

I. PHYSICAL ELECTRONICS

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A. ELECTRON EMISSION PROBLEMS

1. Thermionic Emission from Sintered Cathode of Thoria and Tungsten Mixture

Staff: Dr. H. Y. Fan
Professor S. T. Martin

The time change of emission mentioned in the last report has been carefully studied with the aim of determining its cause. The cathode is heated at a definite temperature T_0 sufficiently long for it to come to a steady state. Then the temperature is suddenly dropped to a lower value T_t and the emission is observed at regular intervals. Two values of T_0 are used: 2050°C and 1770°C . For each T_0 , emission is tested at a series of T_t ranging from 820°C to 1650°C . For $T_0 = 2050^\circ\text{C}$, the emission at a T_t stays constant at first for a length of time, depending on T_t , it then decays approaching a steady value asymptotically. For $T_0 = 1770^\circ\text{C}$, the emission at all T_t 's rises at first, passes through a maximum and decays to a steady value. Richardson plots taken at various stages of the change of activity show that both the work function and the constant A change. The measurements repeated several days apart show good reproducibility. This fact and the manner in which the activity changes indicate that it is not a gas effect but the inherent properties of this type of cathode.

The evidence points to the following explanation of the phenomena. The change of emission is caused by the variation of the amount of free thorium adsorbed on the surface of the cathode. Free thorium is produced as the result of reduction of thoria by the admixed tungsten powder. Due to the abundance of thoria the production of free thorium in this type of cathode will be much more intensive than in a thoriated tungsten cathode. On the other hand, free thorium on the surface of the cathode will evaporate at a rate depending on the temperature. As we may be dealing with evaporation of thorium from thoria surface rather than from tungsten, the heat of evaporation can be quite different from that observed for thoriated tungsten. This may well be the reason of observed emission changes at very low T_t (below 1200°C), at which temperature change of activity of thoriated tungsten cathodes should be extremely slow.

To test this explanation a new tube was made with a pure tungsten filament mounted between the sintered cathode and the anode. If thorium is evaporated from the cathode as we predict, it should be detectable by the change of the activity of the tungsten filament. The tube is now ready for test.

2. Studies on Oxide-Coated Cathodes. Correlation of Pulsed and D-C Emission and Decay of Pulsed Emission

Staff: R. P. Bien

This investigation has been completed and the results will be published in the near future as a technical report.

3. Work Functions and Conductivity of Oxide-Coated Cathodes

Staff: G. W. Mahlman

Although the study of oxide-coated cathodes to determine the relationship between the photoelectric and the thermionic work functions has been temporarily interrupted, the detailed results to date are available in a thesis on file in the Library under the title, "Work Functions and Conductivity of Oxide-Coated Cathodes". A technical report with the same title is also available.

The investigation is to be continued along very closely related lines by Mr. W. E. Mutter.

4. Thermionic Emission from Oxide-Coated Cathodes under Retarding and Accelerating Fields

Staff: Professor W. B. Nottingham
C. S. Hung

A tube has been completed under the new design which would reduce possible electrical leakages. Careful cleaning and pre-baking of all parts were done before the cathode was finally mounted. Undesirable electrical leakage between the collector and the guard rings, which has caused the greatest trouble, is avoided. High retarding-field measurements show nice fit with the theoretical curve. The contact potential difference between the oxide cathode and the tantalum collector is remarkably high as compared to the usual case of contaminated collectors. Further investigations are under way.

5. Determination of the Thermionic Emission Properties of Single Tungsten Crystals by a Photometric Method

Staff: G. J. Marcinkowski

Two single tungsten crystals, approximately 4 inches long, have been grown in a 5-mil wire. Their growth was observed by studying the thermionic emission pattern on a fluorescent screen. At the growing temperature of 1950°K numerous small imperfections in the large crystals occurred. It was necessary to remove these for quantitative tests of thermionic emission. Most of these imperfections were absorbed by the large crystals by raising the temperature. A very prolonged and vigorous heating failed, however, to remove all of the imperfections; the wire eventually broke on account of the evaporation of tungsten.

