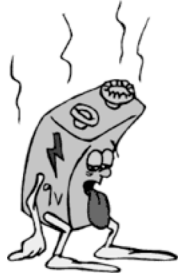


Batteries

Engineering is always a
TRADE-OFF

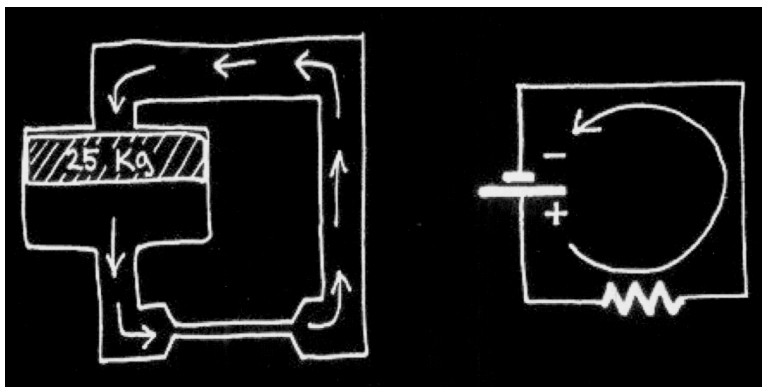


cost
size
weight
energy density



fire-explosion hazard
toxicity upon disposal

Diagram of Battery and Ohm's Law



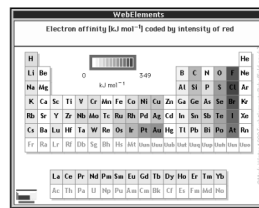
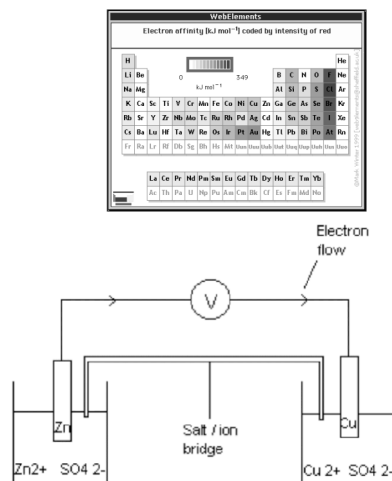
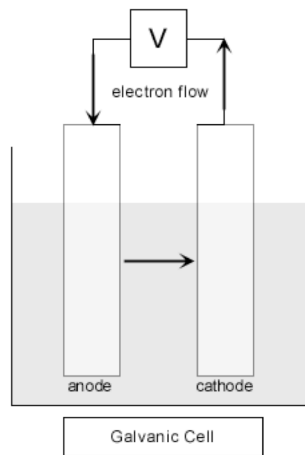
- Voltage is like pressure
- Ohm's law: $\text{current} = \text{voltage} / \text{resistance}$
- Power = current x voltage (how bright is bulb)

Energy in a Battery

- Energy = Power x Time
 - measured in ampere•hours (given voltage)
- Energy Density
 - how much energy per volume or weight.
- Batteries can get hot if short-circuited
 - some may catch fire or explode

How does a battery work

- Electrochemical Reaction
 - Based on electron affinity of various atoms



Different Types of Batteries

- Alkaline
 - AA's, AAA's, C's, D's, and 9V
- Mercury, Silver, Zinc
 - tiny, in watches, hearing aids
- Nickle-Cadmium, Lead-Acid, Lithium-Ion
 - rechargeable

<http://www.ehso.com/ehshome/batteries.php>

Which types are bad in the landfill?

- Really bad
 - lead, cadmium, and mercury (mad as a hatter)
- Somewhat bad
 - silver, zinc, and nickel, lithium
- OK to dump in trash
 - Alkaline (since 1997, used to have mercury before)



<http://www.grinningplanet.com/2004/12-21/battery-recycling-article.htm>

Alkaline Batteries

- Not bad ecologically, can just throw out
- Not rechargeable, however



Rechargeable Batteries

- generally have greater internal leakage, shorter “shelf-life”
- Nickel-Cadmium (“ni-cads”) and Nickel-Hydride
 - bad because heavy metals
 - limited # recharges
 - “memory”, for discharge endpoint, deep discharge is best
 - being phased out
- Lithium-ion
 - greater # recharges, very high energy density
 - fire-explosion hazard, but getting better
 - present favorite for phones and computers
 - no memory, in fact, better to “top off”
 - should still recycle

Lead Acid



- Very large currents
 - can turn the engine over in a car
- Rechargeable many times
- Large amount of lead! Very toxic!
- Sulfuric acid - very dangerous
- Can explode (safer now)
- We have figured out how to recycle.
 - since expensive, large, and heavy,

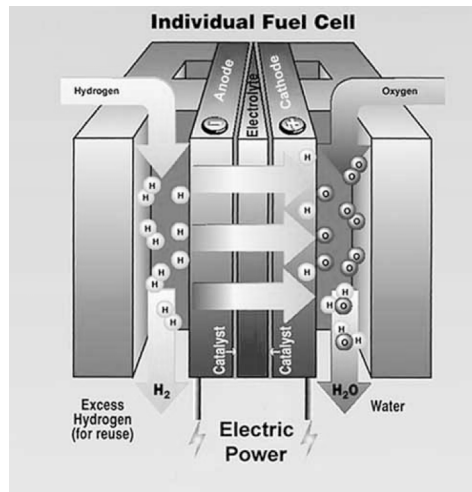
Case History: a Telemetric Egg



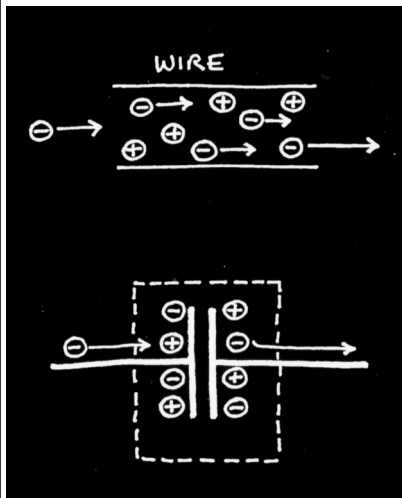
- Needed to transmit for months
- Lithium-ion (highest energy density for non-military)
- Can explode if shorted

Alternate to battery is Fuel Cell

- Uses fuel continuously to produce electricity



Ultimate "battery" may be Super-Capacitor



- Not electro-chemical
- Faster charge rate
- Higher energy density
- Just store electrons
- Infinite # recharges
- Non toxic materials
- Electric cars