Level 1

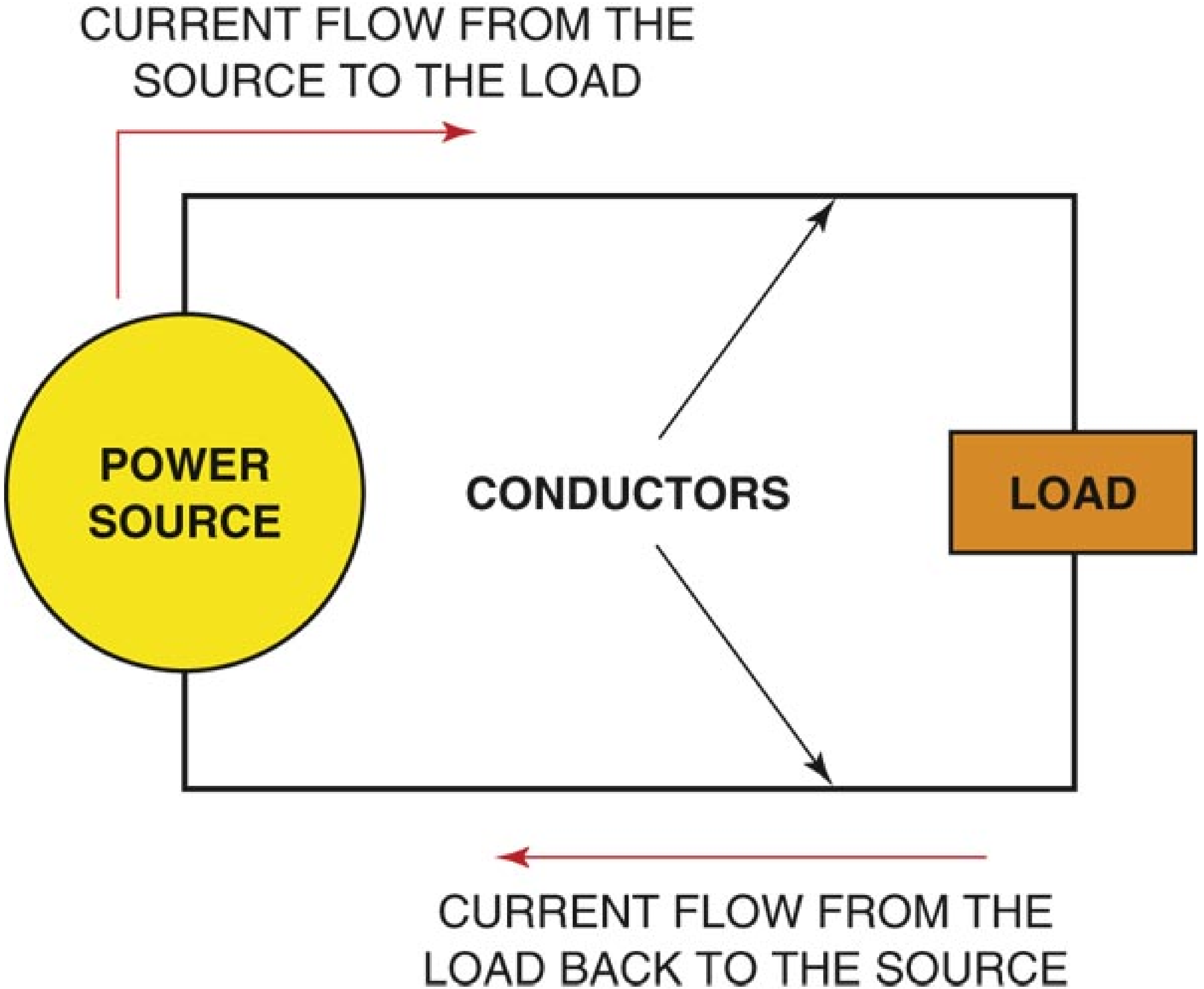
ELECTRIC

HYDRAULICS

PNEUMATICS

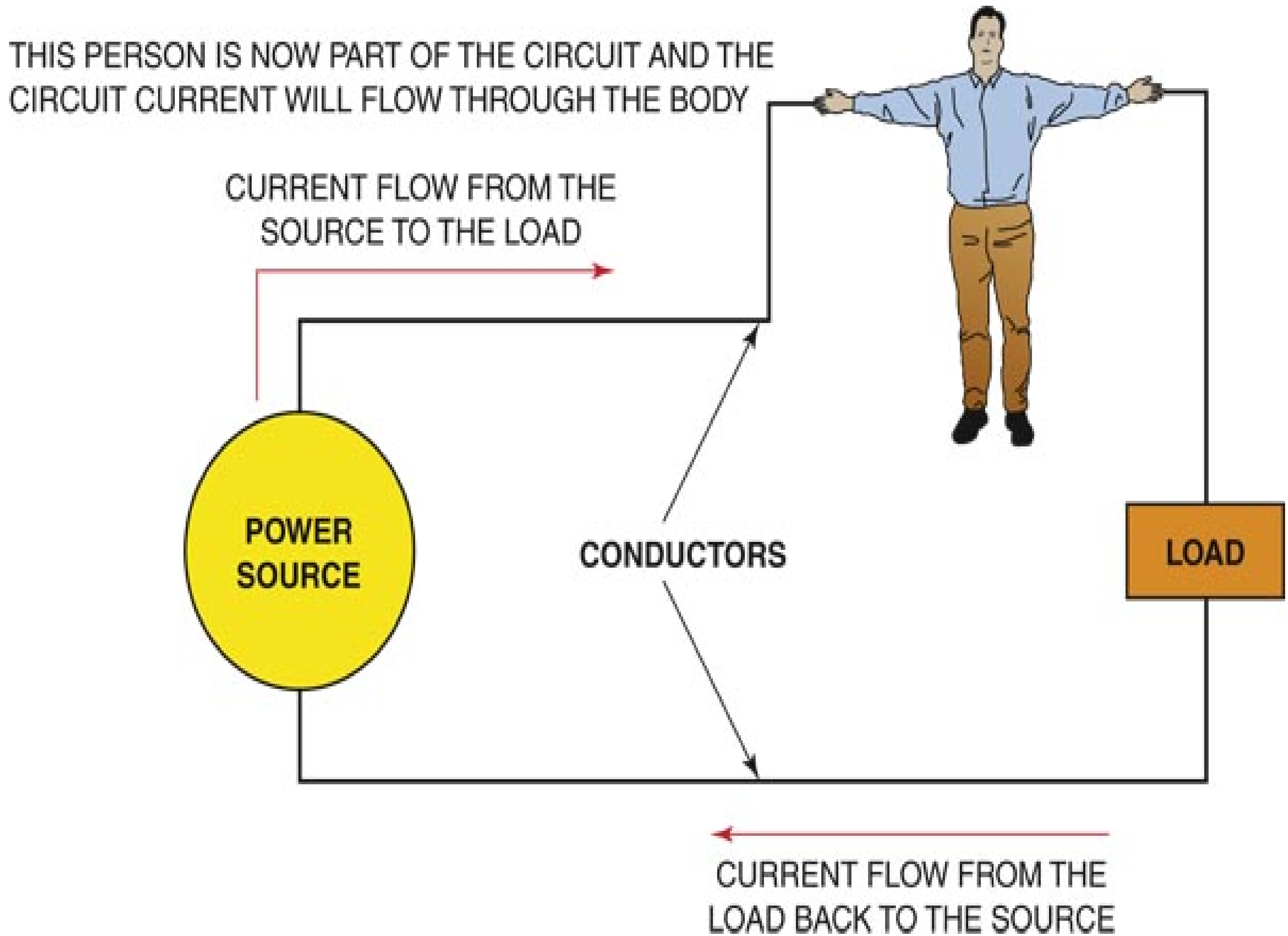
ELECTRICAL SAFETY

- Physiological effects of electricity
- Most of us have experienced some form of electric "shock," where electricity causes our body to experience pain or trauma. If we are fortunate, the extent of that experience is limited to tingles or jolts of pain from static electricity buildup discharging through our bodies. When we are working around electric circuits capable of delivering high power to loads, electric shock becomes a much more serious issue, and pain is the least significant result of shock.


CURRENT FLOW FROM THE SOURCE TO THE LOAD
POWER SOURCE
CONDUCTORS
LOAD
CURRENT FLOW FROM THE LOAD BACK TO THE SOURCE

Shock current path

As we've already learned, electricity requires a complete path (circuit) to continuously flow. This is why the shock received from static electricity is only a momentary jolt: the flow of electrons is necessarily brief when static charges are equalized between two objects. Shocks of self-limited duration like this are rarely hazardous.


THIS PERSON IS NOW PART OF THE CIRCUIT AND THE CIRCUIT CURRENT WILL FLOW THROUGH THE BODY
CURRENT FLOW FROM THE SOURCE TO THE LOAD
POWER SOURCE
CONDUCTORS
LOAD
CURRENT FLOW FROM THE LOAD BACK TO THE SOURCE

Lockout / Tagout (LOTO)

- *Refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities.*

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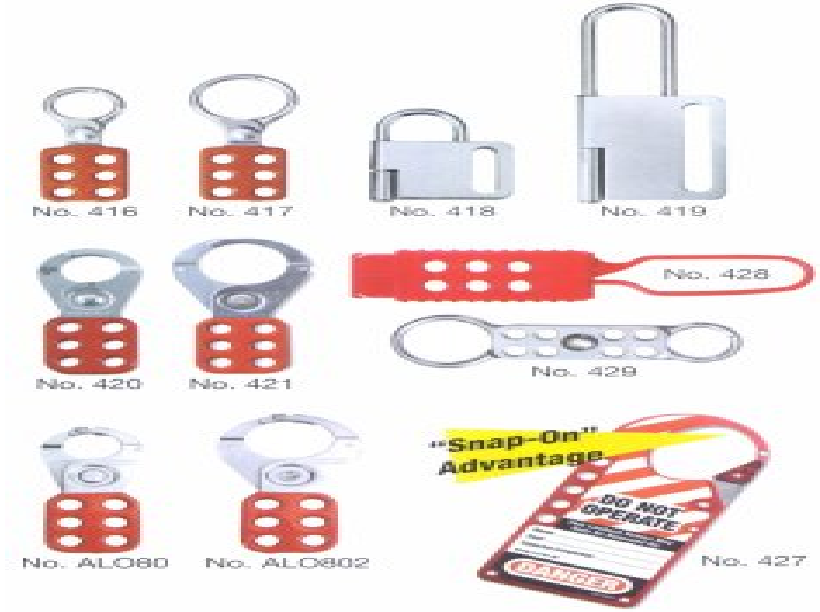
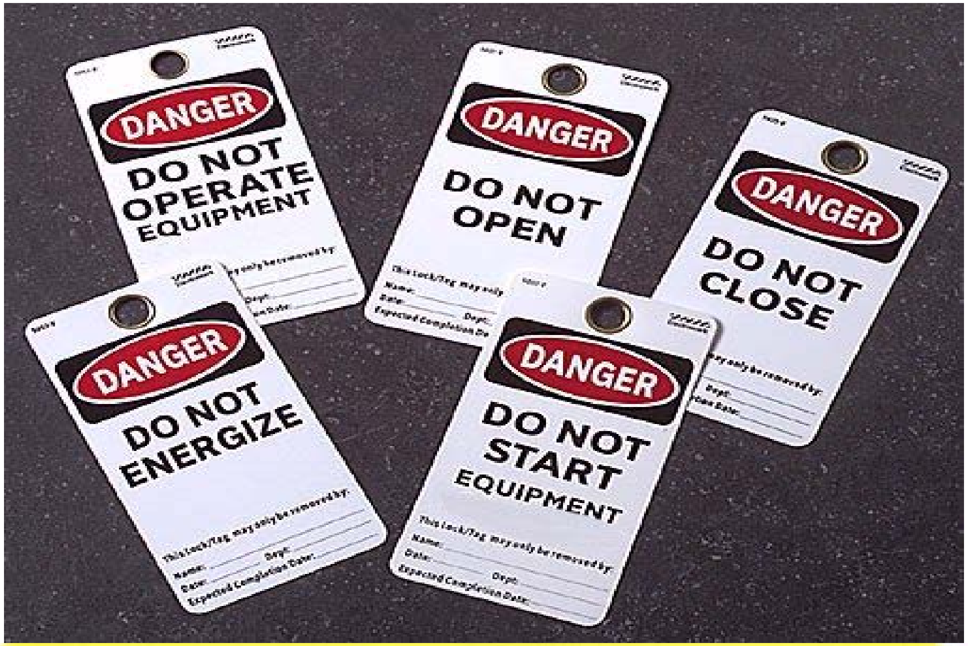



DANGER
DO NOT OPERATE EQUIPMENT
DANGER
DO NOT OPEN
DANGER
DO NOT CLOSE
DANGER
DO NOT ENERGIZE
DANGER
DO NOT START EQUIPMENT


PP10
400
THIS TAG & LOCK TO BE REMOVED ONLY BY PERSON SHOWN ON THE OTHER SIDE


LOCK OUT
CAUTION
LOCK OUT
THIS MACHINE MUST BE LOCKED OUT BEFORE DOING MAINTENANCE.
ALL SOURCES OF ENERGY MUST BE LOCKED IN THE "OFF" OR "SAFE" POSITION. DE-ENERGIZE OR BLOCK ALL STORED ENERGY.

).

OSHA

- Section 5(a)(1) of the OSH Act, often referred to as the General Duty Clause, requires employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees".
- Section 5(a)(2) requires employers to "comply with occupational safety and health standards promulgated under this Act".


CIRCUIT OK
GREENLEE
Voltage Detector
Wiggy
DC Volts
0
120
240
277
600
0
120
240
277
480
600
AC Volts
Solenoid Voltage Tester
MAXIMUM TEST TIME IS 15 SECONDS "ON" OPERATION VOLTAGE 100-600 VAC, VDC
Voltage Tester
DC
AC
Vol-Con
0.01
GREENLEE TEST INSTRUMENTS
AC Clamp Meter

(B)

Service Drop

The lines that bring power from the telephone pole to your house are called service drops. They're connected to the main electrical panel of your house by the power company and they're also maintained by them.

Service Entrance

The service entrance comprises all the equipment through which the utility brings electricity into your home. This includes the mast on your roof where the utility makes the wire connections, the electric meter and an external disconnect switch if one is required.

Measuring Electricity

Voltage

is the pressure that pushes electricity across a conductor. In the United States, most utilities serve residences with two lines at 125 volts each, which can provide up to 250 volts if used together. Common terminology may call this 110 volts or 120 volts.

Amperes

are how much electricity is flowing. The more amperes that flow, the thicker the wire needed to carry it. Wire is measured by gauge and National Electric Code specifies wire thickness for specific amounts of current.

Service Panel

The service panel goes by many names, including circuit breaker box, breaker box, circuit panel and fuse box. The main service panel holds the main circuit breaker and the circuit breakers for branch circuits. It may also serve other panels, called sub panels, that also distribute power to branch circuits.

Branch Circuits

A branch circuit begins at a circuit breaker in a service panel. The branch circuit may supply a single outlet, a permanently wired appliance or multiple outlets. The most common branch circuit has all the outlets for a room including the lighting outlet.

Outlets

An outlet refers to any point where electricity becomes accessible to the homeowner. Receptacles are often referred to as outlets. Other outlets include light fixtures for recessed and non-recessed lighting, wall sconces and dryer and range receptacles. Any light fixture is considered a single outlet even though it may have multiple light bulbs.

Sheathed Cable

Ninety five percent of all homes in the United States have sheathed cable wiring. This is often referred to by the trade name ROMEX®, a company that manufactures one brand of sheathed cable.

A plastic or metal sheath contains two or more current-carrying conductors in addition to a ground wire. Number and letter codes on the cable define the wires inside and the application.

Hot Wire

The hot wire in a circuit carries current from the service panel to the outlet. If a circuit is controlled by a switch, the switch must be on the hot wire. The hot wire in house wiring is usually black or any other color wire except white, gray or green.

Grounded Conductor

The grounded conductor is often mistakenly called the neutral wire. Every 125-volt branch circuit requires a grounded conductor. The grounded conductor carries current back to the service panel after it has been used by an appliance. At the main service panel, the grounded conductor connects to earth ground. Grounded conductors must be white or natural gray.

Ground Wires

Don't confuse ground wires with grounded conductors. A ground wire attaches to anything that might conduct electricity but is not supposed to. The sheet metal of an electric dryer is a good example. If the hot wire accidentally came loose and touched the metal exterior, someone touching the dryer could receive a shock. A ground wire provides a safe path to ground in the event the hot wire touches something it should not. Ground wires are bare or have green insulation.

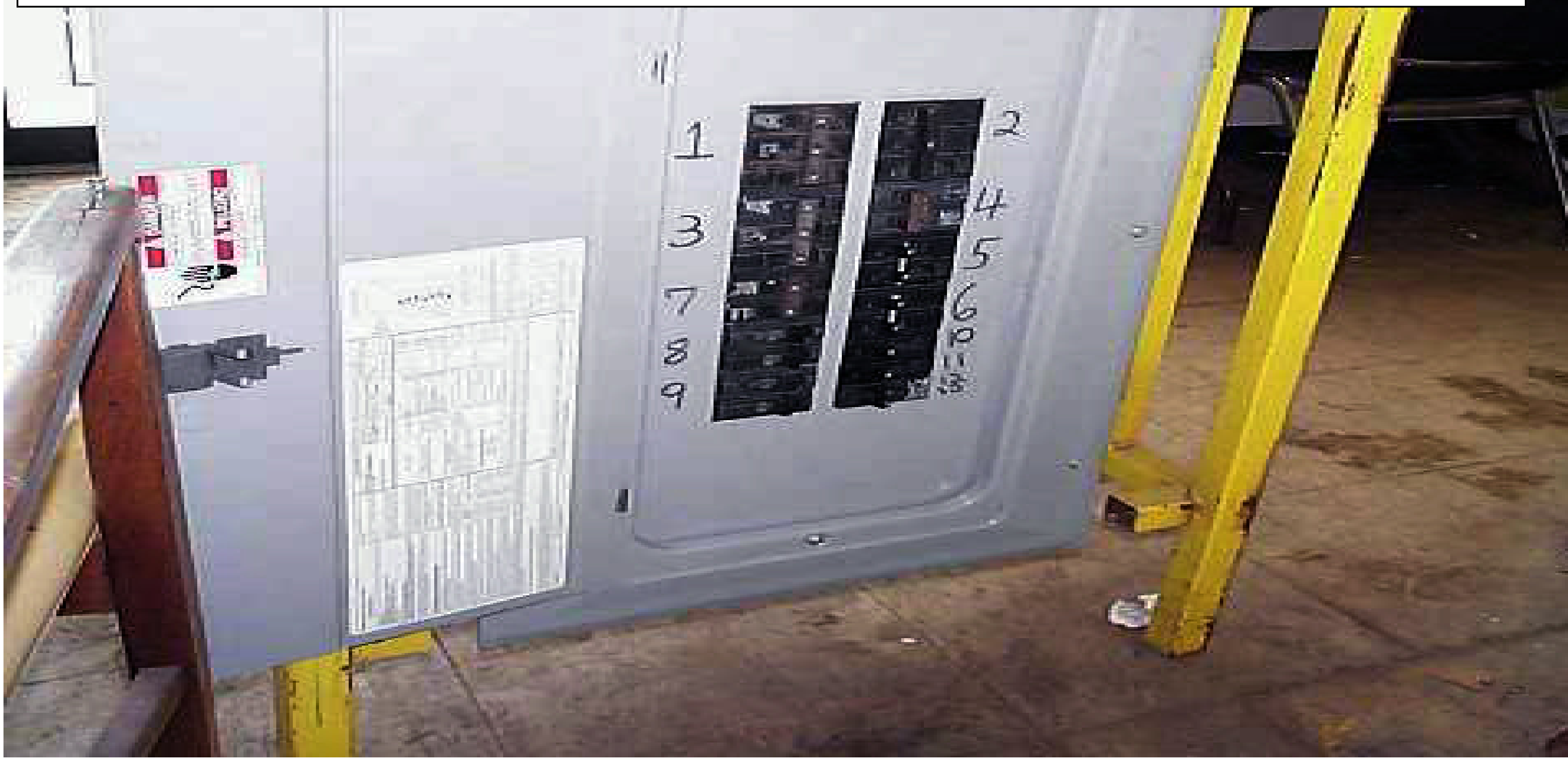
Neutral Wire

A true neutral wire only exists on the line that runs between the electric utility transformer and the service entrance or on branch circuits that use a combination of 125 volts and 250 volts. The neutral wire carries the difference between the two hot wires in these circuits.

Circuit Breaker

This switching mechanism can be turned on or off manually to cut power to the circuit it controls and it trips automatically to turn off power when it detects excessive current on its circuit. Since circuit breakers can only protect a circuit they're rated for, a 15A (Amp) circuit breaker will only prevent a 15A circuit from burning out.

Section 525-16 states that overcurrent protection of equipment and conductors shall be provided in accordance with Article 240. Tents and concession stands that are fed by circuit to which cords or cables are connected must have overcurrent protection that protects the cord or cable as well as equipment in the tent or concession stand. There must be overcurrent protection in the tent or concession. Section 525-30 entitled “Type and Location,” states that “Each ride and concession shall be provided with a fused disconnect switch or circuit breaker located within sight and within 6 ft of the operator’s station.”



