Corrosion Resistance of Chromium

EFFECTS OF ADDITIONS OF PLATINUM METALS

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The addition of small percentages of platinum, palladium or other noble metal to readily passivated metals such as titanium and stainless steel has been shown to be capable of greatly improving their corrosion resistance towards non-oxidising acids. A series of papers by Tomashov and co-workers on stainless steel and one by Stern and co-workers on titanium were reviewed and summarised in this journal (1, 2). Now Greene, Bishop and Stern (3), in a paper presented to the Detroit meeting of the Electrochemical Society, have reported the extension of the work to chromium, a metal in which considerably greater interest is being taken than was formerly the case.

Noble metal additions appear to have two main actions: first, by providing points of low hydrogen overpotential they induce a high anode current density at a high potential over the bulk of the alloy surface, so leading to passivation, and secondly, by somewhat

TABLE I

Effect of Alloy Additions on the Corrosion Resistance of Chromium

CORROSION RATE IN MILS/YEAR

Addition	Boiling H_2SO_4 10%	20%	30%	40%	50%	60%	90%	Conc.	Boiling HCl 5%	10%	15%	Boiling 65% HNO_3
Pure Cr	D(a)	D	D	D	D	D	2,400	300	D(b)	D	D	3
0.5% Ir	1	2	13 (49)	43	100	D	—	—	<1	2 (20)	D	34
0.5% Rh	—	3	16 (23)	68	66	970	—	—	<1 (11)	<3 (45)	D	5
0.5% Ru	2	11	17 (48)	83	7,100	—	—	—	<1 (11)	<1 (D)	D	100
0.5% Pt	3	12 (16)	28	175	120	36	D	185	<1	8 (25)	D	200
0.5% Pd	2	8 (14)	22	180	1,500	1,300	—	—	<1 (56)	D	D	15
0.5% Os	1 (18)	67	560	—	—	—	—	—	5 (2,800)	D	D	8
0.5% Au	600	1,900	—	—	—	—	—	—	D	—	—	120
0.5% Re	D	D	—	—	—	—	—	—	D	—	—	5
2% Cu	2,700	D	D	D	—	—	—	—	D	D	D	70
0.5% Ag	—	D	—	—	—	—	—	—	D	—	—	4

D —Dissolved during test
( )—Samples activated with an iron wire for at least one minute
(a)—Corrosion rate = 100,000 mpy (0.5 hr. test)
(b)—Corrosion rate = 240,000 mpy (0.5 hr. test)

TABLE II

Effect of Platinum and Palladium Alloy Content on the Corrosion Resistance of Chromium

CORROSION RATE IN MILS/YEAR

Addition	Boiling H_2SO_4 20%	30%	40%	50%	60%	70%	Boiling HCl 5%	10%	15%	Boiling 65% HNO_3
Pure Cr	D	D	D	D	D	D	D	D	D	3
0.1% Pt	5 (11)	22	100	840	D	D	<1	9 (1,400)	D	9
0.5% Pt	12 (16)	28	175	120	36	D	<1	8 (25)	D	200
1.0% Pt	6 (3)	22	210	68	21	1,260	<1 (5)	140	D	500
2.0% Pt	6 (18)	18	130	28	9	56	<1	3 (51)	D	300
5.0% Pt	1 (4)	18	51	12	—	55	<1 (1)	170 (280)	D	490
0.05% Pd	0·22 (56)	57	—	D	D	—	D	D	—	6
0.1% Pd	0·20 (20)	31	130	1,600	D	—	0·04 (915)	D	—	5
0.2% Pd	0·13 (13)	23	150	1,400	D	—	0·36 (94)	D	—	7
0.3% Pd	1·12 (13)	21	370	1,400	300	—	<1 (48)	D	—	5
0.5% Pd	8 (14)	22	180	1,500	1,300	—	<1 (56)	D	D	15
1.0% Pd	2 (16)	56	2,800	725	400	—	2 (12)	D	D	23

D —Dissolved during test
( ) —Sample activated with an iron wire for at least one minute

blocking the main part of the surface they reduce the overall anode current density required for passivation.

