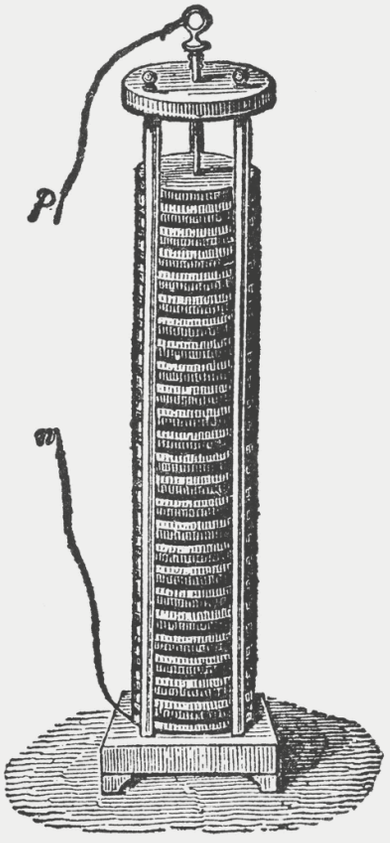


~ 200 anni

L'eredità di Alessandro Volta: le pile dal 1800 a oggi

Luigi Fabbrizzi
Dipartimento di Chimica
Università di Pavia

Scuola Segre 2022 - "XIV edizione 16 - 25 novembre 2022"


DOVE E QUANDO
E' NATA LA
PRIMA PILA?


FINLAND
NORWAY
Baltic
Sea
North
Sea
ESTONIA
LATVIA
LITHUANIA
RUSSIA
BELARUS
UNITED
KINGDOM
IRELAND
GERMANY
POLAND
UKRAINE
FRANCE
Como
1800 d.C.
HUNGARY
MOLDOVA
ROMANIA
Black Sea
Caspian
Sea
GEORGIA
AZER.
ARM.
SPAIN
ITALY
Corsica
Sardinia
BULGARIA
TURKEY
GREECE
Baghdad
SYRIA
CYPRUS
LEBANON
200 a.C.
Sicily
MALTA
Crete
TUNISIA
Mediterranean Sea
ISRAEL
JORDAN
ALGERIA
Gibraltar
(U.K.)

Wilhelm König, Ein Galvanisches Element aus der Partherzeit? *Forschungen und Fortschritte* **1938**, 14, 8–9

La pila di Baghdad – ~200 a.C.

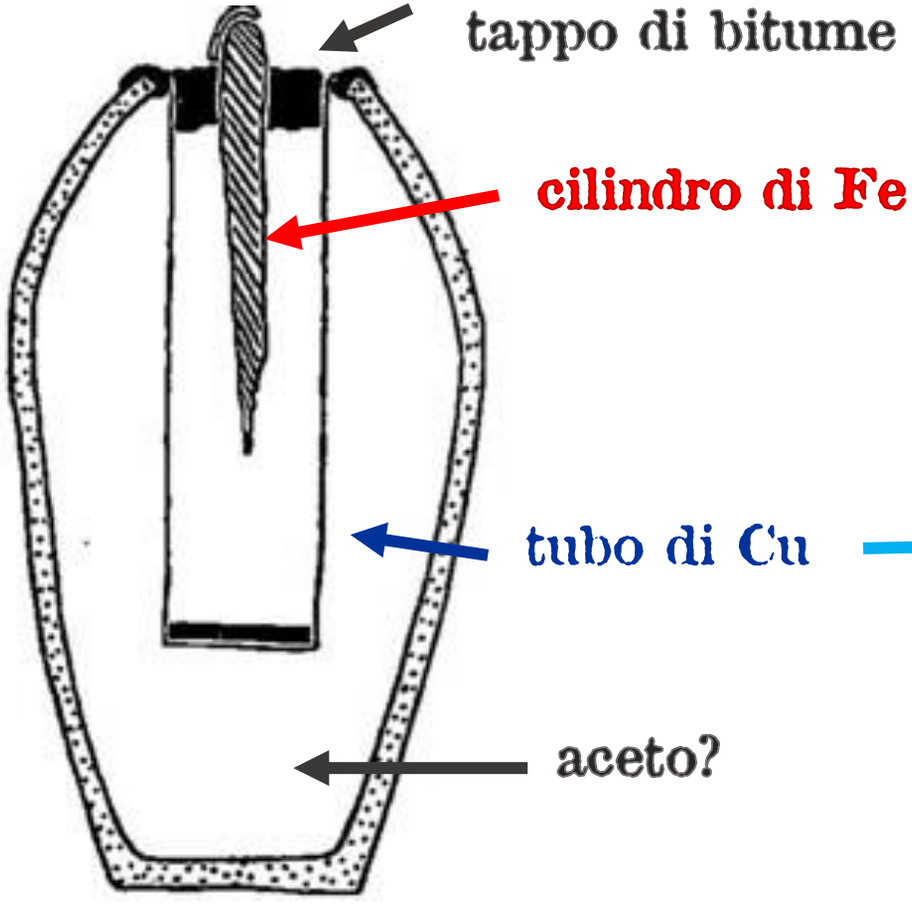
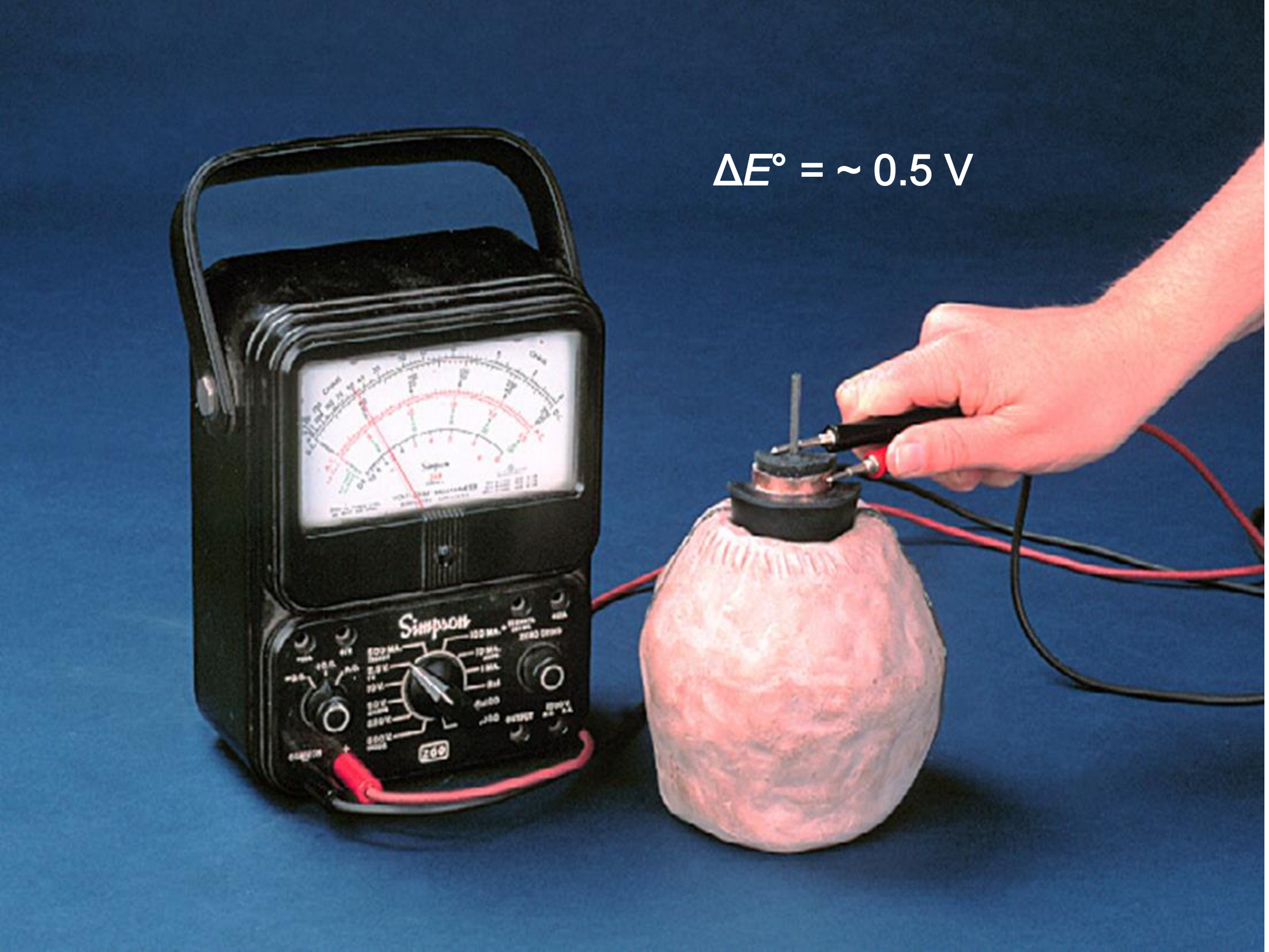


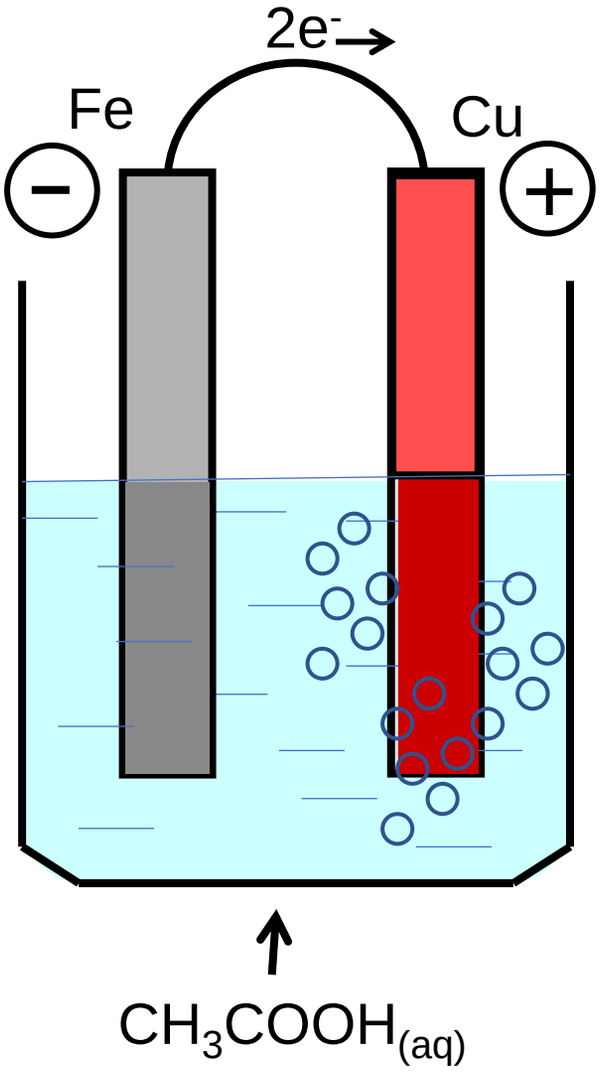
Abb. 2. Schnitt durch das Element

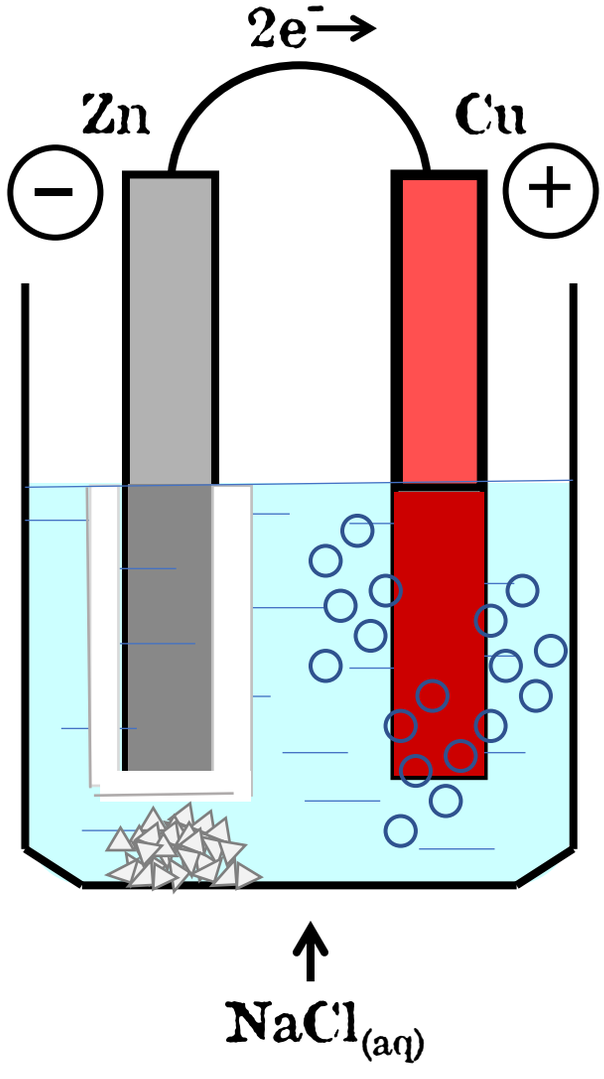
(Fe) donatore $Fe \leftrightarrows Fe^{2+} + 2e^-$ $E° = -0.44$ V

(Cu) inerte $2H^+ + 2e^- \leftrightarrows H_2$ $E° = 0.00$ V

$\Delta E° = 0.44$ V


ΔE° = ~ 0.5 V
Simpson





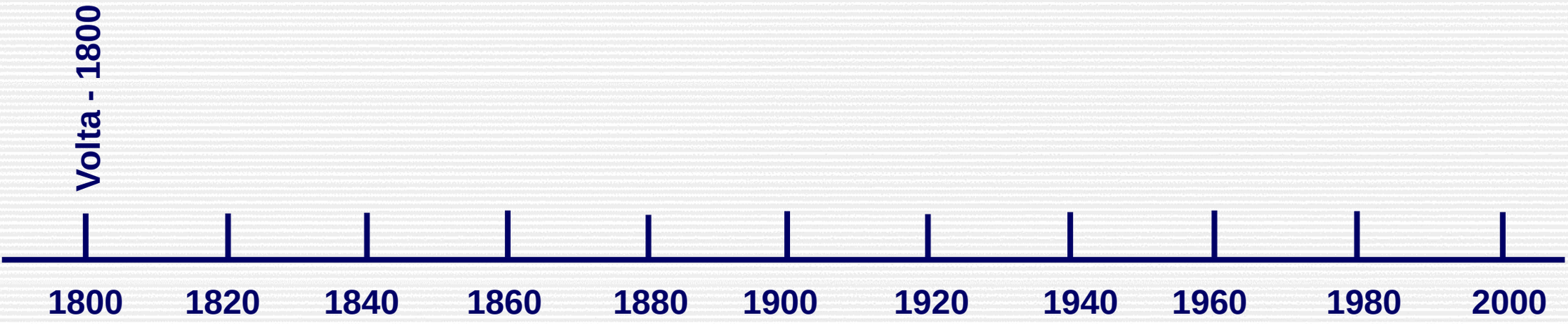
$Fe + 2H^+ \leftrightarrows Fe^{2+} + H_2$

$Zn_{(s)} + 2H_2O \rightarrow Zn(OH)_{2(s)} + H_{2(g)}$

Pila di Baghdad

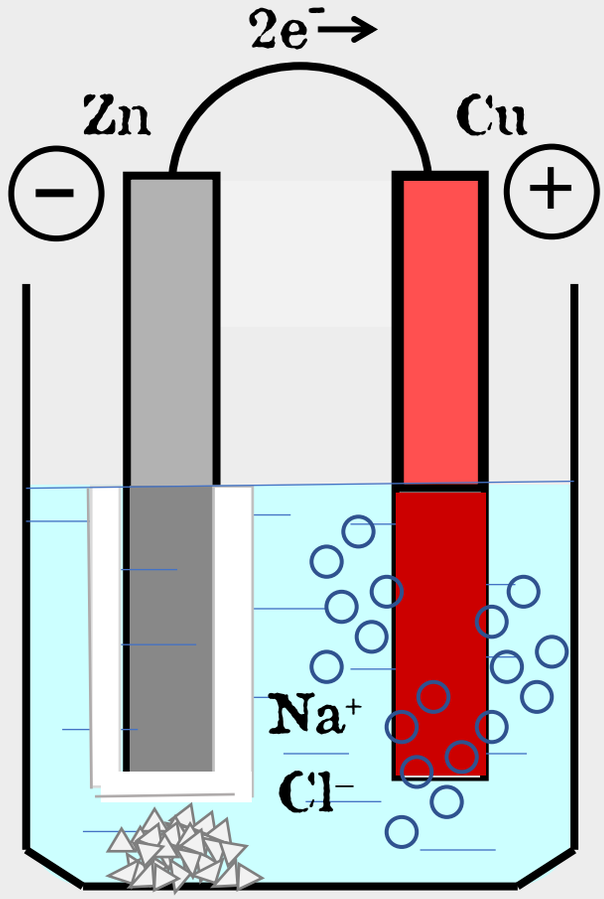
Pila di Volta

Cronologia delle ‘pile’



La pila di Volta (1799) (versione Rame/Zinco) in esposizione presso il Tempio Voltiano, Como

I difetti della pila di Volta



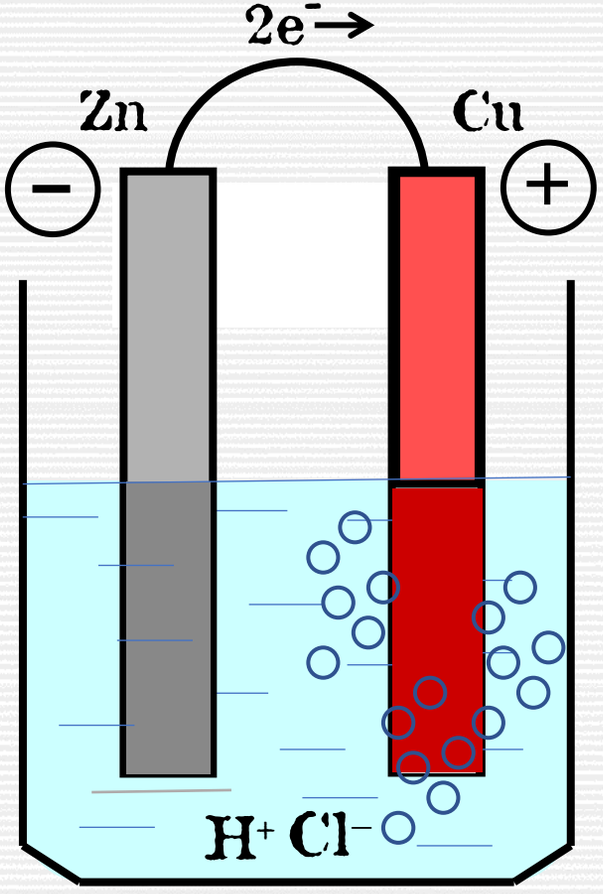
- Si forma $Zn(OH)_2$ sull'elettrodo di Zn
- H_2 viene adsorbito sull'elettrodo inerte (Ag, Cu)

⇨ aumenta la resistenza della cella, diminuisce l'intensità di corrente

William Cruickshank (1740-1811)
Royal Military Academy, Woolwich

Humphry Davy (1778-1829)
Royal Insitution of England, London

usano come elettrolita
NH_4Cl o HCl



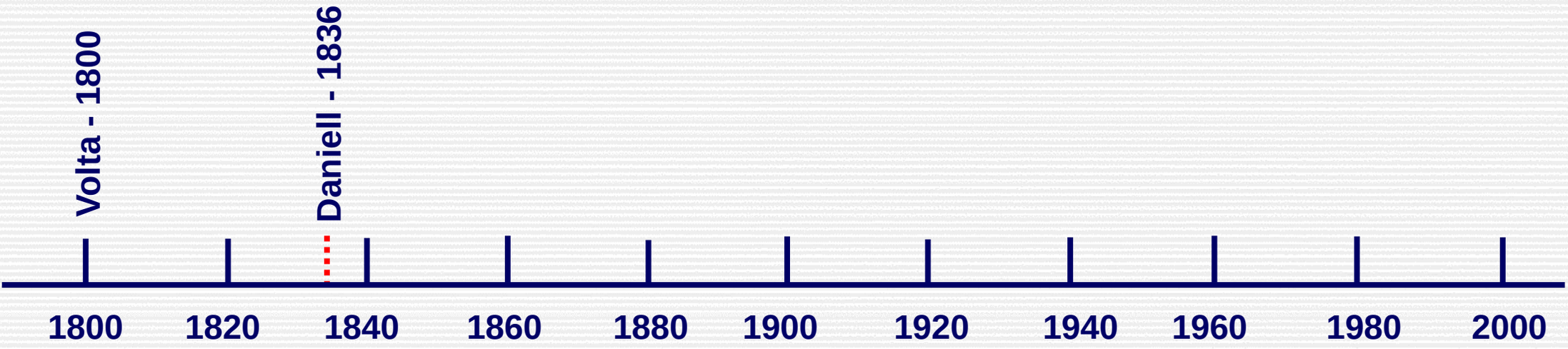
$Zn \leftrightarrows Zn^{2+} + 2e^-$

$2H^+ + 2e^- \leftrightarrows Cu$

acido forte ⇨

non si forma
$Zn(OH)_2$

Cronologia delle ‘pile’



John Frederic Daniell
(1790-1845)
Profesor of Chemistry
East India Company's Military
Seminary at Addiscombe, Surrey

