RESIDENTIAL ELECTRICAL SYSTEMS BCN 1059

CHAPTER 9 ELECTRICAL FUNDAMENTALS

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ELECTRICAL FUNDAMENTALS

WHAT IS ELECTRICITY?

Think of a pipe or a garden hose. When you turn on the water, it moves through the pipe and out the faucet or hose end. In a similar way , you can think of electricity as a current of very tiny particles (electrons) flowing inside a wire and through a light bulb or an appliance that's been switched on. Residential wiring is fundamentally a matter of transporting this current in a safe, efficient manner.

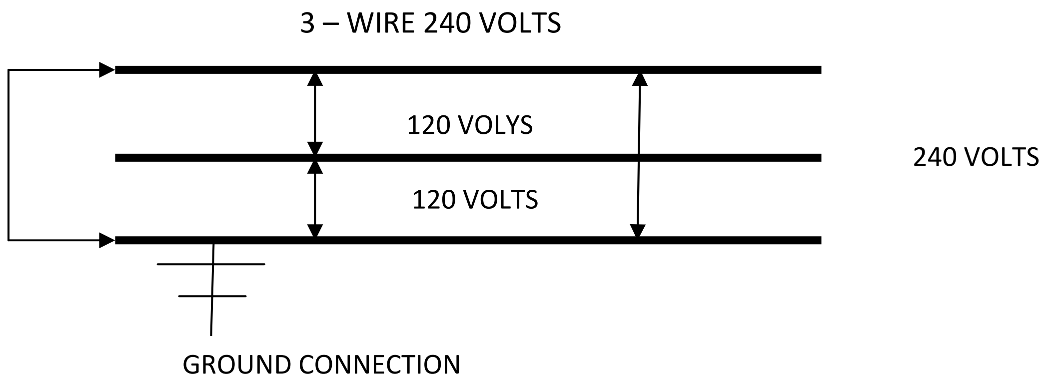
Electrical Fundamentals

In order for electric current to flow, it must travel from a higher to a lower potential voltage.

In an electrical system:

> The hot wires (red or black) are the higher potential than the neutral or grounded wires (white or gray). Therefore, current will flow between the hot wire(s) and the neutral or grounded wires.

The potential difference or voltage between a hot wire and the ground or neutral of a normal residential electrical system is 120 volts.



When three wires are installed (two hot and one grounded) either 120 or 240 volts are available In a three wire system, the voltage between the grounded wire and either of the hot wires is 120 volts

Between the hot wires, the voltage is 240 volts.

The grounded wire is properly called the neutral conductor when associated with two hot wires

BASIC TERMS ASSOCIATED with this flowing current are some basic terms.......

Volts/Voltage:

Water inside a hose moves because it's under pressure from the water behind it. Likewise, electricity is also under pressure, and the force causing the current to flow. This is measured in volts. The voltage is a measure of the force at which electricity is delivered

AMPERES / AMPS:

The amount of current that flows past a given point in one second is measured in amperes (amps). Amps are basically a function of wire size; the larger the wire, the higher the potential current-carrying capacity.

- Current is measured in amperes and is the quantity of flow of electricity
  - It is similar to measuring water in gallons per second

WATTS:

The energy per second consumed by a light bulb or an appliance is expressed in watts. Residential electrical usage is usually figured in kilowatt-hours (units of 1,000 watts multiplied by the time of usage in hours)

THE RELATIONSHIP BETWEEN VOLTS, AMPS, AND WATTS

Represented in the formula: VOLTS X AMPS = WATTS

V x A = W

If you know two of these values, you can figure the third by multiplying or dividing.

EXAMPLE:

A 20-amp circuit at 120 volts can deliver 2,400 watts:

A microwave oven that uses 1,000 watts of 120-volts consumes 8.3 amps;

A 240-volt clothes dryer that pulls 5,600 watts of power requires at least a 23.3-amp circuit

RESISTANCE:

This is the property of an electric circuit that restricts the flow of current. Electrical resistance or impedance is measured in ohms.

