BASIC ELECTRICITY

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PRO-TECH SYSTEMS GROUP

What We Will Learn:

- ➡Definition of Electricity
- ➡Electrical Fundamentals
- ➡Generation & Transmission
- ➡Transformers
- ➡Fuses & Circuit Breakers
- ➡Motors
- ➡Motor Controls
- ➡Safety

What This Session is Not:

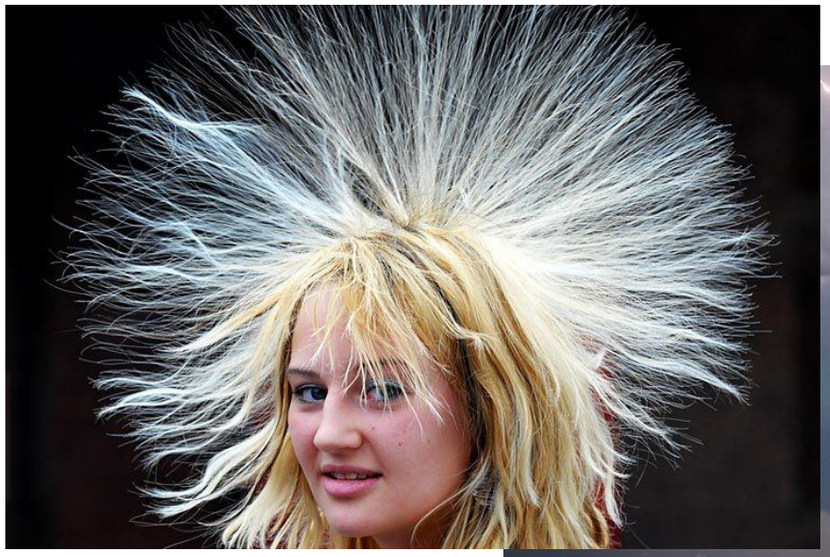
- ➡Electrical License Preparation.
- ➡No Apprentice or Journeyman cards will be issued.

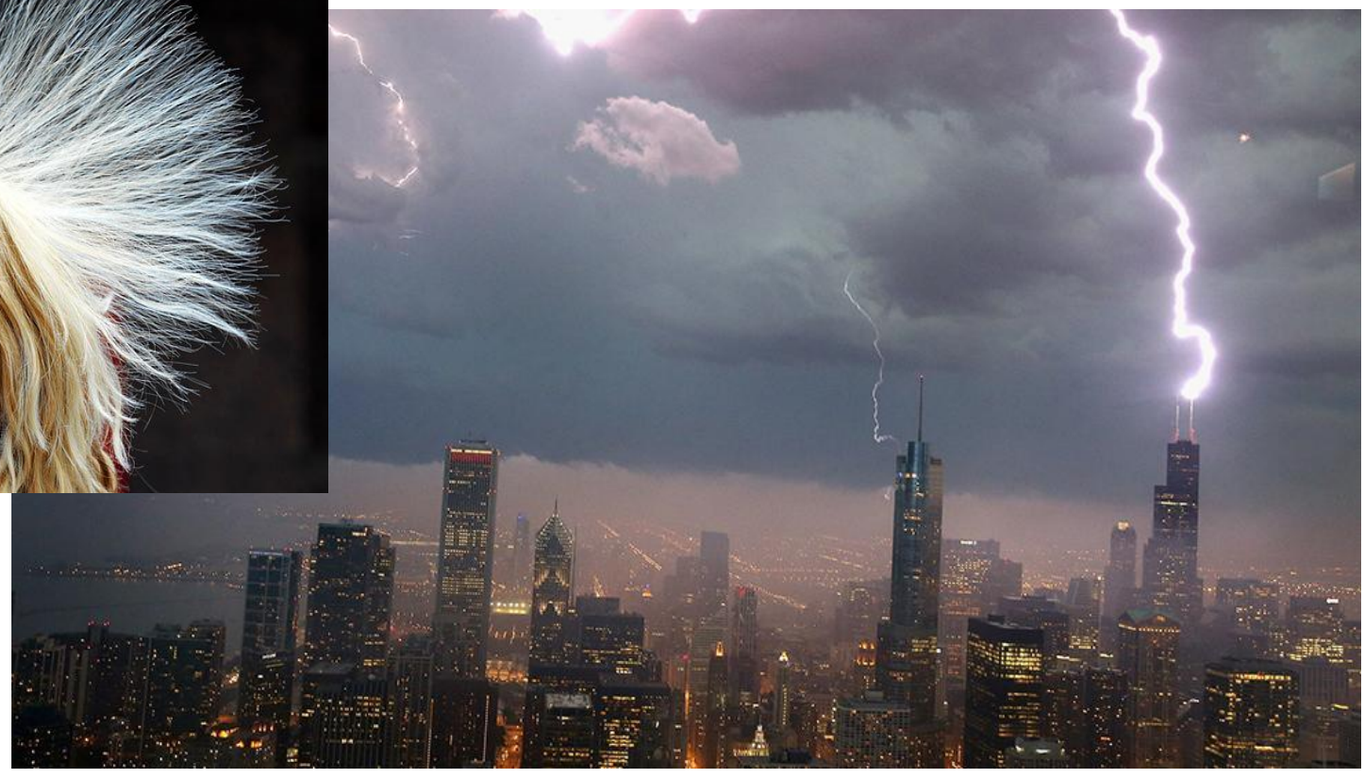

All Electrical Work,
Installation or Maintenance,
Should Be Performed by
Licensed & Experienced
Contractors.

Definition - Electricity

e·lec·tric·i·ty

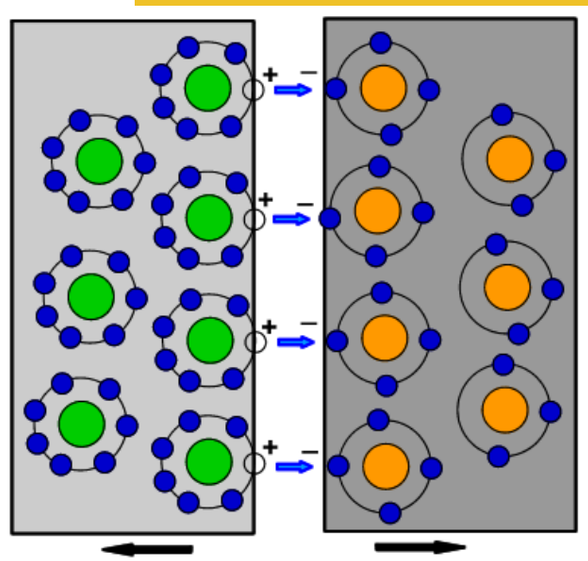
a form of energy resulting from the existence of charged particles, either statically as an accumulation of a charge or dynamically as a current.

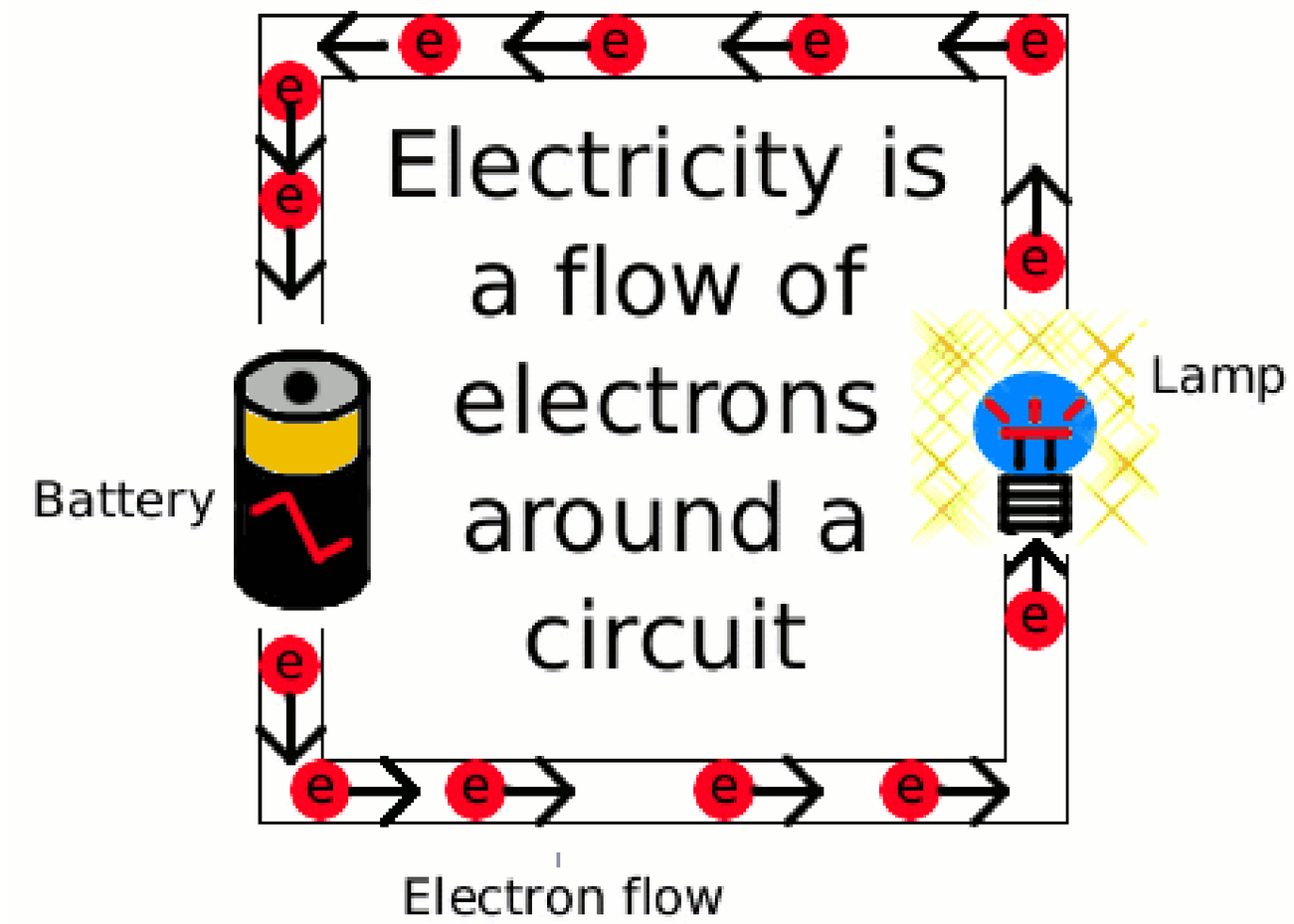




Static electricity is an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric current or electrical discharge. Static electricity is named in contrast with current electricity, which flows through wires or other conductors and transmits energy.

Static Electricity





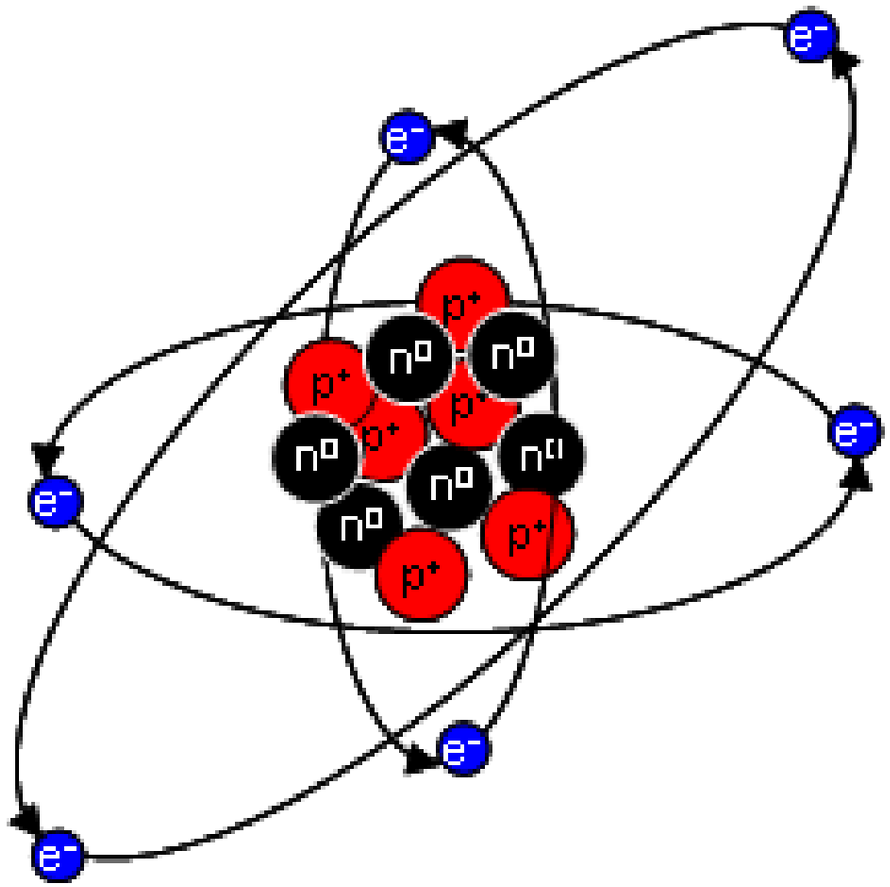
Dynamic electricity is the flow of electric charges through a conductor; in other words, an electric current.

Dynamic Electricity

Dynamic electricity is usable to us as the conveyance of generated energy. In a way, we are connecting directly to the power’s source to perform our desired work.

Electrical Fundamentals

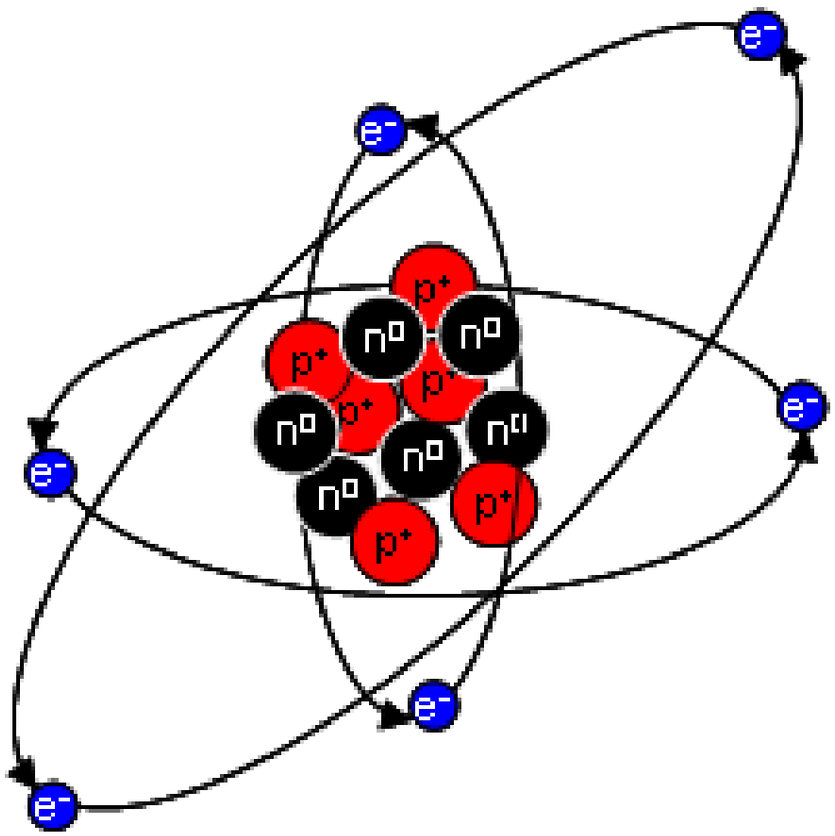
Basic electrical fundamentals begin with the atom.



Protons – Positively Charged

Neutrons – Neutral

Electrons – Negatively Charged

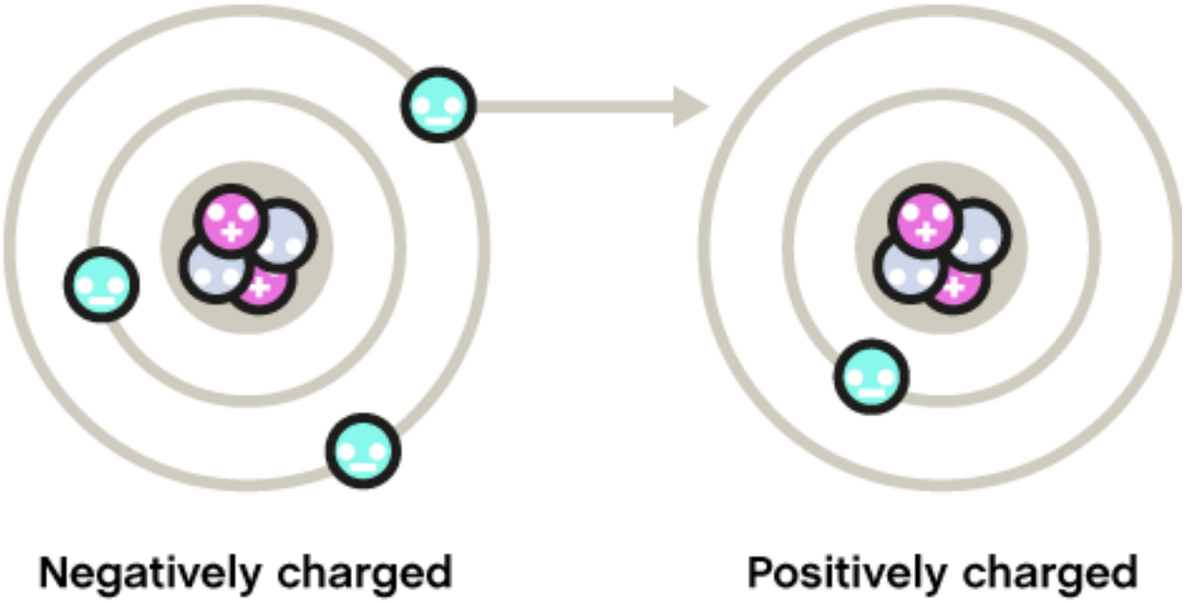


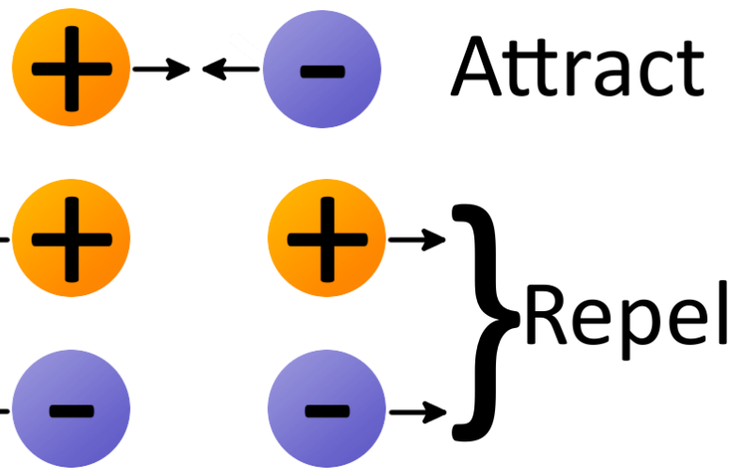
Protons = Electrons – the Atom is Neutral.