Branch Circuit

The electrical wires between the circuit breakers in your main electrical panel and the outlets in your walls are called branch circuits. These outlets also include the lighting receptacles in your ceiling and your major appliance connections.

PLUG

A male electrical connector that's attached to the insulated wires of an electrical device is called a plug. When this male connector is inserted into a wall receptacle's female connector, electricity flows to the device.

Receptacle

A wall plate with female connectors that's tied in to the branch circuit in your home is called a receptacle. When a plug is inserted into this receptacle, electricity flows from the branch circuit to the device the plug connects to.

Line

The wires that bring electricity to a device (incoming) are line wires and the terminals these wires connect to are line terminals. Line voltage is the electrical potential across these wires.

Load

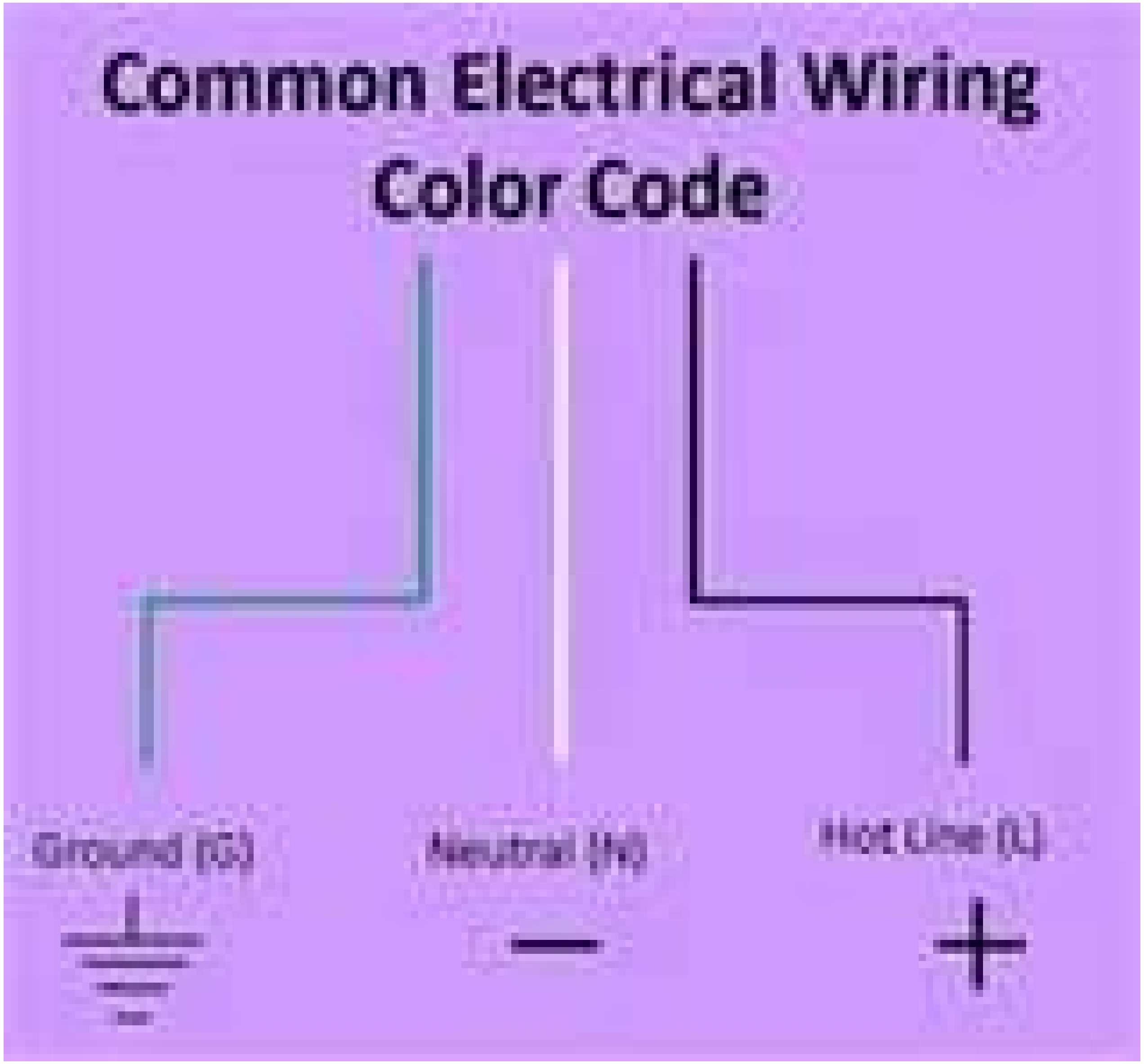
The wires that take electricity from a device (outgoing) are load wires and the terminals these wires connect to are load terminals. A load is also the power consumed by a device when it converts electrical energy to something else (i.e. light, sound, etc.).

Parallel Circuit

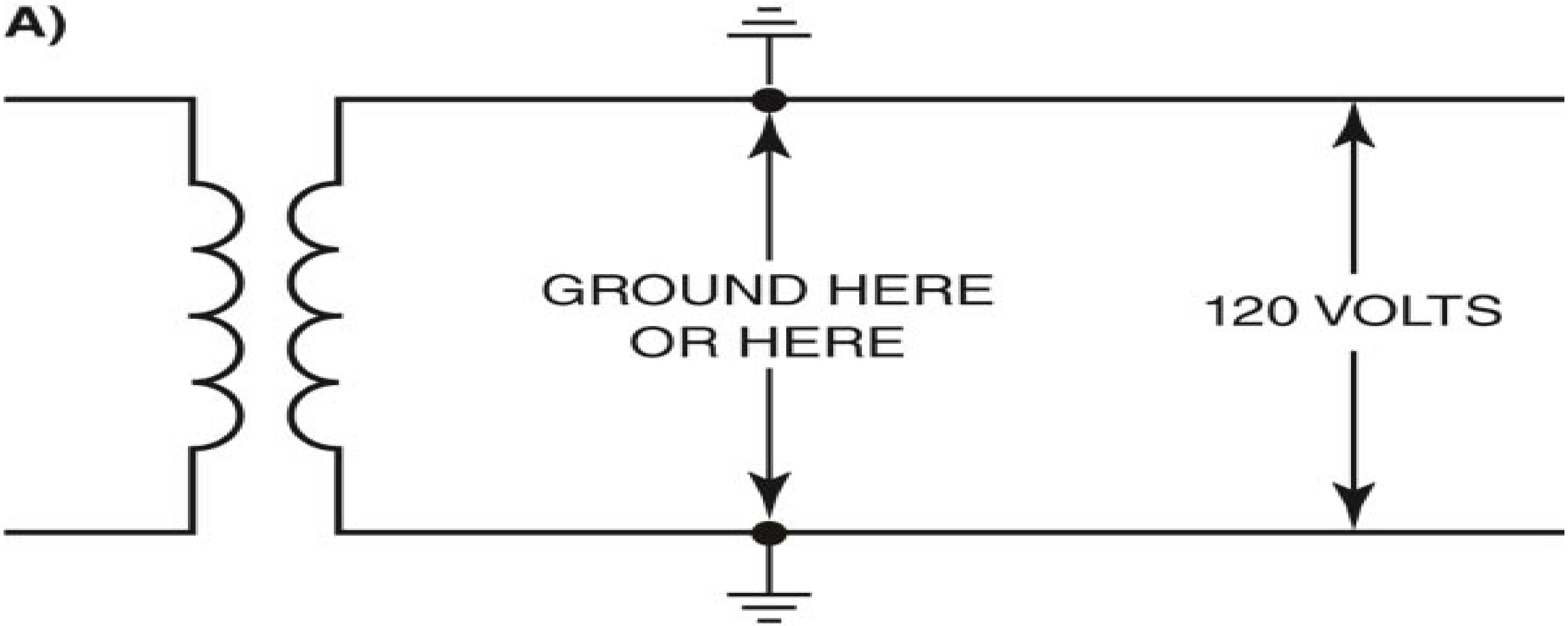
A circuit where electrical current divides and follows several paths is a parallel circuit. Since the voltage (electrical potential) across all the loads in this circuit is the same, you can remove a load (i.e. light bulb) without affecting the others.

Series Circuit

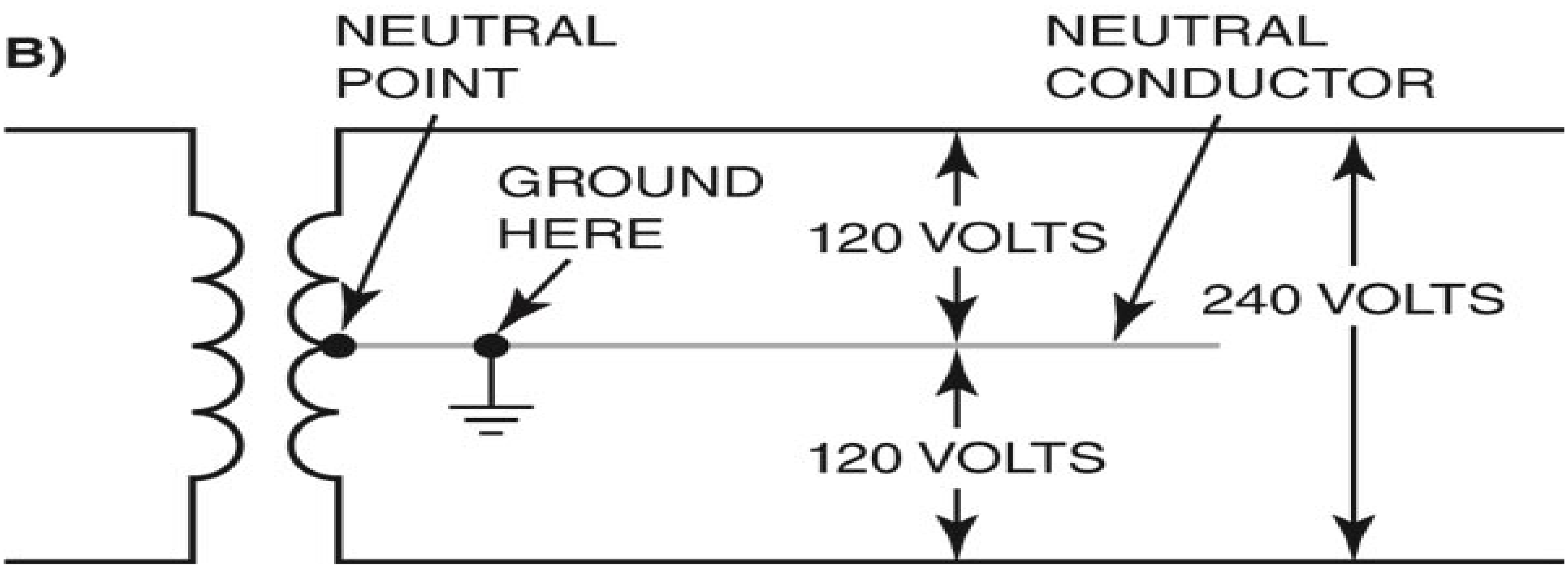
A circuit where electrical current follows one path is a series circuit. Since this current passes through each load to get to the next, if you remove any of the loads you'll create a gap in the circuit and current flow will stop (an open circuit). Christmas tree lights are often wired in series and that's why all the lights go off when one burns out.


Common Electrical Wiring
Color Code
Ground (G)
Neutral (N)
Hot Line (L)

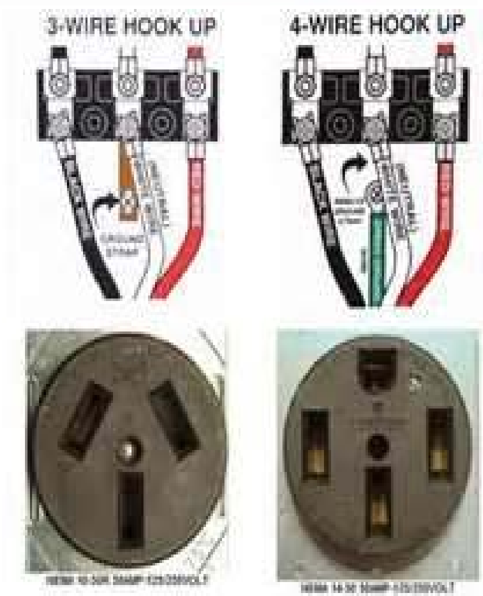
A)

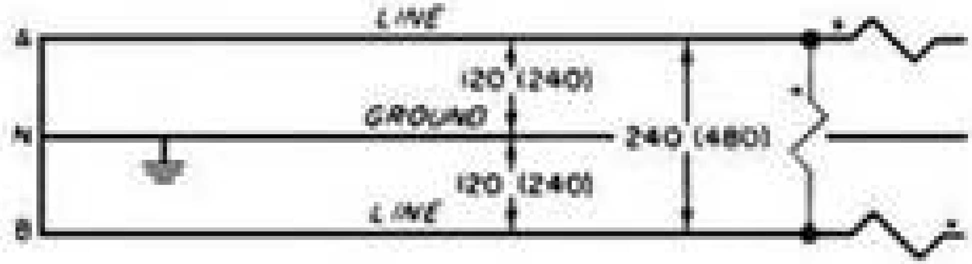

GROUND HERE
OR HERE
120 VOLTS

B)

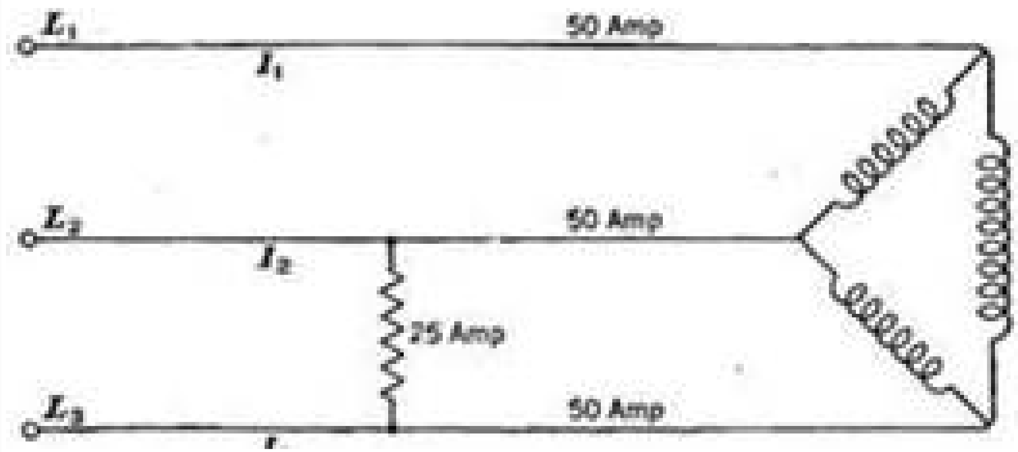

NEUTRAL
POINT
GROUND
HERE
NEUTRAL
CONDUCTOR
120 VOLTS
240 VOLTS
120 VOLTS

120 volts vs 220 volts usa. 3 phase





THREE WIRE



Us vs euro wiring

	»	120	240	3 phase
• Neutral	COPPER/BARE			
• Ground	GREEN			
• Hot		BLACK		
• Hot			RED	
• Hot				BLUE

USA

- Neutral BLUE
- Ground GREEN/YELLOW
- Hot BROWN
- Hot BLACK
- Hot RED

EURO

	L1	L2	L3	Neutral	Ground / Protective Earth
United States [illegible]	Black	Red	Blue	Gray or white	Green, Green/yellow striped or a bare copper wire
United States [illegible]	Brown	Orange (Delta) or Violet (Wye)	Yellow	Gray or white	Green
Canada (mandatory)[3]	Red	Black	Blue	white	Green (or bare copper)
Canada (isolated three-phase installations)[3]	Orange	Brown	Yellow	white	Green
European Union, and all countries who use European CENELEC standards April 2004 (IEC 60446), Hong Kong from July 2007	Brown	Black	Grey	Blue	Green / yellow striped4
Older European (IEC 60446, varies by country[4])	Black or brown	Black or brown	Black or brown	Blue	Green/yellow striped5
UK until April 2006, Hong Kong until April 2009, South Africa, Malaysia	Red	Yellow	Blue	Black	Green/yellow striped (green on installations approx. before 1970)
Pakistan	Red	Yellow	Blue	Black	Green
India	Red	Yellow	Blue	Black	Green
Australia and New Zealand (per AS/NZS 3000:2000 Section 3.8.1)	Red3	white White3 (prev. yellow	Black	Black	Green/yellow striped (green on very old installations)
People's Republic of China (per GB50303-2002 Section 15.2.2)	Yellow	Green	Red	Light Blue	Green / yellow striped

N.A.A.R.S.O.

120 and 220 Volt; 60 Hertz (USA)

60 cycle vs 50 cycles

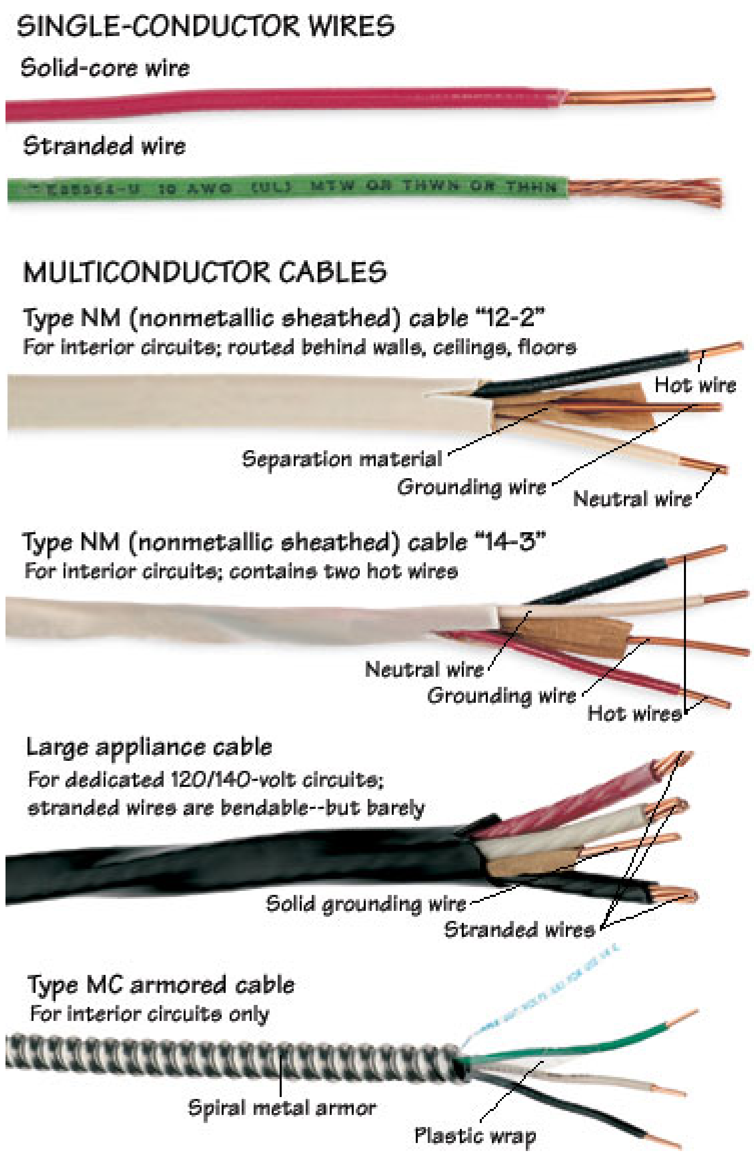
230 Volt; 50 Hertz (Europe & Asia)

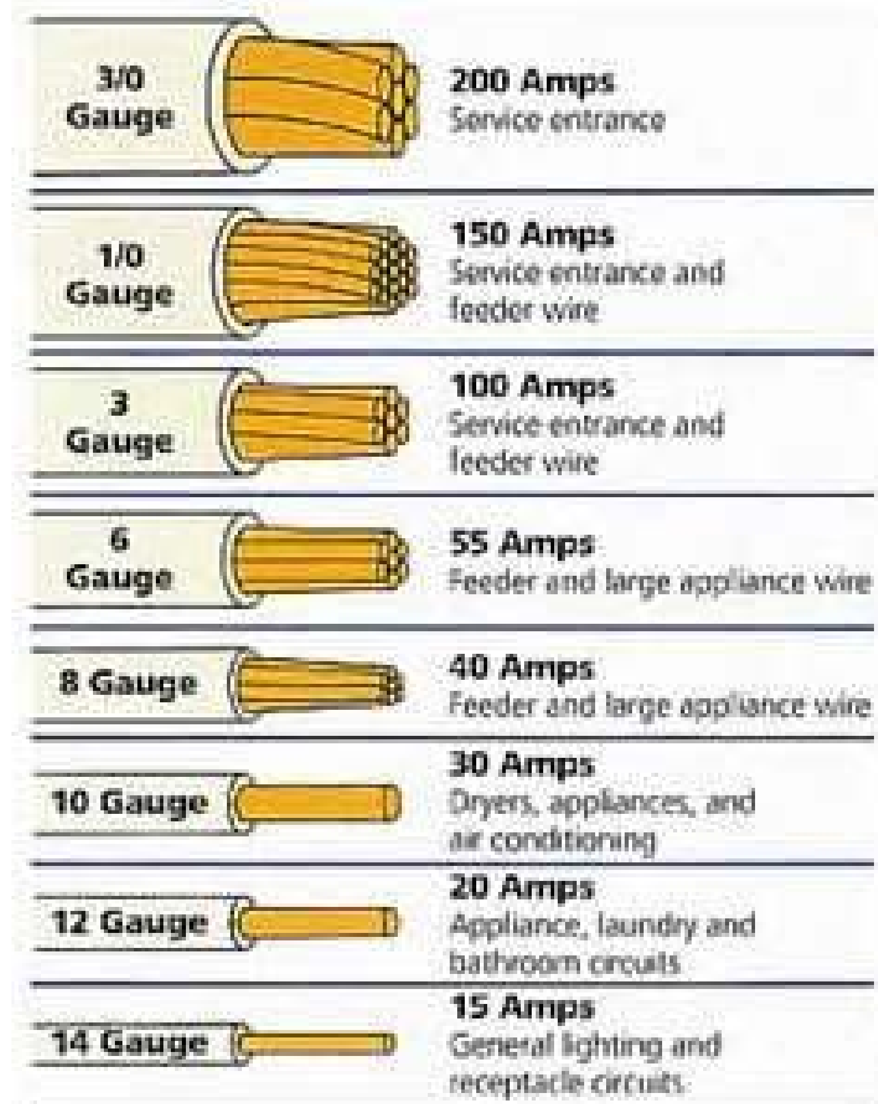
What is the difference between 50 and 60 Hertz for an electric cycle?

