LETTERS TO THE EDITORS

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Anode and Cathode Arcs

ARCS which are in general less than one micron in length occur at the opening and closing of low-voltage switches. These arcs are initiated and maintained by field emission currents. They are of two quite distinct kinds which are most readily distinguished by the marks which they leave on polished surfaces.

One type, which we call an anode arc, produces a circular pit on the anode and a general roughening of the opposed cathode. Photomicrographs of single anode-type arcs were published¹ before the second type of arc was discovered. In Fig. 1 is shown the surface of a cathode after the occurrence of a single arc of the second type, which we call a cathode arc. The corresponding anode often shows no mark whatsoever.

A feature of the cathode arc is the way in which it accentuates scratch lines on an imperfectly polished surface. At high magnification in an electron microscope (Fig. 2), each line on the cathode is found to be made up of a large number of single pits, each the result of the explosion of an original roughness by field emission current of very high density flowing through it. Each pit overlaps one of its neighbours,

Fig. 1. Photomicrograph of the surface of a polished cathode after a single cathode arc. $\times 1,200$

Fig. 2. Electronmicrograph of part of the mark made on a polished cathode by a single cathode arc. $\times 19,800$. Constant current of 4 amp. for 0.45 μ sec.

Table 1. CHARACTERISTICS OF ANODE AND CATHODE ARCS (polished palladium electrodes)

	Anode arcs	Cathode arcs
1. Anode appearance	Hole	Nothing or shallow hole
2. Cathode appearance	Roughened	Along scratches
3. Occurrence		
Striking potential ≥ 400 V.	Never	Always
Striking potential < 300 V.	Sometimes	Sometimes
4. Arc voltage	9-12	13-18
5. Striking field	High, 9×10^4 V./cm.	Low, 4×10^4 V./cm.
6. Metal transfer by radio-active tracers	Both directions, net from anode to cathode	Cathode to anode

indicating that an arc was moving intermittently along the original scratch.

Some of the characteristics of the two types of arcs are summarized in Table 1. For palladium electrodes, both cathode and anode arcs occur at striking potentials of 300 V. and lower, with anode arcs favoured by clean surfaces and cathode arcs favoured by dirty surfaces. At 400 V. and higher, only cathode arcs occur. The difference in metal transfer given on line 6 of Table 1 is of importance in understanding the direction and size of the erosion of electrical contacts. It would appear that the confusion associated with erosion measurements in the past is resolved when we identify the type of arc responsible for the erosion.

Experimental details, together with a theory of the mechanisms of the two types of arcs, will appear in a forthcoming paper.

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¹ Germer, L. H., and Haworth, F. E., *Phys. Rev.*, **73**, 1121 (1948); *J. App. Phys.*, **20**, 1085 (1949). Boyle, W. S., and Germer, L. H., *J. App. Phys.*, **26**, 571 (1955).

Neutron Yields from Americium-Beryllium Alloys

THE neutron yields from two americium-beryllium alloys have been measured. The alloys were prepared by the reduction of americium trifluoride with powdered beryllium metal in vacuum, according to the reaction:

The beryllium fluoride readily distilled, leaving a fluoride-free alloy.

The α -radioactive purity of the americium was > 99.99 per cent. The total inactive impurities were < 0.5 per cent. Americium trifluoride was prepared by fluorinating americium dioxide with a mixture of dry hydrogen fluoride and hydrogen at 650°C . in platinum. The americium trifluoride was mixed with powdered beryllium, 99.8 per cent pure, and heated in a beryllium oxide crucible at a pressure of 5×10^{-5} mm. mercury. The chemical reaction was followed by observing neutrons from the nuclear reaction $^9\text{Be}(\alpha, n)^{12}\text{C}$ using a boron trifluoride counter connected to a Marconi scaler.

The results of one beryllium reduction of americium trifluoride are illustrated in Fig. 1. A mixture of