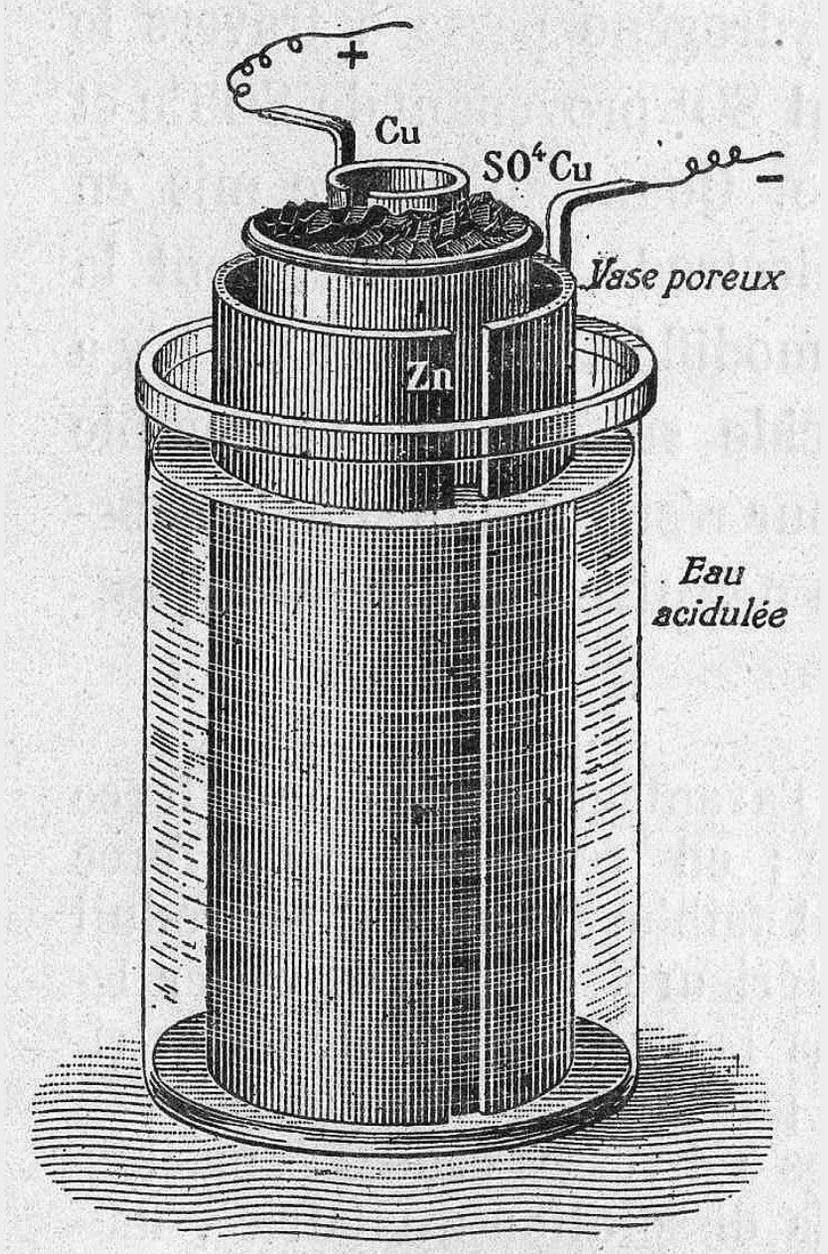
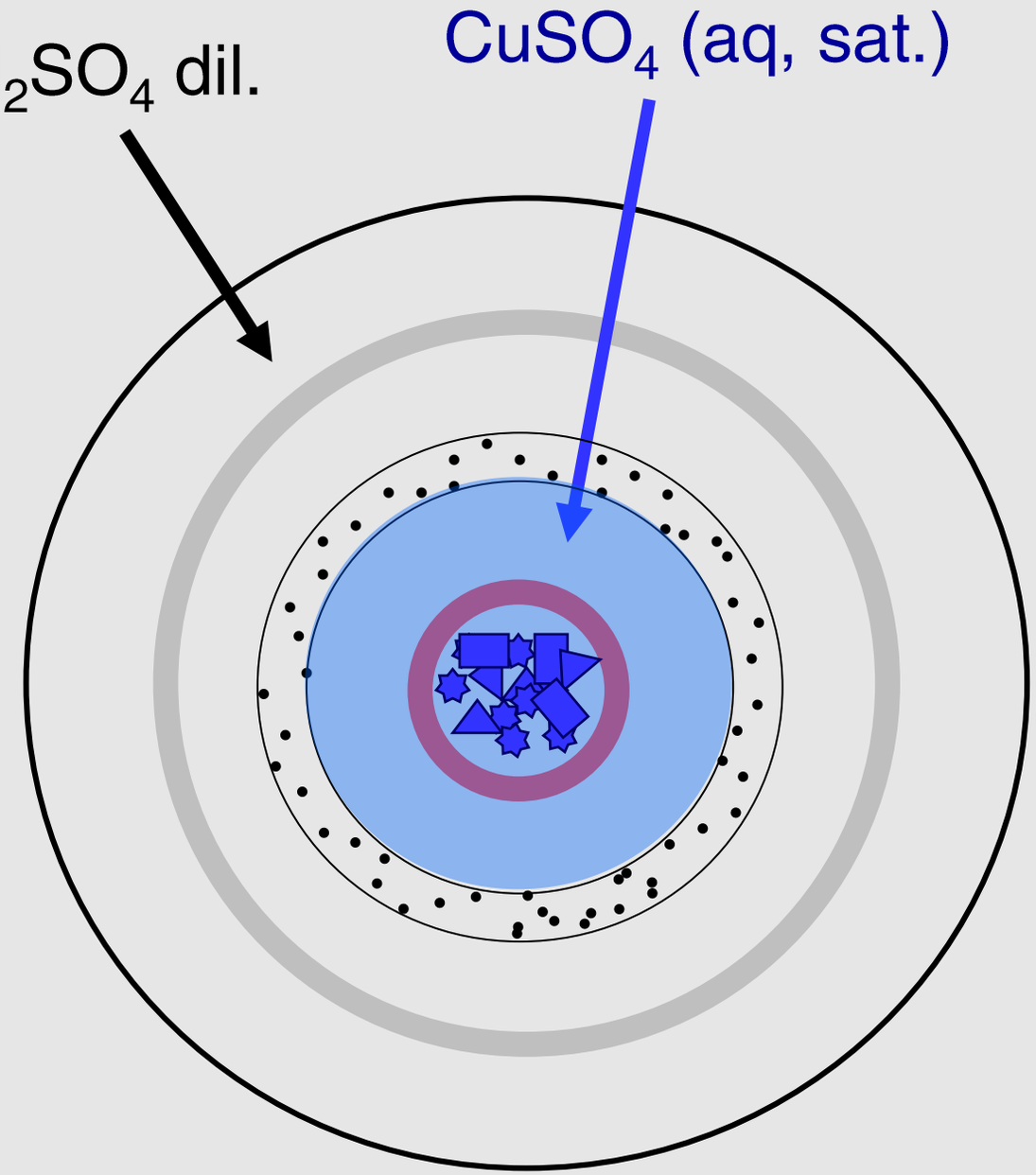


Fig. 284. — Élément Daniell.

La cella Daniell (1836)
Gillard - *Leçons de Physique*, Éditions Vuibert et Nony, Paris, 1904



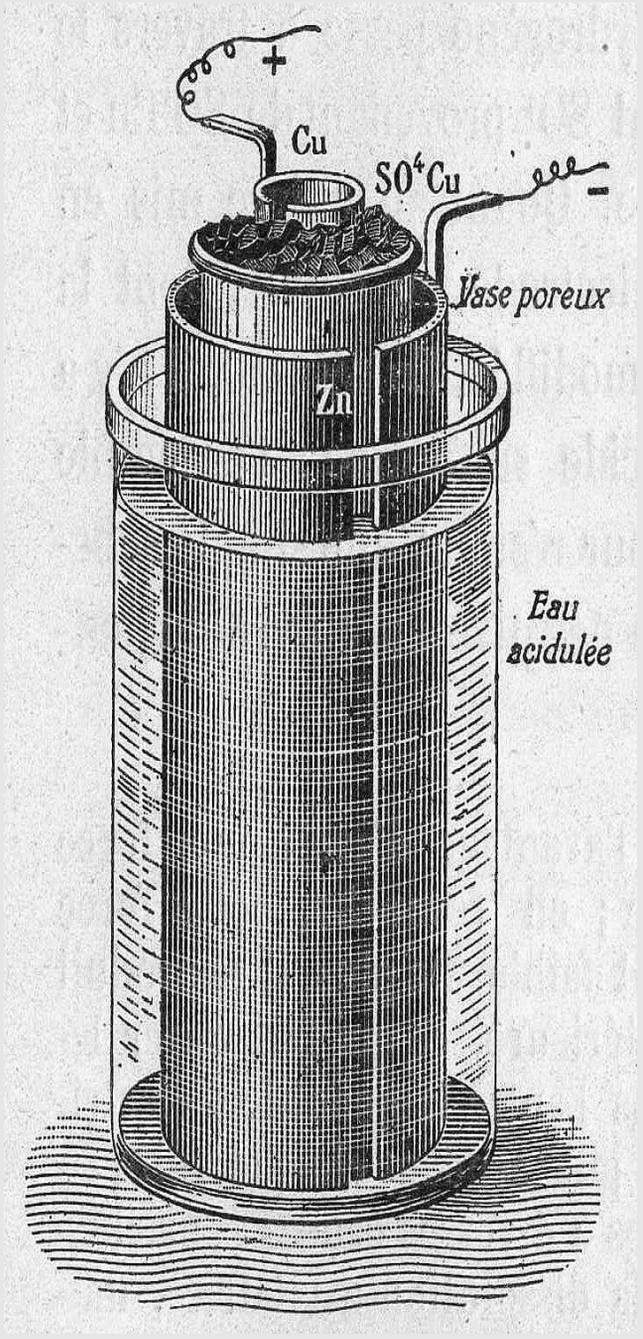
vaso di vetro

cilindro di zinco

vaso poroso

cilindro di rame

$CuSO_4(s)$



$\ominus \quad Zn \rightarrow Zn^{2+}_{(aq)} + 2e^-$

$\oplus \quad Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu$

Daniell cell batteries, 1836, by John Frederic Daniell (England). Exhibit in National Museum of American History, Washington, DC, USA.

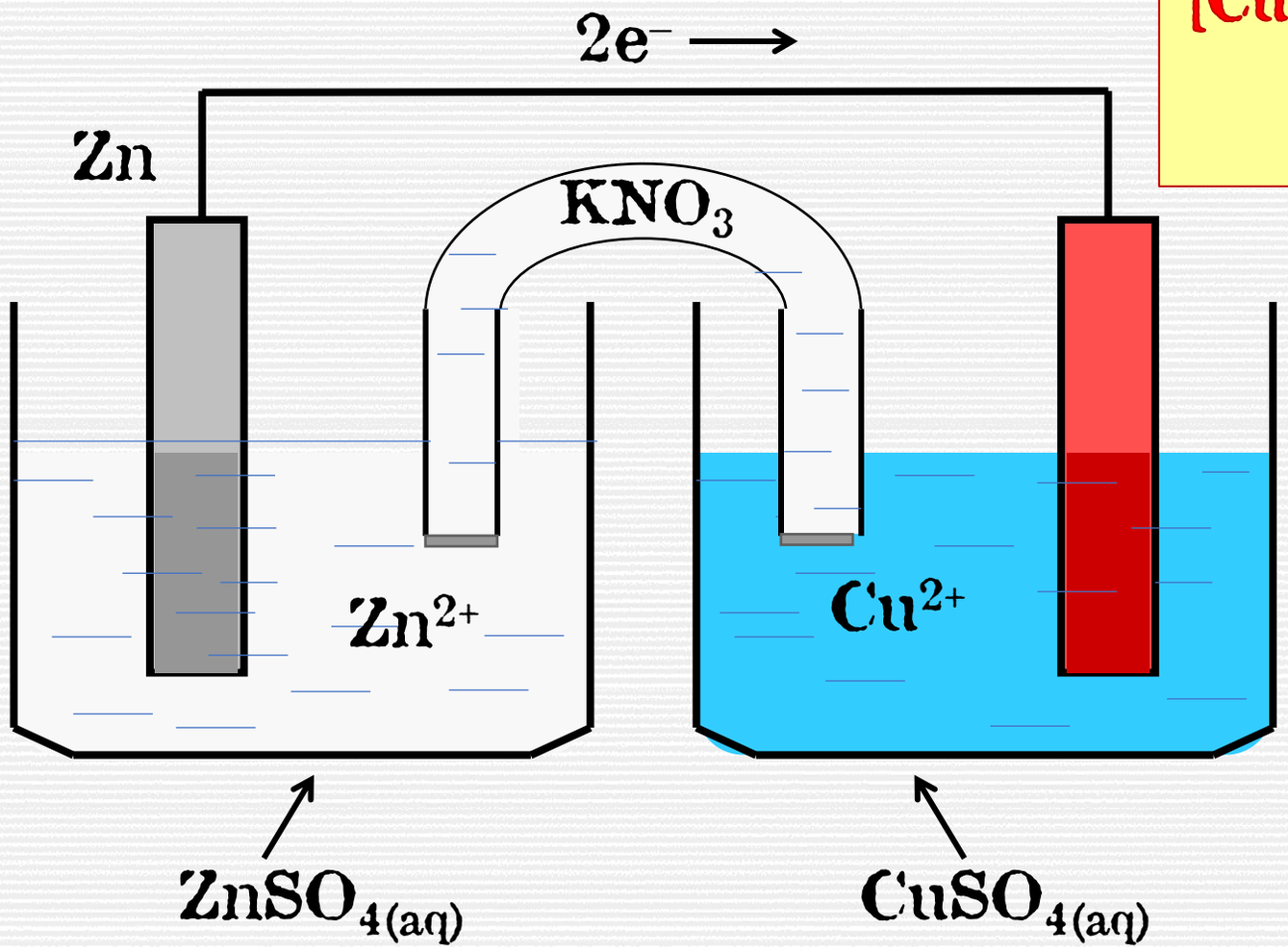
Cella Daniell – versione didattica

$\ominus \quad Zn \rightarrow Zn^{2+}_{(aq)} + 2e^-$

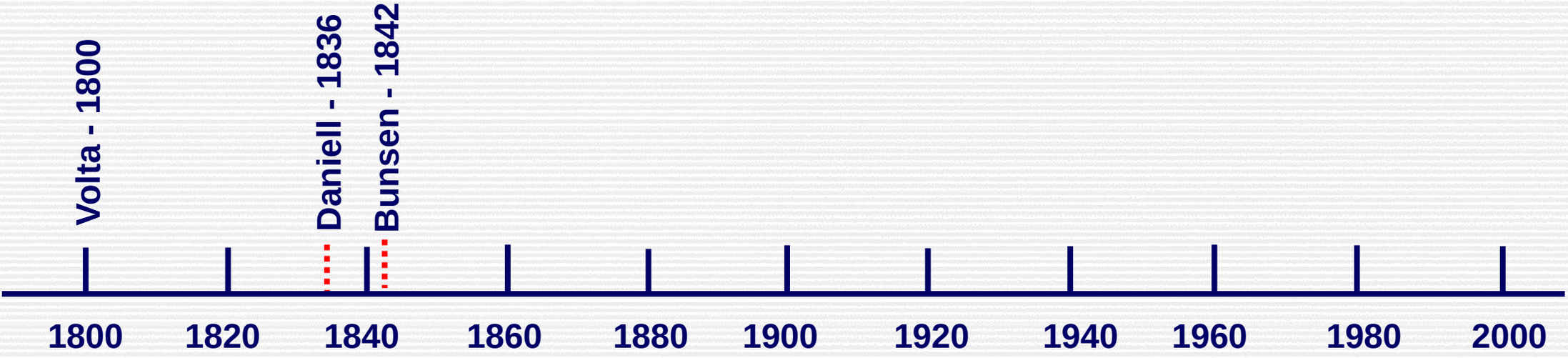
$\oplus \quad Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu$

$Zn + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu$

$[Cu^{2+}] = [Zn^{2+}] = 1\ M$
$T = 25\ °C$
$\Delta E° = 1.10\ V$



Cronologia delle ‘pile’



Robert Wilhelm Bunsen (1811-1899)

Professore a Heidelberg (1852-1889)

- Spettroscopia di emissione degli elementi (con Kirchoff)
- Scoperta e isolamento di cesio e rubidio

Dottorandi: Adolf von Baeyer, Hans Goldschmidt, Fritz Haber, Lothar Meyer, Dmitri Mendeleev, Friedrich Konrad Beilstein, Henry Roscoe, John Tyndall, Edward Frankland.

R. Bunsen, "Über die Anwendung der Kohle zu Volta'schen Batterien (Sull'uso del carbone nelle batterie voltaiche)» *Annalen der Physik und Chemie* **1841**, *130*, 417–430

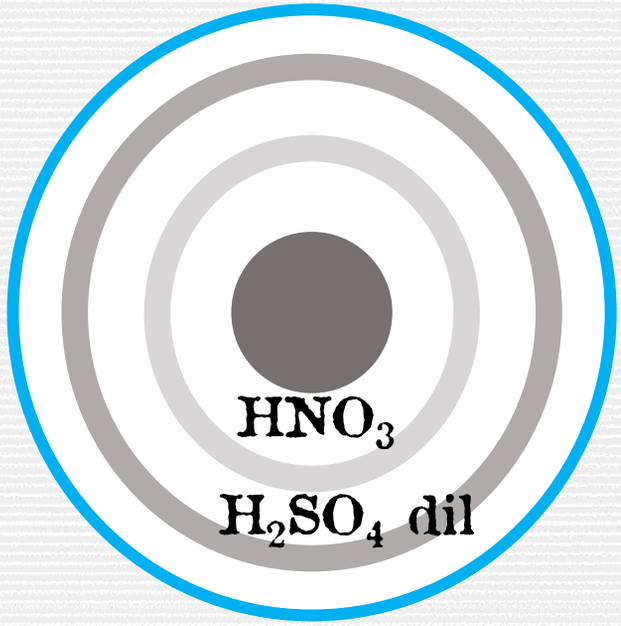
$$Zn + 2\ NO_3^- + 4H^+ \rightleftharpoons Zn^{2+} + 2\ NO_2 + 2\ H_2O$$

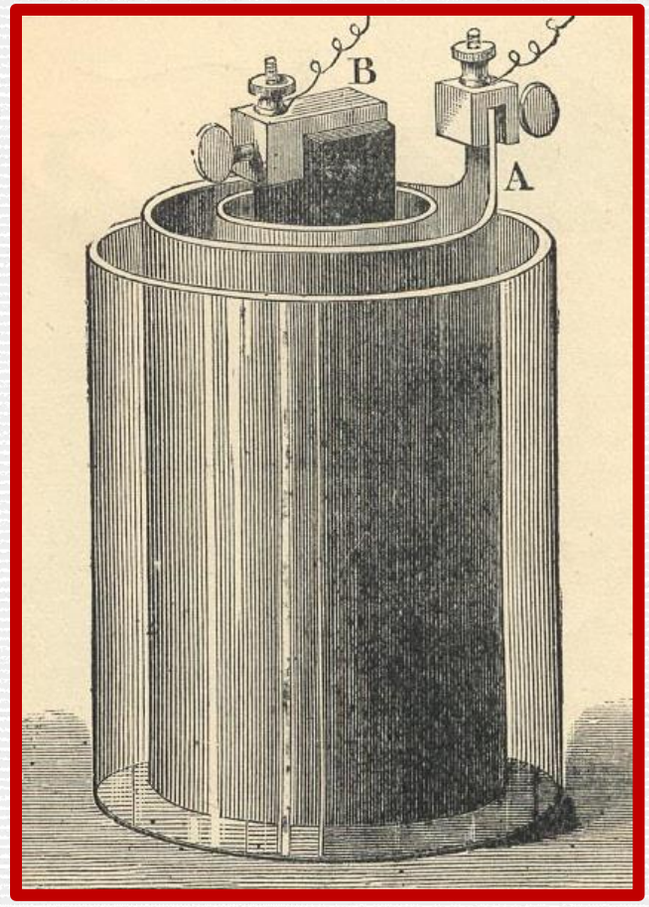
$$3\ Zn + Cr_2O_7^{2-} + 14\ H^+ \rightleftharpoons 3\ Zn^{2+} + 2\ Cr^{3+} + 7\ H_2O$$

elettrodo donatore: zinco

Cella di Bunsen

- vetro
- zinco
- ceramica porosa
- grafite





$$Zn + 2\ NO_3^- + 4H^+ \rightleftharpoons Zn^{2+} + 2\ NO_2 + 2\ H_2O$$

$$Zn \rightleftharpoons Zn^{2+} + 2e^- \qquad E^\circ = -\ 0.76\ V$$

$$NO_3^- + 2e^- + 2H^+ \rightleftharpoons NO_2 + H_2O \qquad E^\circ = \sim\ 0.8\ V$$

$$\Delta E^\circ = \sim\ 1.6\ V$$

Henri Moissan (1852-1907) used a stack of 90 cells for the electrolysis of hydrogen fluoride to obtain fluorine for the first time (1886).

Periodic Table Of The Elements

Number
Symbol
Name
Atomic Mass

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078																36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62																54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.328	89-103 Lant...				76 Os											86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025					107 Bh Bohrium [264]	108	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

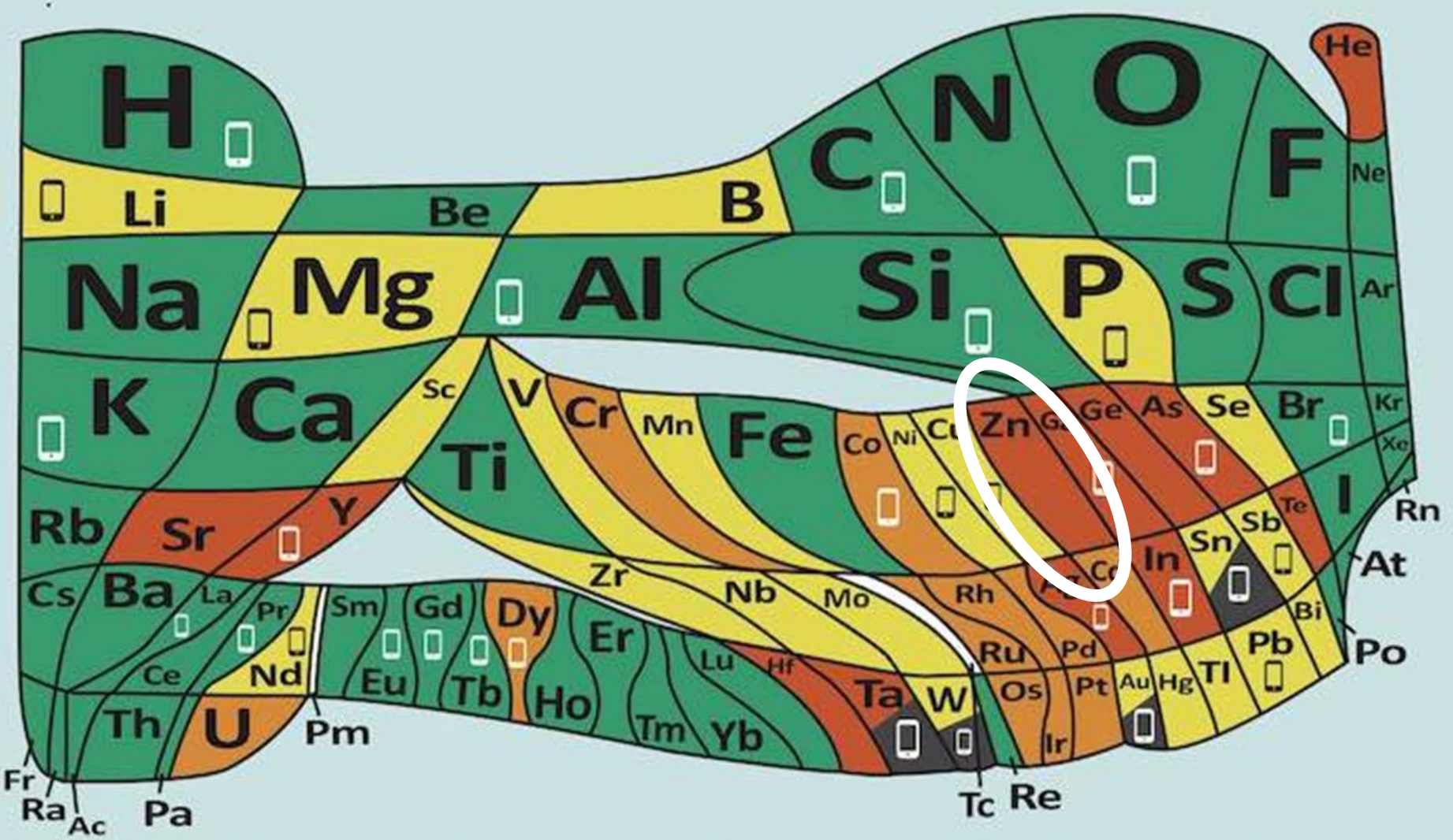
												63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
												95 Am	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Halogen | Noble Gas | Lanthanoid | Actinoid

