Palladium Plating on Telephone Plugs and Sockets

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This article describes the performance of electrodeposited palladium on a typical telephone two-motion selector plug and socket employing contact forces in the range 100 to 300 grammes. The conclusions are based on environmental tests and electrical measurements which indicate that palladium forms a reliable contact finish in this application.

The plug and socket (or more correctly—unitor) employed for connecting two-motion selectors or relay groups to their associated racks in telephone exchanges is illustrated here. It employs nickel silver springs and operates with contact forces of from 100 to 300 grammes. Although these forces are insufficient to disrupt the naturally occurring tarnish film mechanically (1), the practice of imposing 50 V d.c. in telephone circuits is sufficient to disrupt the film electrically. Where 50 V d.c. is not available there is a need for improved contact performance. Silver plating was employed for this purpose but has been abandoned due to silver migration (2). An improved non-tarnishing palladium finish has therefore been developed for these contacts and is considered to be a practical proposition satisfying a wide range of environmental test requirements in low voltage circuits.

Plating Considerations

Barrel plating (electrolytic) was used for this investigation as it provides excellent agitation, gas bubble detachment, uniform deposition and is a convenient means of handling large quantities of contacts. It was found that solution purity, current density, barrel loading (to provide adequate tumbling) and temperature, required reasonably critical control during plating to produce a bright non-porous coating 0.0002 to 0.0003 inch thick. This was achieved by using de-ionised distilled water in the rinsing and palladium solutions and by thorough washing, and scrupulously avoiding transfer of base metals to the palladium bath.

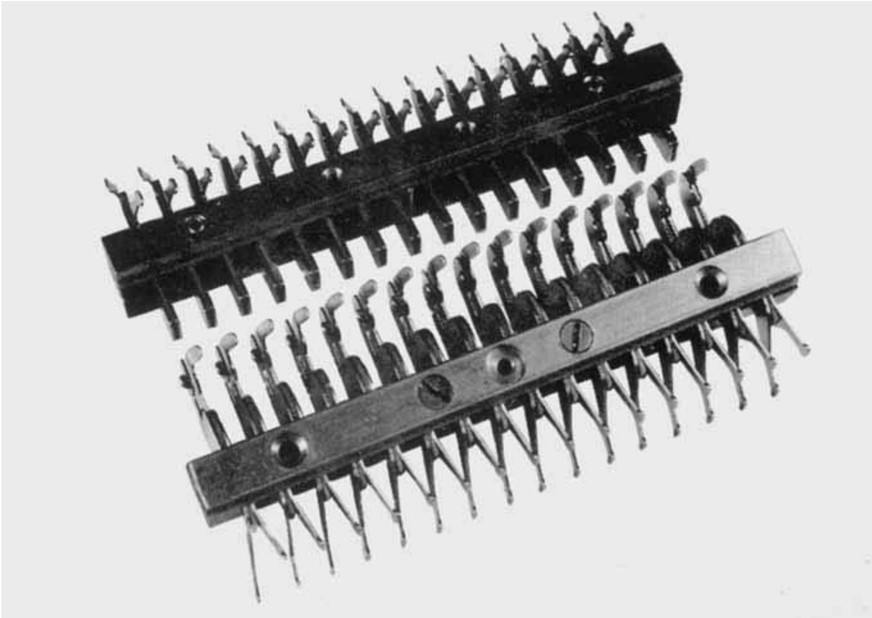
Pre-treatment of the contacts comprised polymotion barrel deburring, chemical cleaning and the application of an acid copper flash. The latter was found to improve adhesion and to show low diffusivity in palladium.

In keeping with most electrodeposits, due to their initial high surface activity immediately after plating, the palladium was prone to fingermark. This is overcome by a hot water rinse which provides a slight measure of passivity.

By barrel plating, the soldering tag terminations of the contacts were coated with 0.0002 to 0.0003 inch palladium. These tags were found to solder very readily with 60/40 tin lead resin-cored solder using a small electric soldering iron. There was no evidence of plating detachment or blistering on a trial of 5,000 contacts.

Contact Resistance

Total contact resistances of the mated plugs and sockets were measured at a maximum open circuit voltage of 50 mV a.c. 1,000 c.p.s. with a current of 50 mA through the contacts. For practical purposes, this



A typical telephone two-motion selector plug and socket

voltage is considered insufficient to disrupt tarnish films at the contact interface.

