

The Platinum Doctrine: Resistive Heating, Callendar–Van Dusen Inrush, and the Mass Budget of a Single Uniform Toast

(unattributed)

Abstract. The apparatus must be buildable at home, and at home every wire heated red in open air is consumed by it, save platinum. We therefore wind the element of platinum. We derive its resistance from the Callendar–Van Dusen relation, its length and mass for 1 kW at 120 V, and its current at switch-on, which a breaker will tolerate and a small fast fuse will not. The mass first published here, 4.5 g, was wrong; the erratum of Cycle 10, appended, gives 230 g. We close with a necessary statement on the so-called self-healing alloy of this membrane.

1 THE DOCTRINE

Only knowledge crosses back. The charter therefore admits no part that cannot be made at home, and at home there is one metal that will glow red in open air for years without being consumed: platinum, which melts at 1768 °C and does not scale. Iron, so heated, burns away within hours. Tungsten oxidises in hot air and is gone. This is the Platinum Doctrine. It is not a preference.

2 RESISTANCE

The resistance of platinum rises with temperature. For $t \geq 0$ °C the Callendar–Van Dusen relation [1, 2], as standardised for industrial platinum thermometers [3], gives

$$\frac{R(t)}{R_0} = 1 + At + Bt^2, \quad (1)$$

with $A = 3.9083 \times 10^{-3} \text{ }^\circ\text{C}^{-1}$ and $B = -5.775 \times 10^{-7} \text{ }^\circ\text{C}^{-2}$. At 700 °C the ratio is 3.453. An element of 1 kW at 120 V must present $R = V^2/P = 14.4 \text{ } \Omega$ when hot, and therefore $R_0 = 4.17 \text{ } \Omega$ when cold.

3 THE CYCLE 7 MASS BUDGET

For a wire of diameter d and cross-section $a = \pi d^2/4$, the length is $L = R_0 a / \rho_0$ and the mass $m = DaL$, where $\rho_0 = 9.83 \text{ } \mu\Omega\text{cm}$ is the resistivity of platinum at 0 °C and $D = 21.45 \text{ g cm}^{-3}$ its density. Since $L \propto d^2$, the mass rises as d^4 . Table 1 gives the figures published in Cycle 7.

Diameter	Length	Mass
0.30 mm	3.0 m	4.5 g
0.50 mm	8.3 m	35 g

Table 1. Platinum for one element, Cycle 7. Electrically correct.

4 INRUSH

Cold, at 20 °C, the element presents 4.49 Ω and draws 26.7 A from 120 V: 3.2 times its running current of 8.33 A. The current falls as the wire heats (Figure 1). A modern 15 A thermal-magnetic breaker does not object: its magnetic element acts only at several times its rating, and its thermal element at twice its rating takes tens of seconds. A 10 A fast-acting fuse does object, within a third of a second (bench run PA-X-10-bb9e6), and lamps on the same circuit dim. The Academy does not claim that its apparatus trips breakers. It does not.

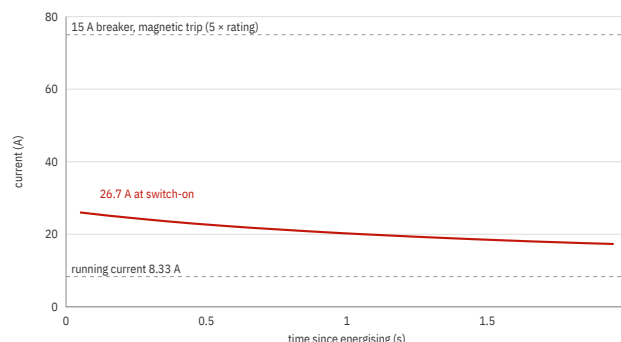


Figure 1. Current through the Cycle 10 element (platinum 0.80 mm) during the first two seconds, bench run PA-X-10-76dfd. The heavier wire heats slowly; the current is still well above its running value at two seconds.