In determining the true thermionic constants of tungsten by using crystals grown in a wire, it is very desirable to grow crystals with the 110 axis coincident with the axis of the wire. To approach this ideal condition more closely a 7-mil wire was ground to 4 mils and polished. The preferred orientation of the small tungsten crystals in such a wire is much better than in a 5-mil wire ground to 4 mils. It is therefore possible that the 7-mil wire may offer a much better chance of starting the growth of large crystals in a favorably oriented small seed crystal. A tube has been constructed with the ground 7-mil wire; crystal growing will start shortly.

Tests are being continued to find a suitable method of evaporating a uniform aluminum coating on the fluorescent screen to be used. It was found in the process of growing the large crystals that the original electron collector electrodes were not suitable. Consequently, it is hoped that the aluminum coating can also be made to serve as an efficient electron collector; its other purposes are to reduce stray, scattered light, and to intensify the thermionic emission pattern. Use of the aluminum coating as an electrode would provide an equi-potential surface with a constant, easily measurable potential. This would allow a more accurate extrapolation to zero field conditions than would be possible if one relied on the secondary emission characteristics of the phosphor alone.

B. GAS DISCHARGES

1. Langmuir Probe Measurements in the Mercury Arc Operating in the Transition Range Between Low and High Pressures

Staff: Katherine L. Franck

The detailed results of this study are available in thesis form under the title, "Langmuir Probe Measurements in the Medium High Pressure Mercury Arc". The investigation yields the interesting result that the

energy distribution is quite accurately Maxwellian over a 1000-fold range in electron current. By studying such electron energy distributions as a function of the position of the arc axis relative to the probe wire, it turns out that the characteristic temperature is nearly independent of probe position, whereas the magnitude of the current varies considerably.

C. EXPERIMENTAL TECHNIQUES

1. Spectral Emissivity of Tungsten

Staff: Professor W. B. Nottingham
W. E. Mutter

A second source tube designed to permit the spectral emissivity measurements to be extended to about 3100°K failed at exhaust because of binding in the thermal expansion joint which caused the triangular prism-shaped black-body cavity to buckle and tear. The tube has been rebuilt and is now ready to be pumped again.

In line with this work on spectral emissivity, some measurements were made on the deviation from Lambert's Law and on the polarization of light emitted by incandescent tungsten. The measurements were made on a ribbon filament Bureau of Standards lamp intended for use in pyrometer calibration. The photometry was done with the 931 multiplier equipment available for the emissivity studies. The results are shown in Fig. I-1. The curves B_{\perp} and B_{\parallel} show the relative brightness as a function of the angle of emission, θ , for the components polarized, respectively, perpendicular to, and parallel to, the plane of emission. Unit brightness is taken as the unpolarized brightness of the filament viewed normally. For a given wavelength, the shape of these curves is independent of temperature over the range 1758 to 2260°K . The deviation from Lambert's Law is such that the brightness of the unpolarized light gradually increases from its value at normal emergence with increase in emission angle to about 77° at which point it is 14 per cent and 10 per cent greater than the normal value for $\lambda = 6600\text{\AA}$ and $\lambda = 5250\text{\AA}$, respectively. For $\lambda = 4250\text{\AA}$, there is a slight decrease followed by a peak at 75° , 3 per cent above the normal value. The ordinates of the B_{\perp} and B_{\parallel} curves sum up to the corresponding unpolarized curves within a few percent; this is in agreement with the experimental error of repeat adjustments of the optics.