The difference between 50 and 60Hz is, well, 60Hz is 20% higher in frequency.
For a generator or motor (in simple terms) it means 1500/3000 RPM or 1800/3600 RPM (for 60Hz).

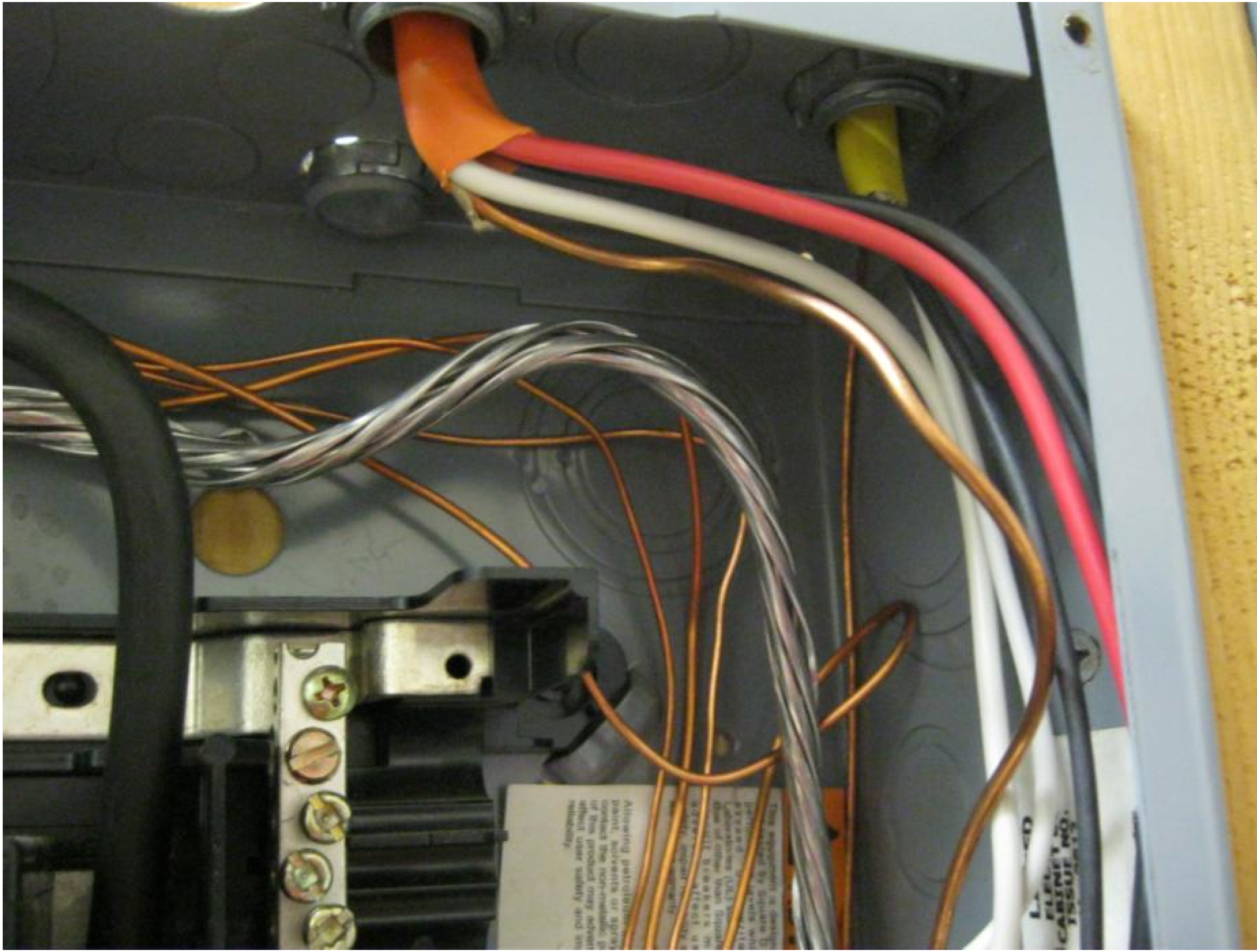
electricity our North American appliances use is delivered at 120VAC (volts alternating current) 60 Hz (60 cycles/second). When the electric current flows it rises from 0 volts to 120 volts back to 0 volts and then it falls to negative 120 volts and rises back to 0 volts. This rise and fall completes one cycle (1 Hz) and is called a "sine wave."

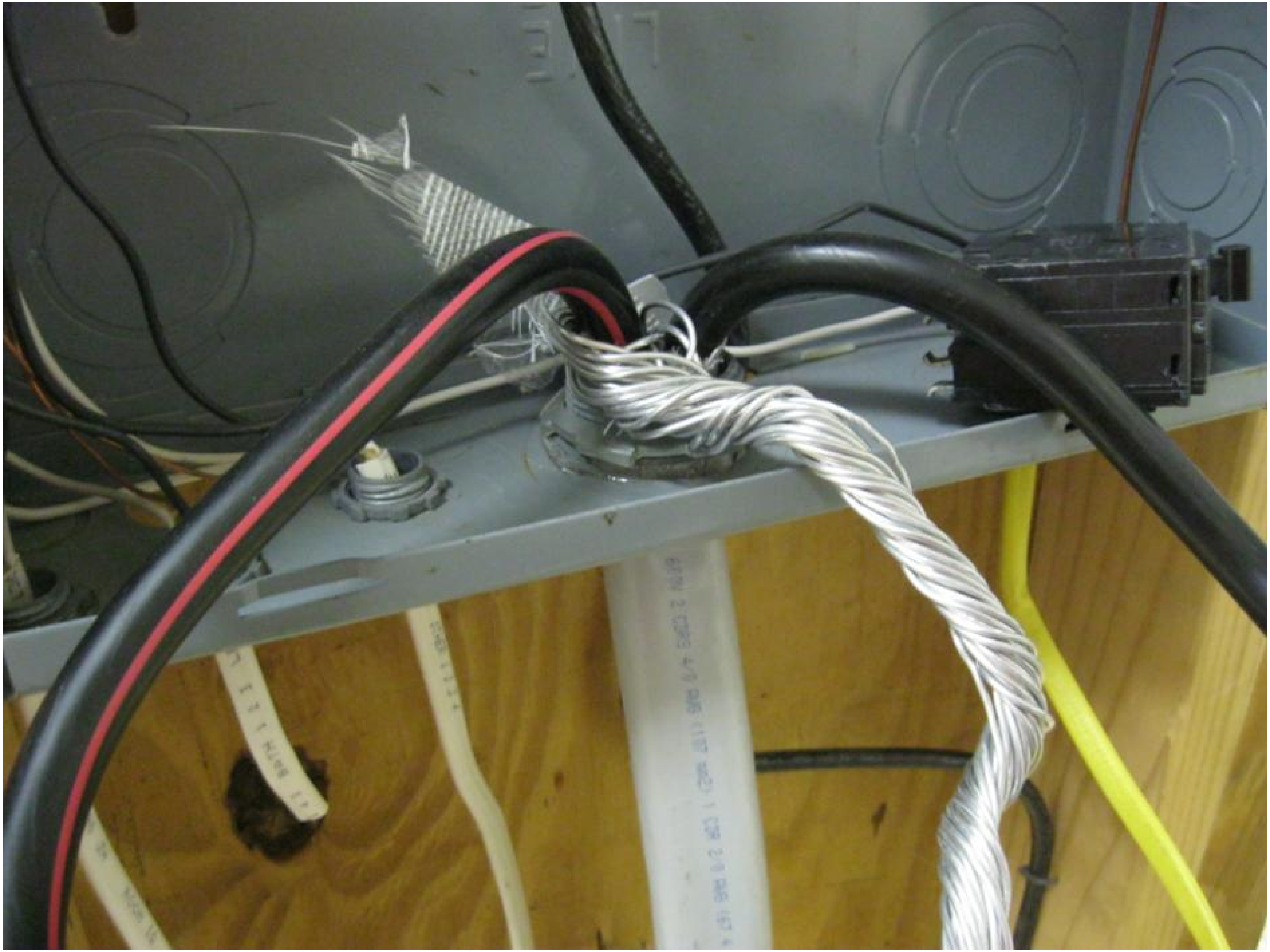
Cycles: 50 Hz vs. 60 Hz
North American 120 volt electricity is generated at 60 Hz Alternating Current (AC). Most foreign 220–240 volt electricity is generated at 50 Hz Alternating Current (AC). This difference in cycles may cause the motor in your 60 Hz North American appliance to operate slightly slower when used on 50 Hz foreign electricity.

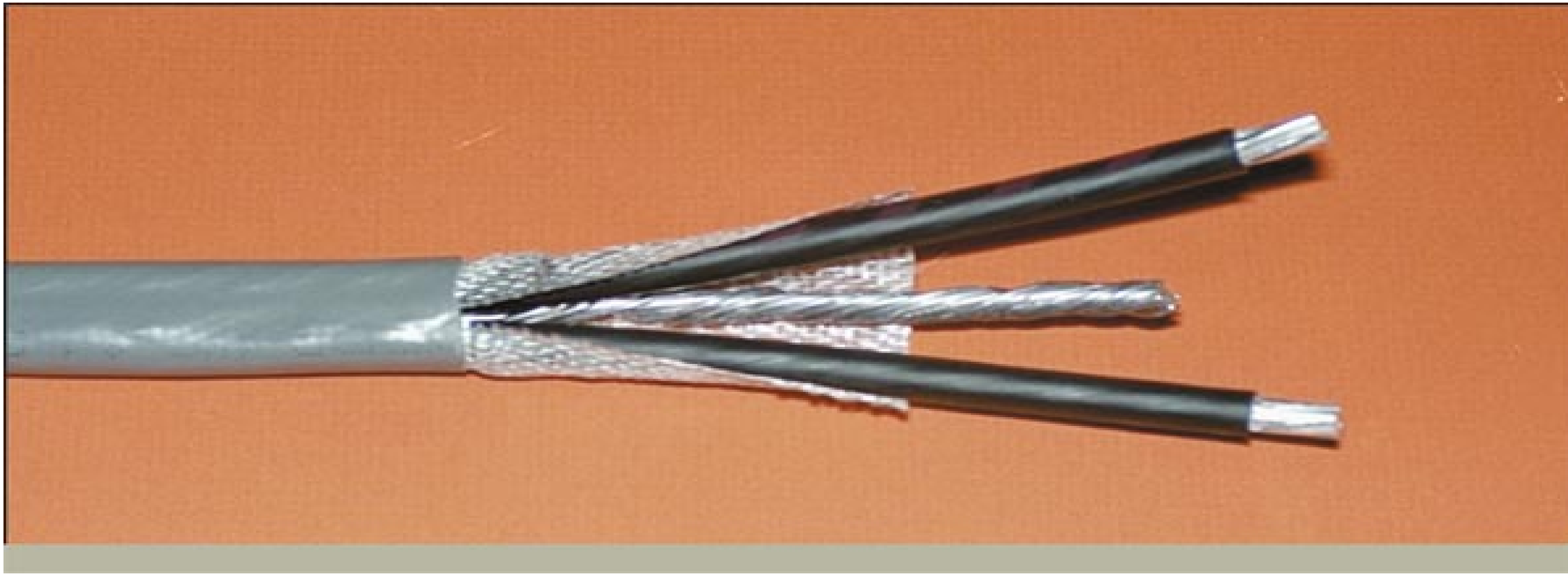

SINGLE-CONDUCTOR WIRES
Solid-core wire
Stranded wire
MULTICONDUCTOR CABLES
Type NM (nonmetallic sheathed) cable "12-2"
For interior circuits; routed behind walls, ceilings, floors
Hot wire
Separation material
Grounding wire
Neutral wire
Type NM (nonmetallic sheathed) cable "14-3"
For interior circuits; contains two hot wires
Neutral wire
Grounding wire
Hot wires
Large appliance cable
For dedicated 120/140-volt circuits; stranded wires are bendable--but barely
Solid grounding wire
Stranded wires
Type MC armored cable
For interior circuits only
Spiral metal armor
Plastic wrap

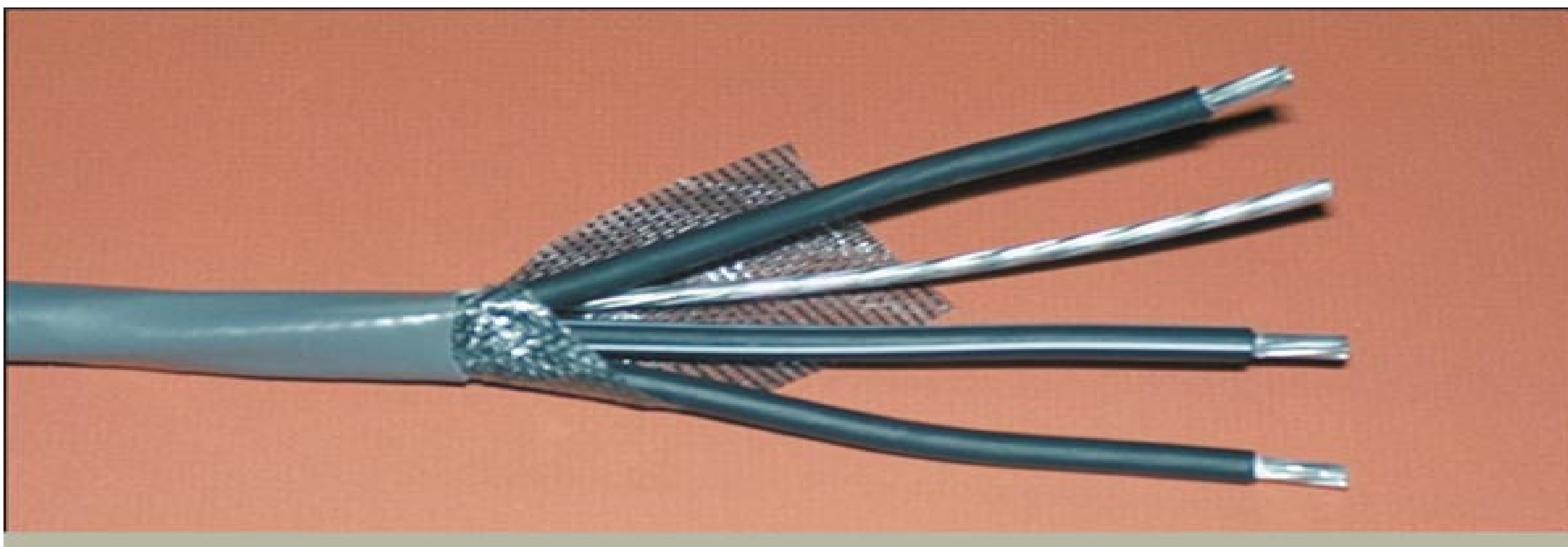

3/0 Gauge
200 Amps
Service entrance
1/0 Gauge
150 Amps
Service entrance and feeder wire
3 Gauge
100 Amps
Service entrance and feeder wire
6 Gauge
55 Amps
Feeder and large appliance wire
8 Gauge
40 Amps
Feeder and large appliance wire
10 Gauge
30 Amps
Dryers, appliances, and air conditioning
12 Gauge
20 Amps
Appliance, laundry and bathroom circuits
14 Gauge
15 Amps
General lighting and receptacle circuits

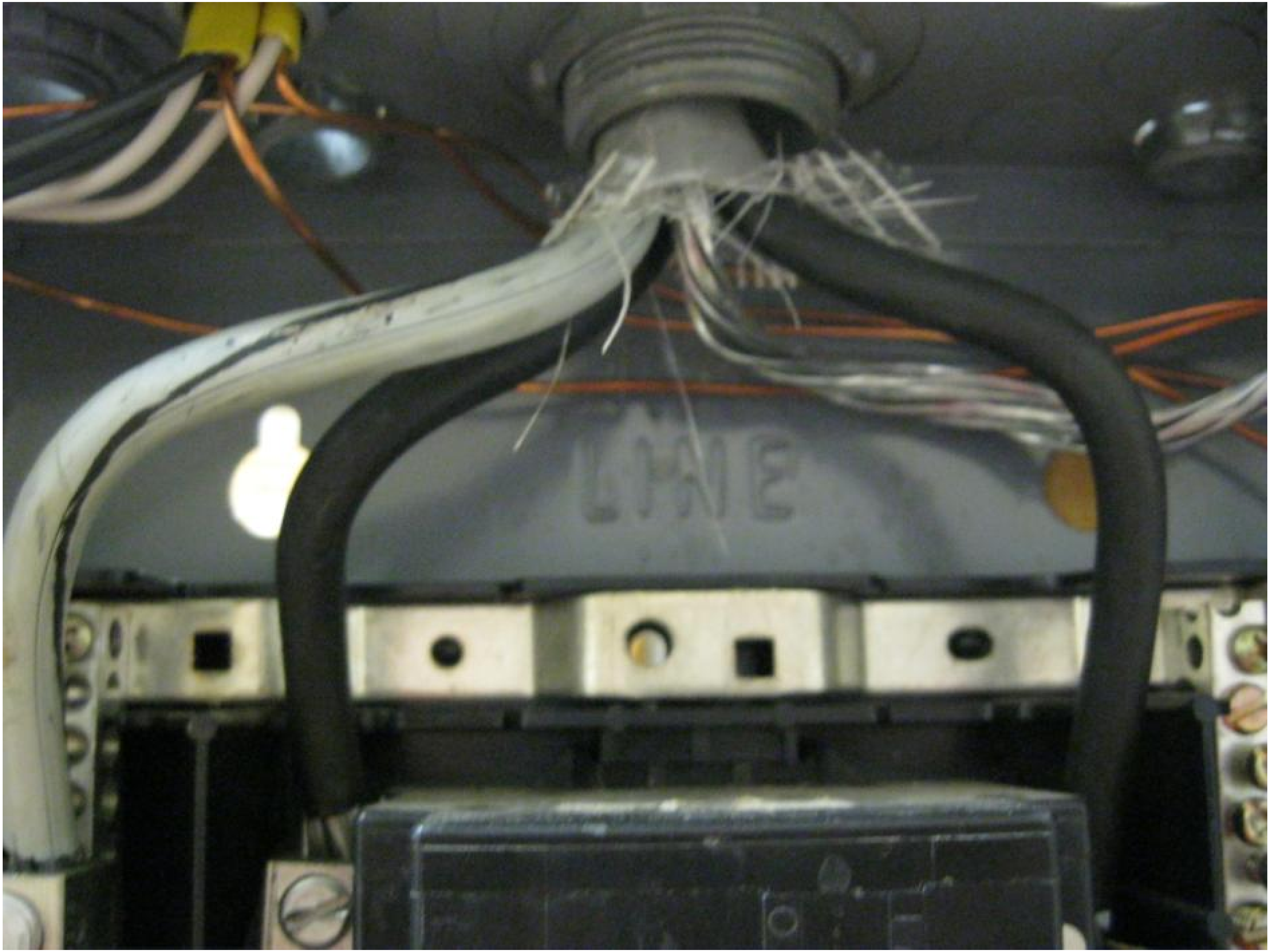

A
B
C










LINE

Examples of Table 400-5 (A)

1. A flexible cord is labeled 4/5 SJO. This indicates that there are a total of 5 conductors in the cable and the size of each conductor would be no. 4 AWG copper. In this cable there are 3 current carrying conductors, a neutral conductor, and equipment-grounding conductor. Using subheading "A" (3 or more conductor cords) of Table 400-5(A) and the no.4 AWG conductor size, the allowable ampacity would be 60 Amps.

2. A 6/4 SO flexible cord has 4 no.6 AWG conductors (2 current carrying, 1 neutral, 1equipment ground) using subheading "B" (2 conductor cords) the no. 6 AWG conductors size of

allowable ampacity would be 55 Amps.

4/5 sjo wire

Means

# of wires 5 wires

[conductors]

4 gauge size awg

[American wire gage]

Wiring Methods.

