to side in the specimen. However, the magnitude of the displacement is about ten times larger than would be expected from the twinning of one pair of planes. The net volume contraction of the tin as viewed from the quartz is about 10^{-8} cm^3.

Somewhat similar experiments carried out with large aluminum crystals failed to give detectable signals.

On the Mechanism of Electron Emission at the Cathode Spot of an Arc

JEROME ROTHSTEIN
Signal Corps Engineering Laboratories, Fort Monmouth, New Jersey

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THE experiments of Smith[1] on the thickness of the mercury arc cathode dark space show that the hypothesis of field emission fails to account for the high current densities (10^4 amp./cm^2) observed at the cathode spot.

The fact that the arc can be extinguished by a current interruption of less than 10^{-8} second,[2] together with evidence indicating a low cathode temperature even at the arc spot itself, shows that thermionic emission is also inadequate.

Smith's[3] theory ascribing the high current density to thermal excitation of the conduction electrons runs into the following difficulty, which applies to thermionic emission as well. Taking the diameter of an arc spot as 10^{-2} cm, the velocity of the spot in a magnetic field as 10^4 cm/sec.[3,4] the arc current as 1 ampere, and the cathode fall as 10 volts, we see that the cathode spot must be excited to full emission in 10^{-6} second by an energy of only 10^{-5} watt second. Furthermore, it is hard to conceive of any plausible mechanism for preventing the "hot" electrons in the cathode spot from losing their energy by interacting with other conduction electrons and even with the atoms of the cathode.

The hypothesis that the entire current is carried by positive ions[5] runs into difficulties such as communicating too much momentum to the cathode, accounting for the high temperature, and inability to explain why an interruption of less than 10^{-8} second should extinguish the arc.

A new theory is proposed that is applicable to the class of arcs characterized by relatively low spot temperature and relatively high spot mobility, e.g., liquid cathodes, Cu, Ag, Au, Fe, Ni. The mechanism may play a partial role in other cases as well. It is assumed that a region possibly 10^{-5} cm thick of very dense metallic vapor exists immediately adjacent the cathode spot. The high density perturbs the atomic fields so that the normally sharp energy levels are spread into bands, including conduction bands. Metallic conduction is then possible from the cathode to this region, which is at a sufficiently high temperature to emit thermionically into the plasma. The ions bombarding the cathode serve to maintain the high local density.

From the work of Birch[6] on the conductivity of Hg in the supercritical region, it appears that a particle density N equal to 10^{22} atoms per cc gives essentially metallic conduction. Consider the arc spot. If n atoms leave it per cm^2 per sec. with a velocity distribution $f(c)$, the particle density in a layer of thickness d outside it is given by

$$p=(1/d)n\int_0^\infty f(c)(\alpha/c)dc=n\int_0^\infty f(c)(dc/c)=N=10^{22},\text{ say.}$$

To estimate n, we recall a current density of 10^4 amp./cm^2, about 10 percent of which is carried by ions, giving 6×10^{21} ions/cm^2/sec. bombarding the Hg arc spot. This is about ten times the net "evaporative" loss, so somewhat more than this number of .atoms leave the cathode. The coefficient of accommodation is probably small, so many of them leave with large velocities giving small contributions to the integral. For want of a better choice at this time, we describe the low velocity fraction by a Maxwellian distribution corresponding to an effective temperature T. We have

$$p=\left[4n\Big/\left(\frac{\pi 2kT}{m}\right)^{\frac{1}{2}}\right]\int_0^\infty xe^{-x^2}dx=N,$$

whence

$$n/(T)^{\frac{1}{2}}\simeq10^{-4}\ N.$$

Taking $N=10^{22}$, $n=10^{19}$ gives $T=100°K$, $n=10^{20}$ gives $T=10^4$. In view of experimental uncertainties, this can be considered satisfactory.

Additional evidence in favor of the conduction theory is afforded by Smith's[1] observation that a continuous spectrum originates within 10^{-3} cm from the cathode surface. As is well known, continuous spectra can be obtained from high pressure Hg lamps.

Mierdel's[2] work gives an independent estimate of the thickness of the dense region. If the arc conduction atoms are leaving with velocities of 10^4 or 10^5 cm per Mc and the source is cut off for 10^{-8} or 10^{-9} second, they can move 10^{-4} or 10^{-5} cm in this time. The fact that this extinguishes the arc indicates that the dense region is somewhere near this thickness or less.

A more detailed paper working out various refinements and consequences of the theory is in preparation.

