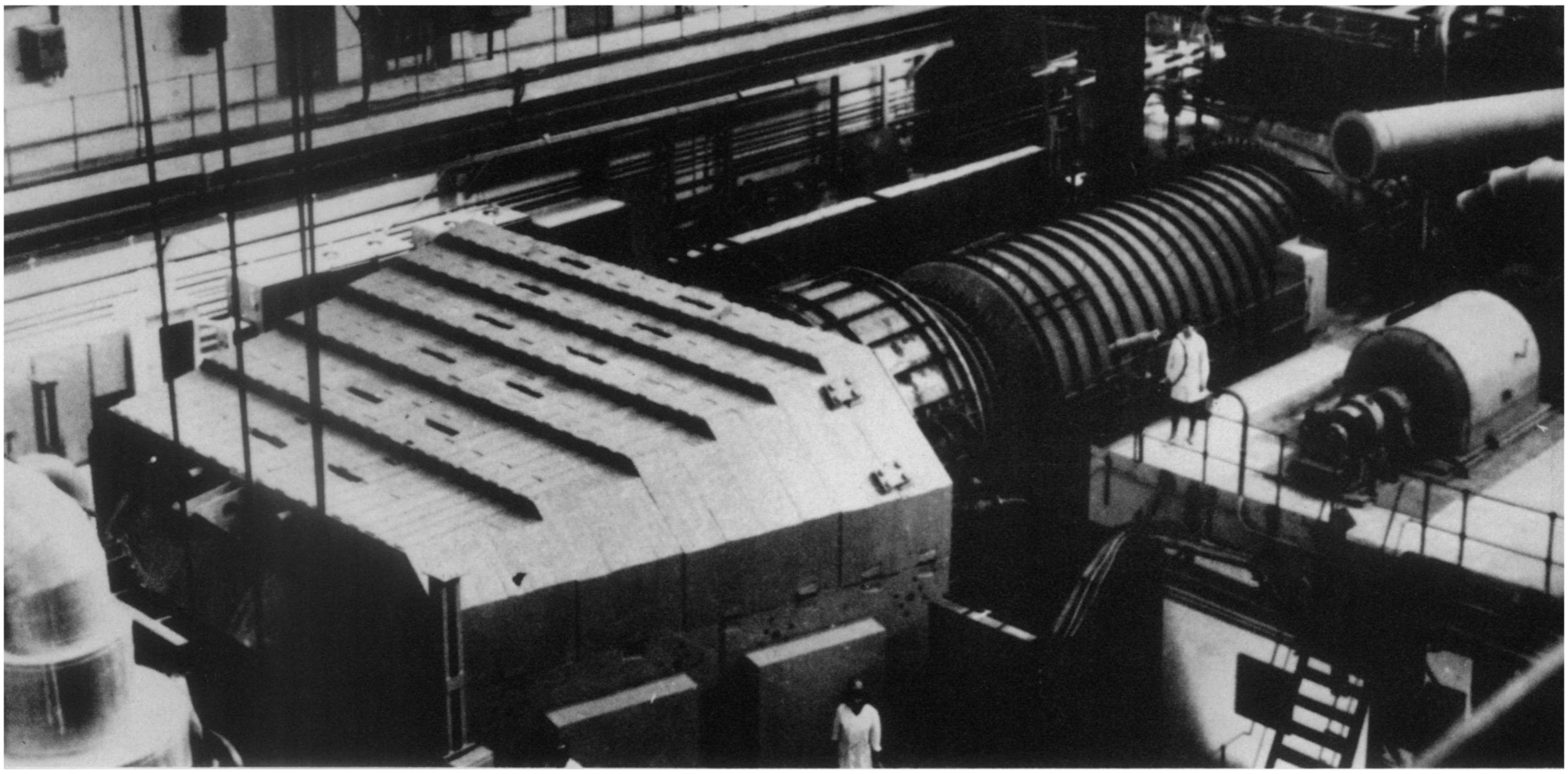


*The MHD generator in the U-25 plant outside Moscow is designed to deliver 25 megawatts of electricity.*

# MHD: High promise, unsolved problems

## Generating electricity directly from hot conducting gases appears to offer a more efficient way to use fuel reserves if problems of funding and technology can be solved

by Dietrick E. Thomsen

"The power station of the future is working," read a headline in Pravda on Dec. 23, 1971. The reference was to a 25-megawatt plant called U-25 that generates electricity through the magnetohydrodynamic (MHD) interaction of a very hot gas. MHD promises to provide power from fossil fuels with less pollution and greater efficiency than conventional steam plants.

