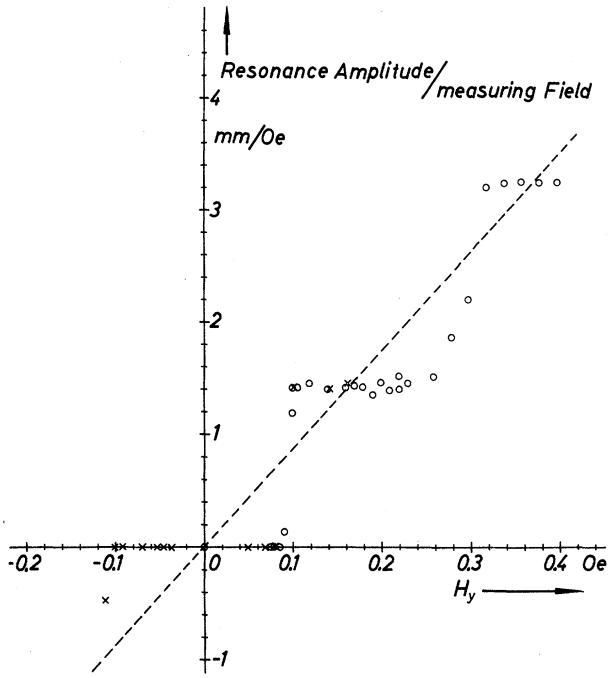

FIG. 2. Resonance amplitude divided by measuring field H_x as a function of the applied field H_y. The ordinate is proportional to the frozen-in flux. ×— First run; o— second run.

the lead tube, Eq. (2) predicts for the interval of the magnetic field strength corresponding to one flux unit a value of $H_y = 0.5$ oe. The experimentally observed interval, however, reaches only 0.2 oe, that is about 40% of the calculated value. So far the reason for this discrepancy is not clear. For example, an error of 60% in the determination of the lead tube's diameter would explain the difference, but such an error is improbable.

The experiments are being continued with higher fields H_y and other superconductors of various diameters.

Mercereau and Vant-Hull[5] also tried to verify London's postulate of the quantization of magnetic flux in a superconducting ring. The result of their experiments was negative.

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EXPERIMENTAL DETECTION OF TRANSITION RADIATION*†

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If an electron approaches the boundary between vacuum and metal, a changing dipole field due to the electron and its image charge is formed which, according to the theory of Ginsburg and Frank,[1] effects the emission of "transition radiation." In the experiment electrons bombarding a metal surface generate a visible radiation known as "Lilienfeld radiation." The results of the experiments done before this work are, however, contradictory.[2-4] Therefore we undertook to exclude by more careful experiments the influence of surface contaminations and to compare the experimental Lilienfeld radiation with the theoretical transition radiation by variation of different parameters.

Our investigations were carried out at pressures of about 10^{-9} mm Hg with massive heatable targets and with condensed films of more than 1 μ thickness. The electron beam was produced by field emission and pulsed with a frequency of 100 kc/sec. The energy of the electrons was in general 2-12 kev. The intensity of the Lilienfeld radiation was measured with a photomultiplier tube and a phase discriminator. The results of our investigations are as follows:

(1) The intensity of the Lilienfeld radiation is independent of the temperature of the target.

The temperature range was 300°K to 2300°K for W targets, up to 1800°K for Ta and Mo, and up to 1300°K for Ti.

The intensity of the Lilienfeld radiation is also independent of the gas pressure, as investigated for tungsten in the range from 10^{-9} to 10^{-5} mm Hg. Consequently, if gas films are adsorbed on the surfaces, they have no influence. Therefore the Lilienfeld radiation is a property of the clean metal surface only, like the transition radiation.

(2) Like the transition radiation, the Lilienfeld radiation of W, Ta, Mo, Ti, and Pt is nearly plane polarized (Table I). The electric field vector is oscillating in the plane given by the normal to the target plane and the direction of observation. Its direction is independent of the angle of incidence of the electron beam. The degree of polarization for Ag and Cs is lower than that for the former metals. This decrease is probably caused by greater roughness of the surfaces.

(3) The intensities of the transition radiation and of the Lilienfeld radiation for W, Ni, Al, and Cu increase linearly with both electron energy and current density. The investigations ranged for electron energy from 6 to 30 kev and for current density from 0.1 to 10 ma/cm^2.

(4) The angular distributions of the Lilienfeld radiation for tungsten and of the transition radiation for a metal with a dielectric constant $|\epsilon| = 3$ are nearly identical from $\theta = 10°$ to $\theta = 60°$ (Fig. 1).

(5) The spectrum of the Lilienfeld radiation, recorded by a quartz spectrograph with a resolution $\Delta\lambda \sim 100$ A, forms a continuum (Fig. 2). The spectra of the Lilienfeld radiation and of the transition radiation for silver are plotted in Fig. 3. Both spectra nearly agree in the slow increase from red to blue and in the following abrupt decrease in the ultraviolet. The theoretical increase of the transition radiation at 3000 A

Table I. Degree of polarization P and efficiency $\eta_{\Delta\lambda}$ of the Lilienfeld radiation and of the transition radiation. Angle of observation $\theta = 65°$ against the normal of the target plane. The efficiency $\eta_{\Delta\lambda}$ is the ratio between the total power of the Lilienfeld radiation in the spectral range $\lambda = 4000$ to 5120 A, $\Delta\lambda = 1120$ A, and the power of the electron beam.

