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EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF AN MGD POWER DUCT

15 July 1964 to 15 August 1964

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During this month the M-4 generator was carefully inspected and any leaks, which had developed during the last set of runs, were eliminated. New thermocouples, pressure probes, and electrical leads were installed where old ones were damaged. Arrangements were made to use an oscillograph to record the data during the next run. Pressure transducers have been specified and are on order; these will replace the manometer bank and yield accurate and reliable data. Arrangements have been made to have a single quadrupole magnetic focus system installed on the electron beam, this should increase the beam output by an order of magnitude. During this time, the general problem of optimizing seed concentrations in non-equilibrium plasmas was studied. Some interesting results were obtained. Where possible, the limiting case of equilibrium was checked with the work of others and found to be in good agreement. The summary and analysis follow:

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THEORETICAL OPTIMUM SEED CONCENTRATIONS IN SLIGHTLY IONIZED NON-EQUILIBRIUM PLASMAS

Summary

An expression is derived for the seed concentration which gives rise to the maximum electrical conductivity in a non-equilibrium plasma. The analysis takes into account both electron-atom and electron-ion collisions, but is strictly valid only when $n_e \ll n_s$. A criterion equation is given, which when followed enables the determination of the optimum seed concentration to be at least 95% accurate. The various species are assumed to possess Maxwellian distributions. Where possible, the results of the limiting equilibrium case are compared with other work and found to be in good agreement. Even in the equilibrium case, the argon-cesium plasma yields much higher conductivities than do other seeded gases or pure alkali metal vapors at the same pressure and temperature. For equilibrium argon-cesium plasmas between 1000°K and 1600°K, and for mole fractions of seed greater than optimum, the conductivity decreases linearly with increasing mole fraction of seed; also a 50% variation in seed mole fraction about the optimum will give rise to no more than a 15% reduction in the electrical conductivity.

Analysis

The total plasma electrical resistivity is given as the sum of con-

tributions due to electron-atom collisions and electron-ion collisions (see Reference 1).

$$\eta_p = \eta_a + \eta_i \qquad (1)$$

Where η_p is the total plasma resistivity, ohm-cm.

η_a is the electron-atom contribution to the plasma resistivity, ohm-cm.

η_i is the electron-ion contribution to the plasma resistivity, ohm-cm.

The resistivity due to electron-atom collisions is given by the hard sphere Maxwellian model (see References 3 and 4):

$$\eta_a = 2.21 \times 10^9 \, T_e^{\frac{1}{2}} \, n_e^{-1} (n_s \, Q_{es} + n_n \, Q_{en}), \text{ ohm-cm} \qquad (2)$$

Where T_e is the average electron temperature, °K.

n_e is the electron density, #/cm^3

n_s is the seed atom density, #/cm^3

n_n is the parent gas neutral atom density, #/cm^3

Q_{es} is the elastic electron collision cross-section for the seed, cm^2

Q_{en} is the elastic electron collision cross-section for the parent gas, cm^2

These calculations are performed with constant electron collision cross-sections for the temperature range 0.1 - 0.3 ev., thus neglecting any