Protons > Electrons – the Atom is Positively Charged

Electrons > Protons – the Atom is Negatively Charged

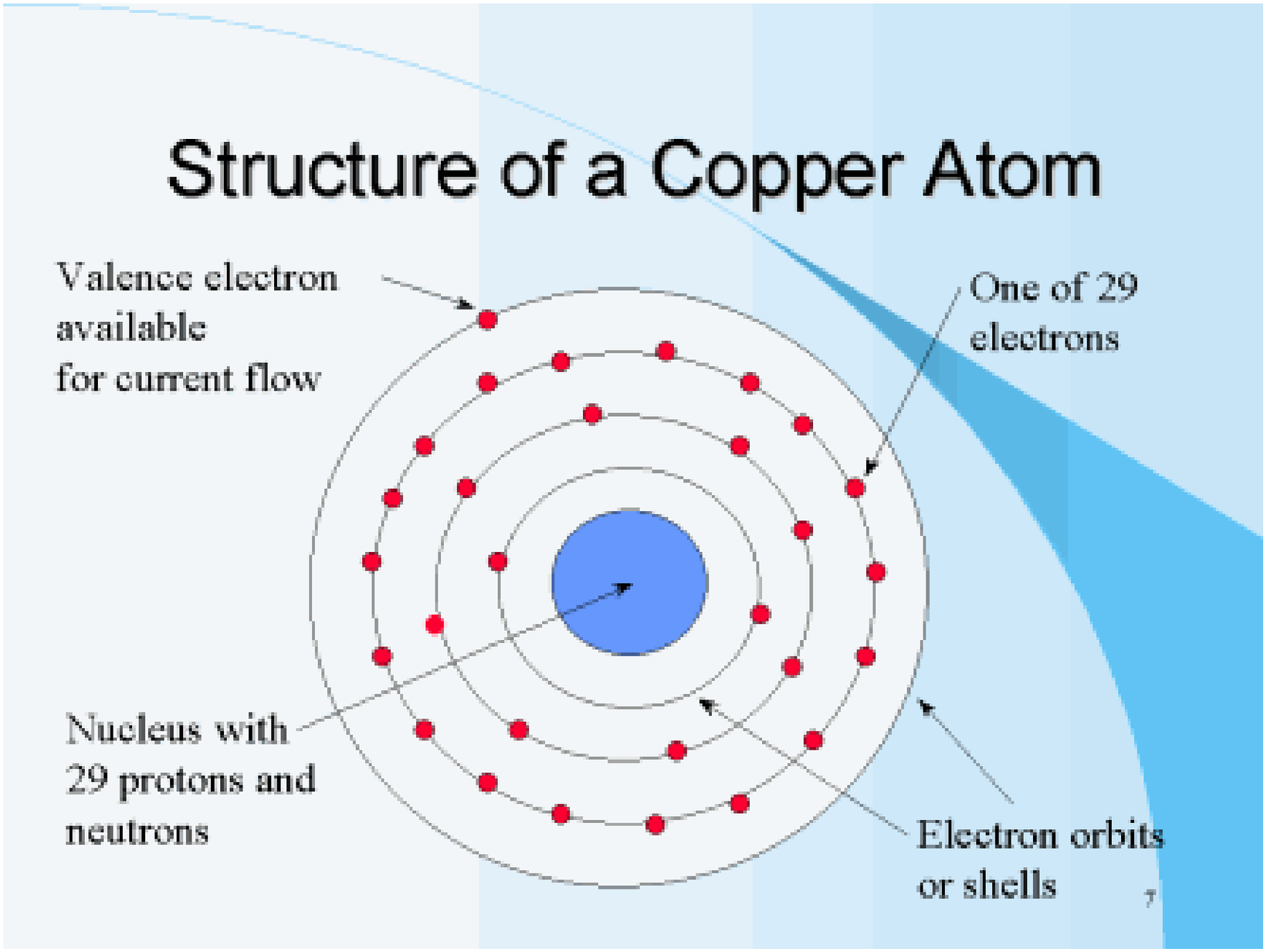
Atomic Charges

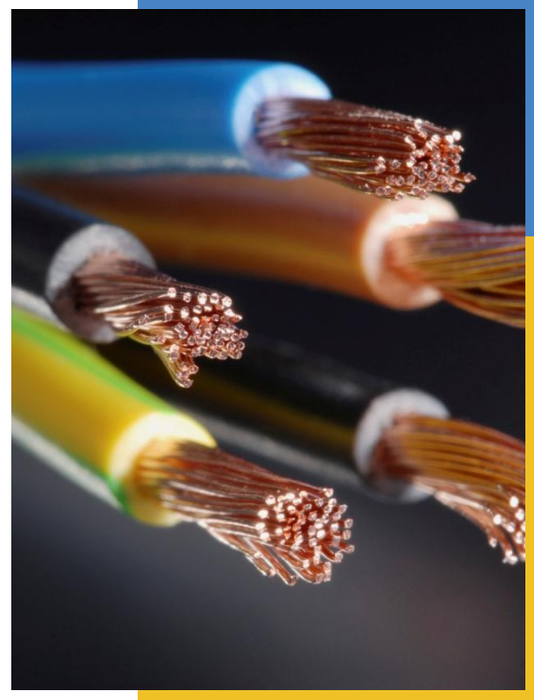




Atomic Charges

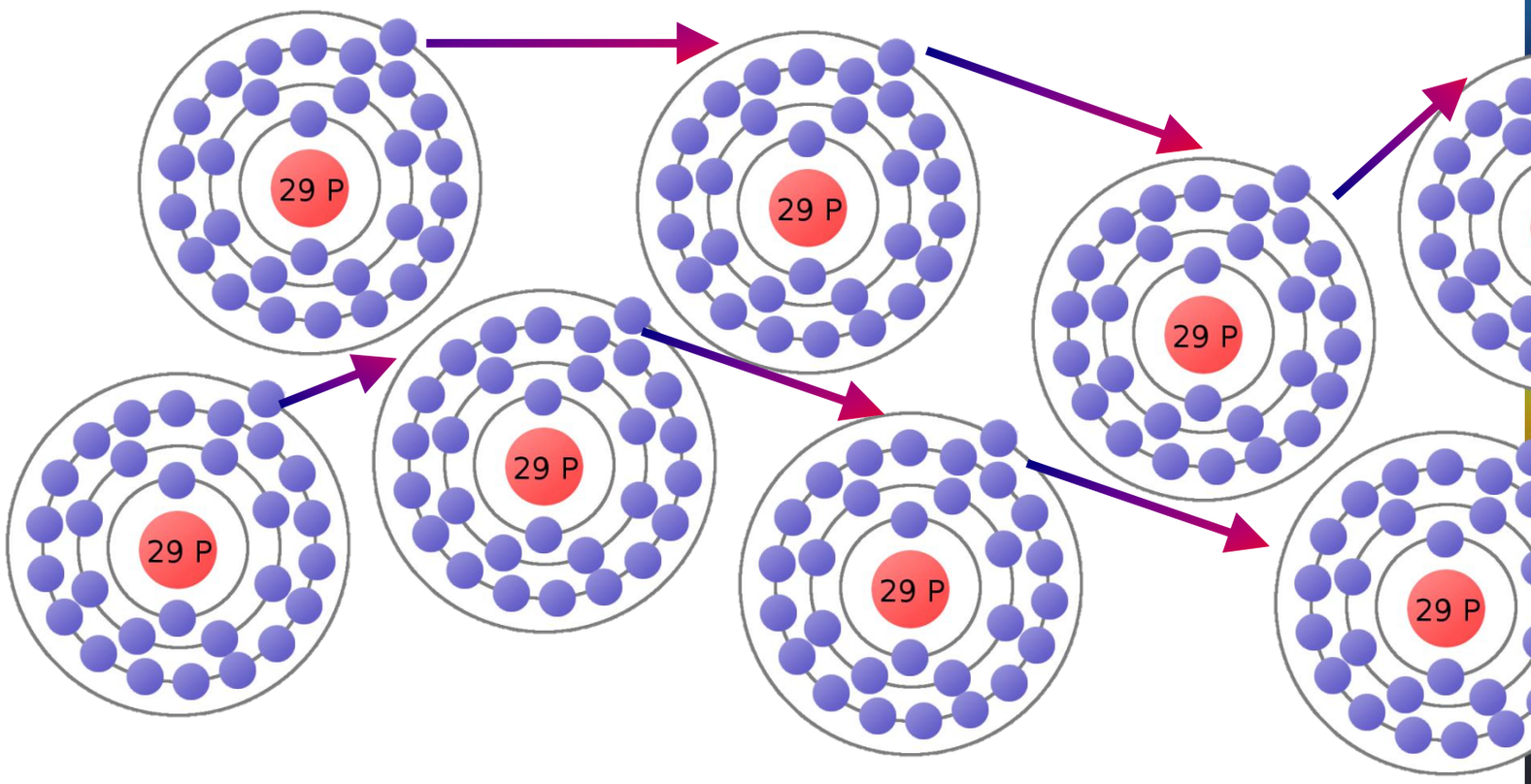
Electrostatic force (also called Coulomb’s law) is a force that operates between charges. It states that charges of the same type repel each other, while charges of opposite types are attracted together.

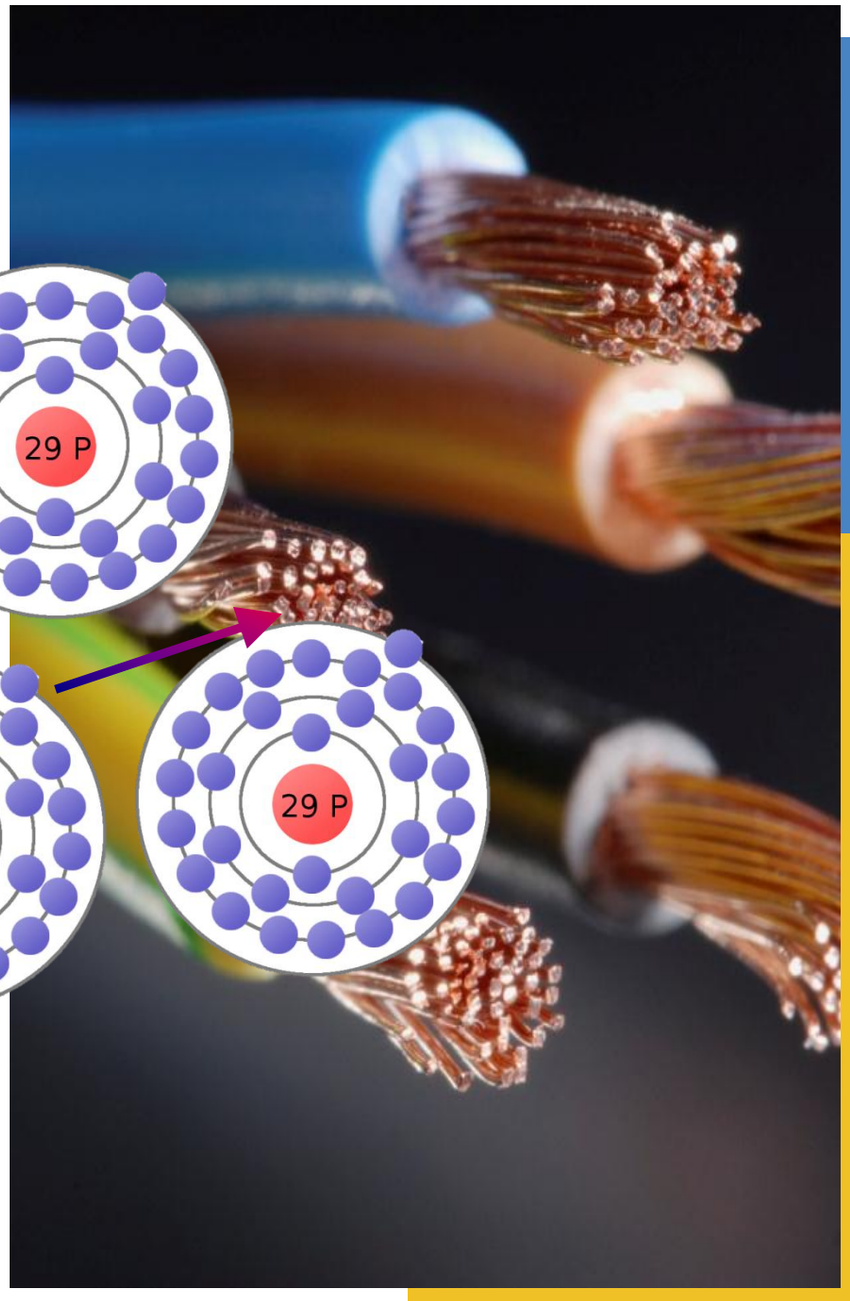




Conductors - Copper Atom

- Conductive Bands (Shells)
- Valance Band

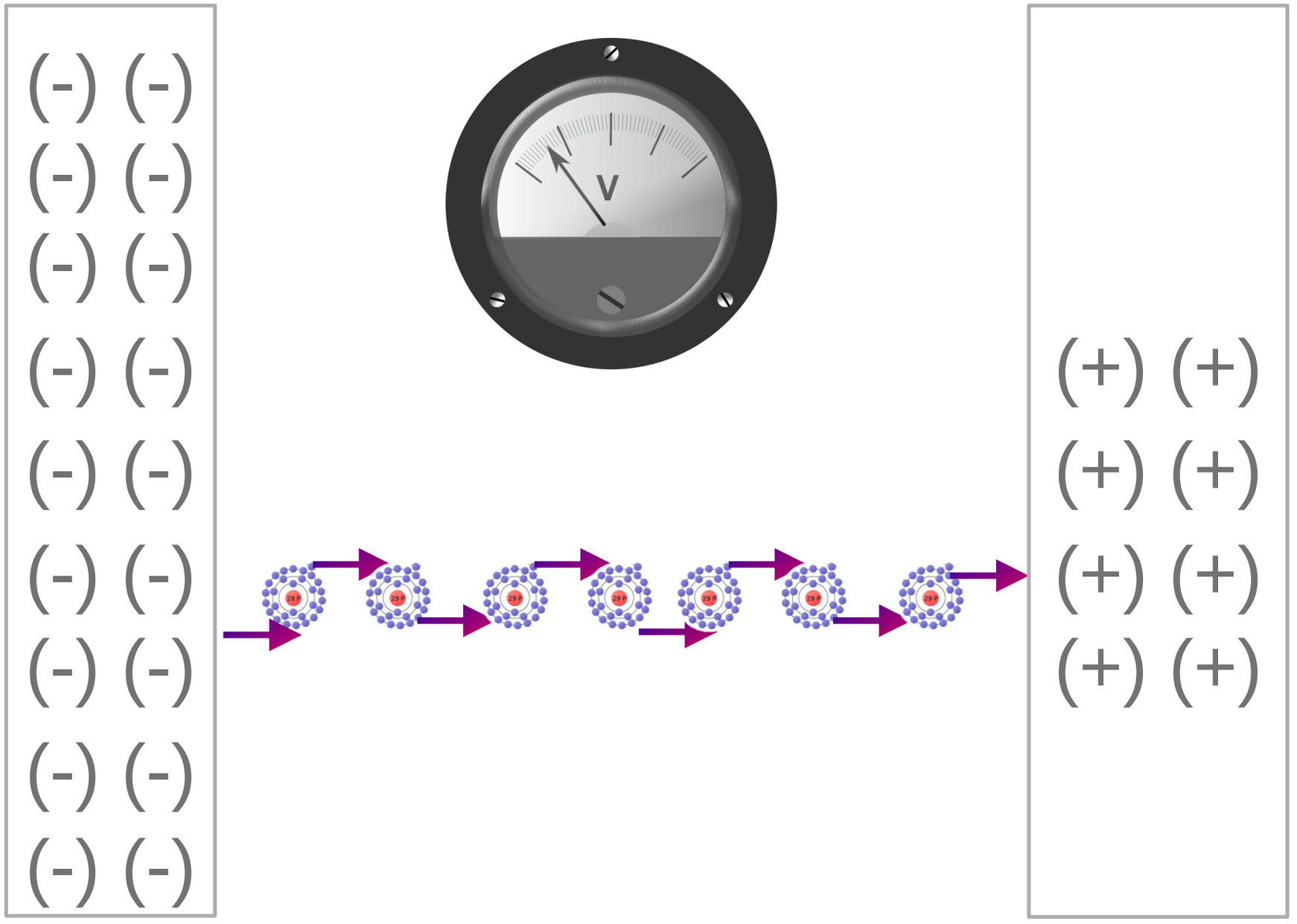




This flow is CURRENT. Flow will continue until Equilibrium, or Balance, is reached.

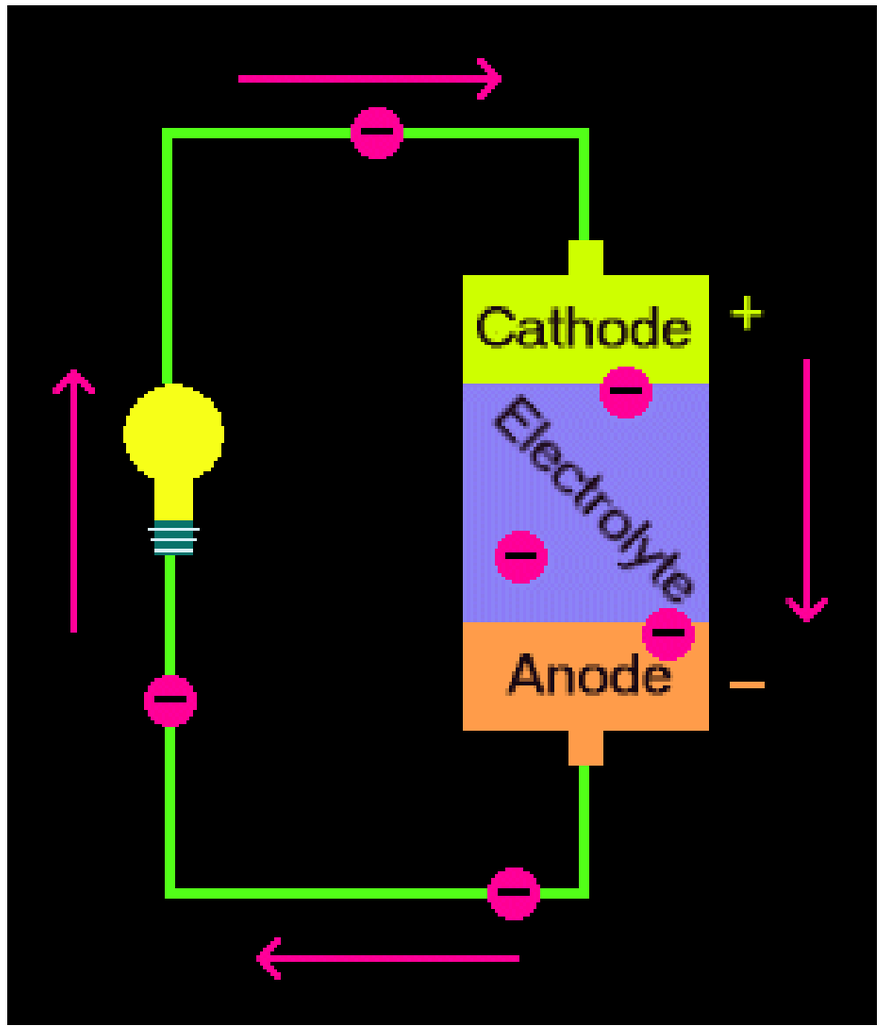
Electron Travel - Amperes

Current is measured in Amperes, or Amps, or the symbol (I).



Different Potentials - Voltage

Electrical Potential is the ability to provide free electrons.
This difference is measured in Volts (V)

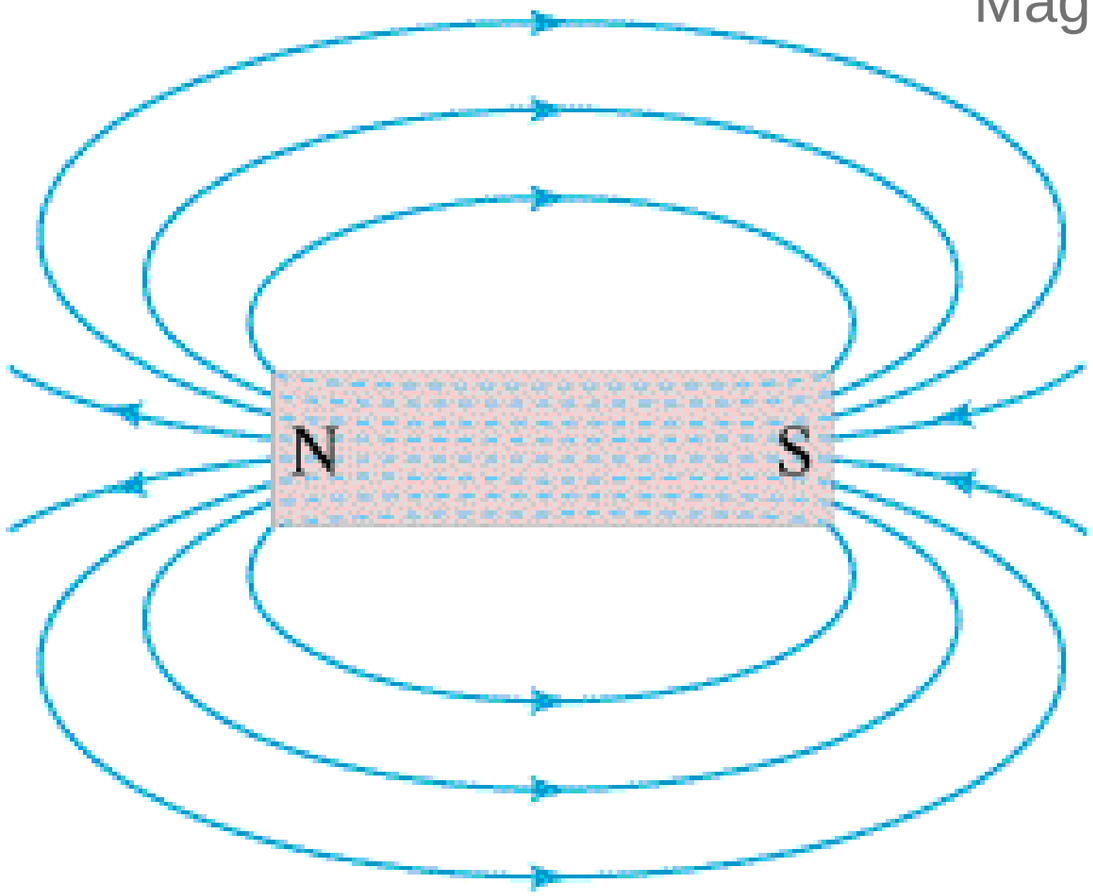


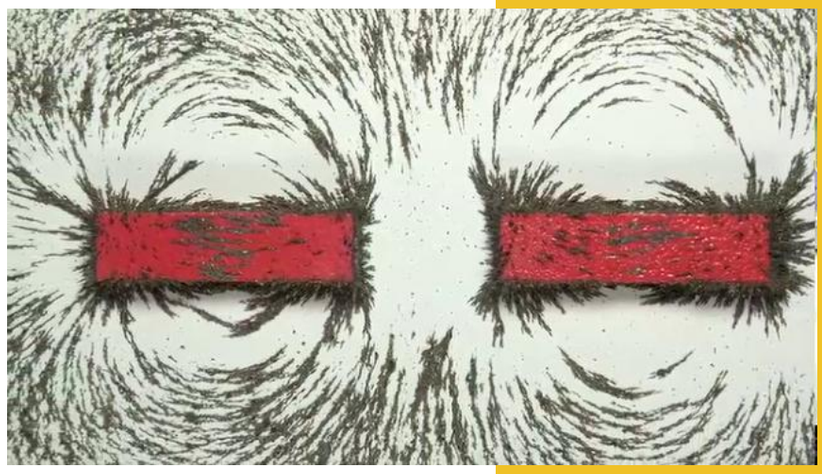
The chemical reactions in the battery causes a build up of electrons at the anode **(-)**. This results in an electrical difference between the anode and the cathode.

Battery Power

That difference, or Potential, will cause the Current to flow when a Conductor is placed between the anode and cathode.

Magnetic Lines of Force

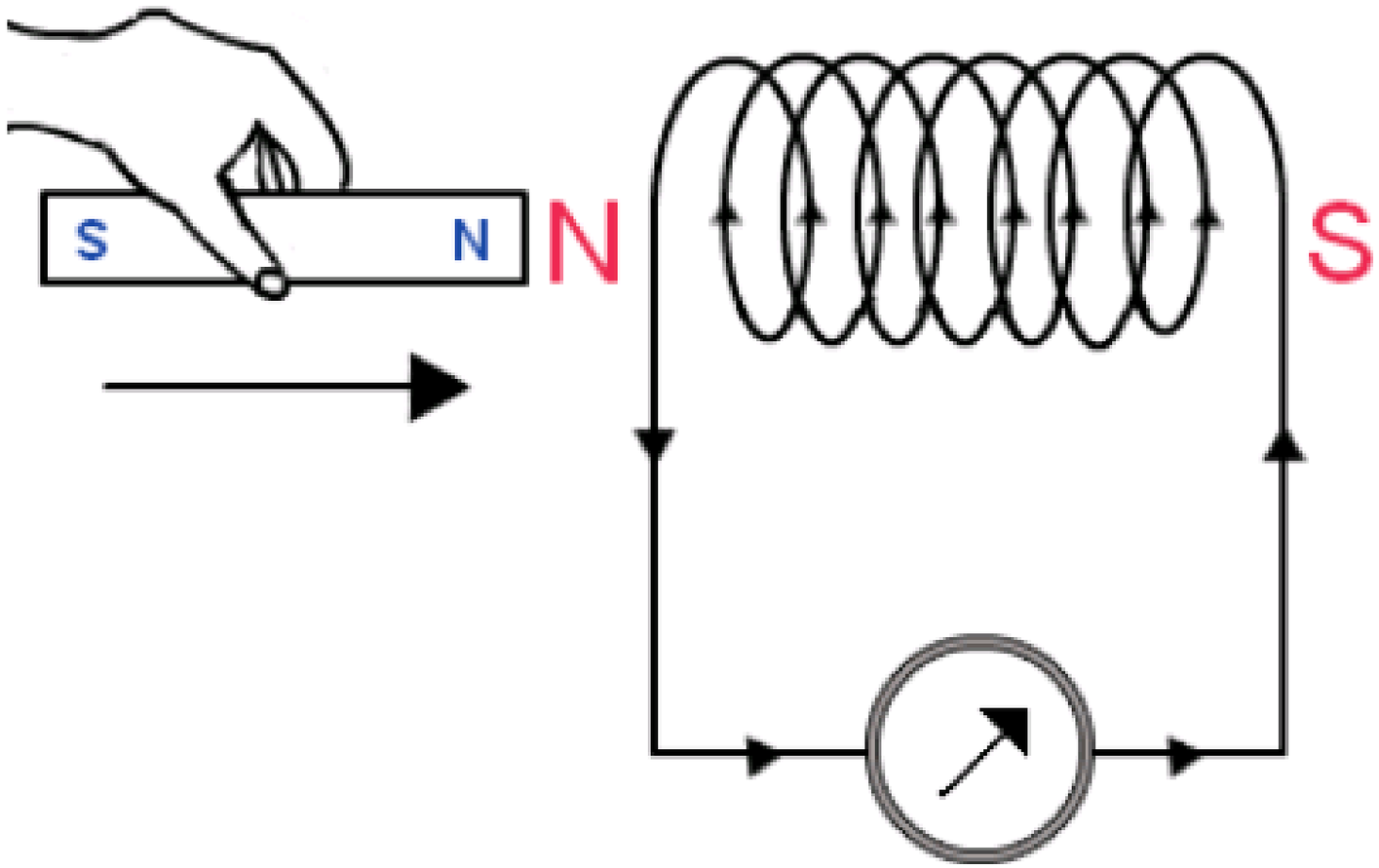




Magnetism is a form of energy, and exerts a force.

