

Magnetism



National Science Foundation
WHERE DISCOVERIES BEGIN

Magnetism

Invisible forces,
like magnetism,
are popular in
science fiction.



Magnets

Basic observations:

Most metals *cannot* be magnetized.

Iron (and a few other metals) are *ferromagnetic*, which means they can become magnetized.

Magnets attract ferromagnetic metals.

Two magnets can either attract or repel each other depending on their poles.



Ferromagnetic Metals

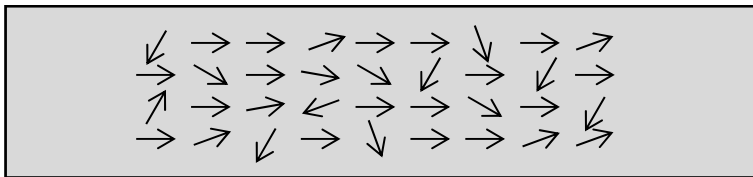


Coins from around the world

Magnetizing Iron

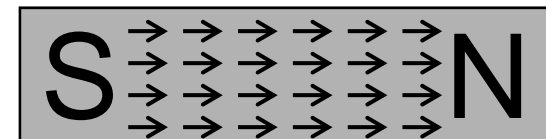
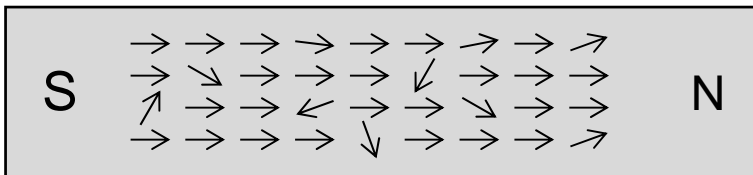
Magnetic domains can be induced to align by an external magnetic field.

Unmagnetized Iron



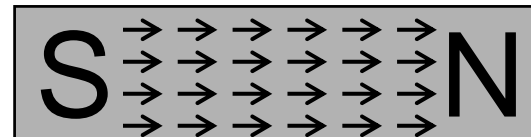
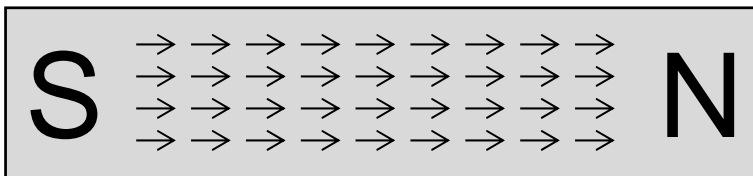
Magnetic domains are not aligned (random)

