KLYSTRON GAS TESTER TECHNICAL NOTE

THIS TECHNICAL NOTE DESCRIBES THE KLYSTRON GAS TESTING PROCESS AND OPERATION OF THE GAS TESTER

The process of “gas testing” a klystron is a method of determining the vacuum quality inside the tube. The gas-tester unit at APS was specifically designed for use with the 350MHz klystrons used at APS.

Ion pump current readings are not always a reliable indicator of vacuum integrity. Ion pumps cannot function if they are overloaded by a poor vacuum. Ion pumps will indicate zero current if they are connected to a system that is up to atmosphere.

The term “gas testing” refers to a process where a relatively low bias voltage (positive relative to the cathode) is applied between the mod-anode and cathode electrodes. Under these conditions, when the cathode is heated to operating temperature and the klystron vacuum is good, a very small, but detectable electron current will flow from cathode to mod-anode.

If the klystron vacuum is poor or the tube is up to air, no electron current will flow between the cathode and mod-anode.

The klystron gas tester is a self-contained unit that provides a variable heater power supply and a variable mod-anode bias power supply to set the proper conditions for the gas test. The filament power supply output voltage is continuously variable from 0 to 25 volts ac, and can deliver a maximum output current of 25 amperes. The mod-anode bias power supply is continuously variable from 0 to +500V dc, and can deliver a maximum output current of 50mA.

Note: A schematic diagram of the gas tester is available in the RF Group drawing storage drawers located in Building 420 and on the third floor of Building 401.

Figure 1 shows the operating controls of the gas tester unit. Power for the unit is connected utilizing a standard IEC line cord. Heater and anode bias voltages are adjustable by separate knobs, and voltages and currents for both power supplies read directly from the meters on the side of the cabinet.

Note: The anode bias current meter has a full-scale current range of 10mA.

Figure 1: Gas tester controls and metering

Electrical connections are made between the gas tester and the klystron under test utilizing standard Pantak connectors, as shown in figure 2. There are no exposed voltages present during the operation of the gas tester when the Pantak connectors are properly inserted.

Note: Because of the relatively low voltages involved, the use of insulating grease on the Pantak plugs is not required.

GAS TEST OPERATION

Put ✓ for steps 1 through 11

1. Position the gas tester within 10 feet of the klystron under test. ☐

2. Connect a ground cable between the gas tester and the klystron. ☐

3. Connect the gas tester to the klystron under test utilizing three standard Pantak cables, as shown in figure 2, connecting the jacks together as labeled. ☐

INSERT THE KLYSTRON-END PANTAK PLUGS FIRST!

