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# GENERATION OF A PLASMA IN A MAGNETIC MIRROR GEOMETRY

by Roman Krawec, George M. Prok, and Clyde C. Swett

Lewis Research Center
Cleveland, Ohio



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# GENERATION OF A PLASMA IN A MAGNETIC MIRROR GEOMETRY

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Lewis Research Center
National Aeronautics and Space Administration
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Experiments on ion-cyclotron-wave generation require plasmas with densities of about $10^{12}$ ions per cubic centimeter or greater. In the Lewis Research Center ion-cyclotron-wave experiment the radio-frequency (RF) power was unable to form such a plasma by itself. It was necessary, therefore, to generate a plasma independently of the RF source. The method discussed herein is an electron-bombardment technique employing a thermally emitting cathode to produce a plasma in a magnetic mirror geometry. A hydrogen plasma, produced in this manner, had ion density of 8.5 $10^{11}$ ions per cubic centimeter at a pressure of 2.2 microns of mercury, measured 90 inches downstream from the cathode. This density is an order of magnitude larger than that obtained with a previous Penning-type discharge used for the same application. In addition, the source met the following objectives: (1) the cathode was located outside the magnetic mirror to provide maximum plasma length for experiments; (2) fabrication and installation were simple; (3) it was reliable, and the cathode had long life under intermittent operating conditions; (4) the plasma column was at least $1\frac{1}{2}$ inches in diameter under the RF coil.

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A longitudinal cross section of the ion-cyclotron-wave experimental apparatus is shown in figure 1.

A steady axial magnetic field having a 2:1 mirror ratio and variable central field strength up to 10,000 gauss is provided by the direct-current coils. A thermally emitting cathode was placed at the left end of the discharge tube and a movable anode at the right end (fig. 1). The cathode [redacted] (fig. 2) is operated at a negative potential with respect to ground, and the anode is grounded. Since the stainless-steel tubing at both ends of the apparatus is grounded, it also acts as an anode. This differs from the usual application where the cathode operates at ground potential (the potential of the surrounding apparatus).

Electrons do not readily cross magnetic field lines, so most of them move in the axial direction and are collected at the movable anode. In this type of discharge the plasma potential is usually close to the anode potential. Hence, when the anode potential is operated above the ground level radial electric fields are created in the plasma which enhance ion diffusion to the walls of the discharge tube. In the present discharge this radial electric field was reduced by operating the anode at ground potential. The order of magnitude increase in ion density, and attendant reduction in wall sputtering indicated the ion wall losses were correspondingly reduced by this method.

Electron density as a function of magnetic field, beam current, pressure, and position of the movable anode was measured with an 8-millimeter-microwave interferometer. Results were relatively insensitive to the axial anode position. The beam appeared to be quite uniform as judged by the distribution of emitted light. Figure 3 shows the effect of magnetic field on the electron density with a beam current of 15 amperes and a pressure of 2.2 microns of mercury. The maximum electron density was reached at a field of 6 kilogauss.

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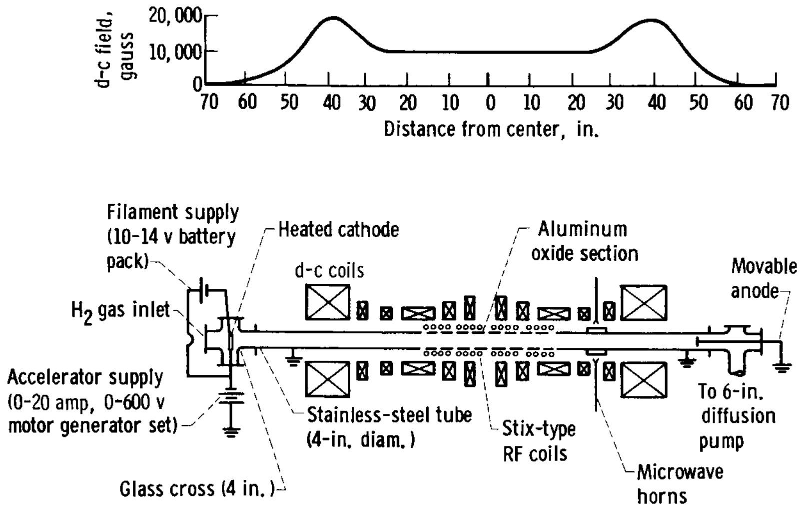


Figure 1. - Schematic of plasma source and ion-cyclotron resonance heating apparatus.

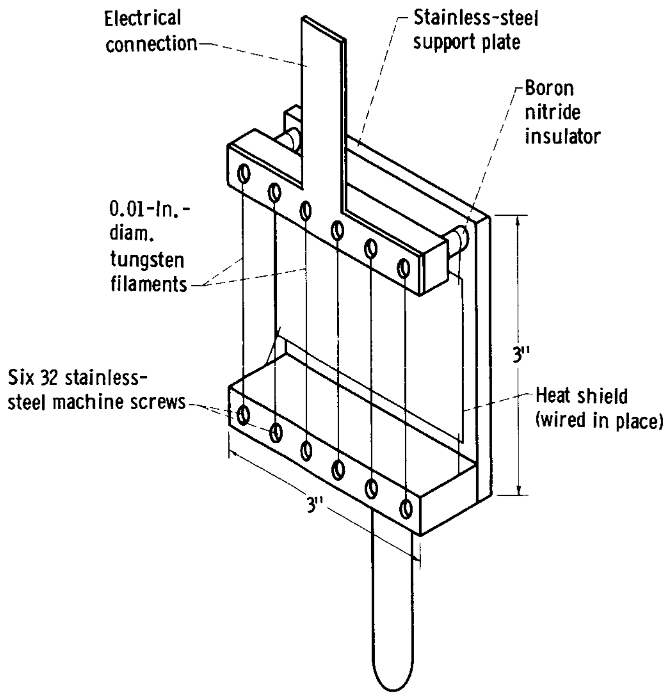


Figure 2. - Diagram of heated cathode.

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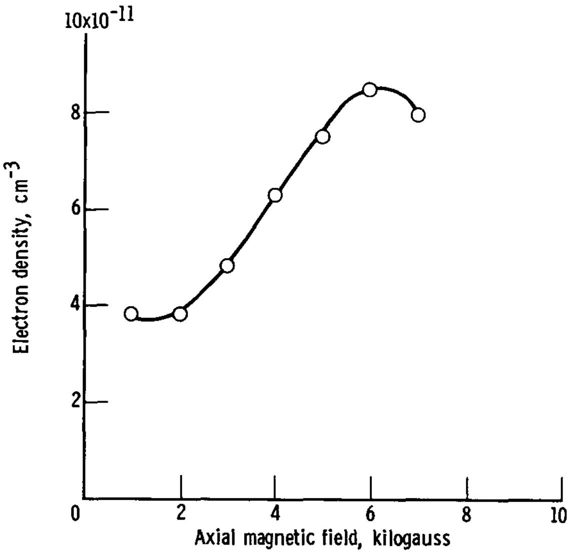


Figure 3. - Electron density as function of magnetic field. Beam current, 15 amperes; pressure, 2.2 microns of mercury.