TAVOLA APOCALITTICA DEGLI ELEMENTI

United Nations onal, Scientific and ultural Organization

2019 IYPT International Year of the Periodic Table of Chemical Elements



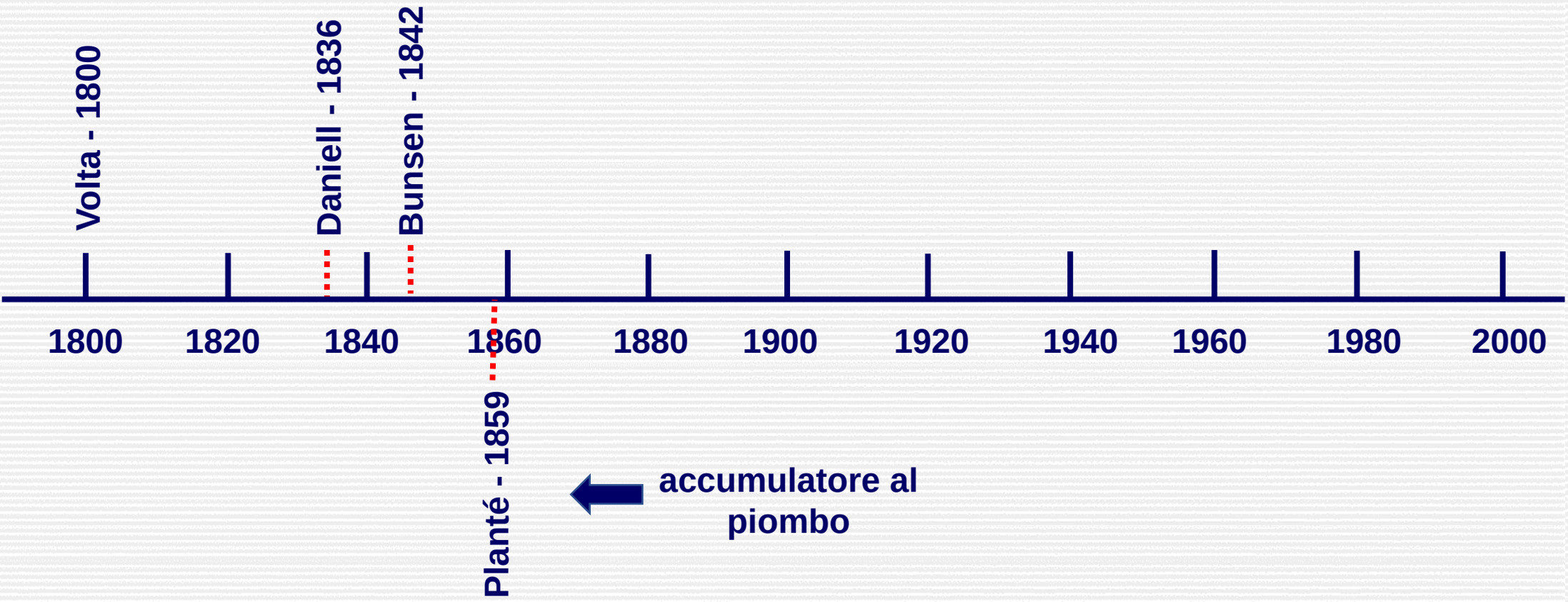
- A grave rischio entro 100 anni
- Sempre più a rischio per il crescente utilizzo
- Disponibilità limitata, a rischio in futuro
- Piena disponibilità
- Di sintesi
- Provenienti da minerali in zone di conflitto
- Presenti negli smartphone

Scopri di più e divertiti con il videogioco su **http://bit.ly/euchems-pt**

EuChemS
European Chemical Society

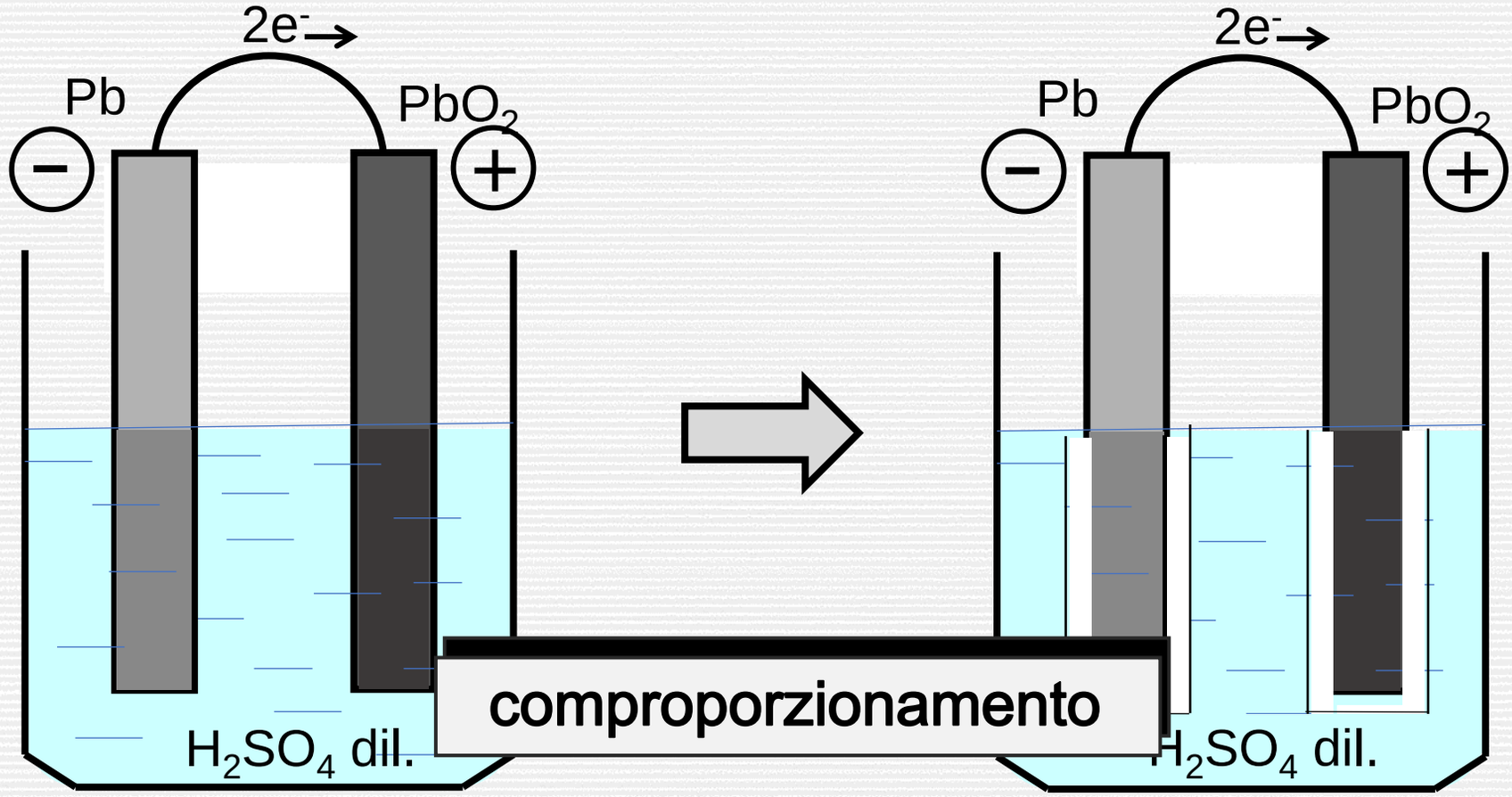
Ispirato a W.F. Sheehan's "A Periodic Table with Emphasis", pubblicato in Chemistry, 1976, 49, 17-18

batterie non ricaricabili



batterie ricaricabili

Cella Planté (accumulatore al piombo)– versione ‘didattica’



$\ominus\ Pb_{(s} + SO_4^{2-}{}_{(aq)} \leftrightarrows PbSO_{4(s)} + 2e^-$

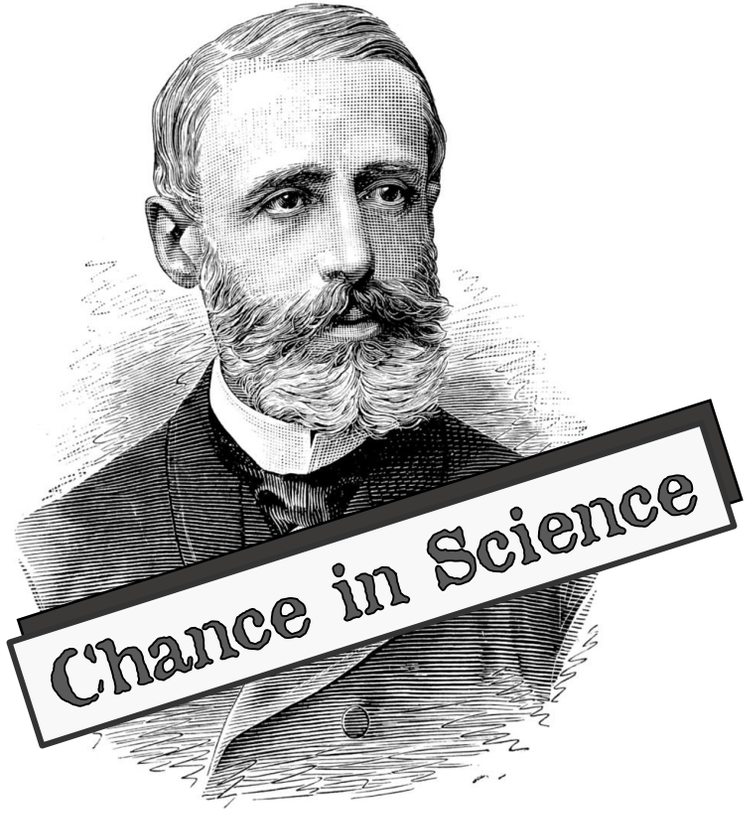
$\oplus\ PbO_{2(s} + 2e^- + SO_4^{2-}{}_{(aq)} + 4H^+ \leftrightarrows PbSO_{4(s} + 2H_2O_{(aq)}$

0 **+4** **+2**

$Pb_{(s)} + PbO_{2(s)} + 2SO_4^{2-}{}_{(aq)} + 4H^+_{(aq)} \leftrightarrows 2PbSO_{4(s)} + 2H_2O_{(aq)}$

scarica →

← **ricarica**



Gaston Planté (1834-1889)
Professeur de Physique à
l'Association Polytechnique
pour le Développement de
l'Instruction Populaire, Paris

RECHERCHES

SUR

L'ÉLECTRICITÉ

PAR

GASTON PLANTÉ

Licencié ès sciences physiques,
Ancien Professeur de Physique à l'Association polytechnique.
Lauréat de l'Institut (Académie des sciences),
Membre correspondant de l'Académie royale des sciences de la Havane,
Membre de l'*American philosophical Society* de Philadelphie, etc.

de 1859 à 1879

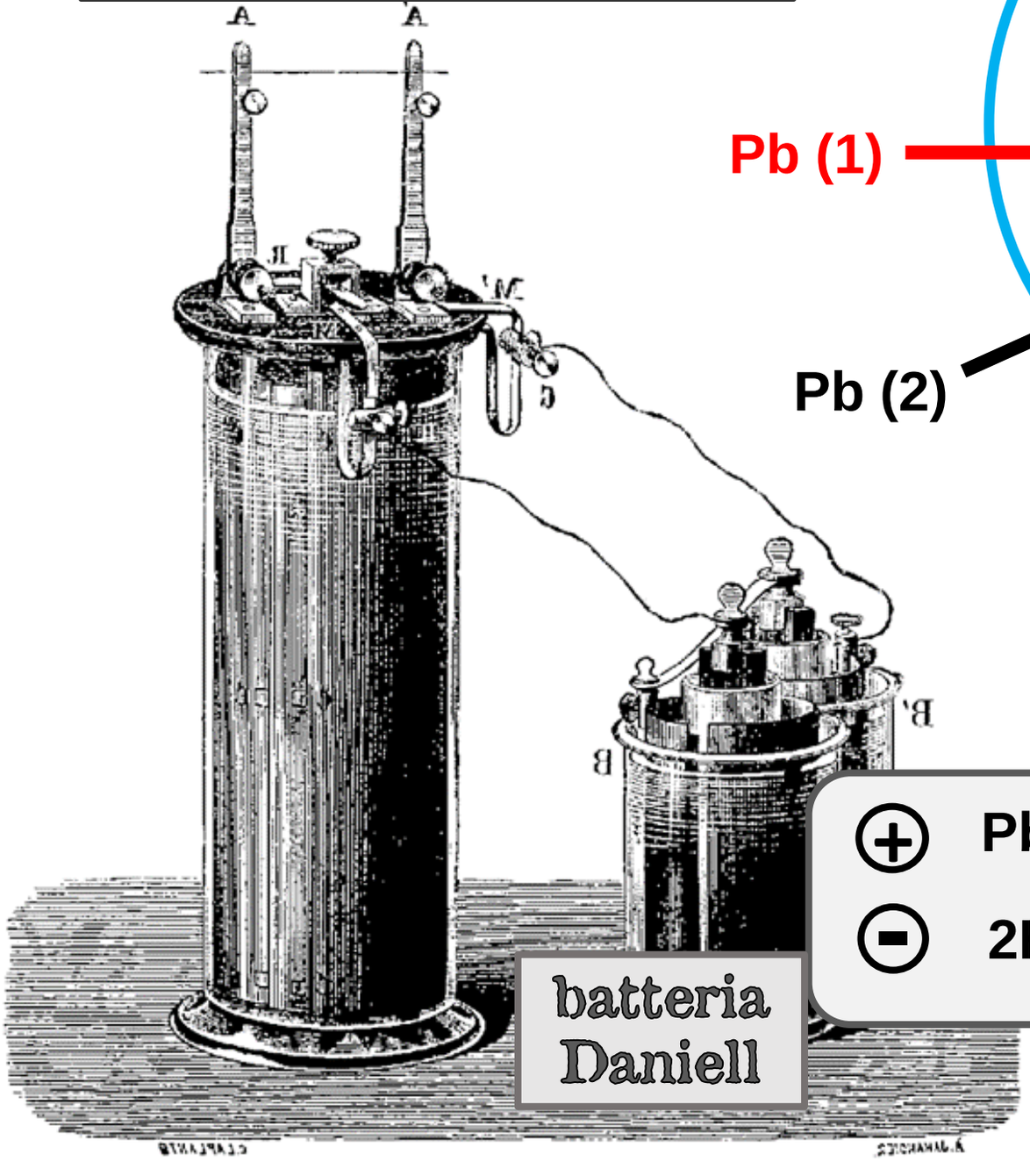
(AVEC 89 FIGURES DANS LE TEXTE)

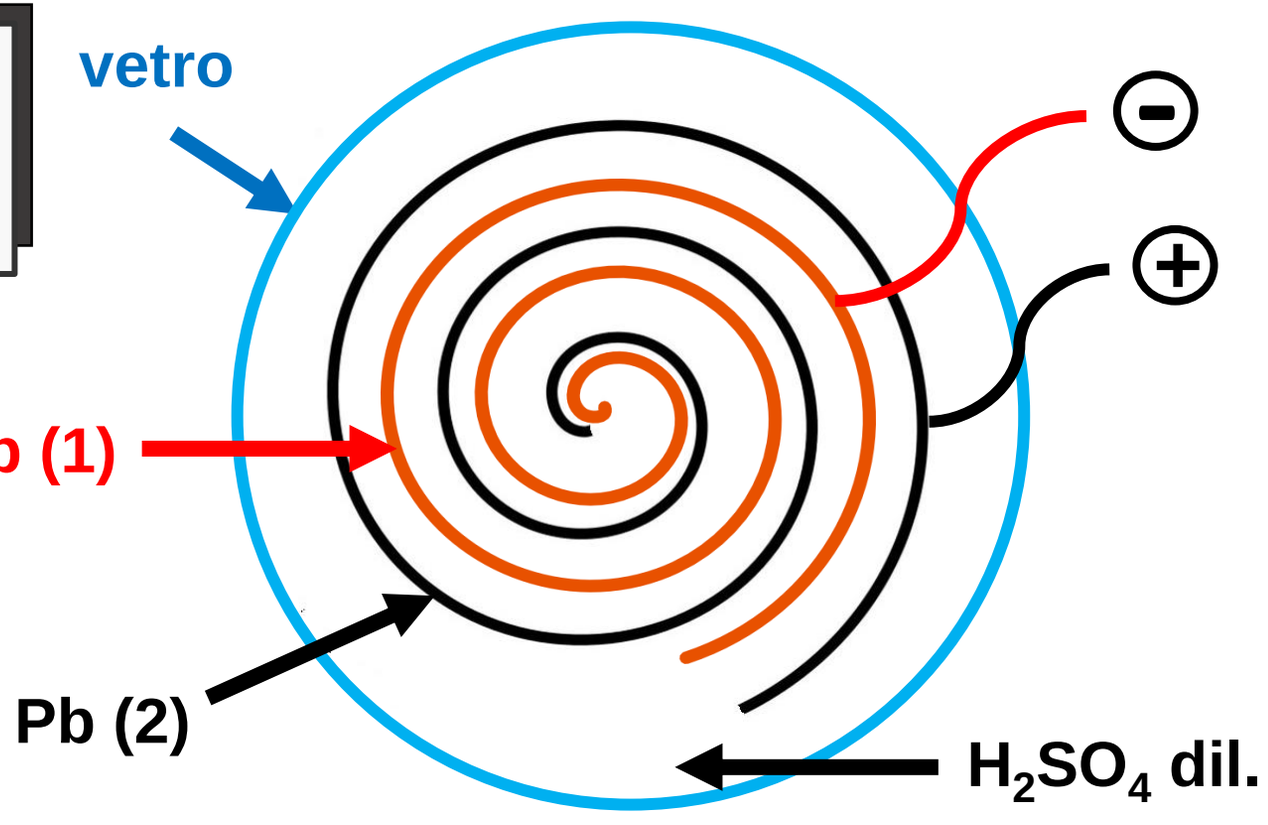
OUVRAGE RÉIMPRIMÉ
SUR LE TEXTE DE LA PREMIÈRE ÉDITION PUBLIÉE
EN FÉVRIER 1879 ET COMPRENANT LES DEUX FASCICULES
SUPPLÉMENTAIRES PUBLIÉS PAR L'AUTEUR
EN OCTOBRE 1879.

PARIS
AUX BUREAUX DE LA REVUE *LA LUMIÈRE ÉLECTRIQUE*
51, RUE VIVIENNE, 51

1883

Elettròlisi su due elettrodi di Pb in H_2SO_4 dil



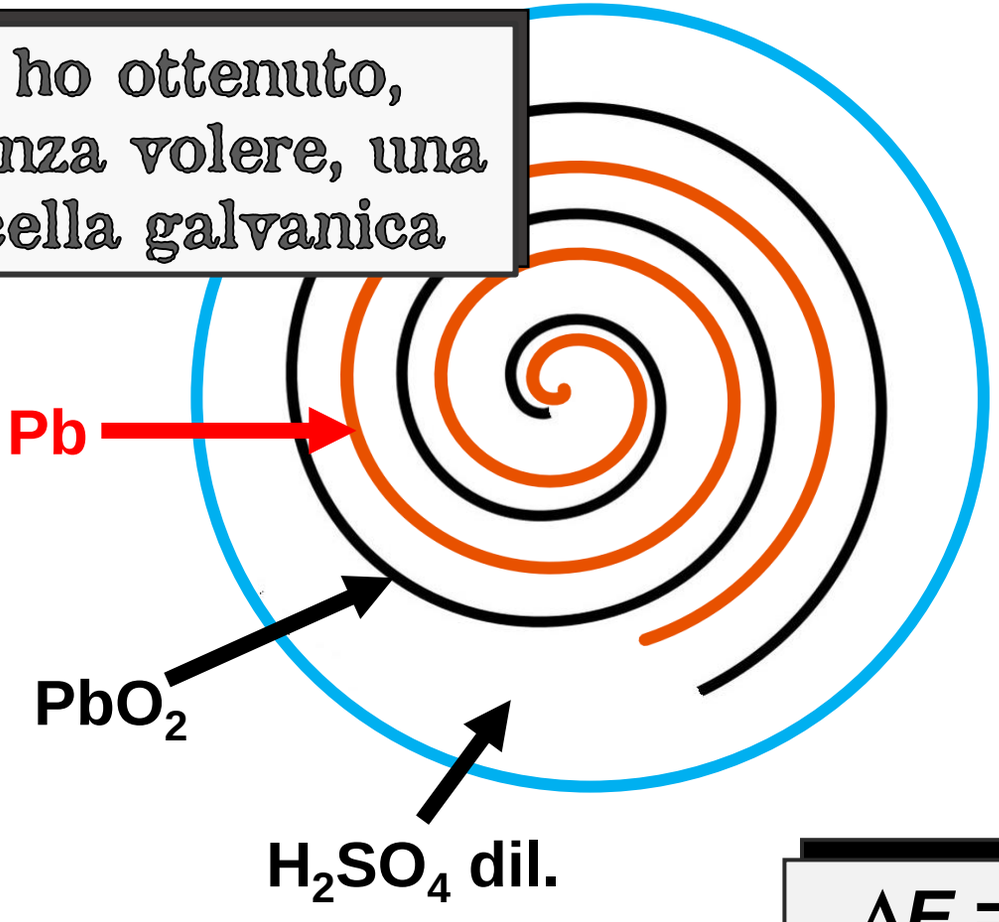


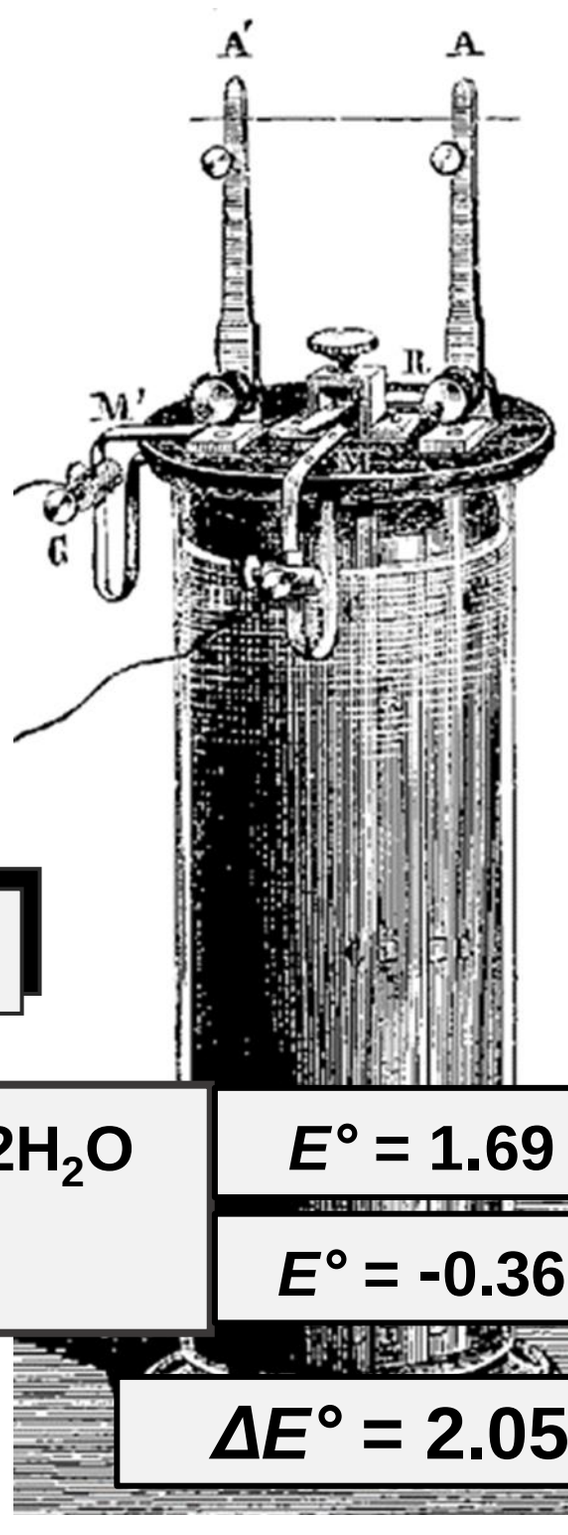
elettrodi: 2 bande di piombo a spirale, **Pb(1)** e Pb(2), inserite l'una nell'altra

