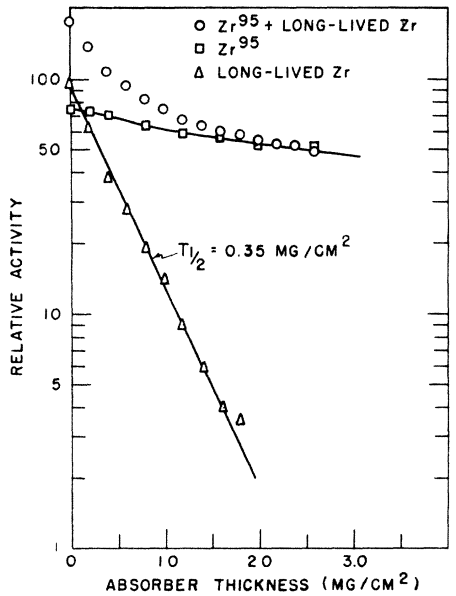

FIG. 2. Absorption curve of long-lived Zr as determined in an internal Geiger counter ("Q-gas counter").

Assuming this long-lived fission product is Zr^{93}, whose fission yield in uranium may be obtained from the smooth yield-mass curve,[1] the ratio of its activity to that of Zr^{95} at a given time after a known period of irradiation permits an estimation of its half-life. The ratio of activities observed at 4.2 yr. after an irradiation of 0.83 yr. was 1.4. This value gives a half-life for Zr^{93} of 5.2×10^6 yr. A possible error in the value of the half-life of the order of a factor of two is estimated from the uncertainty in the half-life of Zr^{95} (65±2 days). Another possible source of error lies in self-absorption by the source, which consisted of ~10 μg of solid material deposited over a small area. This effect should lower the calculated half-life by no more than a factor of two. Thus, the true half-life of Zr^{93} should lie in the range 1.5 to 8.5×10^6 yr. Further work is in progress to eliminate these sources of possible error and to establish the half-life with greater accuracy.

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[5] Freedman, Wagner, Steinberg, and Glendenin (unpublished work).
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Optical Absorption Edge for BaO as Determined by the Method of Ives and Briggs

E. A. TAFT AND J. E. DICKEY
General Electric Research Laboratory, Schenectady, New York
April 20, 1950

TYLER[1] has located the optical absorption edge of evaporated films of BaO at $h\nu\cong3.8$ ev. We have confirmed his result by measuring the photoelectric emission from very thin metallic films deposited on the surface of BaO layers. This method, originated by Ives and Briggs[2] in their investigation of Na films on Ag, has not been applied in the case of ionic substrates. (It is interesting to note that the narrow transmission band of Ag has almost the same location as the absorption edge of BaO.) Figure 1

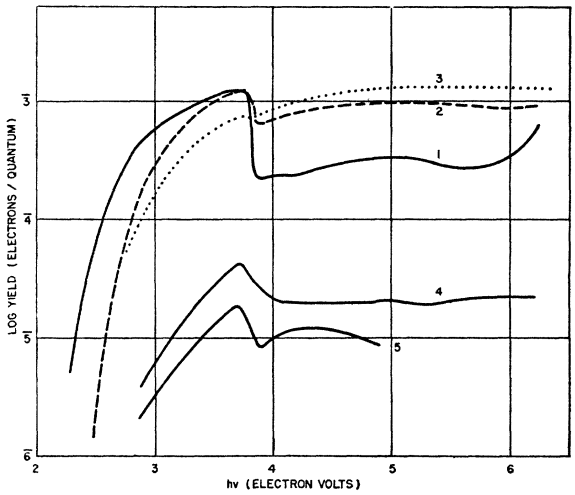

FIG. 1. Photoelectric yield of Ba films on BaO layer; curves 1, 2, and 3 are in order of increasing thickness of Ba. Curves 4 and 5 are results for Na on Ag taken in this laboratory and by Ives and Briggs respectively—the absolute magnitude of the yields being displaced arbitrarily. Note that the characteristics of the logarithms are negative.

