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Facts About General Electric's NUCLEAR FUSION Demonstration

GENERAL ELECTRIC PROGRESSLAND

AT THE NEW YORK WORLD'S FAIR

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Research Information
General Electric Research Laboratory
P.O. Box 1088, Schenectady, N.Y.

For the first time, large general audiences are witnessing actual demonstrations of controlled nuclear fusion, a scientific development of major significance in man's quest for new energy sources. Each demonstration — there is one every six minutes — is a full scientific experiment in which fusion reactions are achieved by the same techniques which have been used for studying these processes at the General Electric Research Laboratory.

What Is Nuclear Fusion?

It is a process in which the cores (nuclei) of two or more atoms collide and combine in such a way that, in accordance with Einstein's basic equation, a portion of their matter is changed into energy. Fusion reactions are the source of the tremendous heat of the sun and stars.

During each demonstration, such as the one you saw, a plasma of deuterium gas is created within a quartz tube, around which is placed an electrical coil that produces an intense magnetic field (sometimes called a "magnetic bottle"). A high bank of capacitors is charged to 60,000 volts. As the countdown reaches "0", an automatic control discharges the capacitors, releasing a tremendous electrical current of a million amperes into the coil around the tube. Within the tube, the rapidly increasing magnetic field created by this current "squeezes" and heats the plasma, producing large numbers of deuterons (deuterium nuclei) having energies equivalent to those which would exist at a temperature of 100,000,000°F. As the capacitor bank is suddenly discharged with a bright flash and loud "bang," the deuterium nuclei inside the quartz tube collide and "fuse" producing energy measured by the output of neutrons. The fusion reactions take place during about six millionths of a second.

Evidence of the fusion reactions is demonstrated on large oscilloscope screens, and electronic digital-counters record the actual number of neutrons released during each experiment.

The Promise

Fusion promises humanity — in the distant future — the benefits of a virtually unlimited supply of energy. Predictions are that it may fulfill man's power needs by using the most common of all natural resources: water. Thus, it has the promise of unlimited power, for an unlimited amount of time, with minimal "fuel" costs.

The fusion process demonstrated in this experiment uses deuterium, a special form of hydrogen found in water. There is enough deuterium in one gallon of water to produce, through controlled fusion, energy equal to that of 350 gallons of gasoline. Extraction of deuterium from ordinary water is an inexpensive process.

Fission / Fusion

The fusion process releases energy by joining together two very light atomic nuclei, such as those of deuterium. Fission, by contrast, involves splitting a very large, heavy nucleus, such as uranium. Fission is the process by which modern nuclear-powered ships and atomic electric-generating plants derive the heat that powers their turbines.

Why Not Now?

The problems involved with fusion reactions, compared with fission reactions, are far more taxing to man's scientific knowledge. Nuclear fission was first demonstrated in 1938, and the first working reactor was activated in 1942. By contrast, nuclear fusion was first discovered in 1932 and still remains a "laboratory phenomenon." The reason for this slow pace of development is that the fusion reaction must take place for a sustained period of time under extreme physical conditions of high pressure and high temperature.

To contain the heated plasma in the demonstration experiment, the magnetic field produces an equivalent pressure of 1500 pounds per square inch (100 atmospheres). The plasma pressure is somewhat lower than this, with the high energy portion being approximately 150 lbs/sq. in. As has been indicated, this portion of the deuterium plasma has an energy equivalent to tens of millions of degrees.

While these deuteron energies and pressures are close to those required for an ultimate practical fusion power plant, the efficiency of heating the deuterium and the time of containment, or reaction time, must both be significantly increased.

What Is Efficient ?

Let's explain it this way. In the G-E World's Fair display, you witnessed a fusion reaction in which over a million pairs of atomic nuclei collided and combined. Each one of these "fusions" released several hundred times the energy required to make the particles react, but for every deuteron taking part in such a fusion, over a billion deuterons did not. In other words, even though you witnessed true nuclear fusion, the energy input required to perform the experiment far exceeded the energy output that the fusion reactions produce. Hopefully, future scientific breakthroughs will make it possible to increase the fraction of deuterium nuclei which actively undergo nuclear fusions to the point where more energy is released than is required to heat and contain the plasma.

You saw an experiment in which the reaction period was about six millionths of a second (six microseconds). For an efficient fusion process, at pressures which have been achieved, the reaction period will have to be extended to more than a hundredth of a second, and the efficiency of heating the plasma will have to be substantially improved. Reaching these extremes will probably still require years of intensive research.

GE's Role

Research in nuclear fusion has been under way at G. E. 's Research Laboratory, Schenectady, N. Y., for over seven years. The Company has thus far invested several million dollars toward development of this future power source. The General Electric program is one of only two large fusion research programs being financed by private industry. Research in fusion is also being pursued in several other U. S. laboratories, principally operated by the U. S. Atomic Energy Commission. Internationally, all the major countries have active fusion research programs.

Are the Reactions Real ?

Yes. The fact that fusion reactions occur is unequivocably demonstrated by the production of neutrons. Neutrons released in the fusion reactions leave the reaction vessel and activate silver foils in the counters placed close to the quartz tubes. Neutrons are the only particles which can activate the silver in this manner.

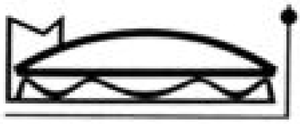
The number of neutrons produced and the variation of the production rate with time tell the scientists about the pressure of the high-energy portion of the deuterium plasma and also about the efficiency of plasma heating.

What Kind of Experiment ?

This apparatus is called a θ*pinch fusion device, so-called because the current in the plasma flows in the azimuthal, or θ-direction, with respect to the compressing magnetic field. Other experimental devices of this type are also being studied in this country at Los Alamos and at the Naval Research Laboratory and in laboratories in several other countries.

θ-pinch type experiments are of particular interest since they provide an energetic plasma having a high energy portion with pressure a hundred to a million times greater than that now obtainable from other types of fusion devices.

Therefore, whether or not these θ-pinch devices find ultimate application as fusion reactors, it is certainly true that they are at this time contributing significantly to our scientific knowledge regarding the behavior of fusion plasmas.



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