Weakly magnetized Iron



Strong Magnet

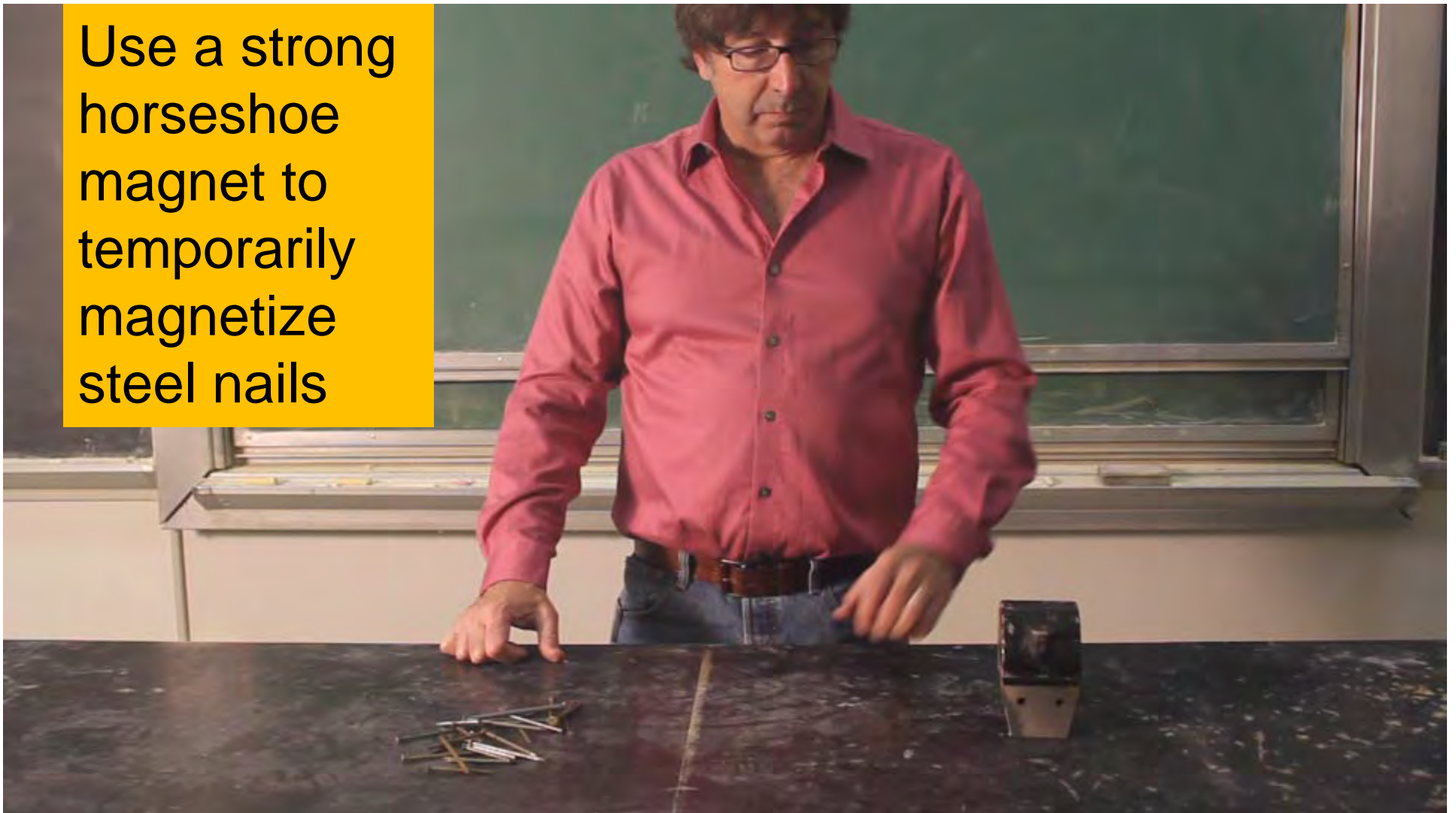
Strongly magnetized Iron



Strong Magnet

Magnetizing Iron

Use a strong horseshoe magnet to temporarily magnetize steel nails

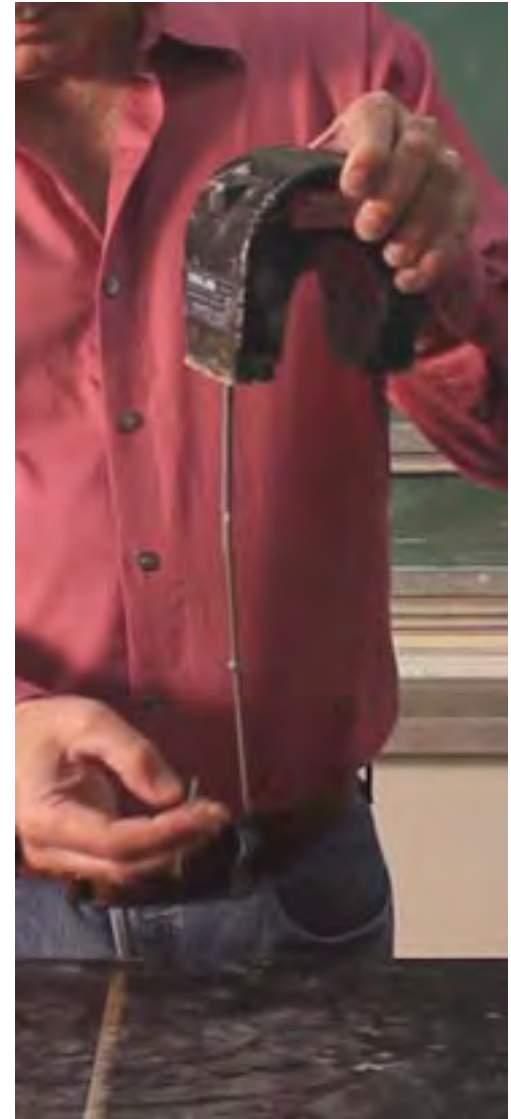


Magnetizing Iron

Magnetic domains in iron nails are induced to align by proximity of the strong magnet.

