

Pbar Note #699

DRF1 Cavity Power Amplifier Repair

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Description:

Please refer to Fermi drawing # 8000-ED-119522 for the complete details. The amplifier consists of two 3CPX10000U7s (Rotator) or similar 3CX10000U7s (Adiabatic). They are grounded grid air-cooled triodes connected in push-pull. The 50-Ohm inputs are applied to the cathode through a T matching circuit, (these are the only adjustable components). A positive bias voltage is also applied to the cathode (the filament is the directly heated cathode). This sets the tubes to run at class C operation. The bias is clamped at 155V with four 50-Watt zener diodes (currently these are RCA brand SK614s' bench matched for same voltage @ 100mA). This keeps the tube from self-cutoff during large conduction swings of drive voltage. The RF is developed across the parallel combination of the tube input element characteristics (grid and cathode) and filament choke coil. The output is coupled into the cavity by a center-tapped coupling loop. It can be viewed as a single turn transformer winding where high voltage applied to the center tap (RF grounded) and the ends connected to the tube anodes (Plate).

The interlocks include operational and safety concerns. Signaling is provided for airflow (air vane switch), temperature (klixon), filament (AC rectified), bias (Voltage divider), anode voltage (Voltage divider), access door and vents (magnetic switch). See interlock control chassis board drawing for specific information (Fermi #8000-ED-216775).

Typical failures and remedies:

(Not in order of frequency of breakdowns)

(1) Bias zener diode(s) stack short.

This failure shows up quickly, displaying a status of no bias. Since the interlock chassis is programmed to safely operate the controls of the complete system, it will inhibit the anode voltages (driver and PA) and turn off the ENI amplifier.

An easy check for a fault in the PA or the Bias supply is to simply unplug the two (parallel) red RG58 cables (labeled) going to the PA. If the voltage reappears, a shorted zener diode stack is a good suspect.

(Please note, that a shorted PA tube can cause a similar symptom, although not as likely).

(2) Bias zener diode(s) stack open.

Yes, it does happen. AND it will happen again. This failure will not have a catastrophic symptom. Instead, you will find that the cavity output is low. This is easily confused with weak output tubes NOT ALWAYS TRUE. Since the tubes are with no clamping from the zener stack they will go deeper into self cutoff during the drive pulse. This inhibits the output from fully appearing at the plates. The bias supply will show the correct voltage (~155V) on the front panel meter and all other appearance will seem to be correct. Watch out for this one! A way to test this is to use an ohm meter with the Negative lead at the bias input. This should read as a normal diode. Remember that there are a number of parallel components (resistors and large capacitors) so refer to the drawing for a clear understanding of its electrical environment.

Replacements for the zener stack are located in AP50 on the accumulator side in a cabinet facing the walkway to the counting room. Refer to the picture in the back of this note for the zener assembly identifying features.

(3) Air flow switch

Sometimes, when the air flow is changed in some way, (dirty filters or faulty blower motor) a disruptive turbulence sporadically opens the air flow switch. This will cause an intermittent crowbar condition. Since the interlock read backs are not latched, the source is easily missed. This takes a little creative troubleshooting before certain diagnosis. The air vane micro switch has also caused similar problems. A 50 pin 3M connector on the back of the interlock chassis is an ideal place to access various test points to help troubleshoot these annoying intermittent problems (see Drawing# 8000-ED-266008).

(4) Defective HV cable connectors

This will show up as an apparent arcing problem. Many times this is confused with defective tubes or a capacitor box issue. An Ohm meter will help the diagnosis; however, the leakage may not always show up with this test. Mechanical inspection is usually best. A defective connector normally blows itself apart or has black soot close to the cable crimp. Re-terminating the Reynolds connector (p/n 167-3516) will be necessary for the repair. Spare cables are installed for fast emergency repairs in the tunnel.

(5) Defective output tubes.

Failure modes:

Weak, shorted, gassy.

A) Weak.

