

## VII. MAGNETRON DEVELOPMENT

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### A. HIGH-POWER 10.7-CM MAGNETRON

#### 1. Testing and Design

No further magnetron testing or construction occurred during the past quarter.

Prototype ceramic-insulated cathode leads were designed, which will be baked at the highest temperature possible. When this temperature has been determined, further magnetrons will be processed at the same temperature. The completion and processing of this diode is expected in the near future.

The necessary parts for the construction and testing of MF-7 are now being made. Cold testing of this tube will begin shortly.

#### 2. Thoria Cathodes

The initial phase of the research on the development of a thoria

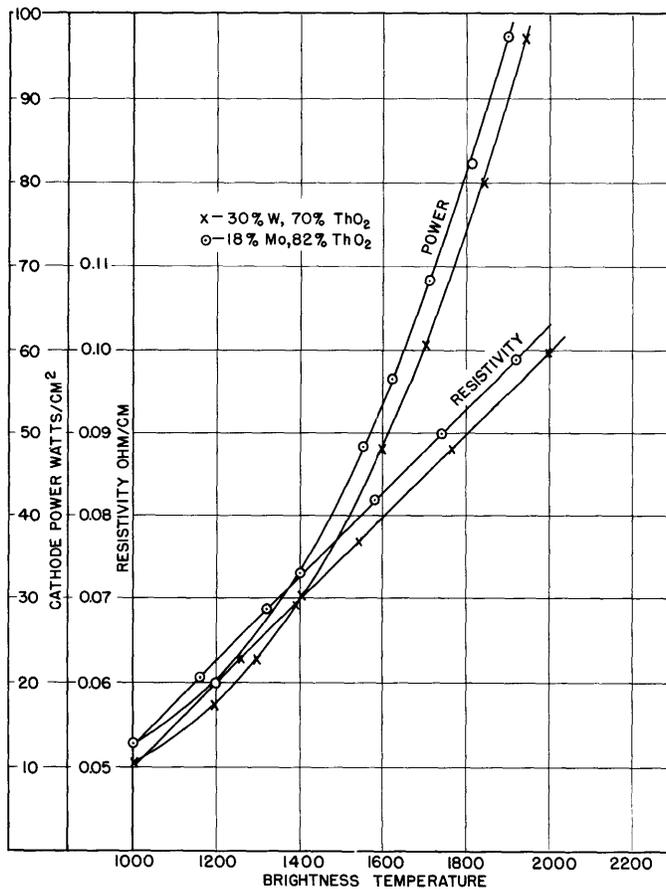


Fig. VII-1 Cathode power and resistivity as a function of temperature.

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cathode for use in the high-powered magnetron has been successfully completed. A satisfactory pressing technique has been devised for use with the split-segment die. Cathodes 3 inches long, 0.860 inch in diameter, and having a 0.060-inch wall thickness have been made.

Small rectangular cathodes, 1/8 inch by 1/16 inch by 5/8 inch, were cut from some smaller cylindrical cathodes and their operating characteristics determined. Two mixtures were investigated, one containing 30 percent tungsten and 70 percent thoria, and the other 18 percent molybdenum and 82 percent thoria. In these mixtures the volume concentration of conducting powder to thoria is 0.212. The equilibrium characteristics of these two cathodes are plotted in Figures VII-1 and VII-2. The two straight lines in Figure VII-2 are the calculated space-charge boundaries. Where