Each nail becomes itself a magnet, which in turn magnetizes the nail below it, forming a chain.

When the strong magnet is removed, most of the domains un-align and nail lose most of their magnetization.



Demagnetizing Iron

Iron nail is attracted to the large magnet due to alignment of domains in the nail.

Heat the nail to a high temperature and the domains become randomized so the nail is no longer attracted to the magnet.



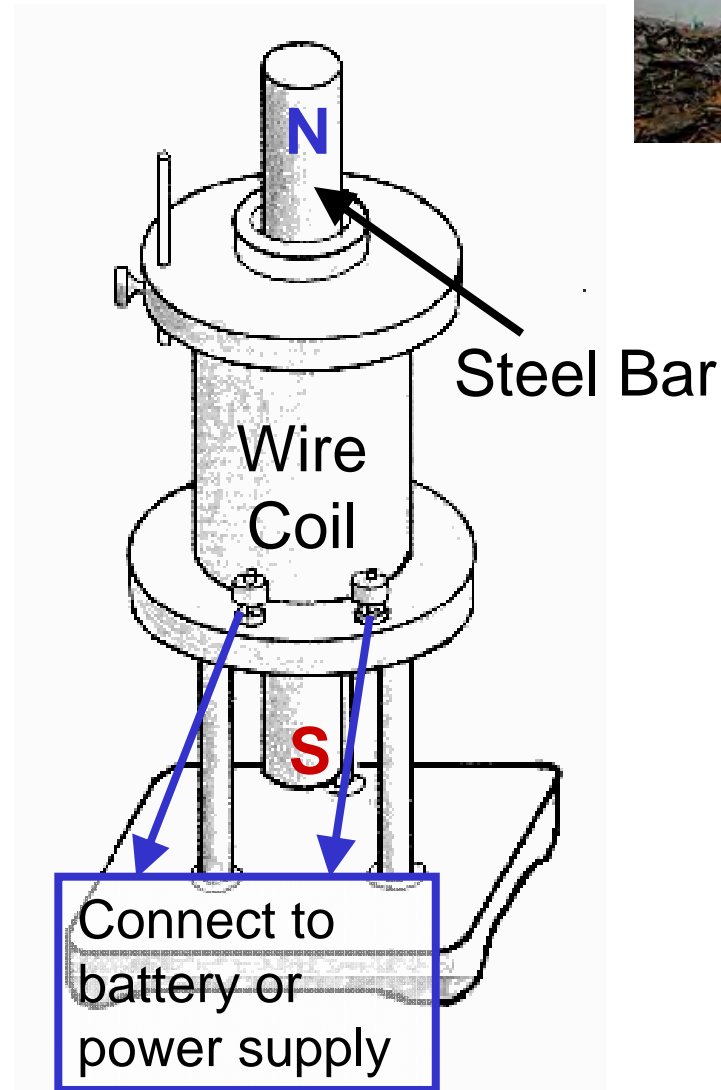
Demagnetizing Iron



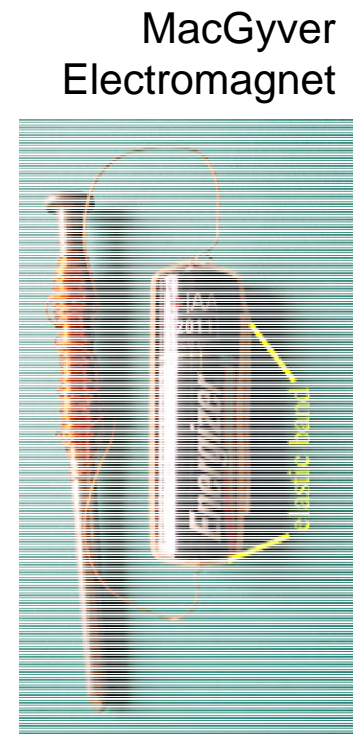
Electromagnets

Electromagnet created by current through a coil of wire.

Electromagnet is stronger when a steel bar is inserted within the coil.

