hands on

FUSION ON A BUDGET

Building your own nuclear fusion reactor is easier than you think

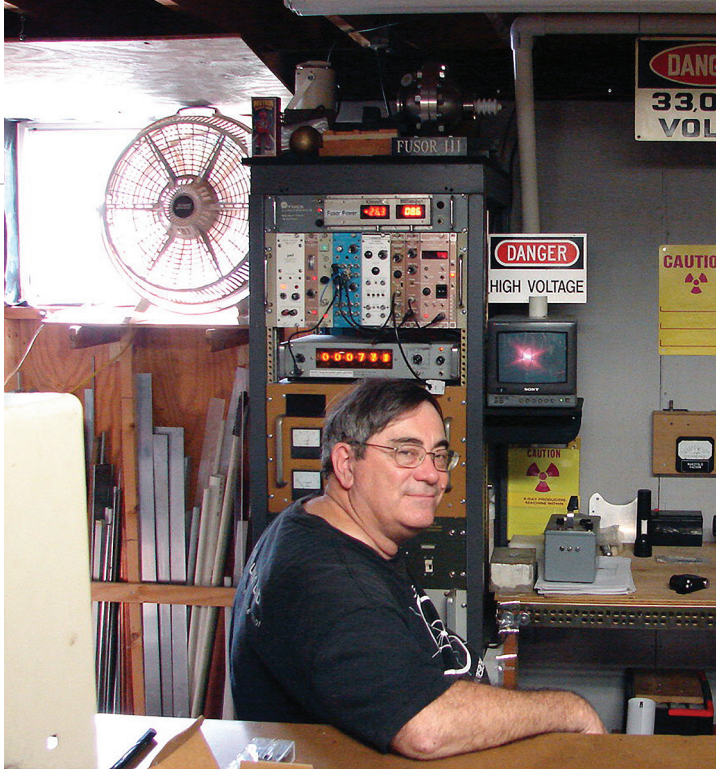
Do you have a few thousand dollars to spare, some basic machining and welding skills, and the ability to follow directions without getting fingerprints inside your equipment? Then you, too, can build a baby fusion reactor, or fusor, in your garage.

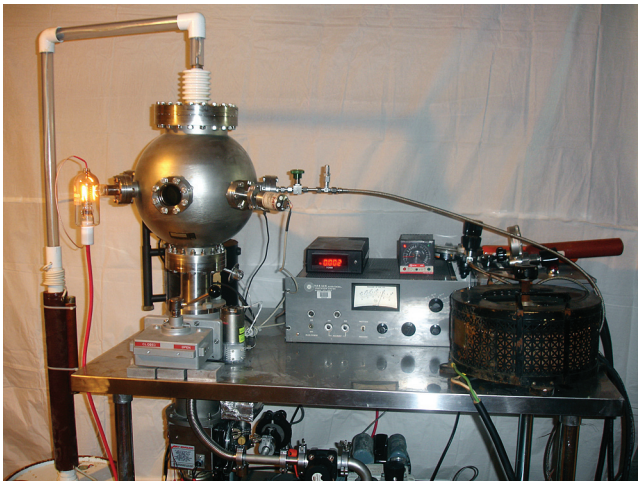
In fact, it's pretty simple, according to Paul Schatzkin, who runs Fusor.net, a Web site where amateur "fusioneers" congregate to swap equipment and advice: "Find two stainless steel half-spheres, seal them together around a wire grid, suck the air out of it, apply some high voltage to the grid, inject a bit of deuterium into the chamber, and sit back and count the neutrons." Don't expect to reach energy breakeven, Schatzkin says, but at least you'll be failing to achieve practical fusion at only a millionth the cost of a tokamak.