Nothing comparable to U-25 exists in the United States, and yet, ironically the Russian program in MHD power generation was heavily stimulated by a 1964 visit to the United States by V. A. Kirillin, now deputy chairman of the U.S.S.R. Council of Ministers and chairman of the State Committee for Science and Technology. More recently Edward E. David Jr., science adviser to the President of the United States, led a delegation to visit the Soviet Union in July as part of the implementation of recent agreements on scientific and technological cooperation. Power is one of the main areas selected for cooperation, and one of the things the David group was interested in seeing was what the Russians have done with MHD in the eight years since Kirillin came to see what the Americans were doing.

*This is another in a continuing series of articles this year examining the potential of new energy technologies. Previous articles have considered thermonuclear fusion (SN: 1/8/72, p. 28), solar-energy conversion (4/8/72, p. 237), and hydrogen engines and fuel cells (7/15/72).*

In principle MHD power generation is simple. The idea is to replace the metal elements that conventional generators use to produce a current with hot electrically conducting gases. In an ordinary generator, metal armatures are moved through a magnetic field by rotation of the shaft on which they are mounted. The motion of the conducting metal through the field causes the electric charges within it (its conduction electrons) to begin flowing as a current. In an MHD generator the metal armatures are replaced by a very hot conducting gas. The motion of this gas across a magnetic field causes its charges to form a current, and the current is collected by electrodes at the sides of the chamber in which the current is made.

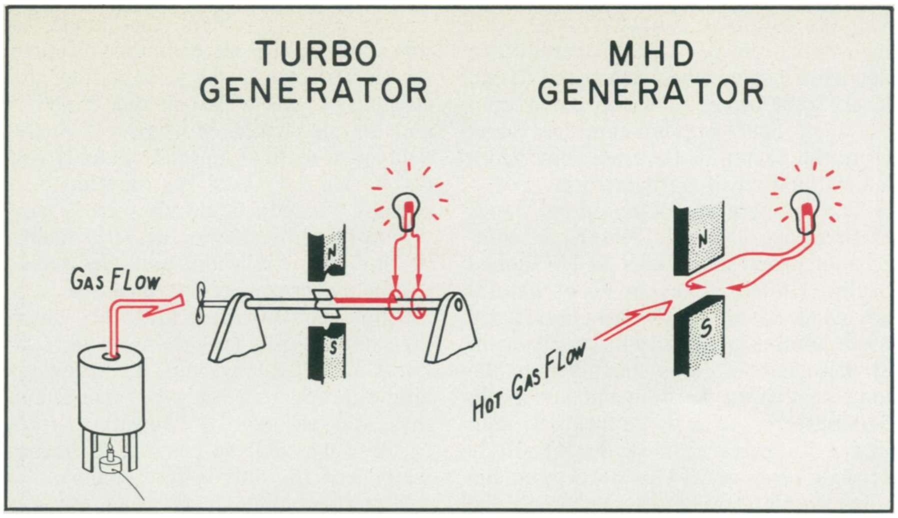
Arthur Kantrowitz, director of the AVCO Everett Research Laboratory in Everett, Mass., describes an MHD generator as "a rocket engine firing into a magnet." The MHD generator omits two energy-losing parts of the conventional cycle: making steam and turning a turbine. Conventional plants get efficiencies around 40 percent; 50 to 60 percent is expected from MHD, especially in an MHD-steam combination where the hot gas is used to make steam for a conventional turbine after it leaves the MHD chamber.

The rocket engine gives an important clue to the history of MHD generation. Although the principle has been known for a century, the gas temperatures required for anything like efficient operation of such a generator had to wait for the development of the kind of technology that produced rocket engines. MHD became a laboratory possibility in the early 1960's. By 1964 AVCO was working on some MHD generators for the Department of Defense. The work was classified. Western scientists were organizing a Pugwash conference that year, and they wanted Kirillin to come. Kirillin said he would if he could see the MHD work that was going on. The work was obligingly declassified, and Kirillin and a group of Russians saw it. They were quite impressed, so much so, says Kantrowitz, that one of them took a penknife to a steel beam to make sure that the thing was real and that they weren't being shown a Potëmkin village.

In 1965, encouraged by their success so far, AVCO and other interested firms got together with the Government and suggested that if they could raise $13 million in private funds for further MHD research, the Government would match the amount. But when the private pledges had been received, the Government had lost interest. It was, says an AVCO spokesman, the "death knell." Only a little work was done in the United States during the next five years.