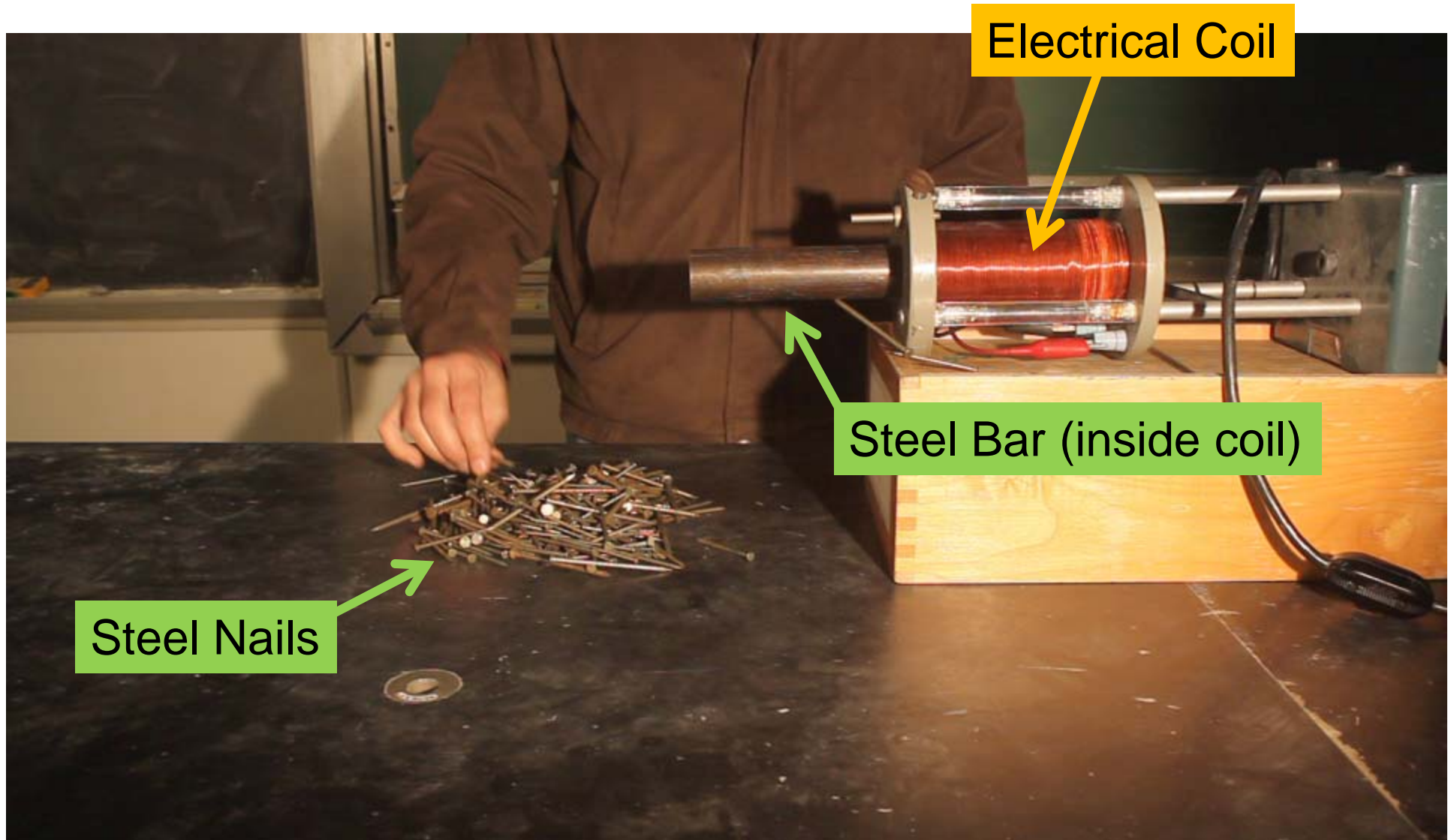


Junkyard
Electromagnet