This will show up as a gradual reduction of cavity output. Quite often one may notice a weakening after 6 months of operation after installation. Slowly reduced to a point that can't be tolerated (subjective judgment) (Typically from 950KV to about 750KV on systems 2 thru 6, #7 is less, typically. 750KV to 500KV). This can take another 6 months or more to happen. Replacement is the only repair option.

B) Shorted.

This failure typically will show up during its' intermittent phase (grid – filament short) as crowbars due to the loss of bias voltage. It may permanently short, in which case it will display a symptom similar to a shorted zener diode stack. Replacement is the only repair option.

C) Gassy.

This is a poor vacuum within the tube. It will internally arc at a lower than normal anode voltage. Many times you will experience this problem at installation and at the end of its life. When new, conditioning will usually work. In this process, the filaments are heated and a low anode voltage is applied, and then slowly increased in small increments (500V steps) until its normal operating voltage is reached. This can take up to several hours (even days) to overcome this condition. Although these tubes are factory new, not all internal contaminants are gone. Sitting on the shelf for months adds to the problem as

well. At the end of life, similar symptoms will be displayed; however, you will find the frequency of internal arcs increase. One can usually lower the anode voltage in small increments to soften the arcing and perhaps increase its useful life. Once again, beyond stated, replacement is the only repair option.

Tube replacement and safety issues:

All cavity power amplifiers have an access door for tube replacement and other maintenance. Please refer to the pictures in back. BEFORE any attempt to access, make sure the system is OFF and the two (parallel) RG213 anode cables are disconnected and locked out at the capacitor bank. AND for redundant safety, remove the HV cables at the cavity as well. Take precautions so as not to mix the cable ends with the spares which are close by.

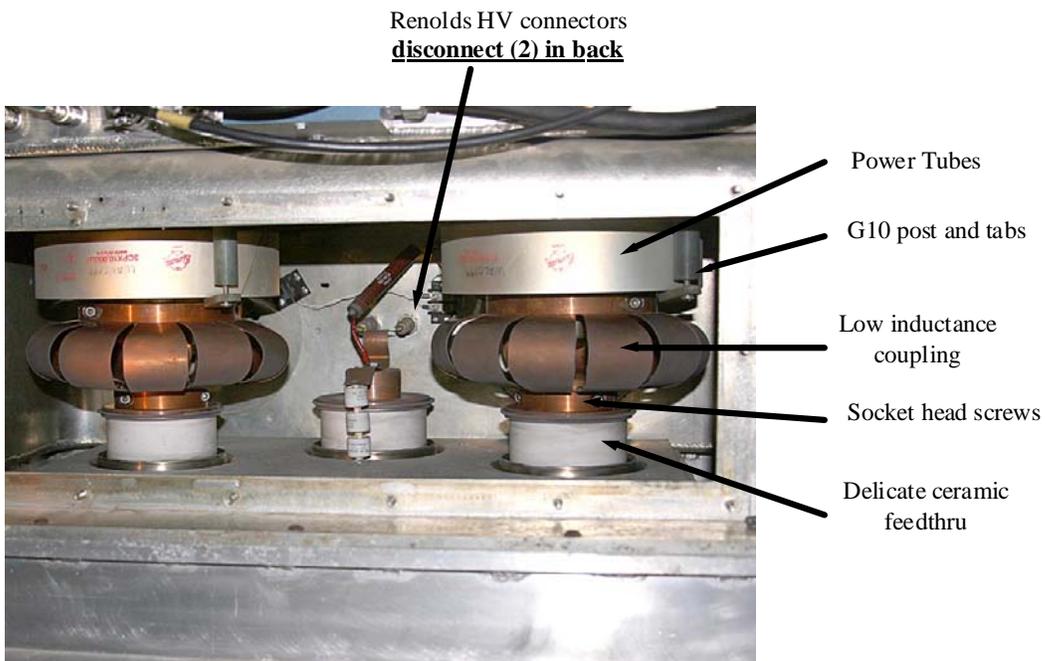
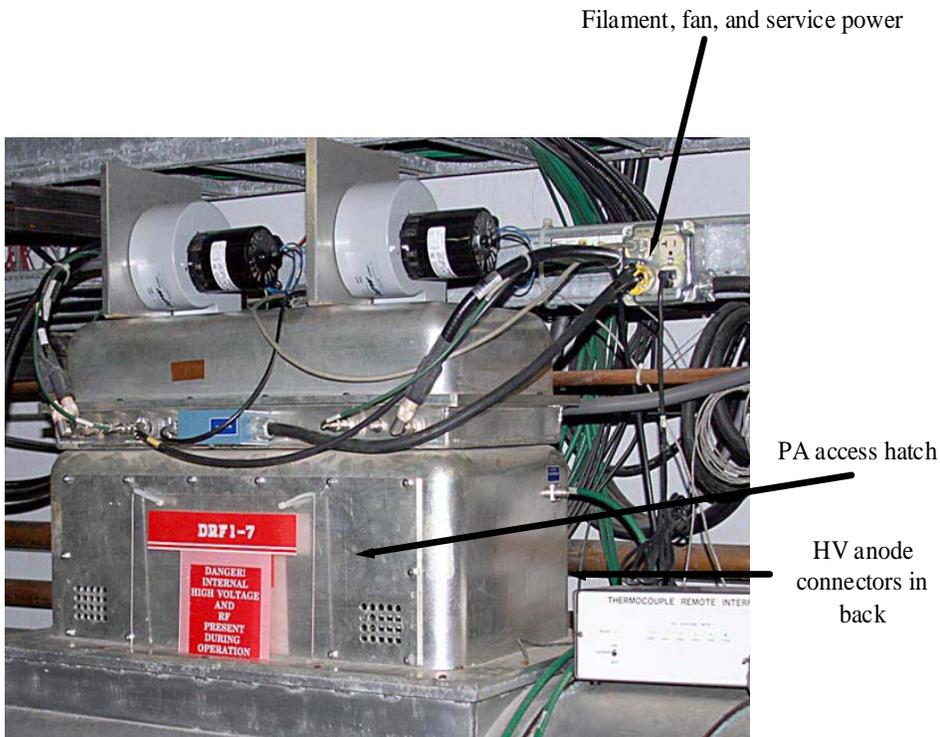
Procedure:

