

# Electrical Contact Phenomena

## THE FIFTH INTERNATIONAL CONFERENCE

*The platinum metals featured in many of the researches reported and in the new devices described at the Fifth International Conference on Contacts, held in Munich in May. Nearly 600 workers attended and 22 countries were represented. A varied programme of papers dealt with both theoretical and practical aspects of contact behaviour.*

The many aspects of contacts considered during the conference included those of molten bridge formation, arc phenomena, contact erosion, tarnishing, welding, wear, and the applications of contacts for contactors, relays, circuit breakers, reed switches, brushes, plug and socket connectors, and even the application of platinum "contacts" to a recently introduced semi-conductor switch.

In an introductory lecture, Professor Dr Ing H. Pausch (State Secretary in the Federal Ministry of Transport and of Posts and Telecommunications) dealt broadly with contacts in telecommunications. To emphasise the present position he pointed out that up to 4,000 contacts may be used for one telephone call, and that the 12½ million telephones in West Germany were used to make a total of 30 million calls per day. Professor Pausch considered telecommunications of the future and visualised a combination of electronics and contacts. He explained that there were many examples of inter-connections where fast switching was not required and that, since contacts have given good reliable service in the past, they would continue to be used.

The subject of the molten metal bridge which forms and explodes as contacts break has continued to provide interest, particularly since some excellent high-speed photographs of separating contacts were shown at the contacts symposium held in Swansea in 1968. In Munich, some further high-speed photographs were shown by P. G. Slade, of

Westinghouse, who used streak photography methods to observe bridge rupture and the initiation of the drawn arc. Slade showed that the bridge can start to rupture but can reform, after losing some material, before finally exploding. M. R. Hopkins and T. M. Thomas, of University College, Swansea, reported measurements, using radioactive tracer techniques, of the amount of metal which migrates from one contact to the other during a single operation, taking care to observe which operations were accompanied by the rebridging phenomenon mentioned above.

Migration, as a function of inductance, was investigated for palladium in the inductive range 0.03 to 4.0 micro-henrys for currents of 3, 5 and 10 amp supplied by a 6 volt accumulator. A general tendency for a net cathode gain was seen, with a small peak occurring at about 0.5 micro-henrys. Perhaps more interesting was the observation that the sum of the anode and cathode gains was considerably larger than the volume of the palladium bridge, suggesting that the micro-arc which follows bridge rupture plays a dominant role in the transfer of metal between palladium contacts.

The radiation from the micro-arc was analysed by Dr M. C. Cowburn, who used a low dispersion quartz spectrograph with a detecting system based on a high sensitivity photomultiplier tube coupled to a high-speed oscilloscope. The system was used on platinum contacts operating in a low voltage d.c. circuit. Under certain conditions

of current and circuit inductance, Coburn observed two pulses of radiation, and estimated that two short arcs had been produced, the first of which resulted in metal vapour pressures possibly up to 40 atmospheres. This work showed considerable promise, and it is hoped that Dr Coburn will enlarge on the few results he illustrated at the conference.

On the subject of tarnishing, W. A. Crossland (Standard Telecommunications) pointed out the present trend towards more compact relays having lower operating voltages and lower contact pressures, then explained that, under these conditions, electrical and mechanical breakdown of surface films are reduced and the problem of tarnishing aggravated. He had carried out tests on silver, 30 per cent palladium-silver and 60 per cent palladium-silver in various sulphur-containing atmospheres and showed that their relative susceptibility to tarnishing was roughly in the ratio 70:4:1 respectively. Crossland measured changes in contact resistance, film thickness and film composition and, from his results, demonstrated that film growth occurs preferentially at structural defects, such as scratches and grain boundaries, as well as at impurity inclusions, for example, of iron or copper.

### Sliding Contacts

Sliding contacts were investigated by a number of the contributors to the conference and here the important parameters measured were contact resistance, wear rates and noise. W. H. Abbott (Battelle) who had worked with alloys of palladium-silver and gold-silver, operated in vacuum, synthetic air and nitrogen, found little correlation between friction, wear rates, wear mechanism and mechanical properties. He did, however, stress the importance of the metallic wear process as a source of contact resistance variation or noise, having found a direct correlation between the variation in contact resistance and both the wear particle size and alloy resistivity. Abbott also illustrated the effects of environmental atmosphere, and

stated that, of the permanent gases, oxygen was shown to give the greatest increase in wear debris and decrease in particle size. Professor K. Mano's contribution to the question of contact noise involved the calculation of the noise frequency distribution for various sliding velocities and further calculation to show that the noise increased in proportion to the mean square value of the variation of contact resistance. Good agreement was obtained between the calculated data and experimental results for whole metal contacts.

On the more practical side, Dr K. L. Rau, of Siemens, described the ESK relay which he found to be bounce free and particularly reliable. Fitted with palladium-silver contacts containing between 30 and 50 per cent palladium, the relay had exhibited satisfactory corrosion resistance and had endured thorough testing in the German telephone exchange. H. S. Woodhead (Standard Telecommunications) described the Diaphragm relay and discussed the various contact materials which could be used in it; life tests of appreciable numbers of these relays had been carried out and the results were shown in which silver, palladium-silver and gold contacts were used.

It is perhaps less appropriate to mention here the excellent contributions concerning heavy duty contacts, high-speed power collection and so on, but are a topic which concerned everyone experimenting in the field of electrical contacts, whether for light or heavy duty, was raised by Dr G. Galle who gave a most interesting lecture on statistics as applied to contact testing. He emphasised that the reliability of contact tests depended on whether we measured the effect we wanted to measure and on the amount of truth we revealed in the results derived. Terms such as "Average", "Median", "Mode", "Scatter" and "Variance" were described, and the various methods of illustrating frequency distributions were discussed.

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