shows the spectral distribution of the photoelectric yield from thin films of Ba metal deposited on BaO layers formed by thermal decomposition of $BaCO_3$. The thinnest Ba films were invisible. They had only a small effect on the incident ultraviolet radiation. However, they suppressed almost entirely the photoelectric emission from the BaO itself. Thus, loosely speaking, one may say that they behaved like metallic photo-emitters with the optical constants of the layer of ionic crystals. The photoelectric yield drops by several-fold between 3.7 and 3.9 ev, in good agreement with the absorption edge found by Tyler. As the films become thicker, the effect becomes less pronounced and finally disappears. The surface then has the properties of bulk Ba metal. We have obtained analogous results with films of Mg on BaO, and with Ag and Pb on KI.

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X-Ray Determination of Hg Arc Temperature

C. KENTY AND W. J. KARASH
General Electric Company, Lamp Development Laboratory, Nela Park, Cleveland, Ohio
April 17, 1950

THE absorption of a beam of x-rays passing along the axis of a carbon arc in air was used by von Engel and Steenbeck[1] to determine the gas density and thence the arc temperature. The method has been applied to the Hg arc by the writers,[2] by Fischer[3] at about the same time, and more recently by Koch.[4] This letter outlines the writers' work as extended in early 1942 and terminated by the war.

The apparatus is shown in Fig. 1. Here an x-ray beam from a 30-kv Mo anode tube passes through a ZrO_2 filter, to render it more monochromatic, through a defining diaphragm, thence along the axis of the arc, entering and leaving the quartz tube through thin inblown windows and passing through hollow electrodes, and finally into an argon-filled ionization chamber where its strength is measured by a string electrometer. Because of the mounting of the x-ray tube, the arc is run horizontally. A special magnet confines the arc well in the axial position except near the cathode, where ordinarily the arc bows upward more strongly. This is corrected by using three cathodes operating in parallel with separate ballasts. The Hg pressure is controlled by the temperature of the furnace F_1, and measured to ~0.3 percent

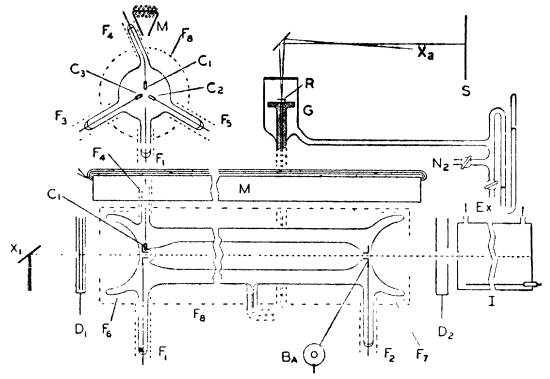

FIG. 1. Schematic diagram of the apparatus.

by a membrane manometer.[5] Furnaces F_2–F_7 prevent Hg from condensing in remote areas. The "cathode" and anode "buttons" of Mo have ~3 mm holes and clear the windows by ~1 mm.

The arc current is ~5 amp. d.c. and the Hg pressure ~1 atmos. (no rare gas). The x-ray tube current is ~28 ma, and the primary voltage 80. The former is held to about 0.3 percent and the latter to about 0.1 percent. The length L of the tube between windows is ~27 cm and the inside diameter 2.0 cm.

The method is to operate the arc at a pressure p_1, measuring the strength of the emergent x-rays, then to shut off the arc and adjust the Hg pressure downward to a pressure p_2, such that the x-ray reading is the same as before. Meanwhile heat is applied by the removable furnace, F_8, to keep the tube at a temperature T_2 well above the Hg condensation point. Then since the x-ray beam traverses the same number of Hg atoms in both cases, it follows that

$$p_1\left[\int\frac{dl}{T}+\frac{L_1}{T_1}\right]=\frac{p_2L}{T_2}, \tag{1}$$

where L_1 is the length of the uniform section of the arc (~25.5 cm) and T_1 its axial temperature. The integral is taken graphically over the end sections, with the help of fine thermocouple measurements of window temperatures and pyrometer measurements of "button" temperatures, extrapolating the temperature curves so found smoothly to T_1. A value of T_1 is thus found by trial which will satisfy (1).