Magnetism

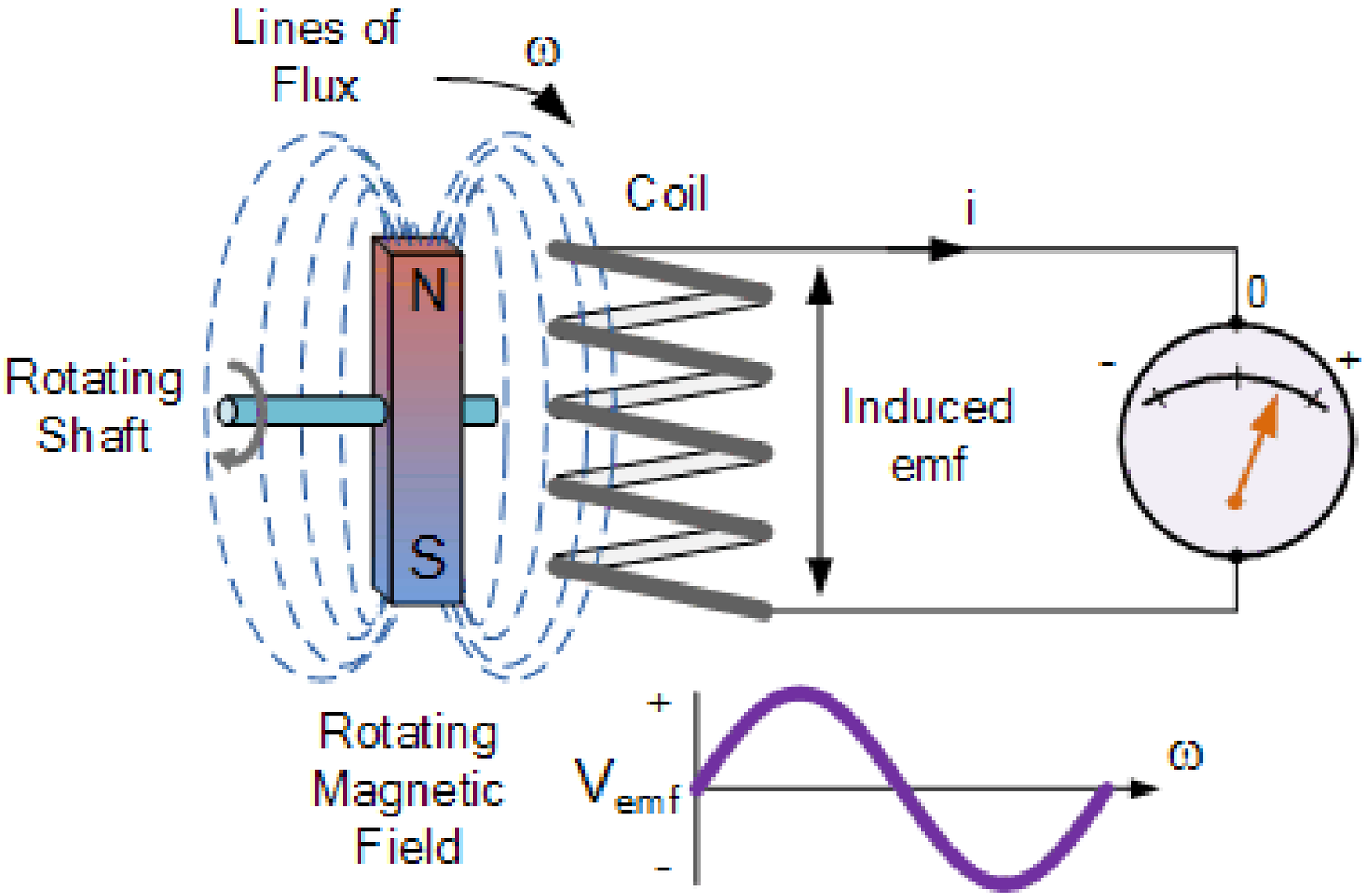
We can use the phenomena of magnetic lines of force, or the ***Magnetic Field***, to begin the flow of electrons.



Electromagnetic Induction - Electromotive Force -

Faraday’s Law of Induction

Induced voltage in a coil is proportional to the product of the loops and the rate at which the magnetic field changes within the loops.



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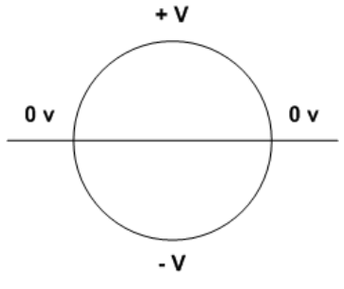

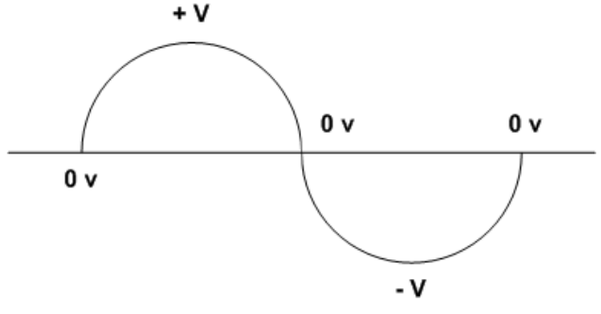

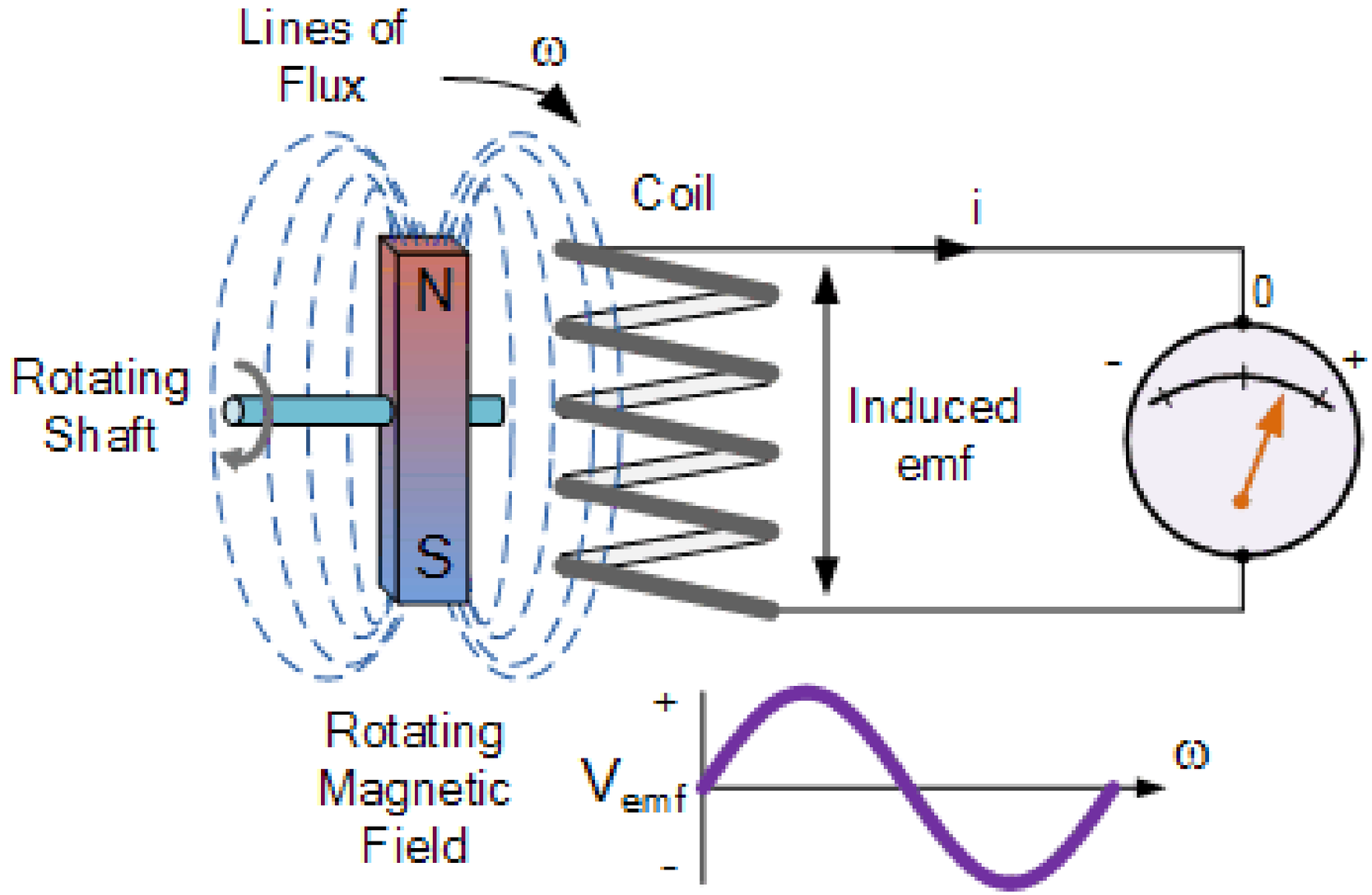

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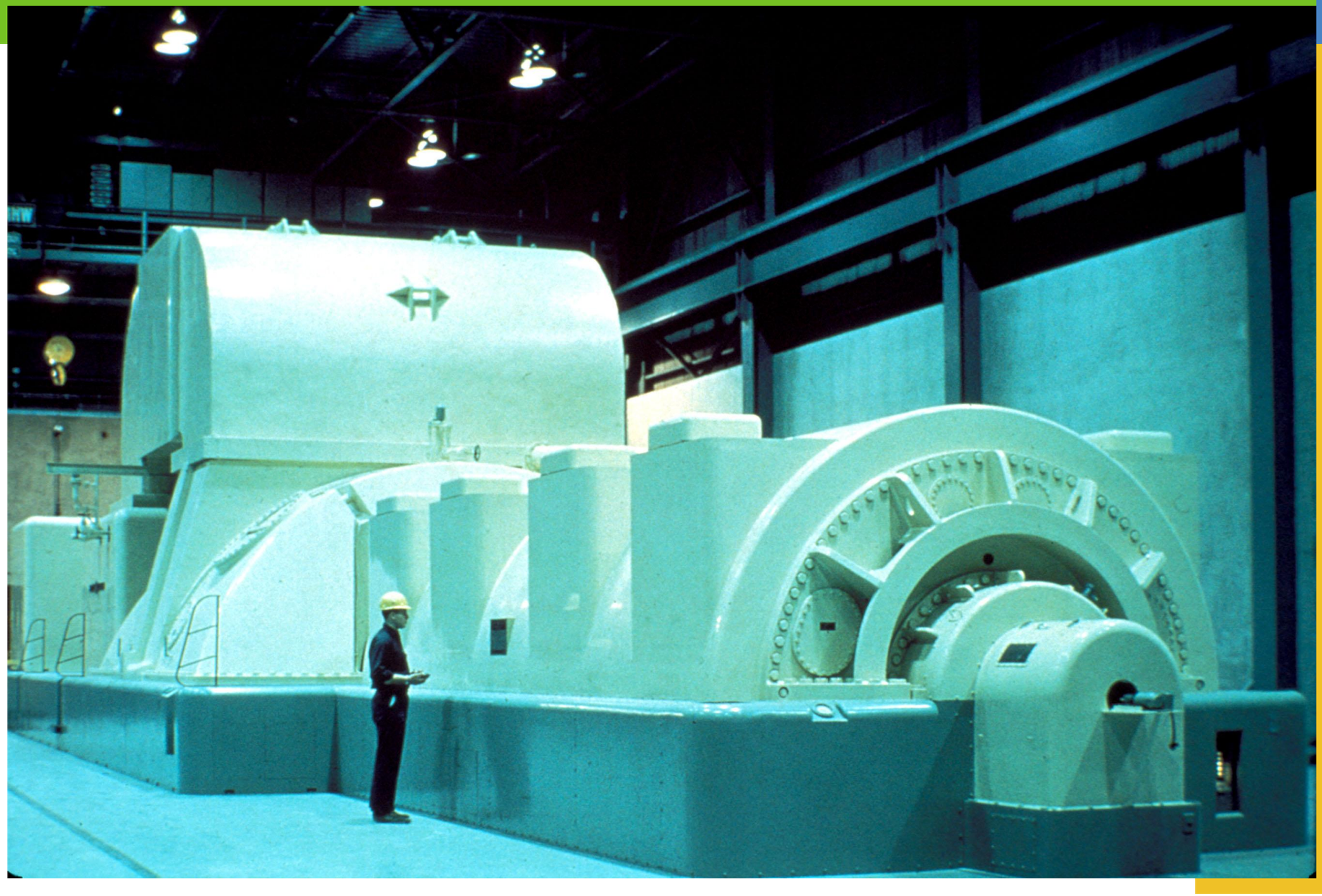
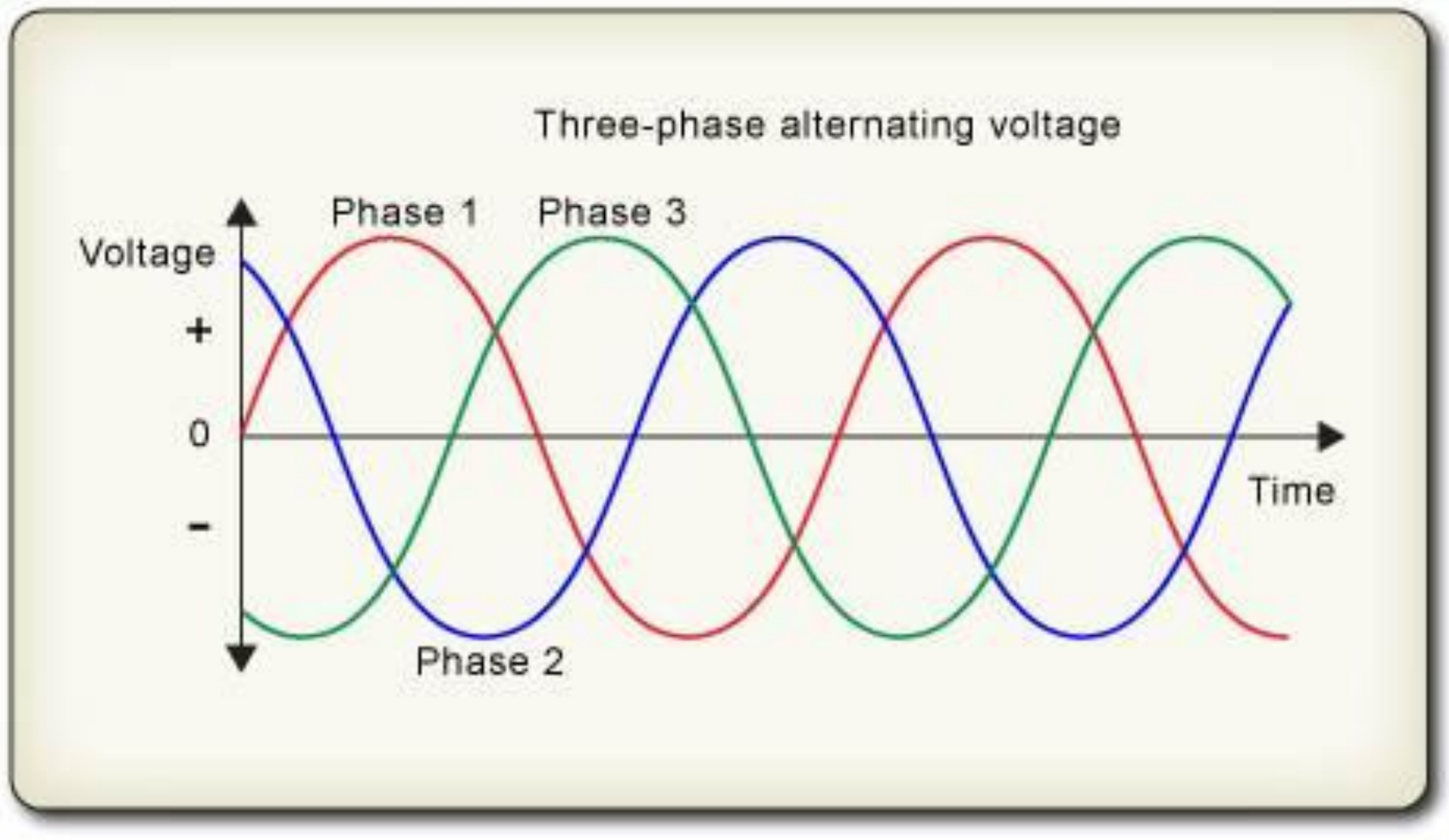
Generation & Transmission



A Generator is a machine that changes mechanical energy into electrical energy

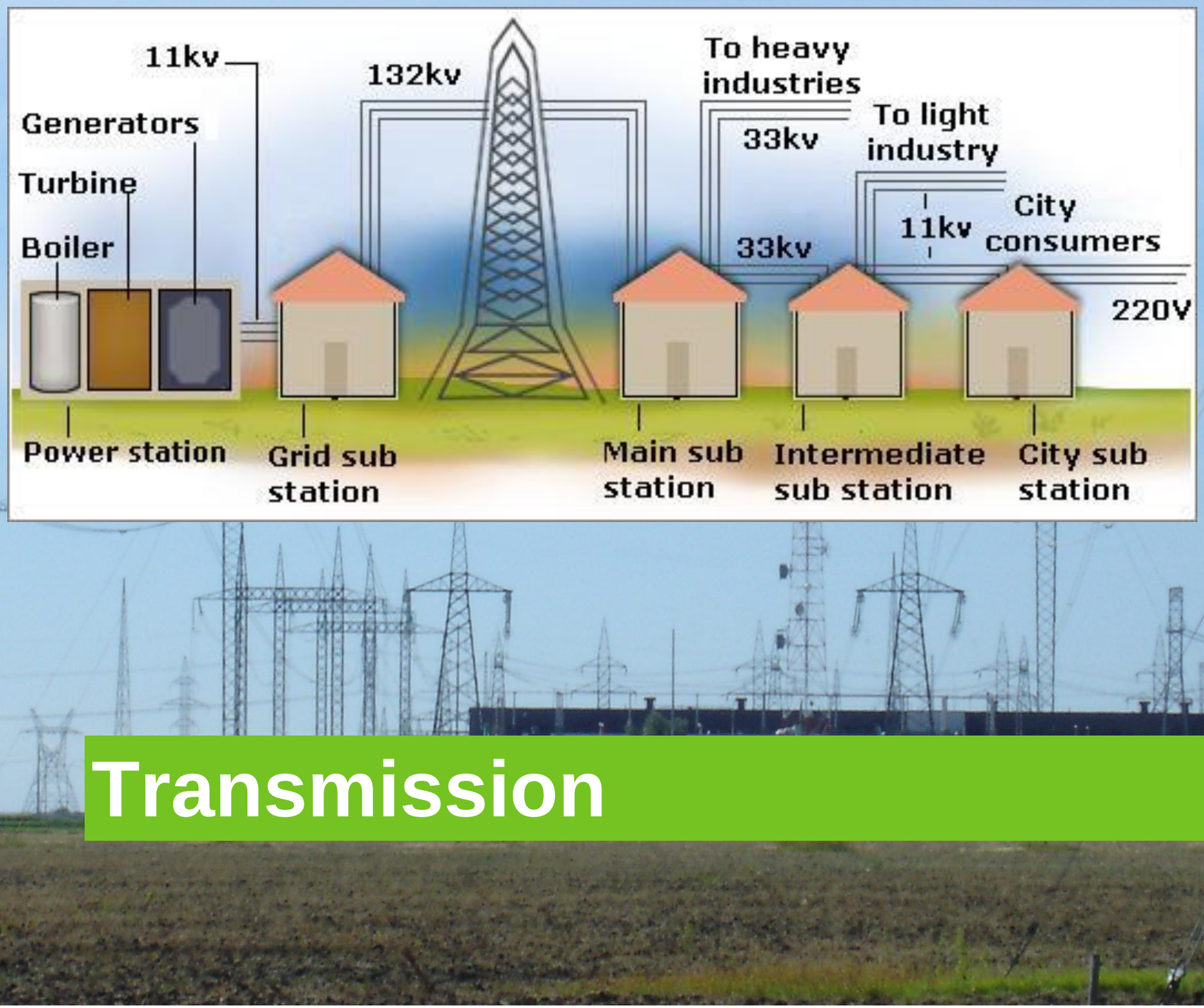
Generated Electrical Power

Generators, without a rectifier, will produce AC power.
(Alternating Current)



Generated Electrical Power

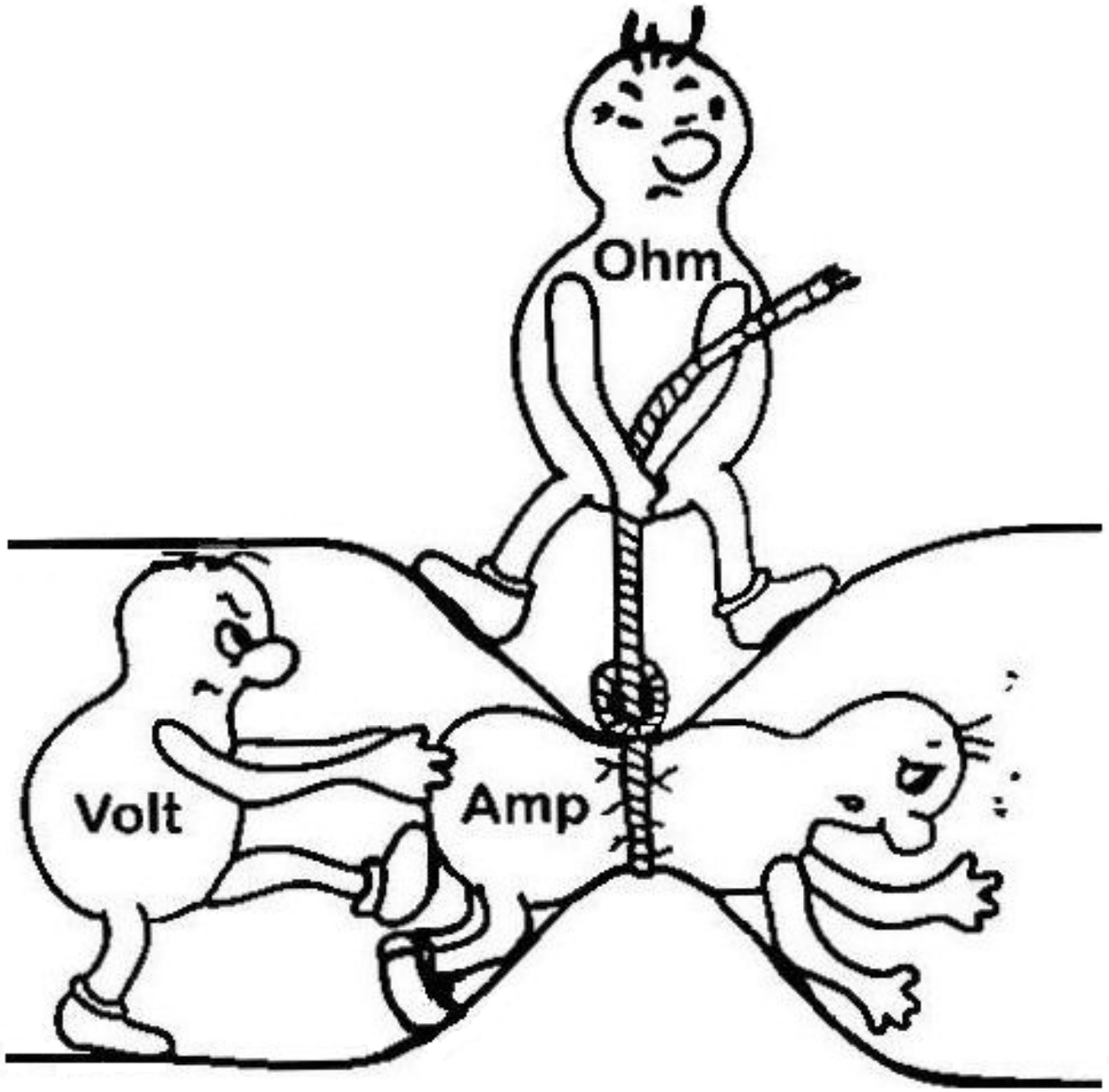
Alternating, 3 phase generated power



Transmission

Transformers

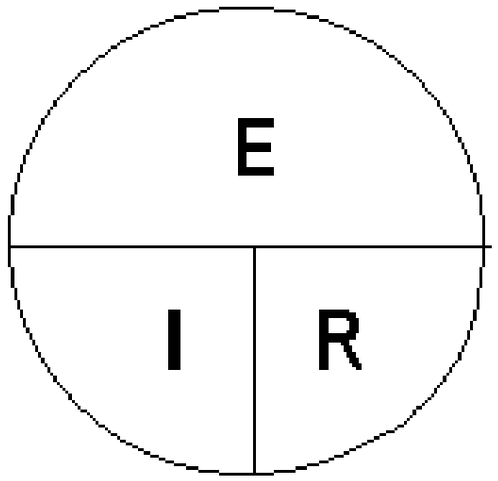
Transfers energy between two circuits through electromagnetic induction



Ohm’s Law

Ohm's law states that the current (amperage) through a conductor between two points is directly proportional to the potential difference (voltage) across the two points.

