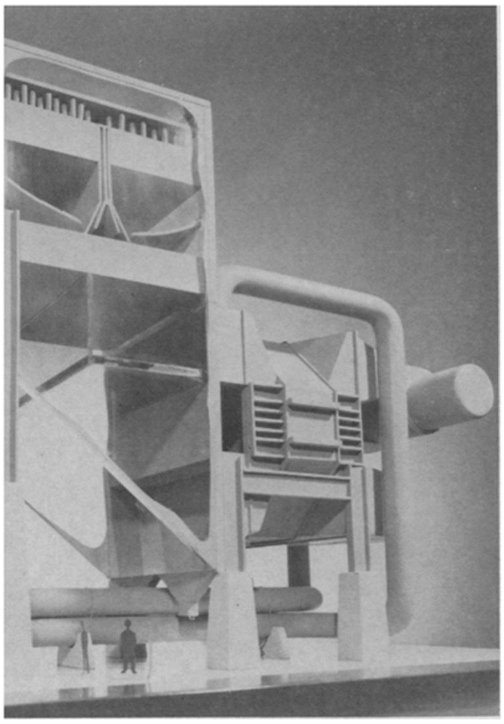


Marc Cohen

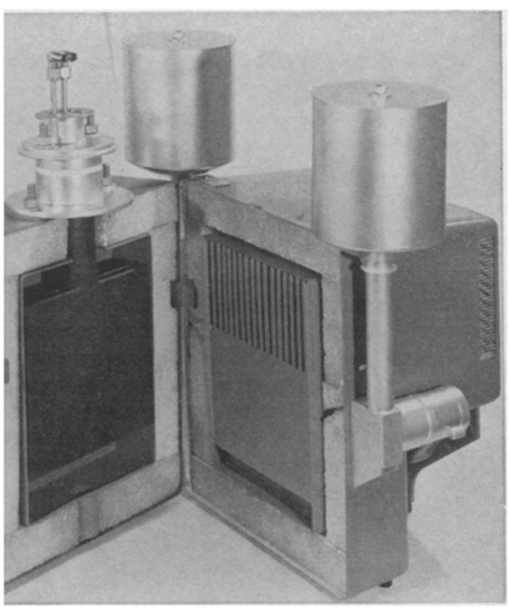
Generator and furnace replace boiler.

Thermionic topping: A stopgap power source

Thermionic emission added to existing power plants may be an interim answer to the growing demand for electricity

by Edward Gross

Cassano: "It's not pie in the sky."



Marc Cohen

Pilot model: Endurance is a problem.

Thermionic topping is a process in which the burning of fossil fuel, mainly coal, produces hot gases which heat a large, metal surface, boiling off electrons. They strike a cooler collecting surface, where they are tapped off as direct current electricity. The extra heat goes into generating steam to produce more electricity.

The underlying principle is not new. Called the Edison Effect, it has been around since 1883, when Thomas Edison described it as an effect of heating a wire filament. It led to the development of the vacuum tube.

Aside from electronics, very little was done with it; its engineering potential languished until 1957, when Dr. V. C. Wilson of the General Electric Co., found he could increase the efficiency by placing cesium gas between the emitter and collector. The cesium neutralized the charge on the collector, enhancing electron flow. After that, engineers took it seriously.

They had to.

The United States consumes yearly 1.2 million million kilowatt-hours of electricity. Ten years ago, the figure was about half that: 569,000 million kilowatt-hours.

To meet the growing demand for electricity, various solutions have been proposed. They range from the most obvious, that of building more conventional and nuclear power plants, to the more radical, such as nuclear fusion (SN: 4/11, p. 373) and magnetohydrodynamics (SN: 2/14, p. 172), where ionized gas in a magnetic field induces a current.

However, controlled fusion is still a long way down the road and MHD is plagued with materials problems. The need for some technologically more feasible, if interim, solution is becoming apparent.