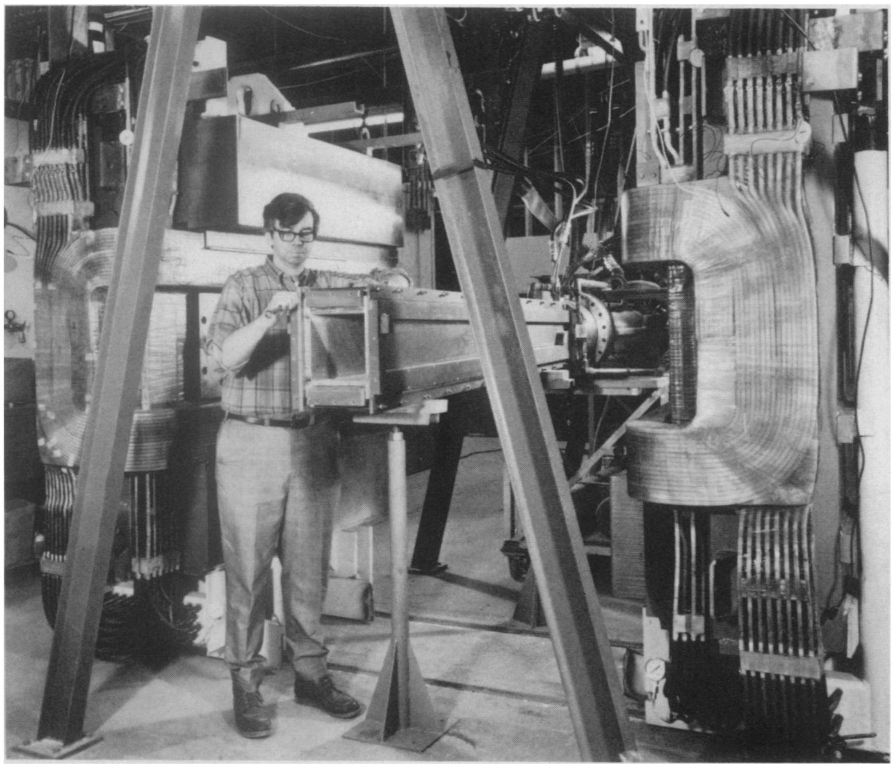
The reasons for the lack of interest seem to be that fission reactors, especially breeders, were generally regarded as the power plant of the future in the United States during those years. But gradually it became clear that fission reactors were not doing as well as expected. Public opposition to their construction and public fear of breeders increased. Meanwhile there remain large supplies of fossil fuels, which could be used to help ease the fuel crisis if more efficient and less polluting means of employing them than conventional boilers were available. For all these reasons and possibly more another look was taken at MHD in 1969.

That year the White House Office of Science and Technology impaneled a committee under the chairmanship of Louis H. Roddis, chairman of the board of Consolidated Edison of New York, to survey the whole energy situation. Considering MHD, the committee determined that its greater efficiency could effect a saving of $11 billion in fuel costs over a 15-year period. The committee recommended spending $2 million a year on MHD research.




*Traditional generator with metal armatures is compared to MHD system.*

Kantrowitz refers to the $2 million recommendation as "a colossal non sequitur." He estimates that in the years since 1964 the Russians have spent 10 times as much as the United States on MHD. An AVCO scientist who visited the Soviet establishments last December, William D. Jackson, estimates that matching the current Soviet effort would cost $50 million to $60 million per year in the United States. The dollar equivalent of the U-25 installation including ancillary equipment is probably between $100 million and $150 million, he figures.



AVCO Everett Research Laboratory

*AVCO Everett's half-megawatt Mark VI is designed for long-duration tests.*

Nevertheless there has been further motion in the United States. The Roddis report led to a study by the MHD Power Generation Study Group of Massachusetts Institute of Technology, which recommends a decade-long program of research and development aimed at showing whether a 1,500-megawatt MHD power plant burning coal with an efficiency of 50 percent and a lifetime comparable to that of a conventional power plant is feasible. (To demonstrate feasibility the program envisions actually building a 300-megawatt plant which would be operated under conditions of time and load that would simulate a 1,500-megawatt plant.) Total cost of the program is estimated at $107 million, with $18 million spent in the first three years.

So far the plan remains a plan, but the budget for MHD research of the Department of Interior's Office of Coal Research is rising. It was $600,000 in fiscal 1971 and $1 million in fiscal 1972. For fiscal 1973 Congress has made it $3.5 million.

How important is MHD regarded by the physics community? The new report of the Physics Survey Committee of the National Academy of Sciences lists MHD 11th of 69 program elements in a rating system it developed to assess the extrinsic merit of areas of physics. MHD was rated especially high in the categories "ripeness for exploration," "potential contribution to technology" and "potential contributions to societal goals." Controlled fusion was the only energy technology rated higher.

Even if money for MHD comes in abundantly, there are still many major problems to be surmounted on the way to the 1,500-megawatt plant. Even though the Russians have the U-25, they have by no means solved all the problems, in the opinion of Americans who have observed their operations.