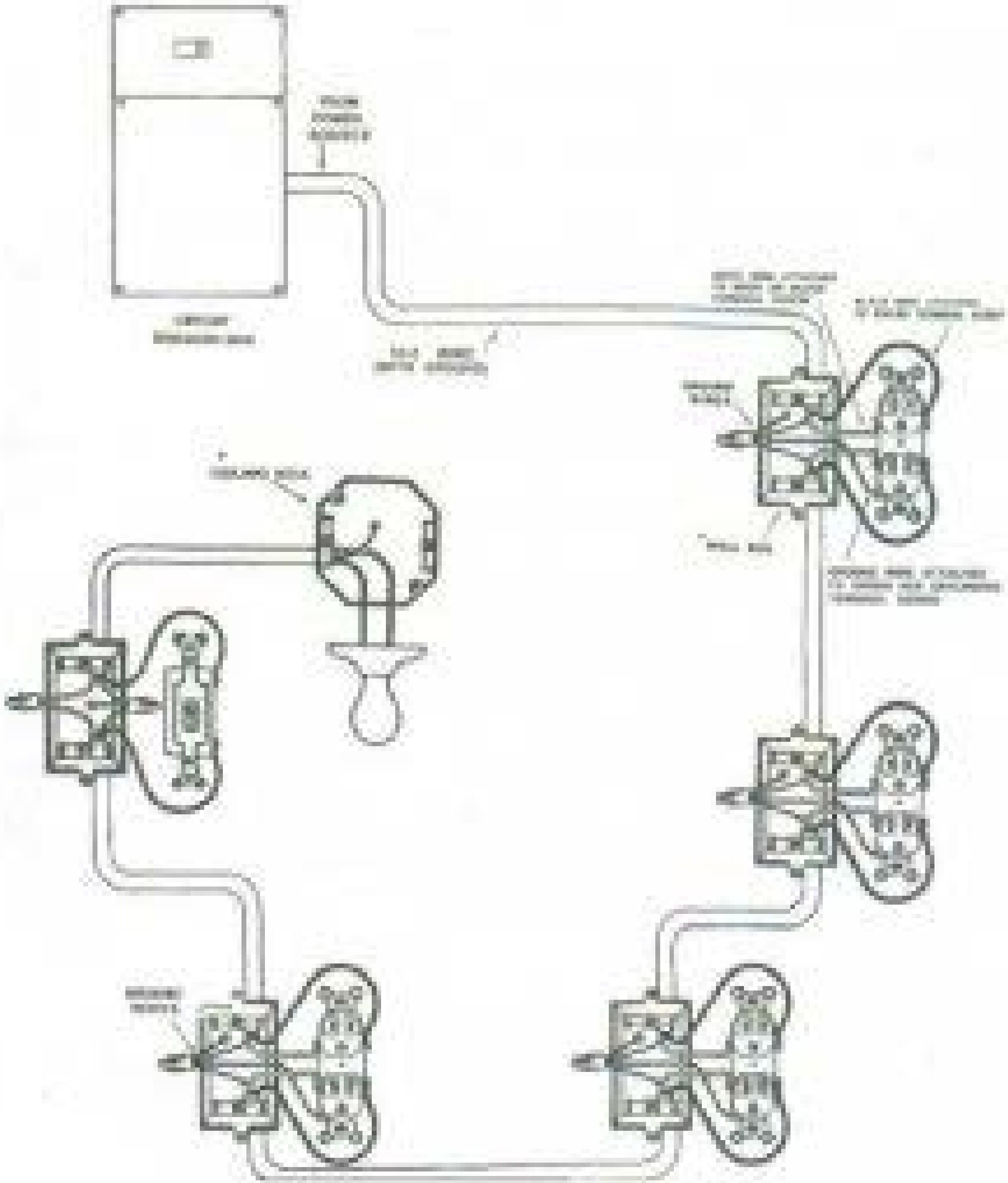
(A) Type. Where flexible cords or cables are used, they shall be listed for extra-hard usage. Where flexible cords or cables are used and are not subject to physical damage, they shall be permitted to be listed for hard usage. Where used outdoors, flexible cords and cables shall also be listed for wet locations and shall be sunlight resistant. Extra-hard usage flexible cords or cables shall be permitted for use as permanent wiring on portable amusement rides and attractions where not subject to physical damage.

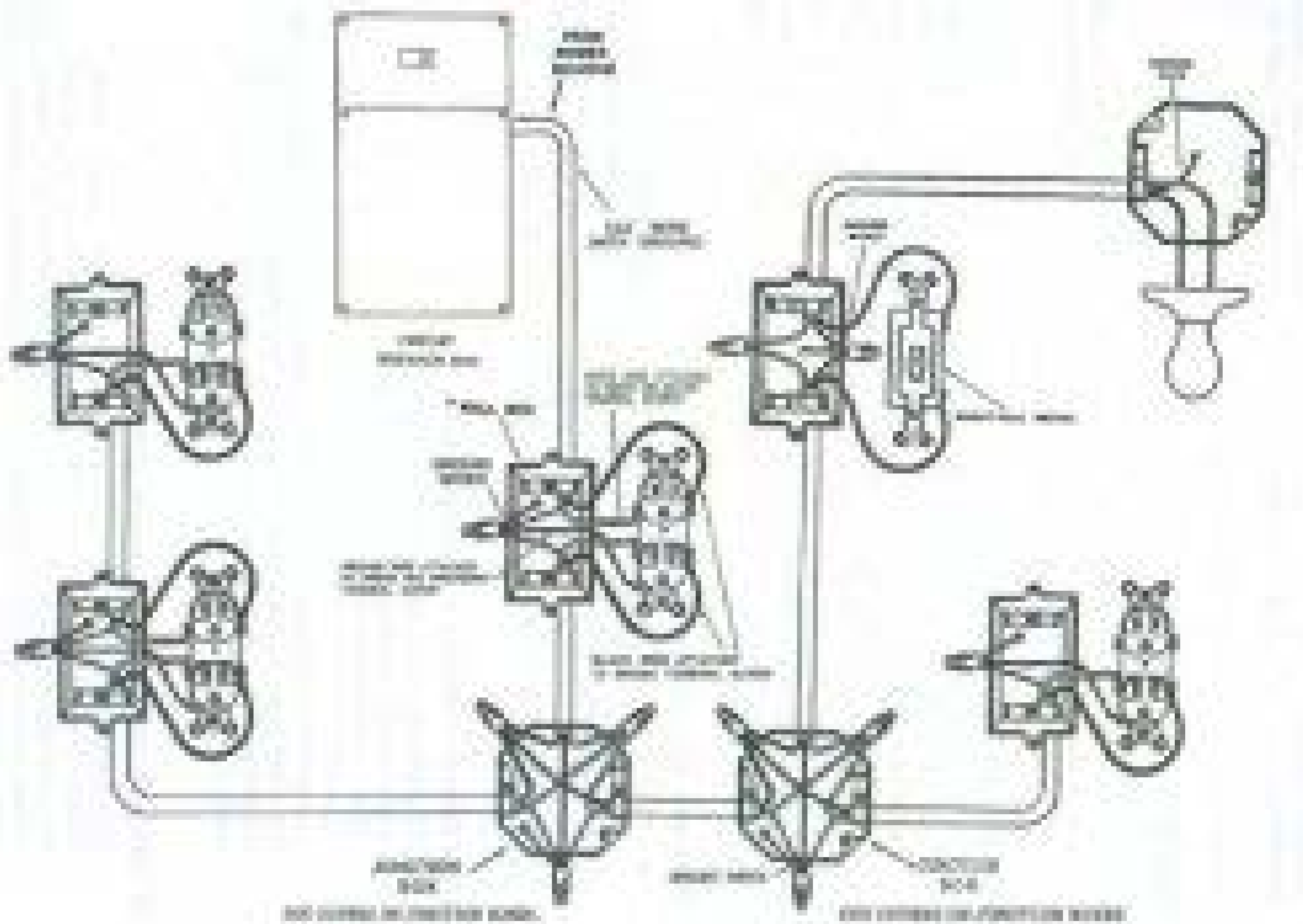
(B) Single-Conductor. Single-conductor cable shall be permitted only in sizes 2 AWG or larger.

(C) Open Conductors. Open conductors are prohibited except as part of a listed assembly or festoon lighting installed in accordance with Article 225.

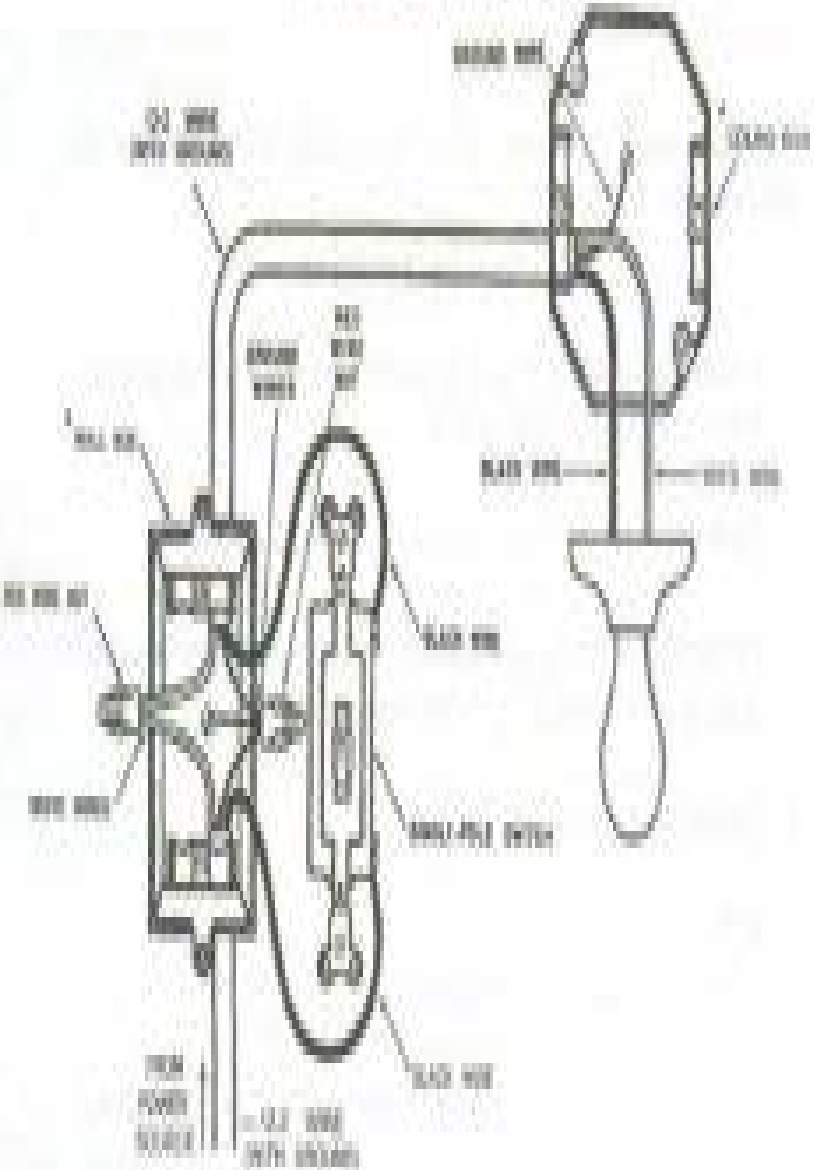
(D) Splices. Flexible cords or cables shall be continuous without splice or tap between boxes or fittings.

(E) Cord Connectors. Cord connectors shall not be laid on the ground unless listed for wet locations. Connectors and cable connections shall not be placed in audience traffic paths or within areas accessible to the public unless guarded.



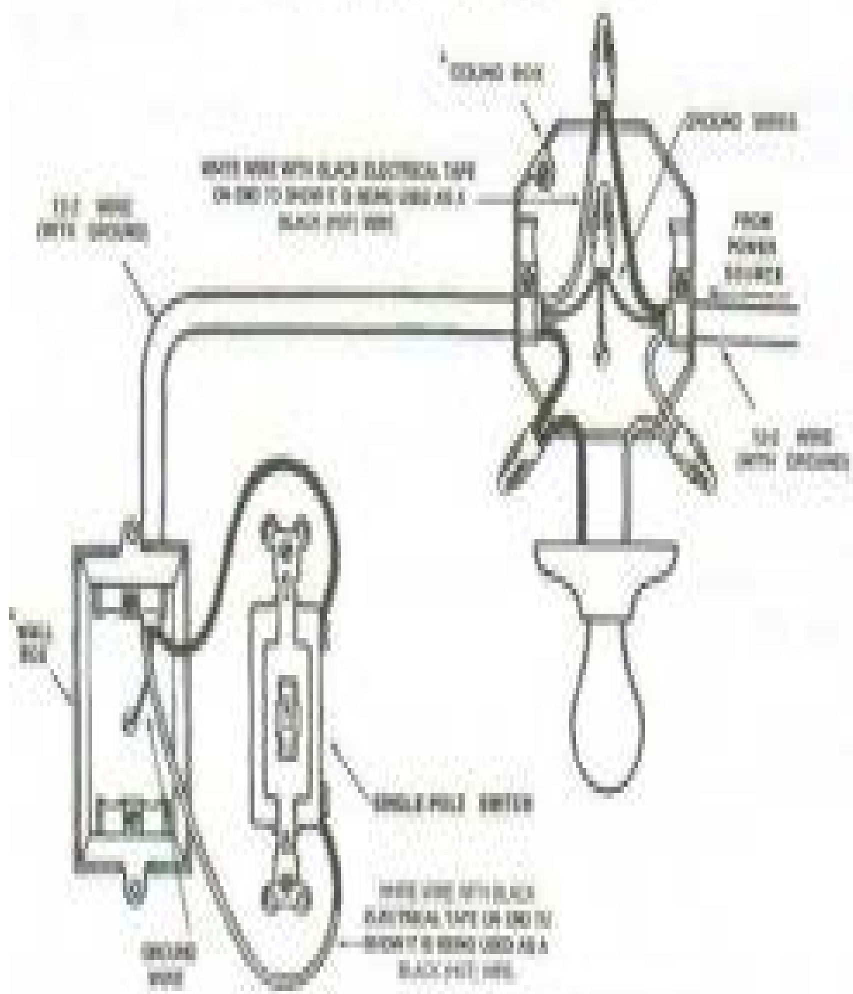


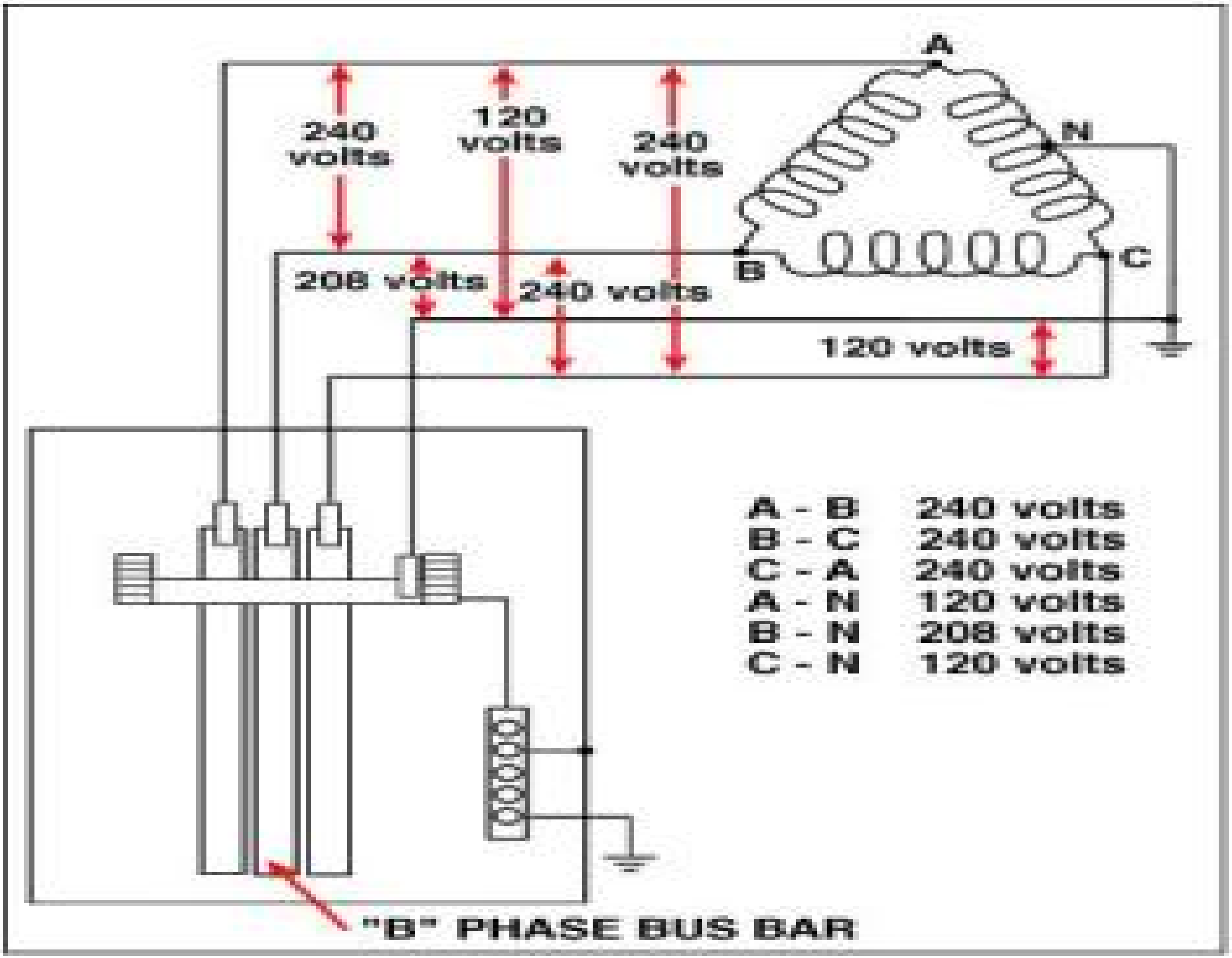
With Switch Controlling One Light

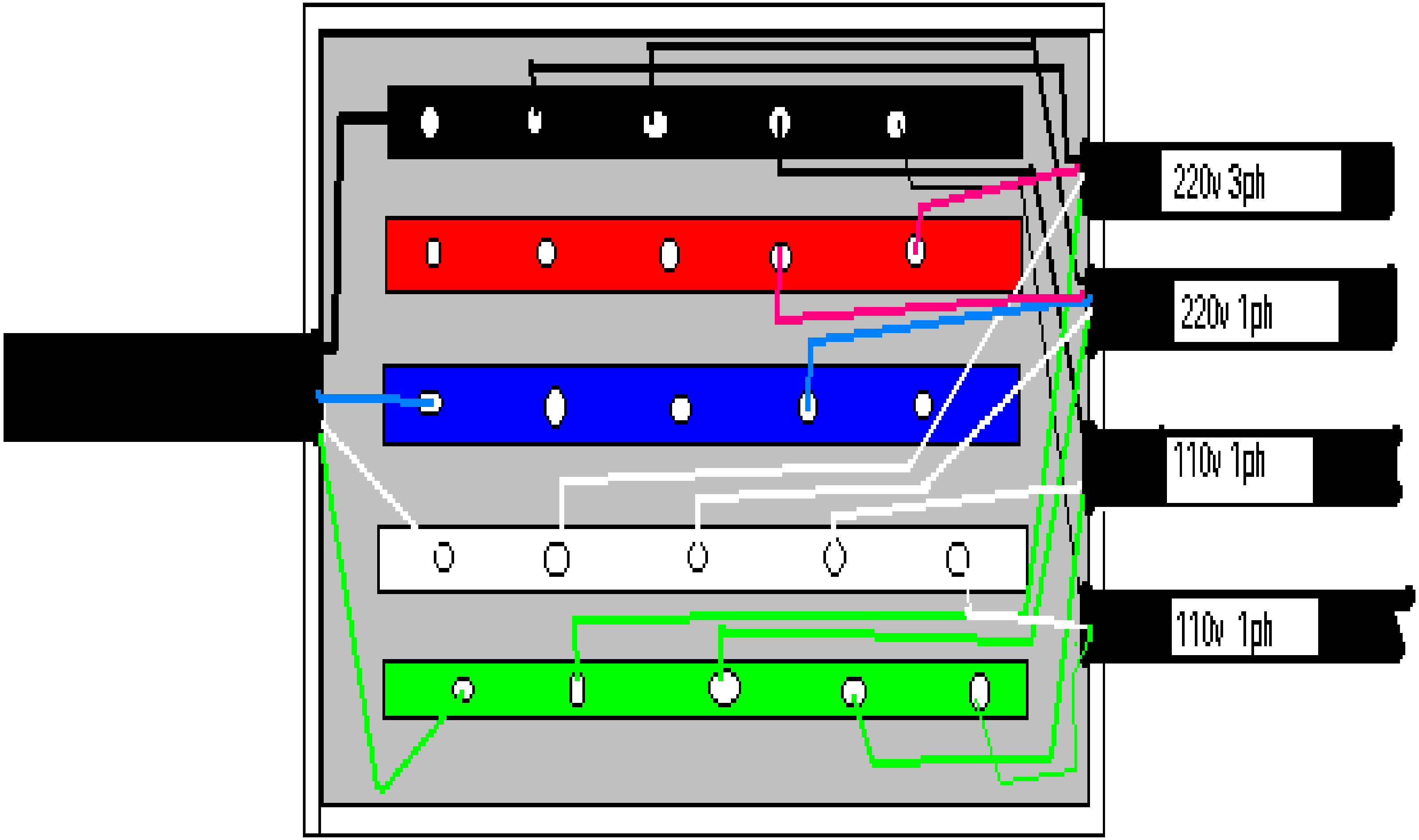


Single Pole Switch

With Switch Controlling One Light




A
N
B
C
240 volts
120 volts
240 volts
208 volts
240 volts
120 volts
A - B 240 volts
B - C 240 volts
C - A 240 volts
A - N 120 volts
B - N 208 volts
C - N 120 volts
"B" PHASE BUS BAR


220v 3ph
220v 1ph
110v 1ph
110v 1ph

AFCIs

vs.