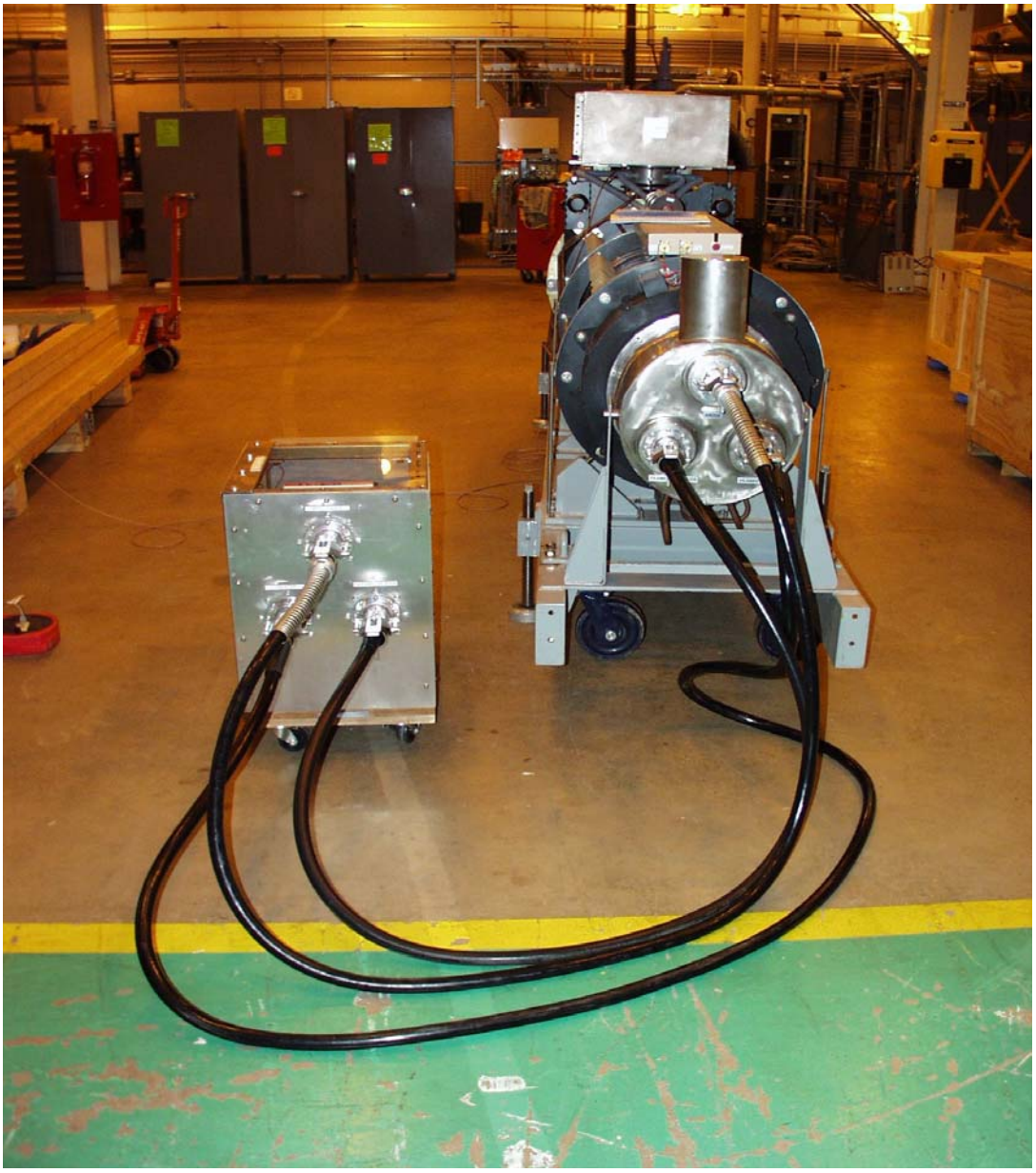

Figure 2: Gas tester connection to klystron under test.

4. Connect an ion pump power supply to the klystron and turn it on. The current reading on the ion pump power supply should be similar to that shown in figure 3. ☐

Figure 3: Typical pre-gas test ion pump current reading.

5. Set the heater and anode bias power supply control switches to the OFF position, and set the output knobs of both power supplies to the minimum position. ☐

6. Connect the 120V ac line cord to the gas tester. ☐

   Note: The "120vac" neon indicator should illuminate at this time.

7. Turn on the heater power supply, and SLOWLY increase the output with the adjustment knob, *keeping the heater current between 18-20 amperes* (see figure 4). ☐

Figure 4: Heater power supply controls.

Caution: DO NOT allow the heater current to go above 20 amperes under any circumstances!

Note: Because the klystron heater wire material has a positive temperature coefficient, the resistance of the heater wire is very low when current is first applied, and increases over time as the heater temperature increases.. The heater power supply output must be manually controlled to maintain a heater current of 20 amperes MAXIMUM (see figure 5).