⊕ $Pb(2) + 2H_2O \leftrightarrows PbO_2 + 4H^+ + 2e^-$

⊖ $2H^+ + 2e^- \leftrightarrows H_2$ Pb(1) fa da elettrodo inerte

ho ottenuto, senza volere, una cella galvanica





ΔE = ~ 2 V

$\oplus$ $PbO_2 + 2e^- + 4H^+ + SO_4^{2-} \leftrightarrows PbSO_4 + 2H_2O$ — $E°$ = 1.69 V

$\ominus$ $Pb + SO_4^{2-} \leftrightarrows PbSO_4 + 2e^-$ — $E°$ = -0.36 V

$\Delta E°$ = 2.05 V

La cella, una volta esaurita, può essere ricaricata

CHAPITRE II

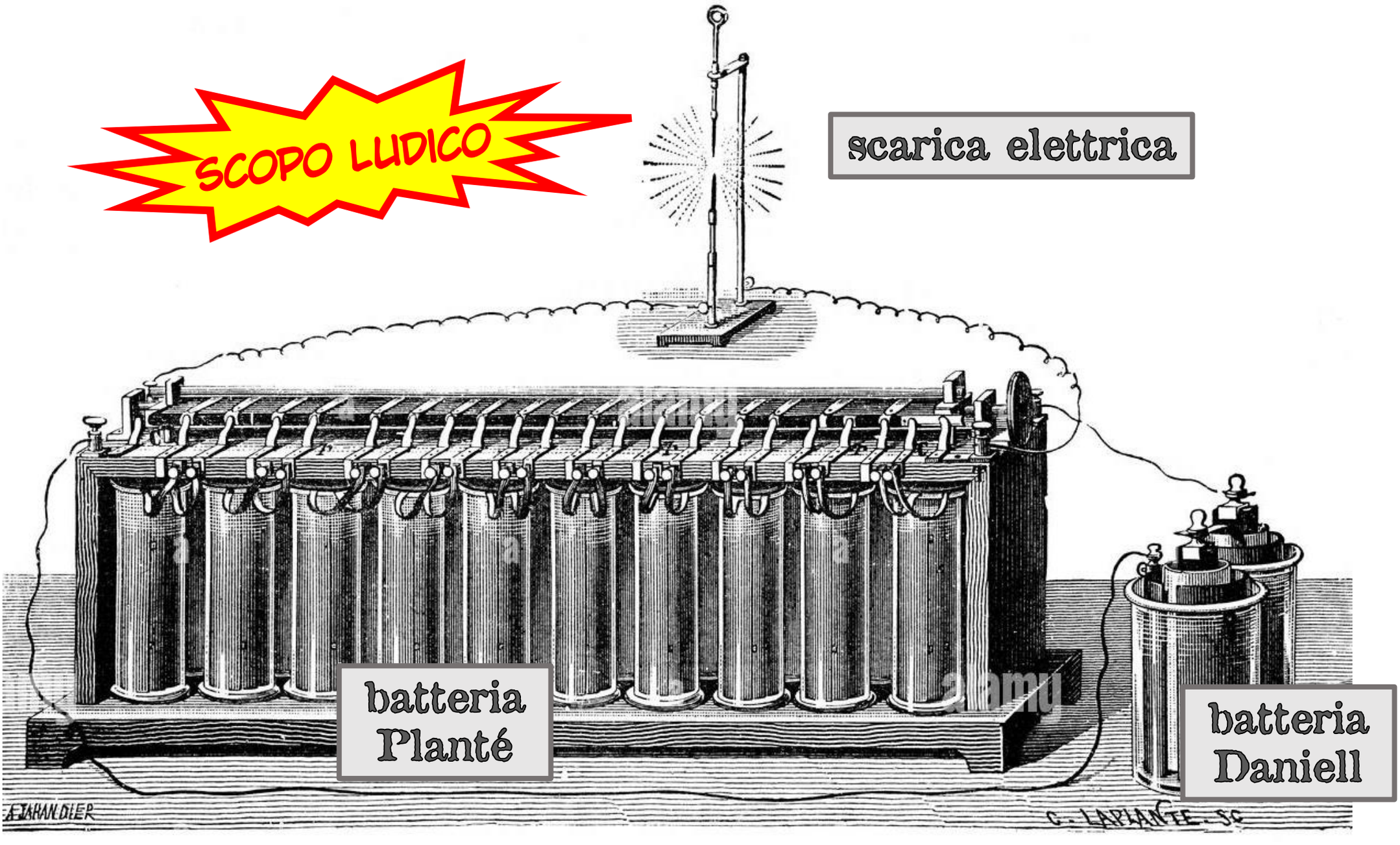
Accumulation de la force de la pile voltaïque, à l'aide de couples secondaires à lames de plomb.

Fig. 7.

La batteria Planté serve a poco: può solo accumulare l'energia prodotta da un'altra batteria

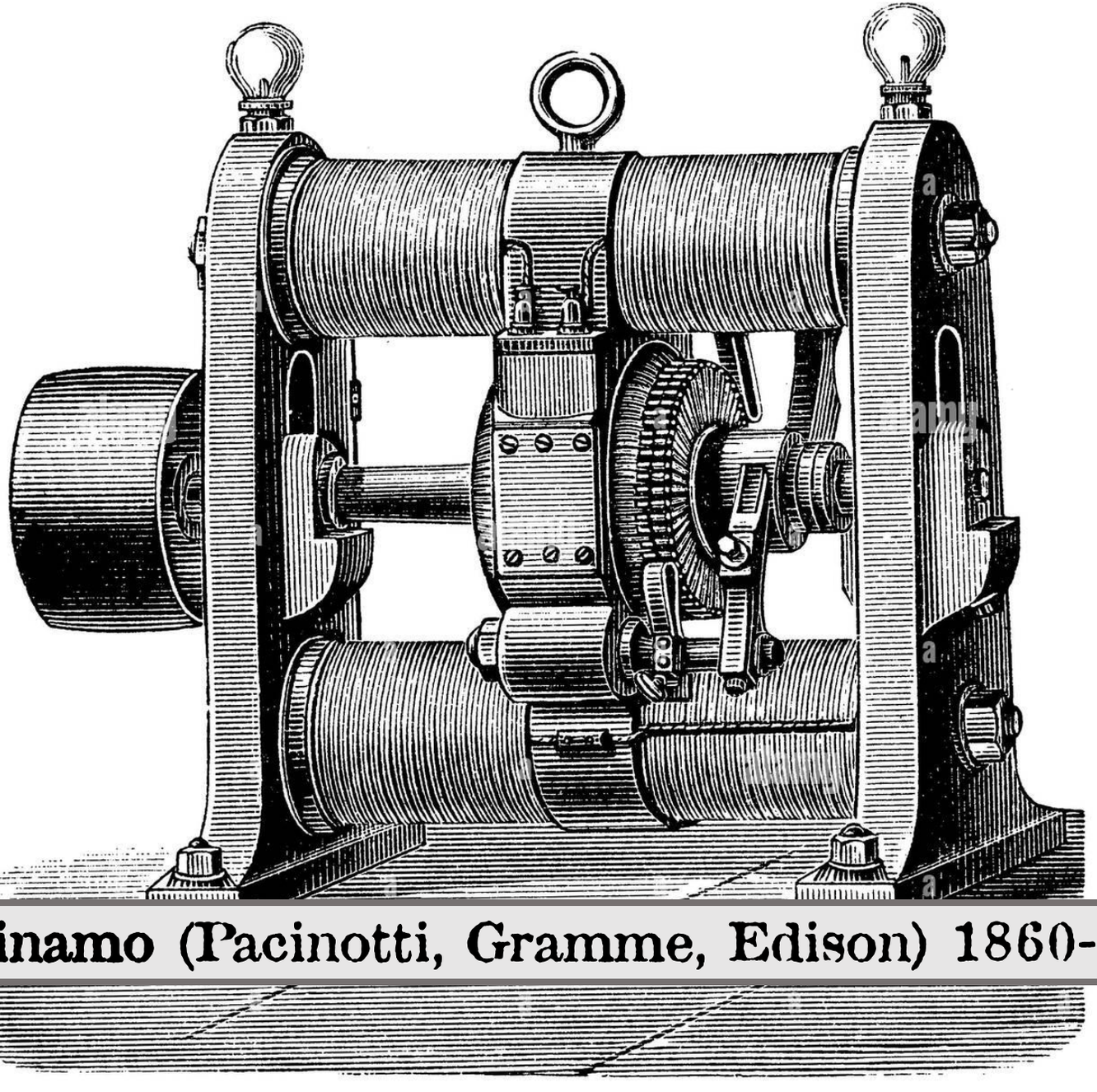
37. — **Couple secondaire à lames de plomb en spirale.** — C'est ainsi que nous fûmes conduit à construire, en 1860 (1), un élément secondaire de grande intensité, en employant une gue à celle qu'Offer- ient employée pour proprement dite, broulant en spirale deux longues et larges lames de plomb, séparées l'une de l'autre par une toile grossière, et les plongeant ensuite dans un bocal plein d'eau acidulée au $\frac{1}{10}$ par l'acide sulfurique.

(1) *Comptes rendus*, t. L, p. 640. Mars 1860.



Louis Figuier, Les Merveilles de la science ou description populaire des inventions modernes, Librairie Furne, Editeurs Jouvet et Cie, 1867-1891.

fino a che... non viene inventata una macchina capace di convertire energia meccanica in energia elettrica: **la dinamo**



Dinamo (Pacinotti, Gramme, Edison) 1860-1880

Le batterie reversibili, tipo Planté, possono essere caricate con energia meccanica. Diventano dei 'serbatoi' di energia elettrica. Non si cosumano materiali

Camille Jenatzy (1868-1913), ingénieur et coureur automobile belge, connu surtout pour avoir été le premier à dépasser les 100 km/h, le 29 avril 1899, à bord d'une voiture de sa conception, «La Jamais Contente», une voiture électrique en forme d'obus ou de torpille. Son nom de famille dérive de l'italien Genazzi, son aïeul ayant migré à Bastogne au XVIII^{e} siècle.

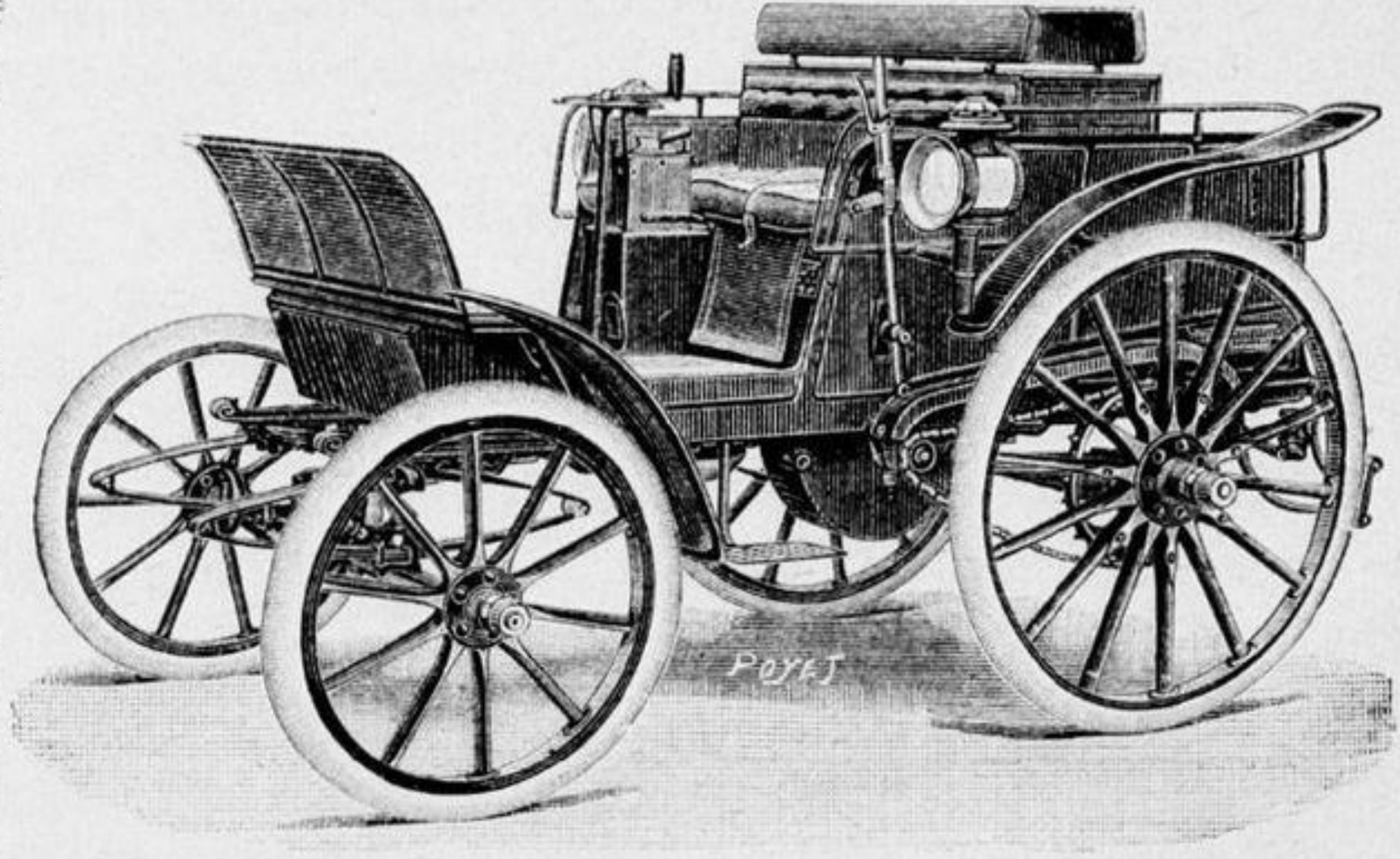
Camille Jenatzy *(Le Diable Rouge)* et sa femme en 1899 aux Tuileries lors de la célébration du record établi avec *La Jamais Contente* (106 km/h). La voiture était alimentée par une batterie au plomb, faite des 100 accumulateurs (100 x 2 V = 200 V)

AUTOMOBILES ÉLECTRIQUES JENATZY

Les plus perfectionnées

DÉTENTEUR des RECORDS du MONDE

de 1 kilomètre en côte (Chanteloup), en 3' 52"
de 2 kilomèt. vitesse (Achères), en 1' 41" 2/5



USINE A BOULOGNE-SUR-SEINE

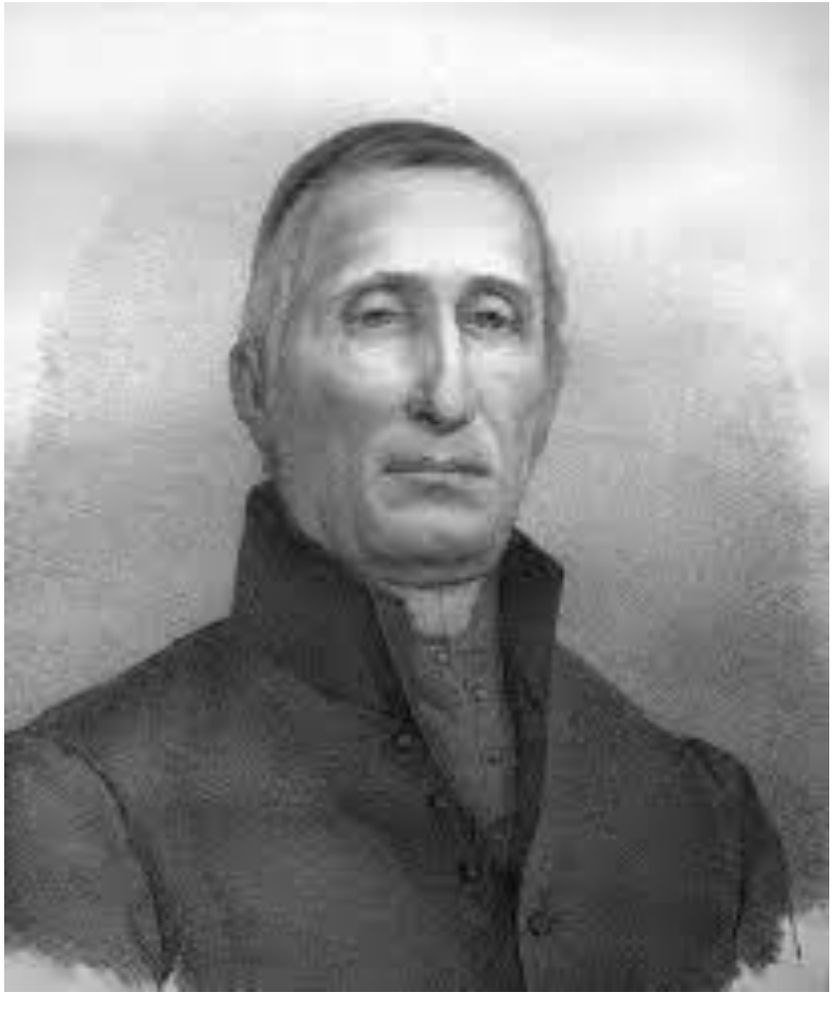
Envoi franco de Devis et Renseignements

Compagnie Internationale des Transports Automobiles

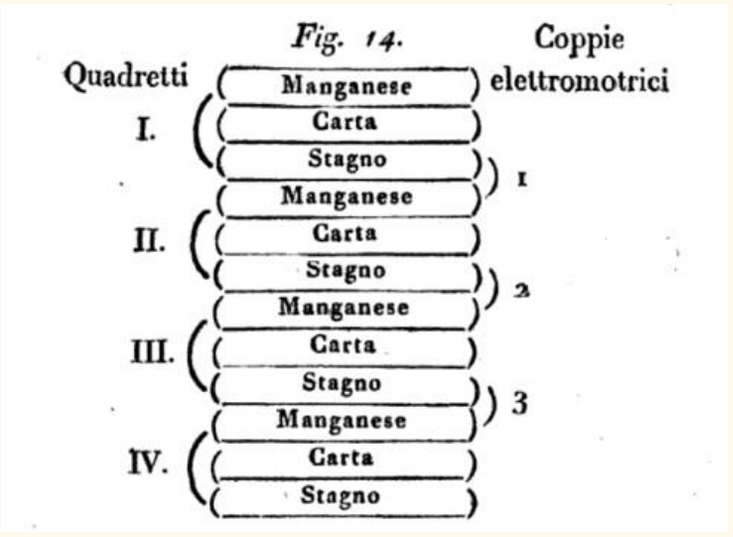
Société anonyme au capital de 1.000.000
56, rue de la Victoire, PARIS


SI', MA IO VOGLIO
UNA BATTERIA PICCOLINA,
LEGGERA, USA-E-GETTA,
PER ALIMENTARE IL MIO
I-PHONE. E SOPRATTUTTO
CHE NON PERDA LIQUIDI.
INSOMMA, VOGLIO
UNA PILA A SECCO