For chromium, Greene and his colleagues obtain the data summarised in Tables I and II. It may be seen that the corrosion resistance in hot sulphuric and hydrochloric acids is markedly increased by noble metal additions. The authors suggest that noble metals accumulate on the surface during dissolution (whether by remaining undissolved or by being re-precipitated), so leading generally to both the effects described above, just as in the previously demonstrated improvement of titanium and stainless steel. In chromium-gold alloy the first effect predominates; in chromium-iridium the second effect.

Chromium, however, exhibits transpassivity, dissolution to Cr^{VI} at very high anode potentials. Consequently its corrosion rate in strongly oxidising nitric acid is increased by noble metal additions, except by those of palladium, osmium and rhodium; palladium and osmium are soluble in nitric acid and thus do not accumulate on the surface, while rhodium, although it is not soluble and accumulates, may be a poor catalyst for the cathodic reduction of nitric acid.

Greene and his colleagues also point out that chromium can be passivated even in hydrochloric acid and shows no evidence of any tendency to *localised* attack when passivity breaks down: these results have much interest apart from the general theme of the paper.

The results generally confirm and extend the theory of Tomashov and of Stern on the mechanism of the action of platinum metal additions. Experimentally, Tomashov has recently reported (4) full confirmation of the Stern school's findings concerning titanium. A further publication by Greene and his colleagues on the effect of noble metal additions on high chromium alloys is promised. All in all, the principle of noble metal additions for increasing the acid resistance of easily passivated metals appears to be now very well established and worthy of extended practical trial.

References

1	T. P. Hoar	*Platinum Metals Rev.*, 1958, **2**, 117
2	T. P. Hoar	*Platinum Metals Rev.*, 1960, **4**, 59
3	N. D. Greene, C. R. Bishop and M. Stern	Paper presented to Electrochem. Soc., Detroit, October 1961
4	N. D. Tomashov	Lecture to Gordon Conference on Corrosion, August 1960

Miniature Moving Coil Relay

IRIDIUM-PLATINUM CONTACT ASSEMBLY

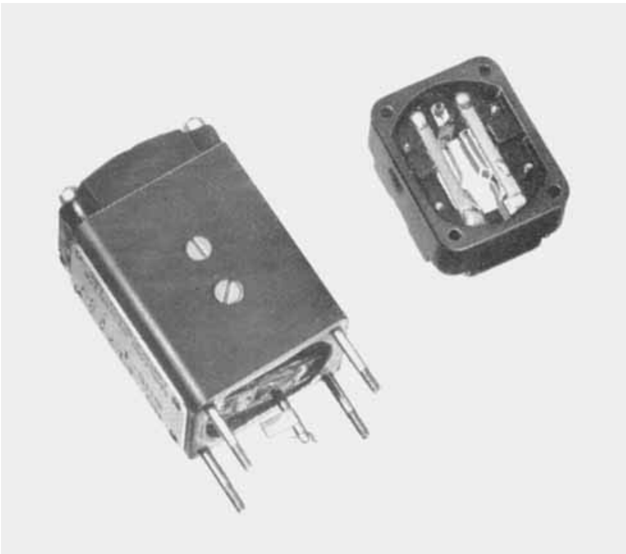
In order to take the fullest possible advantage of the extremely limited operating power available, moving-coil construction is employed for very high sensitivity relays. The type S.115 relay by Sangamo Weston Limited is an example of miniature moving-coil construction, the unit measuring only 51 × 19.5 × 21.5 mm. It can be wound to operate on a current of only 50 microamp.

The contact arrangement comprises a blade of 20 per cent iridium-platinum attached to the lower end of the moving coil, this moving between the two dimpled iridium-platinum strip contacts in the base assembly shown on the right of the illustration.

The hairspring of the relay normally keeps the blade in the central or "off" position.

Provided that spark-quenching is employed, the contacts will handle powers of up to one watt, a.c. or d.c. (substantially non-inductive) and provided that the circuit voltage does not exceed 50 or the circuit current 100 microamp.

Iridium-platinum provides the combination of hardness and complete freedom from tarnish that is essential in this application.



A sensitive moving-coil relay of miniature construction by Sangamo Weston Ltd. Both fixed and moving contacts are in 20 per cent iridium-platinum.