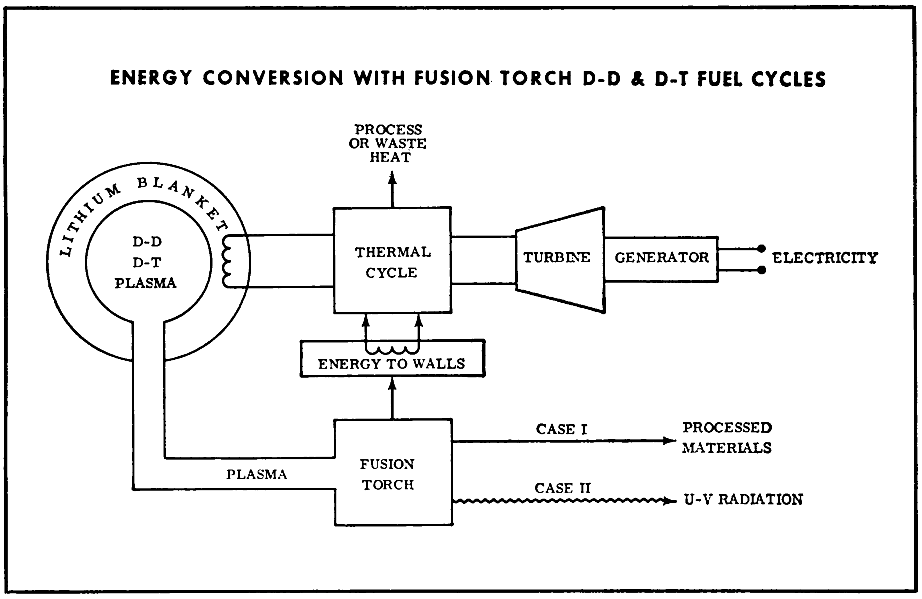
Fusion power to fight the trash glut

Photos: AEC

Eastlund and Gough: It started out as a blue-sky idea but it may be possible.

By the year 2000 a self-sustaining fusion reactor may get rid of garbage

by Dietrick E. Thomsen



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By the year 2000 the United States will have to dispose of 6.8 pounds of solid waste per person per day, or 400 million tons a year. There isn't enough land to bury it, and incinerating it would put 444 million tons of carbon dioxide and carbon monoxide, including what was generated from burning the incinerating fuel, into the atmosphere each year.

"I just can't see 400 million tons of CO_2 being dumped into the atmosphere," says Dr. Bernard J. Eastlund of the Atomic Energy Commission. "There is the alternative of pumping it into the oceans, but the international community may not like 400 million tons of garbage in the ocean."

To replace conventional methods of garbage disposal Dr. Eastlund and his colleague, Dr. William C. Gough, suggest using the plasma from a thermonuclear fusion reactor to reduce the wastes to their chemical elements. Such a system would not pollute the air, would not leave behind any ashes to be dumped, and would provide valuable salvage.

An economical application of this fusion torch, as they call it, to ordinary garbage would require a self-sustaining fusion power reactor, from which the energy for vaporizing and reducing the garbage could be gained as a cost-free bonus. Enough progress has lately been made toward self-sustaining fusion reactors that there is a good hope they may be developed and producing electric power by 2000.

In the meantime the salvage potential of the fusion torch is so good that it may be economically feasible to use a less than self-sustaining plasma for certain kinds of ore reduction and salvage. In such a case it would cost energy, and therefore money, to keep the torch burning. In some cases this could prove cheaper than present ore-refining methods. Its application to salvage may be necessary to save the world from a raw-materials crisis that could leave technology rusting to a stop.

The raw-materials problem is closely connected to the garbage problem. It is into the garbage that the raw materials are disappearing. The raw materials start out as fairly concentrated ore deposits. They are mined, refined and manufactured into objects. The objects are used and discarded and the raw materials wind up as spots of rust or corrosion or pieces of junk scattered over the landscape. Salvage is often uneconomical or impossible.

"By the year 2000," Drs. Eastlund and Gough estimate, "the mineral reserves of the world will have great difficulty keeping abreast of the rapid rise in population. For metals like copper, lead, zinc, tin and many others the outlook will be precarious."

The purpose of the plasma torch is to close the cycle, refining the scrap before it becomes rusty dust, and recovering the metals in a reusable form.