Electric current flows in wire. It flows with relative ease (little resistance) in some materials (copper vs. Iron).

When current flows through a wire, it creates heat. The greater the amount of flow, the greater the amount of heat generated.

Doubling the amperes without changing the wire size increases the amount of heat by four times

The heat is electric energy that has been converted into heat energy by the resistance of the wire

If the amount of heat generated by the flow of current through the wire becomes excessive, a fire may result.

In addition to heat generated, there will be a reduction in voltage as a result of attempting to force more current through a wire than it is capable of carrying

Relationships among Current, Voltage, Resistance, and Power

The basic equation for an electrical analysis is OHM'S LAW

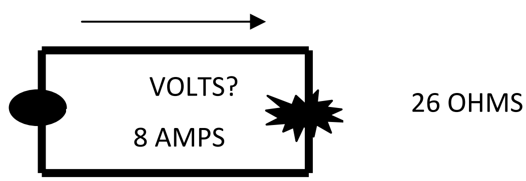
Says that the voltage (V) equals current (A) times the resistance (R)

Three basic equations showing the relationship

V = A x R
A = V / R
R = V / A
V = Volts, A = Amps, R = Ohm's Resistance

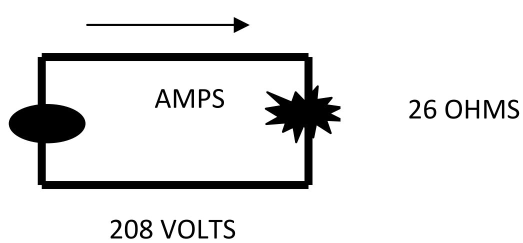
Example 1 - For the system below compute the voltage, given A = 8 amps and R = 26 ohms

- V = R x A
- V = 26 ohms X 8 amps
- V = 208 volts



Example 2 - For the system below, compute the current flow, given V = 208 volts and R = 26 ohms

- A = V / R
- A = 208 volts / 26 ohms
- A = 8 amps



POWER:

The most important relationship is the power provided by the system as it relates to voltage and current. Power is measured in volt amp (V/A)

- Power (in volt amps) = Voltage (in volts) X Current (in amps)

or

- P = (V)(A)

Example: Conductors capable of safely carrying 100 amperes would provide 24,000 volt amps (watts) of power at 240 volts (240 X 100), but only 12,000 volt amps at 120 volts

CONDUCTORS:

The general term "conductor" applies to anything that permits, or conducts, the flow of electricity. Electricity flows in the path of least resistance, and certain materials allow energy to flow more freely than others. Copper, for example, is a good conductor; most wires are made of copper, although aluminum and copper-clad aluminum wires are also used.

ELECTRICAL SERVICE

THE CONTINUOUS LOOP OF A CIRCUIT

In order to flow, electricity must have a continuous, closed path from start to finish – like a circle. The word "circuit" refers to the entire course an electric current travels, from the source of power, through an electrical device, and back to the source.

So what may appear to be a hopeless tangle of wires running through the walls, floors, and ceilings of your home is actually a well-organized system composed of several circuits.

Each circuit can be traced from its beginning in the entrance panel through various receptacles, fixtures, or appliance and back to the panel.

The current flows to the devices (called loads) through a "hot" wire and returns via a "neutral" wire –so- called because under normal conditions it's maintained at zero volts, or what is referred to as ground potential.

HOW ELECTRICITY ENERGIZES YOUR HOME
(Let's trace the electrical path)

Utility companies distribute power to individual households through overhead wires or underground cables.

