The Pallador Thermocouple

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A sensitive thermocouple, of much greater response than the well-known platinum : rhodium-platinum combinations, and free from the oxidation problems associated with base metal thermocouples, is provided by a palladium-gold alloy and an iridium-platinum alloy. This article describes recent investigations that confirm the usefulness of this thermocouple at temperatures up to 1000°C.

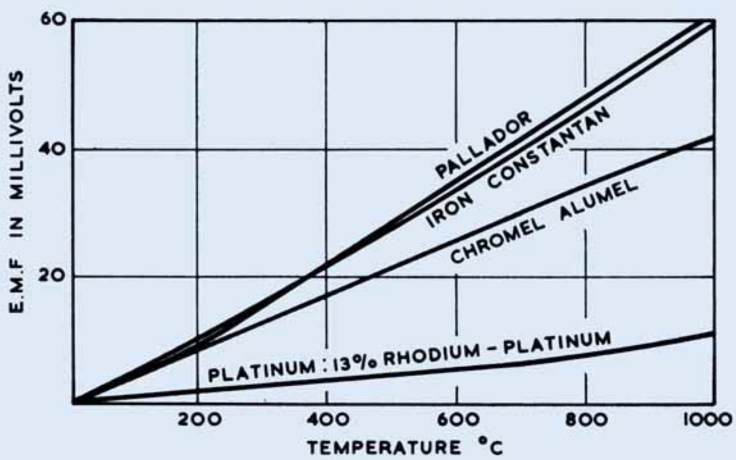
For the measurement of temperatures above 1000°C the platinum : rhodium-platinum thermocouple is outstanding in its reliability and widespread applications. At temperatures below this, several alternative means are available, including the platinum resistance thermometer and the various base metal thermocouples. In some applications the relatively large size of the platinum resistance thermometer and its rather delicate construction make it inconvenient to use, while the base metal thermocouples are naturally susceptible to heavy oxidation and consequent loss of calibration if exposed to high temperatures for long periods. Again, while the platinum : rhodium-platinum couple can well be used below 1000°C, its relatively low thermal e.m.f. in this range is a disadvantage.

For some years now there has been available a noble metal thermocouple which admirably fits into the medium temperature range, but until quite recently it has not been altogether accepted as a completely reliable element. Further research on this combination—a wire of 40 per cent gold-palladium and one of 10 per cent iridium-platinum—has now resolved certain doubts that formerly existed and has shown this thermocouple, known as the Pallador couple, when prepared under careful control, to be reliable and accurate when used at temperatures up to 1000°C even for quite long periods.

The remarkably high thermal e.m.f. of the 40 per cent gold-palladium alloy against platinum was first observed by Wilhelm Geibel (1) as long ago as 1910. Geibel, working in the Heraeus research laboratories in Hanau, carried out a comprehensive study of a number of noble metal alloys, using materials of a higher purity than had hitherto been available. Burgess (2), the collaborator of Henri le Chatelier, described his work as "the most thorough and reliable investigation of the electrical and mechanical properties of the noble metals and their alloys in view of their availability for temperature measurement". Among many other determinations, Geibel found that the addition of gold to palladium had an extraordinarily marked effect on the thermal e.m.f. of the alloys against platinum, with a maximum at 40 per

Physical Properties of Pallador Thermocouple Alloys

	40 per cent palladium-gold	10 per cent iridium-platinum
Specific resistance, microhm-cm at 0°C	27.0	24.5
Temperature coefficient of resistance (0–100°C), per °C	0.00034	0.0013
Thermal conductivity, c.g.s. units	0.070	0.074
Melting point (solidus), °C	1450	1780



Calibration curves for Pallador and other thermocouples

cent of palladium, the value at 1000°C being —42.7 millivolts. He proposed the use of this combination for temperature measurement, commenting that it gave a response no less than six times greater than that of the platinum : rhodium-platinum thermocouple.

In more recent years it was found preferable to use the 10 per cent iridium-platinum alloy as the positive limb, this combination developing a still higher thermal e.m.f.

Various investigators have since reported it to be unstable at high temperatures, the view generally advanced ascribing the instability to oxidation of the palladium, and in consequence it was at one time recommended for use only up to 500°C. The present writer (3) found that heating to temperatures above 900°C was found to cause a progressive increase in e.m.f. of the palladium-gold alloy against the platinum alloy, while the palladium-gold limb became gradually embrittled. Although the appearance of the wire surface remained bright, examination under the microscope showed penetration from the surface of what appeared to be oxide.

More recent work (4) has shown that when the 40 per cent palladium-gold alloy is prepared under conditions that preclude the absorption of any appreciable gas content, and is also given a stabilising treatment prior to drawing, it does not suffer embrittlement or significant change in calibration after prolonged service in air up to 1000°C.

This couple, therefore, with its high e.m.f. and freedom from corrosion when heated for long periods in air, offers a distinct field of usefulness at moderately high temperatures.

The temperature : thermal e.m.f. relationship for the Pallador couple is given in the graph by comparison with those for the iron : constantan, chromel : alumel and platinum : rhodium-platinum thermocouples. The physical properties of the two alloys forming the couple are given in the table.

References

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