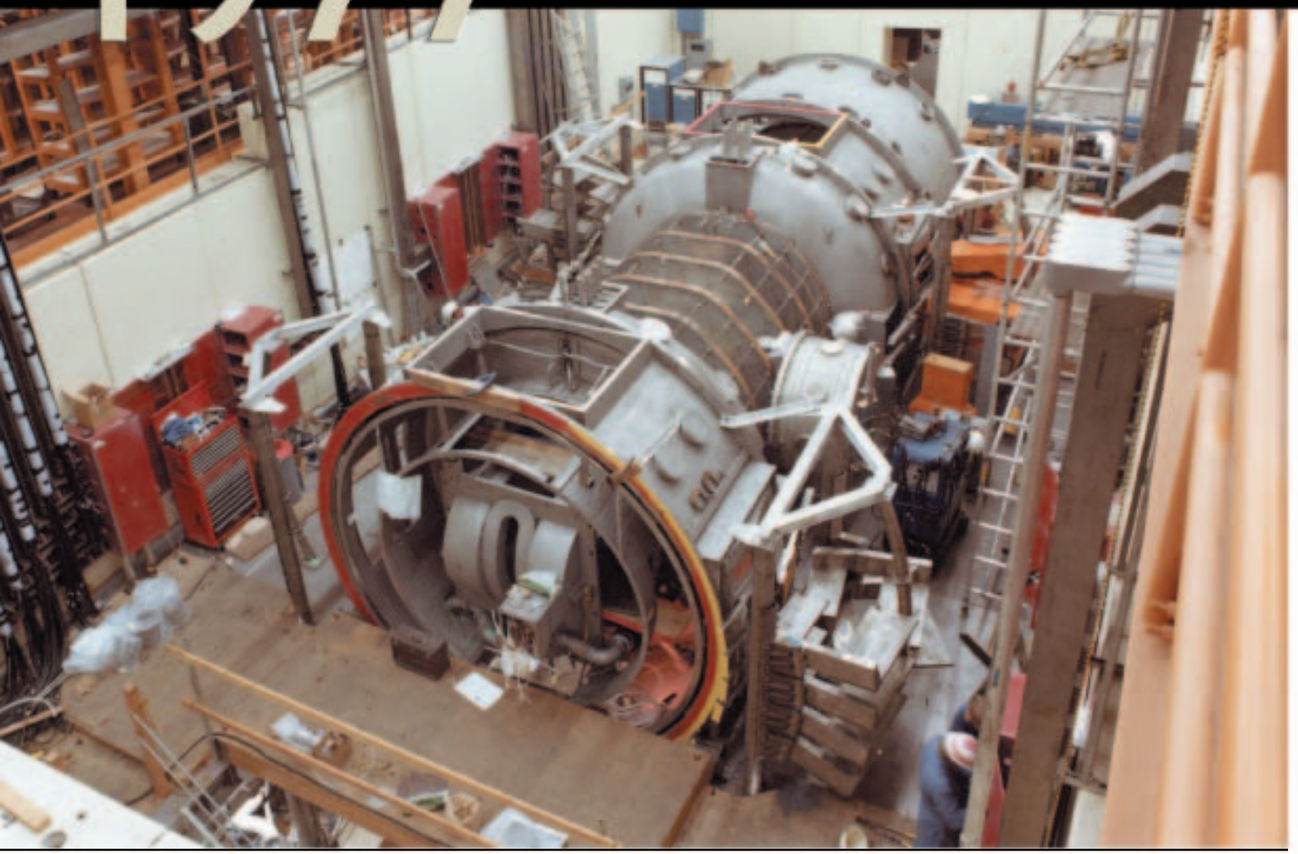
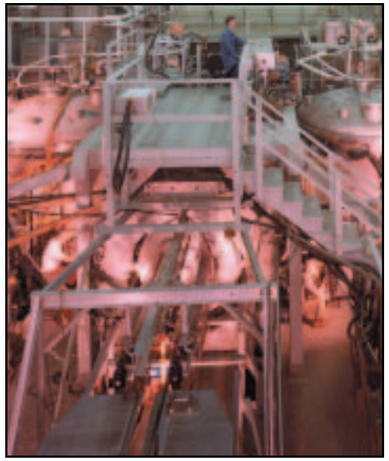
1977 Tandem Mirror Experiment





Great success in the Tandem Mirror Experiment (above) led to TMX-Upgrade (far left and left). The vacuum vessel was enlarged, and new end coils were installed in an attempt to demonstrate the thermal barrier concept and improve performance over TMX.

Enormous Strides in Magnetic Fusion

In 1977, Laboratory researchers were making enormous strides both in the quality of their insights into plasma physics and in the size of their experimental equipment. In the spring, the Energy Research and Development Administration approved $11 million for the Tandem Mirror Experiment (TMX), which promised major performance improvements. That summer, researchers used an intense beam of energetic neutral atoms to generate and sustain a high-density (10^{14} particles/cm^3), high-temperature (160 million kelvins) plasma in the 2XIIB machine, which was the single-cell mirror experiment that set the stage for TMX. And in autumn, construction began on the Mirror Fusion Test Facility (MFTF), an advanced experimental fusion device designed to be an intermediate step between the existing mirror machines and an experimental fusion reactor. The goal was to increase plasma confinement to nearly 100 times that of 2XIIB and to increase plasma temperature to more than 500 million kelvins.

Success with TMX experiments over the next several years led the Laboratory to attempt to improve plasma confinement by heating the electrons at the ends of the machine to create a thermal barrier—a change that turned out to add to instabilities. At the same time, the MFTF design was substantially modified into a large tandem mirror configuration called MFTF-B. With a 58-meter-long vacuum vessel and the largest set of superconducting magnets in the world, MFTF-B was the Laboratory's largest construction project ($372 million) when completed in 1986. However, what could have been learned with MFTF-B will never be known because it was officially mothballed later that year. A scientific tool that had pushed the limits of engineering was turned off before it was ever turned on.

The decision was a major setback for fusion energy research at Livermore, but scientists continued work on other approaches to magnetic fusion. Laboratory researchers are collaborating in experimental studies of tokamak performance using the DIII-D tokamak at General Atomics, and they are providing leadership in the development and use of large-scale simulation of plasmas to carry out fusion research. In addition, Livermore is focusing its attention on advanced and alternative plasma confinement concepts. The Sustained Spheromak Physics Experiment (SSPX) was dedicated in January 1999. Its attractive features are simplicity of design and economy of size and cost when compared to the warehouse-size, technologically complex tokamak.

As one of its significant legacies, the large magnetic mirror fusion effort at the Laboratory led to the establishment of the nation's first unclassified national supercomputing center to provide magnetic fusion researchers nationwide with the computing horsepower that was then available only to nuclear weapons designers. When it opened at Livermore in 1974, the computer center pioneered many practices: remote access by thousands of users; high-performance data storage and retrieval; online documentation; and, around-the-clock support for users. In the 1980s, the center became the National Energy Research Scientific Computing Center (NERSC). It is now located at Lawrence Berkeley National Laboratory.

One of the yin-yang magnets for MFTF-B being moved into Building 431. The magnet system for MFTF-B was the largest superconducting system ever built.