OHM's LAW



E = Electromotive Force
measured in VOLTS

I = Current
measured in AMPS

R = Resistance
measured in OHM's

$E = I \times R \quad I = E \div R \quad R = E \div I$

3600 watt Load = 15amps @ 240v

3600 watt Load = 30 amps @ 120v

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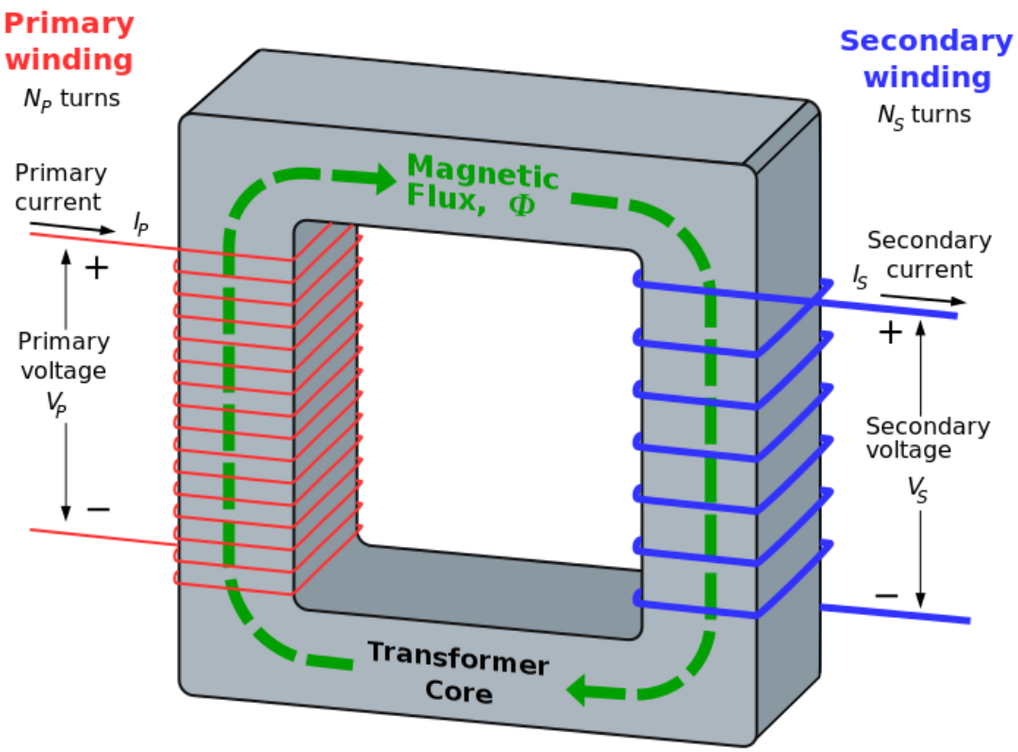

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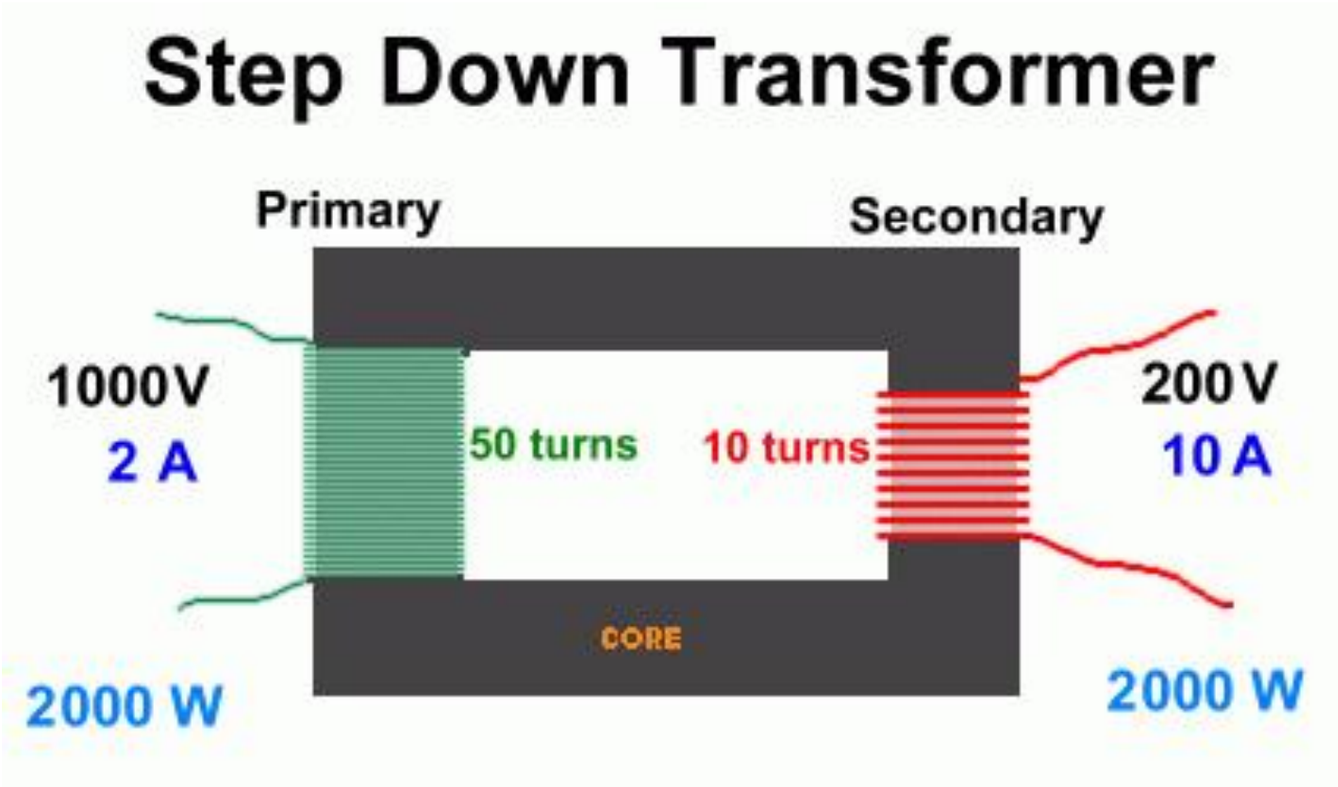

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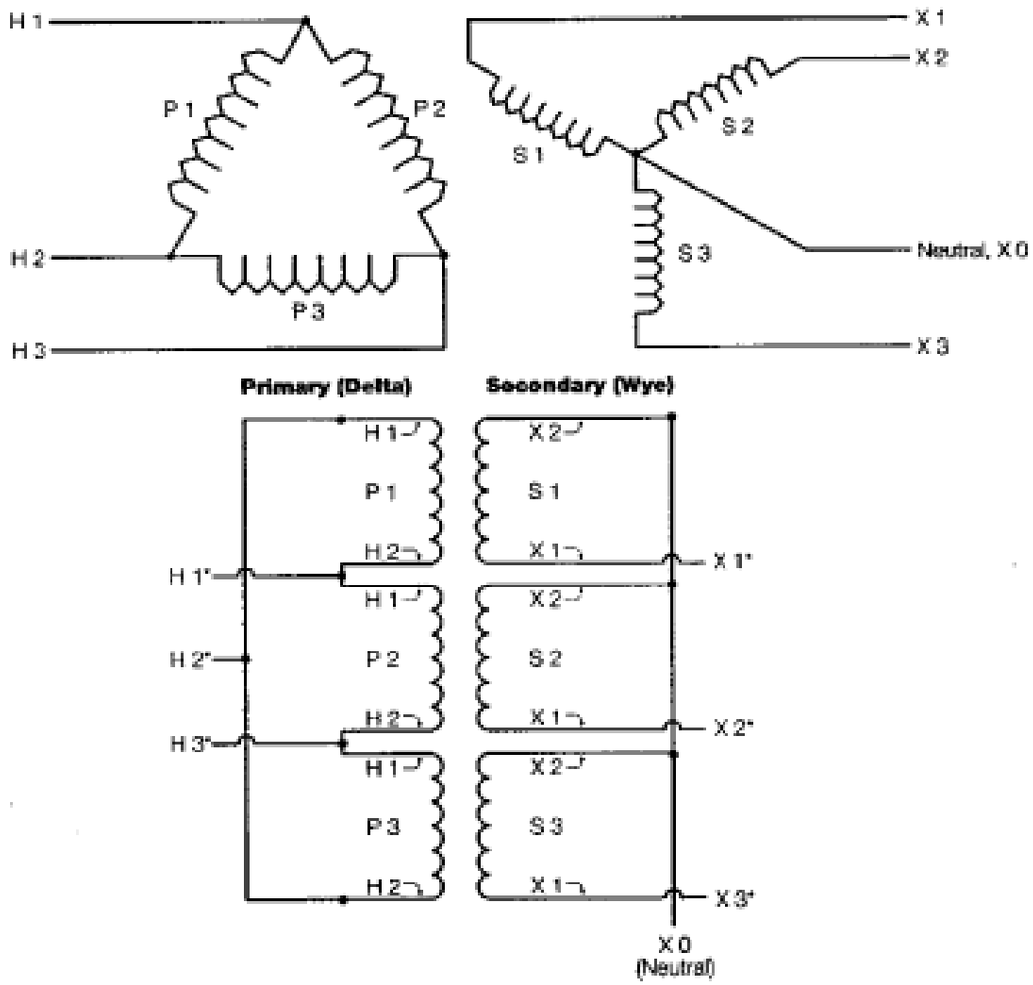
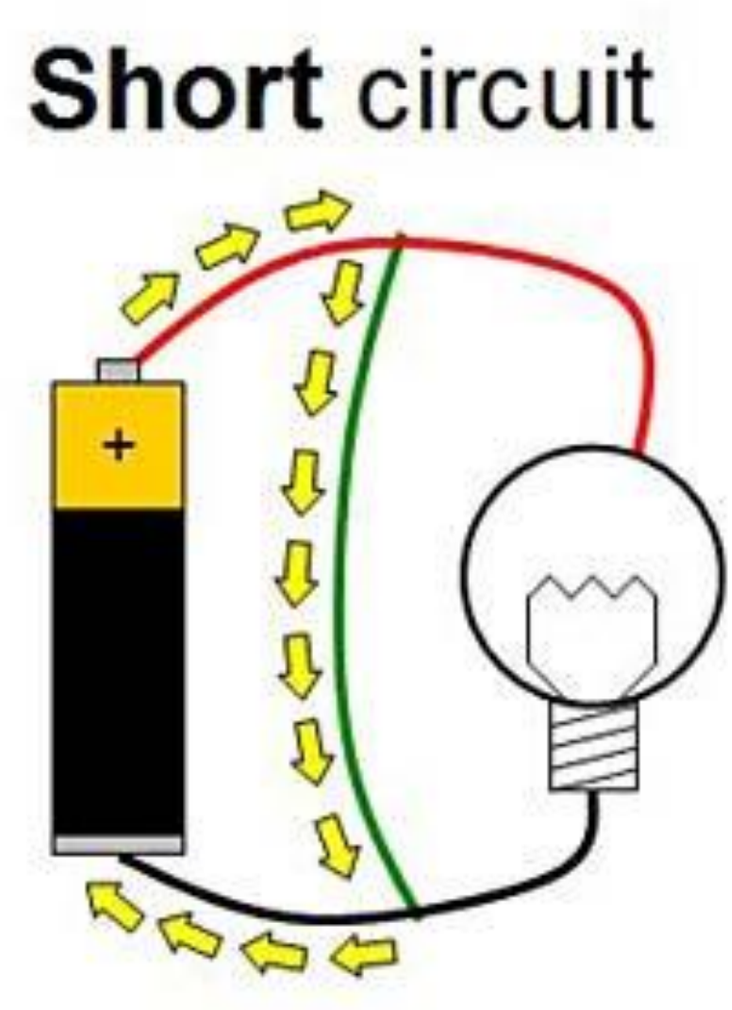


Transformers

Three phase step down transformer – typical of a 480v to 208/120 4 wire system

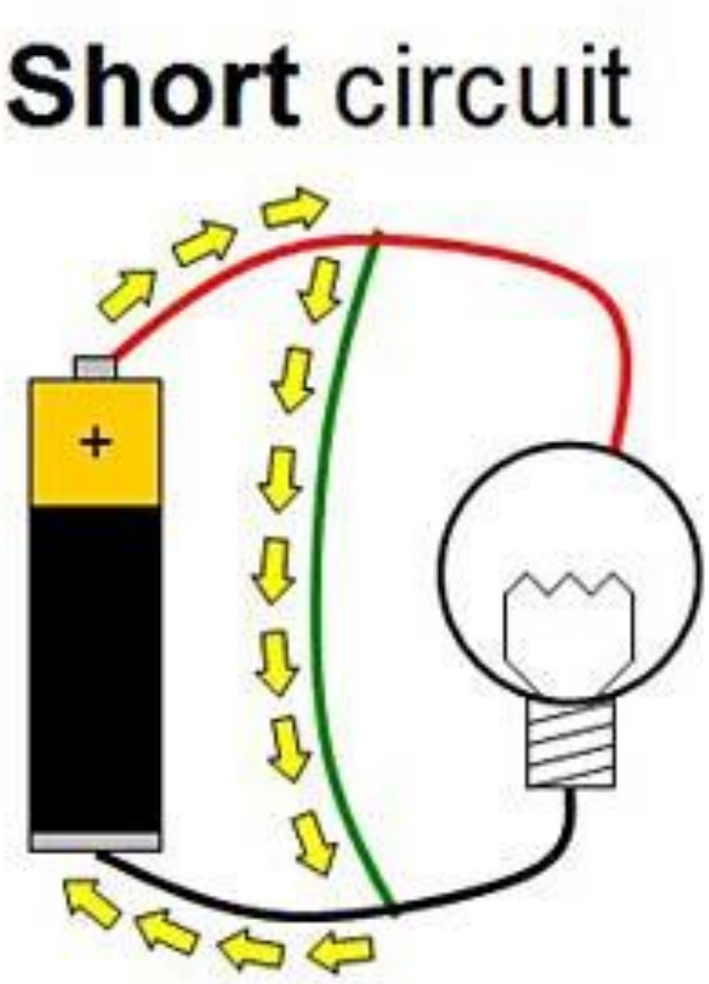
Fuses & Circuit Breakers

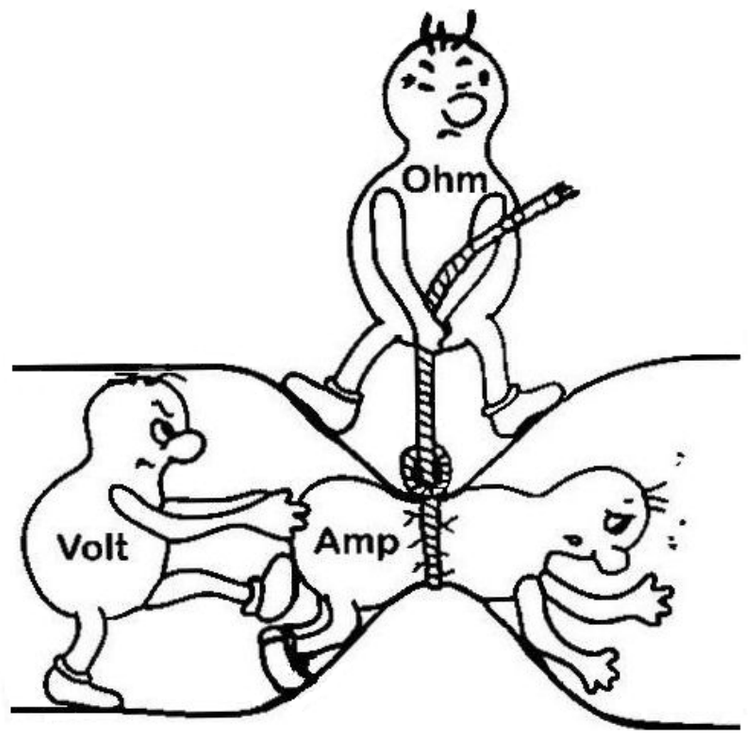
Safety and Control of Electrical Power



Short Circuit

An electrical circuit that allows a current to travel along an unintended path, often where essentially no (or a very low) electrical impedance (resistance) is encountered.





Short Circuit

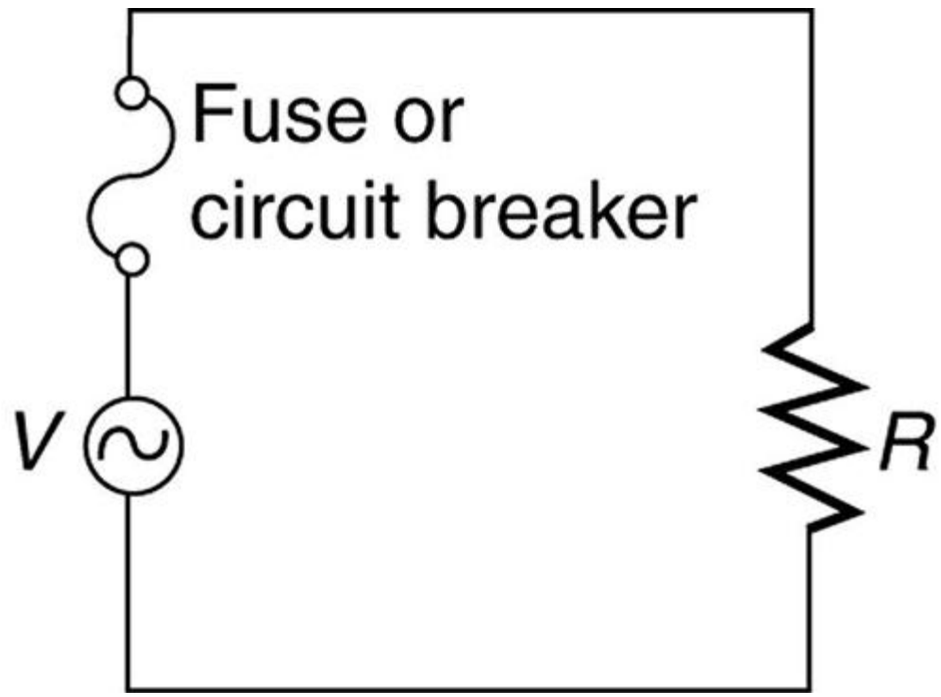
An electrical circuit that allows a current to travel along an unintended path, often where essentially no (or a very low) electrical impedance (resistance) is encountered.

