THOR Experiment

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THOR, a plasma physics experiment at the University of Maryland, is based on the theta pinch

This work, supported by Energy Research and Development Administration (ERDA), is under the direction of Dr. H. Griem working with Drs. A. DeSilva, G. Goldenbaum, and

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NEWSLETTER

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University of Maryland—College Park

THOR at Maryland

THOR, a new University of Maryland plasma physics experiment, is the most recent refinement in a series of plasma heating experiments based on the theta pinch. The experiment, just put into operation, is a major part of the University's effort in the national basic research program aimed at obtaining controlled thermonuclear fusion.

Preceding experiments were with cylindrical geometry; THOR, however, is toroidal. In the earlier experiments, a plasma cylinder was produced with magnetic field lines parallel to the cylinder (z) axis and, in the azimuthal (theta) direction, with strong currents (several thousand amperes) that heated the plasma by exciting waves in the plasma which grow to higher than thermal equilibrium levels. These waves interact with other waves and particles and eventually energize the plasma electrons and ions. This process, sometimes called turbulent heating or shock heating because it results from shock waves in the plasma, is much more rapid than the conventional Joule heating techniques based on electron-ion collisions as, for example, used in tokamaks. Unfortunately, the loss-rate out of the ends of the cylinder proved to be almost as rapid. To prevent this loss, THOR's ends are joined together to form a torus.

In THOR, the plasma is created in a torroidal, quartz vacuum chamber which has a major diameter of 1 m and a minor diameter of 0.4 m. A weakly ionized cold plasma is first created in the vacuum tube by the oscillating electromagnetic field produced by discharging a small capacitor bank ($\sim$10 kJ) through a conductor (the compression coil) which is a one turn solenoid wrapped around the minor circumference of the torus. The higher density and temperature plasma ($n \approx 1\times10^{14}\,\text{cm}^{-3}$, $kT_{ion} \approx 10\,\text{keV}$) is produced by discharging a much more energetic capacitor bank (600 kJ) through the compression coil; this must be done in about a microsecond. In order to get these high power levels (6×10^{11} Watts), a new high voltage technology had to be developed.

The electrical energy storage circuits (swinging LC generators) produce a 600 kV emf. The generator is divided into six modules, each of which is submerged in oil for electrical insulation. The generator output is connected to this compression coil which also must be insu-

(THOR—cont'd)

lated against air breakdown. For convenience though, the compression coil and vacuum chamber is water, rather than oil, insulated.

When the generators are simultaneously switched onto the compression coil, a large electric field is induced in the plasma around the minor circumference of the torus; this produces a current in the plasma. The plasma current stream radially implodes because of the Lorentz force resulting from the magnetic field produced by the compression coil current. As the current sheath implodes through the plasma, large amplitude, small wavelength ($\gtrsim 1\mu$) waves are produced in the plasma. These waves are associated with electron and ion plasma modes as well as upper and lower hybrid modes. Which waves are dominant depends upon local conditions. These waves strongly interact with the plasma particles, efficiently converting stored capacitor bank energy into heat. It is this efficient energy conversion, via the collective modes of the plasma, that Maryland physicists are trying to capitalize on.

However, this is only part of the story. For a controlled thermonuclear fusion reactor to work, one must not only heat the fuel hot enough so that ions can tunnel throug the Coulomb barrier to make fusion reactions, but it is also necessary to contain the plasma long enough for a sufficient number of nuclear reactions to occur to compensate for the ignition energy expenditure and the losses. Various magnetic confinement schemes have been proposed.

One parameter characterizing the efficiency of a confinement system is beta, the ratio of particle kinetic pressure to magnetic field pressure, $\beta=8\pi p/B^2$. Magnetic field is expensive, both energetically and financially, to generate and maintain. An energy economic reactor requires $\beta\gtrsim 0.2$. It appears that conventional tokamaks, for various reasons, will have $\beta\sim 0.05$ to 0.1. On the other hand, it may be possible using the high power heating techniques investigated at Maryland along with a modified tokamak confinement scheme to obtain plasmas with higher beta values.

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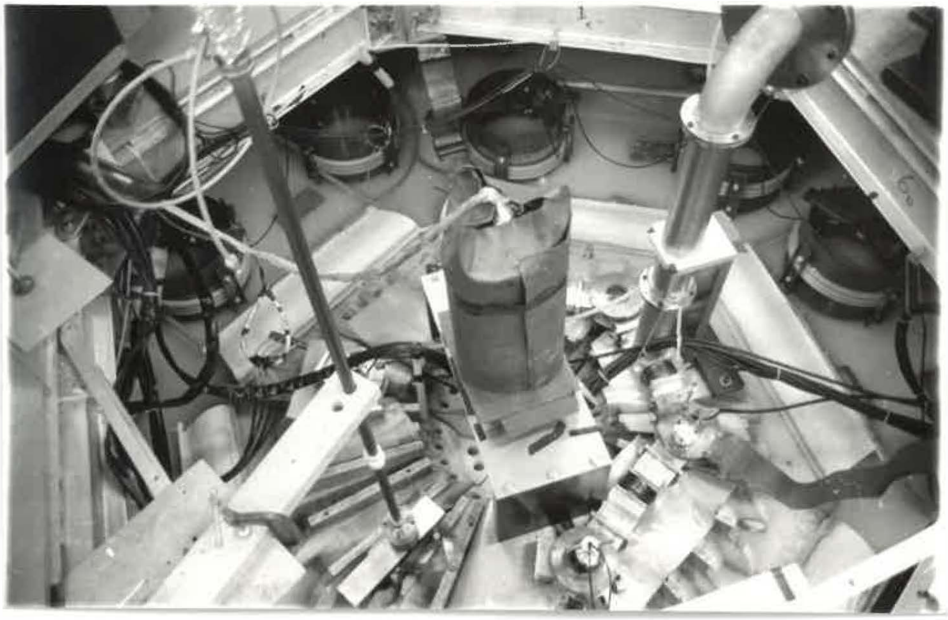