The pole resistance due to the contact springs was measured separately by welding a typical contact by the discharge of a 32 microfarad capacitor at 230 V. By subtracting pole resistance from the total contact resistance the true contact resistance was deduced.

Gas Exposure Tests

To produce by accelerated environmental testing the actual tarnishing of contacts that occurs in practice is virtually impossible.

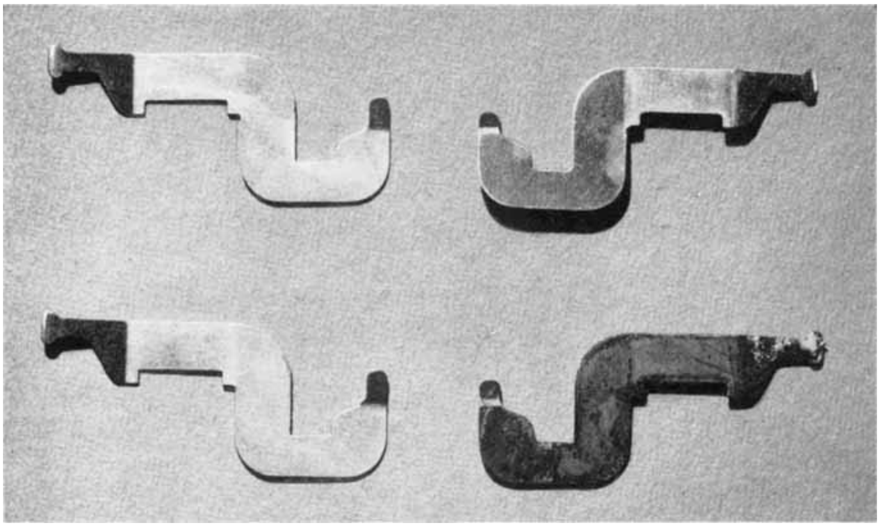
An accelerated test has, however, been devised that produces copious tarnish on base metals and readily detects weaknesses in precious metal deposits. The test has been applied to more than forty commercial plugs and sockets and has consistently discriminated between reliable and unreliable contact.

The actual conditions were as follows: 24 hours in 1 per cent SO_2 in air at 20°C at high humidity followed by 24 hours in 1 per cent H_2S in air at 20°C at high humidity.

The separated plugs and sockets were submitted to these conditions and contact

Table I
Contact Resistance (Milliohms)
(Pole resistance – 7.8 milliohms)

	Before Gas Exposure			After Gas Exposure		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Plain nickel silver	3.5	16	60	15	28,000	320,000
Palladium plated nickel silver	1.6	3.5	7.7	2.5	5.1	12.1



Palladium plated and plain nickel silver contacts before and after the gas exposure test
Top – palladium plated (left) and nickel silver (right) before exposure
Bottom – palladium plated (left) and nickel silver (right) after exposure

resistance measurements were made before exposure and on the first insertion after exposure. The results in milliohms are shown in Table 1 for 192 plain nickel silver and 192 palladium plated contacts.

The results indicated the effectiveness of the palladium plating in preventing the formation of insulating tarnish films. An idea of the severity of the test can be obtained from the photograph which shows palladium plated and plain nickel silver contacts before and after gas exposure.

Constriction Heating

This phenomenon (3, 4) is due to the heating of contact asperities by the passage of current. It may reach a value, characteristic upon the contact metal, at which the voltage drop at the contact interface will produce a softening (softening voltage) or melting (melting voltage) of the asperities.

In the case of base metal contacts, constriction heating accelerates corrosion of the asperities. When plain nickel silver contacts were employed the plug and socket under discussion has developed occasional disconnections in industrial atmospheres due to the passage of 1 A from a 6 V a.c. source. On the other hand, similar adjacent contacts not carrying current continuously, remained unaffected. The mechanism of the former failure has been postulated as follows:

(*a*) Asperities heated slightly by continuous current
(*b*) This accelerates atmospheric corrosion dependent upon the environment
(*c*) Contact resistance and heating increases as the asperities become progressively corroded
(*d*) Eventually the melting voltage is reached at which the asperities melt and the contacts may then either collapse together or become insulated by the corrosion products.

