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The Variation of Cryotron Current Amplification Factor with Temperature*

The current amplification factor of a shielded, thin-film cryotron has been found to increase as the temperature is reduced below the critical temperature of the gate. From the Silsbee hypothesis,[1] this factor is the ratio of the gate-film width to the control-film width. The experimental work shows that the amplification factor is zero at the critical temperature of the gate and rises rapidly in the region when the penetration depth is decreasing, namely just below the critical temperature of the gate.

The current amplification factor is obtained from the cryotron characteristic curve, which is a plot of the combination of the gate and control currents required to make the gate resistive. The resultant field required to drive the gate from the superconducting state to its resistive state is the quadrature sum of the fields from the gate and control currents. A theoretical elliptical curve is predicted using this field hypothesis, and is illustrated in Fig. 1 for a particular temperature. The current amplification factor is the ratio of the intercepts of the curve with the axis.

The cryotron characteristic curve was experimentally determined for a number of cryotrons with tin gate films in the 2000 to 3000 A range, and lead control films in the 5000 to 7000 A range. The two films were separated by a silicon monoxide insulation which was in the 6000 to 7000 A range.

The current amplification factors for all the cryotrons tested were found to be less than one-tenth the width ratio when the helium bath temperature was near the critical temperature of the gate. As the temperature was lowered, the current amplification factors increased rapidly. The current amplification factor as a function of temperature for a particular cryotron with a width ratio of 5, is shown in Fig. 2. The curve changes most rapidly in the temperature range where the penetration depth of the gate changes most rapidly.[2] The asymptotic value of the current amplification factor for this cryotron is 3.1 to 3.2.

In conclusion, the current amplification factor of a thin-film cryotron has been shown to increase as the penetration depth decreases. It seems reasonable to conclude that the ratio of the penetration depth to film thickness is the significant variable, and this places a lower limit on film thickness that can be used in practice.

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1. F. B. Silsbee, *Bull. Bur. Standards* **14**, 307 (1918).

2. D. Shoenberg, *Superconductivity*, Cambridge Univ. Press, 1952, p. 143.

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Figure 1 **Ideal cryotron current amplification curve for the quadrature addition of the gate field and the control field.**

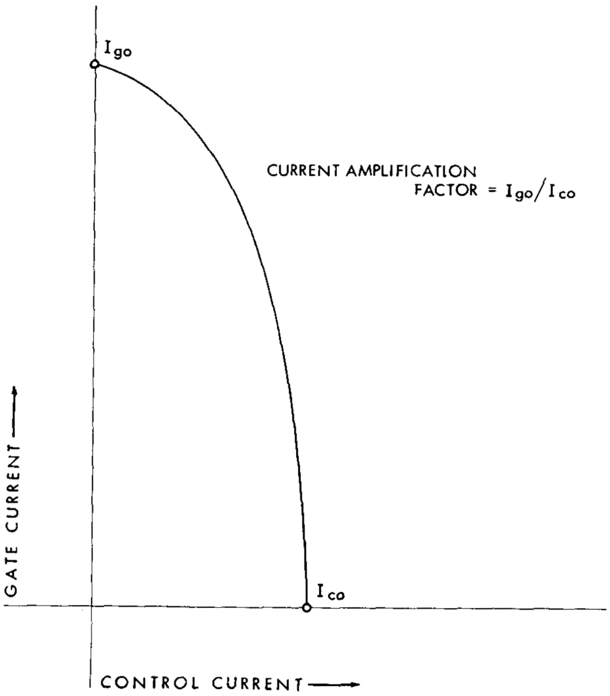

Figure 2 **Cryotron current amplification factor as a function of temperature.**