- 1) Turn off system and lock out the HV (as above).
- 2) Unplug the Filament and Fan power at the electrical box by the PA. See picture.
- 3) Open the access door by removing several cap nuts in front of the amplifier. See picture.
- 4) Discharge and ground out any static voltage on the internal components. (Mainly, this is the tube anodes). A grounding stick or where appropriate an insulated screwdriver may be used for this purpose.
- 5) Loosen and remove the socket head screws holding the low inductance copper connection halves at the tube and coupling loop feed thru. Remove components and set aside for the reassembly.
- 6) The tubes are now hanging in place captured by a G10 tab which prevents it from falling onto the ceramic feed troughs. Please be careful that this doesn't happen, as a vacuum leak in this area is very difficult to repair.
- 7) Lower the tube down. Use your fist as cushion between the tubes and feed thru. Slight manipulation may be necessary to completely remove from the enclosure.
- 8) Install new tubes. Reverse the above steps.

Notes:

- 1) Scribe or write the serial number and date on the tube for convenient reference and good record keeping.
- 2) Notice the connection halves will have a small ridge cut into the top side. This is to conform to the circumference of the tube. When installing, be sure that it is pushed down below this ridge (or it will not fit properly). This is for mechanical AND electrical reasons. Please remember that the size and shape of things can change the electrical characteristic (inductance and capacitance) of the output circuit. This shape was chosen for reducing the inductance of the connector. Do not distort it.
- 3) The input circuitry is wide banded and will not typically need any tuning (although sometimes necessary when expected results are not realized). It should present close to 50 ohm impedance to the drive signal. If tuning is needed, the cavity must also be in tune. The cavities are thermally tuned and take a good fraction of an hour of operation with RF to stabilize. A further access may be required should this tuning be required.

Overview of Power Amplifier



Zener Diode Stack
Located within the top half of PA