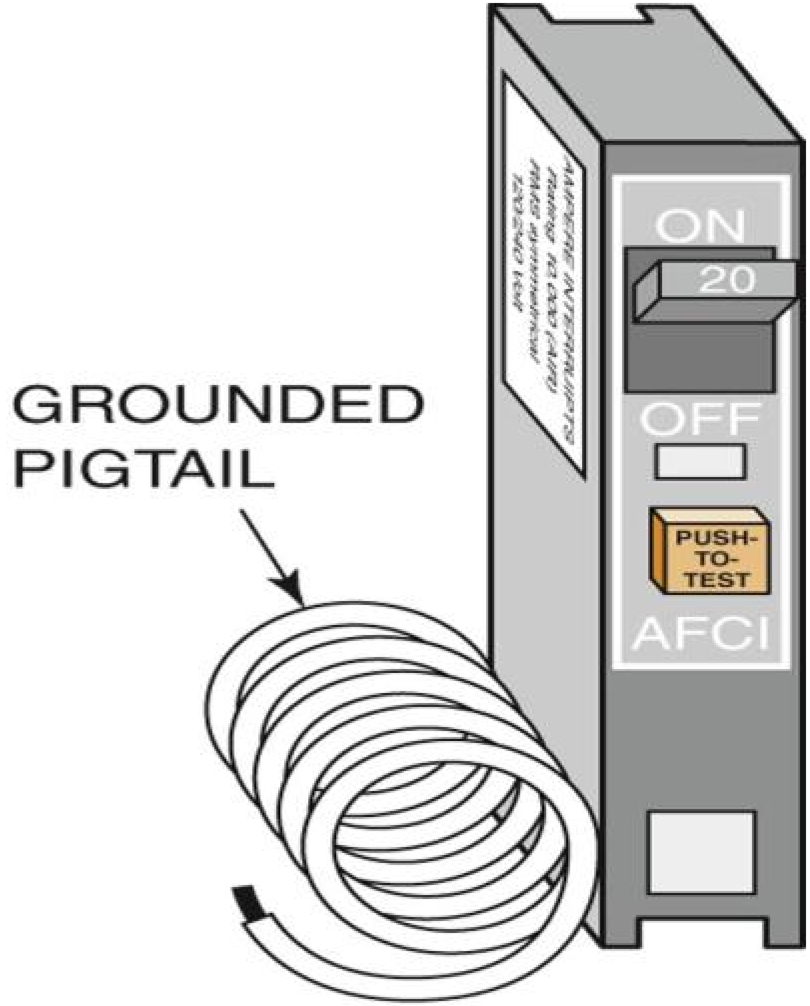
GFCIs:

Arc

Fault

Circuit

Interrupter



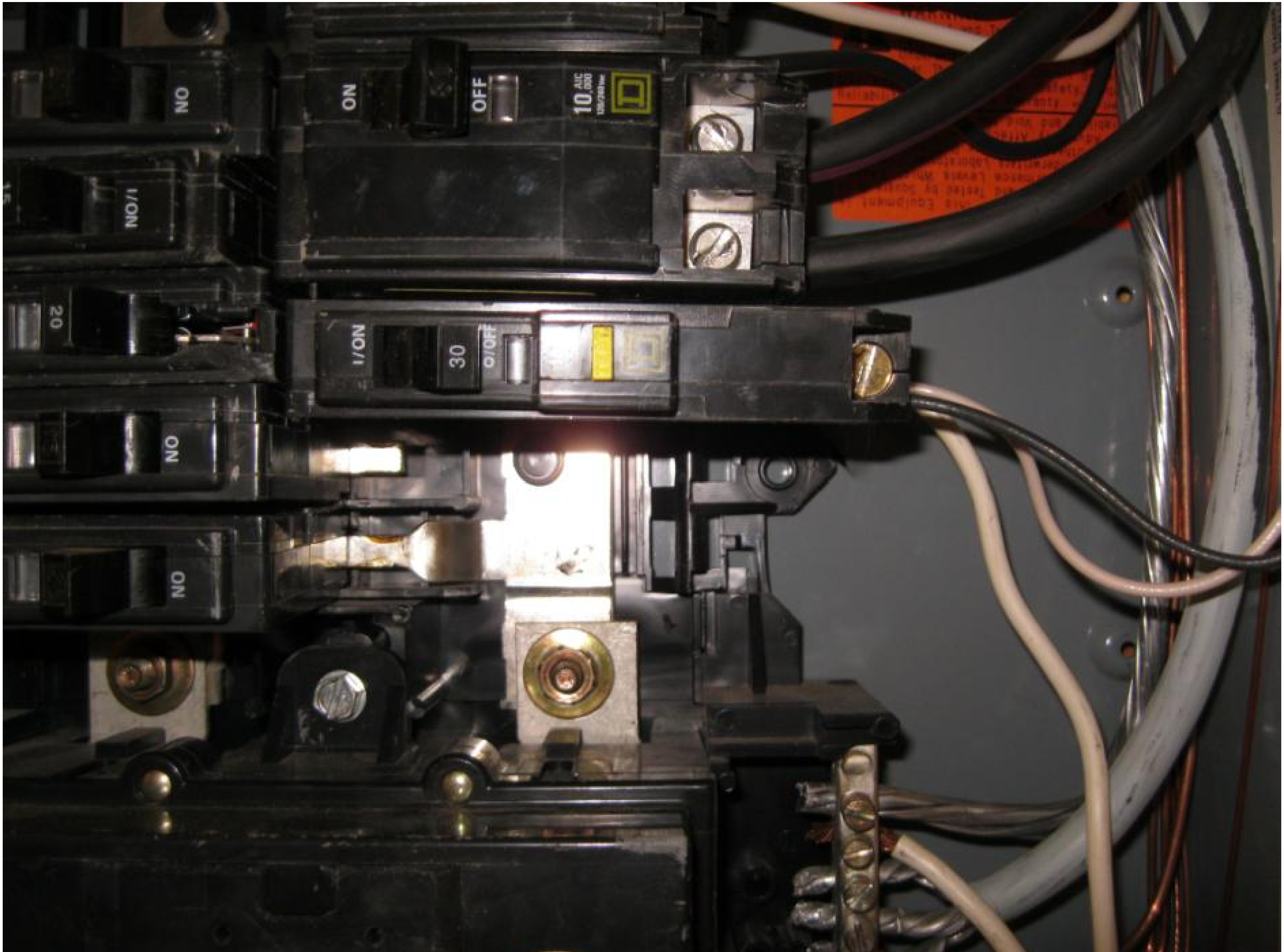
(A) A SINGLE-POLE ARC FAULT CIRCUIT INTERRUPTER CIRCUIT BREAKER

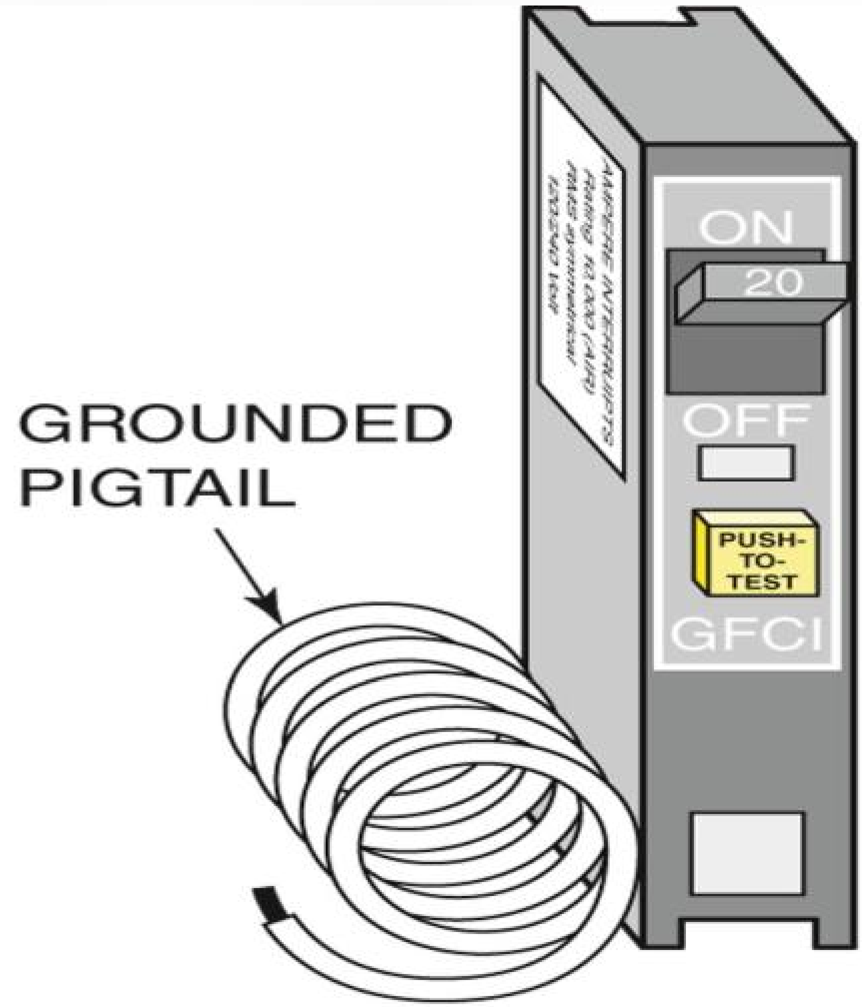
Ground

Fault

Circuit

Interrupter


ON
OFF
10
I/ON
30
O/OFF
20



(A) A SINGLE-POLE GROUND FAULT CIRCUIT INTERRUPTER CIRCUIT BREAKER

AFCIs vs. GFCIs:
What is the difference between an Arc Fault Circuit Interrupter and a Ground Fault Circuit Interrupter?

An AFCI is a device intended to prevent a fire.
It detects a type of arcing in the electrical circuit
that can lead to overheating and a fire.
An AFCI can protect against some types of shock
by detecting a short circuit
if the short is also affecting an individual,
but it is not designed as a shock protector
and
will not detect all of the same faults
as a GFCI.

A GFCI is a device intended to prevent electrical shock.

A GFCI will not necessarily detect the type of electrical arcing that can cause a fire.

The GFCI is designed to protect people from severe or fatal electric shocks while the AFCI protects against fires caused by arcing faults.

The GFCI also can protect against some electrical fires by detecting arcing and other faults to ground but cannot detect hazardous across-the-line arcing faults that can cause fires.

A ground fault

is an unintentional electric path diverting current to ground.
Ground faults occur when current leaks from a circuit.

How the current leaks is very important.
If a person's body provides a path to ground for this leakage,
the person could be injured, burned, severely shocked,
or electrocuted.

The National Electrical Code requires GFCI protection for receptacles located outdoors,
in bathrooms, garages, kitchens, crawl spaces and unfinished basements;
and at certain locations such as near swimming pools.

Grounding to trip the circuit breaker or blow the fuse:

Electrical grounding is necessary to protect people from electric shock
by providing a good electrical path to route a faulty electrical connection
(such as a short circuit) to ground (literally, to the earth)
so that current will flow through
and thus trip the circuit breaker or blow the fuse,
safely and quickly turning off the electrical circuit.
(A short circuit is one of the two ways that a fuse or circuit breaker will blow.
The second is the drawing of more current (amps)
than the circuit is intended to carry.)

Grounding to route stray electricity from static electricity, electrical power surges, lightening, etc. to ground.

This can protect the insulation on electrical wires from damage due to high voltage.

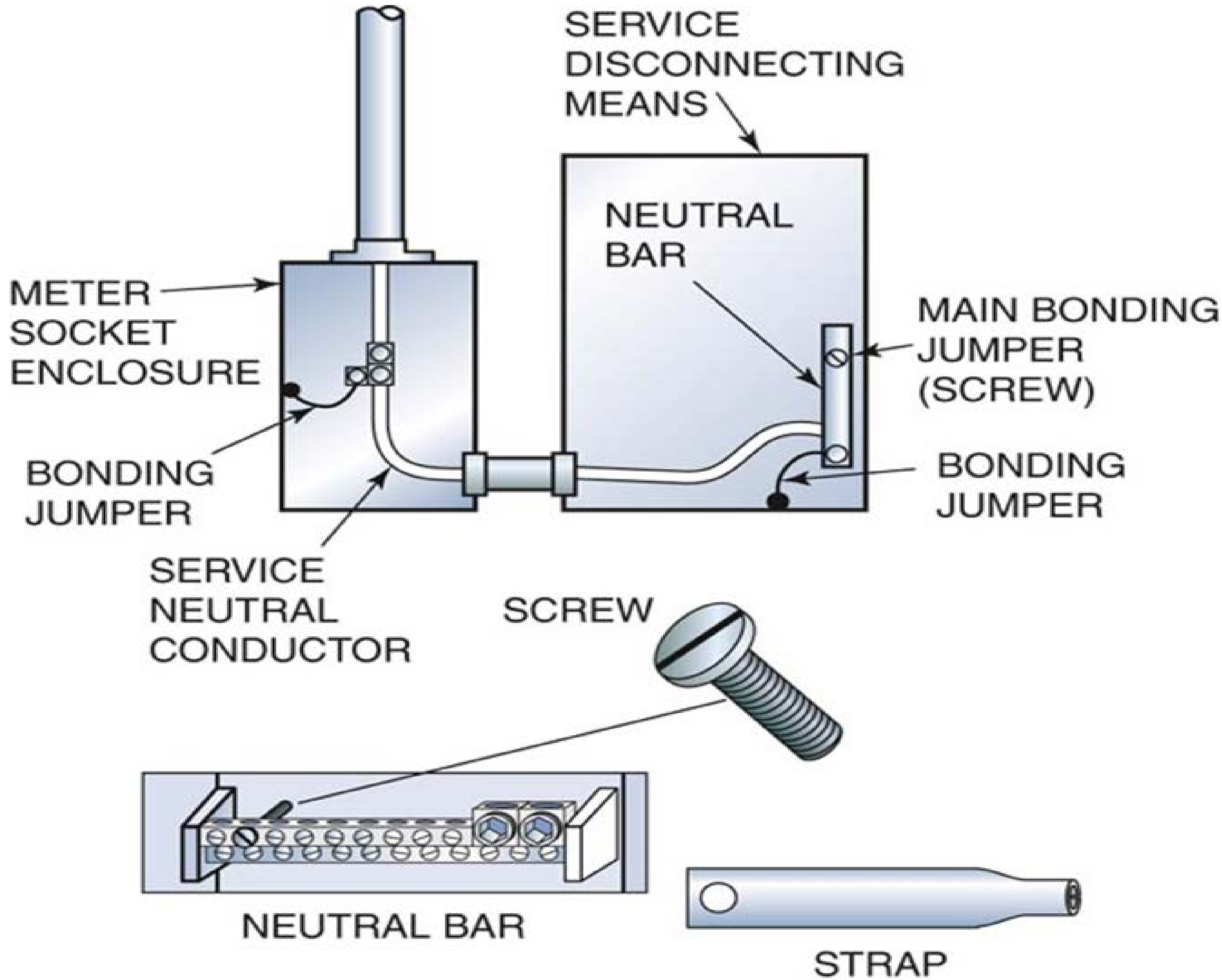
The protection against static electricity helps reduce the chances of an un-wanted spark that can cause damage to electronic components or cause an explosion of nearby combustible gases.

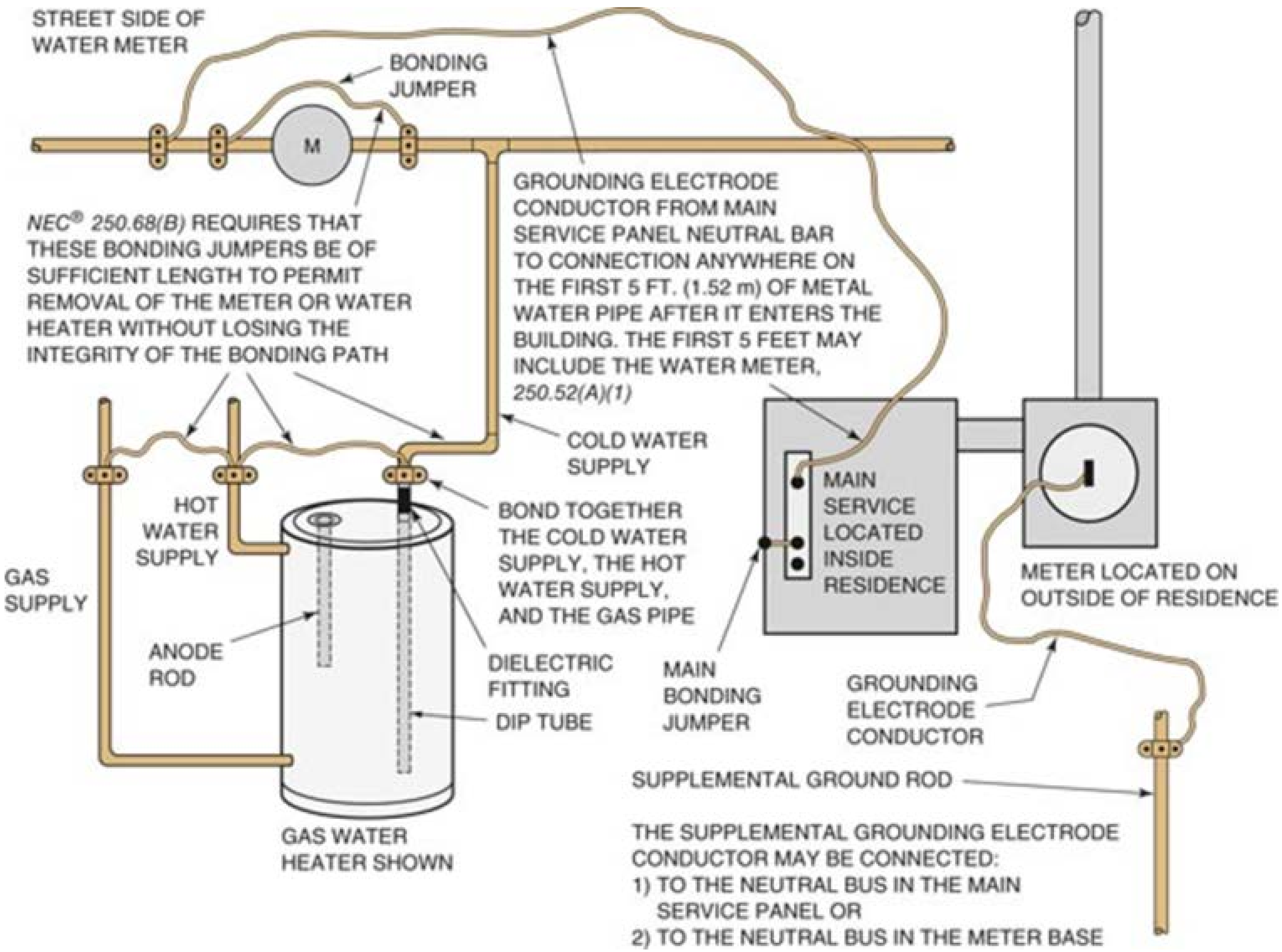
Grounding to provide a normal path for electricity to flow:
energy flows in an building's electrical circuit from a power source
(the utility pole through electrical panel,
though building circuits and electrical devices connected to them)
to the ground, to earth.
If there is no good connection to earth,
electricity does not flow,
though it might if you stand on wet ground and touch a live electrical wire –
an action that could be fatal.
Ground and neutral are related electrical terms.
Neutral is used to describe the "return path“
from in an electrical circuit to the electrical panel.
Inside of the main electrical panel
the neutral wires are bonded
to the ground wires and
to a grounding conductor
that connects that assembly to earth
(typically through a grounding electrode or
"ground rod")

GROUNDING

AND / OR

BONDING


SERVICE
DISCONNECTING
MEANS
NEUTRAL
BAR
MAIN BONDING
JUMPER
(SCREW)
METER
SOCKET
ENCLOSURE
BONDING
JUMPER
BONDING
JUMPER
SERVICE
NEUTRAL
CONDUCTOR
SCREW
NEUTRAL BAR
STRAP


STREET SIDE OF WATER METER
BONDING JUMPER
M
GROUNDING ELECTRODE CONDUCTOR FROM MAIN SERVICE PANEL NEUTRAL BAR TO CONNECTION ANYWHERE ON THE FIRST 5 FT. (1.52 m) OF METAL WATER PIPE AFTER IT ENTERS THE BUILDING. THE FIRST 5 FEET MAY INCLUDE THE WATER METER, *250.52(A)(1)*
NEC® 250.68(B) REQUIRES THAT THESE BONDING JUMPERS BE OF SUFFICIENT LENGTH TO PERMIT REMOVAL OF THE METER OR WATER HEATER WITHOUT LOSING THE INTEGRITY OF THE BONDING PATH
COLD WATER SUPPLY
HOT WATER SUPPLY
GAS SUPPLY
BOND TOGETHER THE COLD WATER SUPPLY, THE HOT WATER SUPPLY, AND THE GAS PIPE
MAIN SERVICE LOCATED INSIDE RESIDENCE
METER LOCATED ON OUTSIDE OF RESIDENCE
ANODE ROD
DIELECTRIC FITTING
DIP TUBE
MAIN BONDING JUMPER
GROUNDING ELECTRODE CONDUCTOR
SUPPLEMENTAL GROUND ROD
GAS WATER HEATER SHOWN
THE SUPPLEMENTAL GROUNDING ELECTRODE CONDUCTOR MAY BE CONNECTED:
1) TO THE NEUTRAL BUS IN THE MAIN SERVICE PANEL OR
2) TO THE NEUTRAL BUS IN THE METER BASE

Ground:

means the physical earth,
the soil or ground.

