L-BAND MAGNETRON IMPROVEMENTS AND FAILURE MECHANISMS

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ABSTRACT

With the ever increasing demand for higher L-Band magnetrons, BURLE has modified the original 30kW device to achieve output levels over 90kW CW. This paper will detail these modifications and resulting performance. A discussion of major magnetron failure mechanisms will also be presented.

INTRODUCTION

In 1972, the RCA Power Tube group (successor company to BURLE Industries, Inc.) began manufacturing 30kW devices to serve the L-Band market (896 & 915 MHz). These magnetrons were designed and built with ten internal anode vanes in a double-ring-strapped anode block configuration. Over the years, the market has challenged RCA/BURLE's technical staff to produce a higher power device with similar operational life and cost. Given the constraints of the existing magnetron body, many subtle and dramatic changes had to be made.

The original 30kW device was modified to achieve 50kW, 60kW, 66kW, and finally 75kW. In the midst of this twenty-five year progression, BURLE introduced another L-Band magnetron capable of at least 90kW CW.

FILAMENT IMPROVEMENTS

The filament structure has been constantly evolving. It is the most complex and difficult component to modify. The BURLE filament is directly heated with helically wound tungsten wire supported at both ends.

With increasing power demands, it was necessary to increase the cathode area. This increased area presented a larger target surface and saw additional back-bombardment. To arrive at the best compromise between additional cathode area and increased back-bombardment, the turns per inch (TPI) of the helically wound tungsten wire was varied. The physical geometry of the wire itself as also changed to produce a higher performance filament. These changes also produced a filament structure that was more rigid, and less subject to sag and fatigue though many thousands of operational hours.

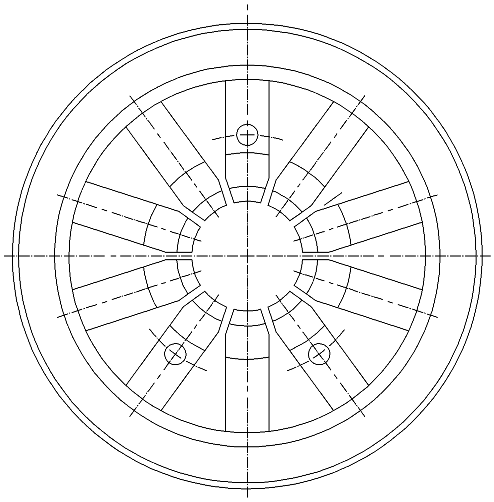
BURLE's technical staff discovered that operation at higher power levels led to cracking of the copper to iron joint on the filament structure. This cracking was the result of additional thermal stress at the joint. The assembly was redesigned (patent pending) and the cracking was eliminated.

ANODE IMPROVEMENTS

The anode is a vane and strap design (Figure 1). With power levels increasing (30 – 90kW), the anode dissipation capabilities rose from 6 to 15kW. This dissipation could only be achieved by increasing the length of the anode.

Another anode change that improved the overall performance of the magnetron was the implementation of a one piece anode. The original design had copper vanes brazed into a cylindrical copper jacket. The current design is made out of a solid copper cylinder. The center is bored out, and the vanes wire cut. Geometric variations in the assembly disappeared. This resulted in more stable operation.

Operation of the magnetron at higher power yielded another problem, voltage hold off. A modification to the internal pole piece on the antenna side of the anode was required. The geometry of this pole piece was changed to increase the linearity of the magnetic field along the axis of the cathode. With a straighter field, voltage hold off problems were eliminated.



Anode Cross-Section
Figure 1

TESTING IMPROVEMENTS

With increasing demands, the number of test facilities at BURLE has more than tripled. L-Band magnetrons can be tested to power levels reaching 150kW. Additional testing facilities have also been implemented for the growing S-Band magnetron product line.

FAILURE MODES

Magnetron failures can be characterized into seven main modes, as presented by George Solomon, BURLE Industries, Inc., International Microwave Power Symposium, 1995. These failure modes are: Broken Dome, Internal Arcing, Pi-1 Mode, End of Life Filament, Filament Overheating, External Arcing, and Manufacturing Defect. The 1995 data showed that the main mode of failure was Internal Arcing. That failure mode has increased as the operational power of the magnetron has increased. The internal arcing evaporates iron and copper within the tube, producing gas and causing tube failures. The most effective way to prevent this phenomena is to add high speed, high voltage protection. Switching power supplies, with low stored energy can switch off the magnetron before any damage occurs.

PLANS

Through computer modeling techniques and an extensive knowledge base, BURLE has been able to respond to the market's demands and produce reliable high power magnetrons. BURLE will continue to expand its product offerings and implement improved design and manufacturing techniques.