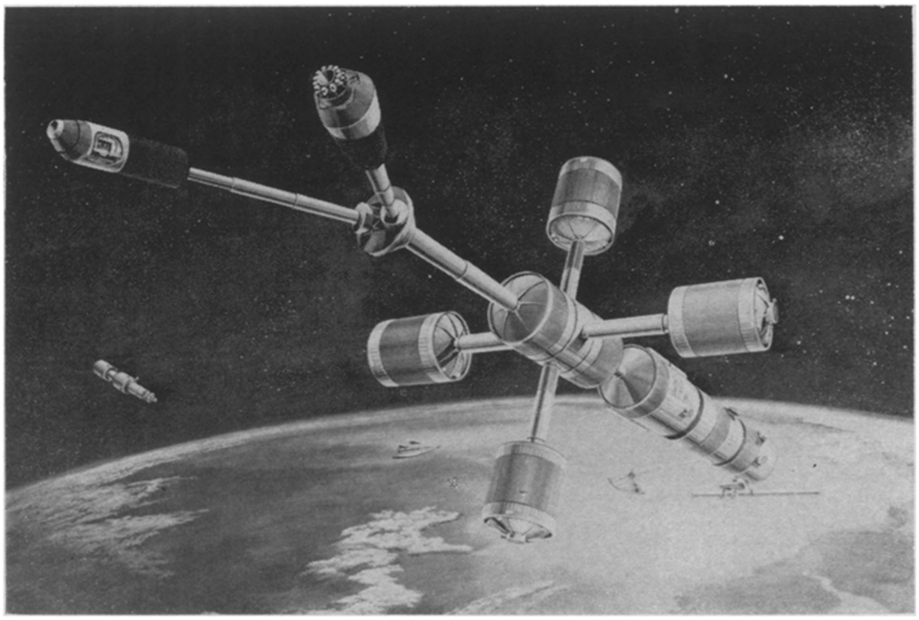
Although thermionic topping will not have the tremendous output of fusion reactors and MHD, it is closer to commercial reality. The Federal budget willing, it could be producing electricity to alleviate the current short supply in a decade.

"We think that the thermionic technology is fairly well established," says Anthony J. Cassano, program manager at Energy Research Corp., Bethel, Conn. "It looks like such a realistic approach. It's not pie in the sky."

One factor that adds to its attractiveness is that it can fit into present-day power plants, where it could be added (topped) before the turbine stage with relatively little trouble. All that need be done is to take out the boiler and replace it with a thermionic generator and a furnace that permits heat exchange between the hot gases and water for steam generation. Since the electricity produced is DC one other small addition is needed: an acyclic motor, which operates on DC and drives a generator to produce AC electricity.

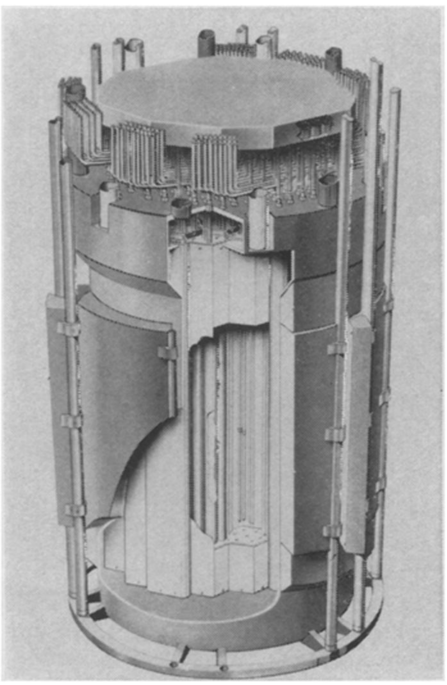
Thus, two options are offered by thermionic topping: Either a new coal-fired plant could be built or an existing one renovated. A theoretical study described in a recent report put out by the Department of the Interior's Office of Coal Research shows that if the Tennessee Valley Authority's Bull Run plant near Knoxville had a thermionic topping system, it could up its present power production from 914 megawatts to 1,139 megawatts—nearly a 25 percent gain in efficiency—and at a cost of $141 per kilowatt as compared to $156.