In some countries the term earth is used and is synonymous with ground.
In the electrical code,
ground means an electrically conducting connection,
intentional or accidental,
between an electrical circuit and the earth.
Grounded means that something has been electrically connected to the earth.
Watch out:
even among inspectors and electricians,
people may use the term "ground“
more loosely to refer to the equipment grounding conductor
or other components.

Grounding electrode or ground electrode:

a metal conductor,

usually a solid copper-alloy rod of specified length,

driven into the ground in order to provide a point for electrical connection

between the building grounding system

and ground or earth.

In the electrical code,

the grounding electrode conductor is the conductor (a wire)

used to connect the grounding rod(s)

to the equipment grounding conductor

(the ground bus and ground wires in the electrical panel)

OR to the grounded conductor

(the neutral bus and neutral wires)

OR to connect both of these to the grounding electrode

(which is usually the case in residential electrical systems).


BENNETT

Grounded Conductor (the neutral wire):

by convention the grounded conductor or neutral wire
is white or gray.
In an electrical circuit the grounded conductor (white or neutral wire)
normally carries electrical current
between the un-grounded (hot) electrical wire
and (back through the main electrical panel and grounding system) earth.
In the electrical code,
a grounded conductor
is one which has been intentionally grounded
- connected to the earth.

The amount of current carried by **the neutral wire**
is called the un-balanced load and
depends on the characteristics of the electrical device
being operated by the circuit.
The neutral conductor is grounded in the main electrical panel.
Be careful, inspectors and electricians, speaking loosely,
may simply call this the
"neutral wire".

Equipment Grounding Conductor (the ground wire):

By convention the equipment grounding conductor (ground wire)
is bare copper or carries green insulation.
the individual wire in a (grounded) electrical circuit
that is connected through the ground bus in the electrical panels
and ultimately in the main electrical panel is connected to ground or earth.

In the electrical code,
a grounding conductor is a conductor (metal wire, metal bar, etc)
which is used to connect electrical equipment (like an electrical panel enclosure)
or the grounded circuit (the neutral wires) of a wiring system
to a grounding electrode (and thus to earth).

The ground wire in an electrical circuit
does not normally carry any electrical current,
but it remains available as an emergency path
to allow current to flow to earth
should an electrical fault such as a short circuit
occur (a connection between a hot wire and some metal
(conductive) material
that could cause an electrical shock to someone),
thus assuring that a fuse or circuit breaker
in the main panel can sense the current flow
and switch off the circuit.
In an older two-wire armored cable (BX) electrical circuit,
the metallic cable of the circuit
may be serving as the only grounding conductor.

It helps to keep these terms straight
if we remember that we use
the **ing** form
of the word **grounding**
to mean that this conductor causes an electrical connection
between earth
and whatever the grounding conductor
is connected to.

Grounding and bonding

You must bond the following equipment together, if they are connected to the same power source [525.30]:

Metal raceways and metal-sheath cables.

Metal enclosures.

Metal frames and metal parts of rides, concessions, tents, trailers, trucks, or other equipment that contain or support electrical equipment.

Ground the metal parts of all electrical equipment to the grounded (neutral) conductor at the service disconnecting means per 250.24(C) (or the separately derived system per 250.30(A)(1)) [525.31].

Bonding or Bonded:

means that metallic parts
are permanently joined
so as to assure that they form a reliably continuous electrical path and that the parts are capable of conducting any electrical current that may be imposed on them.

A bonding jumper

is a reliable electrical conductor used to connect metal parts together
and a **main bonding jumper**
is the connection between the grounded circuit conductor
and the equipment grounding conductor
at the electrical service (panel).

Ground bond:

refers to a physical electrical connection
between any metal component
(like metal water pipes,
metal gas piping,
a metal electrical panel enclosure,
or a neutral or ground bus in the main electrical panel)
and the building electrical ground system.

In the main electrical panel
the neutral wires
are physically bonded
to the ground wires
(by a larger diameter wire or by a metal bar inside the panel)
and the ground wire bus
(a metal bar)
is further connected to a grounding conductor
that connects those components to the building ground system:
one or more grounding electrodes
and possibly a connection to an incoming metal water pipe that is buried outside.
An electrician would say that the building's ground
and neutral wires are bonded to earth

Bonding electrical components together

makes certain that all of the joined items are at the same

electrical potential

(that is, that current will not flow from one to the other).

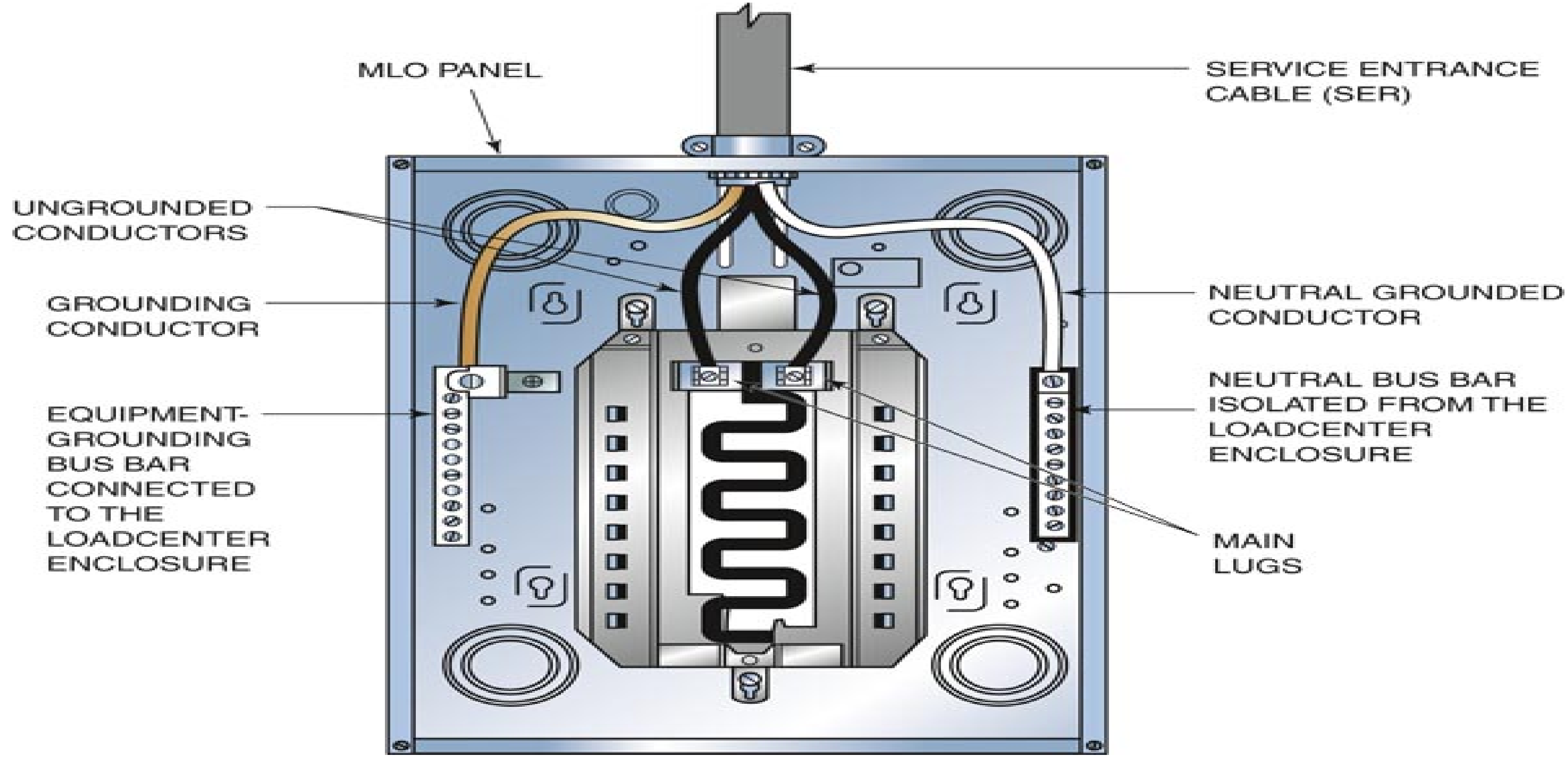
Examples of electrical bonds in buildings include:

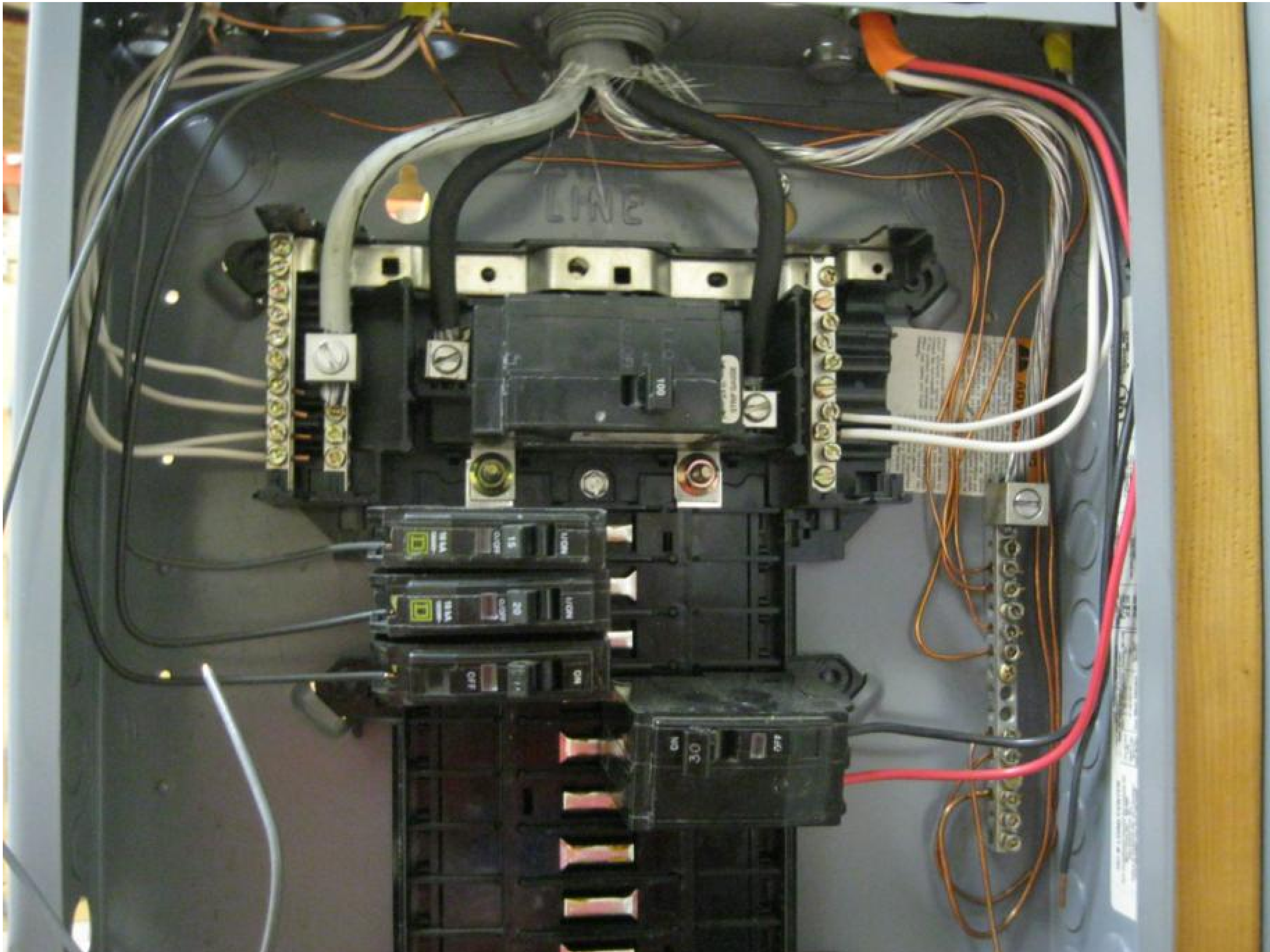
In individual electrical panels or sub-panels

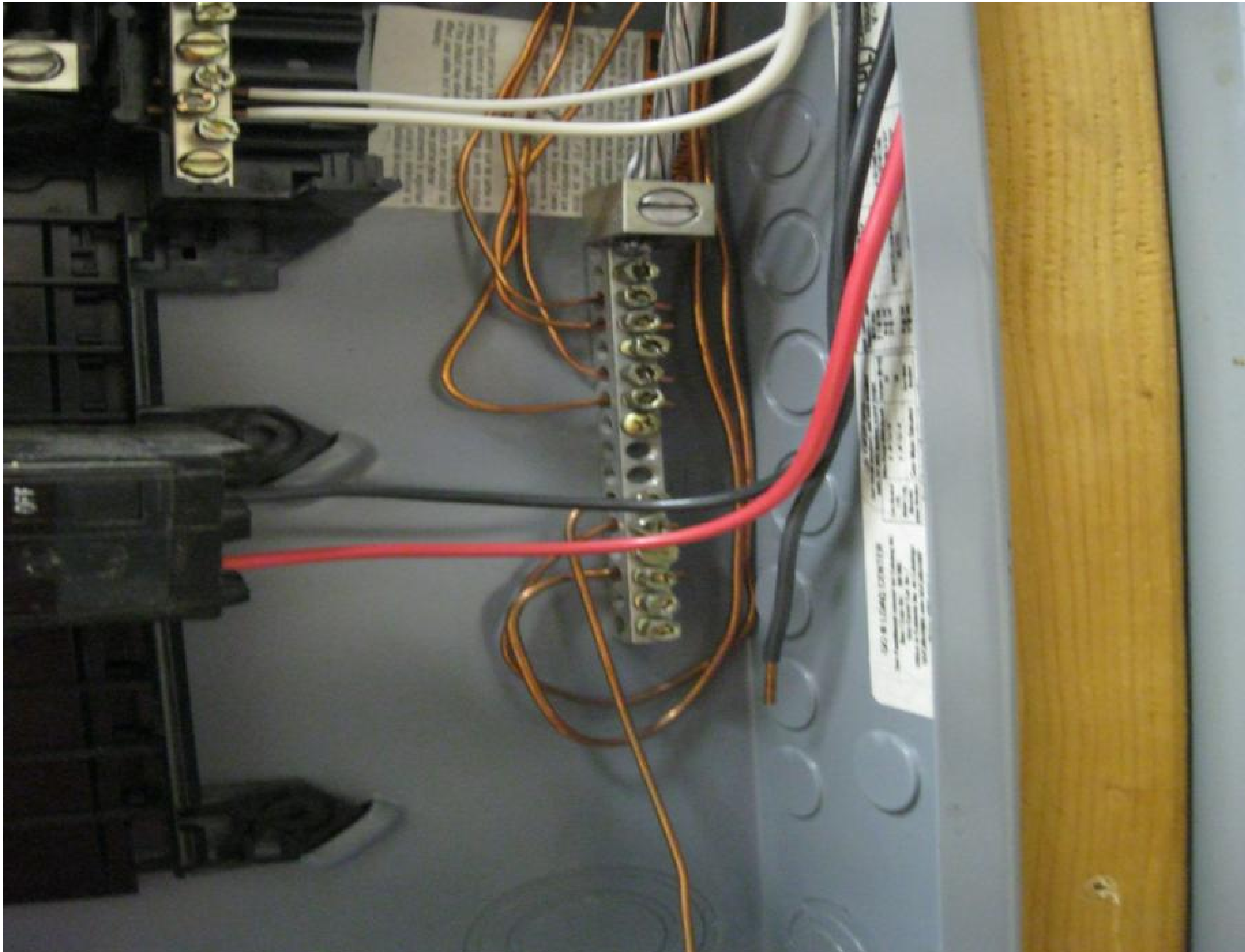
the ground wires

are

all bonded together on a ground bus or bar.



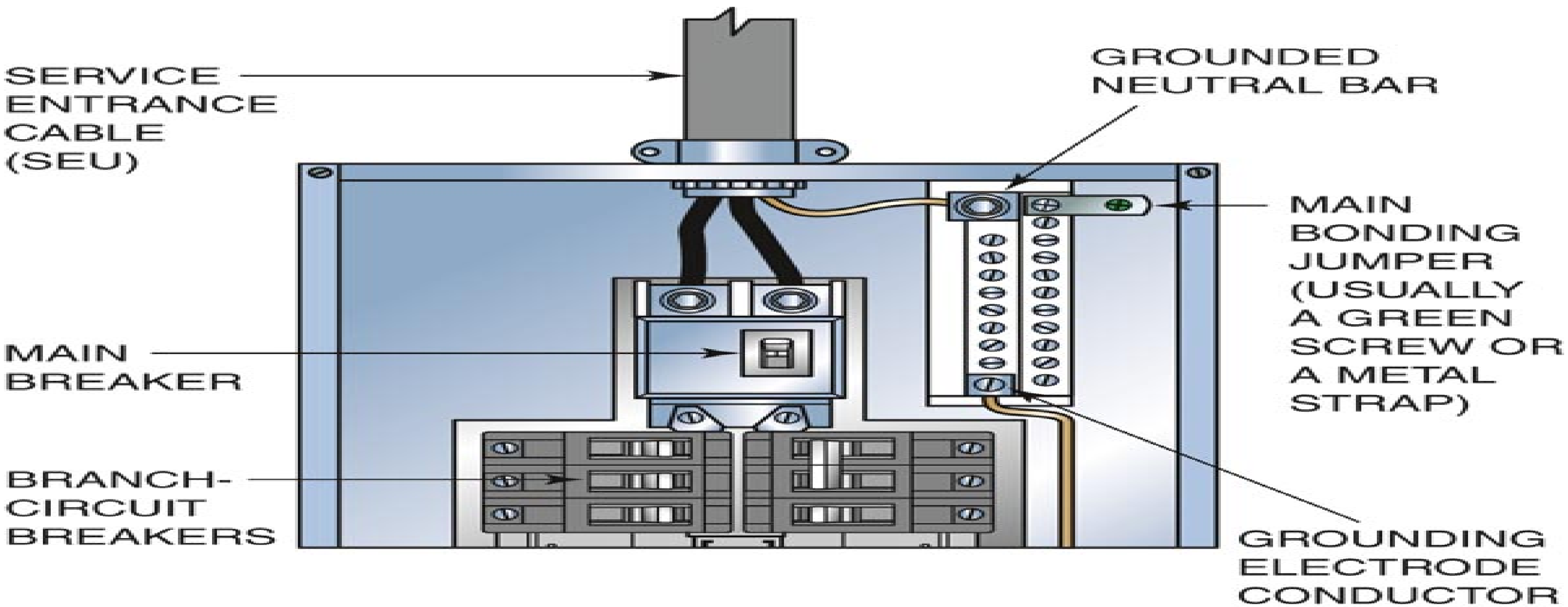

LINE
ON
30
OFF

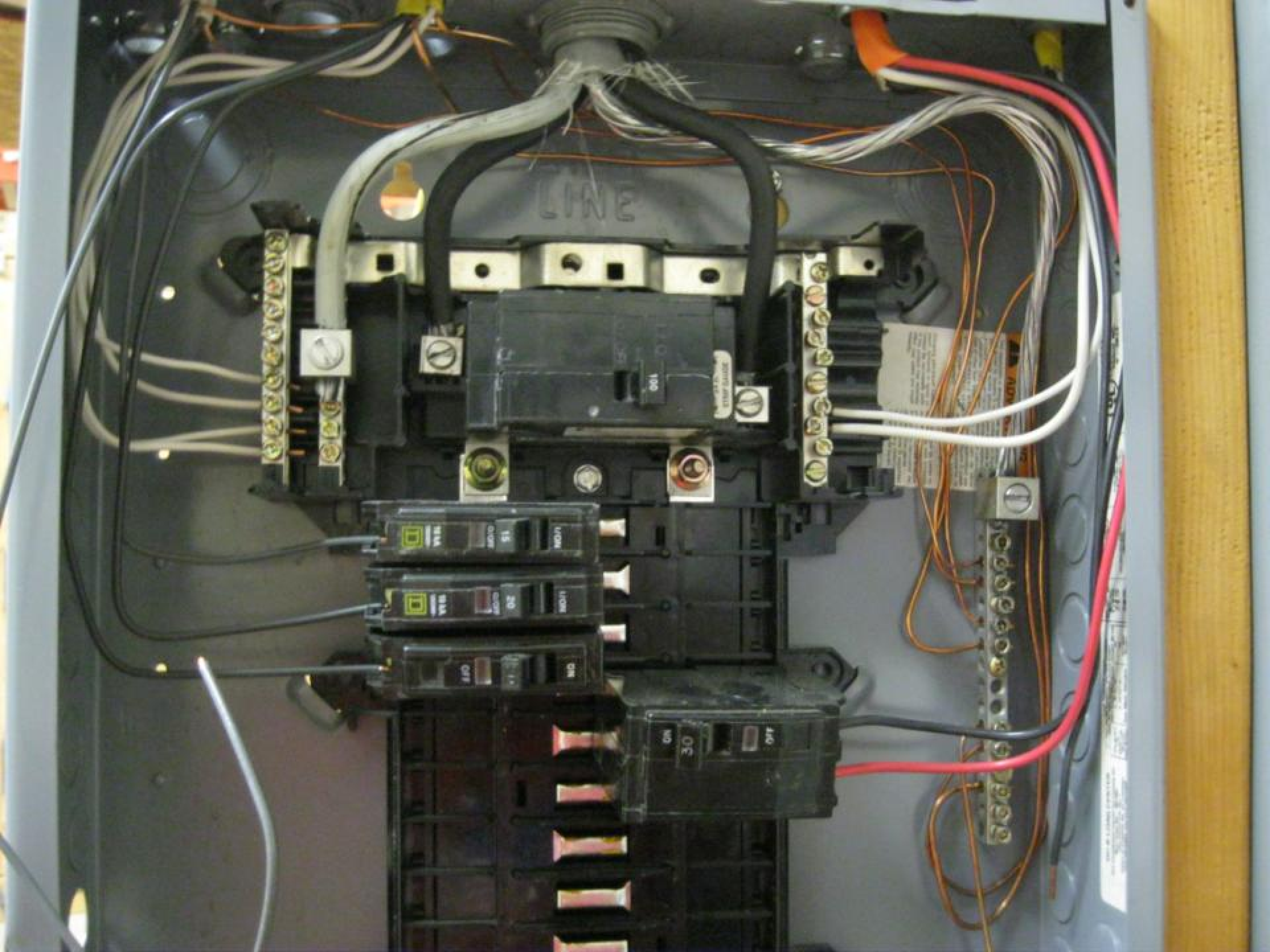


In the main electrical panel at a building,
the neutral bus
and ground bus
and electrical panel itself

are

all bonded together
and are connected to the building grounding system.

