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A Measurement of the Relative Efficiency of a Channeltron

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The original goal of this project was to determine the characteristics of a channeltron, a device used to detect electrons. While most channeltrons have entrance cones which are quite small, the channeltron we were to study had a significantly larger one. Due to its large size, the possibility existed that the channeltron would be more efficient at detecting electrons which hit near the center of the channeltron entrance than at detecting the electrons which hit near the edge. The main purpose of the experiment was to determine the relative detection efficiency of the channeltron as a function of the position where the electrons hit it.

Before describing the experiment itself, it is necessary to explain how a channeltron works and what the movitation for this experiment was. A channeltron is a device which amplifies a very weak electron signal to the extent that it can be detected by an ammeter. A schematic of a channeltron is shown in figure 1. When an electron strikes the semiconductor surface of the channeltron, secondary electrons are produced which are attracted toward the throat of the channeltron by an applied voltage. As the electrons enter the throat of the channeltron, they strike the sides, causing more secondary electrons to be produced. This "avalanche" process continues until the electrons reach the end of the channeltron, where they are collected and measured by an ammeter. This amplification is large enough to allow the detection of a single electron. In most channeltrons, the conical entrance surface has a diamater of about .5 cm which is small enough that the location where the electron first strikes is unimportant. However, the channeltron we are studying had an entrance cone with a diameter of 2.5 cm. This meant that an electron striking the channeltron near the edge of the entrance aperture would have a significantly lower chance of being detected than one which struck the device near its center.

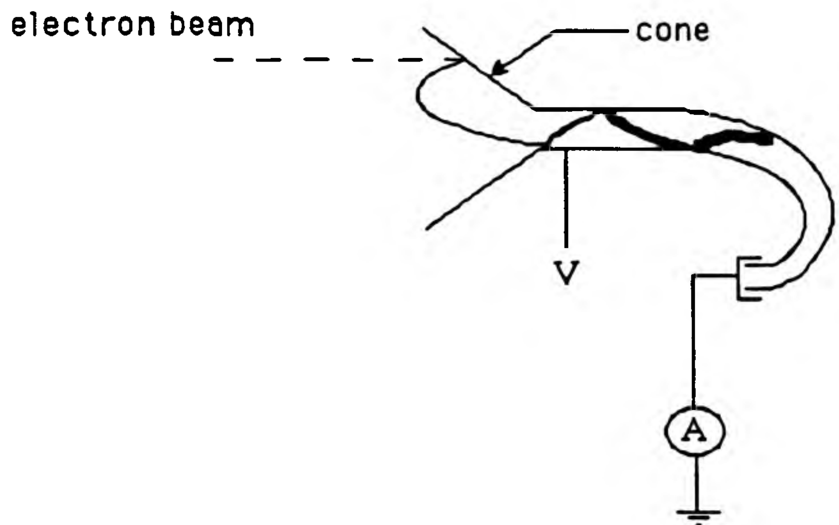

Fig.1 Schematic of channeltron.

In the experiments in which this channeltron was to be used, it was very important to know the relative detecting efficiency of the channeltron as a function of where the electron strikes. The efficiency was to be measured by scanning an electron beam across the mouth of the channeltron and measuring the current produced in the channeltron. Therefore, an electron beam whose characteristics were well-known and which could be finely controlled was needed.

I was required to use a vacuum system, since a channeltron is only operational under a vacuum. Fortunately, a facility was available which was small enough to allow the system to be quickly pumped down to vacuum and brought up to air, although it was necessary to thoroughly clean the system and replace some of the components of the system which had been removed. The vacuum system could be pumped down to a vacuum of approximately 10^{-6} torr in about 2 hours and could be brought up to air in about 5 minutes. This capability also greatly facilitated the testing of the electron gun, since the gun could not be tested at atmospheric pressure.