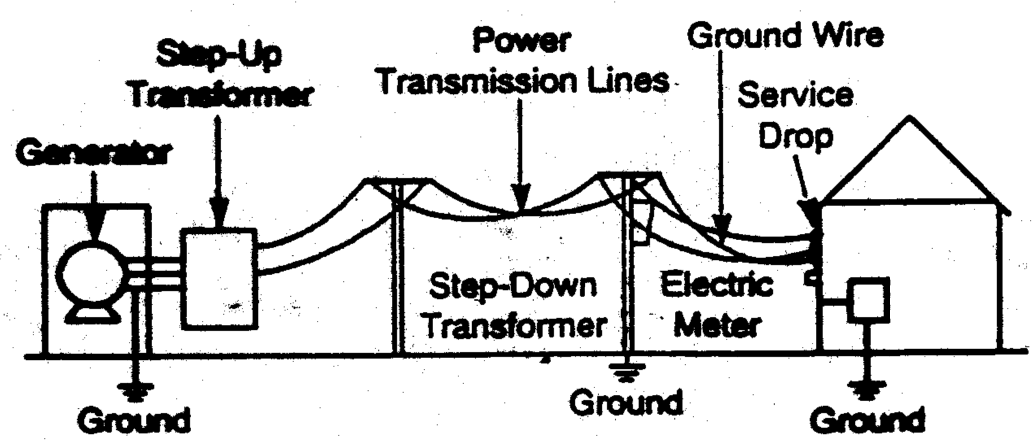
1. Electricity travels from the power plant through "step-up" transformers that boost voltage via huge magnetic coils and send it along high-voltage lines to substations, where it then moves through "step-down" transformers.

2. From the substation, this reduced power moves along city streets until it nears your home, where yet another step-down transformer converts it to household voltage.

3. The wires that connect this last transformer to your home (called a service drop) enter

via an overhead service head or through buried conduit (pipe).

PROVIDING ELECTRICAL ENERGY TO A BUILDING



YOUR ELECTRICAL SERVICE

Most of today's homes have a three-wire service. That is the utility company connects three lines to your home's service entrance panel.

Two hot conductors each supplying electricity at about 120 volts, and one neutral conductor

Three-wire service provides both 120-volts and 240-volt capability.

> One hot conductor and the neutral combine to provide for 120-volt needs such as light fixtures.
>
> Both hot conductors combine with the neural to provide 120/240 volts for large appliances, such   as a range.

The selling feature of 240-volt power is that it's twice as powerful and twice as efficient as 120 volts (allows you to run higher-wattage appliances at half the amps).

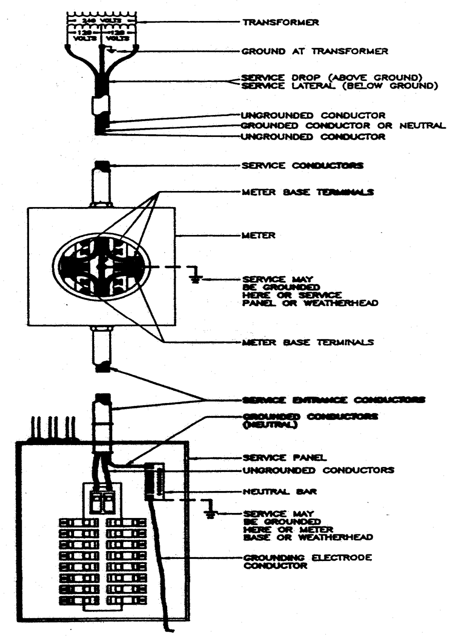
THE SERVICE ENTRANCE PANEL

The control center for a home electrical system is the service panel (panel box or fuse box).

The box usually houses the main disconnect (the main fuses or main circuit breakers) which shuts off power to the entire electrical system

Electricity runs from the utility company lines, through the meter, and into the service panel.