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Hyperfine Structure in the Spectrum of Np^{237} *

F. S. TOMKINS
Argonne National Laboratory, Chicago, Illinois

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IN the course of numerous routine spectrographic analyses of very small samples of Np^{237} it was observed that many of the neptunium lines appeared very broad, even under moderate dispersion (5A/mm), suggesting the presence of wide hyperfine structure.[1] The widest neptunium line in the region investigated, at 3829.15A, was then photographed by use of the third order of a Baird three-meter grating spectrograph (dispersion = 1.7A/mm), with the result that this line was shown to be a flag-pattern type hypermultiplet in which the first three components were resolved.

Larger samples of the isotope have become available and the spectrum has been investigated in some detail using a Fabry-Perot interferometer. The source used was a water-cooled Schuler type hollow cathode tube, and the spectrograph a Bausch and Lomb large littrow type with glass optics.

Under high resolving power all lines exhibiting hyperfine structure appear as flag patterns, some degraded in spacing and intensities toward the red and the others toward the violet. Approximately fifty of these lines have been completely resolved——in each case into six components. This is strong evidence that we are here concerned with a case analogous to that found in praseodymium, where every line showing hyperfine structure which can be resolved is shown to consist of six components.[2]

For neptunium, as in the case of praseodymium, this can be interpreted only to mean that for each of the widely split spectral terms involved, J is greater than I and, consequently, the number of hyperfine levels into which the term is split is equal to $2I+1$. Thus it appears that for Np^{237}, $I = 5/2$.

This work will be published in detail in the near future.

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Characteristics of the Parallel-Plate Counter

L. Madansky and R. W. Pidd
Randall Laboratory of Physics, University of Michigan,
Ann Arbor, Michigan

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THE measurement, by means of particle counters, of very short time intervals is important in the study of successive nuclear transitions and in the measurement of the lifetime of the meson. Lifetimes as short as 10^{-7} second have been measured.[1,2] One of the fundamental limitations in such measurements is the inherent delay time of the counter. In a Geiger counter this delay has its origin in the drift time of the secondary electrons from the point of production to the small avalanche region surrounding the central wire, and consequently varies from one count to another. When the paths of the primary electrons are restricted, by means of slits, to a very small region about the central wire, the delay time can be limited to about 10^{-7} second. The lower limit in lifetimes that can be measured is about 0.3 the average delay time of the counters, provided the distribution of inherent counter delays is accurately known. Hence, the Geiger counter is not applicable to the measurement of lifetimes less than 3×10^{-8} second even with extreme collimation.

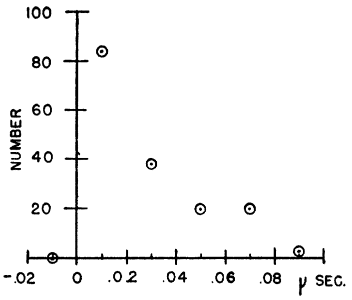

FIG. 1. Time delay distribution.

Since the delay time is inherent in the cylindrical geometry, it has been proposed[3] that parallel-plate electrodes be substituted for the cylindrical electrodes in the Geiger counter. In the case of the parallel geometry the whole counter volume should be uniformly avalanche sensitive; thus, the beginning of the avalanche should follow the formation of the initiating ion without delay.

For the experiment to be described a counter was constructed using 3-mil copper foil as the parallel surfaces. The foils were stretched as "drum heads" in 2-inch diameter circular frames, and were placed 1 mm apart. The counter was filled to a pressure of 2 atmospheres with a mixture of 90 percent argon, 10 percent N-butane. It was necessary to quench the discharge with a Neher-Pickering circuit having a time constant of 10^{-2} second. Under these conditions the counting threshold was 3000 volts with a 900-volt plateau. The pulses produced (without amplification) in a 70-ohm transmission line were about 600 volts in amplitude and had a rise time of less than 10^{-8} second, which agrees with the breakdown time given by Loeb.[4] The efficiency of the counter for electrons was 10 percent.

The delay was measured by causing beta-rays to traverse a thin walled cylindrical Geiger counter and the parallel-plate counter in tandem. To reduce as far as possible the delay in the Geiger counter the beam was restricted by slits which limited it to a 1-mm region surrounding the central wire.

The parallel-plate pulse initiated a $\frac{1}{2}$-microsecond sweep on an oscilloscope (5RP11 tube operated at 10 kv) and the Geiger pulse was displayed as a vertical deflection. A point on the sweep which represented "zero" delay for both counters was found in an auxiliary experiment by connecting the parallel-plate counter simultaneously to the horizontal and vertical circuits. To place the zero in the best part of the screen, a small fixed delay was introduced into the vertical deflection circuit. A deviation to the right of zero on a sweep going from left to right indicated an excess of Geiger delay over parallel-plate delay, whereas a deviation to the left of zero indicated a larger delay for the parallel-plate counter. Results of photographs of the dispersion of the Geiger pulses are shown in Fig. 1. It is seen that, within the accuracy of measurement, there are no pulses to the left of zero, while the distribution to the right shows an average delay for the cylindrical