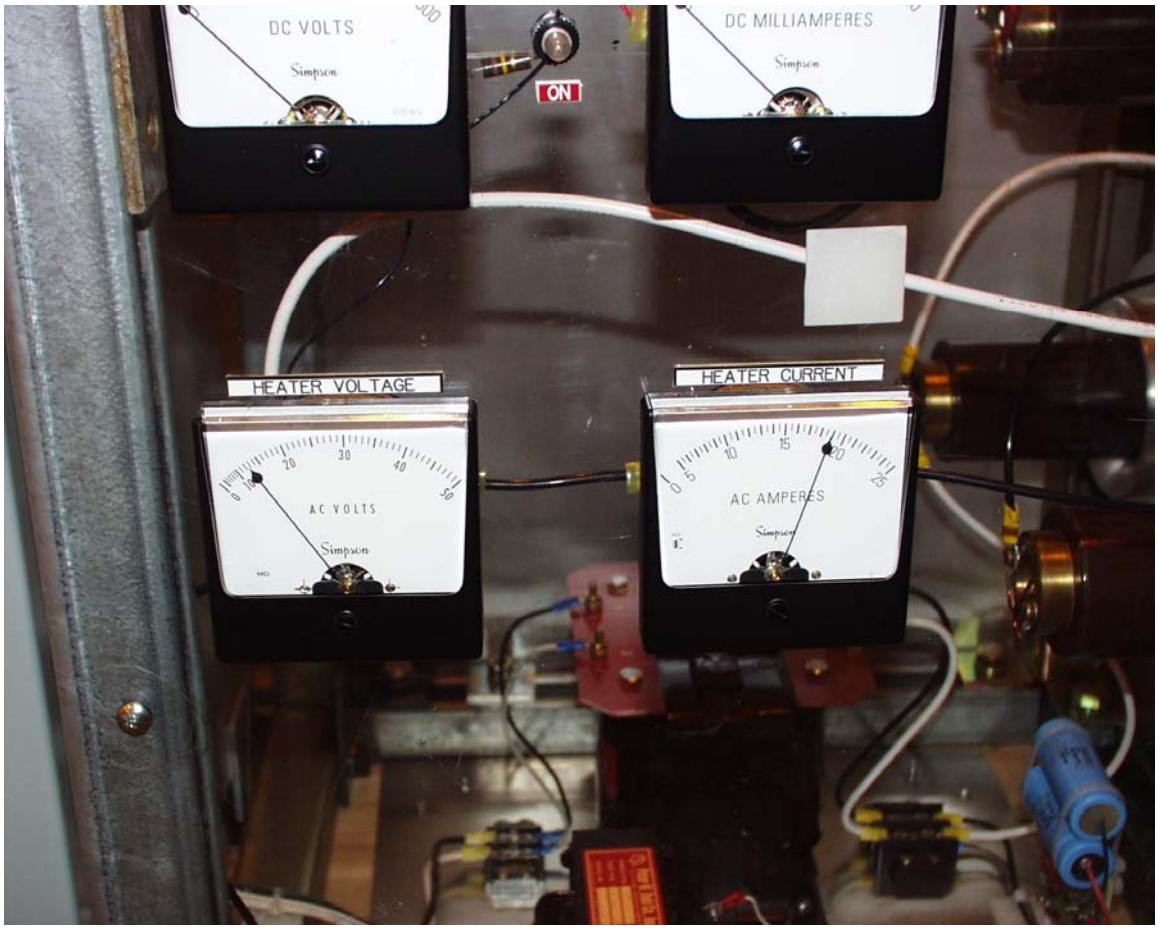

Figure 5: Heater current and voltage during initial warm up.

As the heater wire temperature increases, the electrical resistance will increase, causing the current to slowly decrease. The output of the heater power supply can then be slowly increased to maintain 20 amperes of filament current. After approximately 10 to 15 minutes of warm up, the resistance of the heater should begin to approach the nominal value of ~ 1 ohm (see figure 6).

