RESEARCH IN MHD POWER GENERATION

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INTRODUCTION

This program is directed toward the development of non-thermal and metastable ionization for closed cycle MHD electrical power generation systems with either metal vapors or seeded gases for naval applications. The program shall first, demonstrate non-thermal and metastable ionization, and second, generate actual power with such ionization. The cognizant scientist for ONR is Mr. Jack Satkowski, Power Branch, and for ARPA is Dr. John Huth.

Experiments on non-thermal ionization are being conducted in the 2"x2" shock tube and the argon-barium diode. Power generation is being conducted in the shock tube.

SHOCK TUBE STUDIES

The major progress made during the last quarter was the verification of magnetically induced ionization by means of the cinespectrograph, the calibration of the conductivity probe and the initiation of low temperature experiments in Neon-Argon mixtures. In addition a study was initiated to determine the effect of the Lorentz body force on magnetically induced ionization.

The spectrograph is an instrument which is capable of measuring the electron temperature and density. This is due to the dependence of atomic line radiation on the electron temperature. Therefore, by observing the variation of the emitted spectra inside the MHD generator as a function of the magnetic field one can observe qualitatively the increase of electron concentration due to magnetically induced ionization. A series of experiments in Xenon at 8000°K showed a dramatic increase in the luminosity of both the continuum and line spectra as the magnetic field was increased from 0 to 20,000 gauss. This was an independent verification of magnetically induced ionization.

As reported in the last quarterly report, the conductivity measured downstream of the MHD generator increased as the square of the magnetic field. It was necessary to calibrate the conductivity probe to obtain a quantitative measurement of the conductivity rise in order to establish if the peak conductivity obtained was higher than the equilibrium conductivity at the gas temperature. The need for this calibration is that in Xenon shocks there exists a "delayed ionization" effect which results in a lower conductivity than the thermodynamic equilibrium value; hence it is not possible to calibrate the probe against the calculated equilibrium electrical conductivity. The conductivity coil was calibrated by means of an aluminum rod of known conductivity. It was verified that the measured initial gas conductivity at zero magnetic field was 200 mhos/meter, as compared to the calculated equilibrium value of 600 mhos/m at the gas temperature. However, at 5000°K and 11,000 gauss the measured electrical conductivity was 1100 mhos/meter. One can therefore conclude that initially the magnetic field raises the conductivity to the equilibrium value and that only at higher magnetic field strengths does one obtain non-equilibrium ionization.

It has been pointed out in previous reports that a Neon-Argon mixture might be an attractive gas to utilize for magnetically induced ionization because of the metastable ionization effect. This effect works only in a non-equilibrium gas. Hence the gas must be externally preionized. To determine the feasibility of this method shock tube studies were initiated in Neon-Argon. The gas temperature calculated from the measured shock velocity was 1000°K (similar to an actual MHD generator). It was observed that preionization with a hot cathode was possible and that the data was very reproducible. Work is now in progress to use this mixture in an MHD generator.

One unresolved question was the effect of the Lorentz body force on the gas flow. This force can produce either shock or compression waves which might thermally ionize the gas. Although no ionization effect was observed due to the Lorentz force it was still necessary to determine if any shocks existed in the MHD channel. It was decided that if the open circuit induced Faraday voltage, UB, were measured at various points in the channel the presence of shocks could be detected. Xenon was again chosen as the test gas. The experiments are now in progress and to date no Lorentz force induced shocks have been detected.

In the next quarter it is planned to finish the Lorentz force work and the Neon-Argon work. In addition a gas purity program will be initiated using a mass spectrometer and the cinespectrograph. Work on the modified test section and 50,000 gauss magnet will be completed.

BARIUM DIODE STUDIES

Several more determinations of the conductivity of a saturated barium vapor have been carried out. Attempts to observe the emission of various barium atom lines have been made with the intent of obtaining atom temperatures as a function of the electric field. Preliminary work has begun on the preparation of the final report.