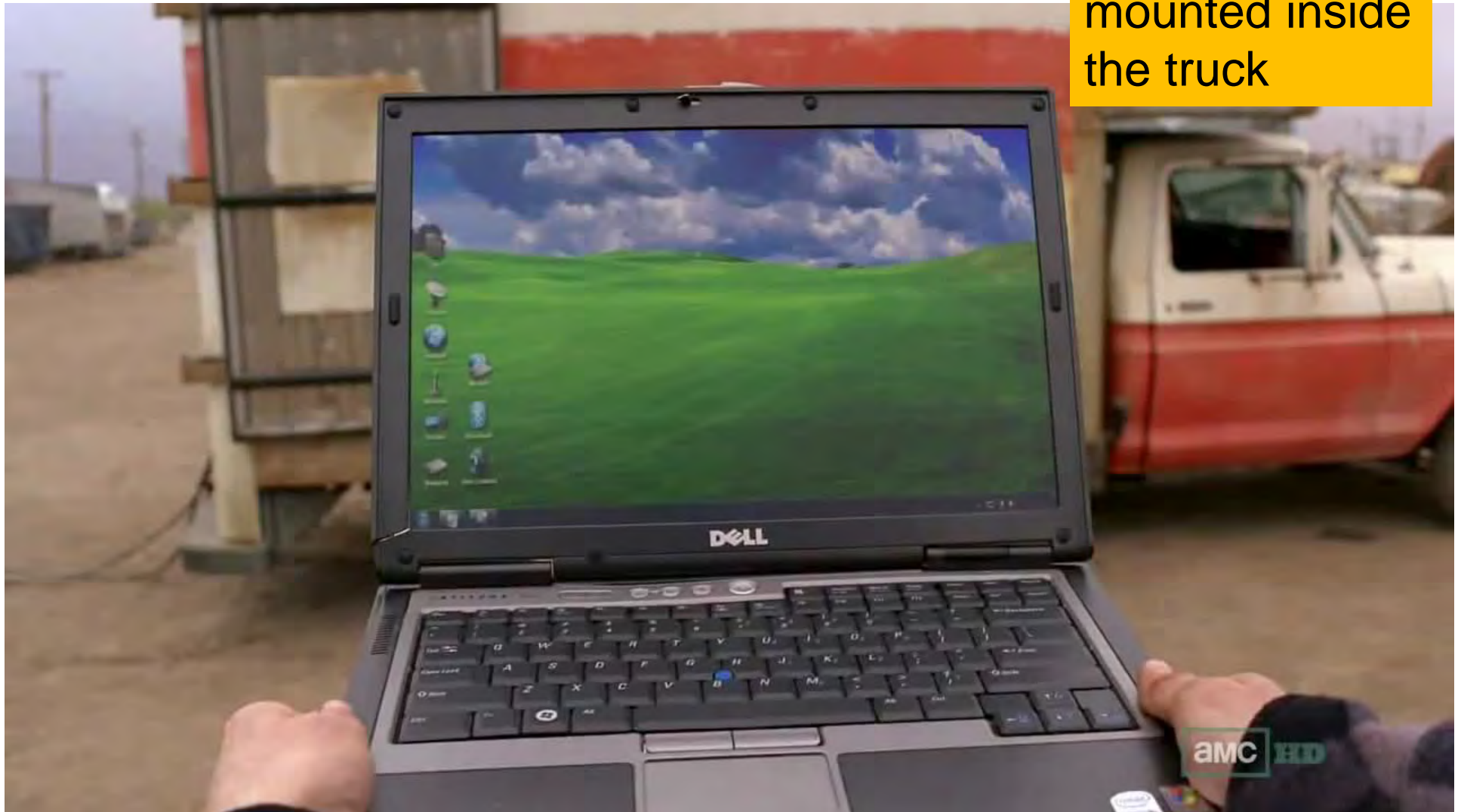
MacGyver
Electromagnet

Electromagnets



Breaking Bad (Season 5)