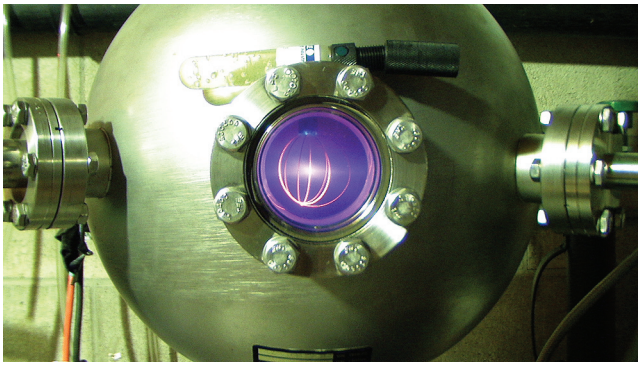
Tokamaks, the multibillion-dollar fusion reactors that have occupied physicists' attention for more than 50 years in their quest for limitless clean energy, use a magnetic field to confine a plasma heated to about 100 million kelvins and compressed so that the deuterium nuclei inside will collide and fuse. A fusor is even simpler: Just make a very deep electrostatic potential well for your nuclei to fall into, and make it radially symmetrical so that they wallop into each other when they reach the middle [see "Fusioneering" and "Tabletop Fusion"]. Nuclei at a temperature of 100 million kelvins have the same energy as those that have traversed a potential drop of only about 9000 volts, so getting your nuclei to travel fast enough will not be a problem.

The idea comes from Philo Farnsworth, the inventor of the modern television, who, along with Robert Hirsch, built his first fusor in the mid- to late 1960s.

Since then, professional and amateur researchers alike have found more than enough other problems to make personal fusion reactors a matter of research interest only. The list of issues under discussion by participants in the online community at Fusor.net is well-nigh endless: not enough ion density, too much energy spent in creating ions, ion and electron collisions with the charged grids that create the potential wells, grids melting under the resulting current, vacuum systems that won't evacuate, and so on. Still the fusioneers press onward, motivated by both the simple love of tinkering and the dream



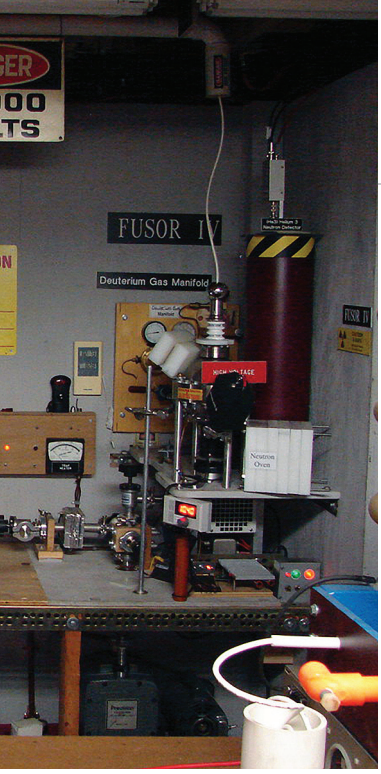




FUSIONEERING: Richard Hull [above] hosts an annual gathering of fusioneers at his lab in Richmond, Va.

Eric Stroud's 30-centimeter fusor [left, top] is typical of reactors built by amateurs. The brown stalk at far left is the high-voltage ballast resistor. The glowing bulb next to it is a hot cathode gauge for measuring deep vacuum. The vacuum meters indicate high-vacuum conditions approaching 1×10^{-6} torr.

If fusors aren't energy-efficient, they can at least be beautiful. A star-mode plasma [left, bottom] is not only visually spectacular, it also indicates good vacuum, gas control, and neutron production. *PHOTOS: ABOVE, RICHARD HULL; LEFT, ERIC STROUD (2)*