A plasma torch would begin with plasma that either leaks from a fusion reactor or is deliberately diverted from one. Magnetic fields would lead the plasma to an interaction chamber where the scrap or garbage would be introduced. The heat of the plasma (about 50 million degrees C.) would vaporize the solid material and ionize and break up the chemical compounds in it.

. . . plasma torch

"It started out as a blue-sky idea," says Dr. Eastlund, but as he and Dr. Gough began to do calculations they found that the "physics stayed within manageable limits." In particular they found that the vaporization of solids would be done by a shock wave rather than by ablation. That is, the encounter with the plasma would cause a shock wave to run through a solid piece, vaporizing it all at once instead of little by little from the surface. The shock heating means quicker vaporization and processing plants that can go through large volumes of garbage quickly.

Calculation also shows that the energy for garbage reduction would come free. For the sort of fusion generators now envisioned by plasma physicists the efficiency for conversion of energy generated by fusion in the plasma into electricity is about 60 percent. The energy for vaporizing garbage would come from the unused portion, without lowering the electrical efficiency.

For example, Drs. Eastlund and Gough calculate that a city of 10 million with an all electric economy will need about 132,500 megawatts by the year 2000. If this electricity is all produced by fusion reactors using deuterium and tritium as fuel, 33,700 megawatts of fusion-torch energy would be available. Garbage processing would take 42,000 kilowatt-hours per ton so that these plants could take care of 22,000 tons of refuse a day. The city would produce approximately 34,000 tons a day. Thus most of the garbage disposal could be a free ride on the electric generating system.

Even before there are power-producing fusion reactors, very hot plasmas could be used to reduce ores or scrap in cases where valuable elements need to be recovered. Dr. Eastlund gives the example of alumina ore or aluminum oxide.

It takes about eight kilowatts of power per ton to reduce alumina ore and it may prove more economical to supply the energy with a plasma torch even if the plasma does not generate its own energy but has to be supplied from outside.

Once the plasma has dissociated the compounds in the substance to be reduced, the problem becomes how to separate the different elements. Electromagnetic methods such as those now used in laboratories to separate ions of different weights are a prime possibility. At present these methods are both delicate and expensive. But Drs. Eastlund and Gough point out that their most common present use is to separate isotopes whose atomic weights are very close to each other. In a fusion torch they would be used most often to separate elements with quite different weights, such as aluminum (27) and oxygen (16). They would therefore not need to be so delicate and might be made cheaper.

A separation method especially suitable to the fusion torch is the so-called fast quench technique. If the plasma is cooled suddenly, for example, by blowing cold gas across it, it will form simple gaseous molecules.

Another method is called selective recombination. For each species of ion there is a combination of temperature and pressure under which it is most likely to recombine, to neutralize itself by picking up electrons from the plasma. If the plasma is brought to conditions favorable to recombination of one element, neutral atoms of that element will collect on the walls while electromagnetic forces remove the remaining ions. Another method would be to introduce a neutral gas; the chance that ions will take electrons from the gas varies according to the element, so this method could also be used for separation. The introduced gas would become ionized and could be led away electrically while the wanted substance collected in the chamber.

Other means of separation, both chemical and physical, are under study, but a good deal of work remains before it is known whether they will be both effective and economical.

In addition to vaporizing solids, plasma torches could also be used to heat liquids. A gas that radiates ultraviolet light when it is energetically excited would be introduced into the interaction chamber of the fusion torch. The gas would take energy from the plasma and reradiate it as ultraviolet.

Ultraviolet light at 1,850 angstroms wavelength will penetrate to a meter's depth in water, and thus presents a means for quickly delivering heat throughout the bulk of a small tank or the whole diameter of a meter-wide pipe. Present methods of heating water transfer heat from a hot surface to the surface of the water and depend on convection to spread the heat through the water. Sterilization of liquid sewage and desalination of seawater are two applications suggested by Drs. Eastlund and Gough.

The fusion torch is not likely to be burning garbage very soon. Dr. Eastlund stresses that it will take "a tremendous amount of effort to make it go." For handling solid wastes, he says, a fusion torch would have to be attached to a working reactor, and that will not be "for quite a number of years." For the short term, reduction of selected materials with non-self-sustaining plasmas may be possible. □