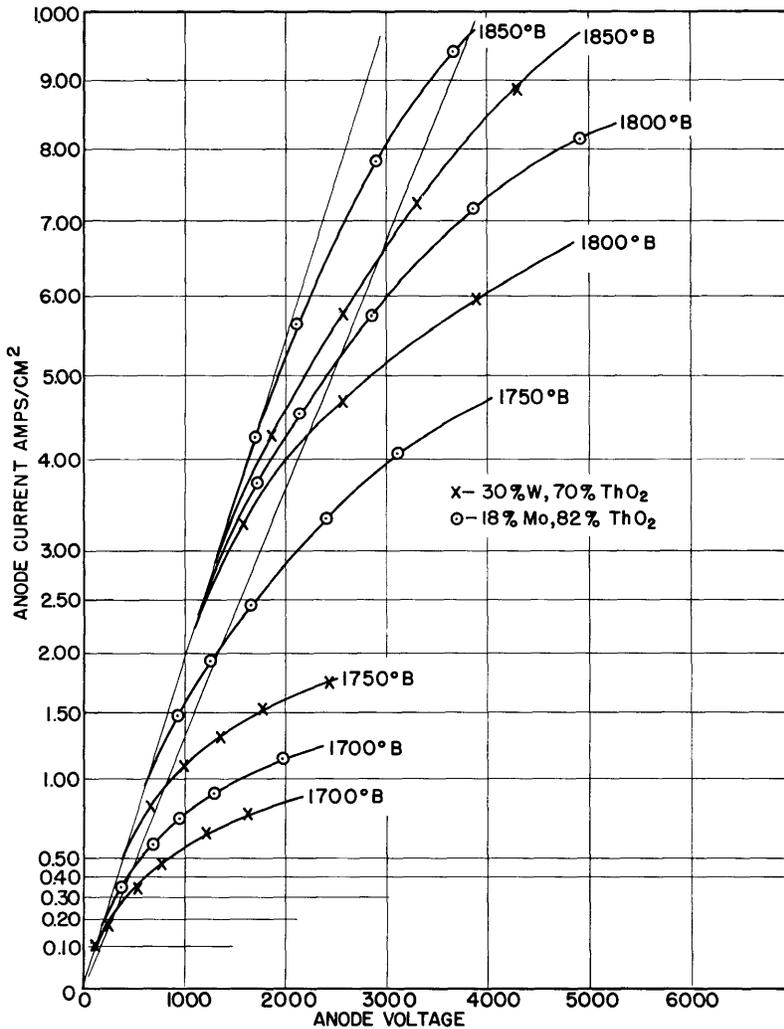


Fig. VII-2 Pulsed emission from rectangular sintered thoria cathodes.

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the plotted curve intersects the lower line, the approximate temperature-limited emission is obtained. The molybdenum mixture showed a much longer activation time at a low temperature after the cathode was flashed at a high temperature for a short time. Emissions greater than 1 amp/cm<sup>2</sup> were obtained at 1550°B for periods approaching 100 hours after the cathode was flashed at 2000°B. For the tungsten cathode this period was less than 10 hours.

A cylindrical cathode 1.2 inches long and 0.860 inch in diameter was also mounted and operated in a test diode to obtain preliminary data on a mounting scheme suitable for the high-power magnetron.

### 3. Auxiliary Equipment

#### a. Filament Transformer

The filament step-down transformer described in the Progress Report, April 15, 1949, has been received from the manufacturer and tested.

#### b. Electro-Magnet

The 3500-gauss electro-magnet which has been under construction for some time is nearing completion and should be ready for use in the very near future.

#### c. Vacuum Furnace

The high-temperature vacuum furnace to be used for sintering and platinum-brazing of pressed thoria cathodes has been redesigned and is in the process of construction.

The heating element will consist of two concentric cylinders of sheet molybdenum, 2.5 and 3 inches in diameter by 6.8 inches long. Direct current will flow down through one cylinder and up through the other. Surrounding the heating element are to be two more concentric molybdenum cylinders to act as heat shields. With all losses taken into consideration the power consumption is expected to be 30 kw at an equilibrium temperature of 2400°C.

At present, a major problem is that of rapid exhaust of the vacuum tank and maintenance of high vacuum. Since no leaks have been found, a larger diameter pumping line must be installed.

## B. Magnetron Research

### 1. Mode Stability

A 718KY magnetron, one of the type chosen for mode interaction tests, was cold-tested, but later found to inoperable because of a bent cathode

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pipe. Another 718EY has been successfully operated, but has yet to be cold-tested.

A model 9 hard-tube pulser was set up and modified to supply 3-msec pulses to the above magnetron. It was found, however, that the drop in output voltage during the pulse was excessive in spite of the fact that the value of the output coupling condenser had been tripled on account of the greater pulse duration. Better results were obtained by pulsing the 718EY with the model 12 hydrogen-thyratron line-type pulser.

