Calutron Girls

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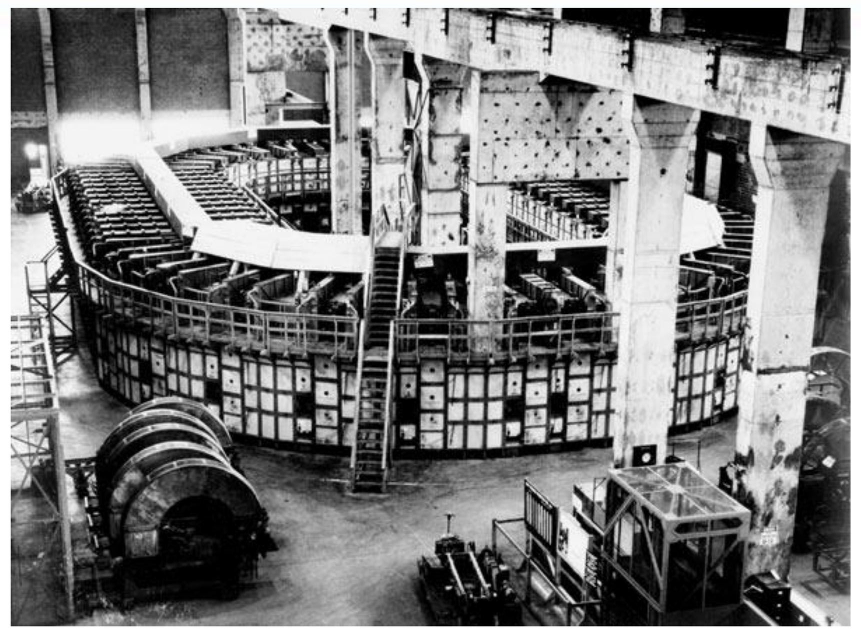


The Y-12 Calutrons

The Calutron

During the Manhattan Project, Ernest O. Lawrence developed a mass spectrometer used for separation the isotopes of uranium called a Calutron. Natural uranium (U-238) was combined with chlorine to for uranium tetrachloride. The uranium tetrachloride is then vaporized and is placed inside the calutron, the vaporized uranium is then bombarded with high energy electrons that causes the uranium to become positively charged ions. Now that they have a positive charge, this allows them to be accelerated and subsequently deflected by magnetic fields. Once they collide with a plate, the ions produce a measurable electric current. This allows the scientists to calculated the mass of the ions based on the charge of the ions and the strength of a field that was produced. The magnetic field causes the ions to move in a radial path in the chamber. The heavier U-238 isotope travels on a bigger radius than the lighter U-235 isotope. This causes the desired separation. The separated isotopes are then captured as packets as flakes of metal.

Who were the Calutron Girls?

During WWII, the Tennessee Eastman Corporation was forced to recruit young women who were primarily high school graduates and farm girls due to labor shortages. When the women were working in at the Y-12 plant they were not told what they were producing. Most of the women never questioned what they were doing. If the women talked about what they were doing, they would end up “missing”. While at work, the women would make necessary adjustments to switch boards, to keep the beam current maximized in the calutrons. At the time the girls did not know what they were adjusting on the switchboards. These woman who were operating the boards were called the Calutron Girls.

The Calutron Girls

Mathematical Analysis of Calutron Process

- Ion Current Density Distribution for an Isotope

$$\int_s^{s+w} i(x)\,dx$$

- Ion Current Density Distribution for Several Isotopes

$$i_T = \epsilon_w[i(x+d_w)] + \epsilon_x[i(x+d_x)] + \epsilon_y[i(x)]$$

- Ion Current Through Two Slots for Two Isotopes

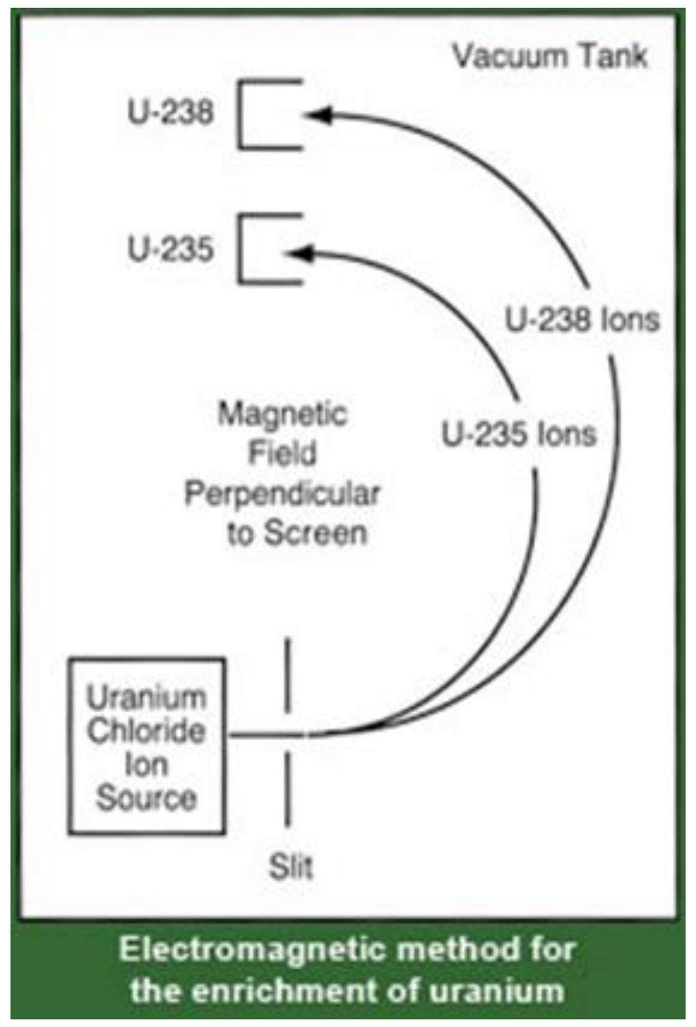
$$i_T = \epsilon[i(x+d)] + (1-\epsilon)[i(x)]$$

- Enhancement and Current Ration

$$n = \frac{\int_s^{s+w}[i(x)]\,dx}{\int_{s-d}^{s-d+w}[i(x)]\,dx}$$

- Enhancement Distribution

$$n(x) = \frac{i(x+d)}{i(x)}$$



Electromagnetic method for the enrichment of uranium

- Process Efficiency

a) Charge to Mass Relation

$$m = .037311 \int i\,dt$$

b) Source Process Efficiency

$$\alpha = \frac{\frac{1}{k}\int dt\ \int_s^{s+w} i(x)\,dx}{\int G\,dt}$$

c) Receiver Process Efficiency

$$\mathrm{r}_x = \mathrm{KRX} = \frac{X\ recovered\ from\ R\ pocket}{\frac{1}{k}\int RX\,dt}$$

d) Tank Process Efficiency (TPE)

$$RX_{\mathrm{TPE}} = \frac{X\ recoverd\ from\ R\ pocket}{charge\ X\ consumption}$$

Future uses of Calutrons

Calutrons are a costly piece of equipment, even when not in use. The calutrons used in WWII are currently kept in a standby mode, and cost about $2 million to maintain each year. The future of calutrons depends on the government’s and independent research facilities’ funding in order to continue operation and research. That research would look into medical uses of calutrons- using the isotopes to separate plasma and in Positron Emission Tomography (PET) scans. While calutrons were effective almost 80 years ago, there have since been easier and more cost-effective ways to separate isotopes, so the effort put forth into calutrons will likely cease.

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