Resistance creates heat. Heat creates resistance.
Resistance creates heat. Heat creates resistance.
And so on…

Short Circuit

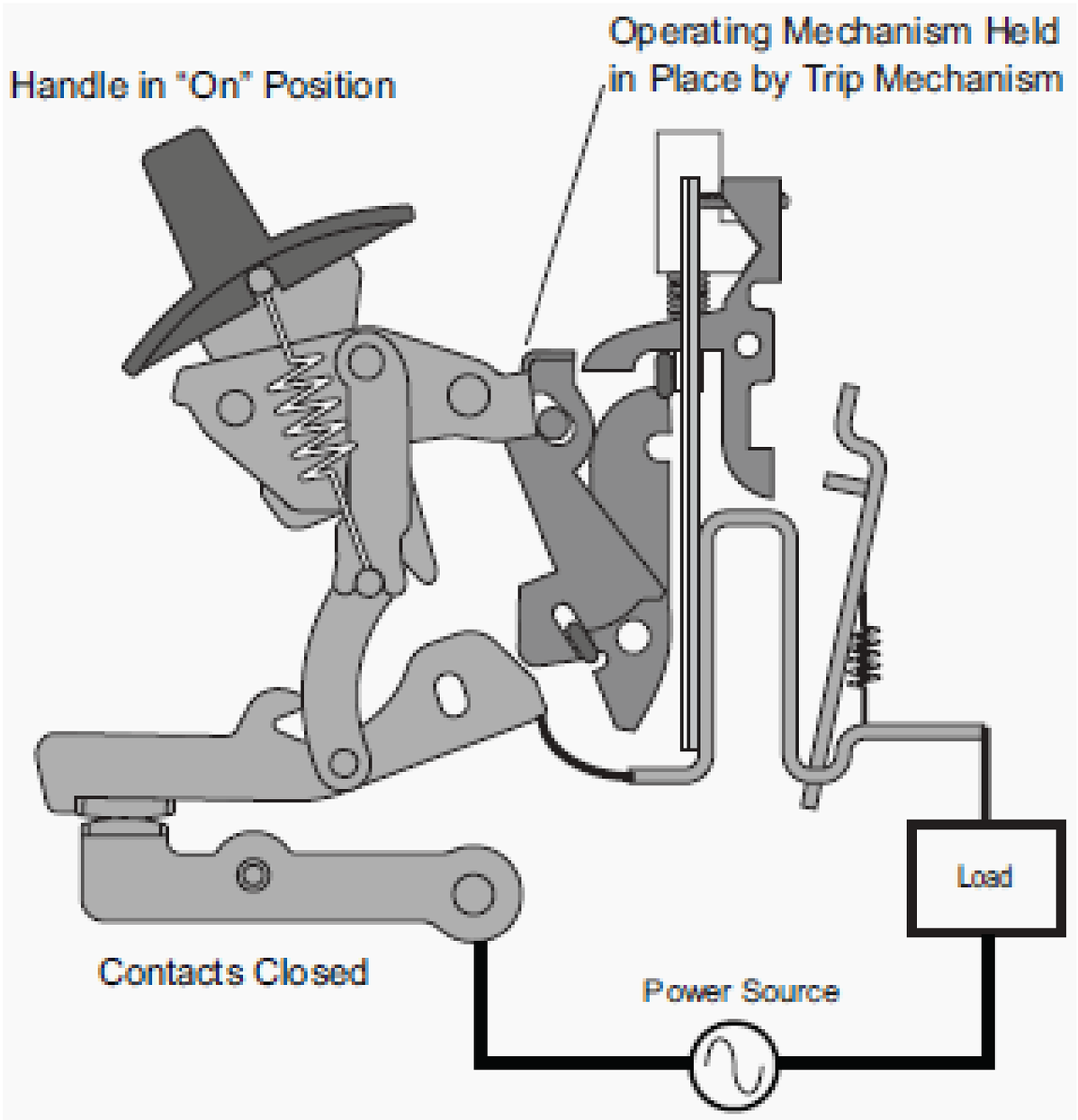
An electrical circuit that allows a current to travel along an unintended path, often where essentially no (or a very low) electrical impedance (resistance) is encountered.

A Fuse is a type of low resistance resistor that acts as a sacrificial device to provide overcurrent protection to the load, power source, and conductors.



Fuse Protection

A Fuse will limit the potential harmful excessive current. Fuses are usually non-resettable.



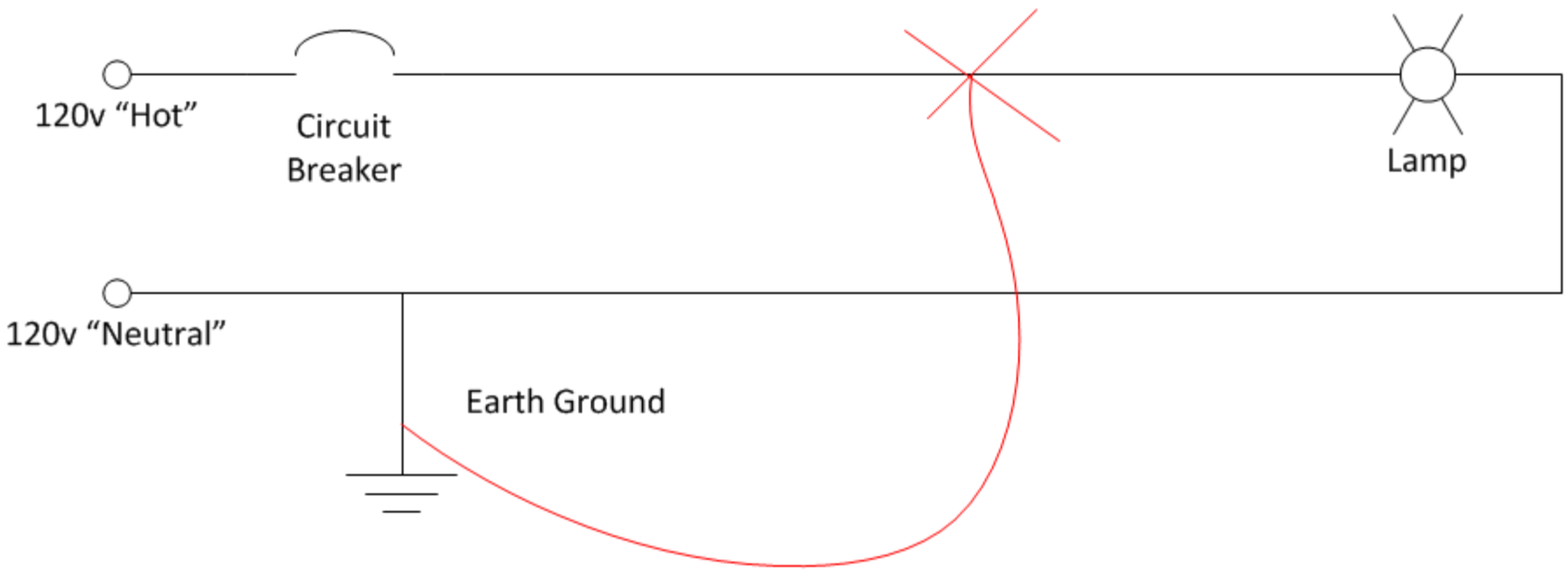
Circuit Breaker Protection

A circuit breaker will open in a fault or over current condition. Circuit breakers can be reset after tripping.

Neutral – Grounded Conductor

In the US, the Neutral conductor is ***grounded*** to provide the path back to trip the breaker. Always remember – the Neutral potentially carries the same amount of current as the “hot” conductor.

Ground Short Circuit



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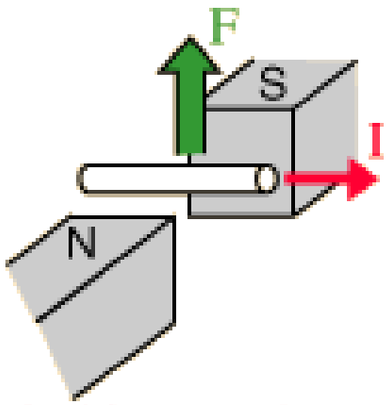
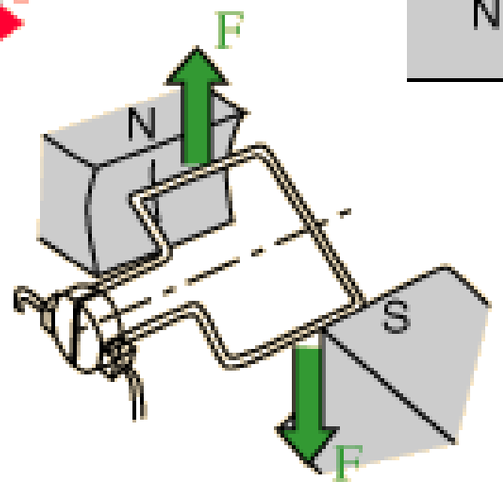
Motors

Converts electrical energy into mechanical energy.

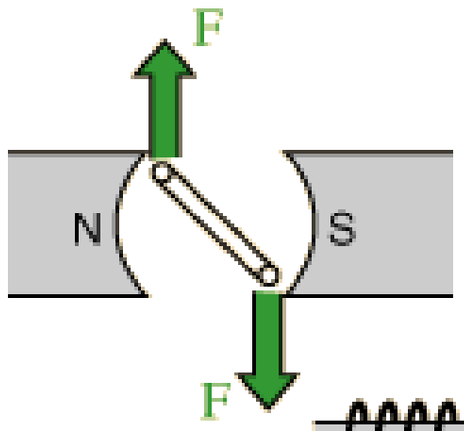
Simple DC Motor



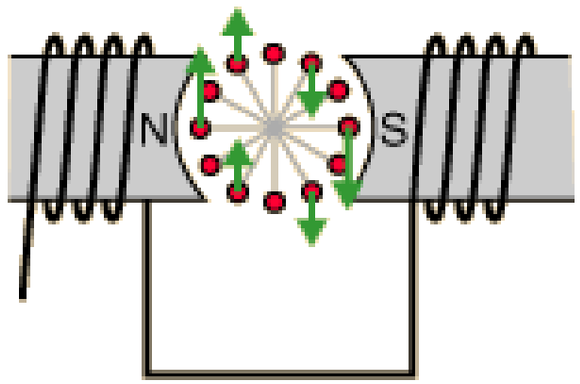
An electric current in a magnetic field will experience a force.



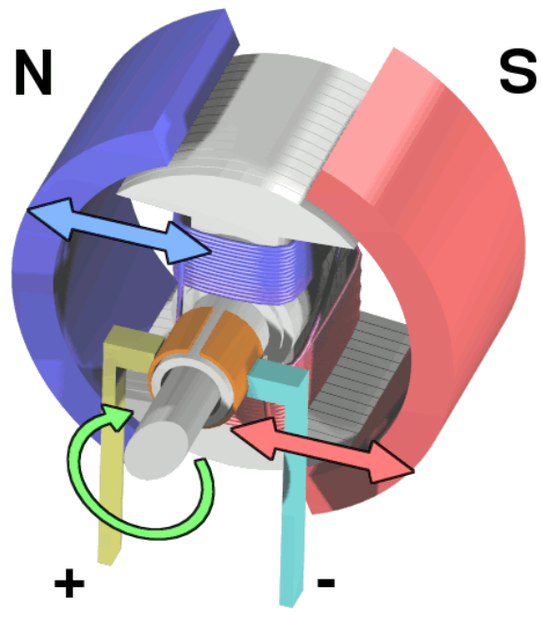
If the current-carrying wire is bent into a loop, then the two sides of the loop which are at right angles to the magnetic field will experience forces in opposite directions.

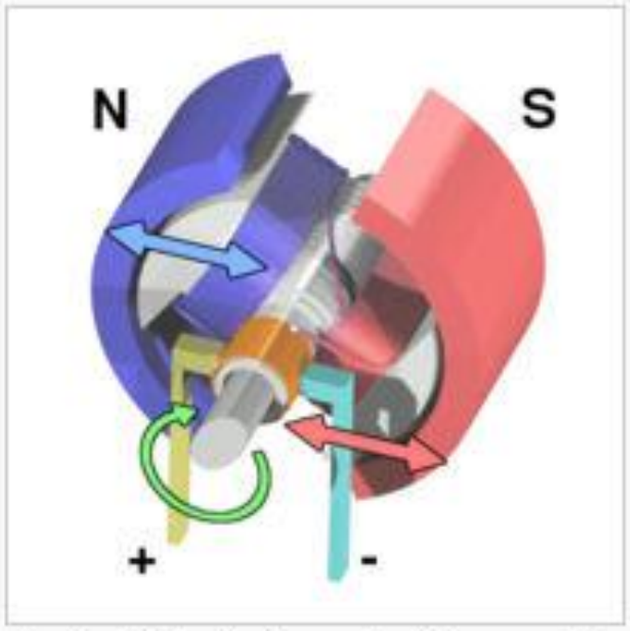


The pair of forces creates a turning influence or torque to rotate the coil.

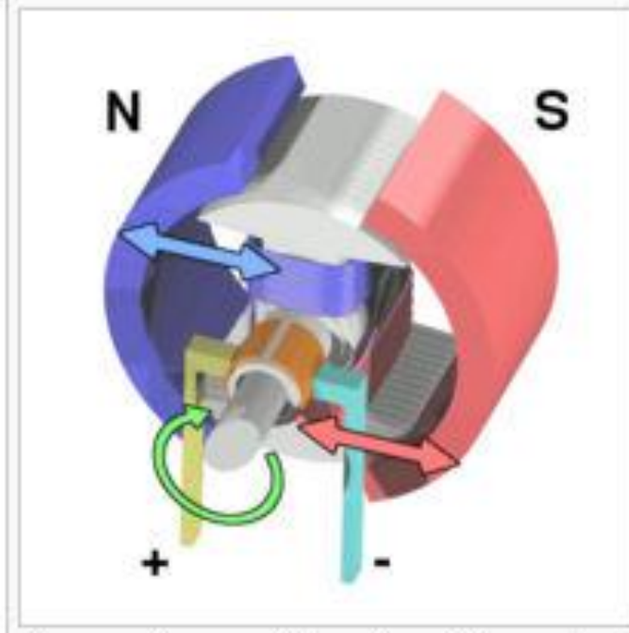


Practical motors have several loops on an armature to provide a more uniform torque and the magnetic field is produced by an electromagnet arrangement called the field coils.

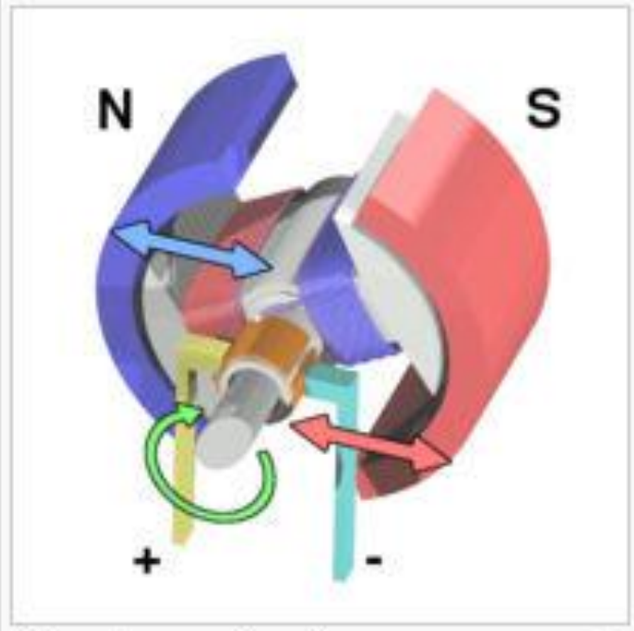




A simple DC electric motor. When the coil is powered, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn toward the right, causing rotation.

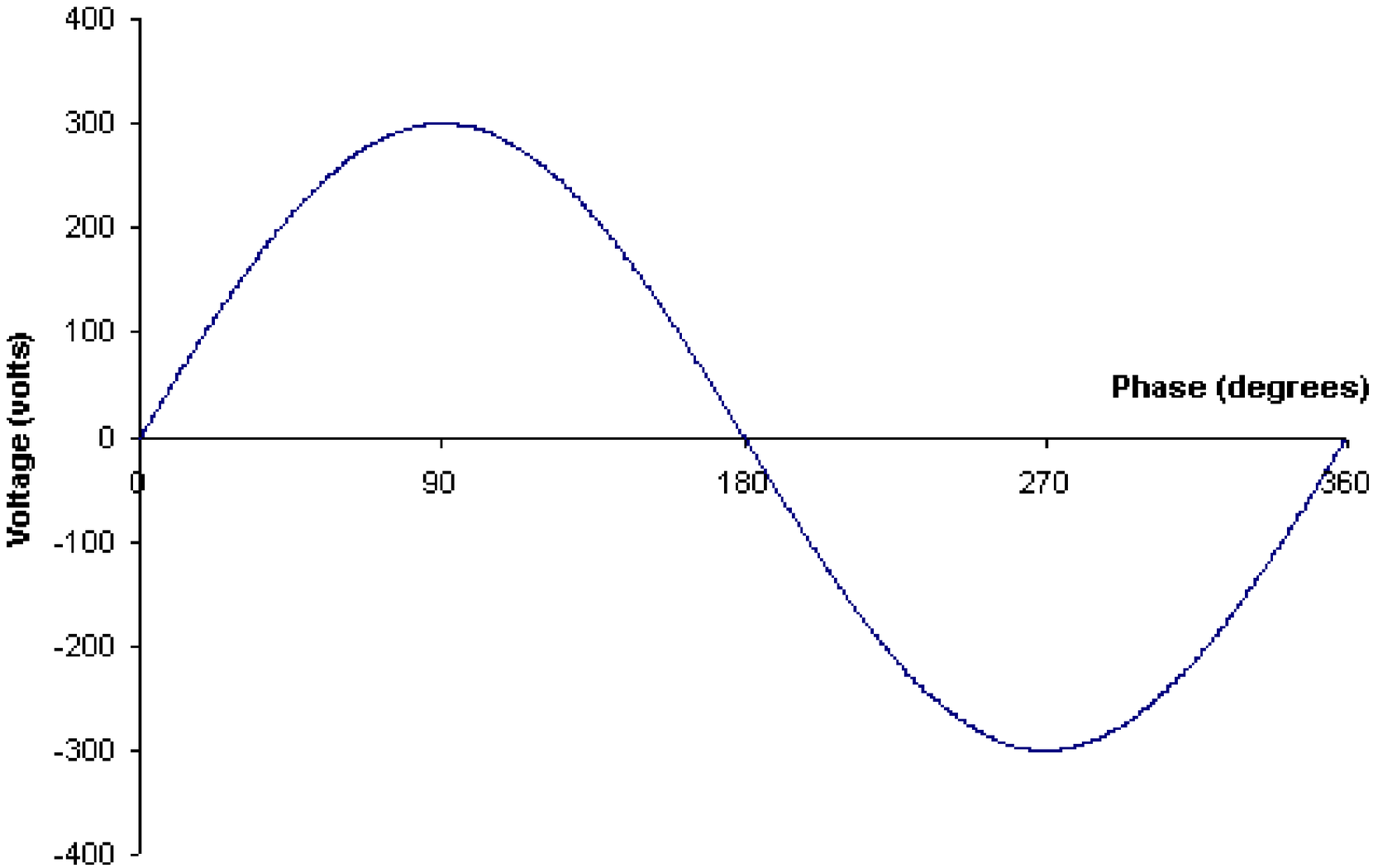


The armature continues to rotate.



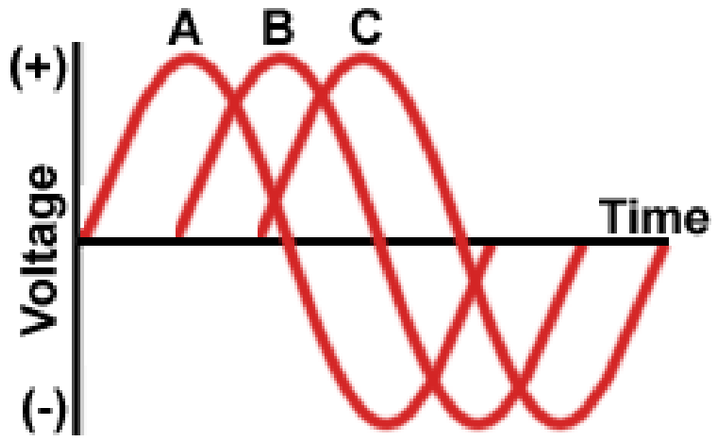
When the armature becomes horizontally aligned, the commutator reverses the direction of current through the coil, reversing the magnetic field. The process then repeats.

Simple DC Motor



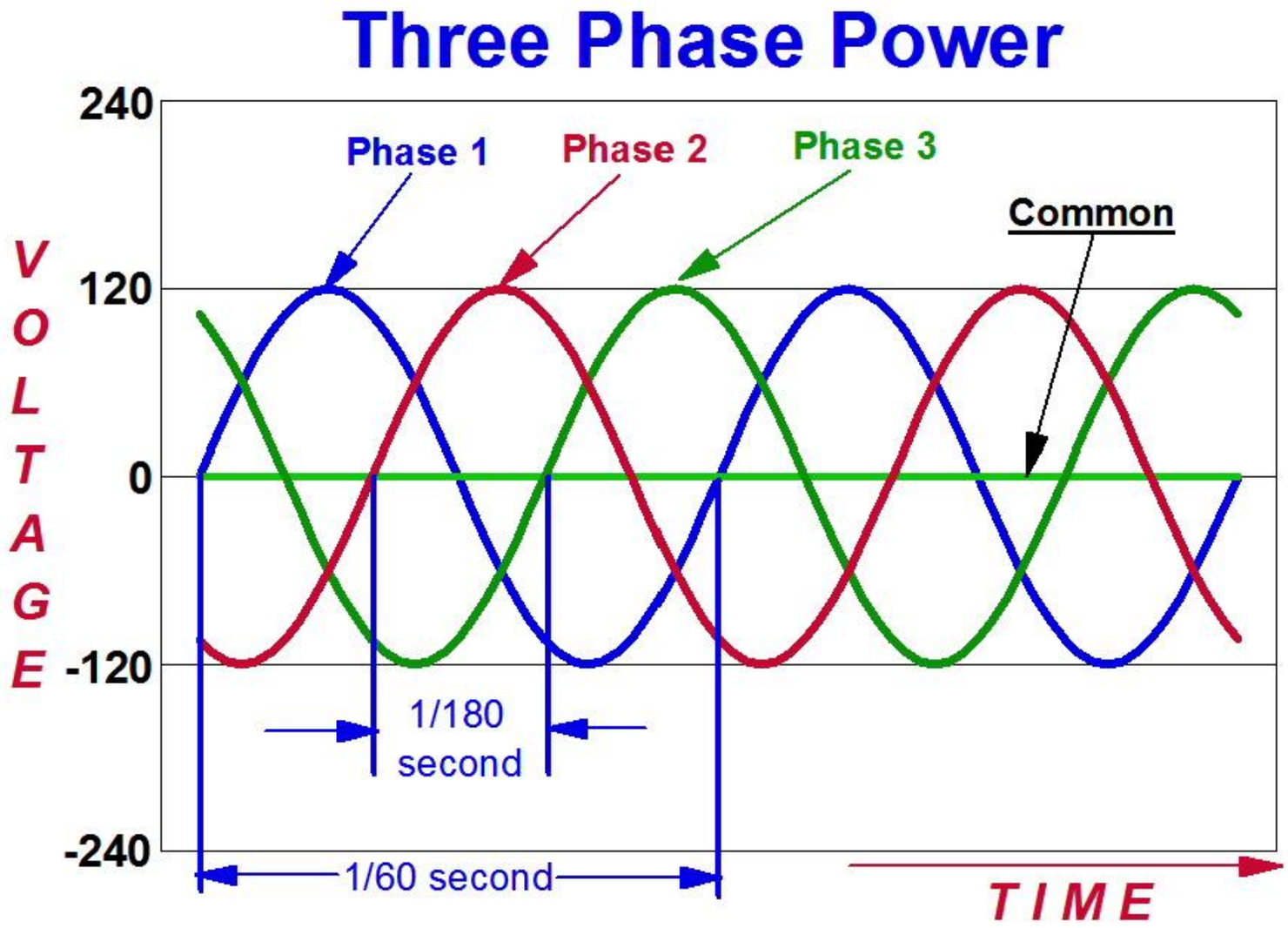
Single Phase AC Currents

Three-phase power is designed especially for large electrical loads where the total electrical load is divided among the three separate phases. As a result, the wire and transformers will be less expensive than if these large loads were carried on a single-phase system.