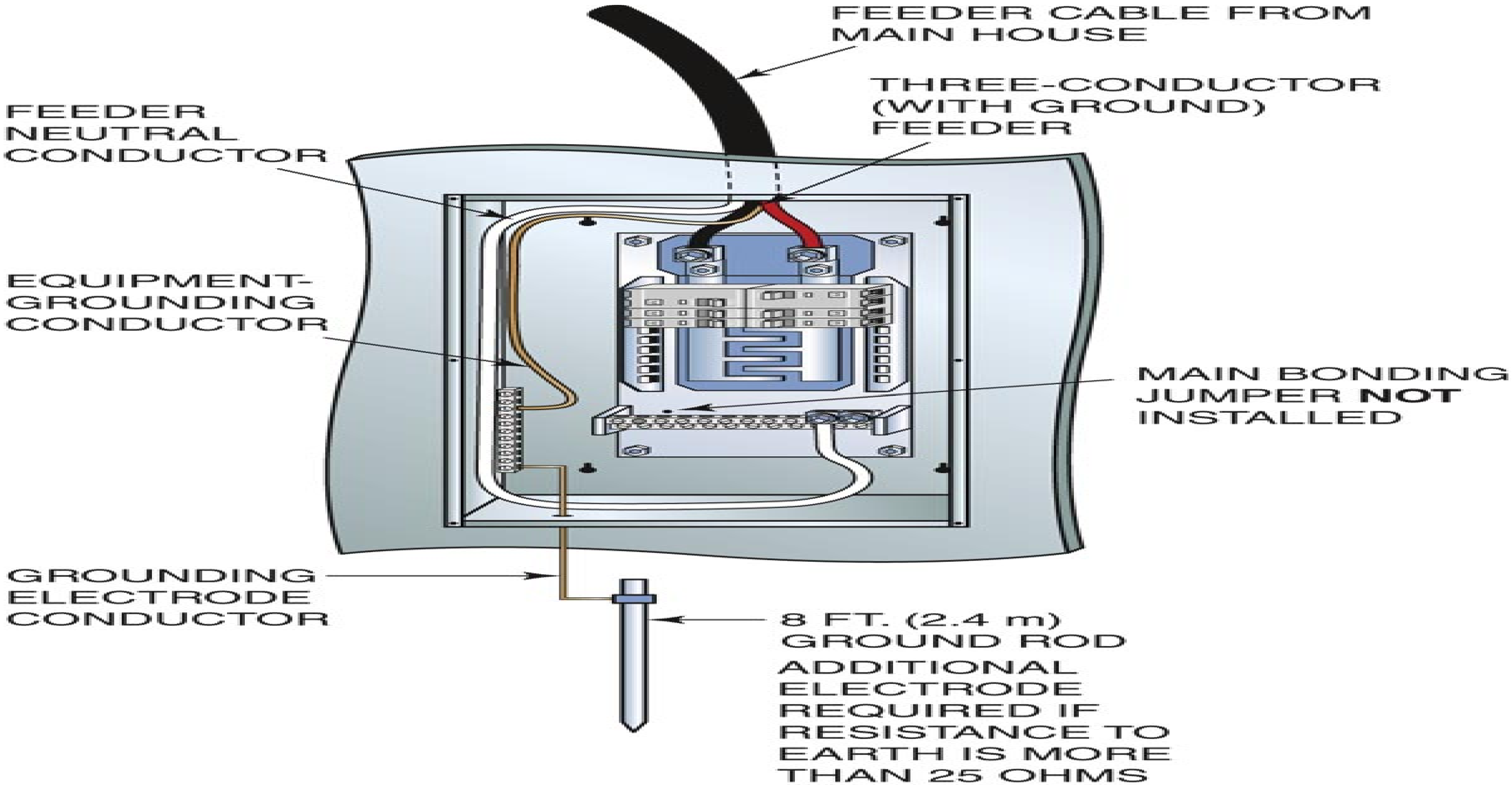


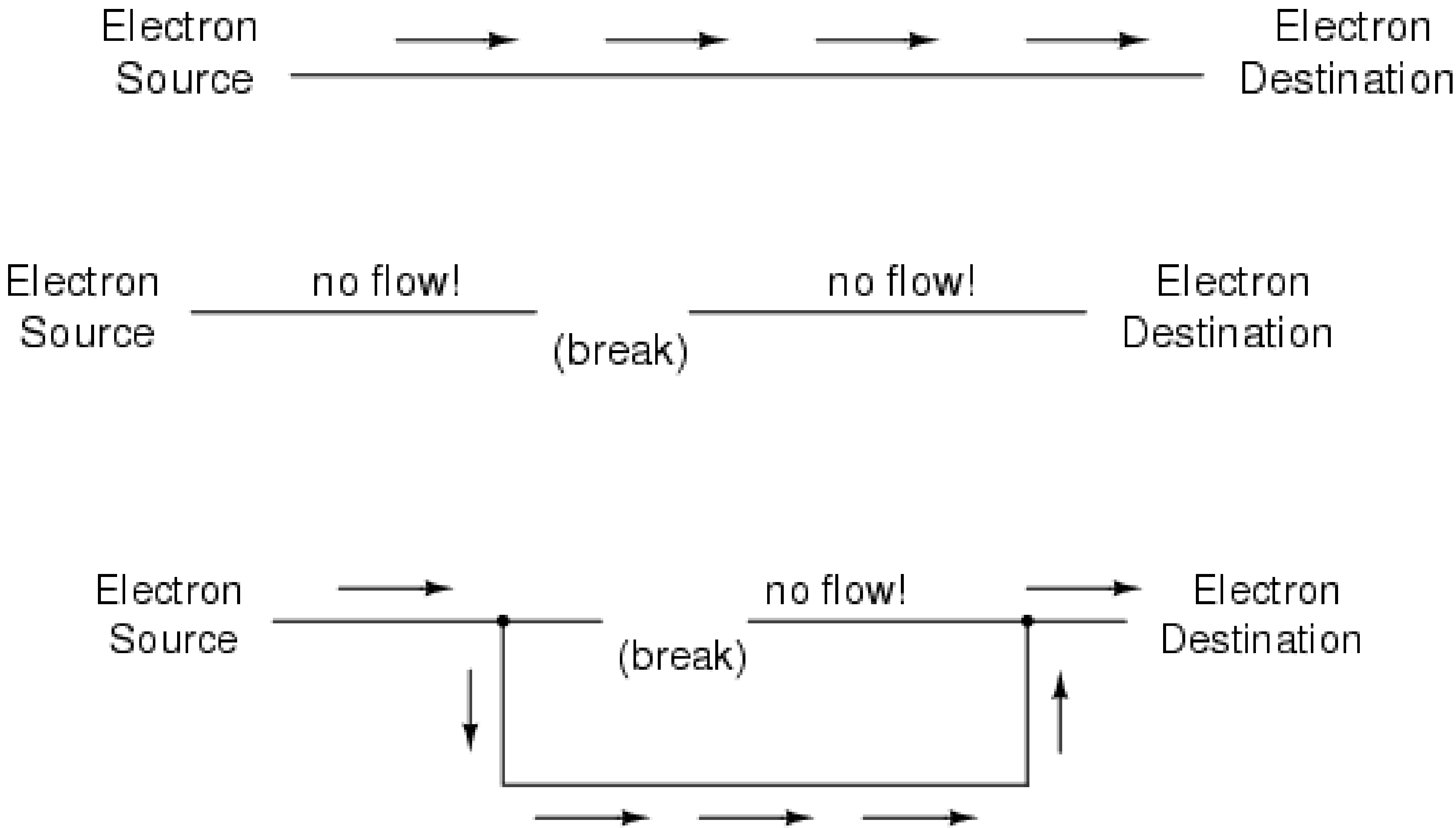

LINE

the neutral bus and ground bus

are not

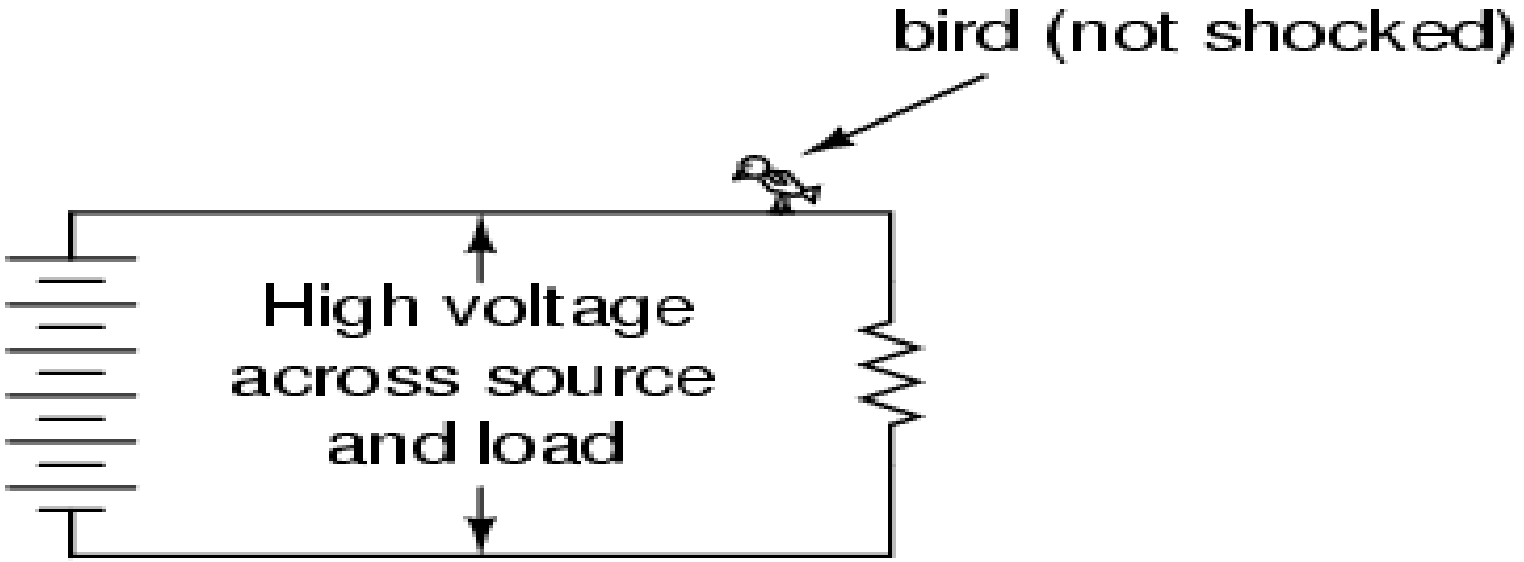
bonded together and
must be kept separate.




Electron Source
Electron Destination
Electron Source
no flow!
(break)
no flow!
Electron Destination
Electron Source
(break)
no flow!
Electron Destination

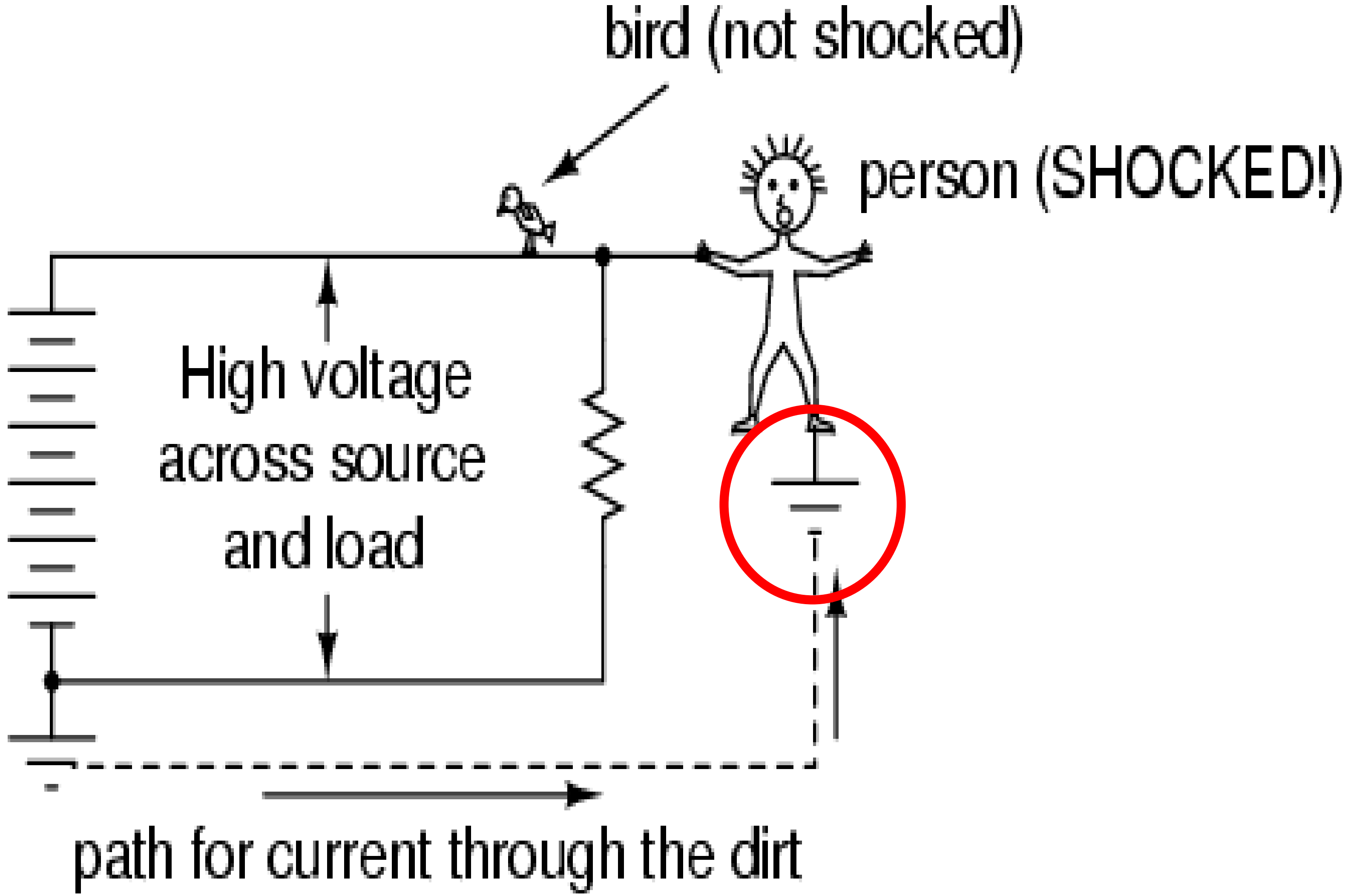
Without two contact points on the body for current to enter and exit, respectively, there is no hazard of shock.

This is why birds can safely rest on high-voltage power lines without getting shocked: they make contact with the circuit at only one point.



In order for electrons to flow through a conductor, there must be a voltage present to motivate them. Voltage, as you should recall, is always relative between two points. There is no such thing as voltage "on" or "at" a single point in the circuit, and so the bird contacting a single point in the above circuit has no voltage applied across its body to establish a current through it. Yes, even though they rest on two feet, both feet are touching the same wire, making them electrically common. Electrically speaking, both of the bird's feet touch the same point, hence there is no voltage between them to motivate current through the bird's body.

This might lend one to believe that its impossible to be shocked by electricity by only touching a single wire. Like the birds, if we're sure to touch only one wire at a time, we'll be safe, right? Unfortunately, this is not correct. Unlike birds, people are usually standing on the ground when they contact a "live" wire. Many times, one side of a power system will be intentionally connected to earth ground, and so the person touching a single wire is actually making contact between two points in the circuit (the wire and earth ground):


bird (not shocked)
person (SHOCKED!)
High voltage
across source
and load
path for current through the dirt

The ground symbol

is that set of three horizontal bars of decreasing width
located at the lower-left of the circuit shown,
and also at the foot of the person being shocked.
In real life the power system ground
consists of some kind of metallic conductor buried deep in the ground
for making maximum contact with the earth.
That conductor is electrically connected
to an appropriate connection point on the circuit with thick wire.
The victim's ground connection is through their feet,
which are touching the earth.

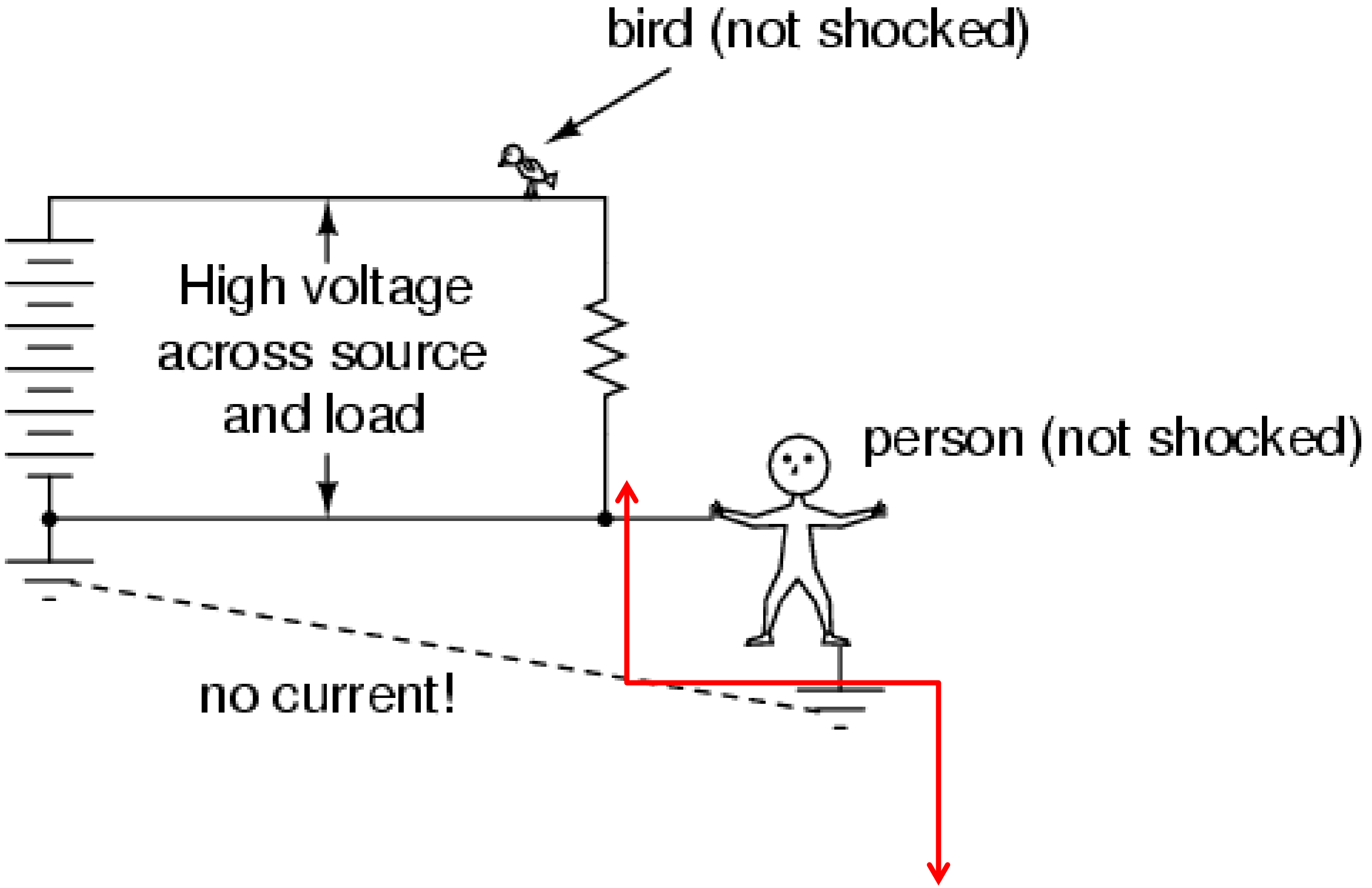
A few questions usually arise at this point in your mind :

1.If the presence of a ground point in the circuit provides an easy point of contact for someone to get shocked,
why have it in the circuit at all?
Wouldn't a ground-less circuit be safer?

