

VII. MAGNETRON DEVELOPMENT

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A. HIGH-POWER 10.7 CM MAGNETRON

1. Testing and Design

During the past quarter, no further operation of MF-5 was undertaken as maximum effort was expended in the assembly and processing of MF-6.

A cold test was made on MF-6 after it had been assembled and processed, but before it had been operated. The results of this test gave a loaded Q for the tube of 270, this value agreeing with the Q measured before the tube was sealed up.

The tube was placed in operation following the procedure outlined in the Quarterly Progress Report of April 15, 1949, and again, as with MF-5, a rather rapid break-in period was experienced. The tube was operated for 25 hours before a vacuum leak developed around the ceramic window. Peak power output of 2.5 Mw was limited by arcing in the pressurized waveguide system and not by arcing inside the tube, which was decreasing rapidly with aging.

This arcing external to the tube seemed to occur consistently at a peak power of 2.5 Mw when the waveguide was pressurized to 90 lb/sq. in., regardless of the operating point of the tube. When the tube was removed from the test position, there was evidence of consistent arcing around the window and the tube mounting flange. The elimination of this arcing appears to be a major obstacle in attaining the maximum output for this design of tube.

The maximum operating conditions reached on MF-6 are as follows: plate voltage 42 kv; plate current, 120 amps; magnetic field 2760 gauss; peak power output 2.5 Mw; efficiency 50 per cent. Under these conditions there was very little arcing inside the tube, but even a slight increase in plate voltage would cause a violent arcing in the pressurized waveguide system.

The results of a post-mortem on MF-6 are not available at the time of writing.

In order to decrease the loaded Q, a new design has been made for the quarter-wave section of waveguide which serves as the output transformer of the magnetron. In MF-6, and in all previous tubes, the output transformer design was such that the external Q was about 300 with matched window. The new design is expected to lead to an external Q of 200.

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In order to minimize the effective reactance of the output system, the length of the newly designed transformer section was made slightly less than the theoretical value of $1/4$ guide wavelength to compensate for the shunt capacitance introduced by the discontinuity between the transformer section and the waveguide. The value of the capacitance was calculated, and was checked by an experimental model of the discontinuity. The length of the transformer section was then set at a value which would give a purely resistive impedance at the input of the transformer when the output is a waveguide with matched termination.

An output section incorporating the new transformer design is under construction and will be used in the construction of MF-7.

No further tube construction is planned until the completion of a new type of cathode pipe in which glass is replaced by a ceramic.

2. Thoria Cathodes

An excellent fit has been obtained between the three segments of the split-segment pressing die. Preliminary pressings have been made and show no cracks when the mandrel and pressing sleeves are removed from the die. Considerable difficulty has been encountered, however, in removing the pressing sleeves from the mandrel so that the cathode may be slipped off. This is caused by powder jamming between the mandrel and the pressing sleeve during the pressing operation. Two methods of eliminating this trouble are to be tried. The first is to adjust the tolerance between the pressing sleeve and mandrel and the second is to press the mandrel completely through the pressing sleeves and cathode before they are removed from the die.

3. Auxilliary Equipment

a. 20-Megawatt Pulse Transformer

The 20-megawatt pulse transformer described in the Progress Report of April 15, 1949, has been received, and has been given preliminary tests. An operating test was carried out, in which the transformer was driven by the 20-megawatt modulator operating at 5μ sec. pulse duration, and was loaded with a resistance bank. It was observed that both the current and the voltage pulse on the secondary of the transformer rose rather slowly. However, if only the leakage inductance calculated from the design data is considered to be effective in slowing down the rate of rise, the time constant (L/R) calculated is about 0.6μ sec., which is consistent with the observed results. R-f bridge measurements on the transformer were in

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reasonably good agreement with calculated values for both leakage inductance and shunt capacitance.

The maximum voltage reached in the operating test was 60 kv, as compared with the 80 kv for which the transformer is designed. This voltage limitation was imposed by the inability of the resistance bank to withstand higher voltages.

The filament transformer designed for thoria cathode operation has been received but has not yet been tested.

b. New Vacuum System

Initial progress on the new magnetron vacuum system capable of baking the tube at about 600°C and pumping the magnetron while it is operating was reported in the last progress report. All components except the 3500-gauss magnet have been installed and tested. The pumping system, composed of a Welch Duo-Seal forepump and a three-stage fractionating oil diffusion pump with a copper pumping lead, has attained pressures less than 10^{-7} mm of mercury.

B. MAGNETRON RESEARCH

1. Mode Stability

A magnetron, the 718EY, has been chosen for use in an investigation of interaction between magnetron modes. It was chosen because both the $n = 4$ (π -mode) and the $n = 3$ mode lie within the frequency range of conventional S-band test apparatus. It is hoped that it will be possible to determine to what extent simple non-linear oscillator theory can be applied to magnetron mode stability.

2. Noise Properties of the Pre-Oscillating Magnetron

Since the last progress report, two insulated-end-cap tubes have been completed, but neither has survived long enough to be put into operation, in spite of several attempts to repair them. Several design changes have been made with an eye to eliminating features discovered to be undesirable, but mechanical difficulties have prevented the achievement of a satisfactory tube. It is proposed to make one tube with a pure tantalum cathode and another with an oxide-coated cathode. The tantalum cathode will enable us to study changes in the noise properties of the pre-oscillating magnetron with variations in emission as predicted by Twiss, while the oxide cathode will enable studies to be made at higher values of emission current than can be obtained with a pure metal emitter.