The mean of four series of runs occupying about 10 hours each gave for T_1 the value 6600±200°K. This appears to be at least 800° higher than would be predicted for this arc either from the work of Koch[4] or from the latest work of Elenbaas.[6]

A fuller account will be published elsewhere. We are indebted to Professor C. Nusbaum and the Case Institute of Technology Physics Department for the use of their x-ray facilities, and to Mr. P. D. Cargill for assistance in making the later measurements.

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The Temperature of the Mercury Arc

CARL KENTY
General Electric Company, Lamp Development Laboratory, Nela Park, Cleveland, Ohio
April 17, 1950

USING a quartz Hg lamp as its own gas thermometer,[1] the average temperature of the vapor is calculated from the volume of the bulb, the observed pressure, and the weight of Hg. Pressures are measured to 0.3 percent with a quartz membrane manometer.[2] Corrections are calculated for the relatively cold vapor in the end sections, with the aid of fine thermocouple measurements made all over the lamp. The lamps were 2.0 cm i.d., approximately 25 cm long, and contained about 3 mg Hg per cm of length. (No rare gas.)

The average temperature of the vapor in the uniform section, based on three different lamps operating horizontally with magnetic control on d.c. at 40 w/cm (~5 amp.) is 2850±50°K. This is 12 percent higher than the value obtained by Elenbaas[1] for a similar arc. The difference is ascribed to differences in the method of making end corrections.

With an axial temperature of 6600°K determined by x-rays (see preceding letter), and a wall temperature of 845°K, taken from the thermocouple measurements, a $T(r)$ curve is now found by trial, using graphical integration, which will give an average temperature of 2850°K and satisfy a $T^{9/8}$ power law[3] of heat conductivity from the edge of the arc core (at $r\cong0.5$ cm) to the wall.

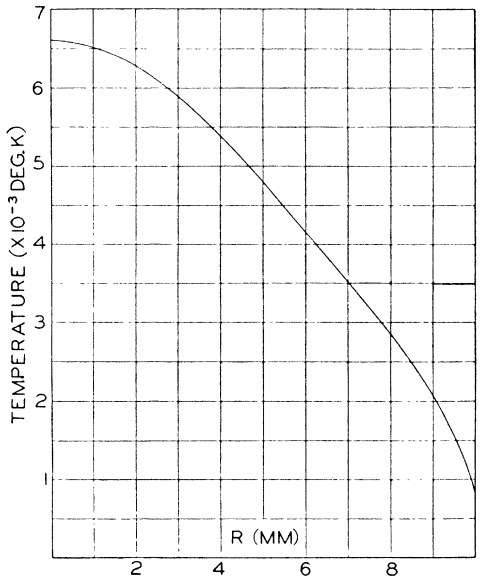

FIG. 1. Temperature distribution in the Hg arc.

This temperature curve (Fig. 1) and the measured gradient (7.94 v/cm) and current (5.07 amp.), together with the Saha and Langevin equations, are used to calculate the cross section σ for elastic collisions of electrons with Hg atoms. The result is 12×10^{-15} cm² (420 cm²/cm³) in quite good agreement with the results of Brode,[4] but threefold larger than the value found by Elenbaas in studying a dissimilar arc.[3]

With the above value of σ, Cravath's formula predicts the observed elastic heat loss[5] of ~10 w/cm if the electron temperature exceeds the gas temperature by ~40°K.

The output of the yellow lines as measured for a dissimilar arc by Elenbaas[3] can be accounted for on the basis of Boltzmann populations for the $6^3P_{2,1,0}$ states and cross sections for two-stage excitation of 6^3D which are tenfold greater[6] than for single-stage excitation, provided a temperature is used which is 450°K higher than that used by Elenbaas, whose calculations failed to account for the excitation by a factor of 100.

With this same temperature increase, σ as calculated from Elenbaas' experiments agrees with the value found here.

The present results indicate that the A values for the yellow lines, found by Schouten and Smit[7] and used by Elenbaas in calculating Hg arc temperatures are several-fold too high. This appears possible from calculations which indicate that there was self-absorption of the 2537A line in Schouten and Smit's experiments and that there were far too few electronic collisions to give