Electromagnet
mounted inside
the truck

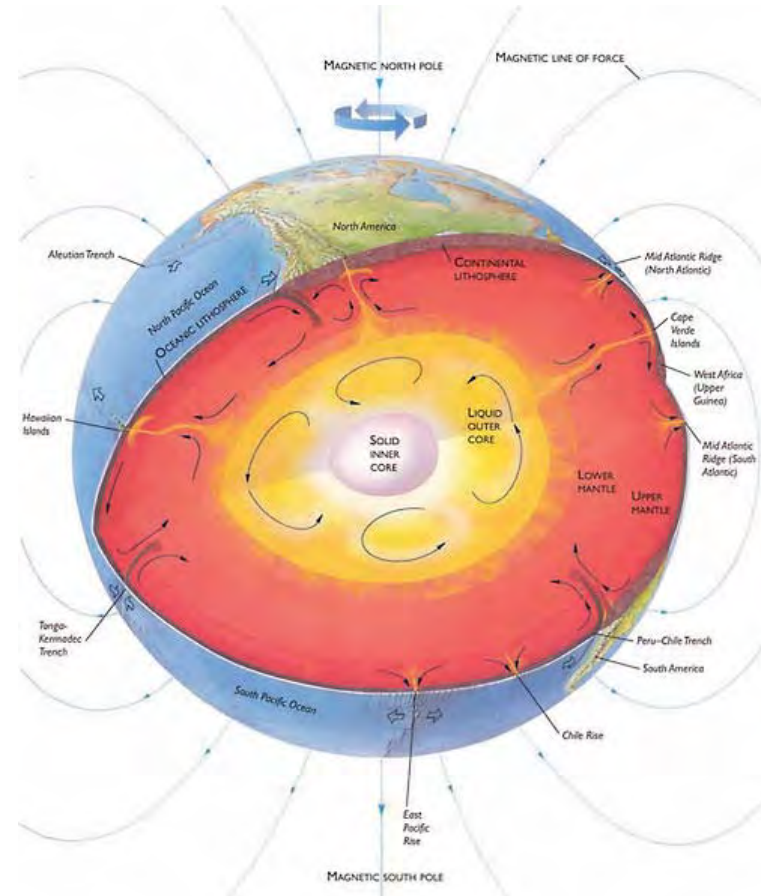


Earth's Magnetic Field

Earth's magnetic field is produced by a giant electromagnet inside the metal core.

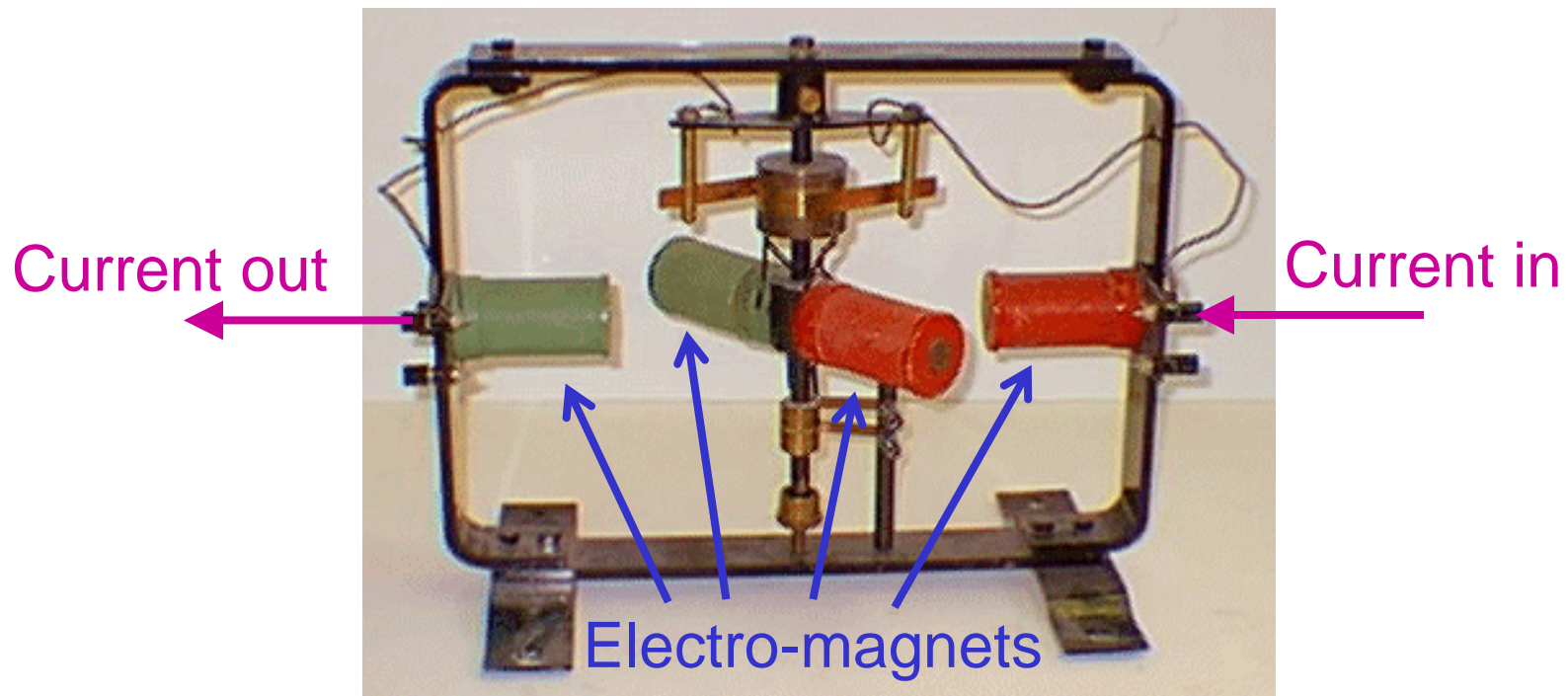
Electrical currents within the molten core create the magnetic field.

