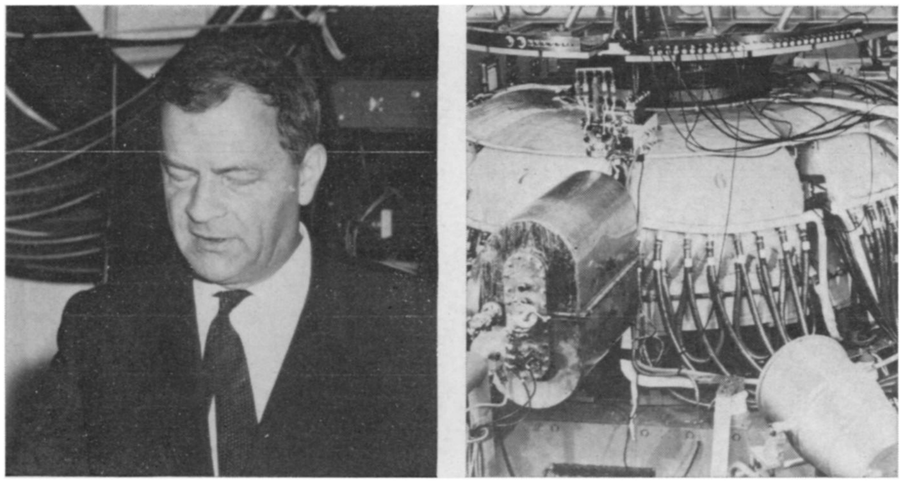
Plasma Confinement Grows

Russian touring U.S. reports significant step toward controlled fusion



MIT

Artsimovich at MIT *reported new plasma data from his Tokamak machine.*

For two decades physicists in many parts of the world have sought to achieve controlled nuclear fusion. Their goal has been to develop a machine in which the energy given up, as light atomic nuclei fuse into heavier ones, can be used for controlled steady power production.

But to get nuclear fusions going in sufficient number to produce a continual self-sustaining energy-producing reaction, a hot plasma, a gas whose nuclei have been separated from their attendant electrons, must be confined in a narrow space for a sufficiently long time.

This problem of plasma confinement has taxed the best efforts of experts in the field, and is far from solved, but the last year has seen some significant steps along the way (SN: 11/2, p. 438). The latest is reported from the Kurchatov Institute in Moscow.

The leader of the work at the Kurchatov Institute, Academician Lev A. Artsimovich, reported in a series of lectures at Massachusetts Institute of Technology and elsewhere in the United States last week that he and his colleagues had managed to hold a hydrogen plasma of 70,000 billion atoms per cubic centimeter and 5 million degrees Kelvin temperature for 0.02 second in a machine they call Tokamak.

This is ten times the previous confirmed confinement time for this kind of plasma and over three times what Dr. Artsimovich reported last summer.

American experts have taken mainly a wait-and-see attitude toward the Russian report. There are problems with the way the figures were determined that leave some ground for caution.

The reason that plasmas need to be contained is because they are hot and therefore tend to expand. They have to be hot in order to make fusions possible, since fusions do not happen spontaneously. Atomic nuclei all have positive electric charge and therefore repel each other. If they can be brought very close together, however, another force, the strong nuclear force, will overpower the electrical repulsion and cause them to fuse.

The plasmas are therefore heated to give the nuclei enough energy to overcome the repulsion and get close enough for fusions to occur.

But plasmas, in the magnetic fields that confine them, are very intractable physical entities. They are subject to many kinds of instabilities that disturb or disrupt them and they all suffer diffusion, a steady drift to the walls of the chamber.

Plasma physicists hope to overcome the instabilities, and there has been some progress in this direction, but they will always have to live with diffusion. The classical theory of plasmas predicts a rock bottom amount of diffusion that is inescapable.

Controlled fusion could live with the classical diffusion. The problem is that until recently classical diffusion had never been seen. Instead plasmas had exhibited a much faster rate known as Bohm diffusion. So important is Bohm diffusion that the time it would take to dissipate any given plasma is often used as a measure of improvements in confinement.

In such terms, the present figure claimed for Tokamak is 100 times the Bohm diffusion time. This compares with a previous confirmed result of 10 times the Bohm time. For controlled fusion in this kind of plasma one does not need to go all the way to the minimum classical diffusion; 1,000 times the Bohm time should suffice.

Actual classical diffusion was reported twice in 1968, from the Culham Laboratory in England and from the Max Planck Institute in Garching, West Germany. But in both cases the work was with relatively cool, low-density plasmas of materials unsuited to a fusion reactor for power purposes.

The Russian work, on the other hand, is with temperatures, densities and materials that approach those needed for controlled fusion. Dr. Bernard Eastlund of the Atomic Energy Commission likens the two steps to a young man contemplating marriage: "The German work shows that girls exist; the Russian indicates you might be able to get engaged."

The question of whether or not the claim should be accepted arises from the way the figures were measured. The neutrons that came out of the plasma were studied to estimate conditions inside. These neutrons are produced by such fusions as occur, and they carry off with them most of the energy released. They are thus far more energetic than the average plasma particle, and experts say using the most energetic objects to infer average conditions is a procedure open to serious mistakes.

Recently a team of British plasma diagnosticians, as people who study conditions in plasmas are called, went to the Kurchatov Institute. They intend to study conditions inside the Tokamak plasma by bouncing laser beams off the particles. For a judgment of exactly how much has been achieved, American experts suggest waiting a few months for the British report.