The work of Van der Pol (1),(2) on the subject of non-linear triode oscillators with two degrees of freedom (i.e. two possible modes in the resonant circuit) has been examined for its possible application in the interaction of magnetron modes. Such an analysis shows that oscillation in either mode tends to suppress oscillation in the other mode, and that under certain conditions, either mode is stable and once started, will completely suppress the other mode. Present experimental efforts are directed toward investigation of these results, in order to discover whether they have any application to the magnetron problem.

### 2. Noise Properties of the Pre-Oscillating Magnetron

A functioning insulated-end-cap tube with an oxide cathode has finally been completed and put into operation. Preliminary results seem to indicate that most of the pre-oscillating anode current noted with ordinary tubes is not leakage current to the end caps, but is instead a true anode current. For example, at magnetic fields of the order of 1500 gauss (near the usual operating field of this anode as an oscillator) and anode voltages of a few hundred volts, the true anode current is of the order of milliamperes.

At present, measurements are being made on d-c characteristics only: the cutoff characteristic and the voltage-current characteristic of the end caps with fixed anode voltage (using the end caps as probes, with both accelerating and retarding voltages), at various values of magnetic field and cathode emission. When the d-c characteristics have been fairly well explored, an investigation will be made of the noise output and  $Q$  (for the  $\pi$ -mode resonance) as a function of anode voltage, magnetic field, and cathode emission.

### C. CATHODE RESEARCH

During the processing of the oxide-coated cathodes used in the high-power magnetron it has been observed upon several occasions that there are few or no signs of further activation of the cathode once the conversion

process has been completed. In the case of this large cathode, with a surface area of approximately  $50 \text{ cm}^2$ , when there is no increase in pressure in the vacuum system as the temperature of the cathode is raised, not only is the conversion process complete, but the activation is also apparently complete. Therefore, it seems possible that full and complete activation of the cathode may be obtained by heat alone, and that drawing current from the cathode is not a necessary step in the processing, contrary to current established practice.

In an attempt to prove this theory, a double envelope diode has been designed and constructed. It is illustrated in Figure VII-3. The cathode

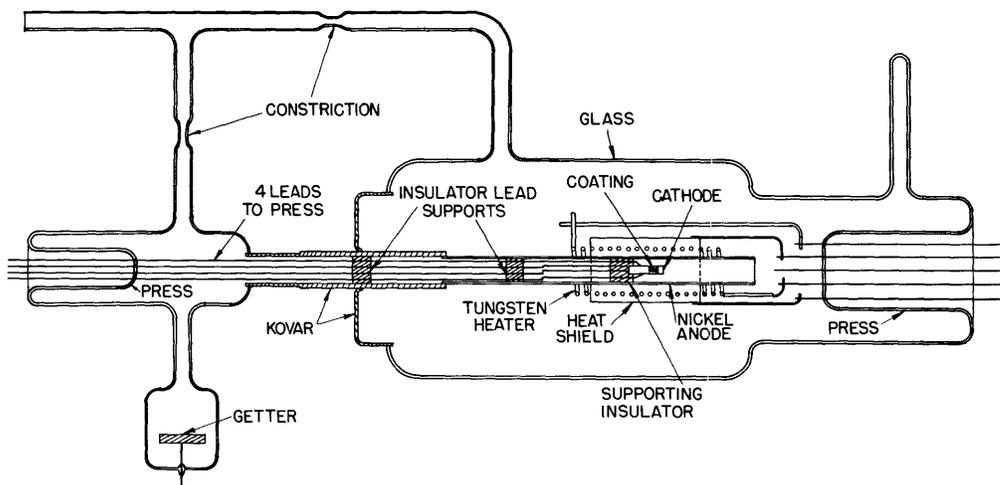


Fig. VII-3 Experimental tube for investigating oxide cathode activation.

is heated to the normal cathode breakdown temperature by heating the anode with the external heater for a protracted length of time, at the end of which period, the activation is presumed complete. The outer envelope is then sealed off from the inner envelope and used as a water jacket for cooling purposes. This work will constitute the material for a master's thesis.

#### References

- (1) B. Van der Pol, "On Oscillation Hysteresis in a Triode Generator with Two Degrees of Freedom", *Phil. Mag.* 3, 700-719 (1922).
- (2) B. Van der Pol, "The Non-Linear Theory of Electrical Oscillations", *Proc. I.R.E.* 22, 1051 (1934).