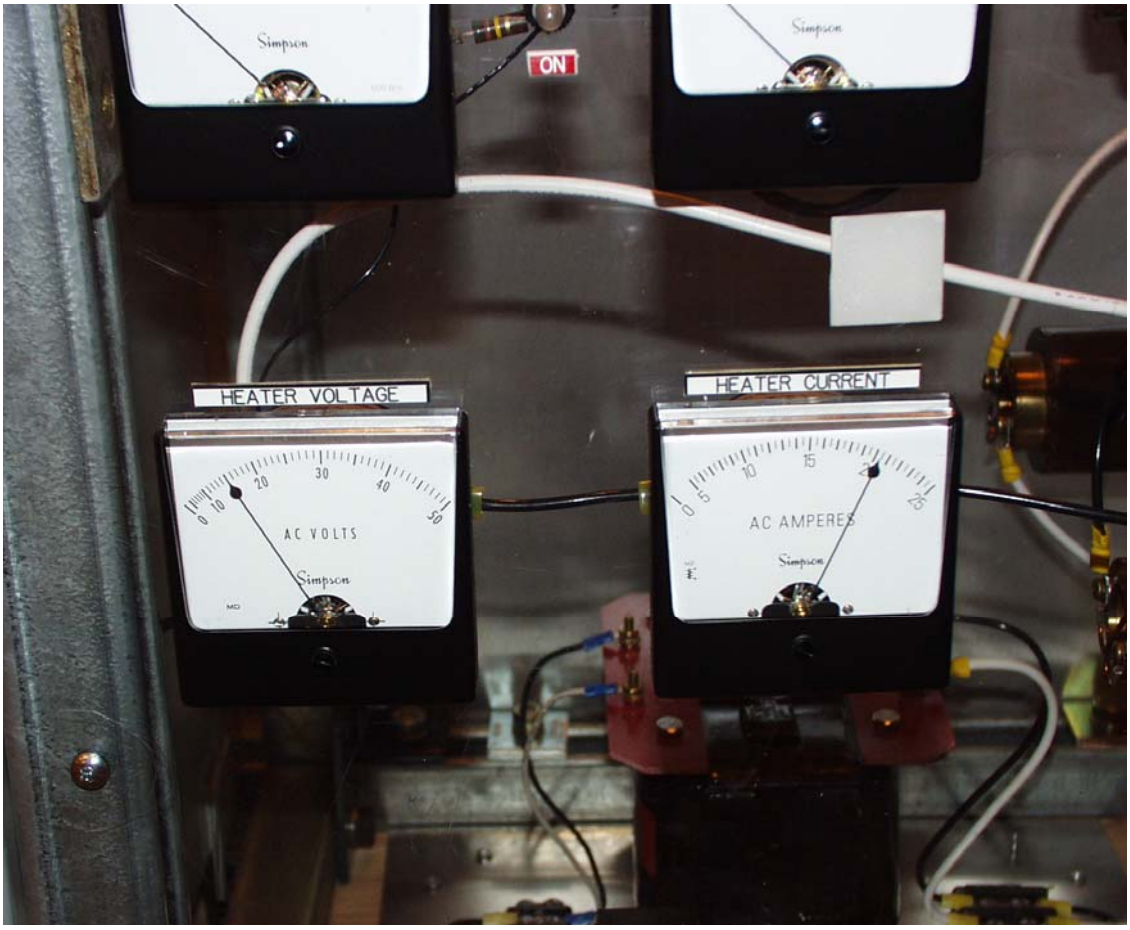

Figure 6: Heater voltage and current after 10 minute warm up.

8. As the cathode assembly in the klystron starts to heat up, it should outgas, resulting in a sharp increase in ion-pump current (see figure 7). ☐

   Note: Depending on the condition of the klystron, the ion pump current could reach 50µA or more during initial cathode warm up. However, the ion pump current should recover to less than 5µA within 10 minutes (see figure 8)*.*

