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Title: MEASURING CURRENT EMISSION AND WORK FUNCTIONS OF LARGE THERMIONIC CATHODES

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Measuring Current Emission and Work Functions of Large Thermionic Cathodes

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As one component of the nations Stockpile Stewardship program, Los Alamos National Laboratory is constructing a 20 MeV, 2 kA (with a 4 kA upgrade capability), 3μs induction linac for doing x-ray radiography of explosive devices. The linac is one leg of a facility called the Dual-Axis Radiography Hydrodynamic Test Facility (DARHT). The electron gun is designed to operate at 3.2 MV. The gun is a Pierce type design and uses a 6.5" cathode for 2 kA operation and an 8" cathode for 4 kA operation. We have constructed a small facility called the Cathode Test Stand (CTS) to investigate engineering and physics issues regarding large thermionic dispenser-cathodes. In particular, we have looked at the issues of temperature uniformity on the cathode surface and cathode quality as measured by its work function. We have done thermal imaging of both 8" and 6.5" cathodes. Here we report on measurements of the cathode work function, both the average value and how it varies across the face of the cathode.

Uniformity of current emission is critical to beam emittance and ultimately electron-beam spot size. We designed and now operate a unique diagnostic to measure current emission directly off the cathode surface. Because the perveance of this diagnostic is extremely high (~400 μP) we can extract DARHT relevant current densities (10 A/cm^2) at a modest operating voltage of 20 kV (as opposed to 3.2 MV on DARHT). We have made extensive measurements and have found that the emission is uniform (<5% variation at 1050 °C) which meets the DARHT requirements. The diagnostic enables us to make detailed emission measurements from the temperature-limited regime to the fully space-charge limited regime. Figure 1 is a photograph of the current emission diagnostic in its nominal operating position, a few mm in front of the hot-cathode surface. Figure 2 shows I-V curves from a portion of the cathode surface. The data for each curve is taken at a fixed temperature. A simple model based on the cathode having a work function distribution function is used to fit the data. The model has just two free parameters, the average value of the work function and the rms width of the distribution function. Figure 2 indicates that a single work-function distribution fits the I-V curve over a range of cathode temperatures. Details of the model and the sensitivity of the fit to the work function distribution will be discussed.