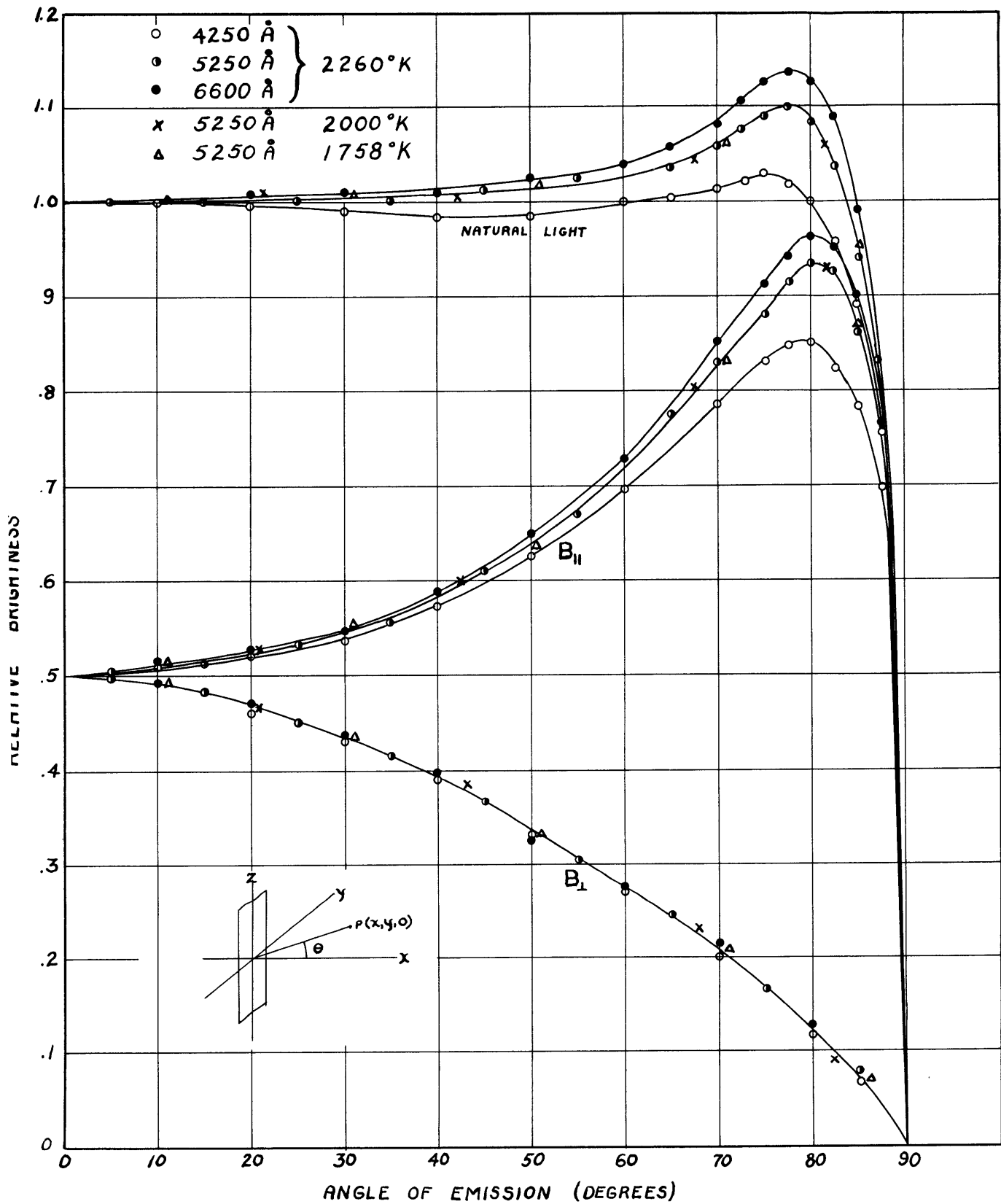


Fig. I-1. Results of measurements made on the deviation from Lambert's Law and on the polarization of light emitted by incandescent tungsten.

2. Ionization Gauge

Staff: Professor W. B. Nottingham
L. E. Sprague

Studies of vacuum technique and vacuum measurement are continuing. By following the general principles of the previous tube, a new tube has been designed that permits the measurement of the ionization current within a given tube by two methods, namely, the conventional triode type of ionization gauge structure and a new structure that makes possible the measurement of ions that are bent around an internal shield by means of electrostatic forces. The theory behind the use of this gauge is that if both methods of measuring ions give the same results, then it is considered that the ionization current is not disturbed seriously by spurious effects. The most interesting result to date is that the ionization-current measurement itself changes very little with the present technique of processing to obtain high vacuum. However, the length of time required for a monolayer to form on a cold, clean tungsten filament is extremely sensitive to the processing and the operation of the vacuum system. Although attempts have not yet been made to lengthen the time for the formation of a monolayer to its maximum, the present state of the development yields a time of approximately 7 hours for monolayer formation.