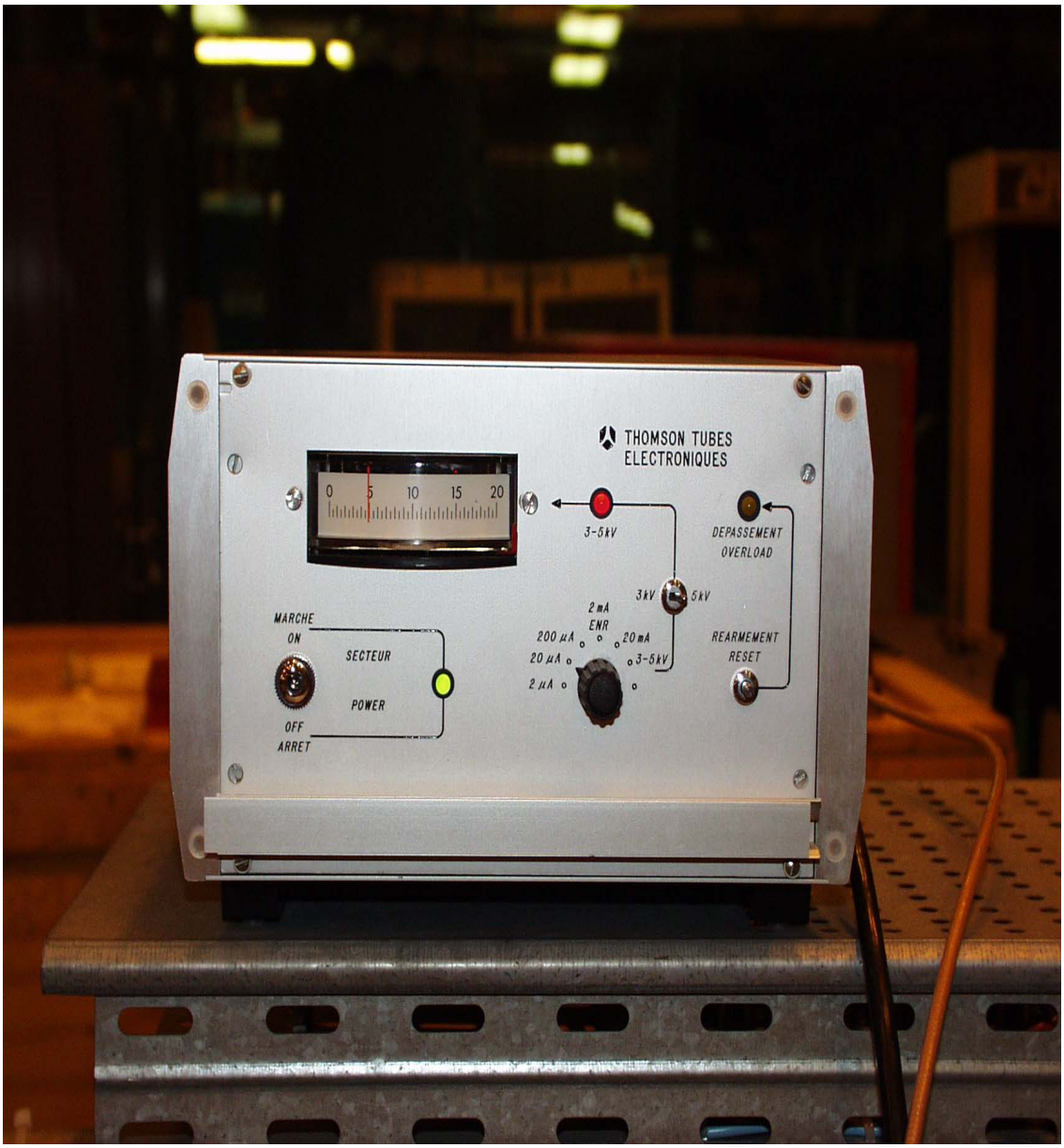

Figure 7: Ion pump current after 3 minutes of heater warm up.

Figure 8: Ion pump current after 15 minutes of heater warm up.

8. After 10 minutes of heater warm up, turn on the anode bias power supply, and increase the output voltage to 500 volts (see figures 9 and 10). ☐

   Note: The cathode must be at operating temperature before sufficient electrons are available to produce current flow between the cathode and mod-anode. If the cathode is not at operating temperature due to insufficient warm-up time, you will have zero bias current out of the gas tester (see figure 10).

Figure 9: Anode bias supply controls.