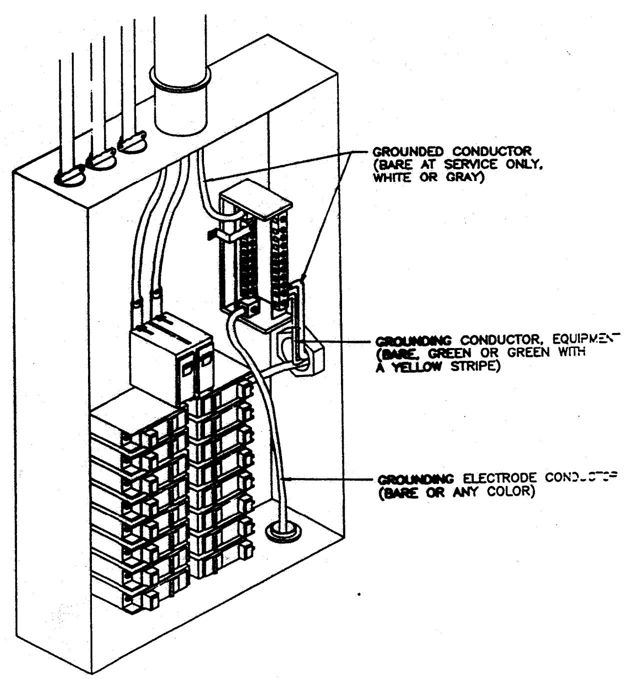
The service drop typically contains three conductors (two hot conductors go to the main disconnect. The neutral conductor goes directly to a device called the neutral bus bar, which in turn connects to the grounding electrode conductor. This continuous conductor connects the neutral bar to the metal water supply pipe entering your home and to a metal ground rod driven into the earth. This safety feature provides excess current with an uninterrupted metal pathway into the ground).



THE DISTRIBUTION CENTER

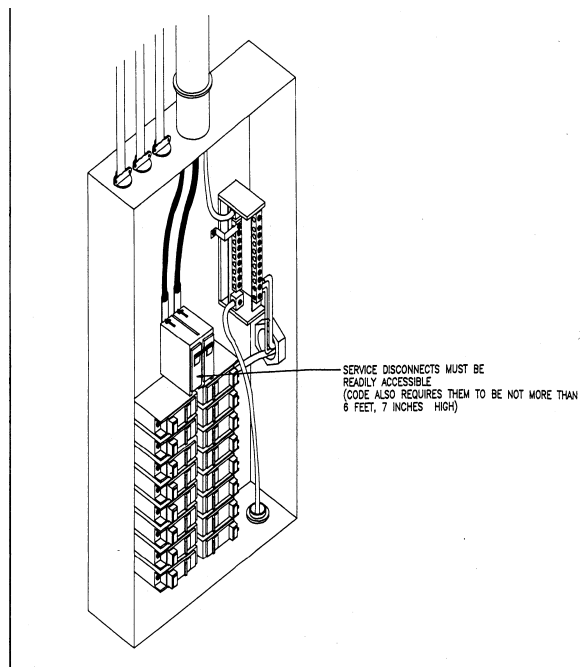
After passing through the main disconnect, each hot conductor connects to one of two hot bus bars in the distribution center, where energy is divided to branch circuits

The hot bus bars accepts the amount of current permitted by the main fuses or circuit breaker and allows you to divide that current into smaller units for the branch circuits.



ELECTRICAL SERVICE

Electrical Service must be Readily Accessible: Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is necessary to climbing over or removing obstacles or to resort to portable ladders, chairs, etc.



Service Equipment: The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, and intended to constitute the main control and means of cutoff of the supply

Service Conductors: The supply conductors that extend from the street main to transformers to the service equipment of the premises supplied

Service Drop: The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structures

Service-Entrance Conductors Overhead System: The service conductors between the terminals of the service equipment and the point of connection to the service lateral

Grounding Electrode Conductor: The conductor used to connect the grounding electrode equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system_

GROUNDING

GROUNDING

Electrical codes require that all 120 and 240-volt circuits have a system of grounding.

Grounding assures that all metal parts of a circuit that you might come in contact with are connected directly to the earth, maintaining them at zero voltage. This is a preventive measure.

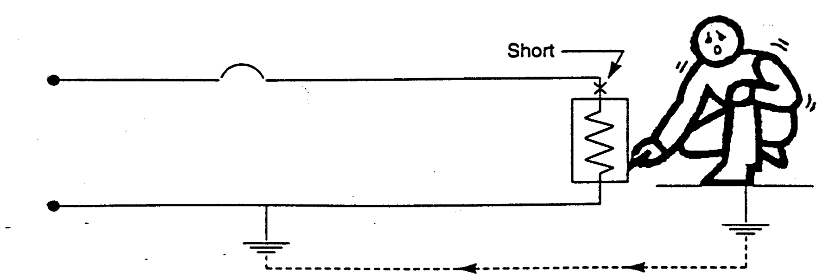
During normal operation, a grounding system does nothing; in the event of a malfunction, however, the grounding protects you and your home from electric shock or fire.