Metal	Lilienfeld radiation (exp.) P	Lilienfeld radiation (exp.) $10^9\eta_{\Delta\lambda}$	Transition radiation (theor.) P	Transition radiation (theor.) $10^9\eta_{\Delta\lambda}$
Tungsten	0.96	4	1.0	4.3
Tantalum	0.96	3.5	1.0	3.9
Molybdenum	0.96	4	1.0	4.3
Titanium	0.88	2	1.0	2.1
Platinum	0.92	5	1.0	5.1
Silver	0.6	8	1.0	5.7
Cesium	0.5	11	1.0	3.9

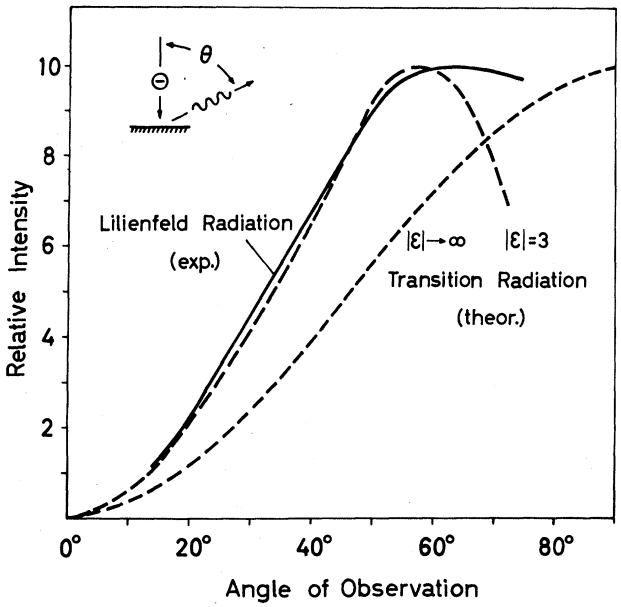

FIG. 1. Intensity of the investigated Lilienfeld radiation (solid line) for tungsten and of the calculated transition radiation (dashed line) versus the angle of observation. ϵ = dielectric constant.

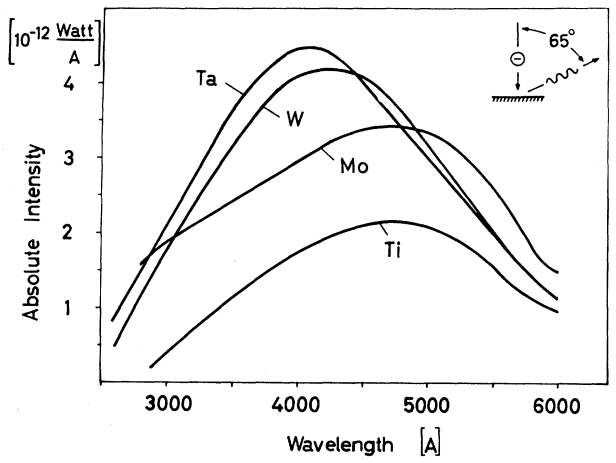

FIG. 2. Spectrum of the Lilienfeld radiation for Ta, W, Mo, and Ti. Absolute intensity relative to 1-watt electron beam power and to a range of wavelength $\Delta\lambda = 1$ A.

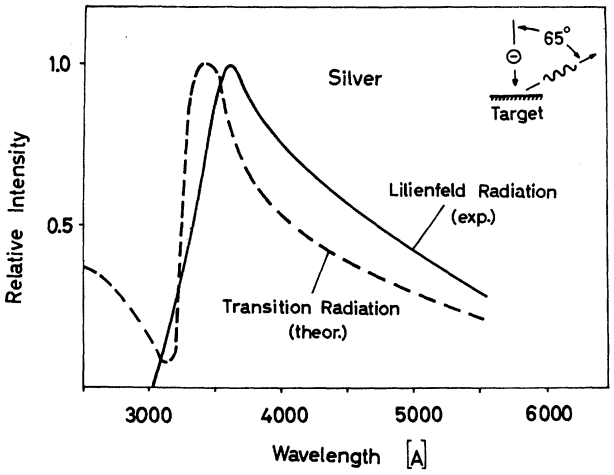

FIG. 3. Spectra of the Lilienfeld radiation (exp.) and the transition radiation (theor.) for silver.

is not reproduced by the experimental spectrum. It is probable that in this part of the spectrum the sensitivity of our apparatus is not sufficient.

(6) The efficiency $\eta_{\Delta\lambda}$ of the Lilienfeld radiation for W, Ta, Mo, Ti, and Pt agrees surprisingly well with the calculated efficiency of the transition radiation (Table I). The efficiency for the condensed metals Ag and Cs is only of the same order.

On account of these corresponding characteristics the Lilienfeld radiation, produced by metals in the energy range mentioned above, is to be interpreted as the transition radiation due to Ginsburg and Frank. We think it impossible to interpret the Lilienfeld radiation as the visible part of the bremsstrahlung. The Lilienfeld radiation also cannot be interpreted as "plasma radiation" according to the theory of Ferrell,[5] because the plasma radiation only appears on foils with two boundary surfaces, whereas the investigated Lilienfeld radiation is observed on compact metals with only one boundary surface within the depth of penetration of the electrons.

The transition radiation may also contribute to the background of the radiation from thin foils (two boundary surfaces) which had been experimentally studied by Steinmann,[6] and Brown et al.[7]

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