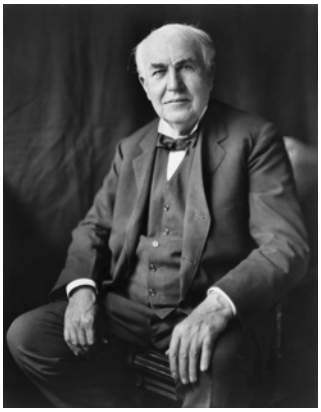
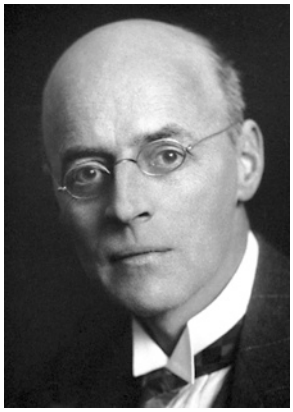
Thermionic Emission

Despite its name does not suggest that, "thermionic emission" concerns electrons. When it was first observed, well before the concept of electron was proposed, the effect was simply identified as the emission of particles from a heated metal. In other words, some sort of "evaporation" mechanism that involved unknown particles (initially called "thermions" because they are released by heating). One of the most important scientists that were early involved in the study of this effect is Thomas Edison. His studies on incandescent lamps were so relevant that the effect itself was sometime called the "Edison effect". Later, in the early 20th century, O.W.Richardson developed further the study of thermionic emission and found a specific relation between the temperature of the metal and the current of the emitted electrons, which made him win the Nobel Prize in Physics in 1928.



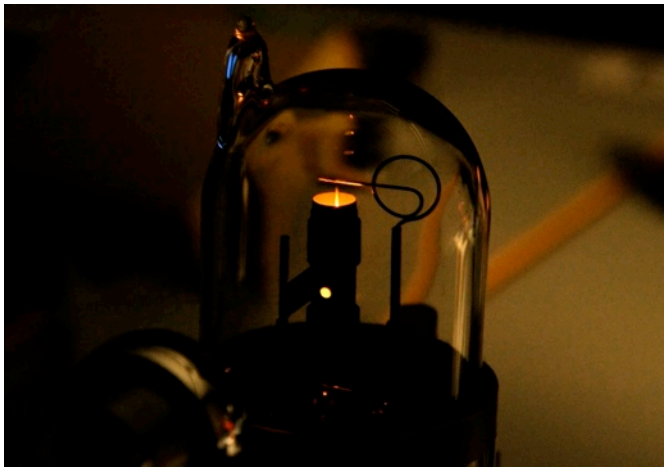


Left: Thomas A. Edison; right: Owen W. Richardson.

In this experiment, the student can reproduce some of the observations that were made in the early times of the study of thermionic emission. The experimental setup is composed of a wire of Tungsten that can be heated up to temperatures of 2500 K and a series of tools to measure the current of the electrons emitted from the wire. The fundamental part of the experiment is testing the relation between the emitted electron current and the temperature of the wire, so to probe the law of the "evaporation" of electrons from Tungsten as described by Richardson:

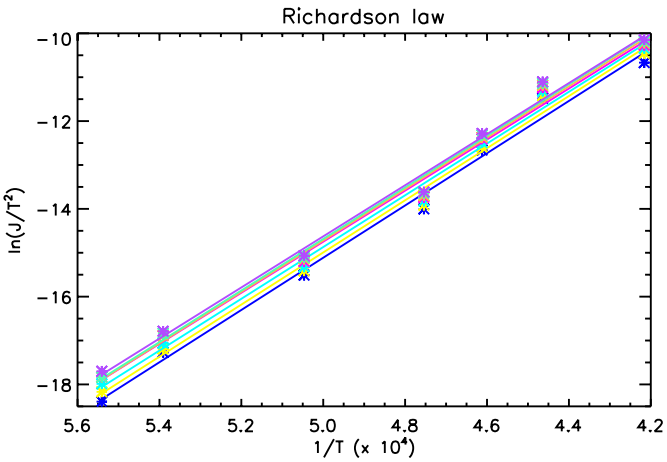
$$J = AT^2 e^{\frac{-W}{kT}}$$

where J is the current density of emitted electrons, T is the temperature of the wire, A is a parameter that depends on fundamental constants and some



The incandescent Tungsten wire inside the vacuum chamber used in the experiment.

properties of the emitting material (in this case Tungsten), and W is the energy needed to release the electrons, called the "work function". Determining the work function of Tungsten is one of the main goals of the experiment, but more in general this experiment involves many factors that make it a very good introduction and training in advanced experimental physics: a simple instrumental setup that can be easily controlled by the student in almost all its parts, measurements that require (but also help in getting) a good understanding of the ongoing physics, dealing with uncertainties and errors related to experimental as well as theoretical approximations, and above all the need to repeat and refine the measurements so to understand better and better what Nature is telling us, one of the fundaments of experimental physics.



Testing Richardson's law: the work function is given by the slope of the linear fit to the datapoints showed in colors.