WHAT CAUSES SHOCK?

Current flows in a continuous closed path from the source, through a device that uses the power, and back to the source.

But electricity need not flow in wires to make the return trip to the source. It can return through any conducting body-including a person-that contacts the earth directly or touches a conductive object that in turn enters the earth. And if you accidentally become a link in an electrically live circuit, you'll get a SHOCK.

The key word is "LINK." To get an electrical shock, you must be touching a live wire or device at the same time you're touching a grounded object or another live wire.



The case becomes connected to the ungrounded side of the line (a short to the case)

EXAMPLE

If the hot wire accidentally became dislodged from a light fixture terminal and came into contact with the light fixture's metal canopy, which is highly conductive, the fixture would become charged, or "hot."

If you were then to touch the fixture under these conditions, a current leakage, or "ground fault," could occur in which you would provide the path to ground for the electric current, and you would get a SHOCK.

This shock could have been prevented if the circuit had a grounding system. A grounding wire connecting the neutral bus bar in the service entrance panel to the metal housing of the light fixture would provide an auxiliary electrical path to ground.

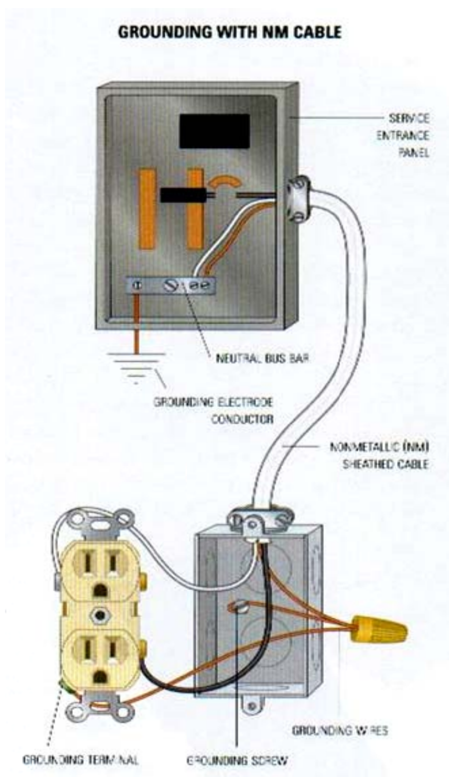
This grounding wire would carry the fault current back to the distribution center, where the fuse or circuit breaker protecting the circuit would open, shutting off all current flow.

GROUNDING LOGISTICS

The bare grounding wire of the NM cable provides the grounding continuity (NM cable is a nonmetallic sheathed cable containing a grounding wire).

The final grounding connection to the receptacle is made through a short piece of wire called a jumper that is bonded to the metal box with either a grounding screw or a grounding clip.

If a nonmetallic box were used instead, the grounding wire would be connected directly to the receptacle because that kind of box needs no grounding.



PRINICLES OF GROUNDING

The electric power utility provides grounds both at the generating station and at the power pole carrying the step-down transformer for service to the dwelling

The earth, by virtue of moisture contained within the soil, serves as an effective conductor

At the house, or the point where the electricity is to be used, the circuit is completed by another connection to the ground

Every building is required to have an independent ground, called a system ground

SYSTEM GROUND

The system ground provides for the limiting of the voltage upon the circuit, which might otherwise occur through exposure to lighting, or for limiting the maximum potential to ground due to normal voltage

The system ground's main purpose is to protect the electric system itself and offer limited protection to the user