This phenomenon was investigated by passing a maximum current of 1 A from a 6 V a.c. source for three months through nickel silver plugs and sockets having (*a*) plain nickel silver contact surfaces and (*b*) palladium plated contact surfaces. The plugs and sockets were placed in an atmosphere of

Table II
Contact Resistance (Milliohms)

	Initially			After 3 months in 10 ppm SO_2 at 1 A 6 V a.c.		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Plain nickel silver	3.8	20	58	55	525	3,100
Palladium plated nickel silver	2.8	3.1	4.9	3.1	3.8	6.0

10 ppm SO_2 in air throughout this test. In each case 32 contacts were employed.

It was observed that the current could not be maintained through the nickel silver contacts due to contact resistance fluctuations. The current through the palladium plated contacts remained constant. Low voltage contact resistance measurements before and after this treatment are shown in Table II.

Influence of Dust

New plugs and sockets were wired to carry 1 A through ten connections from a 6 V a.c. source. Dusts of fuller's earth, barium titanate and powdered glass were liberally applied while the plugs and sockets were inserted and withdrawn fifty times. With both nickel silver and palladium plated contacts no disconnections occurred during this test.

The contact springs were then oiled with a light mineral oil and the test repeated. Barium titanate and fuller's earth produced one disconnection in twenty operations on nickel silver and one in thirty on palladium. Powdered glass produced one disconnection in three operations on nickel silver and one in five on palladium.

Wear

As a realistic mechanical life test, new plugs and sockets were submitted to 500 insertions and withdrawals at 20°C and a frequency of five insertions per minute. Contact resistance measurements were made as before and are shown below in Table III for ninety-six contacts in each finish. The contact surfaces in both cases were burnished, but did not show visible wear.

Friction Polymers

To investigate the possibility of organic friction polymer interference (5) on the palladium finish, one 32-contact assembly with palladium plated contacts was submitted to 500 insertions and withdrawals in benzene vapour in air. The closed assembly was then vibrated 100,000 times in this vapour. Contact resistances and appearances are given overpage in Table IV. The brown deposit after 100,000 vibrations conformed to the description of a friction polymer. It did not influence the contact resistance appreciably and apparently had been displaced by the normal contact forces and is not considered detrimental in this application.

Table III
Contact Resistance (Milliohms) after 500 Insertions

	Minimum	Average	Maximum
Nickel silver contacts	9.8	15.5	80.0
Palladium plated contacts	3.5	4.5	7.2

Table IV

	Contact Resistance (Milliohms)			Appearance of Contact Surface
	Minimum	Average	Maximum	
Initially	4.0	4.9	5.0	Bright and clean
After 500 closures in benzene vapour ..	4.0	4.3	5.4	Bright and clean
After 100,000 vibrations; closed assembly in benzene vapour	3.6	5.1	7.2	Bright with a little brown deposit around the contacting area

References

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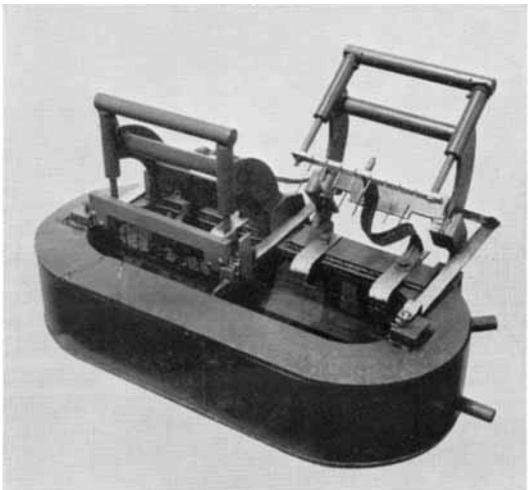
COBALT-PLATINUM MAGNETS RESIST CORROSION



The combination of outstanding magnetic properties and resistance to chemical attack has made possible the use of Platinax II cobalt-platinum alloy magnets in conditions where ferrous magnets would suffer severe corrosion. The photograph shows an apparatus developed by Thorn-A.E.I. Radio Valves & Tubes Ltd for the electrolytic polishing of nickel radio valve components. In this equipment are eight Platinax II magnets, each 0.375 inch in diameter by 0.2 inch long, attached to the positive electrode. The nickel components, which have to be highly polished both internally and externally with no contact marks beyond the closed end, are held in position by these magnets. With a high current density in a strongly acidic electrolyte operating at 60 to 70°C there have been no apparent burns or marks at the point of contact between the nickel parts and the magnets, which have been in use for over a year without showing any sign of attack or of loss in magnetic strength.