare tubes was nearly exhausted and ITT had been sold to Triton Services, which had deteriorated to the point it could no longer supply good working tubes (in 2008 Triton would declared bankruptcy and close its doors).

So a government contractor responsible for maintaining the radar asked Eimac if it could make an equivalent to the F8147A. Having nothing similar, Eimac developed the EI8147A (5960-00-720-0615) – and CPI continues to supply that tube for the FPS-85, the only system using it.

A SECOND CRISIS

Then, an opportunity for a second "Bail Out" occurred.

In 2007 the USAF asked Eimac if it could supply an equivalent to the WX-4778. As is normal practice for government systems, they had purchased a large number of WX-4778 and warehoused the tubes. But now, the situation was getting urgent because they had almost depleted their stock of spares of this unique tube – yet Westinghouse had discontinued that tube when it went out of business in the late 1960's or early 70's. The WX-4778 tube is truly "extinct."

Fortunately the operating life of the WX-4778 was good, so the use-rate was fairly low, delaying the critical point where they suddenly found themselves with almost no spares and another crisis was at hand!

A SOLUTION THAT KEEPS WORKING

I was asked to recommend something.

After comparing the constant current curves of all the triodes Eimac made in 2007 to those of the WX-4778 and I was able to find one tube with very similar curves: the 3CX1000A3. Although this was a tube with thoriated-tungsten filaments and was quite a bit larger than the WX-4778, theoretically it appeared it should work with little or no other changes.

The filament transformer was different and there were a few mechanical details associated with the socket. Chris at Universal Transformers in Farmersville, TX supplied a custom filament transformer and delivered it to the contractor at Eglin and – when everything was installed in place of a WX-4778 tube – the radar worked perfectly.

The FPS-85 has now been fully retrofitted to use Eimac tubes in both critical sockets.

Thus, I am proud to say that Eimac (CPI) – an aging (82-year-old company) – successfully twice rescued and keeps a 52-year-old radar going!

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Reid Brandon (W6MTF) worked for Eimac's tube division for 27 years, until his retirement in 2013.

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