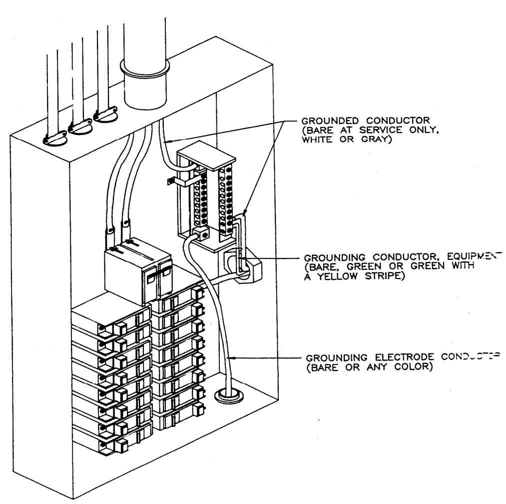
The system ground should be a continuous conductor of low resistance and of sufficient size to conduct current safely from lighting and overloads so that the over current protection can be tripped, thus breaking the circuit

Grounded Conductor: A system or circuit conductor that is intentionally grounded

Grounding Conductor: A conductor used to connect equipment or grounded circuit of a wiring system to a grounding electrode or electrodes

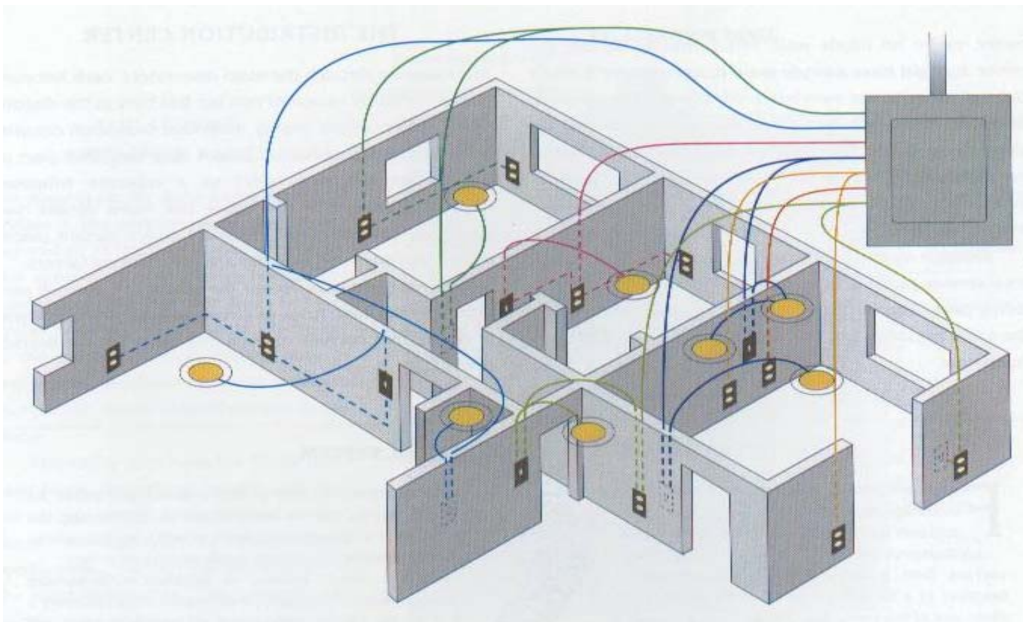
Equipment Grounding Conductor: The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system

Grounding Electrode Conductor: The conductor used to connect the grounding electrode equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system



CIRCUIT BRANCH CIRCUITS

Branch circuits feed power to receptacles, switches, fixtures, and appliances in different areas of the house. Each one attaches to one or both hot bus bars in the distribution center by means of a branch circuit over current protection device (fuse or circuit breaker)



BRANCH CIRCUITS

A 120-volt circuit consists of one hot conductor and one neutral conductor. The hot conductor originates at the breaker or fuse connected to one of the hot bus bars.

A 240-volt circuit requires both hot bus conductors, so it originates at a breaker or fuse connected to both hot bus bar.

All neutral conductors for branch circuits originates at a neutral bus bar in the distribution center. They are all in direct contact with the earth through the grounding electrode conductor at the main service entrance panel. In order that ground potential (zero volts) be maintained at all times, a neutral conductor must never be interrupted by an over current protection device.