G. Zamboni, «Della pila elettrica a secco», *Giornale di Fisica, Chimica e Storia Naturale* **1812**, *5*, 424.

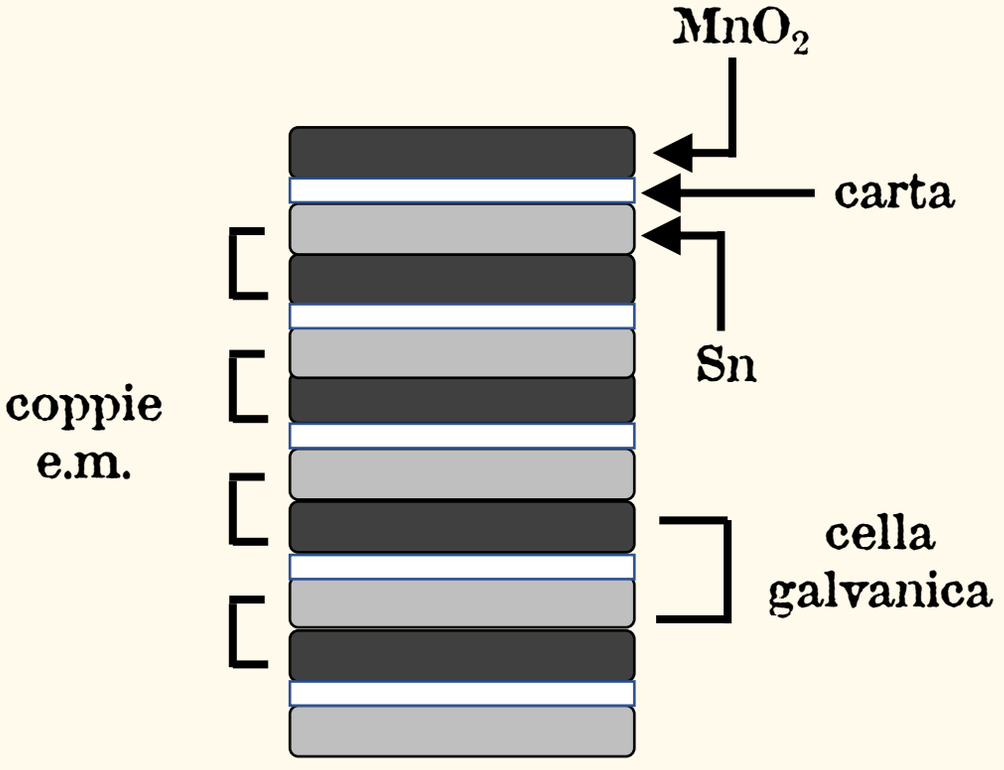


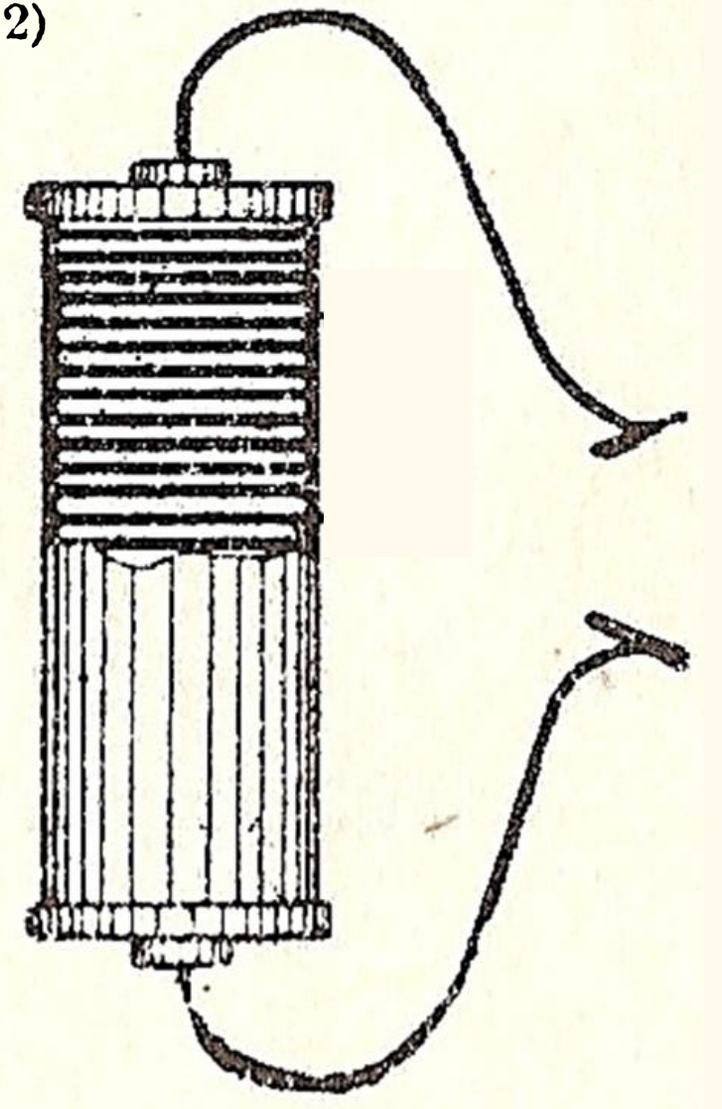
Giuseppe Zamboni
Arbizzano 1776 – Verona 1846
abate, fisico
docente presso l'*Imperial Regio Liceo* di Verona



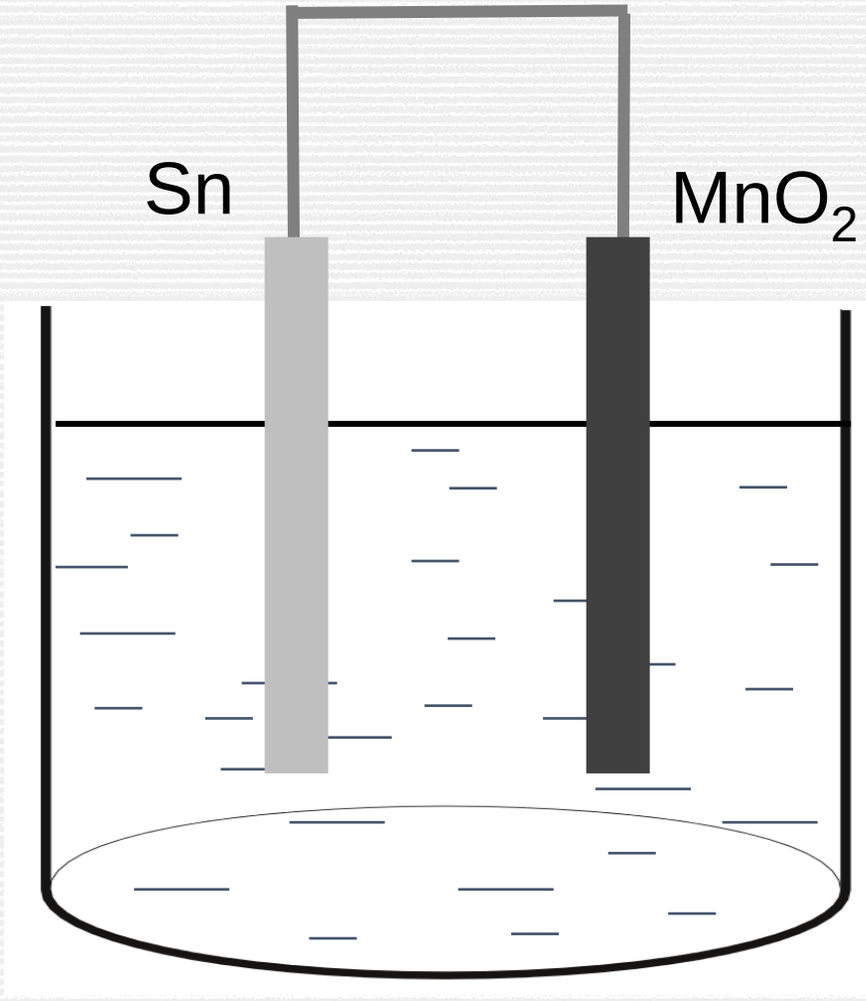
dischetti di carta che interfacciano un dischetto di foglio di Sn (o Zn) e uno strato di MnO_2 impastato con colla (suggerito da **A. Volta**).

«... manganese nero di ottima qualità supera di assai nella facoltà elettromotrice e la piombaggine *[Mo, ndr]* e il miglior carbone». **Lettera di A. Volta a G. Zamboni (1812)**



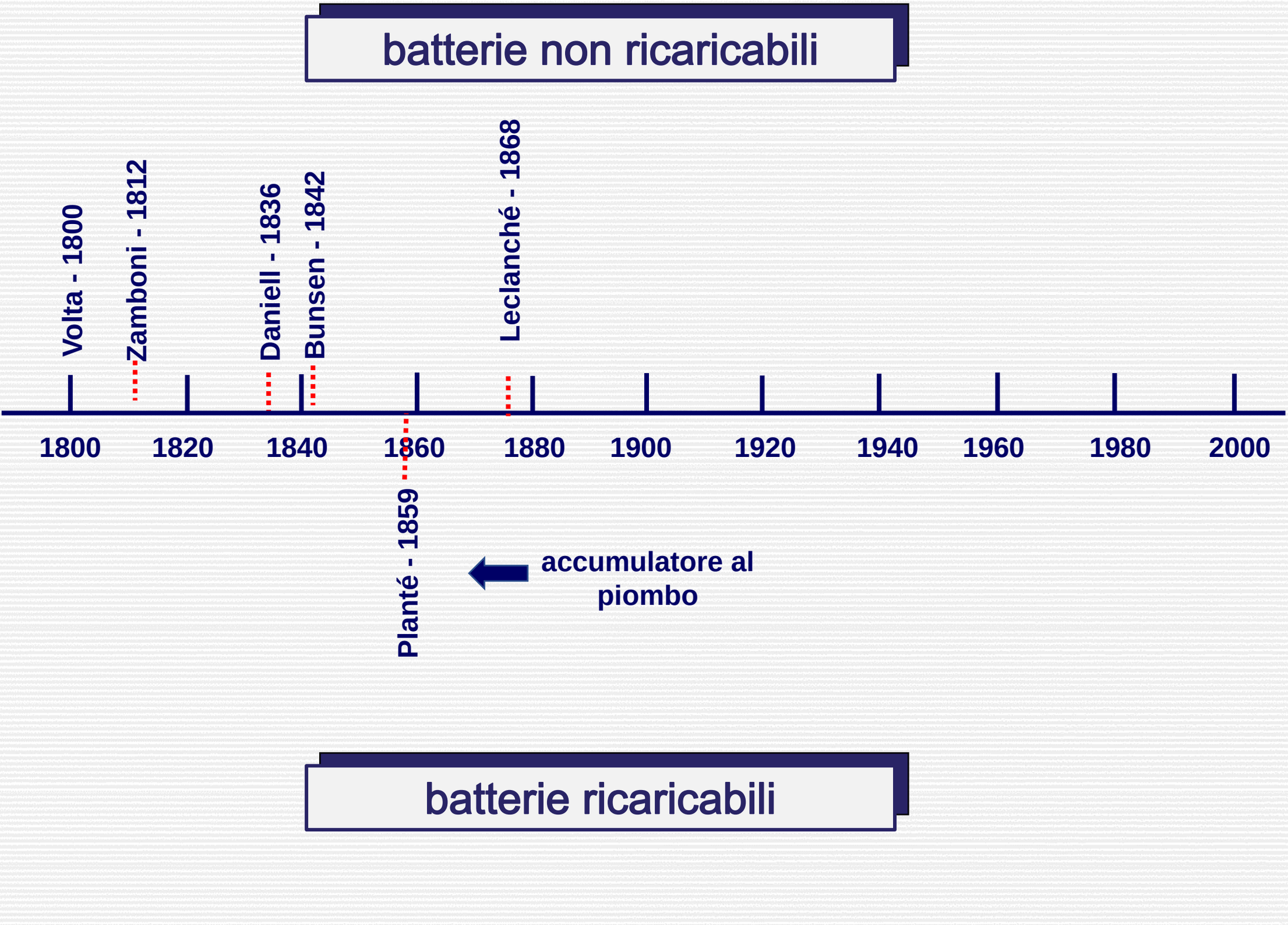


La cella di Zamboni (versione didattica)



$Sn \rightarrow Sn + 2e^-$

$2MnO_2 + 2e^- + 2H_2O \rightarrow Mn_2O_3 + 2OH^-$


batterie non ricaricabili
Volta - 1800
Zamboni - 1812
Daniell - 1836
Bunsen - 1842
Leclanché - 1868
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Planté - 1859
accumulatore al piombo
batterie ricaricabili

Georges Leclanché

1839–1882

Ingegnere e industriale francese

G. Leclanché, "*une pile à oxyde insoluble*" Brevet français no. 71 865 (publié le 8 juin 1866)

Leclanché, Georges (1867). *Notes sur l'emploi des piles électriques en télégraphie, pile constante au peroxyde de manganèse à un seul liquide.* Paris: Impr. de Hennuyer et fils.

Leclanché, Georges (1869). *Notice sur la pile Leclanché : précédée de quelques considérations sur l'emploi des piles électriques en télégraphie.* Paris: Jamin, Bailly et cie, Librairie Burndy

La cella Leclanché

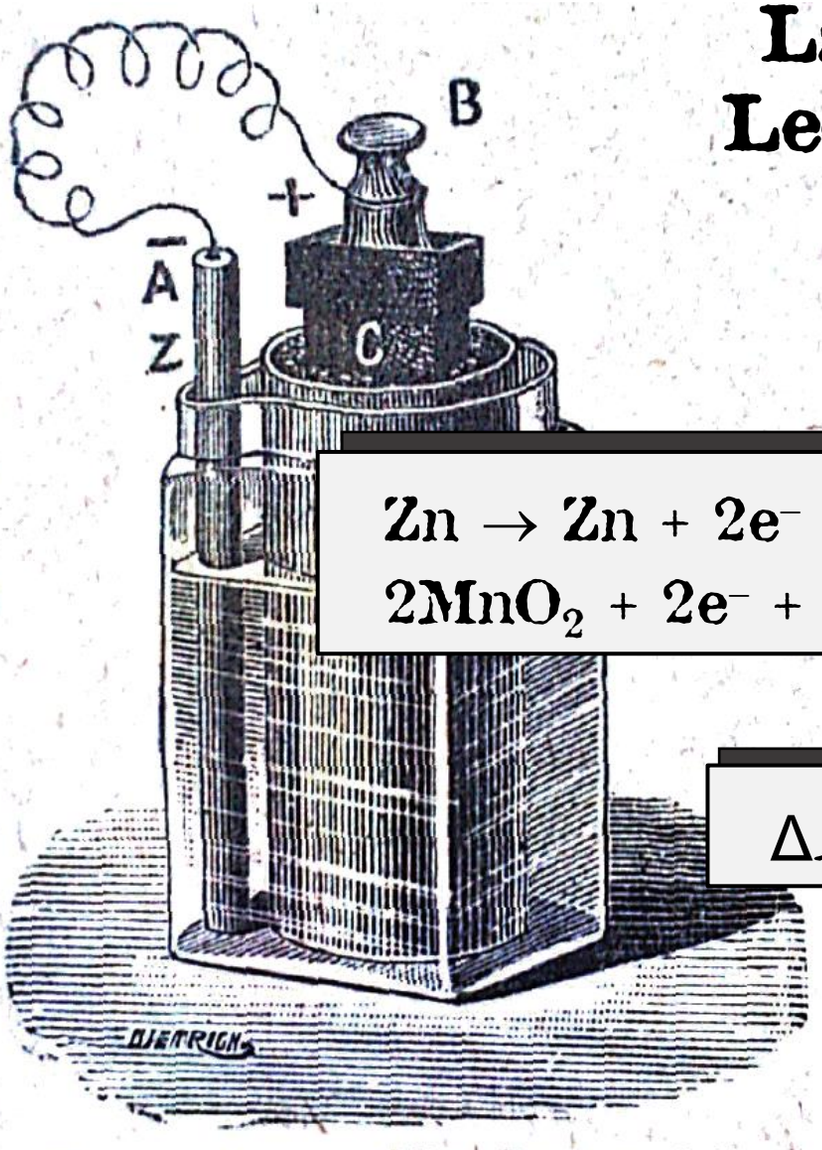
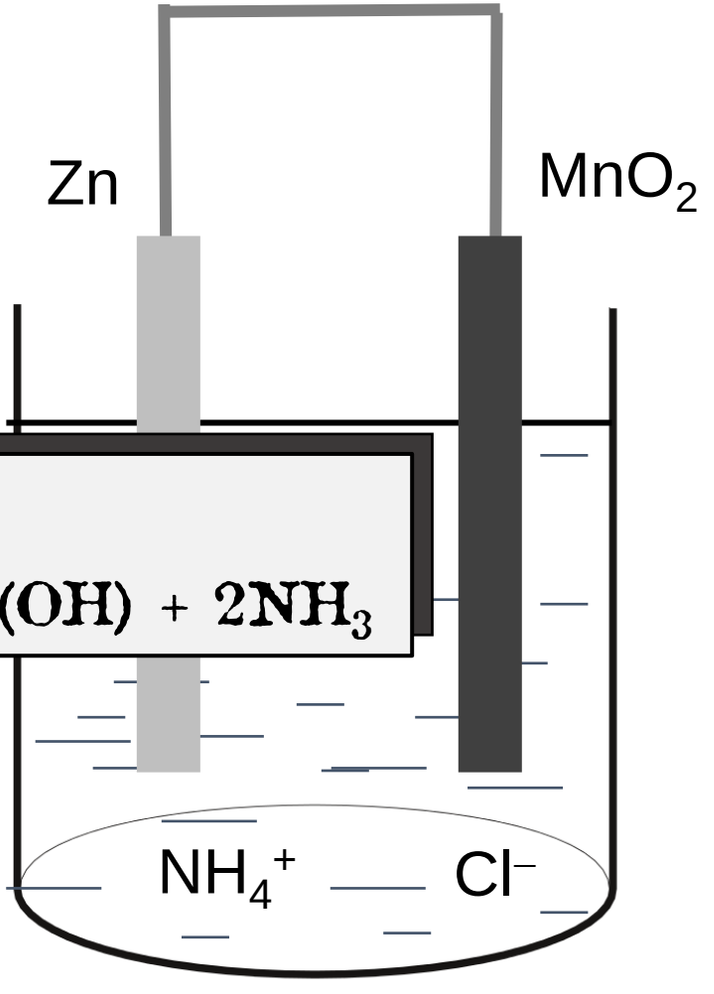


FIG. 153. — Pile Leclanché. — V, vase de verre renfermant une solution saturée de sel ammoniac ; Z, cylindre de zinc amalgamé ; T, vase poreux renfermant du bioxyde de manganèse (MnO^2) ; C, charbon de cornue.



$$Zn \rightarrow Zn + 2e^-$$

$$2MnO_2 + 2e^- + 2NH_4^+ \rightarrow 2MnO(OH) + 2NH_3$$

$$\Delta E = 1.5\ V$$

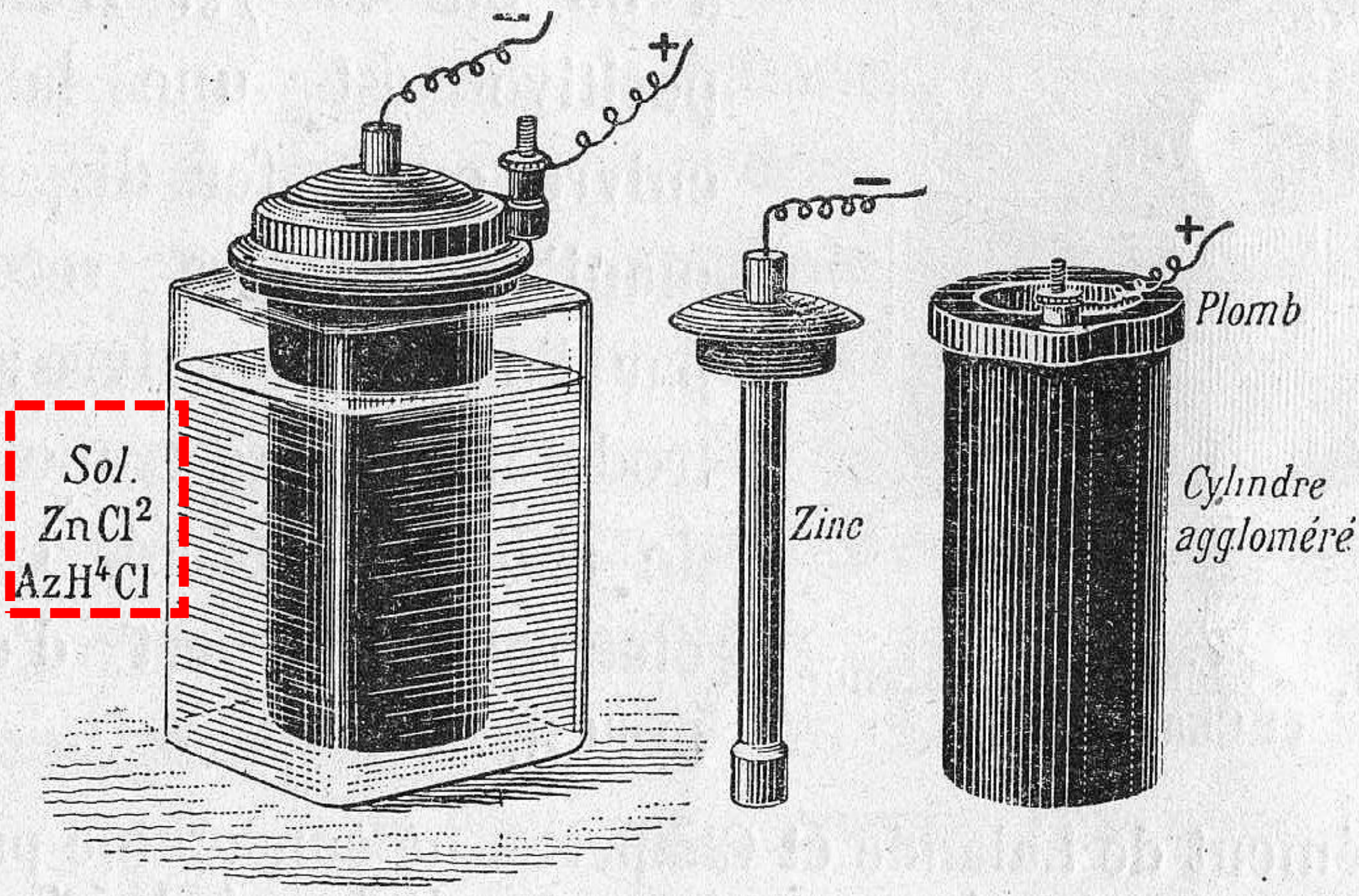
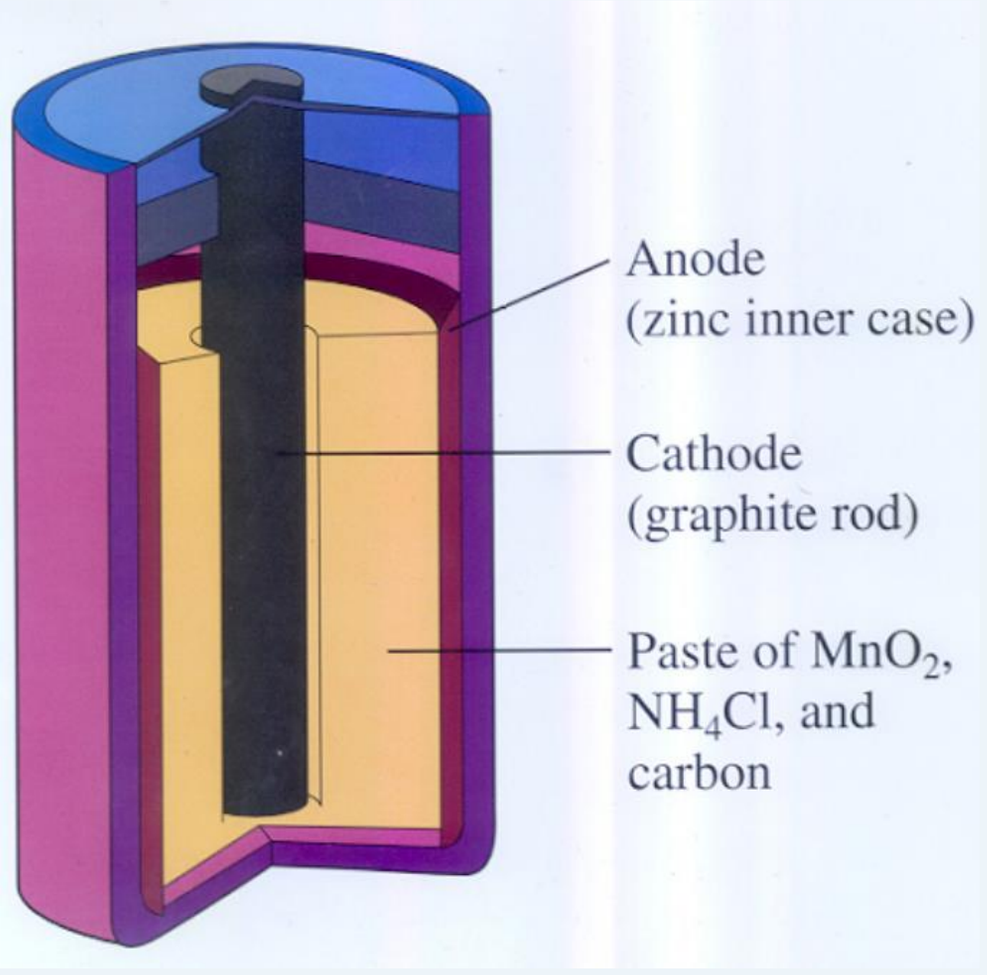