In addition, the system's greater effi-



GE

Manned space station application: 100 kilowatts sometime in the 1980's.



GE

Thermionic reactor: Nuclear use too.

ciency helps reduce air pollution because less coal need be burned per kilowatt of electricity. Thermal pollution—one of the problems with nuclear power plants—is also reduced since most of the waste heat goes into steam generation. In a general topping system, the combustion gases would hit 3,100 degrees F. and heat the emitter to 2,750 degrees F. The extra heat from the collector goes into steam generation at 1,000 degrees F.

But more than just theoretical calculations have been done. Working laboratory models have been built and tested. Although not impressively powerful—133 watts was the maximum power output—the object of the tests was not power but lifetime. Obviously, how long a thermionic unit can stand up is a critical factor in success. In a coal-fired environment, a thermionic converter ran for 85 hours. This is still far short of the estimated 160,000-hour lifetime considered desirable by Interior and points up the chief obstacle facing the devices: materials problems.

A major step toward alleviating the situation was taken when Energy Research engineers found a way to prevent corrosion of the heart of the system, the diode, which is the source of the electrons. Oddly enough, corrosion occurred at the cool end rather than at the hot end of the cylindrical converter. What happened was that the protective ceramic envelope to protect the diode failed, and corrosive hydrogen gas was getting through. By keeping the same silicon carbide ceramic envelope but changing its processing and fabrication, the ceramic was made to maintain its structural integrity and also function properly when it expanded around the diode.

However, this does not mean an end to materials problems. Failures still occur at the hot end, and much work remains to be done in coating development. Without the severe conditions encountered in a power plant situation, life for the converters would be much simpler.

Although the technology has demonstrated its feasibility, success is not just around the corner and it will still be awhile before it is producing commercial power, unless the Government lends a hand. The alternative would be for industry to foot the bill.

"There's a heck of a lot of work to be done," comments George Staber of the Office of Coal Research. "Another 10 or 15 years of work unless large sums are spent."

And the way things are going now, large sums are unlikely. To date, the Interior Department has spent only $242,000 on the project, with no funds having been allocated for it in this year's budget.

Still optimistic, Cassano estimates that thermionics could be at work in a one-megawatt pilot plant in three years at a minimum. The step after that would be to a 100-megawatt power plant.

The Atomic Energy Commission is also looking at thermionic power but from a nuclear standpoint. The principle is the same but instead of coal, nuclear fuel would supply the heat. The AEC's plans are way down the line. The earliest date seen for plant construction is roughly the end of the century. An important thermionic reactor experiment is planned for sometime in the 1970's, when a reactor prototype will be built and tested.

The AEC has spent $35.7 million on nuclear thermionic work and has put down $4.5 million for it in its fiscal 1971 budget. Almost none of the work is for direct commercial application, however. In fact, the first application for a thermionic reactor is expected to be in the United States space program, where it would supply power for an orbiting manned space base. The National Aeronautics and Space Administration has plans for a 100-kilowatt reactor for such a project in the 1980's. General Electric is doing the work on the project and on some additional ones more down to earth—and under the sea.

These include using thermionic reactors as sources of transportable power in land areas remote from conventional sources. The reactors would be housed underground while the water cooling system would be on the surface. It is expected that such a plant could run practically unattended for two years without refueling. It could be used for construction work in isolated regions or scientific and exploratory research.

GE also has conceptual designs for nuclear thermionic reactor power plants that would be used in undersea habitats for oceanographic studies, oil exploration work and ocean bottom mining.

Success will depend on economics, which will determine the financial attractiveness of using nuclear thermionic power in such applications. At present, the whole area is in the development stage, sums up James E. Gingrich, manager of applications engineering at GE's Pleasanton, Calif., branch. He adds, however, "This is one of the prime candidates for future power generation." □