OVERCURRENT PROTECTION

Purpose: To protect wiring, insulation, switches, receptacle, and other devices and equipment from load currents above their rating (overload) and from fault or short circuit. Over current protection is installed to provide automatic means for interrupting or opening a circuit.

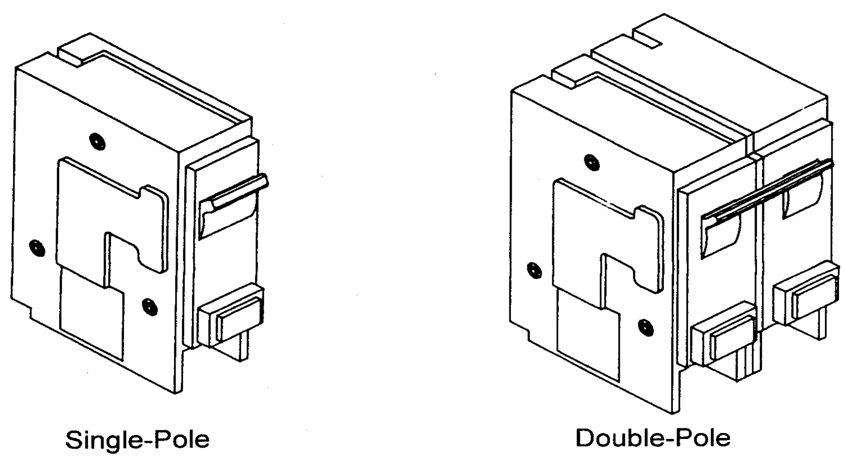
The amperage (current flow) in any wire is limited to the maximum permitted by using an over current device.

Two types of over current devices are in common use, circuit breakers and fuses, both rated in amperes.

Circuit Breakers: Looks something like an ordinary electric light switch, with a handle that may be used to turn power on or off. If a circuit overload, the mechanism inside the breaker trips the switch and breaks the circuit. The circuit breaker may be reset by simply flipping the switch.

A circuit breaker is capable of taking harmless short-period overloads (such as the heavy initial current required in the starting of a motor, for a washing machine or air conditioner) without tripping but protected against prolonged overloads.

After the cause of trouble has been located and corrected, the power is easily restored by flipping the circuit breaker



Fuse-Type Panel Boxes: are generally found in older homes. They are equally safe, and in fact, open faster than a circuit breaker of equivalent capacity, provided fuses of the proper size are used, and that substitutes (such as a penny) are not used.

Fuses are designed to protect circuits against the dangers of overloading and short circuits, and do this in two ways:

When a fuse is blown by a short circuit, the metal strip is instantly heated to an extremely high temperature, and this heat causes it to vaporize. A fuse blown by a short circuit may be easily recognized because the window of the fuse usually becomes discolored.

In a fuse blown by overload, the metal strip is melted at its weakest point, and this breaks the flow of current to the load. In this case the window of the fuse remains clear; therefore, a blown fuse caused by an overload may also be easily recognized.

Sometimes, although a fuse has not been blown, the bottom of the fuse mat be severely discolored and pitted. This indicates a loose connection due to the fuses not being screwed in properly.

There are several types of fuses:

All ordinary plug fuses have the same diameter and physical appearance regardless of their current capacity. Thus, if a circuit designed for a 15 ampere fuse is overloaded so that the 15 ampere fuse blows out, nothing will prevent a person from replacing the 15 ampere fuse with a 20 or 30 ampere fuse, which may not blow out. If a circuit wired with No. 14 wire (current capacity 15 amperes) is fused with 20 or 30 ampere fuse and an overload could pass through the circuit. The result would be overheating of the wire and a potential fire.

Type S fuses, nontamperable fuses have different lengths and diameter threads for each different amperage capacity. An adapter is first inserted into the ordinary fuse holder, which adapts the fuse holder for only one capacity fuse. Once the adapter is inserted, it cannot be emoved.

A cartridge fuse protects an electric circuit in the same manner as an ordinary fuse. Cartridge fuses are often used as main fuses.