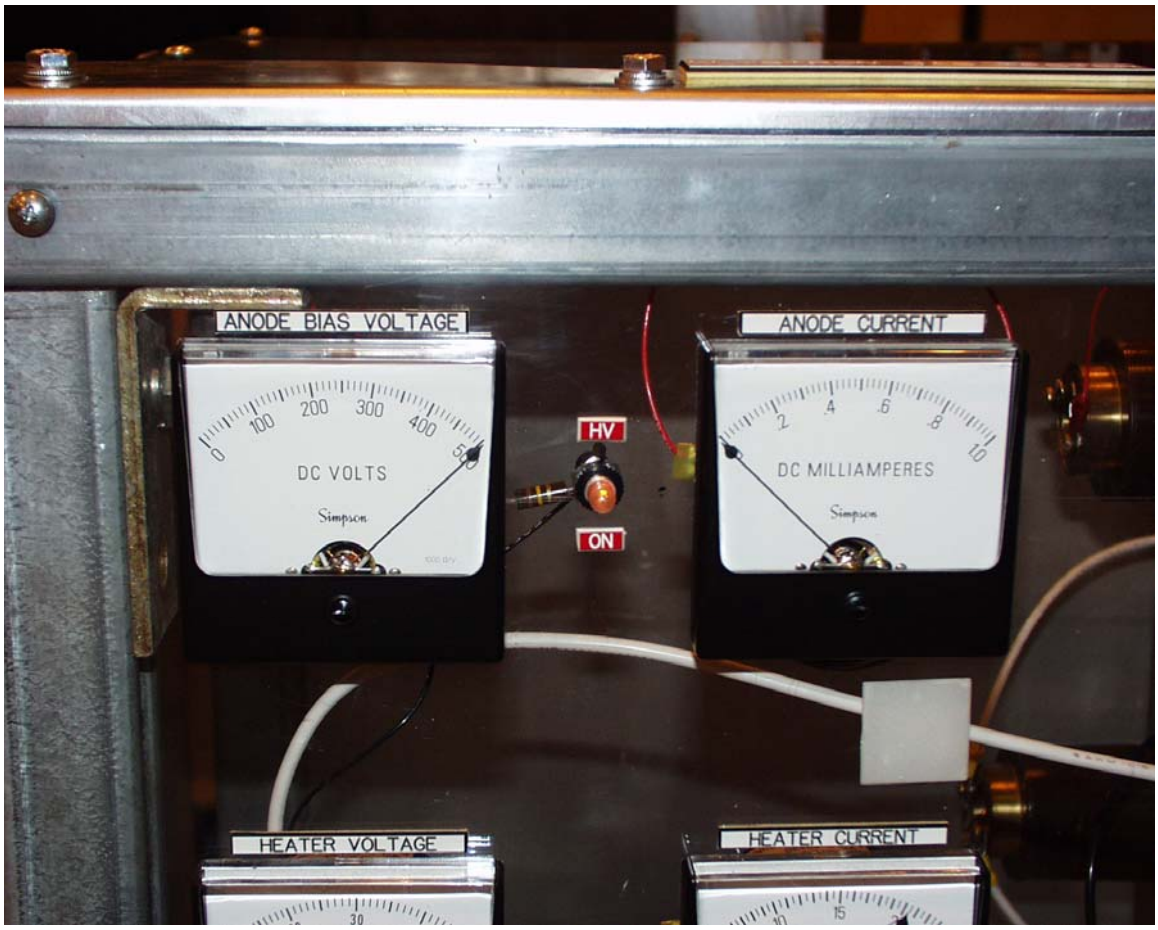

Figure 10: Initial turn-on of anode bias voltage with possible cold cathode.

9. If the klystron vacuum is good, approximately 10mA of current should be indicated on the anode bias current meter (see figure 11). ☐

Note: The anode bias current meter reads 10 mA full-scale.

If zero current is detected on the anode bias current meter, suspect poor or lost vacuum in the klystron!

Note: Depending on the klystron, it can take up to 15 minutes for the cathode to reach a temperature sufficient for electron emission under these conditions.

