NASA TECHNICAL MEMORANDUM

NASA TM X-52626

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RICHARDSON DUSHMAN EQUATION NOMOGRAPH

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Lewis Research Center
Cleveland, Ohio

June, 1969

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ABSTRACT

This report presents nomographic solutions to the Richardson Dushman equation. The nomographs have been scaled to meet the emission conditions of the emitter and the back emission condition of the collector. Values of work functions are presented at 20^{o} K intervals in the temperature range from 600^{o} to 2500^{o} K. The current density ranges from $1{\times}10^{-7}$ to $1{\times}10^{2}$. The reading error of work function was determined to be less than 0.01 V.

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SUMMARY

This report presents nomographic solutions to the Richardson Dushman equation. The nomographs have been scaled to meet the emission conditions of the emitter and the back emission conditions of the collector. Values of work functions are calculated at 20° K intervals in the temperature range from 600° to 2500° K. The current density ranges from 1×10^{-7} to 1×10^{2}. The reading error of work function was found to be less than 0.01 V.

INTRODUCTION

This memorandum presents nomographic solutions to the Richardson Dushman (RD) equation[1, 2] found to be convenient in treating electron emission of thermionic converters and similar devices. The nomographs have been scaled to meet the conditions of the emitter (fig. 1) and the back emission conditions of the collector (fig. 2).

The effective work function[3, 4, 5] is used in this presentation, that is, the pre-exponential constant is set equal to the theoretical value of 120.1. The surface reflection coefficient is assumed to be zero, the common practice for metallic electrodes. The RD equation then reduces to

$$J = 120.1\ T^2 \exp - \frac{e\varphi}{kT}$$

where

J current density in amp/sq cm

T electrode temperature, $^{\circ}K$

e electron charge in Coulombs

φ the effective work function in volts

k the Boltzmann constant in $J/^{\circ}K$

Although the RD equation describes electron emission under idealized conditions rarely met experimentally, the effective work function is convenient to use in comparing the relative emission capabilities of surfaces. Also, the use of this thermodynamic equilibrium expression is of value in the heat engine analyses of energy conversion devices.

The solution of the RD equation is usually presented in the form of tables[6] and charts[3, 7]. We have found the nomographs provide a reasonably accurate condensation of this information. The reading error of φ was determined to be less than 0.01 V. Experimental values of work functions usually involve an uncertainty greater than ±0.05 V, thus the figures above should be adequate for many uses.

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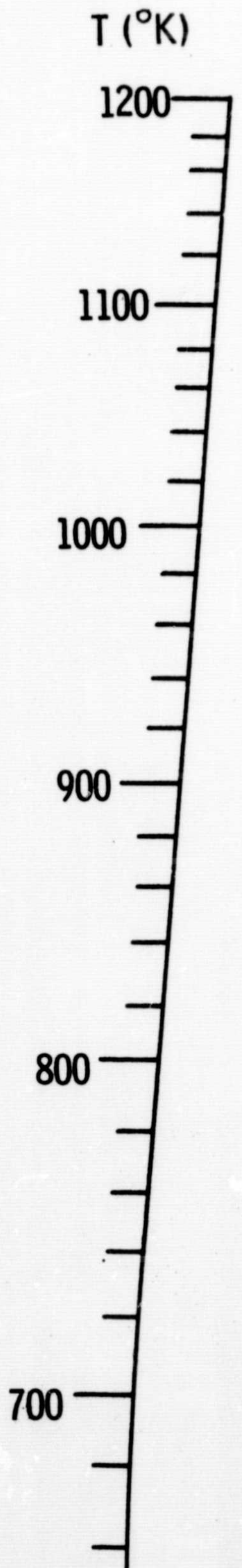
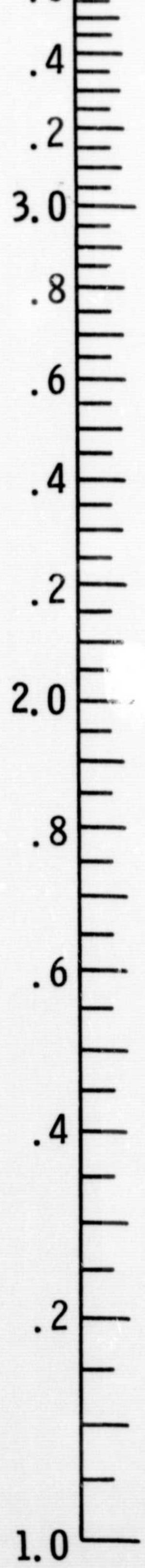


Figure 2. - Emission current density based on the solution of the



on of the Richardson Dushman equation for various effective work function (φ) and electrode temperatures (T).

