# RESEARCH PROGRAM ON CLOSED-CYCLE MAGNETOPLASMADYNAMIC ELECTRICAL POWER GENERATION WITH NON-EQUILIBRIUM IONIZATION

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## 1. Introduction

The objectives of this program are to experimentally demonstrate the principle of non-equilibrium ionization under actual closed-cycle magnetoplasmadynamic generator operation conditions, to verify the basic phenomena underlying the behavior of moving ionized gases in the non-equilibrium state when interacting with a magnetic field by correlation of the experimental results with the theory of non-equilibrium ionization and to investigate the potential performance of the MPD power generator with non-equilibrium ionization in closed-cycle systems having a reactor heat source.

To bring about these objectives a closed-cycle MPD electrical power generator research loop has been fabricated and erected, a theory of the MPD generator with non-equilibrium ionization has been developed and is being correlated with experiments on cesium-seeded helium discharge tubes and the performance of the closed loop MPD electrical power generator with non-equilibrium ionization is being investigated with respect to the feasible duct and loop arrangements.

## 2. Closed Loop for MPD Electrical Power Generation Experiments

During the past quarterly period the fabrication and installation of the closed loop for MPD electrical power generation experiments have been completed. The checkout, purging, and outgassing of the entire loop assembly is being carried out, first at low temperature using a low temperature duct assembly consisting of a flow resistance to simulate the pressure drop through the heater, a low temperature nozzle for Mach number 0.3-0.56, a duct 3/8" x 1 1/8" x 2 5/8" (with four pairs of electrodes) and an exhaust section for connection to the cooler. The low temperature duct is capable of operation at temperatures around 800°K.

## 3. Non-Equilibrium Ionization Studies

More cesium-seeded helium discharge tubes with hot electrodes have been fabricated and tested. The helium number density used in the experiments was $n_g = 1.61 \times 10^{24}$ atoms per cubic meter and the cesium number density could be varied by controlling the liquid cesium temperature (the maximum cesium seed number density used in the experiments is $n_{so} = 8.18 \times 10^{21}$ atoms per cubic meter). The experimental results have been correlated with the theory on non-equilibrium ionization and the comparison between test and calculations was presented at the 4th Symposium on the Engineering Aspects of MHD, in Berkeley, California, April 11, 1963*.

## 4. Closed Loop MPD Generator Studies

Three different solutions of the equations governing the behavior of the ionized gas in the MPD electrical power generator duct with conditions

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* "Comparison Between Test and Calculations of Non-Equilibrium Ionization Conductivities and the Corresponding Electric Fields Required," Paper by M. E. Talaat.

suited to the case of non-equilibrium ionization of the gas have been carried out and will be applied to typical experimental conditions.

5. Plans For Next Period

The checkout of the system using the low temperature duct will be carried out. After the satisfactory completion of the checkout runs the low temperature duct subassembly will then be replaced with the high temperature duct subassembly and the system will be evacuated, outgassed and purged. It will then be charged with the highest purity He available. The impurities will be monitored with a chromatograph, reduced to a minimum, and some runs with non-equilibrium ionization will follow. In addition, correlation of the experimental results with the theory on non-equilibrium ionization are planned and the closed loop MPD generator studies will continue.

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