Three phase generators usually have three separate windings, each producing its own separate single-phase voltage. Since these windings are staggered around the generator circumference, each of the single-phase voltages is "out of phase" 120 deg with one another. That is, each of the three reaches the maximum and minimum points in the AC cycle at different times.

Three Phase AC Currents



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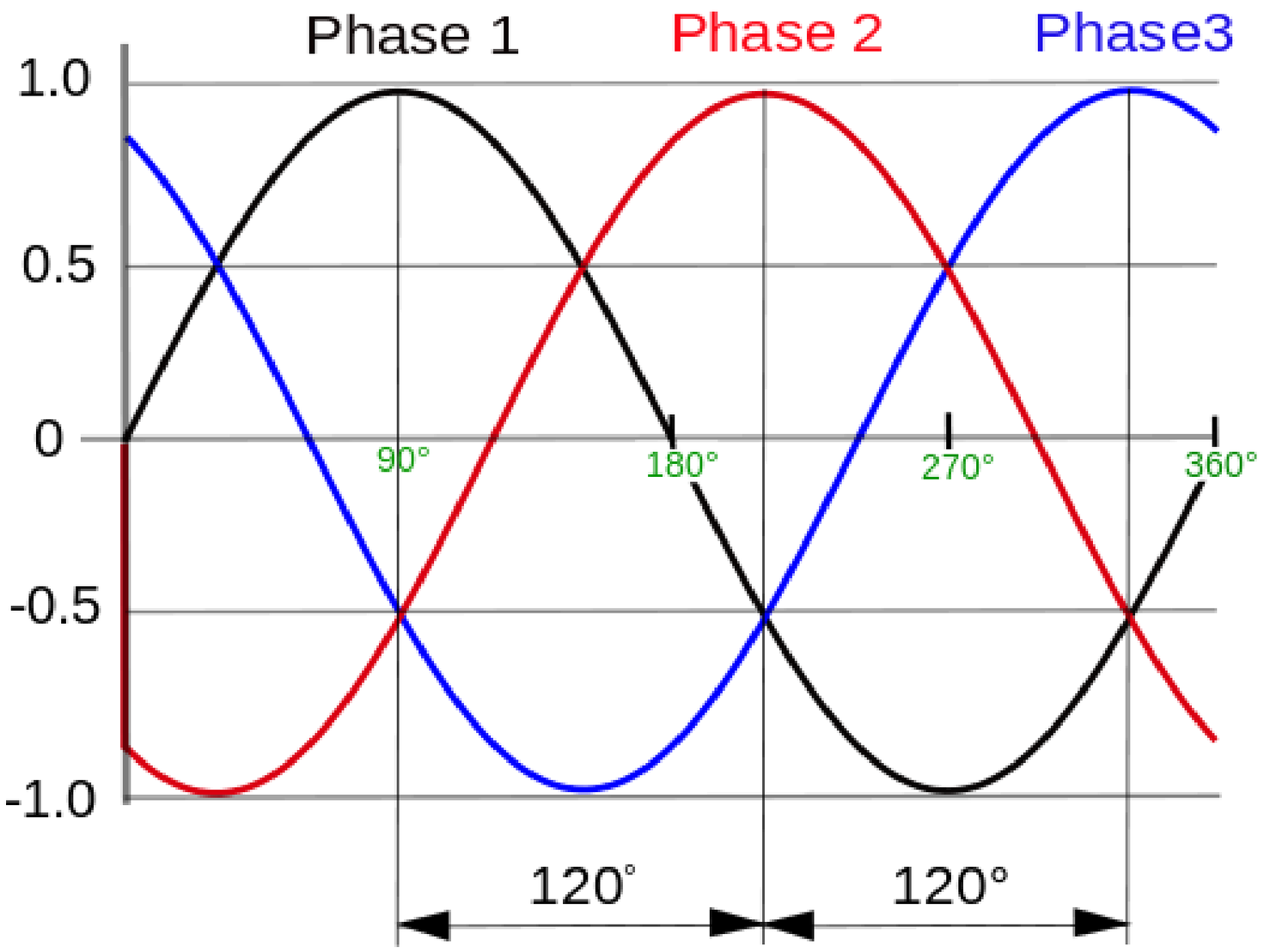
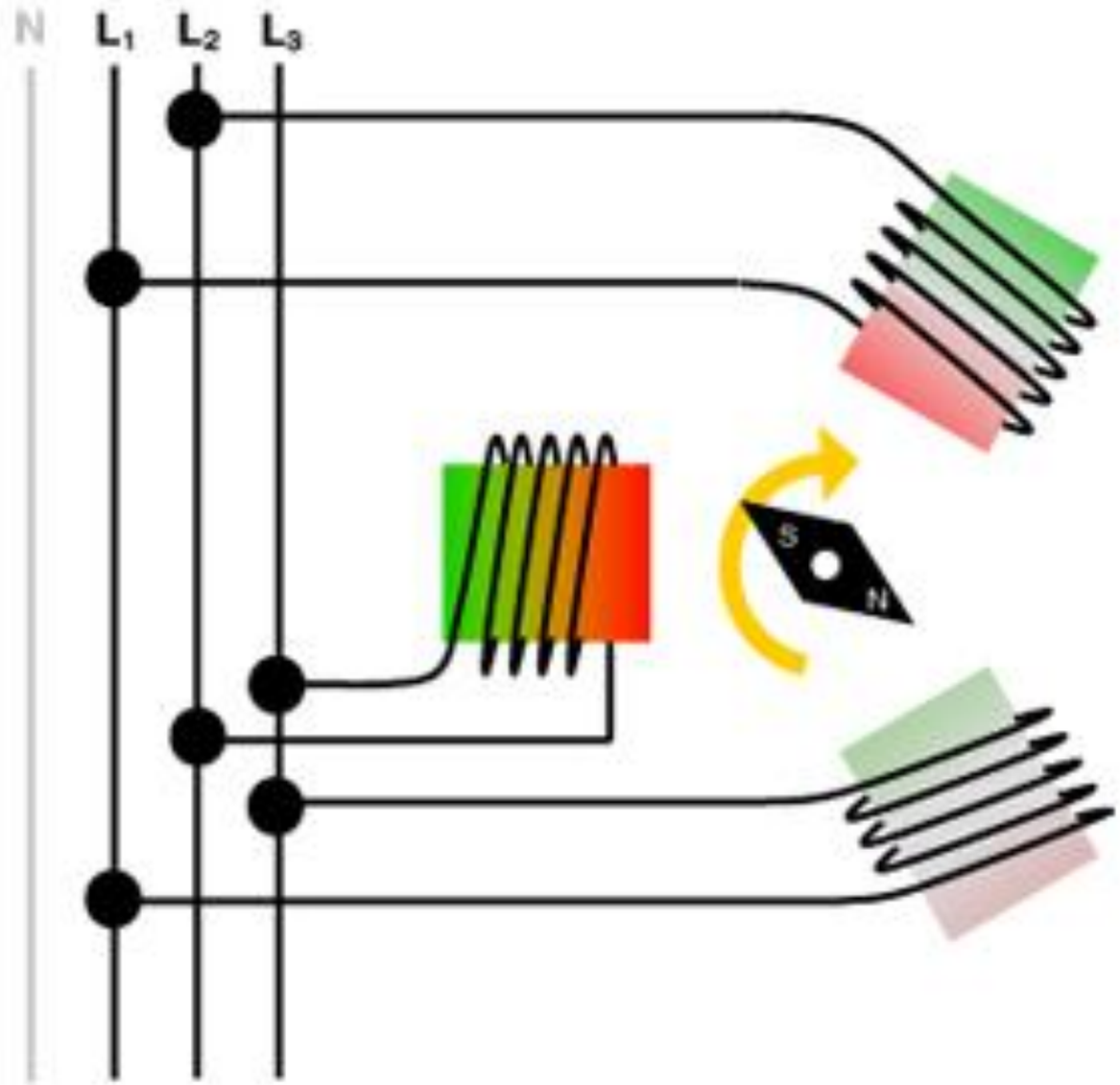


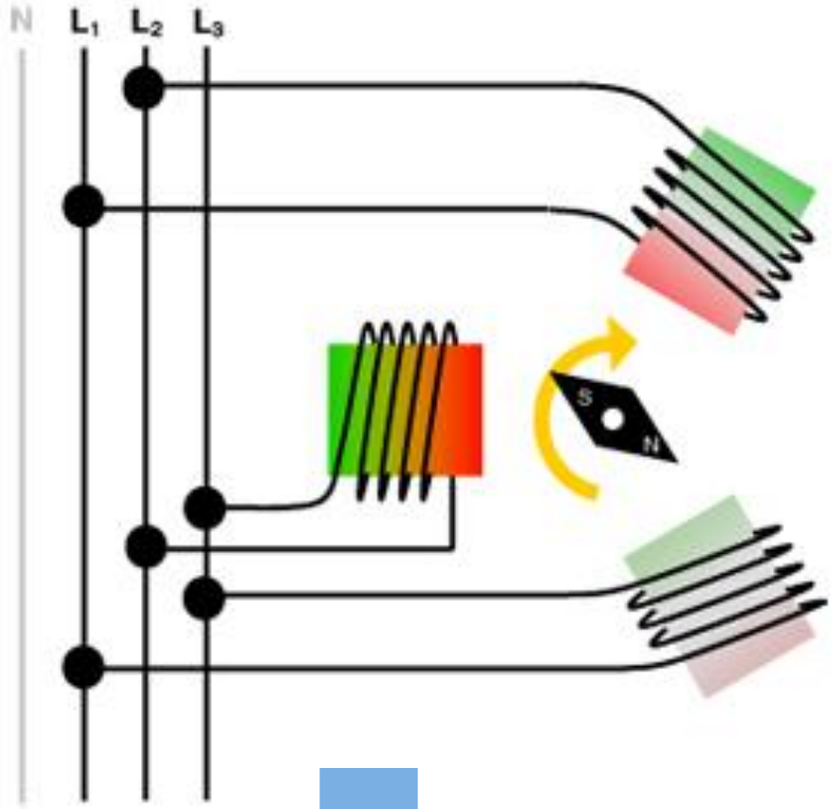
Three Phase AC Currents

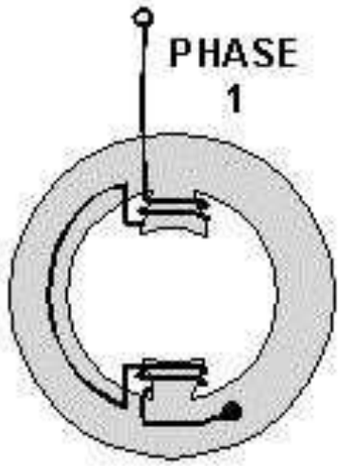
Three-phase power is designed especially for large electrical loads where the total electrical load is divided among the three separate phases. As a result, the wire and transformers will be less expensive than if these large loads were carried on a single-phase system.