Fig. 293. — Élément Leclanché-Barbier.

pile saline → pile sèche
(industrie Leclanché)

- La soluzione di NH_4Cl viene gelificata con amido.
- La pila diviene trasportabile.
- Viene prodotta industrialmente e messa in commercio.

versione finale



1960

zinco-carbone

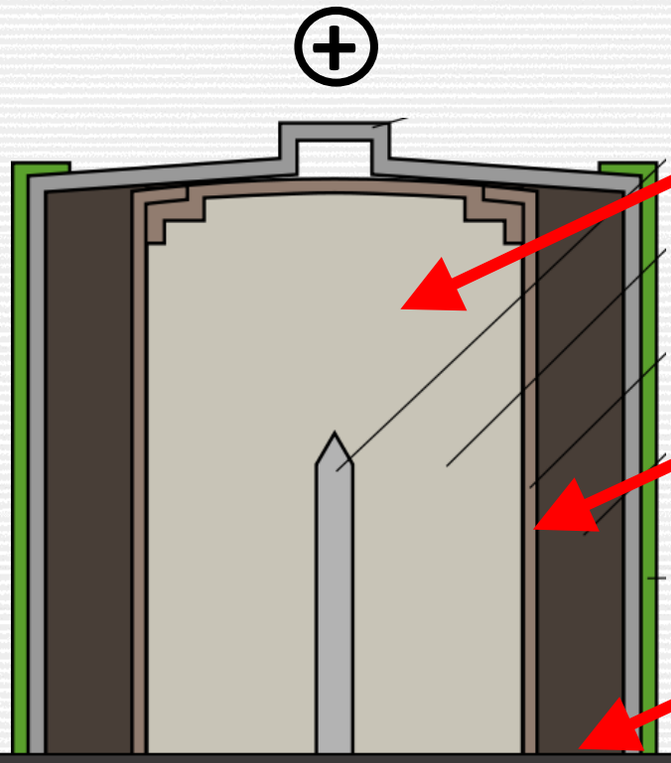
alcalina

$$MnO_{2(s)} + H_2O_{(l)} + e^- \rightarrow MnO(OH)_{(s)} + OH^-_{(aq)}$$

$$Zn_{(s)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)} + 2e^-$$

$$Zn_{(s)} + 2MnO_{2(s)} + 2H_2O \rightleftharpoons Zn(OH)_{2(s)} + 2MnO(OH)_{(s)}$$

La batteria alcalina (brevetto Union Carbide 1960)



Zn
polvere di Zn dispersa in un gel contenente KOH

separatore
(polimero o cellulosa)

MnO_2
pasta di MnO_2 con polvere di *C*

$$MnO_{2(s)} + H_2O_{(l)} + e^- \rightarrow MnO(OH)_{(s)} + OH^-_{(aq)} \qquad E^\circ = 0.15\ V$$

$$Zn_{(s)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)} + 2e^- \qquad E^\circ = -1.28\ V$$

$$Zn_{(s)} + 2MnO_{2(s)} + 2H_2O \rightleftharpoons Zn(OH)_{2(s)} + 2MnO(OH)_{(s)} \qquad E^\circ = 1.43\ V$$

zinco-carbone

$2MnO_{2(s)} + 2e^- + 2H^+ \rightarrow 2MnO(OH)_{(s)}$ (pH = 5) $\quad E^\circ = 0.68$ V

$Zn_{(s)} + 2H^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ $\quad E^\circ = -0.76$ V

$Zn_{(s)} + 2MnO_{2(s)} + 2H_2O \rightleftharpoons Zn(OH)_{2(s)} + 2MnO(OH)_{(s)}$ $\quad \Delta E^\circ = 1.44$ V

alcalina

$MnO_{2(s)} + H_2O_{(l)} + e^- \rightarrow MnO(OH)_{(s)} + OH^-_{(aq)}$ $\quad E^\circ = 0.15$ V

$Zn_{(s)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)} + 2e^-$ $\quad E^\circ = -1.28$ V

$Zn_{(s)} + 2MnO_{2(s)} + 2H_2O \rightleftharpoons Zn(OH)_{2(s)} + 2MnO(OH)_{(s)}$ $\quad \Delta E^\circ = 1.43$ V

E DOVE STA IL VANTAGGIO ?

- Le Batterie Alcaline (BA) hanno una più alta densità energetica, a parità di prestazione pesano di meno.
- A differenza delle batterie Zinco-Carbone (ZC), le BA resistono meglio alle basse temperature.
- Le BA non sono soggette alla perdita di liquido come le ZC e garantiscono un trasporto più sicuro.
- Le BA presentano una minor resistenza interna delle ZC e forniscono una corrente Maggiore.

Jacques-Louis David (1788)
Portrait d'Antoine-Laurent Lavoisier et de sa femme
peinture à l'huile, 260 × 195 cm
Metropolitan Museum of Art, New York

William Robert Grove (1811-1896)
Welsh judge and physical scientist. He anticipated the general theory of the conservation of energy and was a pioneer of fuel cell technology. He invented the Grove voltaic cell.

THE

LONDON, EDINBURGH AND DUBLIN

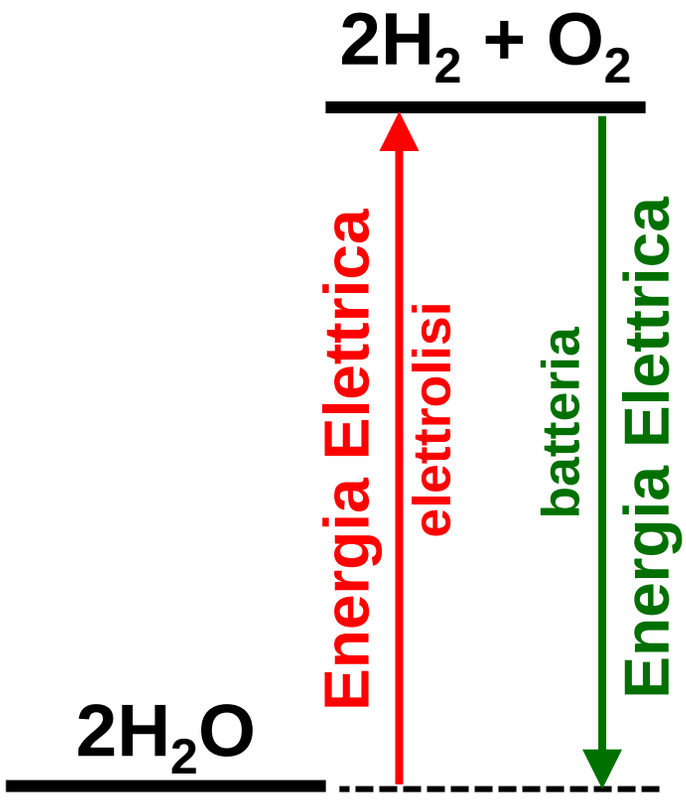
PHILOSOPHICAL MAGAZINE

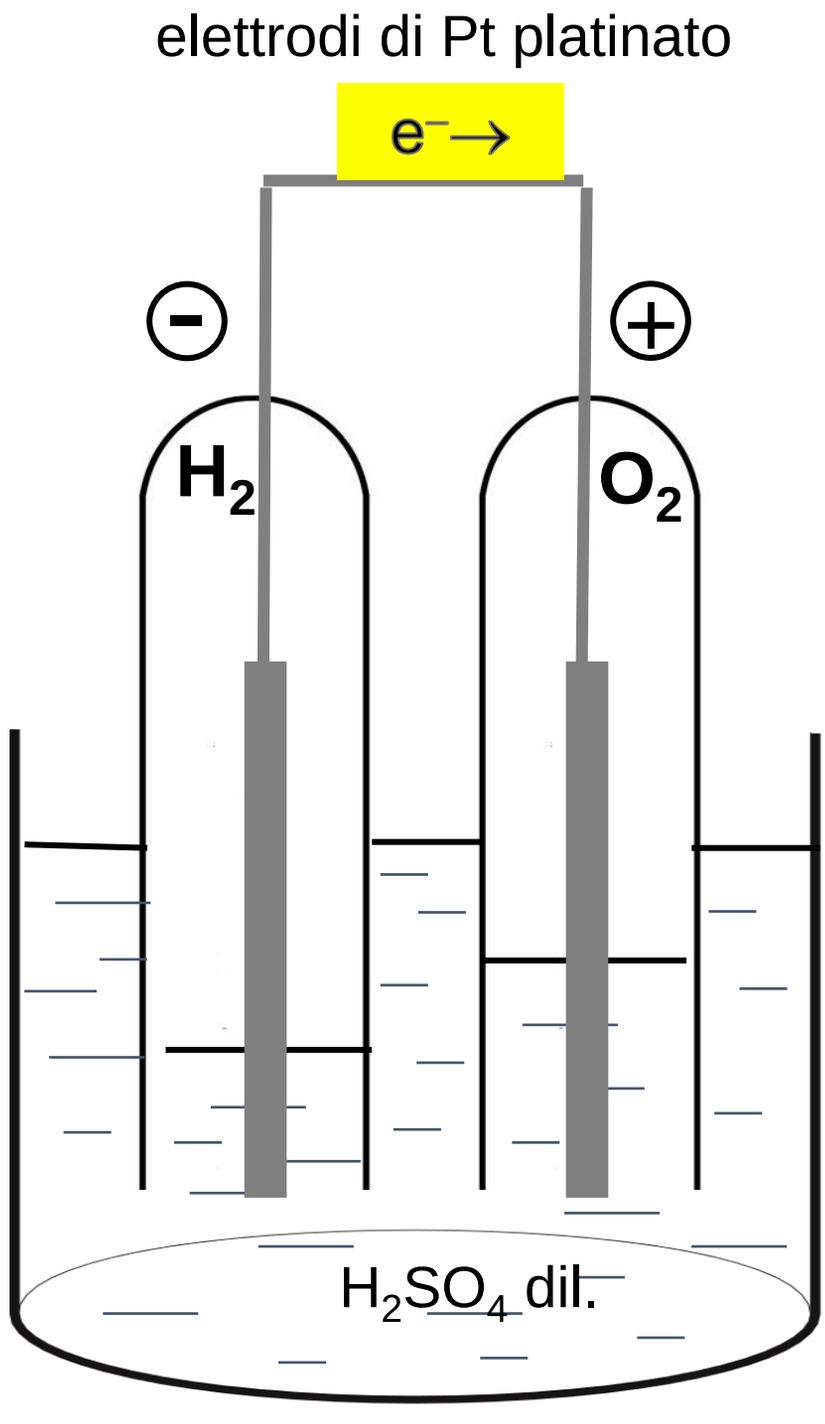
AND

JOURNAL OF SCIENCE.

DECEMBER 1842.

LXXII. *On a Gaseous Voltaic Battery.* *By* W. R. GROVE, *Esq., M.A., F.R.S., Professor of Experimental Philosophy in the London Institution.*



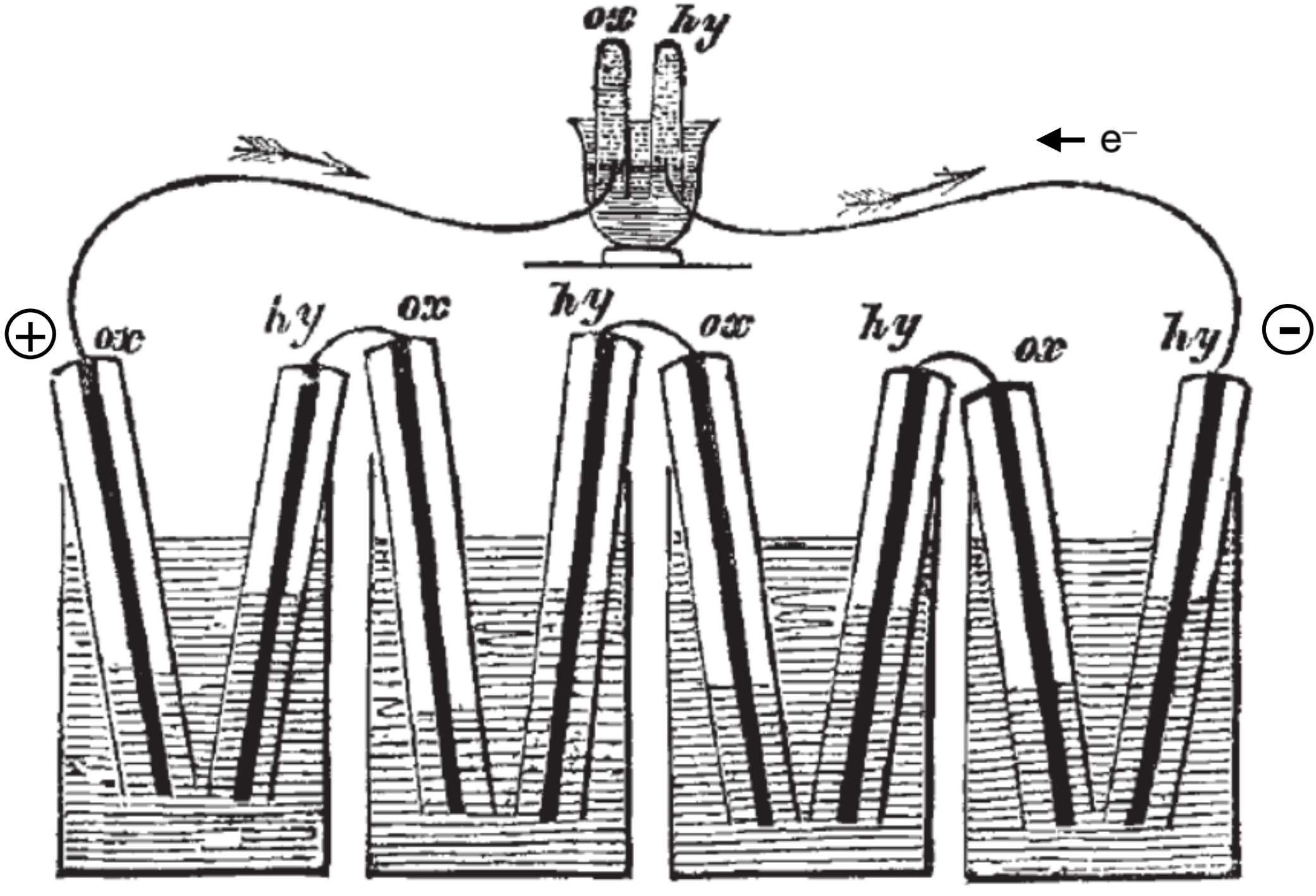


⊖ $2H_2 \leftrightarrows 4H^+ + 4e^-$ $E° = 0.00$ V

⊕ $O_2 + 4e^- + 2H_2O \leftrightarrows 4OH^-$ $E° = 0.82$ V

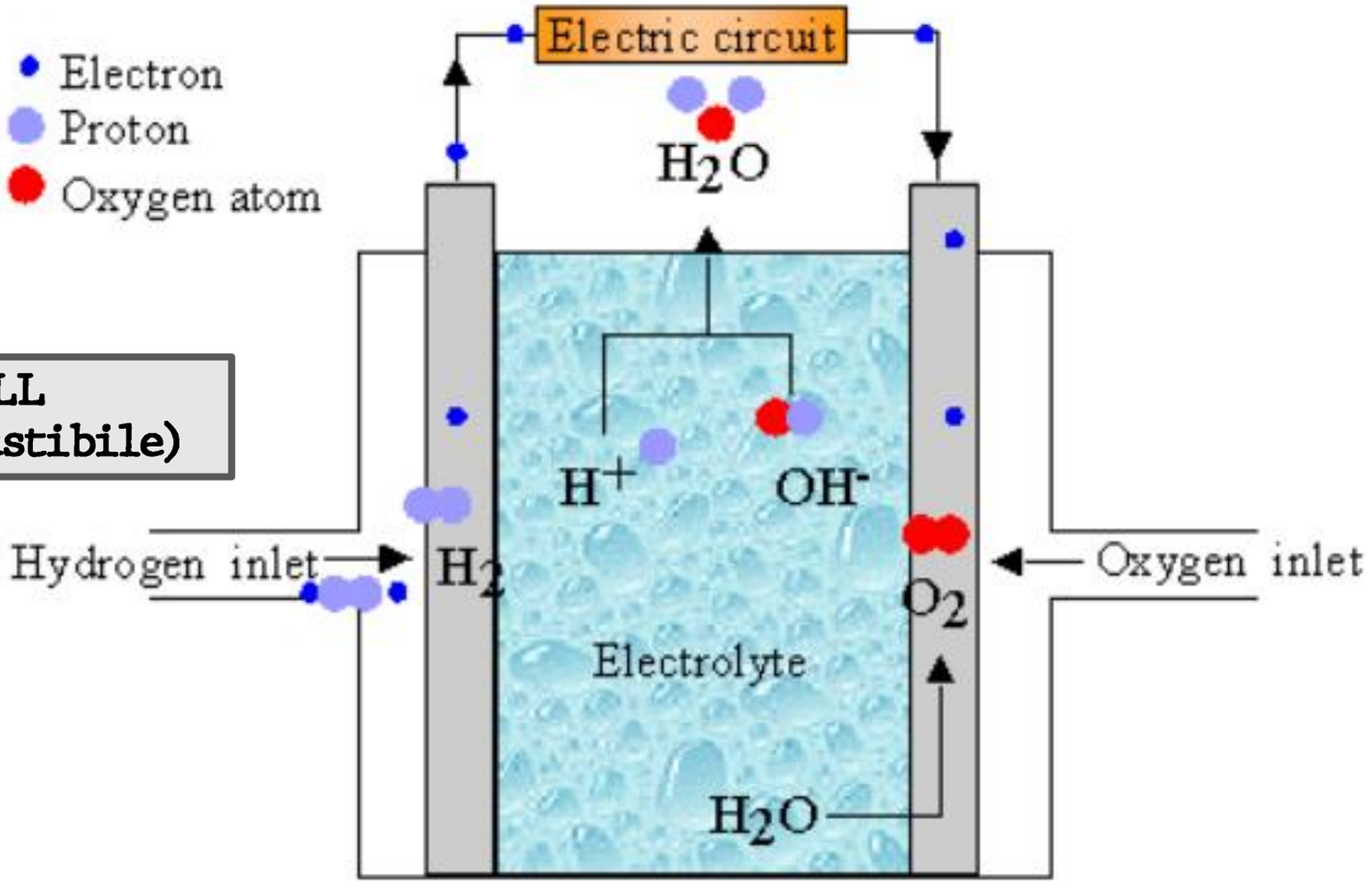
$2H_2 + O_2 \leftrightarrows 2H_2O$ $\Delta E° = 0.82$ V

$\Delta G° = - n \times F \times \Delta E° = - 76$ kcal mol^{-1}



Una batteria Grove a 4 elementi, usata per fare l'elettrolisi dell'acqua

FUEL CELL
(cella a combustibile)



Electrolyte: NaOH aq, Sulfuric Acid, Phosphoric acid, Proton Exchange Membrane, Solid Polymer, Molten Carbonate & Solid Oxide

1889 Ludwig Mond e Charles Langer introducono il termine **'fuel cell'**

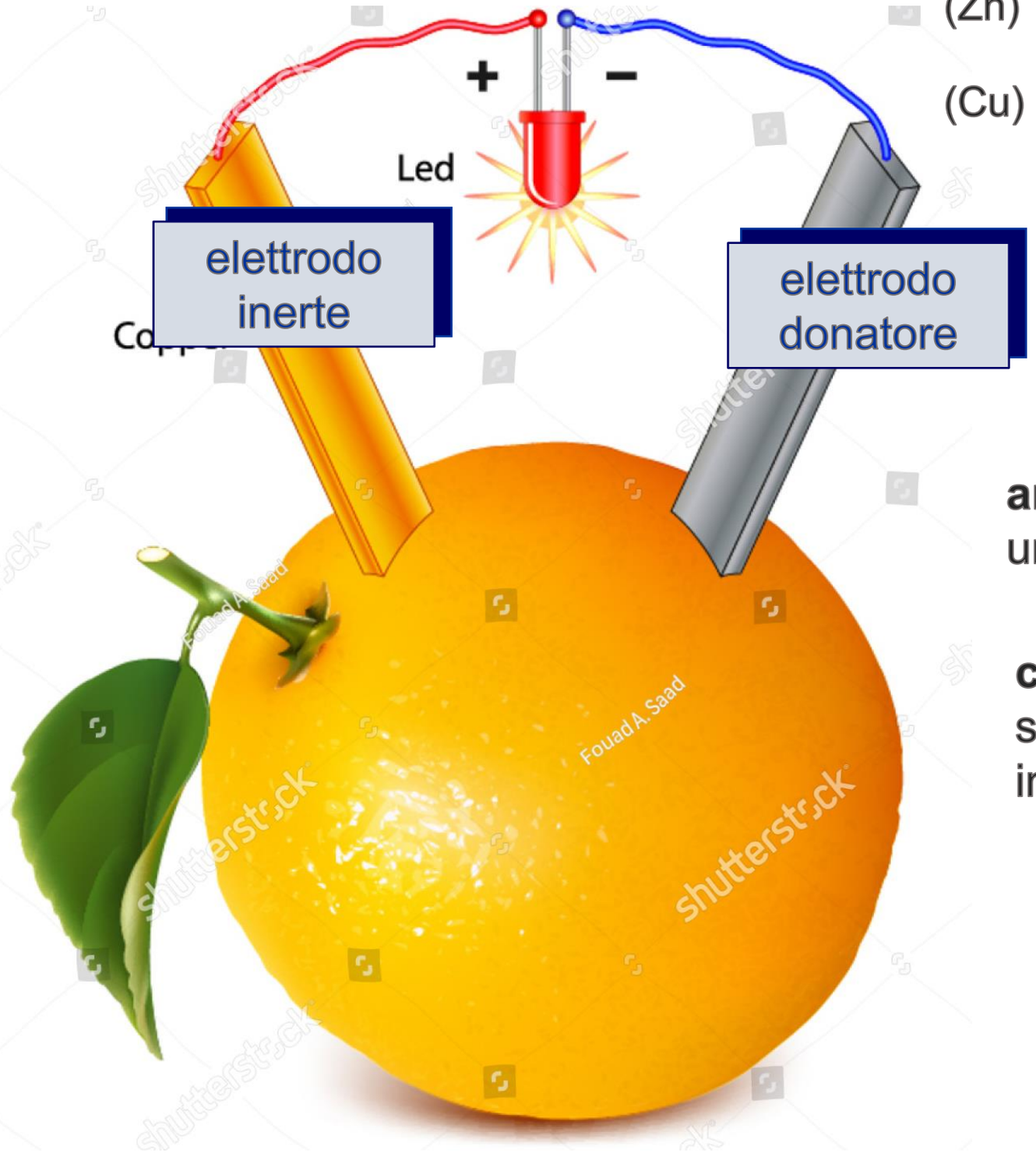
1932 prime applicazioni delle *fuel cells* (trattore a 20 HP)

1960 NASA, applicazioni aerospaziali

1970 Giappone, applicazioni nell'industria automobilistica

quasi quasi mi faccio una pila anch'io...