This core is too hot for the iron to remain magnetized without these currents.



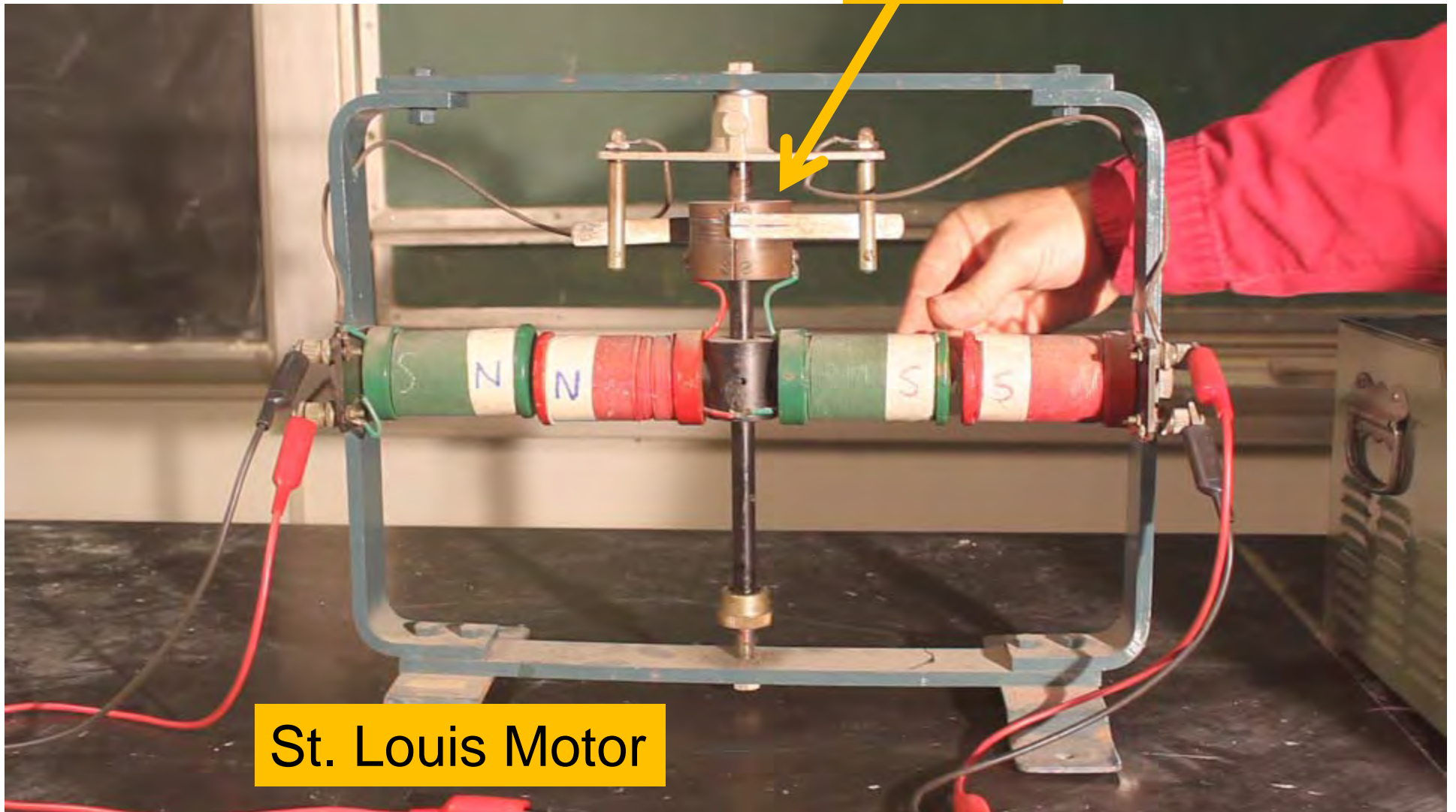
Electric Motor

An electrical motor has electromagnets mounted on a rotating shaft.



