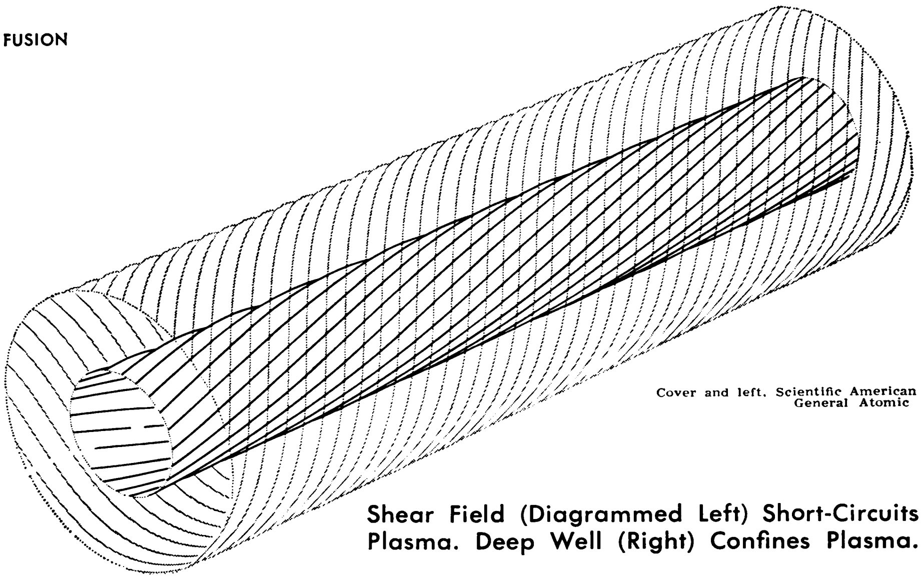

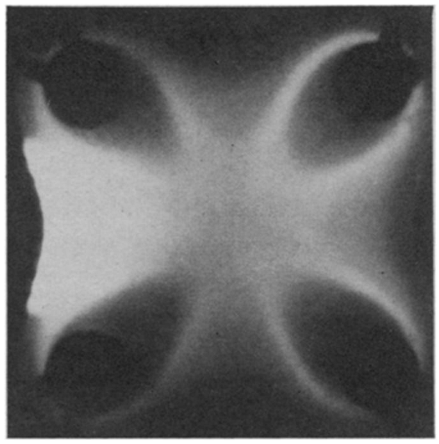

Cover and left, Scientific American
General Atomic

Shear Field (Diagrammed Left) Short-Circuits Plasma. Deep Well (Right) Confines Plasma.

Hopes Brighten for Fusion

by Ann Ewing

The promise of achieving controlled power from nuclear fusion is now brighter than ever.

Eight years ago the governments of the world made public their searches for a way to tame the awesome energies released in stellar interiors and hydrogen bombs. The immediate reaction was one of great optimism, fanned by enthusiastic press accounts. Fusion was to produce cheaper, cleaner power than even nuclear fission in reactors.

The glow of high hopes faded within three or four years, however. Now two new developments have rekindled expectations that controlled fusion may, after all, be within reach.

"The feeling of greater optimism is certainly there," says Dr. Melvin B. Gottlieb, director of Princeton University's Plasma Physics Laboratory. "The new confidence is based on an increased agreement between theory and experiment, so that we now think we know why earlier results were discouraging and what to do about them."

Nevertheless, Dr. Gottlieb believes there is still a long way to go and a very definite need for a new, much larger machine to test the agreement.

Helping to bring experiment and theory closer to a meeting point are the new geometries known as the magnetic well and short circuit by magnetic shear. Equally important is the increasing understanding of plasma physics, so that theoretical scientists can now make detailed analyses of what is actually happening in experiments.

A geometry is the shape of the magnetic "bottle" in which scientists seek to squeeze atoms together, releasing energy in the fusion process.

The U.S. Atomic Energy Commission, which funds most of the U.S. research work on fusion, agrees that new, large devices are urgently needed. Its official position on this and related matters concerning thermonuclear reactions will be presented to Congress.

The United States, once a leader in controlled fusion research, now lags far behind the rest of the world. Only immediate and substantial increase in this country's support, now $22.6 million, will help bring the U.S. abreast of other nations, AEC contends.

Power from controlled fusion would give man a virtually unlimited energy source, without the drawbacks of fossil fuels or nuclear reactors because the deuterium, or heavy hydrogen, in the oceans could be tapped for fuel.

Fusion—or joining together of two light atoms—to form a heavier one occurs in stars, where the atoms are squeezed by the star's own, very strong gravitational field. The hydrogen bombs exploded by man are also fusion reactions, but uncontrolled. There the squeezing is done fast by a chemical or nuclear explosive wrapped around the heavy hydrogen.

The tremendous energies result from the conversion of mass to energy.

Fission, the opposite of fusion, occurs when a heavy element like uranium splits to form two middleweight elements.

Fusion reactions require a very high kindling temperature, equaling that in a stellar interior—some 100 million degrees. At such temperatures matter becomes a plasma, a fully ionized gas as in the sun and other stars.

Scientists around the world can now routinely create matter at such temperatures for minute fractions of a second.

But the basic problem to solve before mankind can tap useful energy from controlled fusion is how to maintain plasma at this temperature for a sufficiently long time that a sizable number of fusion reactions take place. Since all containers of solid material would vaporize at 100 million degrees, researchers have focused their attention on various types of magnetic "bottles" whose walls are formed by magnetic lines of force.

However, the magnetic field in which the plasma is contained produces instabilities in the gas, resulting in its dissipation in less than a microsecond. Now new ways have been found to squeeze the plasma and hold it there, not for as long as wanted nor for as long as will be required for fusion power but nevertheless longer than previously possible.

One method is based on discoveries made in 1963 by the Russian scientist, Dr. M. S. Ioffe, at the Kurchatov Institute in Moscow. He found that plasma stability can be achieved when the confining magnetic field is so designed that its strength increases in all directions away from the plasma, thereby creating a deep well where the plasma is held at the low point in the magnetic field.

The deep well is obtained by means of a configuration in which the main portion of the magnetic field bends, or bulges inward (see cover and above), convexly, toward the plasma, enabling the field to contain it.

The second method for containing a plasma involves twisting the magnetic field in such a way that the amount of twist changes (see above) with increasing distance from the center. This configuration suppresses the separation of charges within the plasma that leads to another kind of instability resulting from the magnetic field. In effect, it creates a short circuit within the plasma so that the charges in the plasma have much less tendency to separate.