Applications of Electromagnetic Induction

Science — experiments
Mathematics — equations
Engineering — applications

Electromagnetic induction (Faraday)

curl **E** = - d**B** /dt (Maxwell)

Electric generators
- Faraday and Henry (1831)
- Pixii (1832)
- Siemens and Wheatstone (1867)
- Gramme (1871)
- Brush (1876)
- Tesla (1886)
- Steinmetz (1892)

An electric generator is a device that converts mechanical energy (the kinetic energy of rotation) into electrical energy (electromagnetic field energies).

It consists of stationary coils of wire (the stator), rotating coils of wire (the rotor), a primary power source that exerts a torque on the rotor.

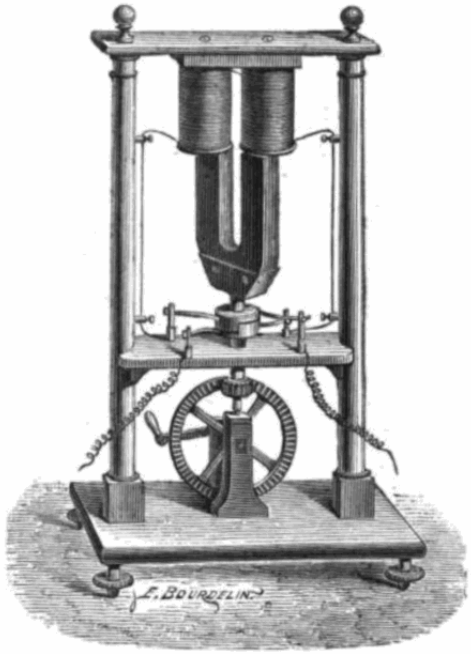
A common example of the primary energy source is burning coal and a steam turbine.

Electric generators and dynamos

A generator (or dynamo) creates E.M.F. by electromagnetic induction:

As the magnetic flux through a coil of wire changes, an EMF around the coil of wire is induced. If the coil is connected to an appliance, the EMF will drive current through the circuit. The appliance will do something useful.

Hippolyte Pixii (Paris, 1832)



This would be called a “dynamo” because the magnet rotates and the EMF producing coils are fixed. It produced a pulsed direct current (DC) because of the commutator. The primary power source is the person who turns the crank.

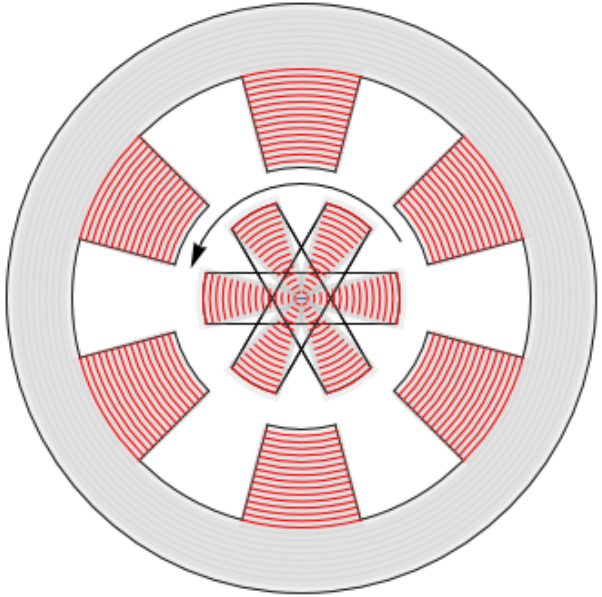
Electric generators and dynamos

The historical development of electric generators…

edisontechcenter.org/generators.html

Siemens and Wheatstone (1867): replace the magnet by electromagnets; self-excitation
Gramme (1871): wrap the coils around iron cores
Brush (1876): manufactured dynamos for arc lighting; street lighting
Edison (1884): the Pearl Street Station
Tesla (1886): designed AC generators (“alternators”) for the Westinghouse company
Steinmetz (1892): the mathematical theory of AC generators for GE

