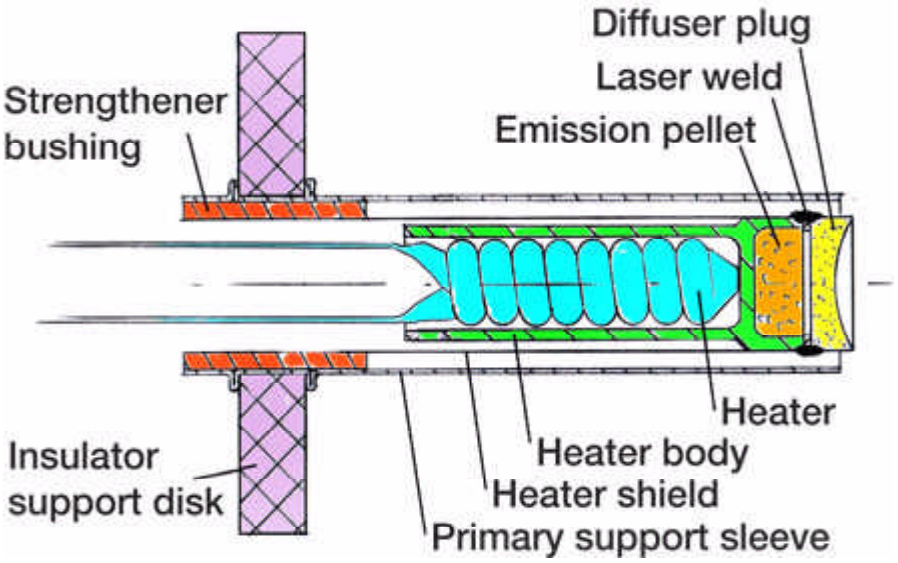
Power-Efficient, High-Current-Density, Long-Life Thermionic Cathode Developed for Microwave Amplifier Applications

A power-efficient, miniature, easily manufactured, reservoir-type barium-dispenser thermionic cathode has been developed that offers the significant advantages of simultaneous high electron-emission current density (>2 A/cm^2) and very long life (>100,000 hr of continuous operation) when compared with the commonly used impregnated-type barium-dispenser cathodes. Important applications of this cathode are a wide variety of microwave and millimeter-wave vacuum electronic devices, where high output power and reliability (long life) are essential. We also expect it to enable the practical development of higher purveyance electron guns for lower voltage and more reliable device operation. The low cathode heater power and reduced size and mass are expected to be particularly beneficial in traveling-wave-tube amplifiers (TWTA's) for space communications, where future NASA mission requirements include smaller onboard spacecraft systems, higher data transmission rates (high frequency and output power) and greater electrical efficiency.

The major life limitation of the impregnated-type barium dispenser cathode results from a limited supply of barium, an uneven rate of barium dispensation over cathode life, and the temperature-driven barium depletion rate, which becomes more rapid at the higher operating temperatures required for higher emission current. In contrast, the reservoir cathode has a constant rate of barium dispensation over the life of the cathode, which is limited only by the amount of barium in the reservoir, hence the capability to sustain high current densities. The capability of simultaneous high current density and very long life is being demonstrated by NASA-owned prototype reservoir cathodes now on life test at the Naval Surface Warfare Center in Crane, Indiana (ref. 1). These cathodes, operating at 2 and 4 A/cm^2, show a continuing unprecedented robust performance and stability after more than 85,000 hr of continuous operation.



Reservoir cathode design.

Long description: Illustration shows the strengthener bushing, insulator support disk, diffuser plug, laser weld, emission pellet, heater, heater body, heater shield, and primary support sleeve.

The reservoir cathode described here is the result of an effort initiated and sponsored by the NASA Glenn Research Center that is now being pursued under a Small Business Innovation Research (SBIR) contract with FDE, Inc. The SBIR objective is the development of a low-cost, easily manufactured, electrical power efficient version of the NASA prototype reservoir cathode now on life test by combining the best features of the prototype with a low-heater-power, thermally efficient impregnated cathode design developed under a previous SBIR contract with FDE, Inc. (ref. 2). Foremost among these features is a thermally and chemically stable electron-emitting surface with a uniformly low work function distribution. The low-cost fabrication is based on manufacturing methods used in the highly efficient cathode ray tube industry.

Although the emphasis has been on small size (0.060 to 0.100 in. diameters) and emission current densities up to 5 A/cm^2, the basic design (shown in the figure on the preceding page) can be readily adapted to significantly larger sizes and higher current densities for both pulse and continuous operation. Glenn is pursuing the development of the reservoir cathode for microwave/millimeter-wave tube applications.

References

1. Tri-Service/NASA Cathode Life Test Facility, Annual Report, Naval Surface Warfare Center, Crane, IN, Jan. 2000--Jan. 2001.

2. Wintucky, Edwin G.: Novel Low-Cost, Low-Power Miniature Thermionic Cathode Developed for Microwave/Millimeter Wave Tube and Cathode Ray Tube

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