Electric Motor

Switch

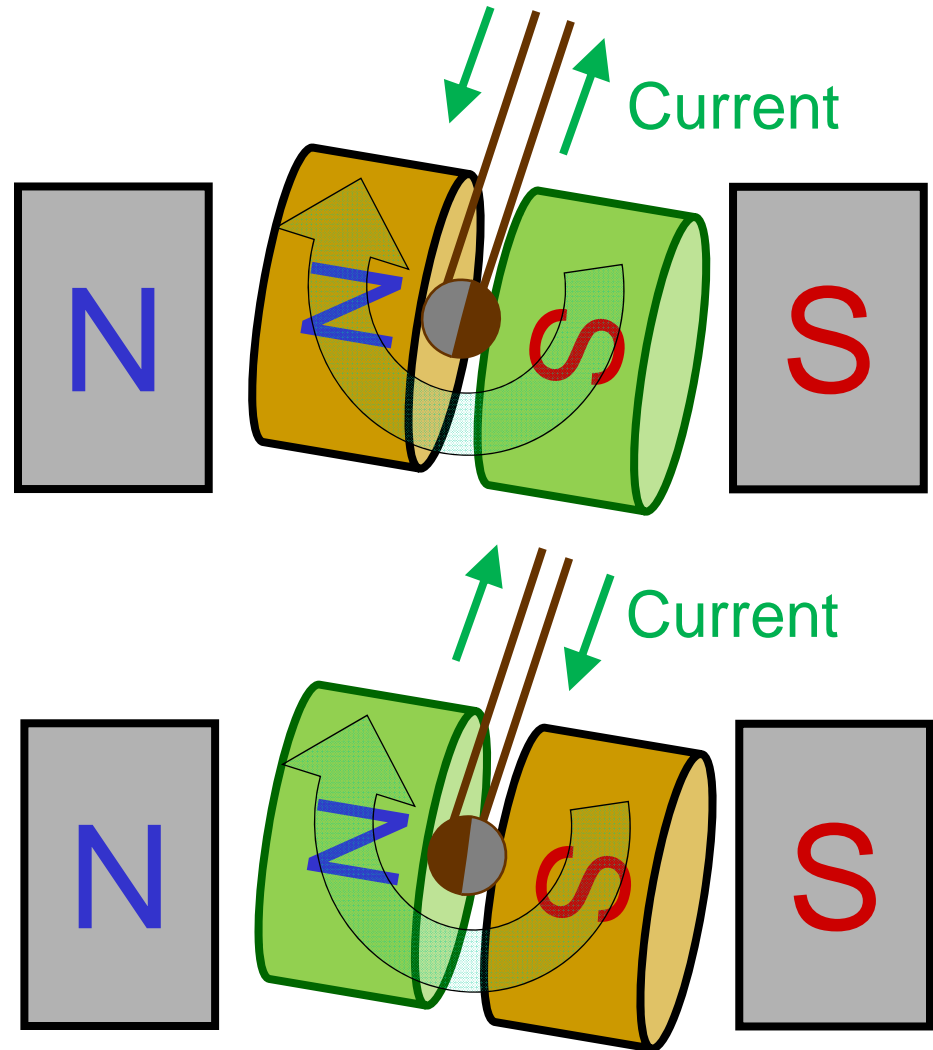


St. Louis Motor

Electric Motor, Analyzed

Electromagnets are mounted on a shaft with opposing magnets on each side.

Current's direction is always such that the shaft's electromagnet are repelled, causing shaft to turn.



Summary

- Most metals cannot be magnetized.
- Ferromagnetic metals, such as iron, can be magnetized by a magnetic field.
- Opposite poles (N & S) of magnets attract; like poles (N & N or S & S) repel.
- Magnetism may be removed by heating.
- Electric currents produce magnetic fields, as with an electromagnet.
- Earth's core acts as an electromagnet.
- An electric motor uses electromagnets to create the force that turns the motor's axle.