Design of the Y-12 calutrons

Earlier, we examined the decisions and actions leading to the construction of Y-12. Now we will consider the design of the calutrons and the buildings that were to house them.

Ernest O. Lawrence and his staff at The Radiation Laboratory of the University of California at Berkeley worked throughout 1942 on the basic operation of the calutron (named for the **CAL**ifornia **U**niversity Cyclo**tron**). They also experimented with the largest magnet in existence at the time, a magnet with a pole diameter of 184 inches and a pole gap of 72 inches. This huge magnet was ready for use by May 1942.

Lawrence's calutron research was funded by private funds from the Rockefeller Foundation, donations from the Research Corporation, the John and Mary Markel Foundation and the University of California, according to the *Atomic Energy for Military Purposes,* by Henry DeWolf Smyth. This crucial funding allowed Lawrence to continue working through the fall of 1942 on experiments that supported his position that the calutron could indeed produce the needed uranium 235.

Smyth also describes the organization for planning and construction of the giant electromagnetic separation plant in East Tennessee. Six major groups were involved. Research and development was the responsibility of The Radiation Laboratory (Lawrence's lab at the University of California in Berkeley). The mechanical parts, sources, receivers, pumps, tanks and other equipment, were the responsibility of Westinghouse Electric and Manufacturing Company.

General Electric Company was responsible for the electrical equipment and controls. The Allis-Chalmers Company was responsible for the magnets. Stone and Webster Engineering Company was responsible for the construction and assembly of the plant. And finally, Tennessee Eastman Company was responsible to operate the plant.

Each of these five major industrial companies were engaged because they were the companies that were known to be among the very best in their particular expertise. Stone and Webster had been approached in June of 1942 by General Marshall, General Groves' predecessor with the understanding that their specific role would be defined later. Now that was beginning to happen.

The five industrial firms kept engineers at Berkeley working with Lawrence's team on the planning. This proved to be a good approach and kept the design laboratory involved in every step of the construction and early operation of the plant.

Interestingly enough, the theory of operation of a calutron remains somewhat nebulous even today after many years of successful operation. In the early days of Lawrence's design efforts many assumptions and partial measurements had to be relied upon. The final operational characteristics were somewhat intuitive and were measured primarily on the amount of desired material captured in the receiving pocket, without much concern for understanding the interim activity of the material as it went from the charge box to the receiver.

Because of the need to settle on a design that could be built in a timely manner, the actual development work at Berkeley continued using the giant 184 inch magnet, but the design for the plant to be built in East Tennessee had to be frozen in the late fall of 1942. The basic design that was chosen was quite different from the one being used for the experiments. The theory was the same, of course, but the physical characteristics were quite different.

It was highly desirable to build a prototype unit using the design for the plant. The unit was finished and operating in the big magnet building at The Radiation Laboratory by April 1943 at the same time production units using the frozen design were being built for Y-12. A third magnet was built in that same building and all the magnets were used for experiments and improvements on the basic design, yet the frozen design was used for the construction of Y-12.

So, these improvements had to take the form of modifications that could be added without modifying the basic design of the calutrons being built and installed at Y-12. Ultimately there were six separator and many variations of source and receiver units built and operated to learn which modification resulted in improved collection of material.

The calutron's basic design was to be a "batch process" where a quantity of uranium and chloride was placed in a charge box and the unit operated for a while and when the charge box was near empty the receiver pocket would be removed along with the charge box. The uranium 235 would be isolated from the receiver pocket and processed for use and the charge box reloaded with feed material. A new receiver pocket and the filled charge box would then be ready to be re-inserted in a calutron vacuum chamber. All this would need to be done without turning off the magnet.

The design of the calutrons as separate operating units inserted into large magnets made for excellent flexibility. This allowed the design to be frozen for the construction of the plant, but allowed experimentation with improvements to the units. The thought was that any improvements could be inserted in the magnets later as the construction of the plant continued. The fact that portions of the plant could be started before the entire plant was completed also provided very attractive options.

With the design frozen, Stone and Webster could proceed with the construction of the first buildings at Y-12. While construction on the town site and site clearing in Bear Creek Valley had begun some weeks earlier, February 18, 1943, construction began on the first building at Y-12.

Next we will examine the decision of how large the electromagnetic separation plant was first intended to be, how the shape of the first calutron magnet arrangement came to be known as a "race track," and learn why a very large quantity of silver was used as electrical conductors for the calutrons.