Surface Studies of Platinum Metal Contacts

PAPERS AT THE THIRD INTERNATIONAL SYMPOSIUM ON ELECTRIC CONTACT PHENOMENA

The real area of contact between clean film-free mating contact surfaces, the lubrication of platinum metal contacts, the nature of the brown film formed on palladium contacts when rubbed together in atmospheres containing organic vapours, and a new palladium-base contact material were among the topics dealt with at the Third International Symposium on Electric Contact Phenomena, held in June this year at the University of Maine. The forty-two papers presented were made available to the 230 who participated as a preprinted volume (1), and gave rise to vigorous and wide-ranging discussions.

The relation between the electrical resistance between two clean metal contacting surfaces and the area in contact was re-examined by Dr J. A. Greenwood of the Research Division of Burndy Corporation, Norwalk, Connecticut. He produced experimental evidence that contact must always occur at a series of spots—even a Brinell impression in a block of gold shows a multitude of micro-contacts over the contact area—and he then described a mathematical calculation of the constriction resistance of such a cluster of small spots. The problem, he demonstrated, is equivalent to finding the capacity of a set of coplanar discs having the shapes and positions of the contact spots, taking into account the influence of the charge on each disc on the charges on all the others. The solution, derived by the aid of a digital computer, reveals somewhat surprisingly that the resistance of a cluster of small contact spots may, as a result of interaction of the constriction patterns, be less than the sum of the resistances of the individual spots by a factor of up to eight. For the purpose of calculating contact resistance, it may thus be convenient to represent a cluster of small spots by a single spot having an equivalent resistance, its radius being termed by Greenwood the "Holm radius" of the cluster. In many instances, it is found, the resistance observed is close to that which would be expected if the whole area of the cluster were in electrical contact. The value of the Holm radius depends on the mode of distribution of the contact spots as well as on their number and size, and it would appear that this effect provides justification for increasing the diameter of the contact as the electrical duty becomes more severe. The larger contact would be expected to allow the contact spots to be more widely distributed, increasing thereby the Holm radius, and reducing contact resistance.

Lubrication and Wear of Sliding Contacts

The performance of sliding contacts and also of pin connectors is often disastrously impaired by severe wear and galling between the surfaces. Striking improvements can be secured by proper lubrication, and Gunther Steinberg reported the results of an investigation at Stanford Research Institute, Menlo Park, California, on the conditions necessary for the effective use of very thin films of a solid lubricant—in particular of octadecylamine hydrochloride (ODA.HCl)—for this purpose. He found that very thin films of this lubricant, equivalent to 75 to 100 monolayers in thickness (0.15 to 0.2 μg/mm²),

could provide low friction and long working life to sliding gold contacts without interfering at all with contact resistance, provided that the gold surfaces were *not* highly polished. Highly polished surfaces seized after a few operations; surfaces lightly abraded with 600 grit silicon carbide papers operated for long periods with no detectable wear. Boundary lubrication evidently operated in these conditions by a reservoir mechanism, the grooves acting as sinks for the lubricant displaced by the slider. Some earlier work had suggested that lubrication by ODA.HCl might be specific for gold. Steinberg finds, however, that rhodium-gold and rhodium-rhodium systems can be effectively lubricated with this compound. Rhodium plated pin and socket contacts, which without lubrication failed before reaching one hundred insertions, operated for long periods when lubricated with ODA.HCl. Curiously enough, platinum contacts do not appear to respond to lubrication, and more work is evidently needed to explain why this should be. In the discussion, it was pointed out that soft metals such as gold, applied in a very thin layer on a hard surface such as rhodium plate, can by themselves often provide lubrication (like solid ODA.HCl); and the further suggestion was made that in electrodeposited rhodium the minute crack network which is often present may serve as a reservoir for the lubricant.

Films on Palladium

The thin brown polymeric film that forms on palladium contacts when they are rubbed together in air containing traces of certain organic vapours was first described in 1958 by Hermance and Egan, of the Bell Telephone Laboratories, following a systematic study of the contamination of telephone relay contacts during all stages of manufacture and switch-room service. These workers found that foreign deposits could be removed completely for microchemical study by pressing a clear thermoplastic sheet into contact with the warmed contact surfaces, and established that the films which interfered with the performance of palladium contacts were not random dust particles but were composed of a dark powdery substance which formed only in the presence of a very wide variety of organic materials. The deposit is produced on platinum as well as on palladium but not on silver and negligibly on gold. The behaviour of only a few palladium or palladium-rich alloys appears to be known; the effect is usually combated by the use of gold overlay. The composition of the organic film, moreover, has never been positively determined so that it has been uncertain whether it is a compound of palladium or whether palladium acts solely as a catalyst for its formation.

In a paper which unfortunately suffers from translation uncertainties, G. Kamoshito, M. Hirano and N. Hara of the Central Research Laboratories of Hitachi Limited, Tokyo, described an electron-microscope examination of the brown powder before and after electron irradiation which suggests that the powder is in fact a compound of palladium. They also describe the results of infra-red spectrographic analyses which lead them to believe that aromatic compounds are converted to aliphatics by catalytic action by the palladium surfaces. Finally they put forward as a new contact material a mixture of palladium with up to 9 per cent of lead sulphide. The contacts are pressed from a mixture of the powdered constituents and sintered in vacuum for two hours at 800 to 1050°C. The contacts are claimed to have excellent electrical properties with low contact resistance and low noise level, and to inhibit polymer formation.

The Conference, which was a model of good organisation, will certainly be remembered as a major contribution to the study of electrical contact phenomena.

J. C. C.

Reference

1 Proceedings of the Third International Research Symposium on Electrical Contact Phenomena, June 1966. 397 pp. (Department of Electrical Engineering, University of Maine, Orano, Maine. $12.00)