PILE ORTOFRUTTICOLE



(Zn) $Zn \leftrightarrows Zn^{2+} + 2e^-$ $E° = -0.76$ V

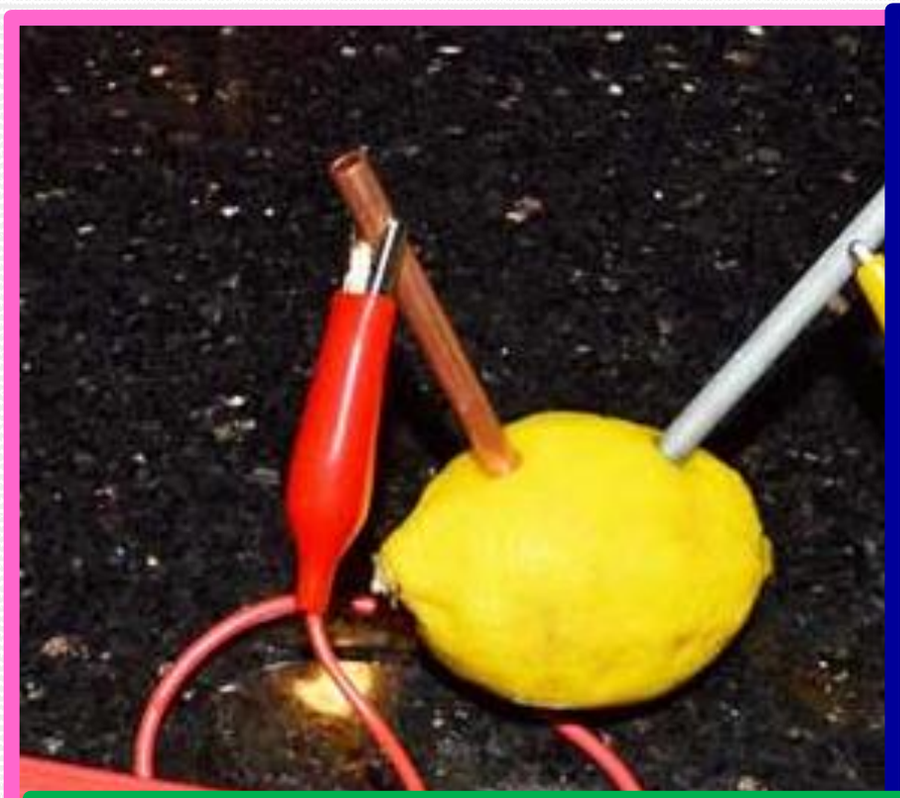
(Cu) $2H^+ + 2e^- \leftrightarrows H_2$ $E° = 0.00$ V

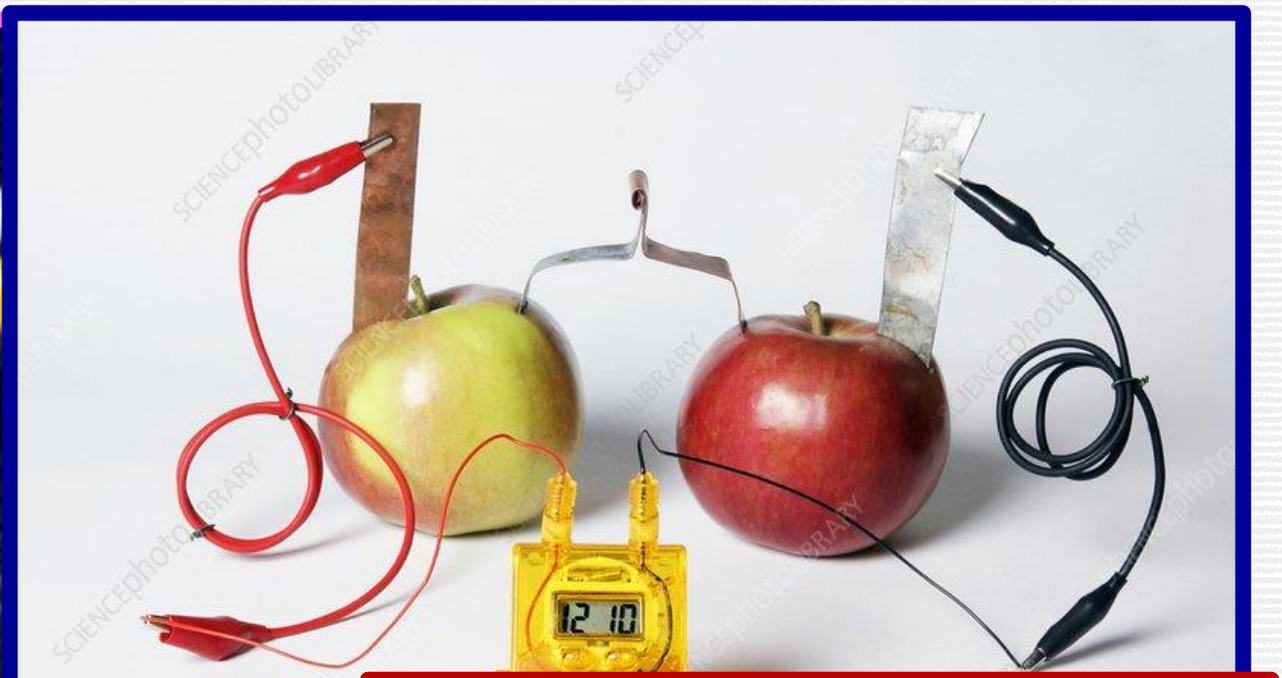
anodo: elettrodo donatore ⇨ un metallo con $E° < 0.00$ V

catodo: elettrodo inerte ⇨ un supporto conduttore redox inattivo (metallo, grafite)

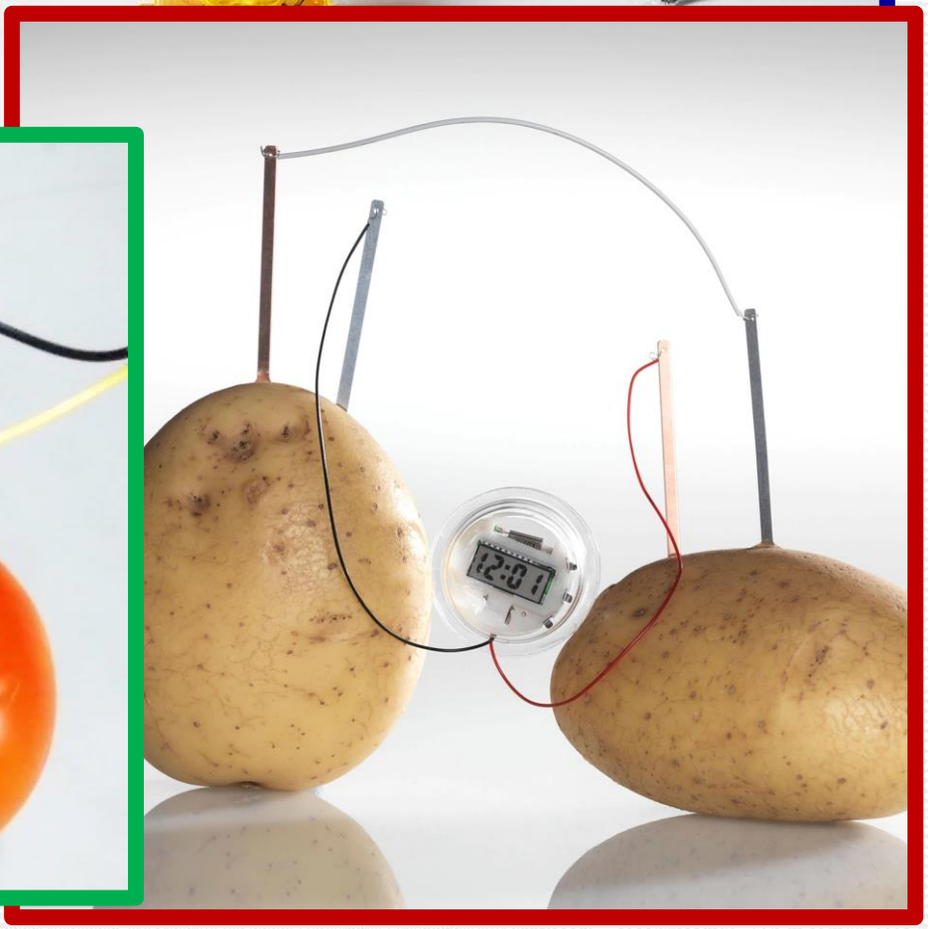

SCUSA, PICCINA, PERCHE' USI LA COPPIA ZINCO-RAME?
PERCHE' L'HA FATTO ALESSANDRO VOLTA
Zn
Cu
12:00


ESSELUNGA
ORTOFRUTTA
PILE ORTOFRUTTICOLE






MAHESHTECH
couronne de
tomates



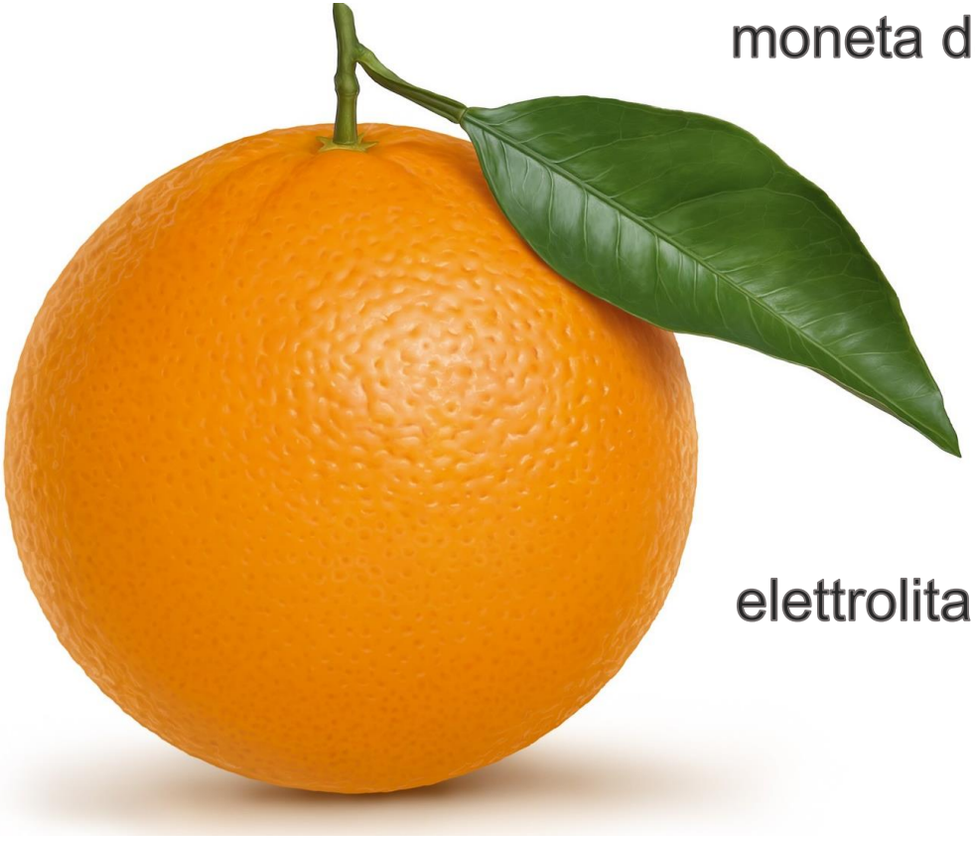
Pila all'arancia (Zn/Cu)

elettrodo donatore (Zn)

Fe zincato

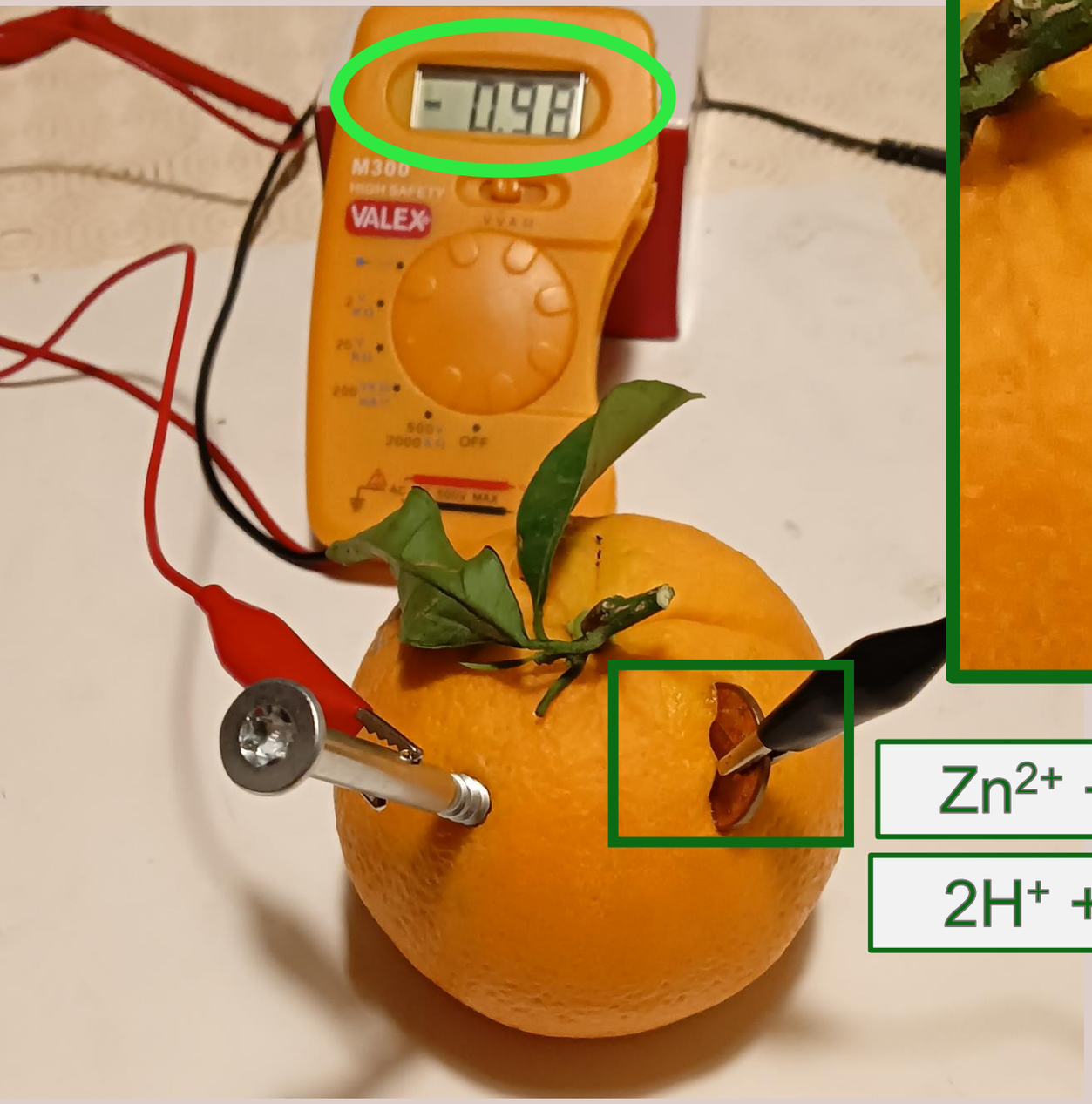
elettrodo inerte (Cu)

moneta da 5 cent



elettrolita

Esperimenti in cucina #1



$Zn^{2+} + 2e^- \leftrightarrows Zn \qquad E° = 0.76\ V$

$2H^+ + 2e^- \leftrightarrows H_2 \qquad E° = 0.00\ V$

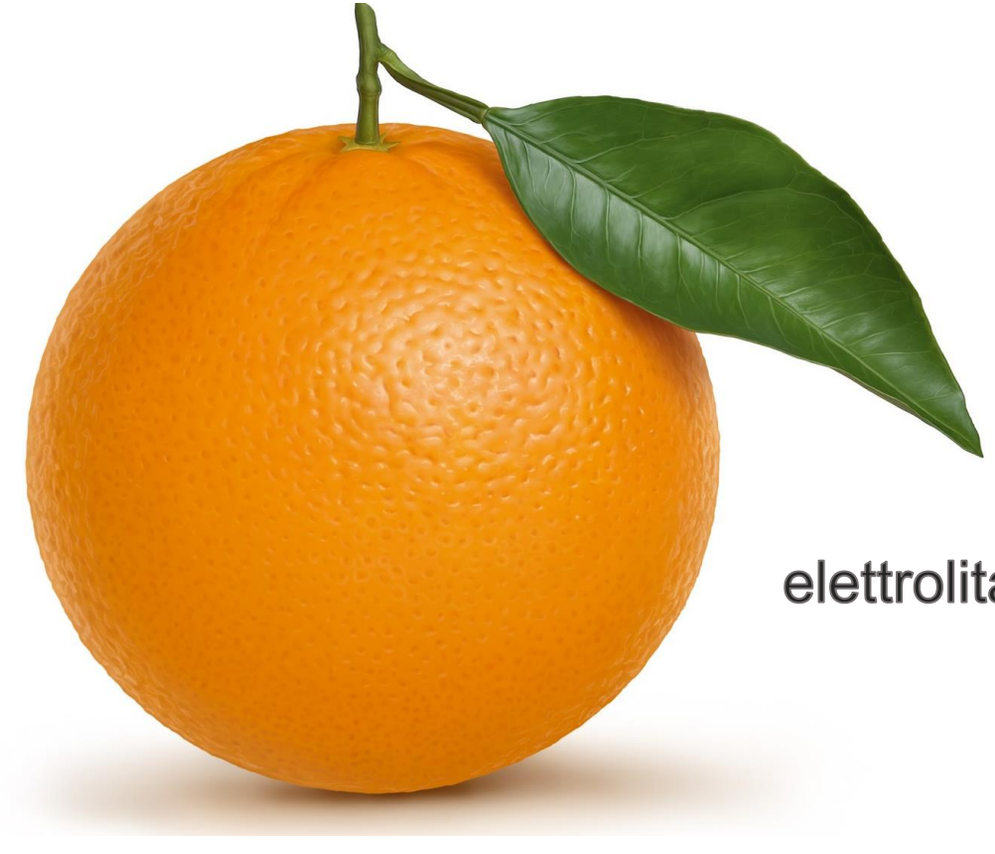
emf = 0.98 V

$\Delta E° = 0.76\ V$

Pila all'arancia (Zn/Fe_{inox})

elettrodo donatore (Zn)

