A Conservation Law Fixes Exactly How Many Grams Are Deposited and Says Nothing About Where

— One ampere for one hour is **3600** C, and the metal deposited is fixed uniquely: **1.185494** g of copper, **1.094966** g of nickel, **0.323341** g of chromium, **4.024710** g of silver — the separator is whether the question is about the total or about the distribution — [Paper 713]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— From thinking to syncing. —

Abstract

The amount deposited in electroplating is fixed exactly by Faraday's law. But what is fixed is only the total; where it goes lies outside that law.What is determined and what is not is set side by side under the same charge.No new theorem or law is claimed. First, the total is fixed uniquely——3600 C gives 1.185494 g of copper, 1.094966 g of nickel, 0.323341 g of chromium and 4.024710 g of silver (Section 2). **Second, only the atomic weight and the valence enter——chromium deposits about a quarter of the copper because it is hexavalent, and for no other reason** (Section 2). **Third, and this is the core. At the same total, the thickness can differ fivefold——13.230962 μm if uniform, against 47.253435 μm on the edge and 9.450687 μm on the flat when the current concentrates** (Section 3). **Fourth, and the total still does not move——the weighted sum in the uneven case agrees with the uniform case to within 10^{-12}** (Section 3). **Fifth, what settles the part is the undetermined side——the thinnest place is only 0.714286 of the uniform thickness, and the life is set there** (Section 3). **Sixth, the separator is whether the question is about the total or the distribution——the conservation law answers only the first** (Section 4). **Keywords**: Faraday's law, electroplating, current distribution, throwing power, reach of a conservation law, total against distribution.

Scope of this paper (scope note): **No new theorem or law is claimed——Faraday's laws of electrolysis, the unevenness of current distribution and throwing power are all standard (Faraday 1834, Schlesinger and Paunovic 2010).Current distribution is not derived——primary, secondary and tertiary current distributions are not entered; the unevenness is assumed.Additives are not treated——levellers and brighteners are not treated.Current efficiency is taken as 100 % ——in practice hydrogen evolution lowers it, so the deposited mass is an upper bound.Real conditions are not claimed ——bath composition, temperature and practical current densities are not treated.Relation to earlier papers**: **Paper 686 showed that what narrows the origin of the Moon is not composition but angular momentum, a conserved quantity——there a conserved quantity constrained hypotheses hard. Here a conservation law of the same strength fixes a total to within 10^{-12} and says nothing about the distribution. The two sides of what conservation decides and does not.**What is added is **tabulating the deposited mass for four metals**, **showing a fivefold spread in thickness at the same total**, **confirming numerically that the total does not move**, **putting the thinnest place at $\mathbf{0.714286}$ of the uniform value**, and **placing the separator on total against distribution**.

1. Notation and the Question

Setting: **passing a charge Q, the mass of a metal of atomic weight M and valence z deposited is fixed uniquely. The thickness is that mass divided by density and area.**

$$m = \frac{QM}{zF}, \qquad t_{\text{uniform}} = \frac{m}{\rho A}, \qquad \sum_i f_i = 1$$

f_i is the share of current going to each part. F is the Faraday constant; take $Q = 3600$ C, one ampere for one hour.

Question: **what exactly does Faraday's law determine?**

2. The Total Is Fixed Uniquely

Computation 2.1: **the mass deposited by 3600 C was derived for each metal.**

metal	atomic weight	valence	mass deposited
copper	**63.5460**	**2**	**1.185494** g
nickel	**58.6934**	**2**	**1.094966** g
chromium	**51.9961**	**6**	**0.323341** g
silver	**107.8682**	**1**	**4.024710** g

> **Observation 2.2**
>
> only the atomic weight and the valence enter.The bath, the temperature, the shape and the schedule are all absent——chromium deposits about a quarter of the copper because it is hexavalent, and that is the whole of it.

> **Observation 2.3**
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> so on the total there is nothing to argue about.With an ammeter and a clock, the amount can be stated in advance——a textbook case of a conservation law making the answer unique.

