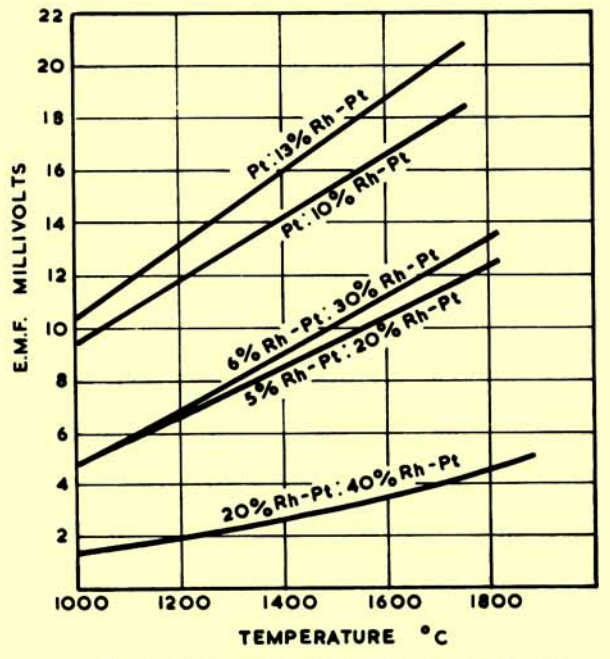
A Rhodium-Platinum Thermocouple for High Temperatures

NEW CALIBRATION VALUES FOR THE "SIX-THIRTY" COUPLE

For a great many years the thermocouple formed by pure platinum and either a 10 or a 13 per cent rhodium-platinum alloy has been the standard means of measuring temperatures of over 1000°C, particularly in the steel making industry. As is well known, however, for the determination of temperatures much above 1650°C this combination does not provide an entirely satsifactory solution. The pure platinum limb is naturally very weak mechanically at such temperatures, and needs to be supported carefully to avoid creep failure under quite small loads. In addition, there is the tendency at very high temperatures for rhodium to be lost from the alloy wire by oxidation and volatilisation and then to be picked up by the pure platinum wire, with a consequent reduction in the e.m.f. of the couple.

For special purposes, therefore, there has been an interest in thermocouples consisting of two different rhodium-platinum alloys, and several such combinations have been proposed to provide increased mechanical strength, less sensitivity to contamination by volatilised rhodium and the possibility of being used to measure somewhat higher temperatures. The e.m.f. developed between two such alloys is, of course, appreciably less than that between the alloy richest in rhodium and pure platinum, and it is desirable to choose two alloys giving as high an e.m.f. as possible. On the other hand the melting point of the alloy lower in rhodium content should be as high as possible. Thus thermocouples of 5 per cent rhodium-platinum: 20 per cent rhodium-platinum ("five-twenty"), 6 per cent against 30 per cent rhodium-platinum ("six-thirty"), and 20 per cent against 40 per cent rhodium-platinum ("twenty-forty") have been developed and have found applications to a moderate extent.



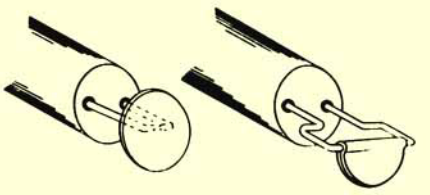
Temperature-e.m.f. characteristics of rhodium-platinum thermocouples above 1000°C. The graph also shows the maximum temperature of usefulness of each combination.

The alloys with 5 or 6

per cent rhodium have a melting point of approximately 1820°C, so that couples employing one of these as the negative limb can be used to measure temperatures up to 1800°C for a short time. The 20:40 combination, although capable of measuring up to as high as 1850°C for short periods, gives an appreciably lower e.m.f. The relative e.m.f. characteristics of these thermocouples above 1000°C, and their maximum temperatures of use, are shown in the graph.

Calibration tables have been prepared for these couples, but not unnaturally there has been very much less investigation of these alloys by comparison with the intensive study that has been given over the years to the pure platinum and 10 or 13 per cent alloys by national standardising bodies.

A new series of determinations of the characteristics of the "six-thirty" couple is thus particularly welcome. This has been carried out by Walter Obrowski and Walter Prinz of the Degussa Research Laboratories, Hanau, and is published in *Archiv für das Eisenhuttenwesen*, 1962, **33**, (1), 1–3.



The disc melting method devised by Obrowski and Prinz for calibration at the gold, palladium and platinum points. A disc of the calibrating metal is either welded or clamped to the hot junction and its melting point can be accurately observed.

Calibration Table for the 6 per cent Rhodium-Platinum: 30 per cent Rhodium-Platinum Thermocouple

Temperature °C.	E.m.f. in millivolts		Difference in microvolts
	New values	Old values	
0	0	0	—
100	0.033	0.056	+23
200	0.177	0.162	—15
300	0.430	0.419	—11
400	0.789	0.790	+ 1
500	1.247	1.245	— 2
600	1.795	1.796	+ 1
700	2.433	2.442	+ 9
800	3.159	3.162	+ 3
900	3.966	3.964	— 2
1,000	4.847	4.839	— 8
1,100	5.795	5.791	— 4
1,200	6.806	6.811	+ 5
1,300	7.871	7.890	+19
1,400	8.977	9.000	+23
1,500	10.113	10.130	+17
1,600	11.267	11.260	— 7
1,700	12.428	12.390	—38
1,800	13.583	13.520	—63

The e.m.f. values of the two alloys were measured by the compensating method at the primary fixed points laid down in the International Temperature Scale, the boiling point of water, the freezing points of silver and gold, and at the secondary fixed points, the melting points of tin, lead, zinc, aluminium, palladium and platinum. For the higher temperatures—the melting points of gold, palladium and platinum—a modified wire melting method was used in which the wire of the calibrating metal was replaced by a disc clamped to and folded over the hot junction. This was found to give an easier and more accurate reading of the melting point. Readings of e.m.f. values were obtained to an accuracy of ±0.1 microvolt, and more than 2,500 determinations were taken in all.

The main values obtained by Obrowski and Prinz are given in the table, together with those formerly accepted, and the differences between the new and the older values. This work helps to establish the "six-thirty" as a standard thermocouple, and alloys are now available that comply with this calibration table within ± 3°C at the gold point and within ± 4°C at the palladium point.

J. A. S.