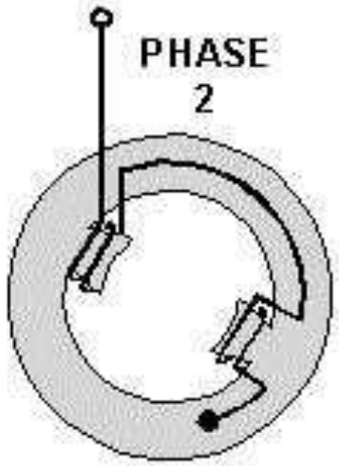


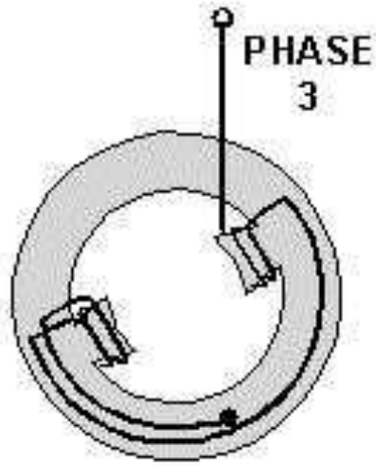
Three Phase AC Motor Fields

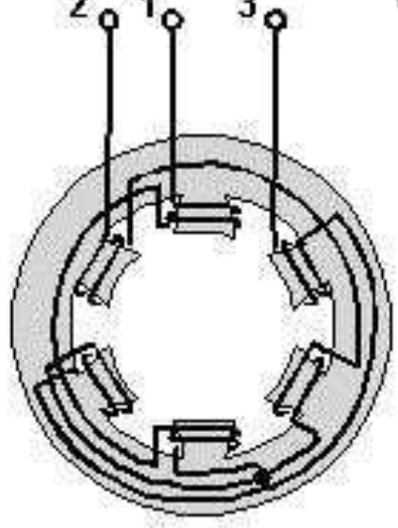
Three-phase power in a motor





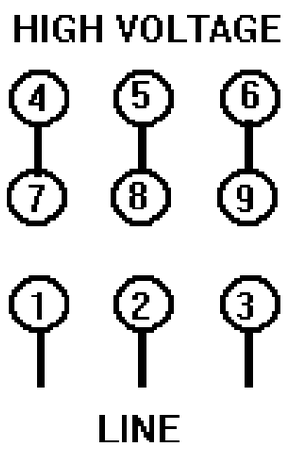


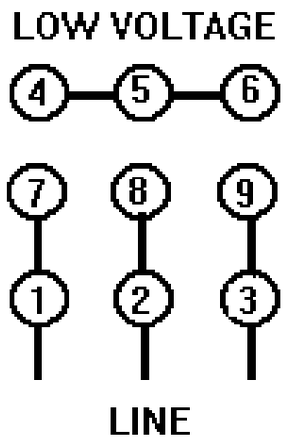


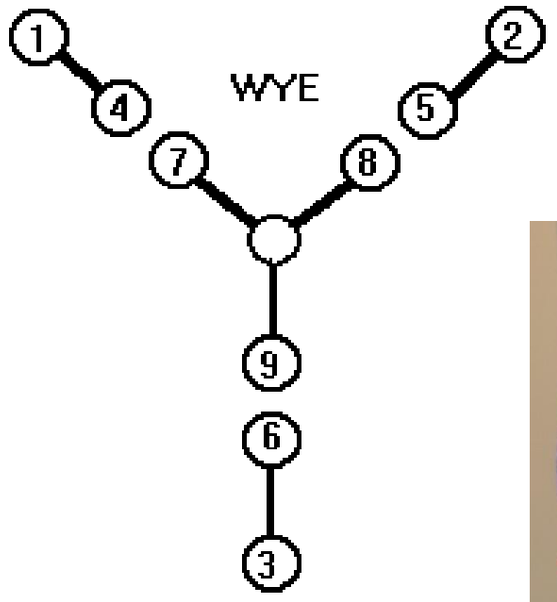


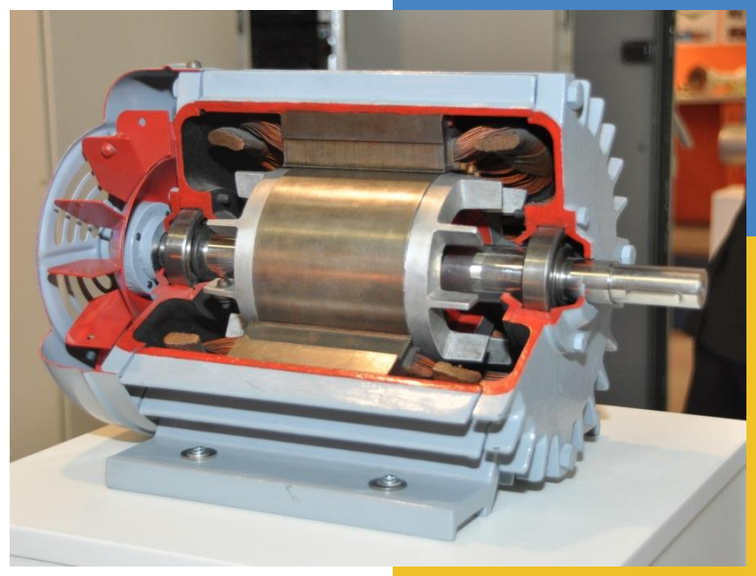
Three Phase AC Motor Fields

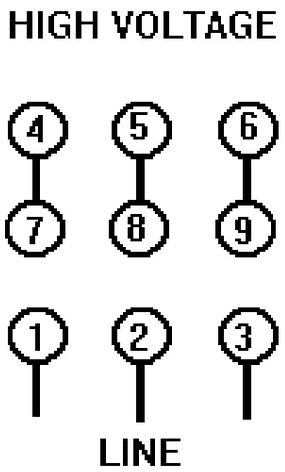
Three-phase power – Field Windings

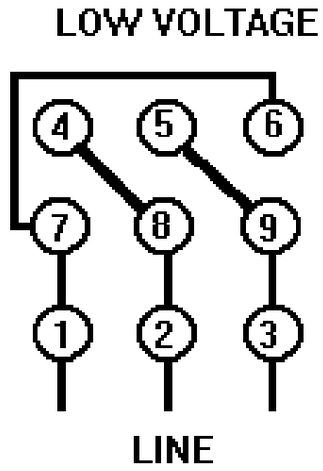


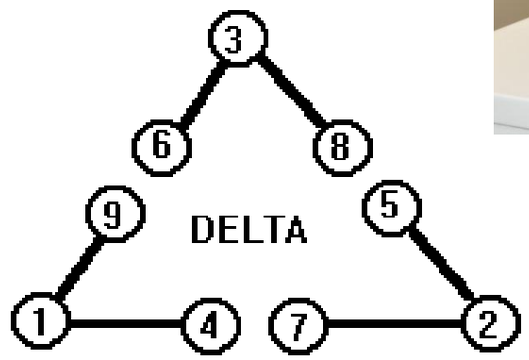






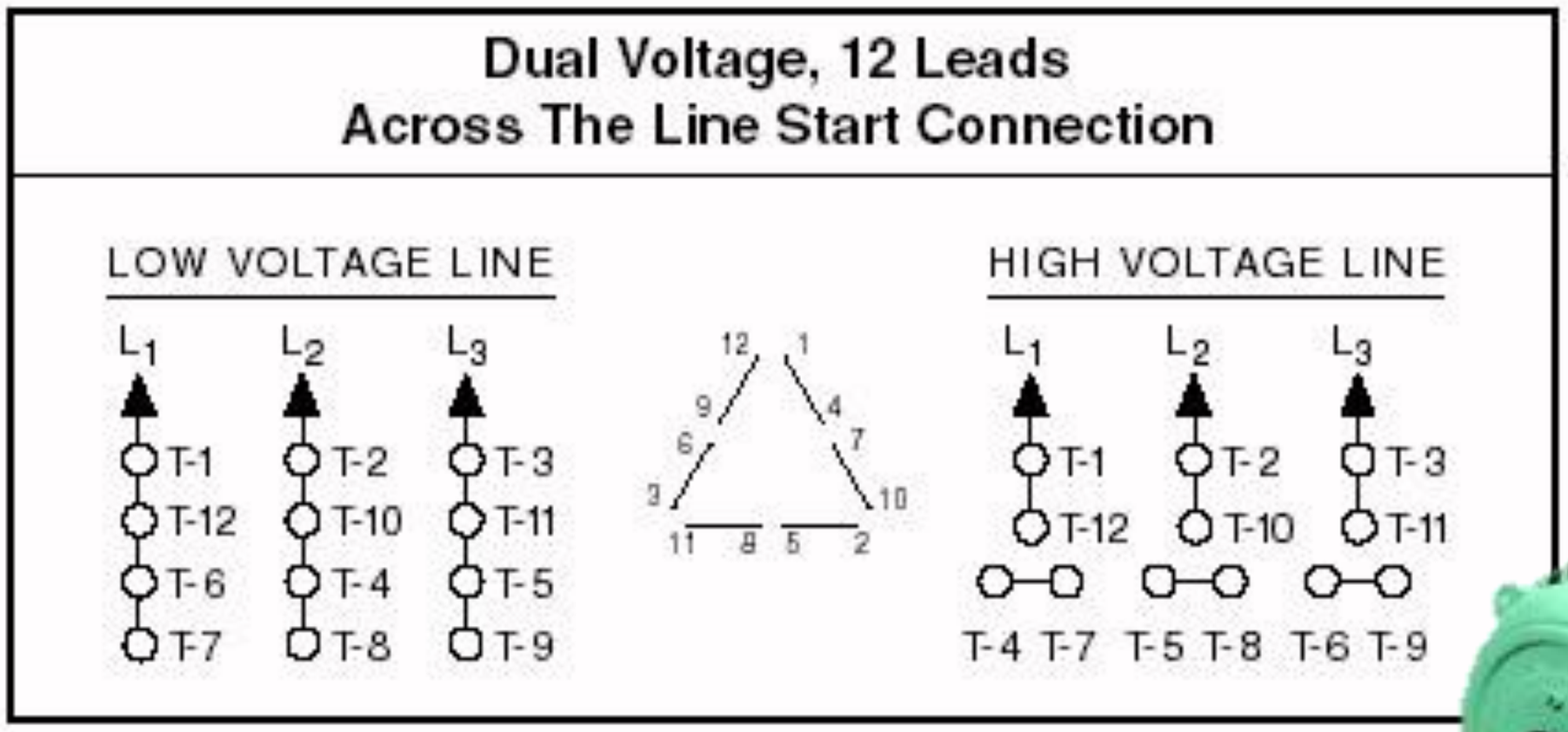






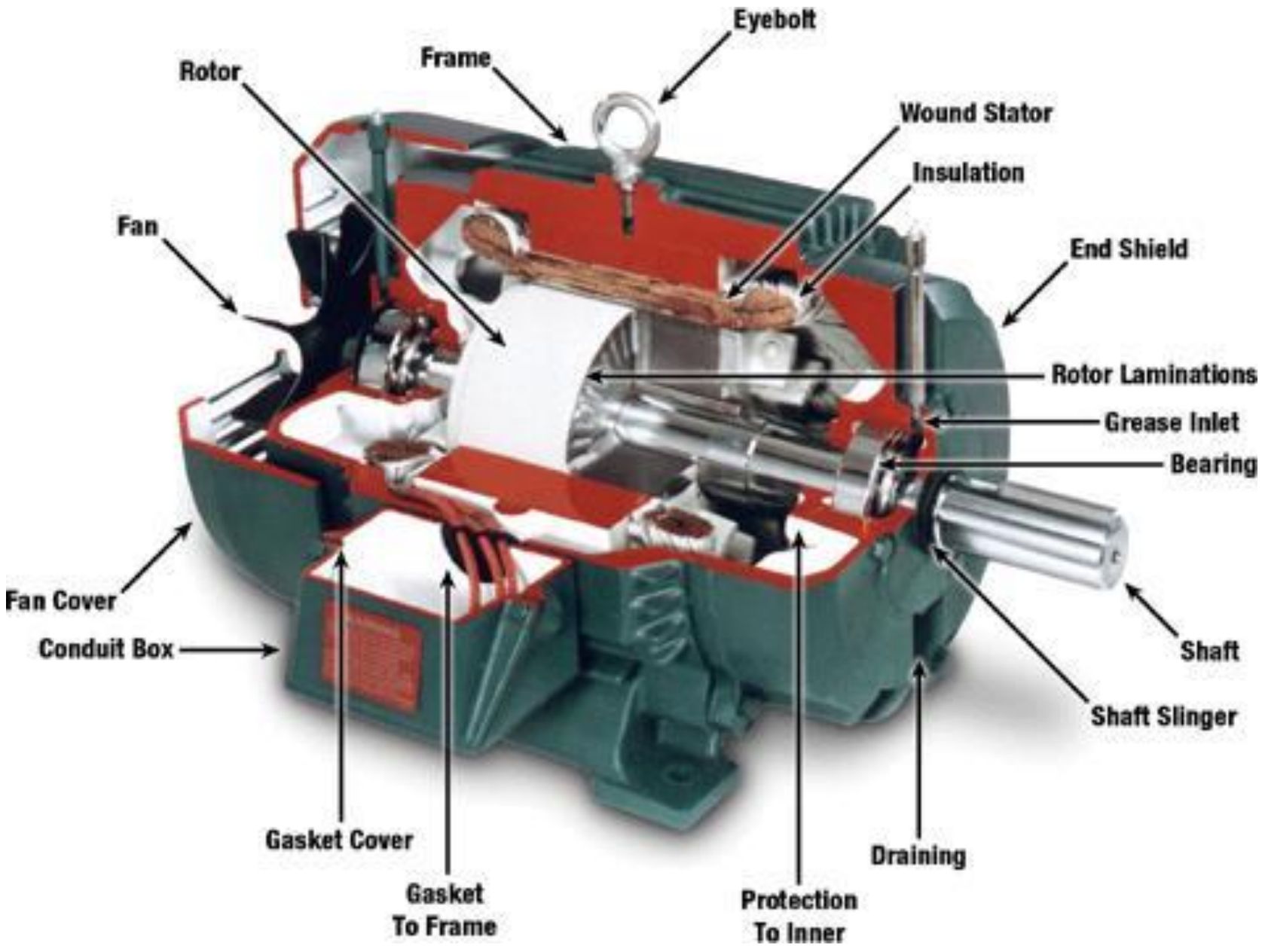
Three Phase AC Motor Fields

Three-phase power – 9 wire Field Windings



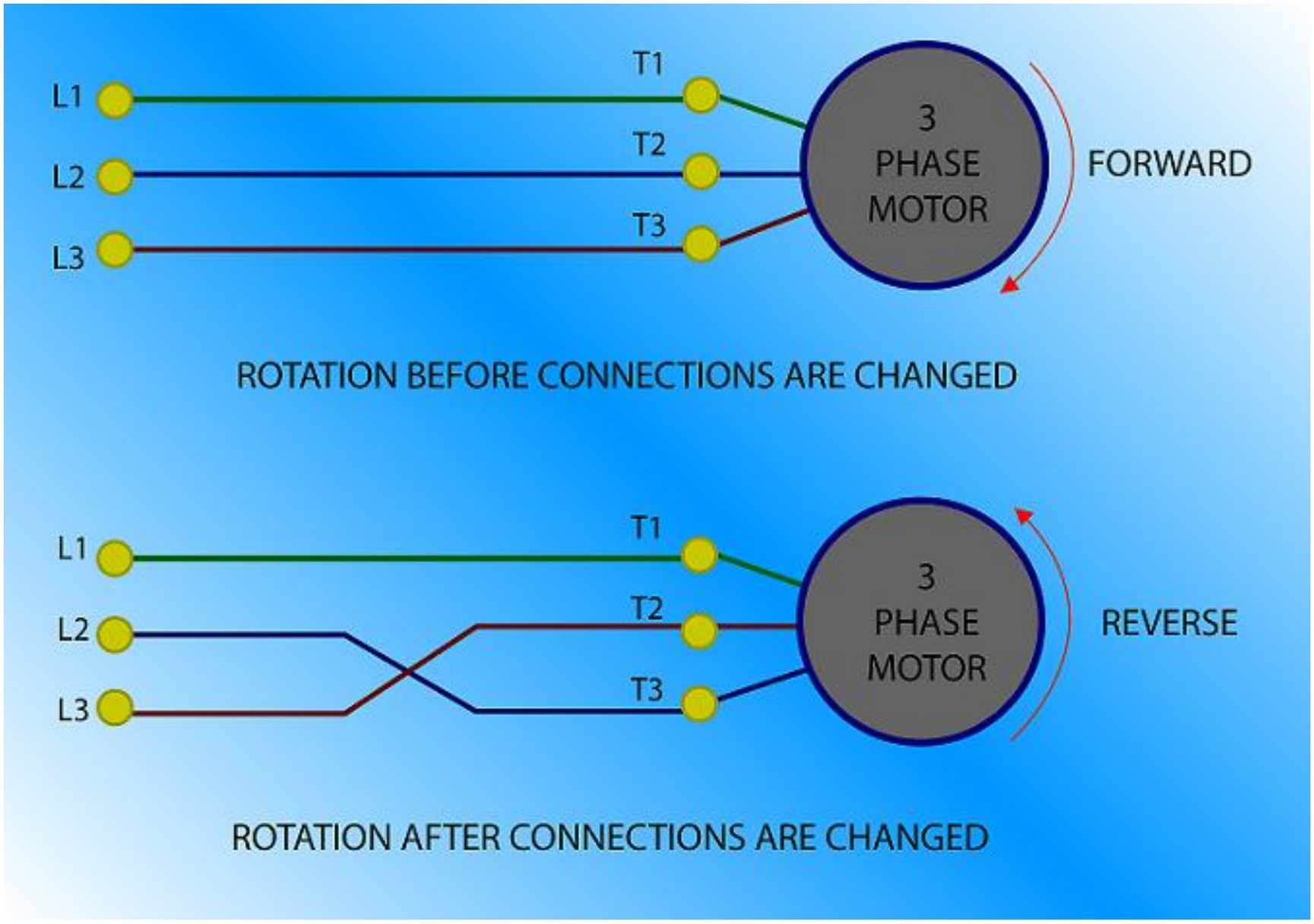
Three Phase AC Motor Fields

Three-phase power – 12 wire Field Windings



Three Phase AC Induction Motor

A Motor is a machine that converts electrical energy into Mechanical energy



Three Phase Induction Motor Rotation

Reversing the Phase Conductors will reverse the motor's direction of travel

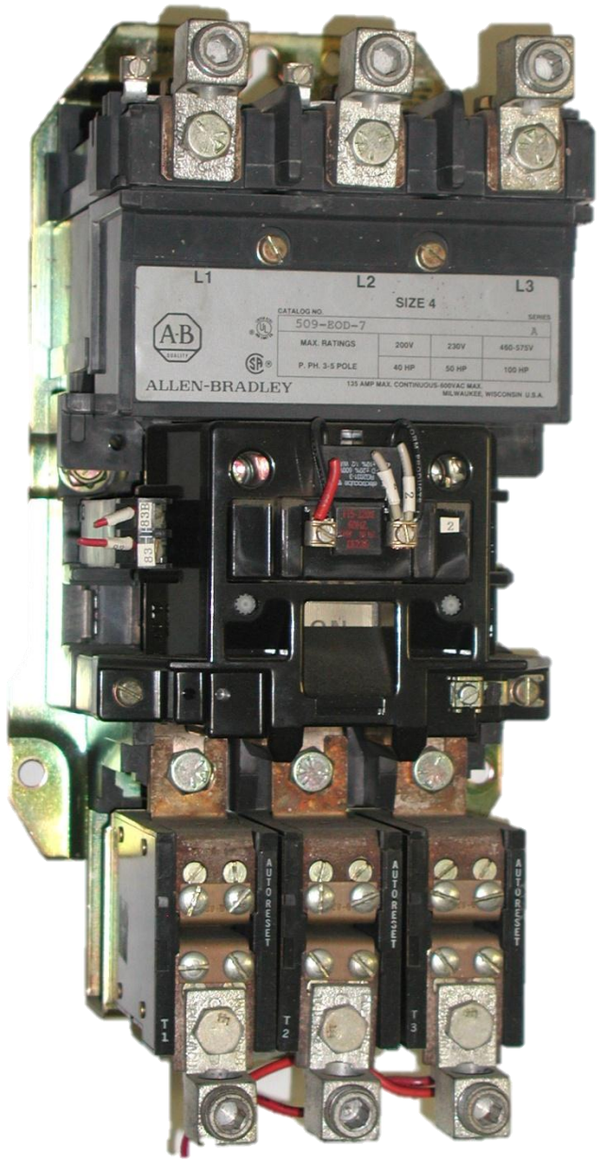
Motor Controls

Motor Starters

Variable Speed Drives

Soft Starters

NEMA Type Motor Starter



Contactor

Coil

Auxiliary Contacts

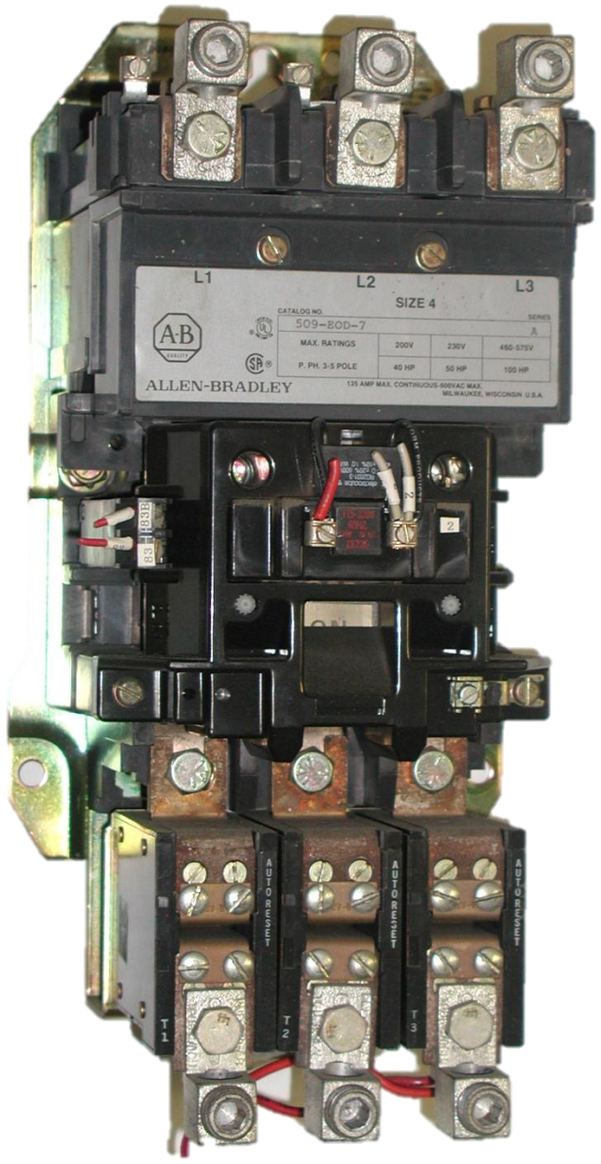
Overload Relay

Heaters

Across The Line Motor Starters

A motor starter consists of a Contactor and an Overload Protection Device.

Coil



NEMA Type
Motor Starter

Contactor

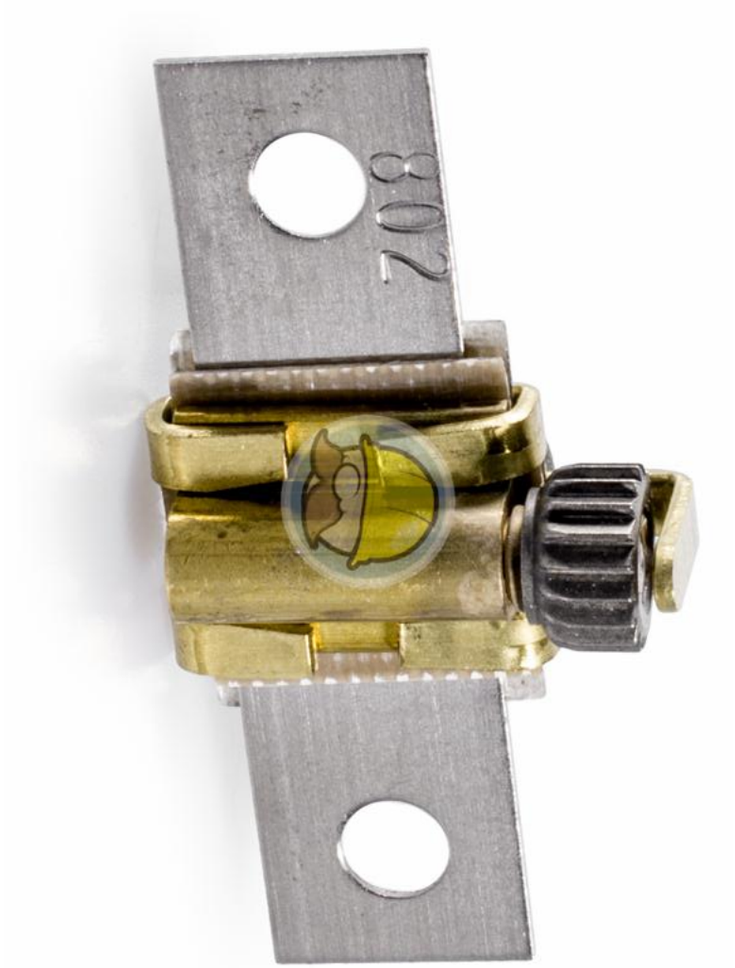
Auxiliary
Contacts

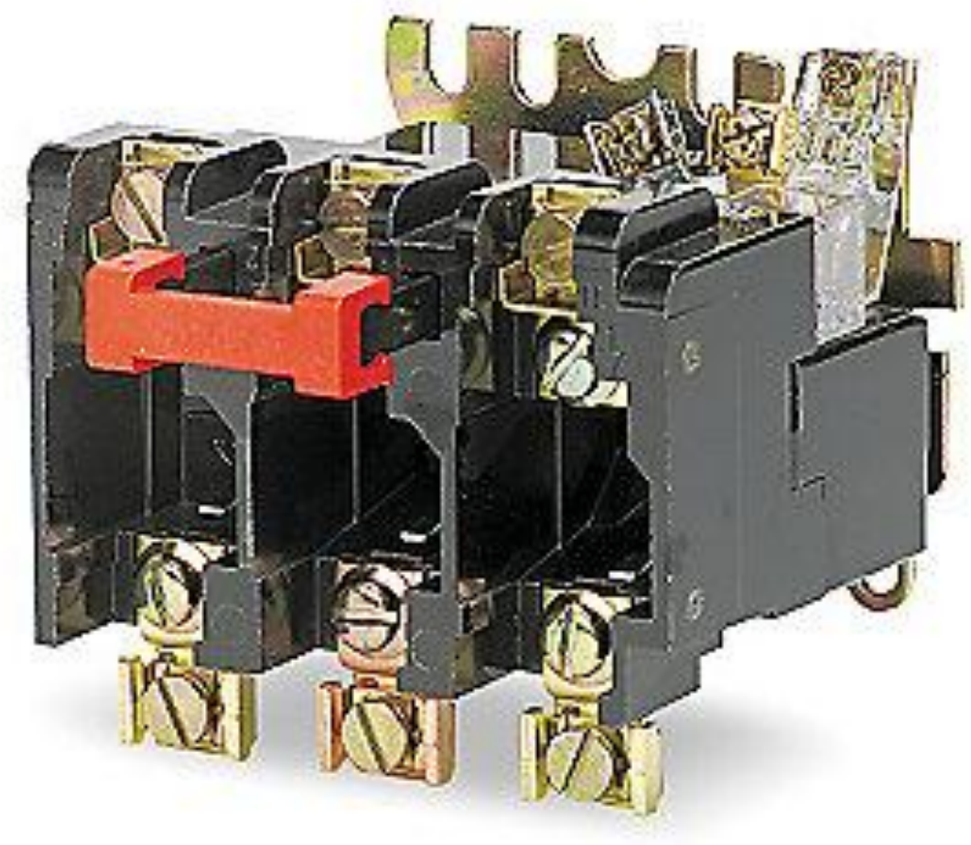
Overload Relay

Heaters

Across The Line Motor Starters

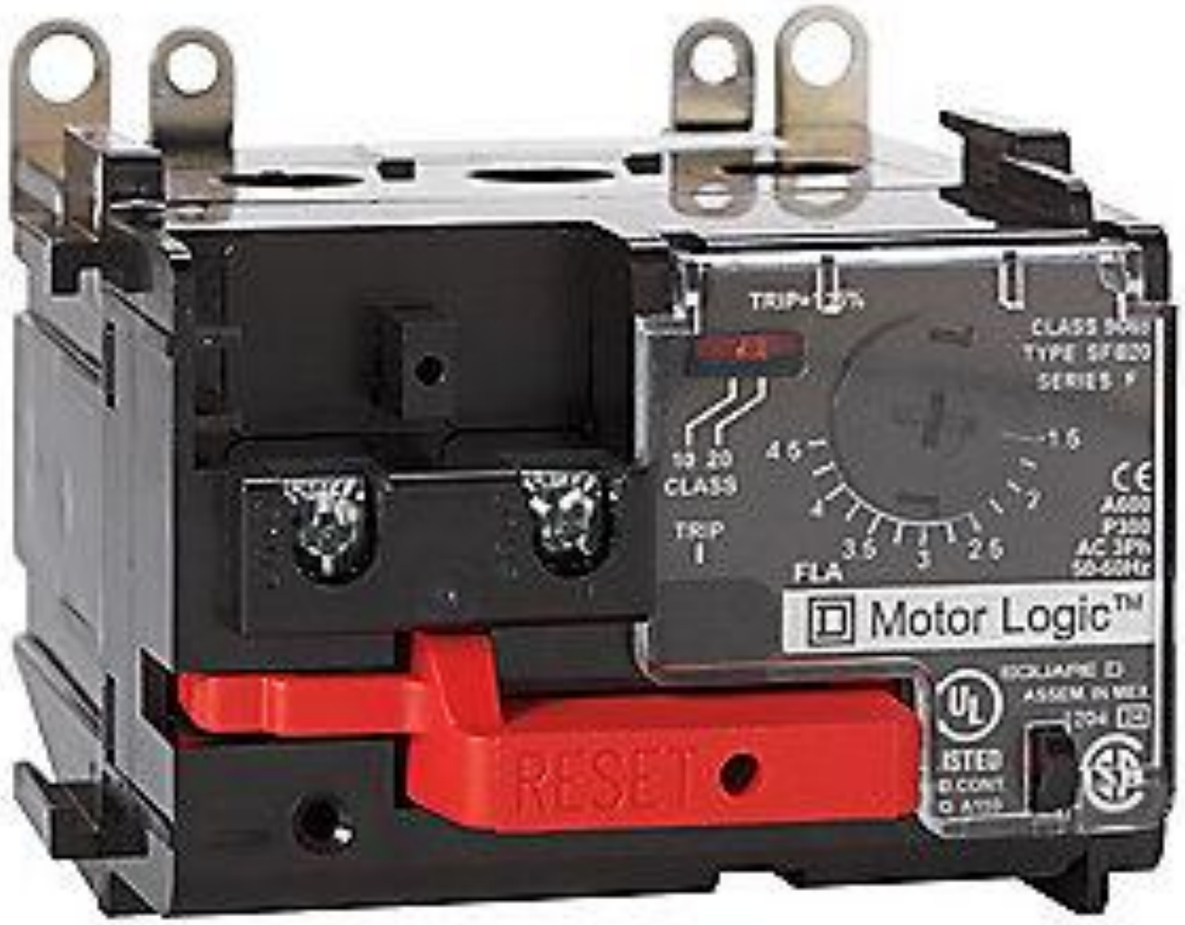
The Contactor’s purpose is to apply power to the load, and open as required, safely extinguishing any arc produced. The contactor coil uses an auxiliary control circuit to close and open the contactor.





Overload Relay – Heater Type

The Overload Relay is designed to protect the motor from loads in excess of it’s design. Often a Thermal Heater is used to provide that protection.



Overload Relay – Thermal Type

The Overload Relay is designed to protect the motor from loads in excess of it’s design.

IEC Type Motor Starter

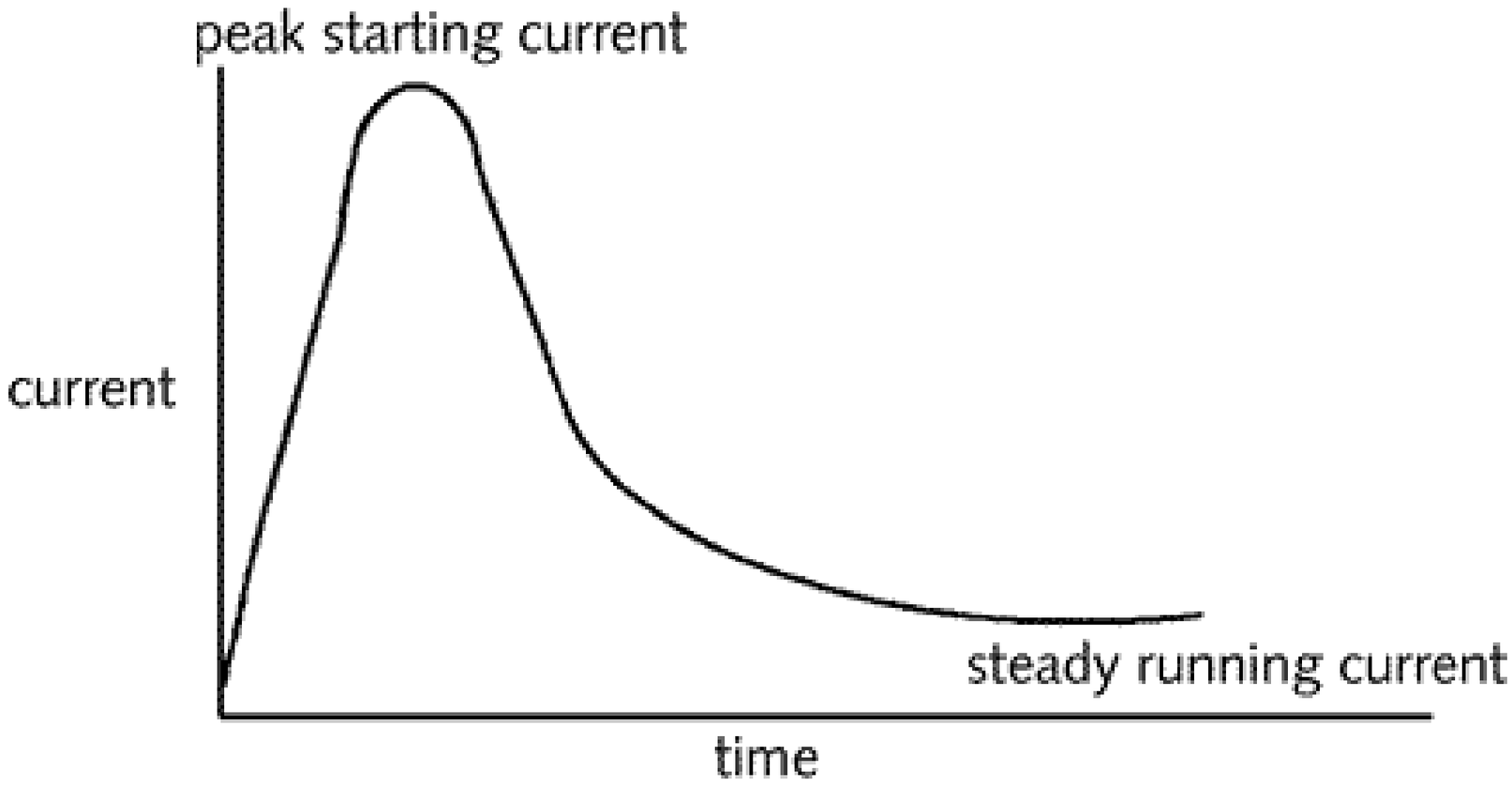
Across The Line Motor Starters

“International Electrotechnical Commission”

IEC Type Combination Motor Starter

Across The Line Motor Starters

This combination starter provides a disconnect, short circuit (fault) protection, and thermal overload protection.



