with the sulfur pollutants in the coal. The university is developing the technology to also separate the seed from the resultant slag so it can be recycled.

Avco Everett Research Labs in Massachusetts recently obtained a 15 percent enthalpy extraction rate on their Mark V Test generator. This is the highest rate obtained by any test generator. A 20-25 percent extraction rate, correspinding to a 50-plus percent efficiency for thermal power plants, is the standard set for commercial MHD power generation. Avco also reported results of studies of their Mark VI machine which were mapped to computer models they had developed, with satisfactory results.

In addition work-in-progress was discussed, including that on gaseous or plasma electrodes that Reynolds Metal Company has been developing. The second joint US-USSR electrode system test was done at the U-02 Soviet test facility with the least deterioration being exhibited by electrodes manufactured by Westinghouse and Batelle Northwest Labs. These are made of alloys containing lanthanum, iron oxides and magnesium and were tested at 2,600 degrees.

One of the most interesting experimental areas is the use of CO_2, helium and cesium to produce a carbon dioxide laser in the MHD channel itself. CO_2 lasers can be used for isotope separation and, if powerful enough, to trigger thermonuclear reactions. L.M. Biberman and others at the High Temperature Institute in Moscow have been working on this idea for the last seven years and reported at the symposium that an MHD laser had been produced at the Institute with an experimental output of 10MW of laser radiation. In this experimental design, the laser and energy source (the MHD electric power generation) are joined together in a single device.

How The Soviets Sputniked The U.S. In MHD

In 1962, at the First International Conference on MHD in England, two prominent Soviet scientists announced that the USSR had embarked on a program to develop commerical MHD. A.E. Sheindlin, the head of the Soviet Institute of High Temperatures, outlined a four-phase program which would bring the Soviets to commercial demonstration by the early 1980s. Academician E.P. Velikhov, the deputy director of the Kurchatov Institute of Atomic Energy and one of the most renowned plasma physicists in the Soviet Union, presented some fundamental analysis of the thermodynamic and electromagnetic instabilities which could be expected under certain conditions in MHD plasmas. Both presentations have since been dramatically realized.

Soviet scientists' initial interest in MHD was for direct conversion of fusion energy to electricity, and the MHD work at the Kurchatov Institute has continued to focus on thermonuclear energy as the source of heat for an MHD generator. The Institute of High Temperature's MHD program has had the parallel goal of demonstrating commerical feasibility of MHD using fossil fuel as the heat source. This latter program, now nearing the successful completion of its third phase, will bring a 1,000 megawatt commercial demonstration plant on line by 1982. It will be the only such plant in the world.

It should not be surprising to U.S. scientists and military intelligence personnel that the Soviets may also have developed an MHD generator fueled by pulsed fusion explosions, nor will such persons be unaware of the possible military implications. The operation of an anti-ballistic-missile particle beam would require a tremendous source of pulsed energy, invulnerable to attack and independent from commercial power grids. Since only thermonuclear explosions could satisfy those requirements and still provide the magnitude of energy needed, it would be necessary to develop a controlled way of converting that energy to electricity. It appears that the Soviets have effectively solved that problem.

In the case of fusion-based MHD, the Soviet Union had undoubtedly pursued both military and commercial applications simultaneously. Likewise, the unique success of the Soviets' fossil-fuel-based program demonstrates their commitment to carry through a 20-year scientific and technical perspective. Furthermore, it should be crystal clear — especially since it has been said directly by Velikhov and others — that it is the Soviets' theoretical understanding of plasma behavior that is the basis on which all of their MHD work, both nuclear and fossil fuel, has been done. This is incomprehensible to many scientists in the United States only because U.S. work on MHD has never been done on such a rigorous scientific basis.

Originally the West was actually ahead of the Soviets in MHD. The U.S. MHD fossil fuel program was initiated by a handful of corporations, as early as prior to World War II. Researchers at Westinghouse, General Electric, and Avco Corporation began by experimenting with small generators, but by the mid-1960s only a government-supported program could have scaled up the experiments and solved the problems associated with a commercial program. The U.S. government chose to fund MHD research only in military and space applications, and the commercial generating designs were scrapped. These noncommerical applications, aiming for a short burst of energy for space propulsion or weapons and radar pulses, did not pose the problems involved in generating electricity for long durations that would have to be solved for utility use of MHD. As a result, when the Soviet Union announced in 1971 that their phase three pilot plant, the U-25, was now running, the United States was left on the short end of the technology gap.