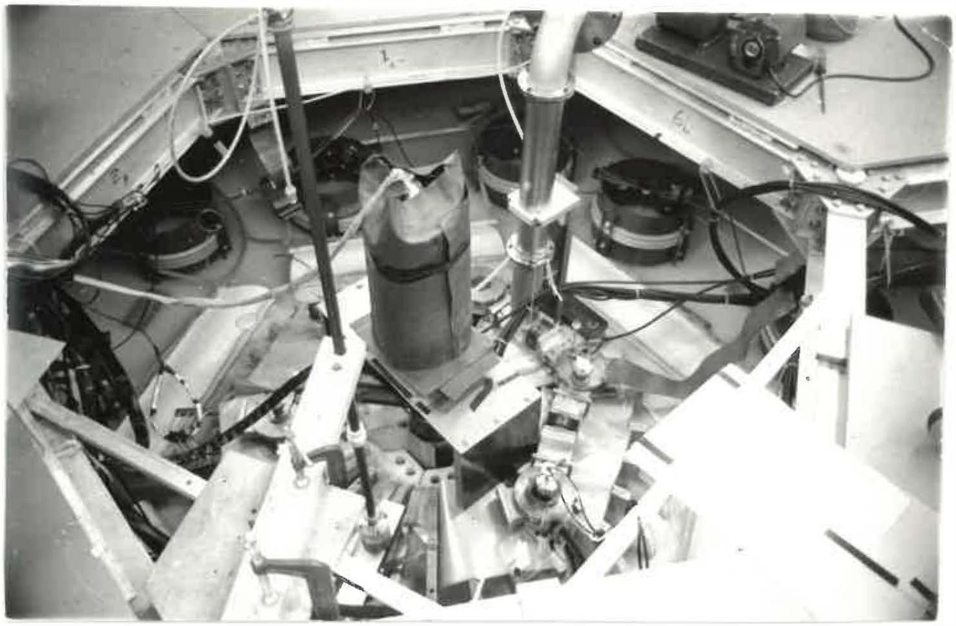

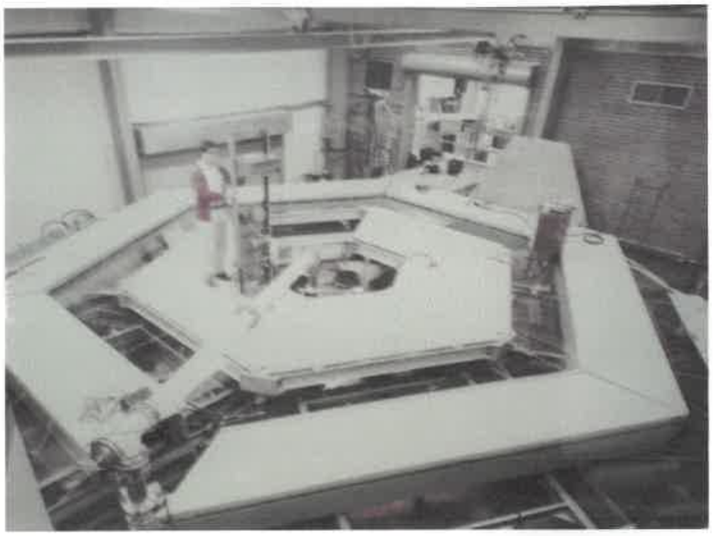


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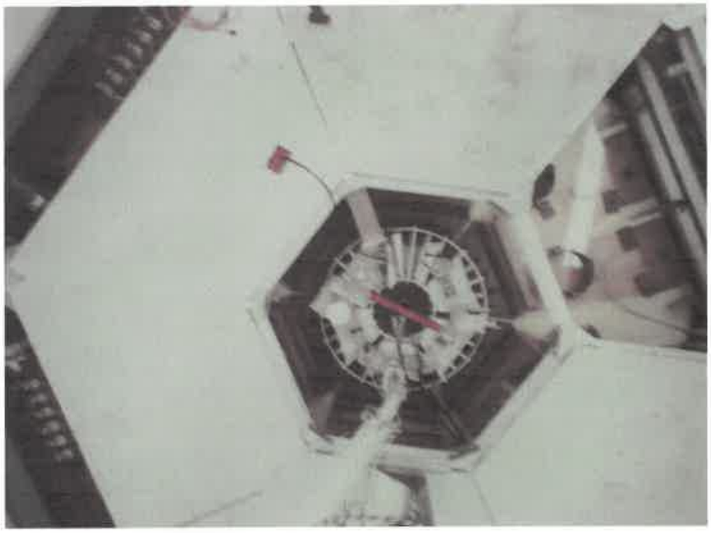


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