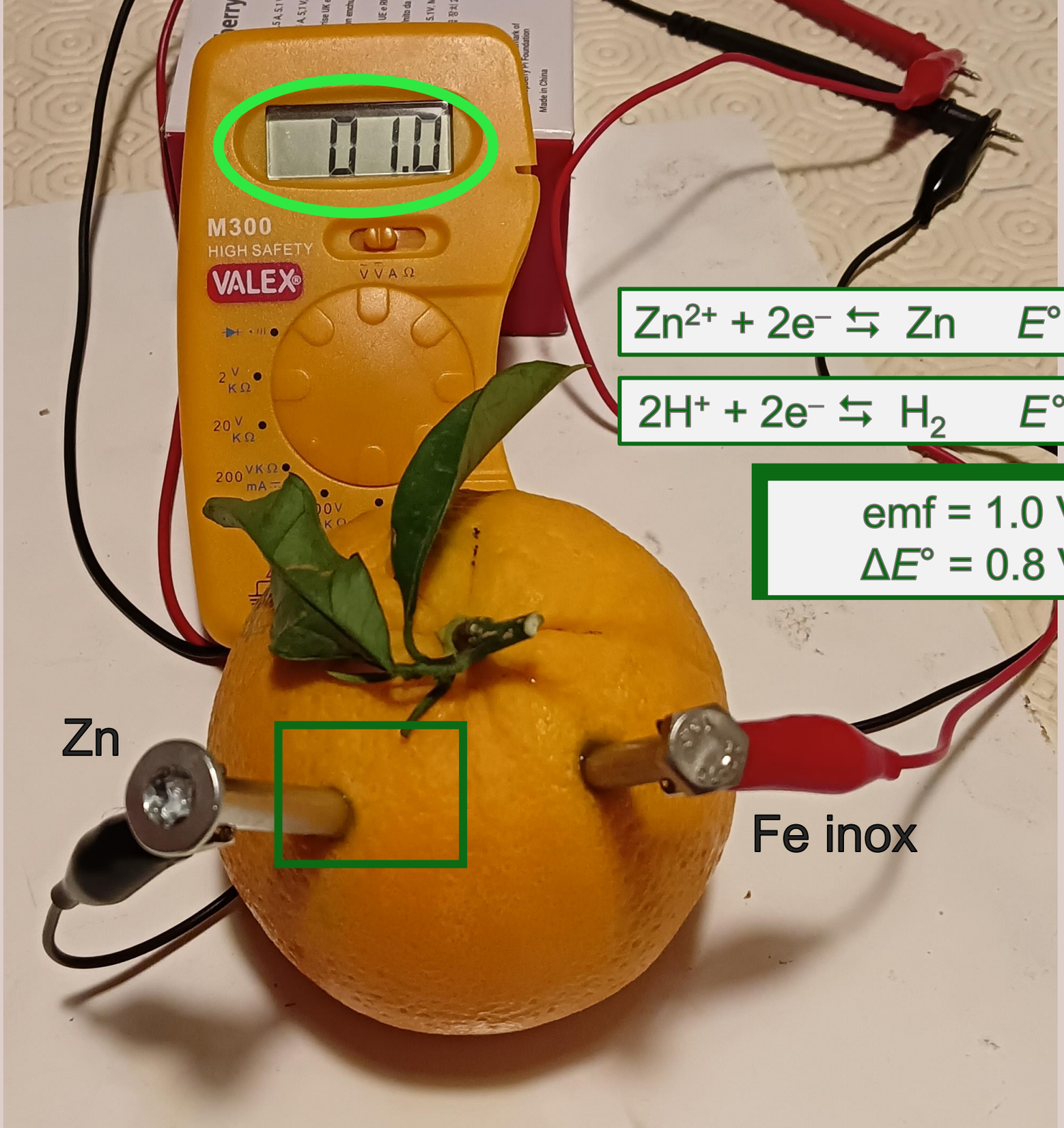
Fe zincato



elettrolita

acciaio inox

elettrodo inerte



$Zn^{2+} + 2e^- \leftrightarrows Zn \quad E° = -0.76\ V$

$2H^+ + 2e^- \leftrightarrows H_2 \quad E° = 0.00\ V$

emf = 1.0 V

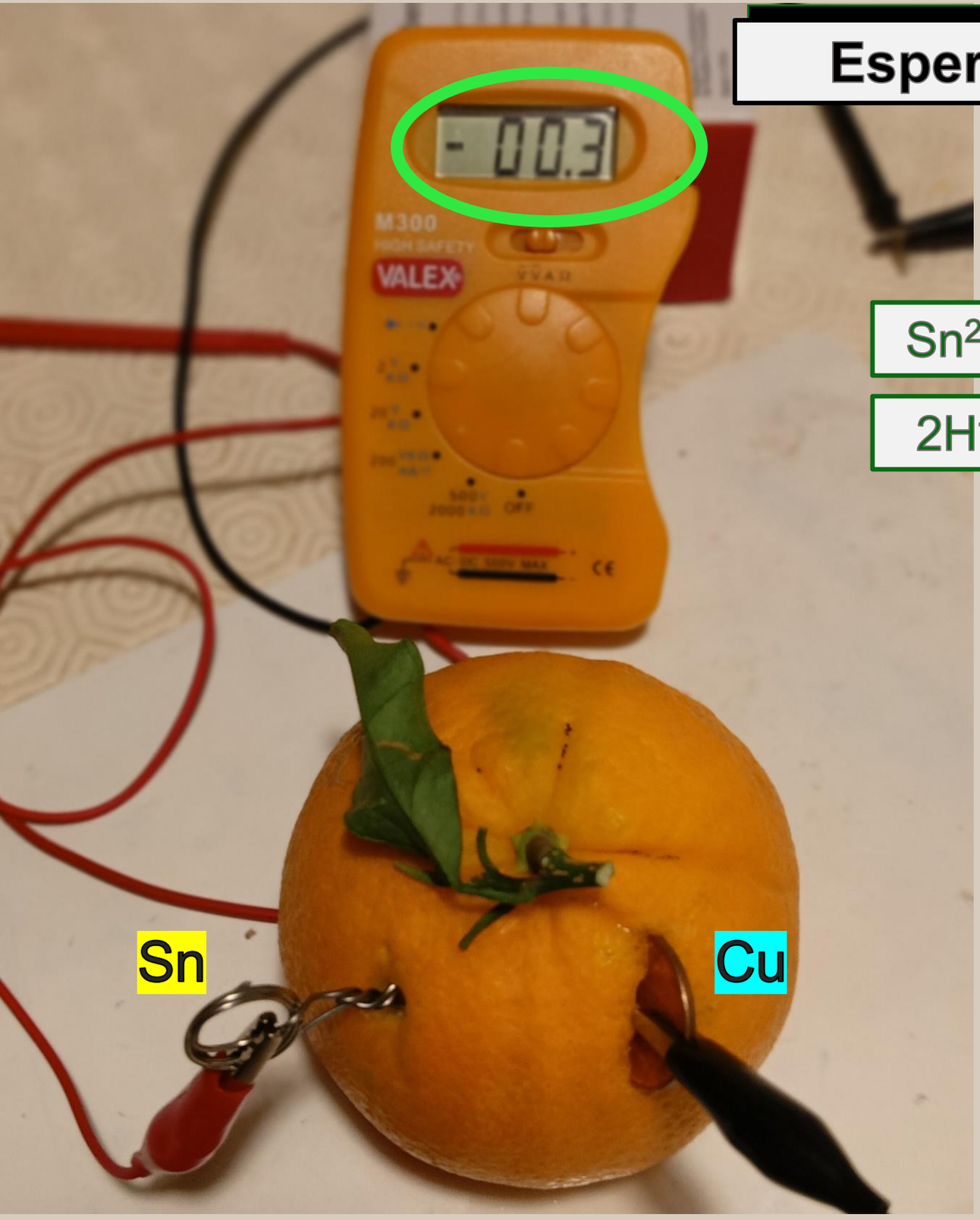
$\Delta E° = 0.8\ V$

E perché non cambiare anche l'elettrodo donatore?
Basta che abbia $E°$ < 0.00 V

$$Sn^{2+} + 2e^- \leftrightarrows Sn \qquad E° = -0.16\ V$$

stagno per saldatori
(4.50 €)

Esperimenti in cucina # 2



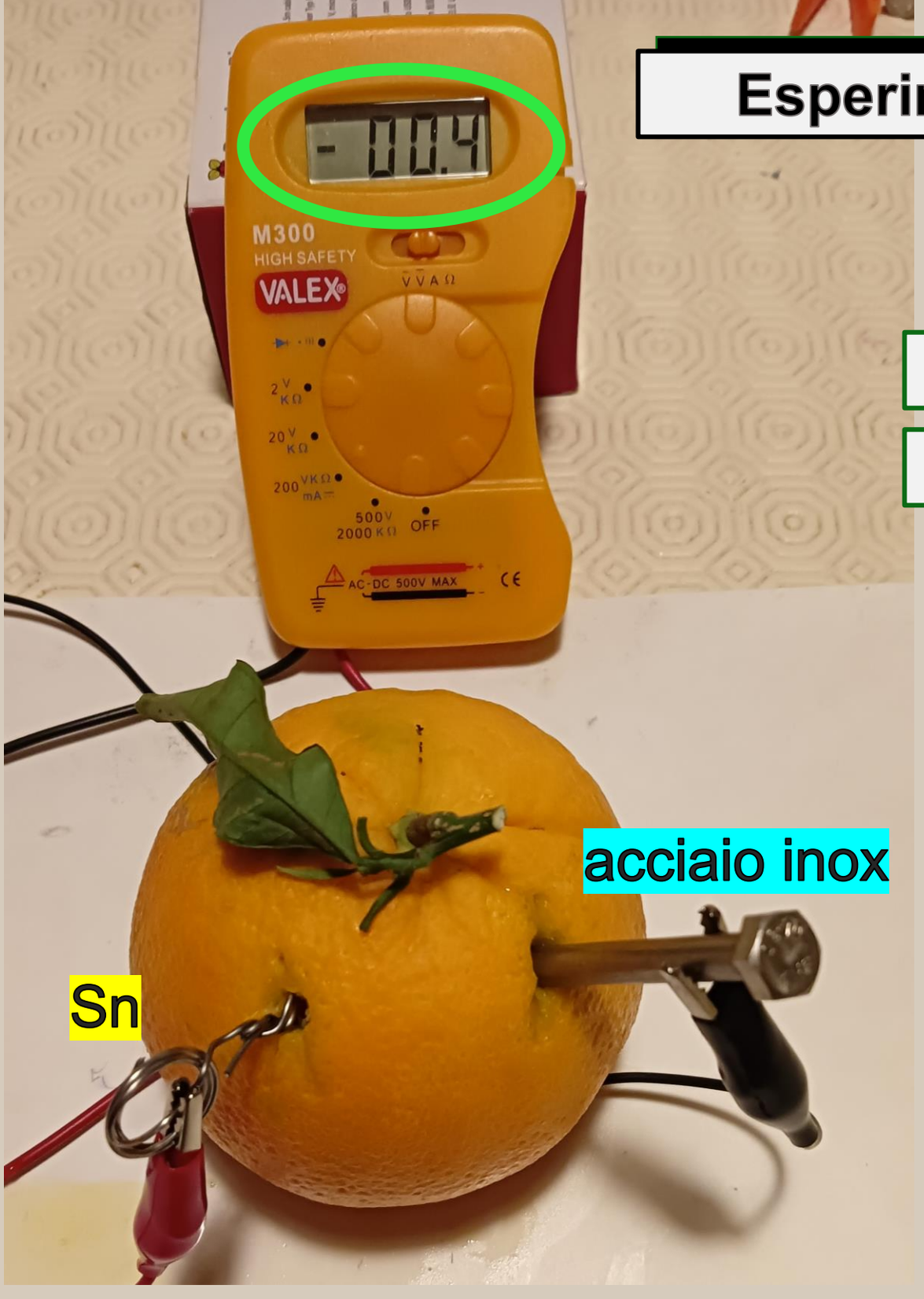
$Sn^{2+} + 2e^- \leftrightarrows Sn \quad E° = -0.16\ V$

$2H^+ + 2e^- \leftrightarrows H_2 \quad E° = 0.00\ V$

emf = 0.3 V

$\Delta E° = 0.2\ V$

Esperimenti in cucina #3



$Sn^{2+} + 2e^- \leftrightarrows Sn \quad E° = -0.16\ V$

$2H^+ + 2e^- \leftrightarrows H_2 \quad E° = 0.00\ V$

emf = 0.4 V

$\Delta E° = 0.2\ V$

JOURNAL OF CHEMICAL EDUCATION

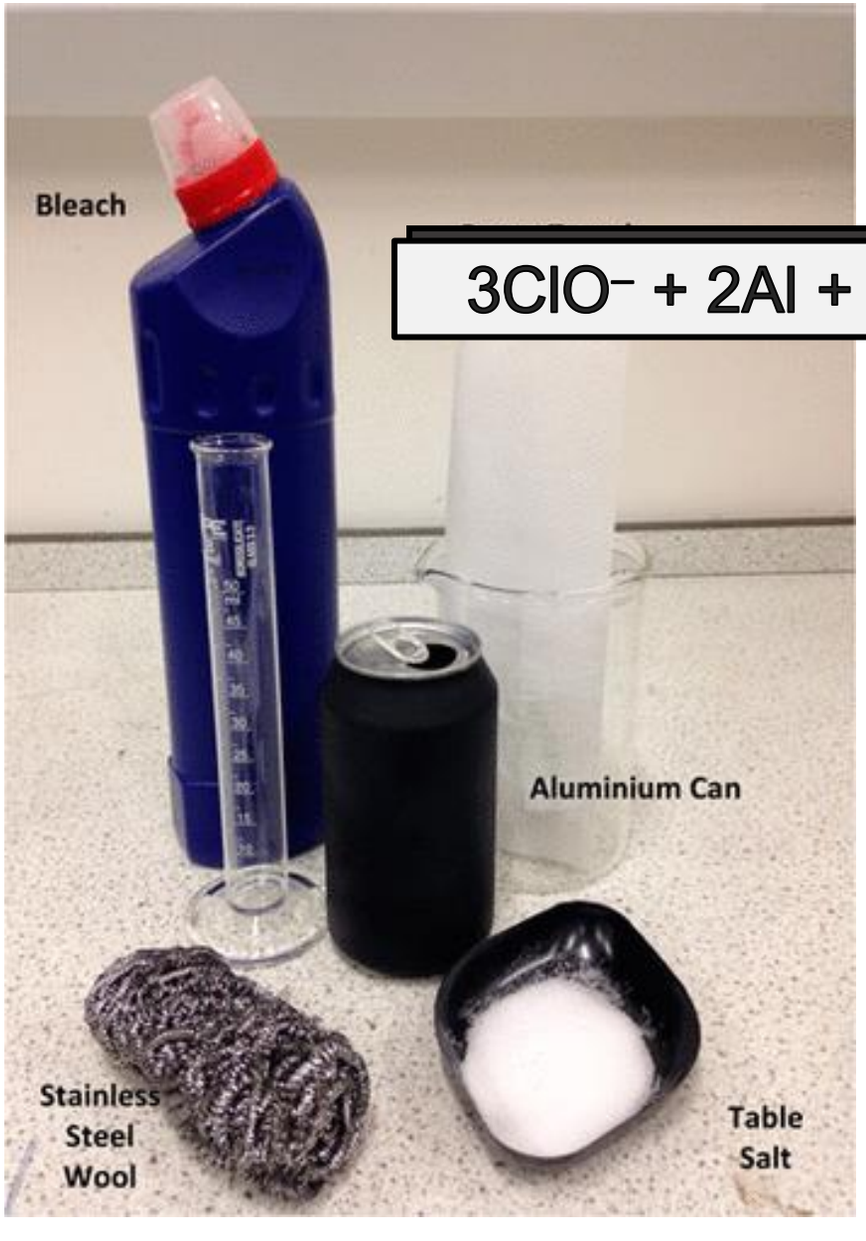
Activity

pubs.acs.org/jchemeduc

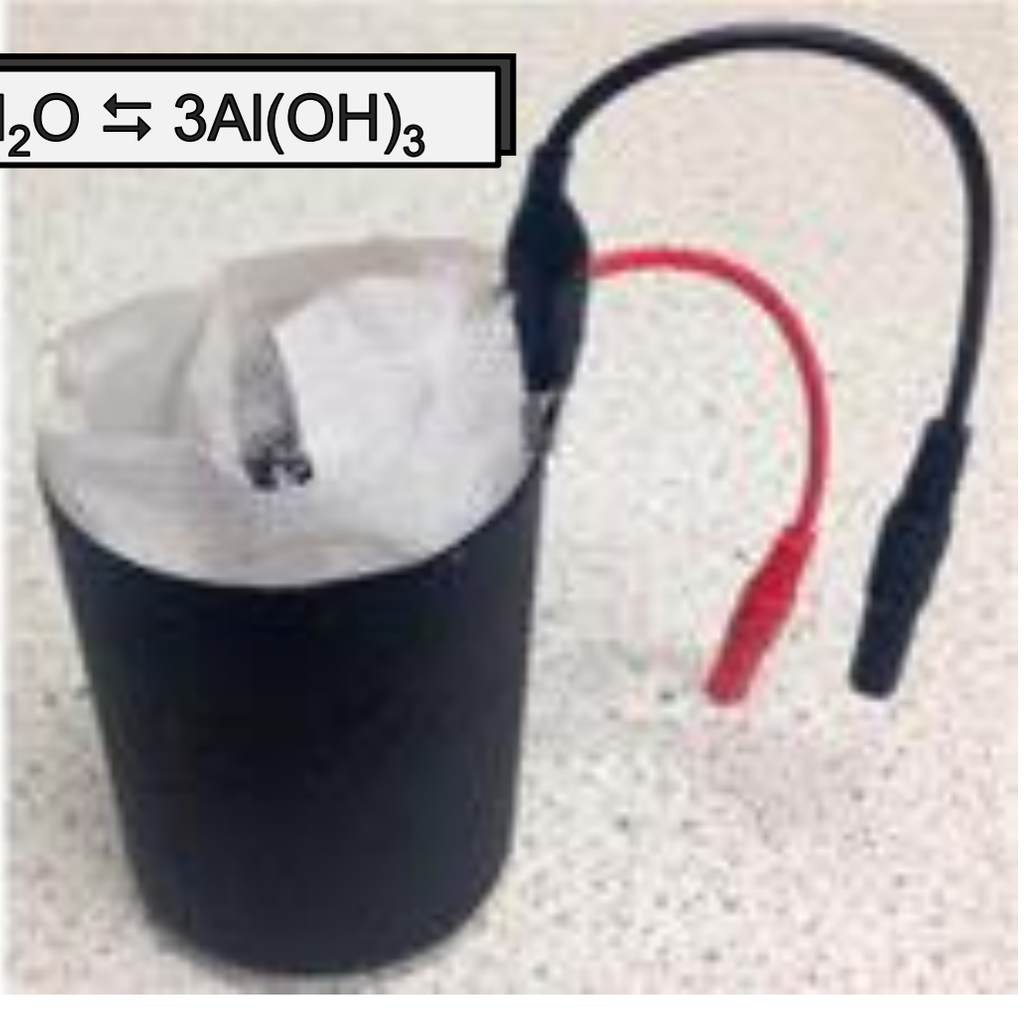
"Can" You Really Make a Battery Out of That?

Michael A. Parkes,*[,†] Thomas Chen,[‡] Billy Wu,[†,§] Vladimir Yufit,[†] and Gregory J. Offer[†,§]

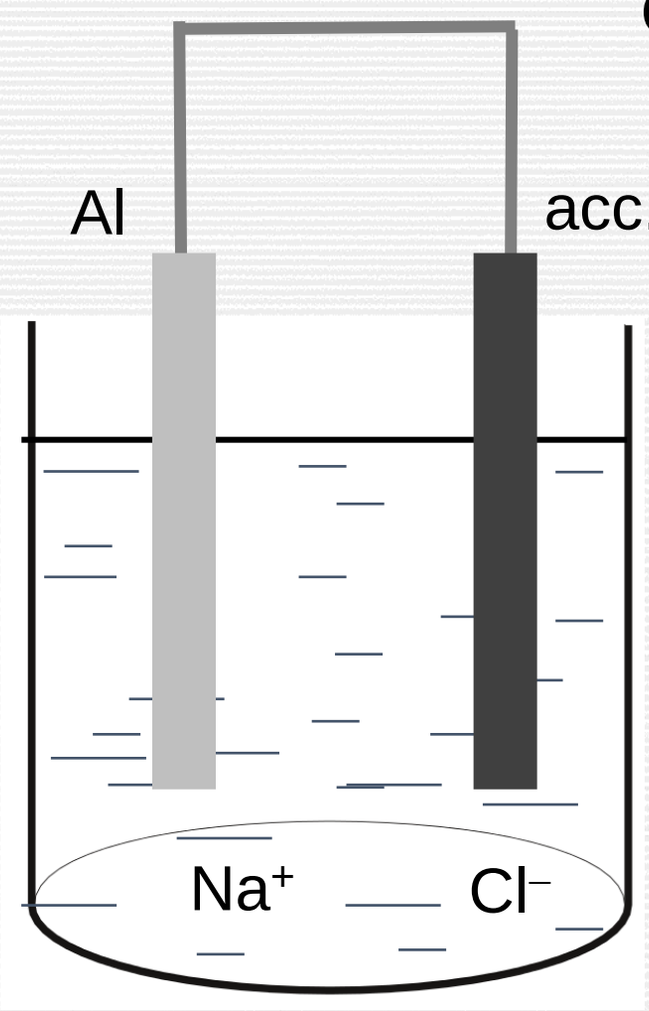
J. Chem. Educ. **2016**, *93*, 681−686



$$3ClO^- + 2Al + 3H_2O \leftrightarrows 3Al(OH)_3$$



Cella alluminio/ipoclorito – versione didattica



$$2Al \leftrightarrows 2Al^{3+} + 6e^-$$

$$3ClO^- + 6e^- + 3H_2O \leftrightarrows 3Cl^- + 6OH^-$$

$$3ClO^- + 2Al + 3H_2O \leftrightarrows 3Al^{3+} + 6OH^-$$

$$3ClO^- + 2Al + 3H_2O \leftrightarrows 3Al(OH)_3$$

$Al(OH)_3 + 3e^- \leftrightarrows Al + 3OH^-$ $\quad E° = -2.31$ V

$ClO^- + 2e^- + H_2O \leftrightarrows Cl^- + 2OH^-$ $\quad E° = 0.89$ V

$\Delta E° = 3.20$ V


VORREI INVENTARE UNA NUOVA BATTERIA, MA NON SO DA DOVE COMINCIARE

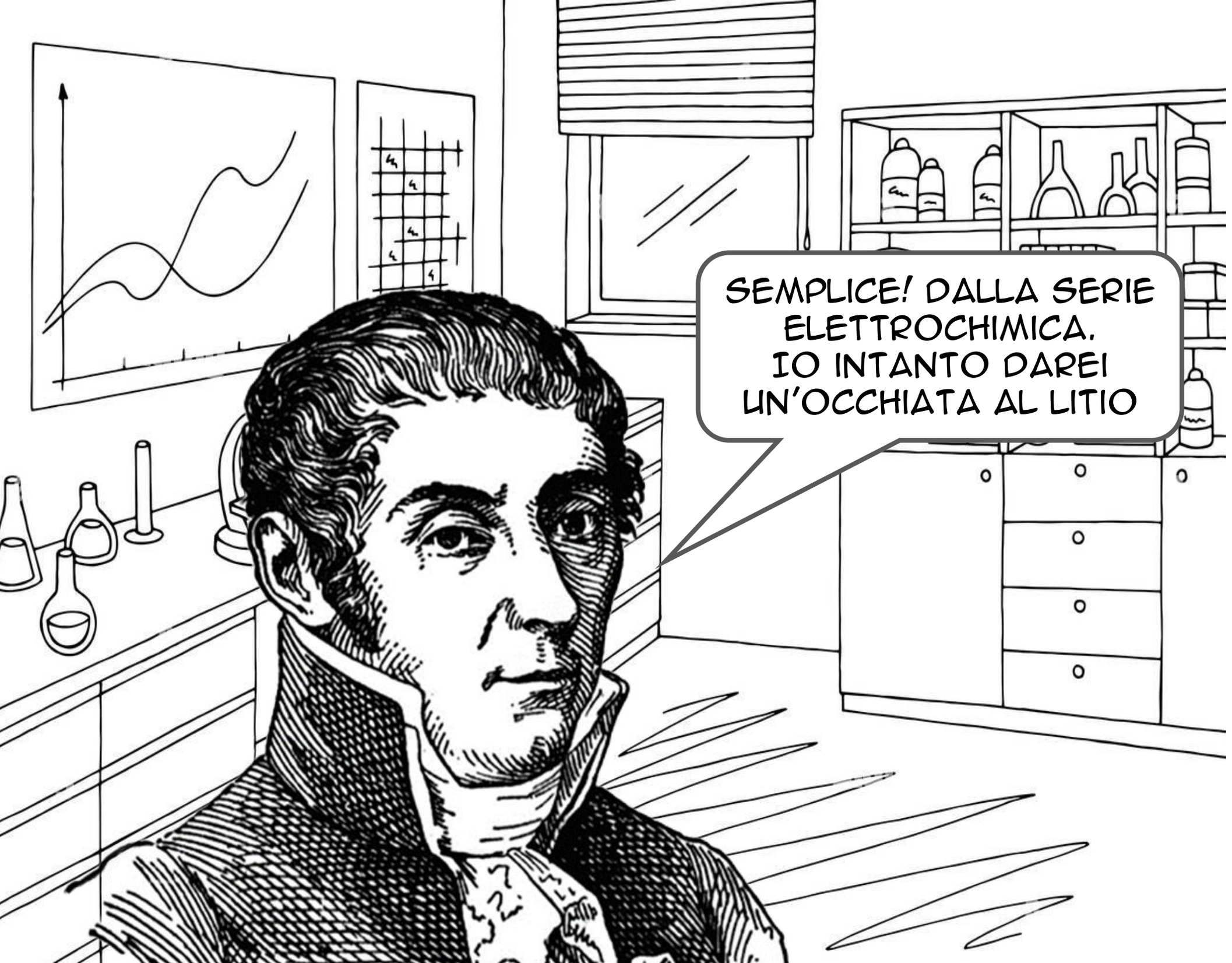

SEMPLICE! DALLA SERIE ELETTROCHIMICA. IO INTANTO DAREI UN'OCCHIATA AL LITIO

TABLE 18.1 Standard Reduction Potentials at 25 °C

Reduction half-reaction	$E°$(V)
$F_2(g) + 2e^-$	2.87
$Ce^{4+}(aq) + e^-$	1.61
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$	1.51
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(\ell)$	1.23
$Br_2(\ell) + 2e^- \rightarrow 2Br^-(aq)$	1.06
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$	0.96
$Ag^+(aq) + e^- \rightarrow Ag(s)$	0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	0.77
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	0.54
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	0.34
$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$	0.222
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	0.15
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.000
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	−0.126
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	−0.25
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$	−0.41
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	−0.76
$Ba^{2+}(aq) + 2e^- \rightarrow Ba(s)$	−1.57
$Al^{3+}(aq) + 3e^-$	−1.66
$Mg^{2+}(aq) + 2e^-$	−2.37
$Na^+(aq) + e^-$	−2.714
$Li^+(aq) + e^- \rightarrow Li(s)$	−3.045

semicella ossidante

$\Delta E°$

semicella riducente

continua...