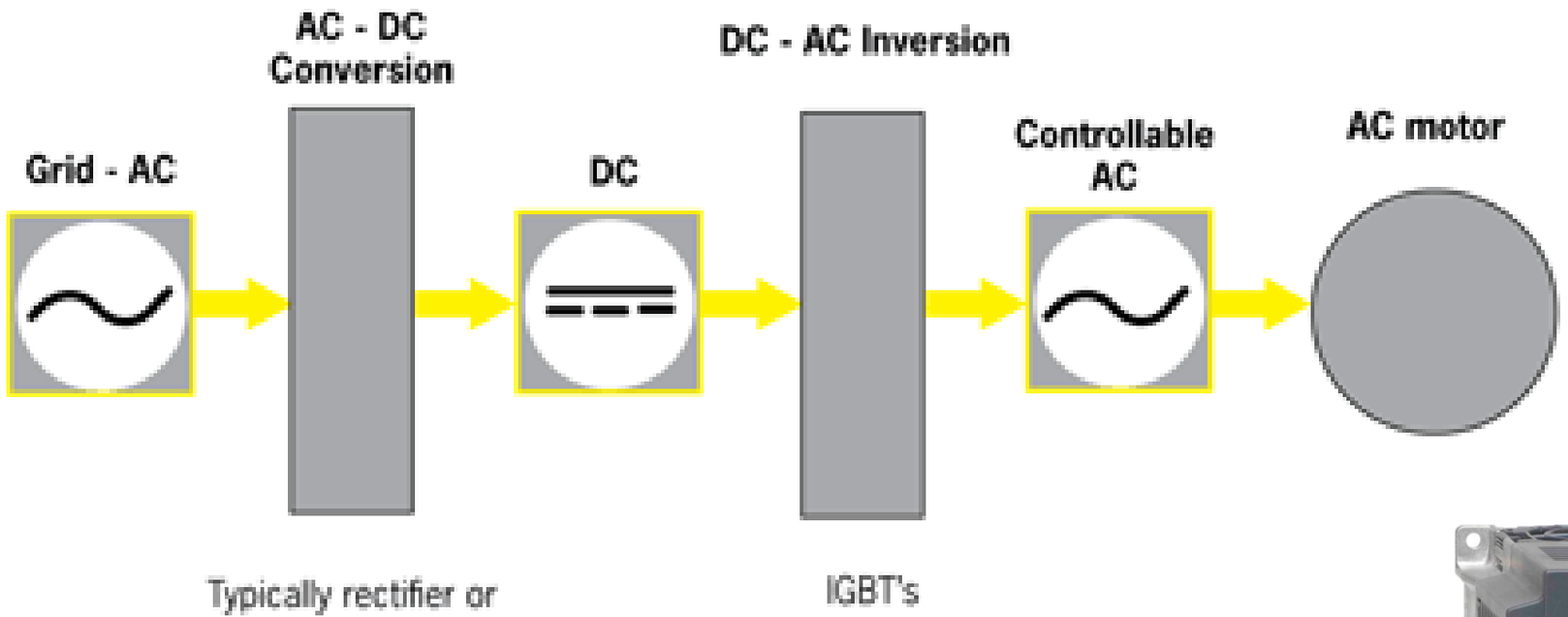
In-rush Start up Current

When an AC motor is energized, a high inrush current occurs. After the first half-cycle the motor begins to rotate and the starting current subsides to 4 to 8 times the normal current for several seconds.

Variable Frequency Drives

A Solid State Motor Control Device that can vary the speed and torque of an AC motor.

VFD basics



Insulated Gate Bipolar Transistors

Variable Frequency Drives

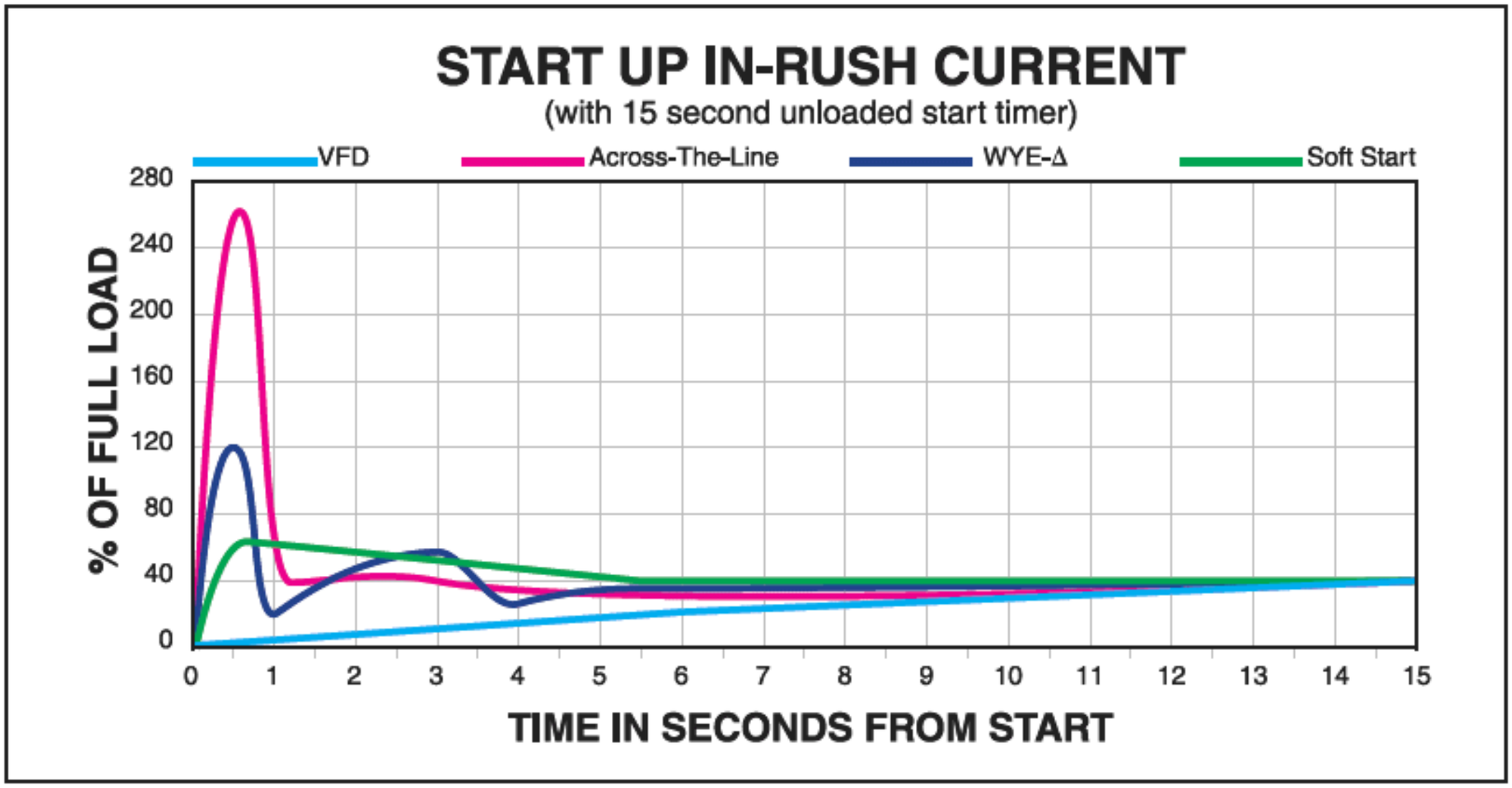
A Solid State Motor Control Device that can vary the speed and torque of an AC motor.

Also Provides:

- Overvoltage/Undervoltage Protection
- Phase Loss Protection
- Overcurrent protection
- Short Circuit Protection

Variable Frequency Drives

A Solid State Motor Control Device that can vary the speed and torque of an AC motor.



In-rush Start up Current

Variable Frequency Drives can eliminate the in-rush start up current.

A **motor soft starter** is a device used with AC electric motors to temporarily reduce the load and torque in the powertrain and electrical current surge of the motor during startup. This reduces the mechanical stress on the motor and shaft, as well as the electrodynamic stresses on the attached power cables and electrical distribution network, extending the lifespan of the system. A Soft Start does not vary the speed of the motor as a VFD does.

Soft Starters

Can be an inclusive solid state device, or added to an across the line starter

Safety


THERE'S YOUR PROBLEM
HOW MUCH DO YOU KNOW ABOUT ELECTRICITY?
PZZZT!
POOF!
THAT ANSWERS THAT QUESTION!!
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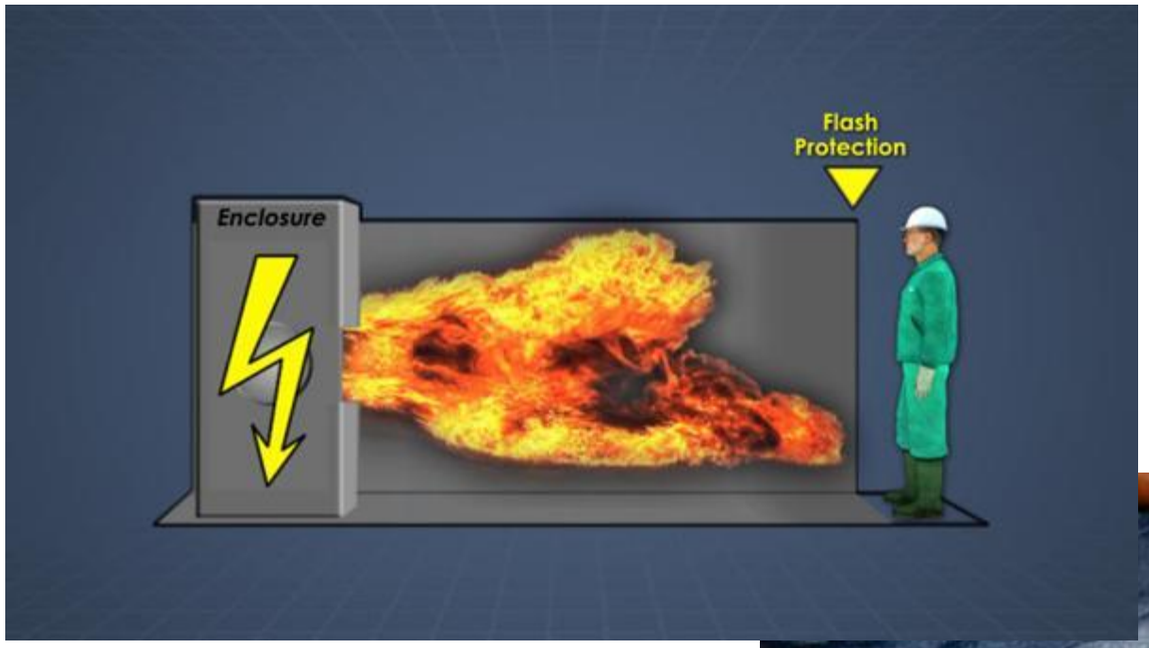
Lock Out / Tag Out

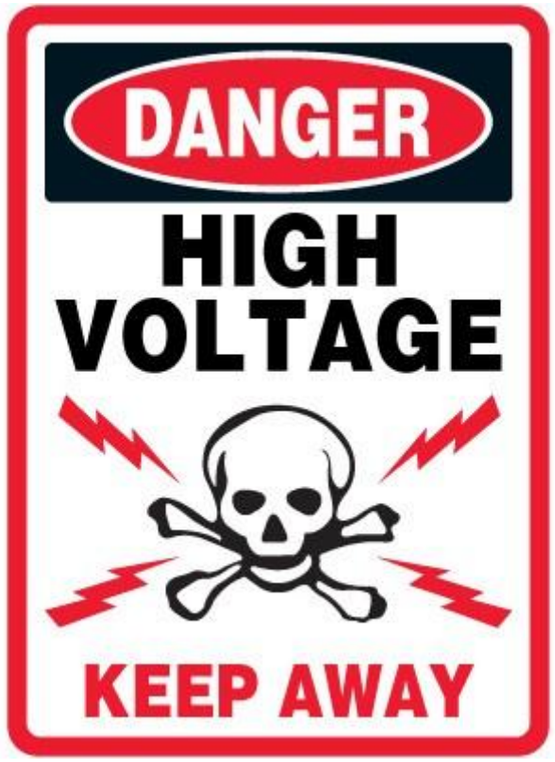
Every facility should have a Lock Out / Tag Out procedure in place.

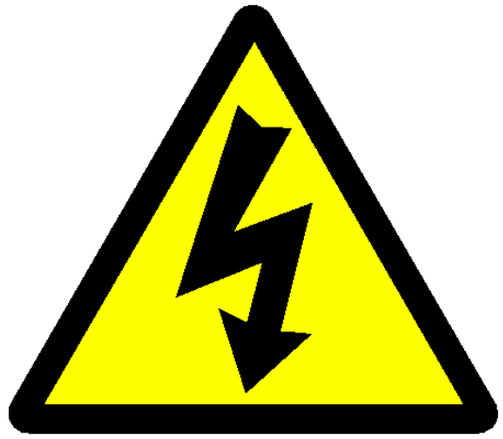
… And it should be enforced

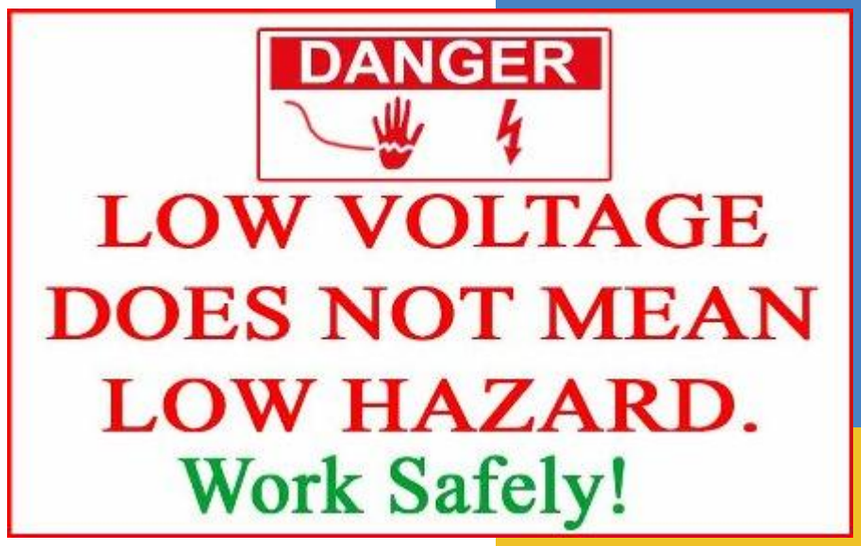


Arc Flash Hazard

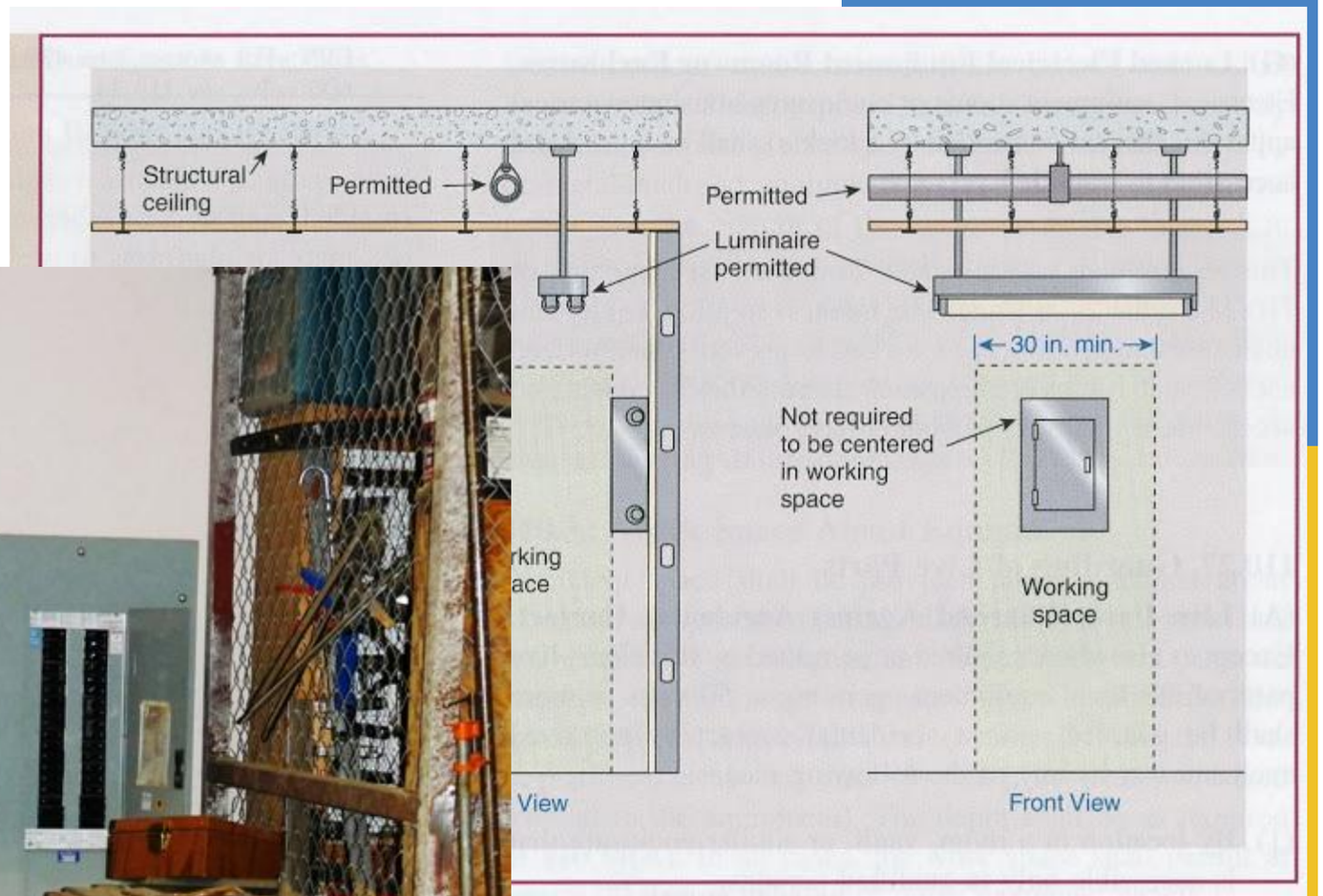
Never work on Live equipment… period





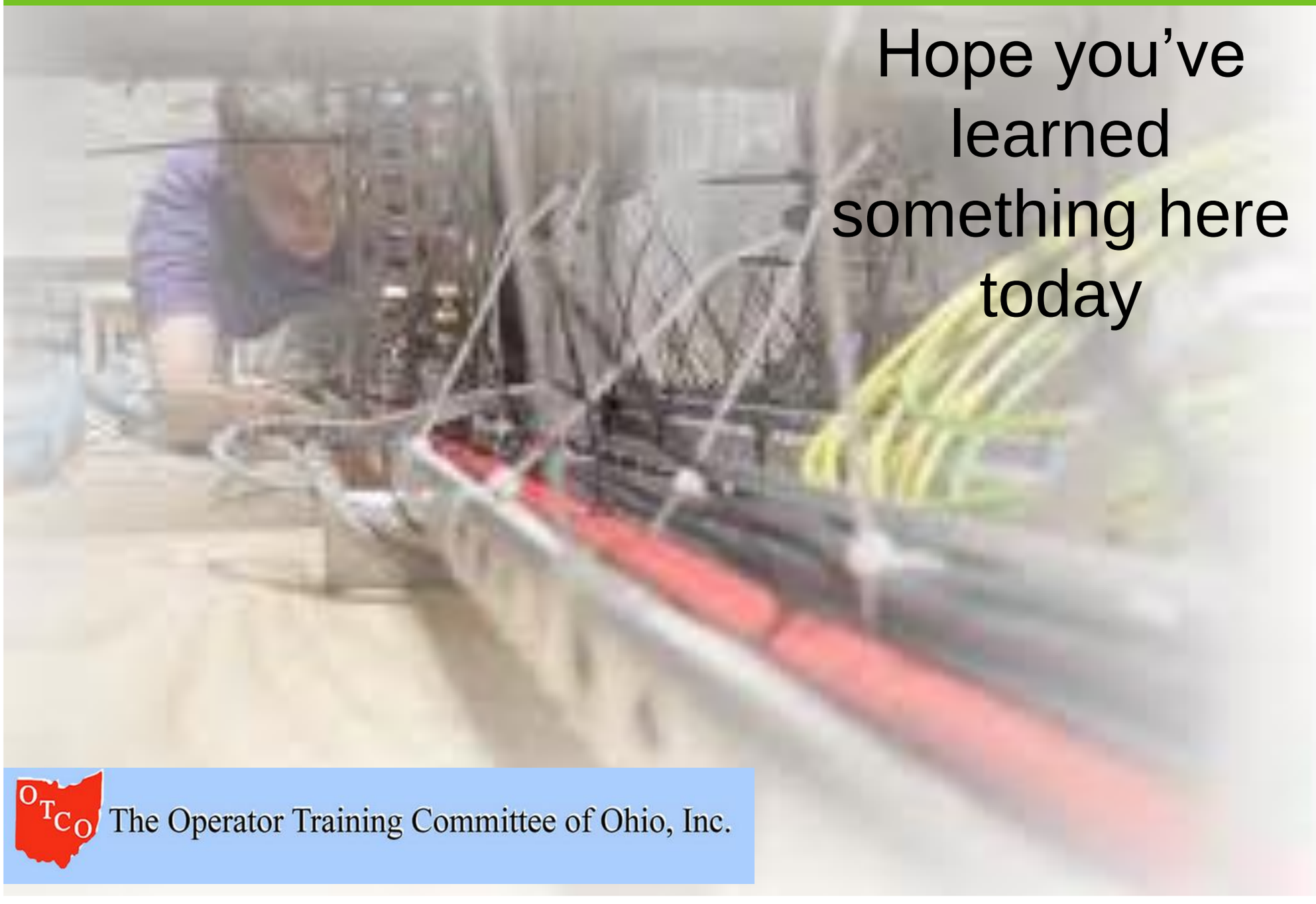


Properly Marked Equipment



Electrical Equipment Clearance

Thank you for your Attention!!



Hope you've learned something here today

Scott Fausneaucht

The Operator Training Committee of Ohio, Inc.

PRO-TECH SYSTEMS GROUP