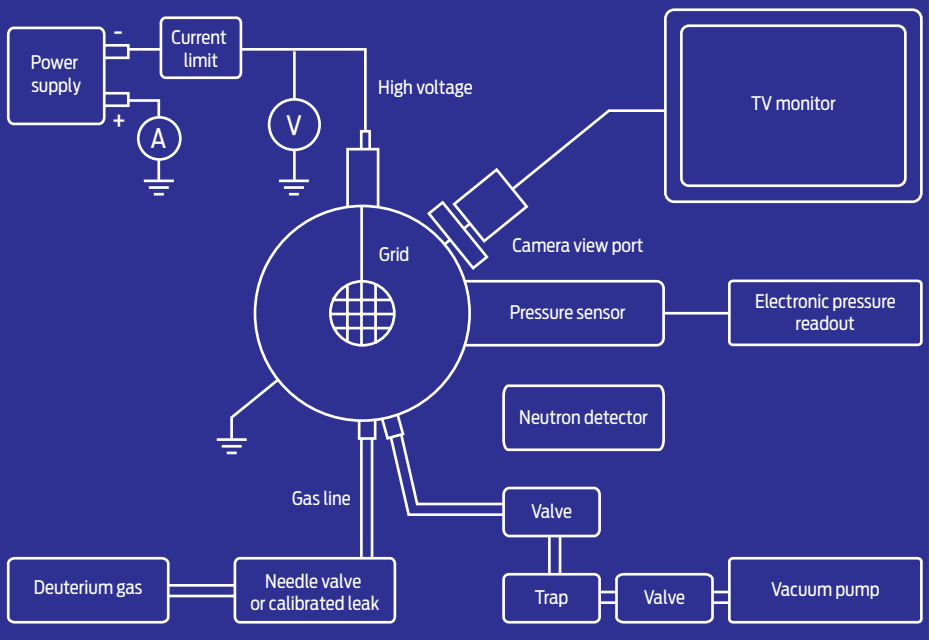


of contributing in some small way to solving the world's energy problems.

Building a fusor is simple enough for amateurs to contemplate because of the enormous global inventory of used lab equipment, says veteran fusioneer Richard Hull. For example, fusion containers need only achieve pressures of about one millitorr; vacuum pumps with that capability make their way to eBay for US $10 to $100. High-voltage feedthroughs are in the same range—or free, if you build your own from microwave-oven salvage. The most expensive items, according to Schatzkin, are neutron detectors, which have to be purchased new. But a cheap workaround is available, Hull says: You can prove your fusor is working by irradiating a piece of silver and watching the decay of the Ag-108 and Ag-110 isotopes with a simple Geiger counter.

What is the fusor good for, other than the smugness of knowing that you've turned hydrogen into helium in quantities almost too small to detect? Nothing at all, says Hull. Although some amateur fusioneers write as if their work might eventually lead to useful power generation, he's convinced that this quest is well beyond the horizon. And although neutron activation of other elements, such as aluminum, iodine, or gold, is a neat parlor trick, if you actually got enough of some longer-lived isotope to do something useful with it, you'd need a federal license, pronto.

—Paul Wallich



TABLETOP FUSION: To make a fusor work, the vacuum chamber and high-voltage accelerating grid inside it must be augmented with both a vacuum system [lower left] to remove air and a deuterium feed. The neutron detector is the final arbiter of when atoms have fused, but a view port may be crucial for observing the behavior of gases inside the chamber while debugging the fusor.

FIVE EASY STEPS TO HOME FUSION

1 CHOOSE YOUR FUSOR DESIGN: Hirsch-Farnsworth [see "Tabletop Fusion"], Elmore-Tuck-Watson, or some variant of your own creation.

2 ASSEMBLE YOUR FUSOR with a fanatical attention to cleanliness. You will need a vacuum-tight shell, a high-voltage grill, various feedthroughs, a valve to admit deuterium, a vacuum pump, and power supplies.

3 PUMP THE FUSOR down to a millionth of an atmosphere or so, fire it up to 10 or 15 kilovolts (or whatever levels your design requires), and see what kinds of discharge it makes without deuterium in it. There are images on fusor sites to suggest what you ought to be seeing; if you aren't, debug until you are.

4 ACQUIRE SOME DEUTERIUM (either as a gas or as heavy water that you can split by electrolysis), some sensors for detecting neutrons or charged particles, and some shielding.

5 TURN ON your fusor, admit trace quantities of deuterium from a safe distance, and collect your data.

—P.W.