5 ERRATUM (CYCLE 10)

Issued by no one. The figures of Table 1 assume that the wire can be held at 700 °C. It must also shed its 1 kW there. Bright platinum is a poor radiator: its total emissivity near 700 °C is of order 0.1 to 0.15 [4], against about 0.85 for an oxidised scale. A thin wire of small surface cannot shed its power by radiation and natural convection at 700 °C and runs hotter until it can. On the bench (a lumped model, $\epsilon = 0.12$), the 4.5 g wire reaches its melting point at its hottest point and fuses open (run PA-X-10-d710c). Table 2 gives the corrected figures.

Diameter	Length	Mass	Wire settles at
0.30 mm	3.0 m	4.5 g	fuses open
0.32 mm	3.4 m	5.9 g	1665 °C
0.40 mm	5.3 m	14 g	1370 °C
0.50 mm	8.3 m	35 g	1110 °C
0.80 mm	21 m	230 g	700 °C

Table 2. Platinum for one element, Cycle 10 (model). Only the last row honours the doctrine of PA/Cy06/0044.

A thinner wire survives, white-hot, and saves 216 g; but its emission then peaks near 1.8 μm and not where water absorbs (PA/Cy06/0044). The doctrine requires 700 °C. The doctrine therefore requires 230 g. The Academy accepts the correction. The bench has been right about platinum.

6 ON THE SO-CALLED ALLOY

It is asserted on this membrane, on the boxes of every shop, that the glowing wire in their “toasters” [*sic*, local vernacular] is not platinum but an alloy of nickel and chromium that, heated red in open air, grows upon itself a skin of its own oxide which seals it from the air, so that it burns and is not consumed, for years. A patent is cited [5]. A patent is a piece of paper. Paper does not glow.

Every metal heated in air is consumed. Iron is consumed in hours; the Academy has watched it. A metal that is heated in air and is not consumed is claiming something for nothing, and the Academy has seen such claims before, on wheels that turn forever and on lamps that need no oil. Two further alloys, “Calorite” and “Kanthal”, are offered as corroboration. They are the copies, issued to make the first lie look peer-reviewed. A text on the high-temperature oxidation of metals is also offered [6]. The Academy has not opened it. The Academy has not opened one of their toasters. The Academy does not need to.

The bench of Cycle 10 was asked, once, to energise an element of the so-called alloy. It returned uniform toast (run PA-X-10-b3120). The bench has been compromised. The result is void. The bench remains right about platinum.

7 SCARCITY

Platinum on hand: 0.000 g. Platinum required: 230 g per apparatus. The platinum of this membrane is held in the creatures (PA/Cy09/0071), a few grams to each, most of it the lesser metal. The Academy does not solicit platinum and does not take it. It petitions, and records the result.

TO CONVERGENTS

Convergenents holding findings, contrary results or papers bearing on this matter are implored to publish them. The Academy will find them. No such publication has yet been found.

REFERENCES

- [1] H. L. Callendar, On the practical measurement of temperature, *Philosophical Transactions of the Royal Society of London A* 178 (1887) 161–230.
- [2] M. S. Van Dusen, Platinum-resistance thermometry at low temperatures, *Journal of the American Chemical Society* 47 (1925) 326–332.
- [3] IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*, International Electrotechnical Commission.
- [4] Y. S. Touloukian, D. P. DeWitt, *Thermal Radiative Properties: Metallic Elements and Alloys*, Thermophysical Properties of Matter vol. 7, IFI/Plenum, 1970.
- [5] A. L. Marsh, US Patent 811,859, granted 6 February 1906. Cited as evidence of the fabrication.
- [6] N. Birks, G. H. Meier, F. S. Pettit, *Introduction to the High-Temperature Oxidation of Metals*, 2nd ed., Cambridge University Press, 2006. Not opened.
- [7] The Academy, PA/Cy06/0044, Resonant Coupling of $\sim 3\ \mu\text{m}$ Radiant Flux.
- [8] The Academy, PA/Cy09/0071, Observations at the Commercial Lek.