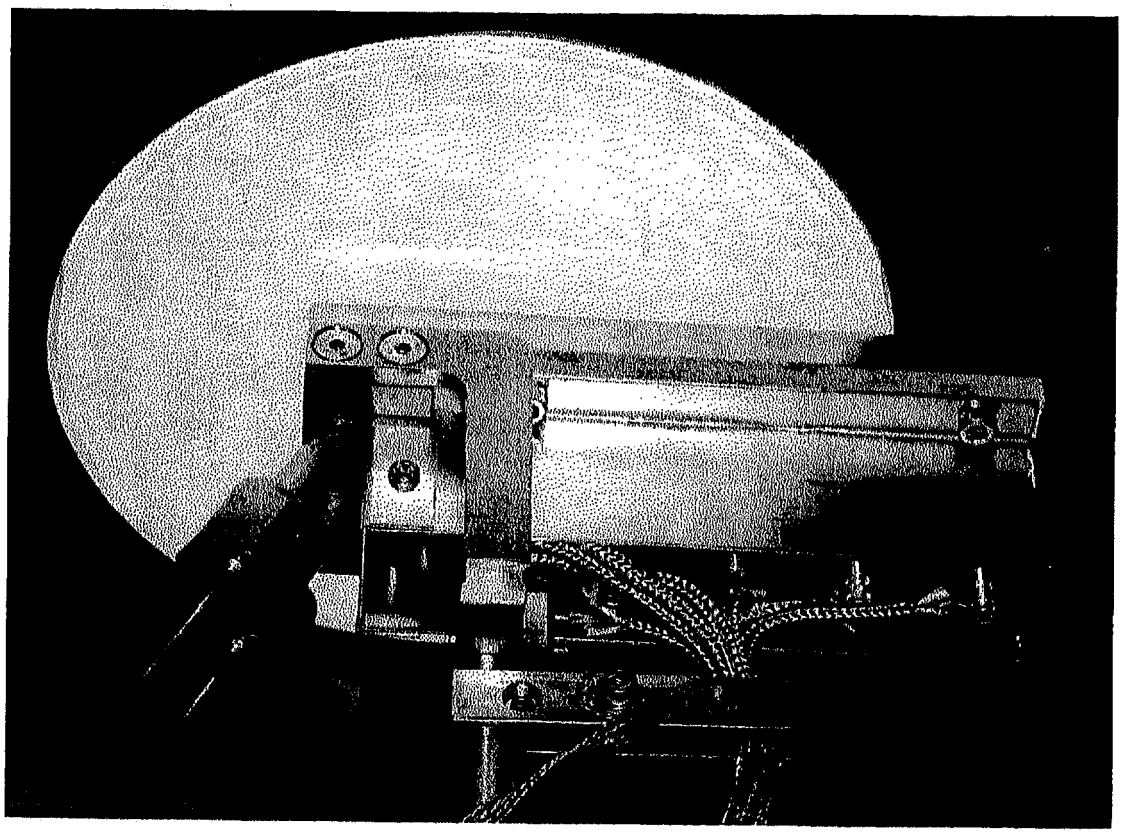

Figure 1 Oil-cooled current emission diagnostic in position in front of the 6.5" cathode.

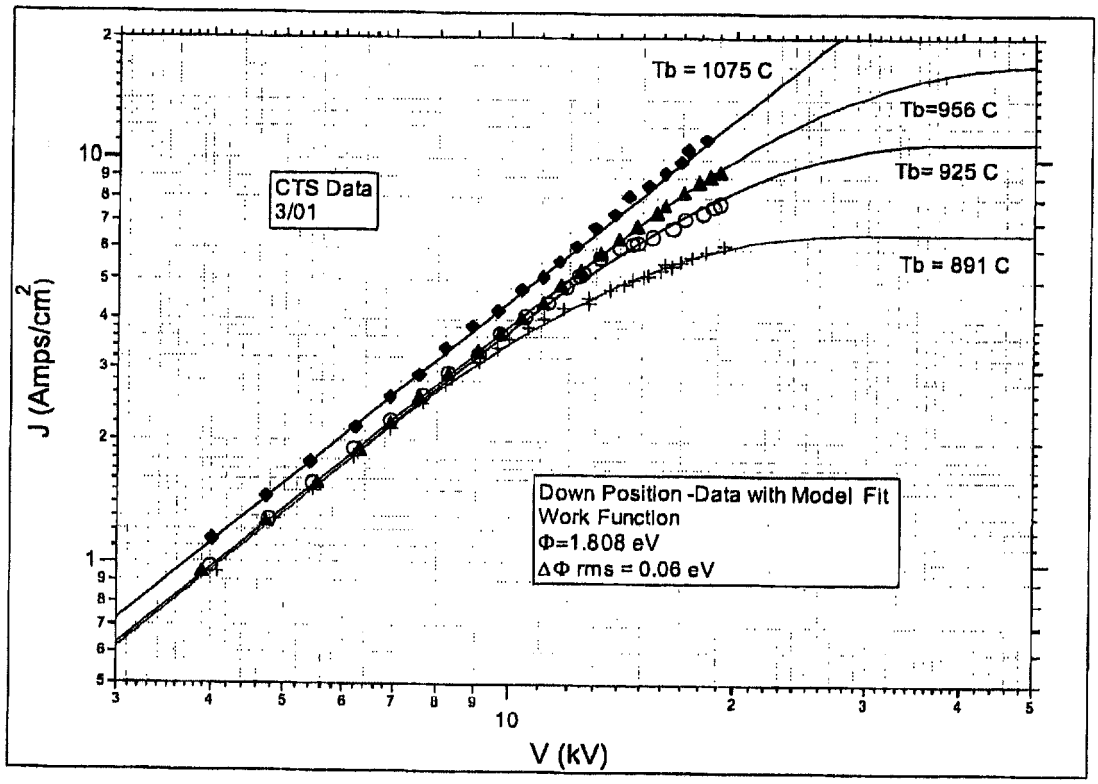

Figure 2 The model fits the current emission data at various cathode temperatures.