After familiarizing myself with the vacuum system, I began work on the electron gun, which was needed to supply the electron beam for the experiment. The electron gun was taken from an oscilloscope and slightly modified to withstand the stresses the gun would experience in going from atmospheric pressure to vacuum and back. The electron gun consisted of a simple tungsten filament, an Einsel lens, and two sets of deflectors. The electrons were emitted from the filament when a current passed through it. They were pulled through the Einsel lens, a set of three collimators used to focus the beam, and deflected by voltages applied to the deflectors. In order to obtain an electron beam from the gun, voltages were applied to the collimators and deflectors of the gun. After much trial and error, a combination of voltages was found which produced an acceptable electron beam of small cross sectional dimension. I then spent a great deal of time trying, unsuccessfully, to characterize the electron beam. Although an absolute value for the current produced by the beam was dependent on too many experimental conditions to make it readily reproducible, a typical plot of the current coming from the gun versus the current flowing through the filament in the gun is shown in figure 2. This data was used to determine the optimum filament current.

The most difficult and most important characteristic of the beam was its profile. This information was necessary in order to minimize the width of the beam which was required in order to obtain the best measurements of the efficiency of the channeltron. An example of one of the better measurements is shown in Figure 3. From plots such as the one in figure 3, we could determine the width of the beam. Although some preliminary results looked respectable, in further experiments, the electron beam proved to be extremely sensitive to various experimental conditions such as pressure, the time that the gun had been running, the filament current, and possibly other unknown conditions. At this point, I voluntarily terminated my involvement in the project. Work on this project was continued by Jason Sutin.

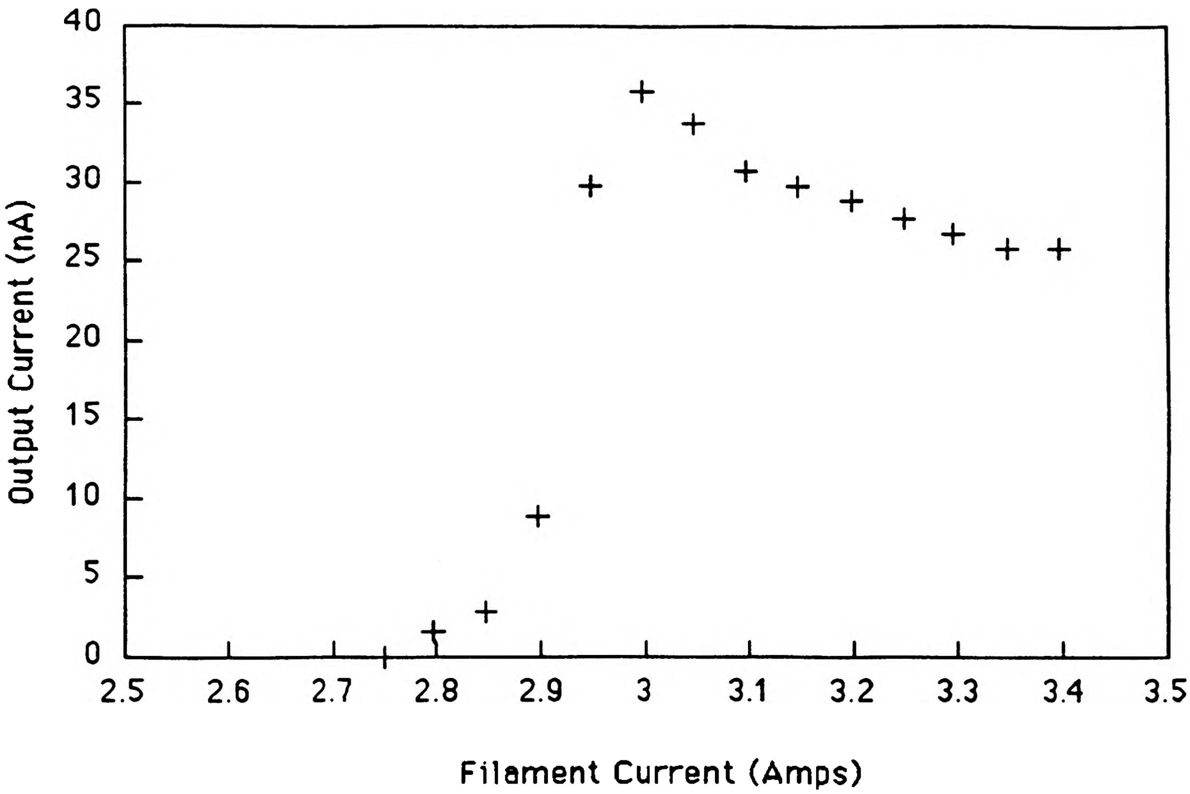

Figure 2. A plot of the output current from the electron gun versus the filament current.

