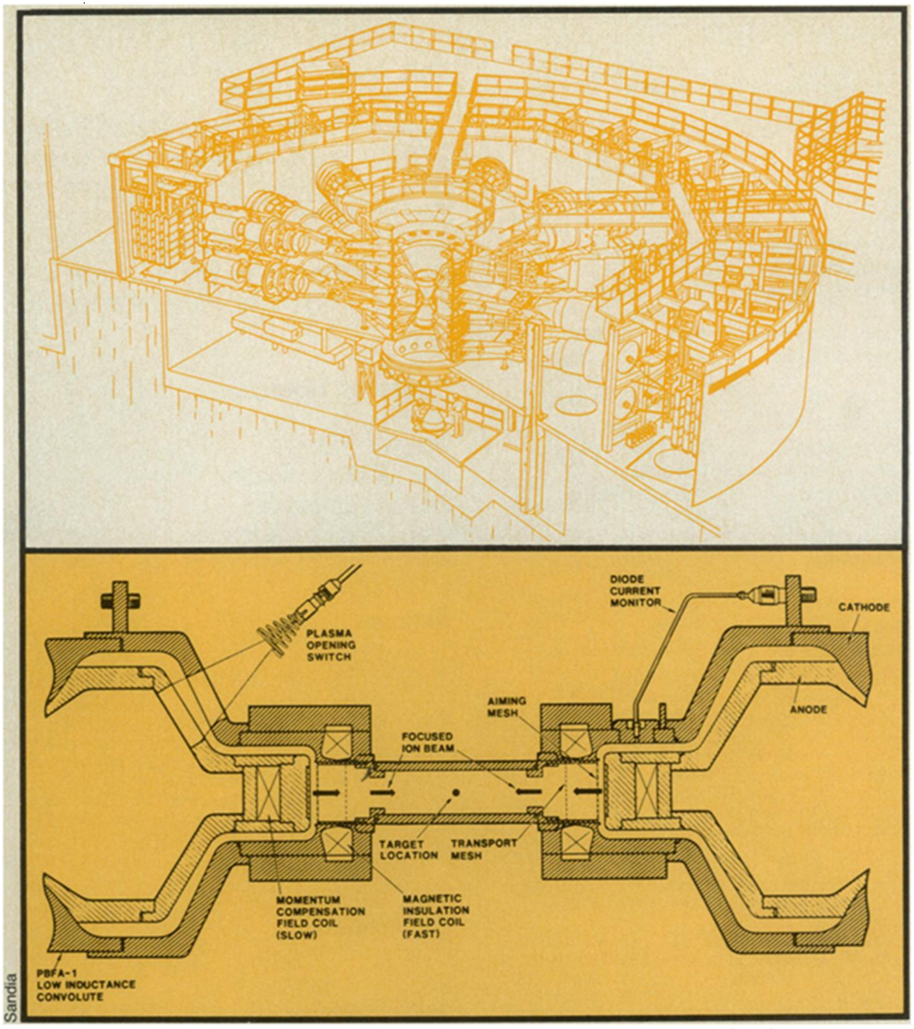
SCIENCE NEWS of the week

Powerful Climb Toward Fusion Power



Sandia

From Marx banks at the circumference, power compression arms will deliver power to central diode in PBFA II (top). Cross section shows PBFA I's diode and target.

Using beams of light ions to implode fuel pellets is a late starter among experimental approaches to generating thermonuclear fusion. The other two major approaches to a fusion power generator— confining and heating a plasma (ionized gas) in a magnetic field, and imploding fuel pellets with laser light — are both older (the magnetic field method about three decades older). Yet now, as a result of successful power-focusing experiments at Sandia National Laboratories in Albuquerque, N.M., the light ion method has "a very reasonable chance of becoming the first in the country to achieve fusion ignition," says William Brinkman, Sandia's vice president for research.

Sandia is the main laboratory in the United States concentrating on the light ion approach. The other two methods are featured at several government and university laboratories around the country.

Ignition means starting a fusion reaction that raises the fuel pellet's temperature to at least twice what it was just after the implosion. The next major step is break-even, the point where the fusion reactions yield as much energy as it took to get them started. About this, too, Brinkman is sanguine: "We may well become the first to achieve break-even."

This development comes at a time when the U.S. government has decided to backpedal the fusion research effort, particularly the two implosion methods. Indeed, the government action has inspired the editors of NATURE to opine, in their April 11 issue, that future hope for U.S. fusion research lies in international collaboration.

The experiments at Sandia focus beams of energetic light ions from all sides on a small target. The energy delivered by the ions will crush and heat a fuel pellet. The most serious problem in the light ion approach has been focusing the ion beams onto the target. Focusing was thought to get much more difficult as the energy of the beams went up; now it appears this may not be the case.

The Sandia experiments were done in an apparatus called Particle Beam Fusion Accelerator I (PBFA I). The process begins with the storage of electrical charge in giant capacitors called Marx banks at the outer circumference of PBFA I. The energy is discharged in pulses that the apparatus compresses in time and space as they move toward a large (30-centimeter-diameter) cylindrical diode in the center of PBFA I. At that point the pulses amount to 8 trillion watts of power.

The electric field generated by this power pulls ions (in this case protons or hydrogen ions) off the anode of the central diode and accelerates them toward a dummy target in the center. The target simulates the response of an actual fuel pellet. The ions should fly past the cathode and be focused on the target by a strong magnetic field in the area between the cathode and the fuel.

Earlier experiments had shown two major problems: Electrons were being emitted from the cathode so as to form an uneven electric field that drew the ions toward the cathode instead of sending them past it; and beyond the cathode, electrostatic fields were forming that defocused the ion beam. John Maenchen, project leader and chief experimentalist, discovered that the insertion of plastic wire meshes, one between anode and cathode and the other farther downstream, could suppress both problems.

The result has given the Sandia experimenters confidence that they can achieve focusing at the much higher powers of the PBFA II apparatus now under construction. PBFA I puts 1.5 trillion watts per square centimeter on the target; PBFA II, a similar but much more powerful installation, will deliver more than 100 trillion watts per square centimeter on the target. As a result of the PBFA I experiments, says Don L. Cook, manager of Sandia's Fusion Research Department, "the likelihood that PBFA II will be able to focus an intense ion beam has gone way up."

One hundred trillion watts of power per square centimeter in 40-nanosecond pulses should equal between 1 million and 2 million joules of energy on target in PBFA II. (A million joules is about the energy of a large car going 60 mph.) With these capabilities, Sandia scientists believe, PBFA II will have the possibility of igniting thermonuclear fusion in the laboratory for the first time. It will use lithium ions on a target of deuterium and tritium, the heavy isotopes of hydrogen.

PBFA II will cost about $48 million to complete. Its first shot is expected in 1986.

—*D. E. Thomsen*