The OST visitors in July came away with the impression that U-25's operation to date is at power levels below the design level. Some of the problems come from the high operating temperature; some from the nature of the fuel, some from a combination of both factors.

The temperature of operation needs to be above 2,600 degrees K. If combustion gases (from coal as envisioned in the United States or from natural gas as done in the Soviet Union) are used, combustors that will supply them at these temperatures steadily over the long term must be designed and built. Combustors are a large priority item in the first three years of the MIT study group's program. (The only thing besides combustion gases that might be used would be exhaust from a thermonuclear fusion reactor, and they don't exist yet. Gases from fission reactors are not hot enough.)

The heat provides a very severe environment for the solid materials used in the generators. Getting rid of the moving parts helps some: Gas turbines, for instance, could not work at these temperatures because thermal effects would foul up the clearances between moving and stationary parts. But there still remain difficult problems of compatibility at the interfaces of different materials.

The major problem that must be solved to ensure an economic lifetime for an MHD generator is corrosion and erosion of the walls of the chamber and the electrodes. Most people in the field seem to think special coatings will do it. Lately AVCO has developed a process whereby liquid zirconia is continuously sprayed into the MHD chamber to coat the walls and electrodes. Company engineers have an experimental machine called Mark VI which they intend for a long-duration test: 20 hours at half a megawatt. The previous long-duration test, an AVCO spokesman says, was at only 10 kilowatts. AVCO's Mark V was able to produce 30 megawatts, but for only a few seconds.

Use of coal gases for fuel requires development of ways to remove sludge from the MHD chamber. Natural gas is cleaner, but the United States has a shortage of natural gas and an abundance of coal. Whatever the fuel, a number of things must be processed out of the gas after it leaves the MHD chamber. First and foremost is the seed material that has to be added to increase the electrical conductivity of the fuel gas. This material will most likely be potassium dioxide. It is so expensive that it must be recovered and recycled for economic operation of the generator. Getting back the seed will provide an antipollution bonus: It will require the installation of very efficient electrostatic precipitators. Precipitators are not necessary to the operation of conventional plants, and there are many complaints that power companies are sluggish about putting them on.

As in all cases where coal is burnt, nitrogen oxides and sulfur oxides will be produced and must be dealt with. Proponents of MHD believe that, in part due to the higher operating temperatures, methods for removing these pollutants can be developed that will be more effective than those used on conventional plants. The high temperature also means less thermal pollution: The higher the operating temperature the less heat the system rejects into the atmosphere.

All in all the proponents of MHD are poised and ready. (The MIT study group found 26 institutions, private, nonprofit and public and 200 professionals plus supporting staff that could be brought in at the beginning of a national program.) They are hoping that current interest and the information exchanges with the Soviets may lead to a takeoff for the American program. But, says an AVCO spokesman, "We're still waiting; it hasn't happened yet." □

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# McGovern's science pie: Any new plums?

## McGovern and Nixon both want more relevant research but differ on what to sacrifice

by Louise A. Purrett

Every four years the tribal councils of the United States undergo a major upheaval, and those who are not actively promoting one potential chief over another are wondering just how a change in government will affect them, if at all. Though scientists as a group are historically aloof from such worldly matters, they have recently become a much more vocal group and often take definite stands on political issues. And indeed, since a large proportion of the money for research in this country does come from the Federal Government they have a very real interest in the outcome of the elections.

The problem is to sift through the masses of verbiage and isolate just what each candidate advocates on a given issue, let alone what he'll do when he gets in office.

President Nixon's science policies have been before the public for four years. It is easier to figure out his policies simply because they have taken the form of concrete actions or nonactions. He has, for example, created a new agency to oversee research in oceans and atmospheres and has increased funding for several areas of applied research. Ft. Detrick, formerly devoted to biological warfare is now in the hands of cancer researchers, and an intensified anticancer effort has been launched. Defense research is as big a giant as ever. In March Nixon sent the first message by a President to the Congress on R&D. Its emphasis was on applying research to society's needs.

> *"Science is slowly dying in this country."*
>
> —Palevsky

McGovern is another matter. He has had less chance to influence science funding and operations, so observers must rely more on what he says. As yet no coherent, official "McGovern Science Policy" has been released. A high-powered group called Scientists for McGovern is in the process of preparing position papers on nine subjects that McGovern's staff thinks are most likely to arise in the course of the campaign: space, energy, environmental control and protection, strategic weapons, conversion to a peacetime economy, employment, transportation, housing and technological institutions (a study of how we fund science and technology).

Scientists for McGovern was formed about six months ago and is headed by Harry Palevsky, a physicist at Brookhaven National Laboratory and Herbert York of the University of California at San Diego. The organization's list of sponsors includes six Nobel laureates and, claims Palevsky, "all the people in physics that count." Palevsky