dilution. This procedure calls for the introduction into the sampling chamber of a known amount of a highly enriched, but normally rare, stable isotope of strontium, ^{84}Sr.

Basic Energy Sciences, through sustained support over four decades of the stable isotope separation program and related research, provided the means by which these and other applications were made possible. The calutrons, spared from certain demise, produced and maintained inventories of stable isotopes not elsewhere available.

The existence of these inventories, accompanied by supportive policies governing access, both enabled and encouraged scientists of all disciplines to investigate isotopic properties and explore their possibilities. By so doing, Basic Energy Sciences and the Oak Ridge calutrons gave birth to a wondrous array of benefits to society.

Over the years, other technologies have evolved which can produce some enriched stable isotopes more efficiently than the calutrons. For many important applications, however, and particularly for the continuing scientific quest of the unexplored, the Oak Ridge calutrons remain the only steadfast and reliable source of enriched stable isotopes in the free world.

TRACE ELEMENT ANALYSIS

For many years, a chemist testing a mixture for traces of contaminants had a problem. There were no dependable and convenient techniques for doing this in complex mixtures and combinations where trace elements are most often encountered. Today, more than 5,000 research facilities worldwide routinely use unique and powerful analytical instruments for detecting minute amounts of contaminants in water, air, and other samples from our environment. The origins of these instruments can be traced to an innovation pioneered at Ames Laboratory by Basic Energy Sciences-funded research.

Called *inductively coupled plasma spectroscopy*, and embodied since the early 1980's in several versions of rapidly selling commercial instruments, the new methods can measure individual elements in rapid sequence or simultaneously by selected groups. Previously, some approaches could measure one element at a time; others could measure elements in sequence but only with substantial changes in experimental conditions from one element to another. Many tests could not show how much of the elements were present. Several methods could measure a limited number of elements and others required lengthy sample preparation and separations to reduce interferences between measurements of different elements.

Some of the new instruments can measure 55 elements simultaneously, providing a computer display of the results in a matter of minutes. In 1985, an inductively coupled plasma instrument was used to analyze more than 80 aqueous samples for 26 elements—more than 2,080 analytical chemical determinations—in an 8-hour period.

The research at Ames Laboratory advanced chemical analysis by greatly increasing the range of two proven methods for elemental analysis, namely light spectroscopy and mass spectroscopy. Both had been long recognized as having the most potential for identifying and measuring amounts of materials at low concentrations.

Light spectroscopy capitalizes on the phenomenon that each of the elements of nature emits or absorbs a characteristic pattern of colors, or *wavelengths*, when it is heated to high enough temperatures. The pattern of wavelengths is a unique signature of the element. In contrast, mass spectroscopy separates materials on the basis of their weight. It not only distinguishes one element from another, but also distinguishes isotopes of the same element. (See Isotopic Geology.)

Specifically, the researchers at Ames Laboratory first solved longstanding problems associated with preparing samples for light and mass spectroscopy. The first step in any spectroscopic analysis is transforming gases or aerosols generated from liquid and solid samples into free atoms, excited atoms, ions, excited ions, molecular ions, and molecular fragments. This is done by heating the gases or aerosols, and the hotter they are heated, the better.

Existing flame, arc, spark, and other excitation sources used in the early 1960's didn't perform this vaporization, atomization, excitation, and ionization step entirely satisfactorily. They also tended to introduce contamination from the fuels used to combust the sample material or from erosion of the electrodes used to create the electric arcs or sparks in which the sample material was heated. Contamination is the bane of any chemical analysis,