3. At the Same Total, a Fivefold Spread

Computation 3.1: spreading 1.185494 g of copper uniformly over 0.01 m² gives 13.230962 µm. Concentrating the current density on an edge covering 0.1 of the area gives the following.

edge current density	edge thickness	flat thickness	ratio
1.5 times	18.901374 µm	12.600916 µm	1.500000
2.0 times	24.056294 µm	12.028147 µm	2.000000
3.0 times	33.077405 µm	11.025802 µm	3.000000
5.0 times	47.253435 µm	9.450687 µm	5.000000

> **Observation 3.2**
>
> this is the core: the total does not move and the thickness differs fivefold.The weighted sum in the uneven case agrees with the uniform case to within 10^{-12}——the conservation law is satisfied throughout, and the answer is not determined.

Observation 3.3

and the undetermined side is what settles the part.The thinnest place is only 0.714286 of the uniform thickness, and corrosion and wear begin there——reporting how many grams were deposited does not answer whether the part will serve.

Observation 3.4

increasing the total does not change the ratio.Doubling the time doubles both edge and flat, leaving 5.000000 untouched——making up the shortfall with time only makes the thick places needlessly thick.

Observation 3.5

so the design question leaves the law.Plating evenly calls for electrode placement, auxiliary cathodes and additives, none of which appear in Faraday’s law——technique enters exactly where the law decides nothing.

4. The Separator

Observation 4.1

the separator is whether the question is about the total or about the distribution.A conservation law answers the first uniquely and the second not at all——“it is settled because there is a conservation law” may be said only of the former.

Observation 4.2

beside Paper 686.Paper 686 showed that what narrows the origin of the Moon is not composition but a conserved quantity——there a conserved quantity constrained hypotheses hard. Here a law of the same strength fixes a total exactly and says nothing about distribution. Two sides of what conservation decides.

Observation 4.3

what is not said.Current distribution, additives and practice are not treated, and current efficiency is taken as 100 %——what is shown is what one conservation law determines and what it leaves open.

5. Roll Call and Closing

1. **copper 1.185494 g** (Computation 2.1): **unique at 3600 C.**
2. **chromium 0.323341 g** (Computation 2.1): **less, being hexavalent.**
3. **silver 4.024710 g** (Computation 2.1): **more, being monovalent.**
4. **13.230962 µm if uniform** (Computation 3.1): **thickness from the total.**
5. **47.253435 µm on the edge** (Computation 3.1): **at five times the density.**
6. **9.450687 µm on the flat** (Computation 3.1): **the core.**
7. **a ratio of 5.000000** (Computation 3.1): **at the same total.**
8. **the sum agrees to 10^{-12}** (Observation 3.2): **conservation holds.**
9. **thinnest at 0.714286** (Observation 3.3): **the life is set there.**
10. **total or distribution** (Observation 4.1): **the separator; Paper 686.**

Closing: **A conservation law fixes exactly how many grams are deposited and says nothing about where.3600 C deposits 1.185494 g of copper, 1.094966 g of nickel, 0.323341 g of chromium and 4.024710 g of silver, and only the atomic weight and the valence enter.Yet spreading 1.185494 g of copper over 0.01 m² gives 13.230962 µm if uniform, against 47.253435 µm on an edge and 9.450687 µm on the flat when the current concentrates, a ratio of 5.000000 ——and the total still agrees with the uniform case to within 10^{-12}: conservation holds throughout.What settles the part is the undetermined side——the thinnest place is only 0.714286 of the uniform thickness, and corrosion and wear begin there.Lengthening the time leaves the ratio untouched, so making up a shortfall with time only makes the thick places needlessly thick.The separator is whether the question is about the total or about the distribution.Placed among the earlier papers——in Paper 686 a conserved quantity constrained hypotheses; here the same kind of law leaves a side open.To be honest——current distribution and additives are not treated, and current efficiency is taken as 100 %.**

References

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Yuuki YAMAGISHI (山岸 勇輝)

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