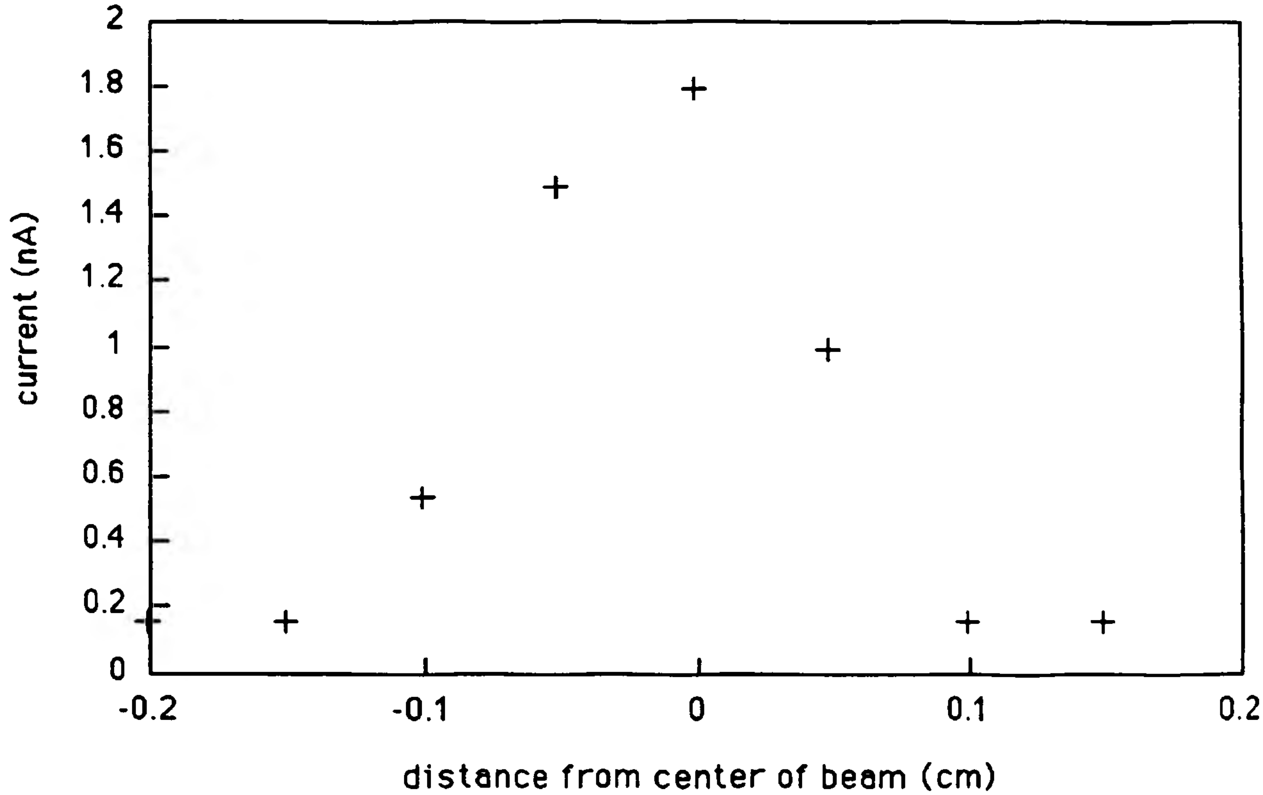

Figure 3. Profile of electron beam.