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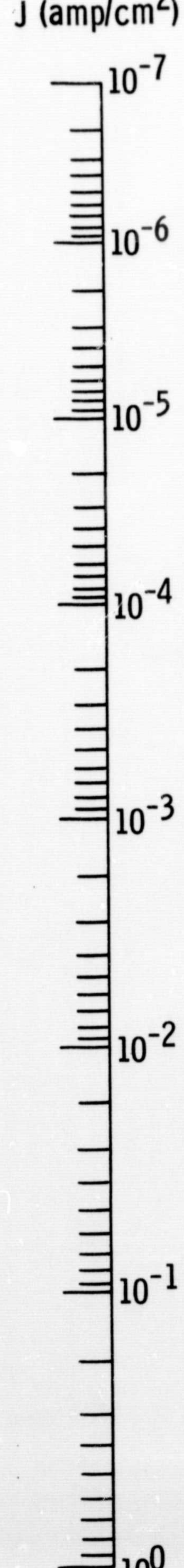

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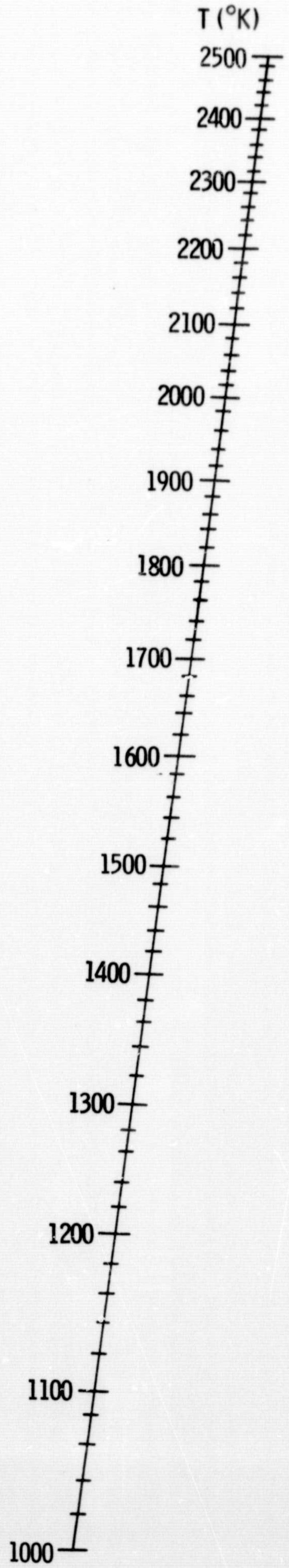

Figure 1. - Emission current density based on the solution of the

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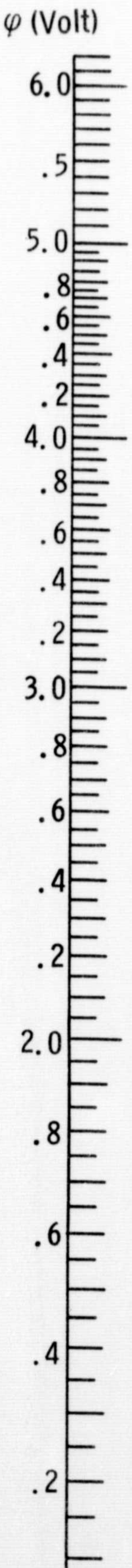
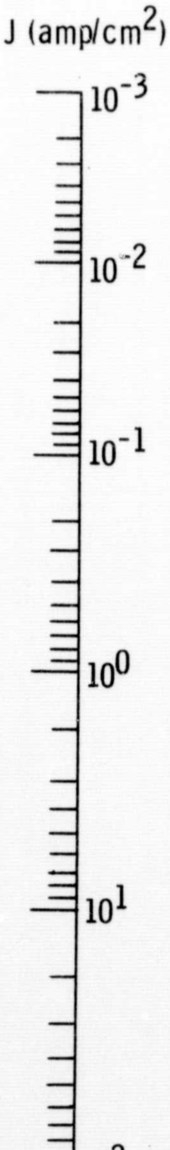


current density based on the solution of the Richardson Dushman equation for various effective work functions (φ) and electrode temperatures (T).



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