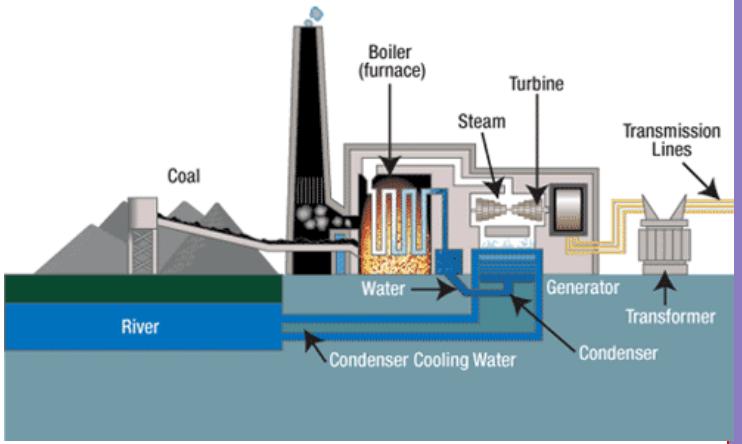
Multipole generators



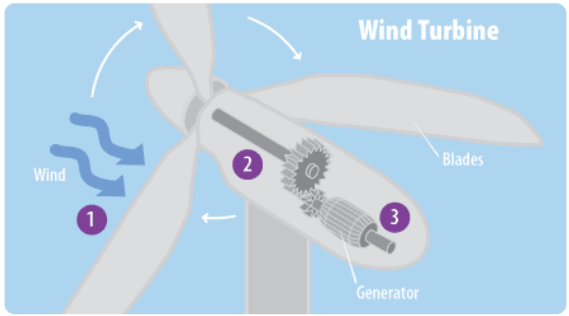
Primary energy sources

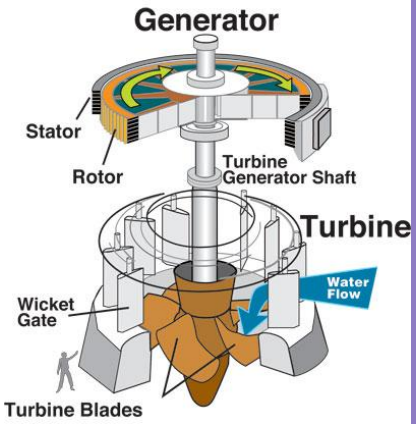
An electric generator is an energy conversion device. It converts rotational kinetic energy to electromagnetic field energy by the phenomenon of electromagnetic induction.

It requires a primary energy source to drive the rotor of the generator.



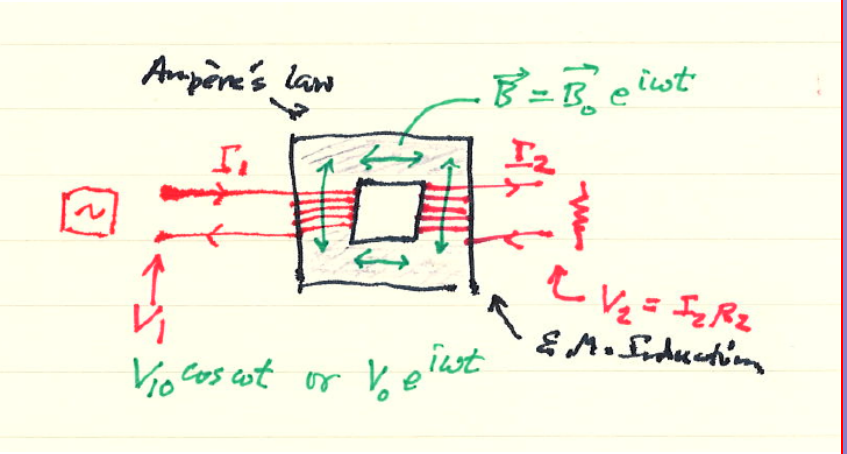
- Steam turbines driven by heat:
  - combustion of coal
  - combustion of diesel fuel
  - a nuclear reactor (fission)
- Water turbines driven by flow of water
  - river
  - hydroelectric dam
- Wind turbines



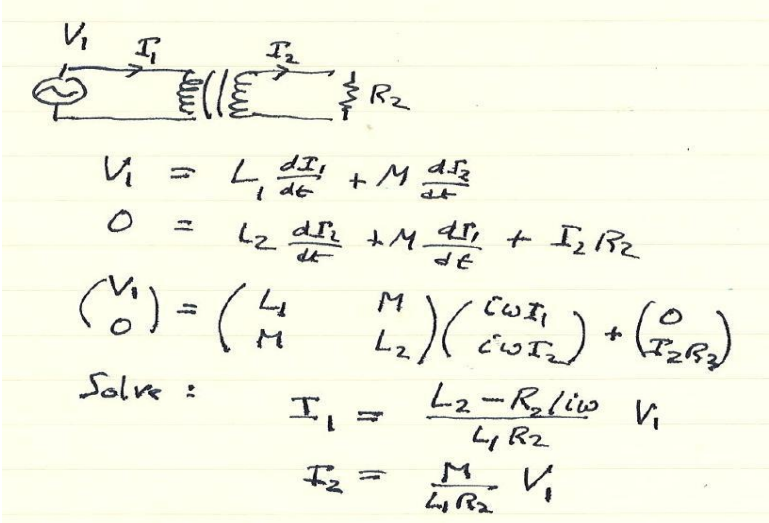


Transformers

A transformer is an AC device that converts E.M.F. (voltage) from high voltage to low voltage (step-down transformer) or from low voltage to high voltage (step-up transformer), by the phenomenon of electromagnetic induction.



Transformer theory



Ideal transformer equations