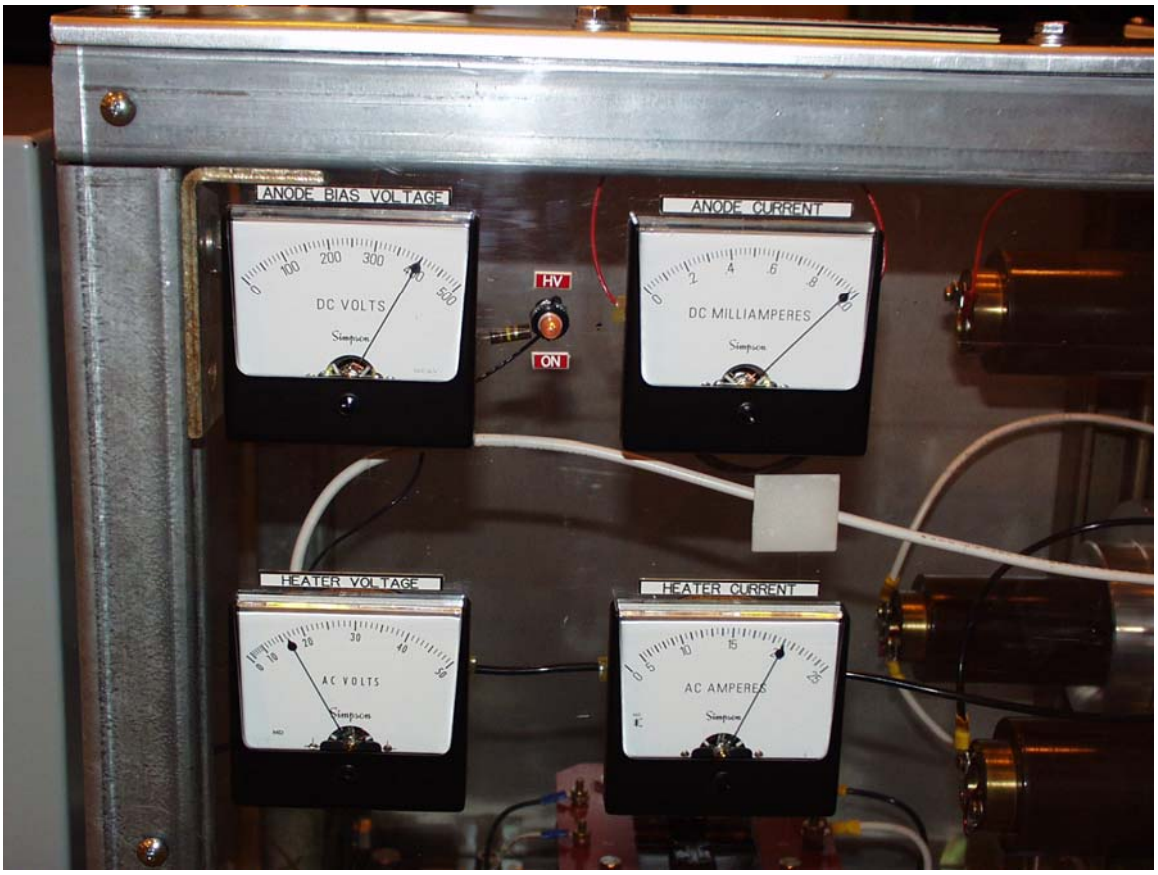

Figure 11: Gas test anode current with good klystron vacuum. The anode bias current reading shown is 9.6 mA.

Note: The anode bias output voltage of the gas tester will fall to a value lower than the initial +500 volts when current flows due to current-limiting series resistors in the output of the anode bias power supply. The bias voltage and current values shown in figure 11 are normal for a klystron with good vacuum conditions.

10. At the completion of the gas test, turn off the heater and bias power supplies, and disconnect the 120 volt ac input power to gas tester. ☐

The gas tester is designed with a shorting relay on the anode bias+500 volt power supply that will discharge the power supply output to ground when system power is removed.

Observe that the anode bias voltage meter is reading zero, and the high-voltage presence neon lamp is dark!

11. Remove the Pantak cables from the gas tester and klystron. ☐

NOTE: UNPLUG THE PANTAK CABLES FROM THE GAS TESTER FIRST, *BEFORE THEY ARE REMOVED FROM THE KLYSTRON!*