2.The person getting shocked probably isn't bare-footed.

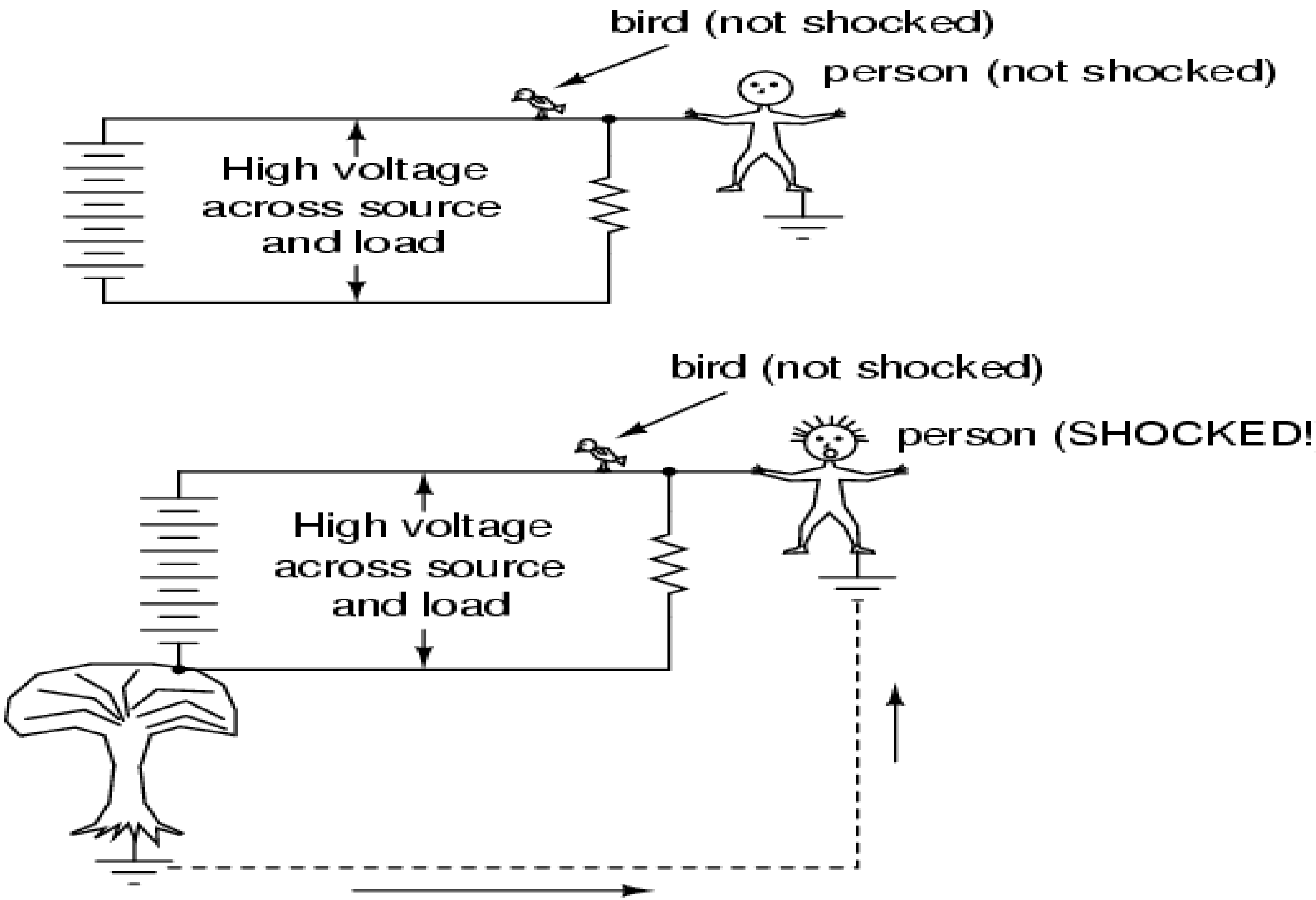
If rubber and fabric are insulating materials, then why aren't their shoes protecting them by preventing a circuit from forming?

3.How good of a conductor can dirt be?
If you can get shocked by current through the earth, why not use the earth as a conductor in our power circuits?


bird (not shocked)
High voltage
across source
and load
person (not shocked)
no current!

In answer to the first question,
the presence of an intentional "grounding" point in an electric circuit
is intended to ensure that one side of it is safe to come in contact with.
Note that if our victim in the above diagram
were to touch the bottom side of the resistor,
nothing would happen even though their feet would still be contacting ground

Because the bottom side of the circuit is firmly connected to ground through the grounding point on the lower-left of the circuit,
the lower conductor of the circuit is made electrically common with earth ground.
Since there can be no voltage between electrically common points,
there will be no voltage applied across the person contacting the lower wire,
and they will not receive a shock.
For the same reason,
the wire connecting the circuit to the grounding rod/plates
is usually left bare (no insulation),
so that any metal object it brushes up against it
will similarly be electrically common with the earth.



accidental ground path through tree (touching wire) completes the circuit for shock current through the victim.

accidental connection between a power system conductor and the earth (ground) is called a ground fault.

Ground faults may be caused by many things,
including dirt buildup on power line insulators

(creating a dirty-water path for current from the conductor to the pole, and to the ground, when it rains),

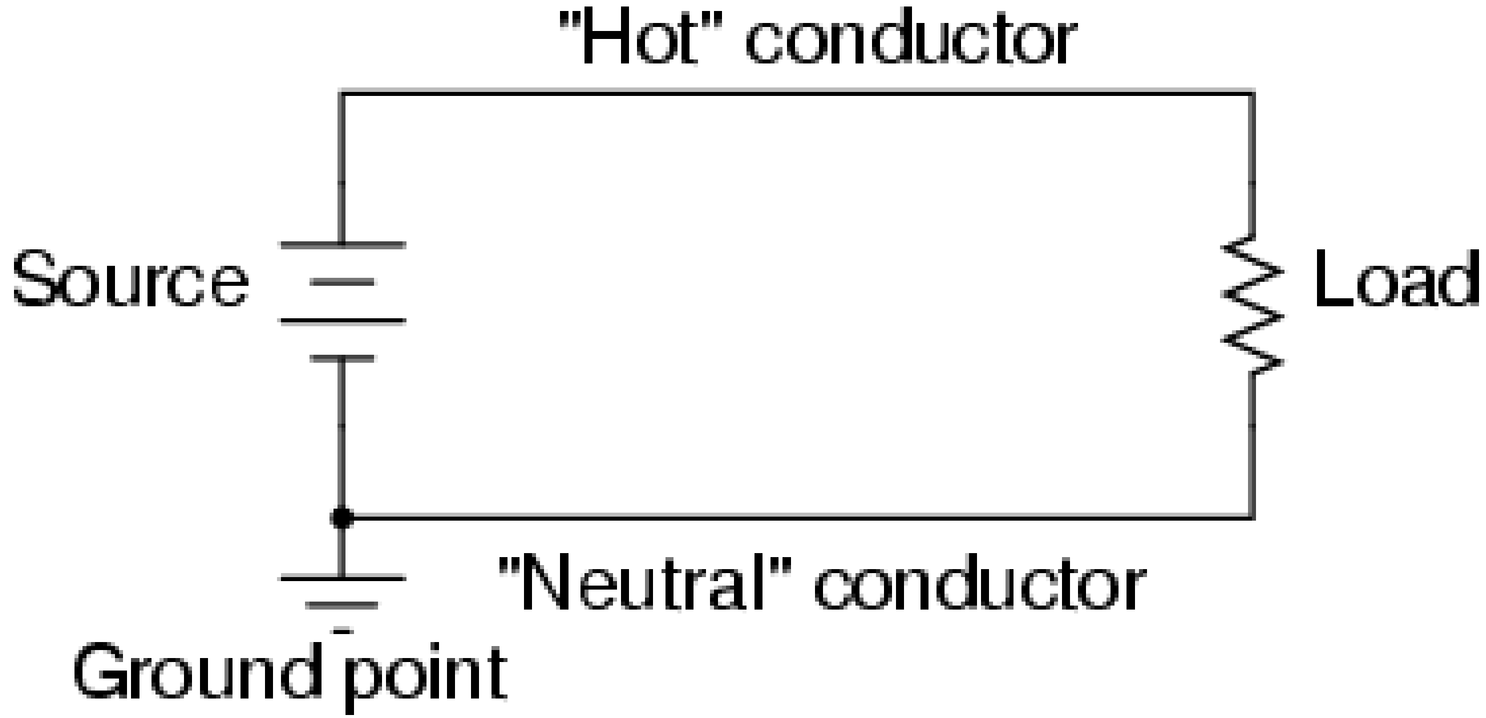
ground water infiltration in buried power line conductors,
and birds landing on power lines,
bridging the line to the pole with their wings.

Given the many causes of ground faults,
they tend to be unpredictable.

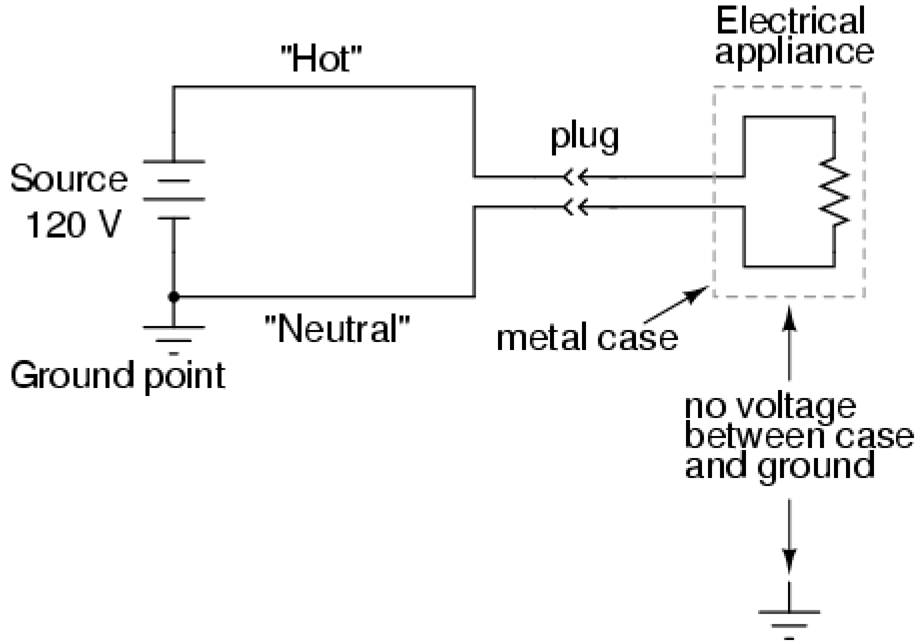
In the case of trees,
no one can guarantee which wire their branches might touch.

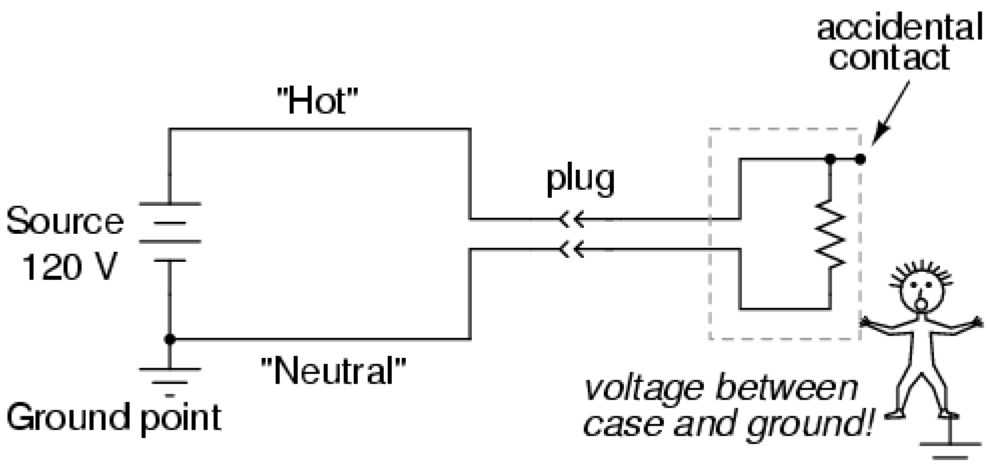
If a tree were to brush up against the top wire in the circuit,
it would make the top wire safe to touch
and the bottom one dangerous –
just the opposite of the previous scenario where the tree contacts the bottom wire:

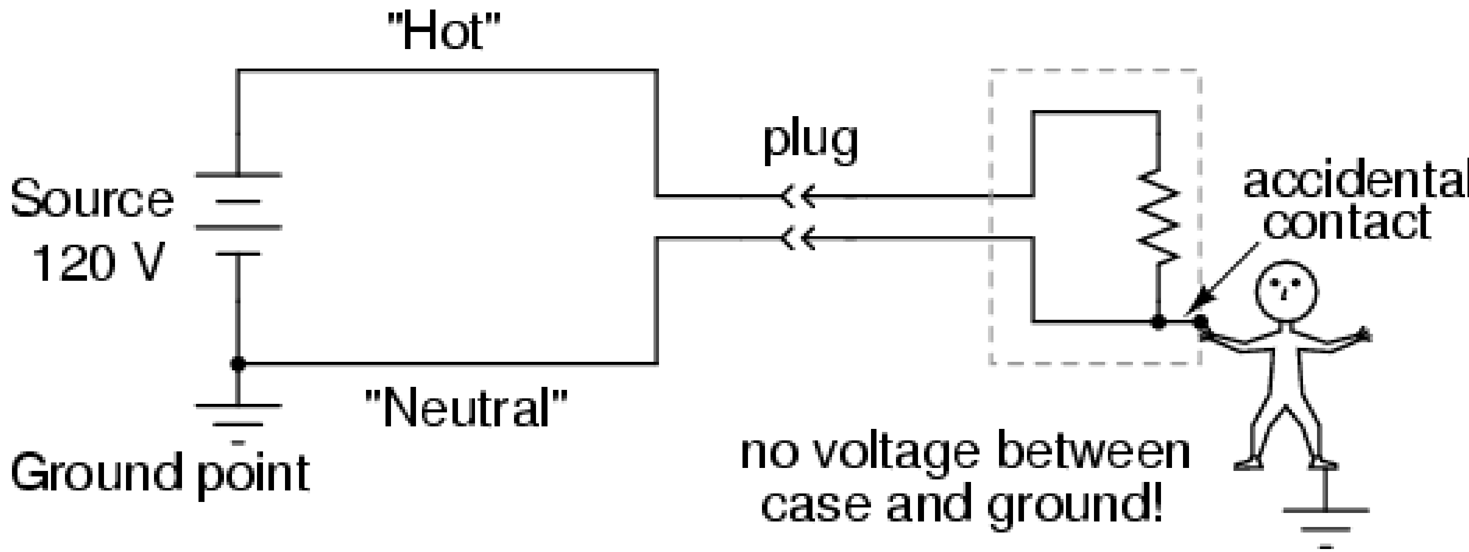
In a simple two-wire electrical power system,
the conductor connected to ground is called the *neutral*,
and the other conductor is called the *hot*,
also known as the *live* or the *active*:

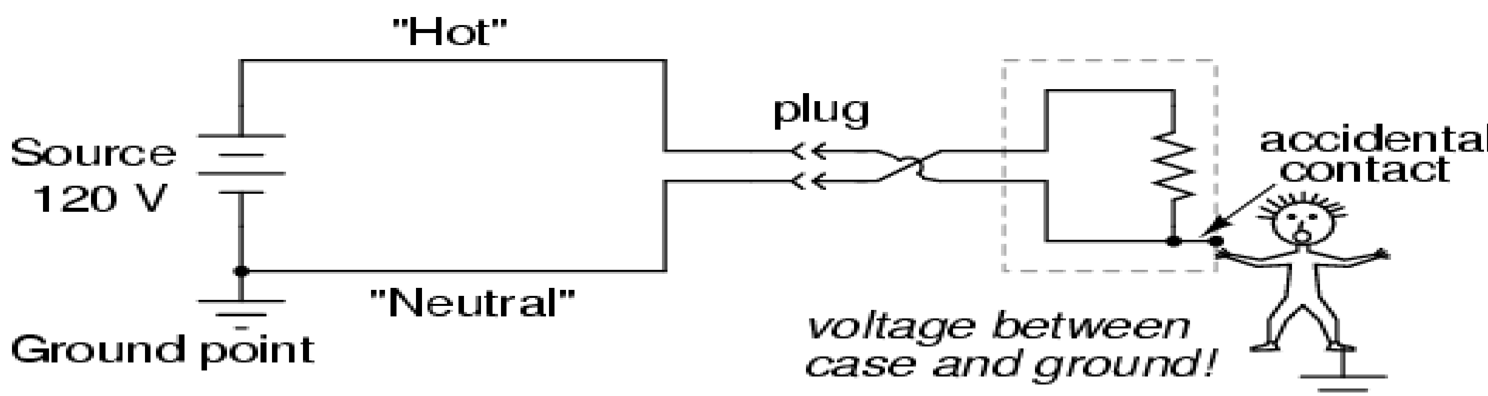


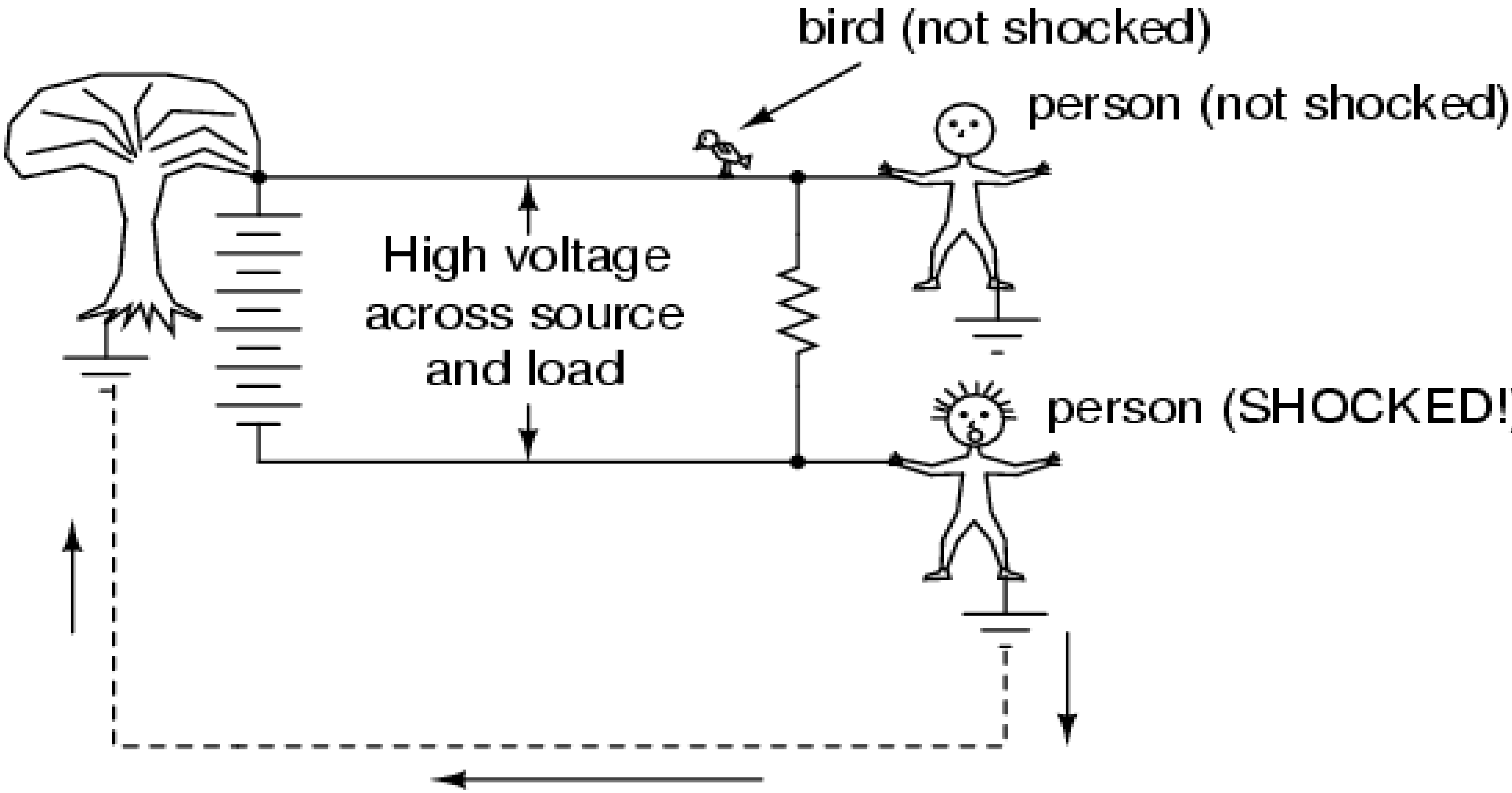
As far as the voltage source and load are concerned,
grounding makes no difference at all.
It exists purely for the sake of personnel safety,
by guaranteeing that at least one point in the circuit
will be safe to touch (zero voltage to ground).
The "Hot" side of the circuit,
named for its potential for shock hazard,
will be dangerous to touch unless voltage
is secured by proper disconnection
from the source


Electrical appliance
"Hot"
plug
Source
120 V
"Neutral"
metal case
Ground point
no voltage between case and ground

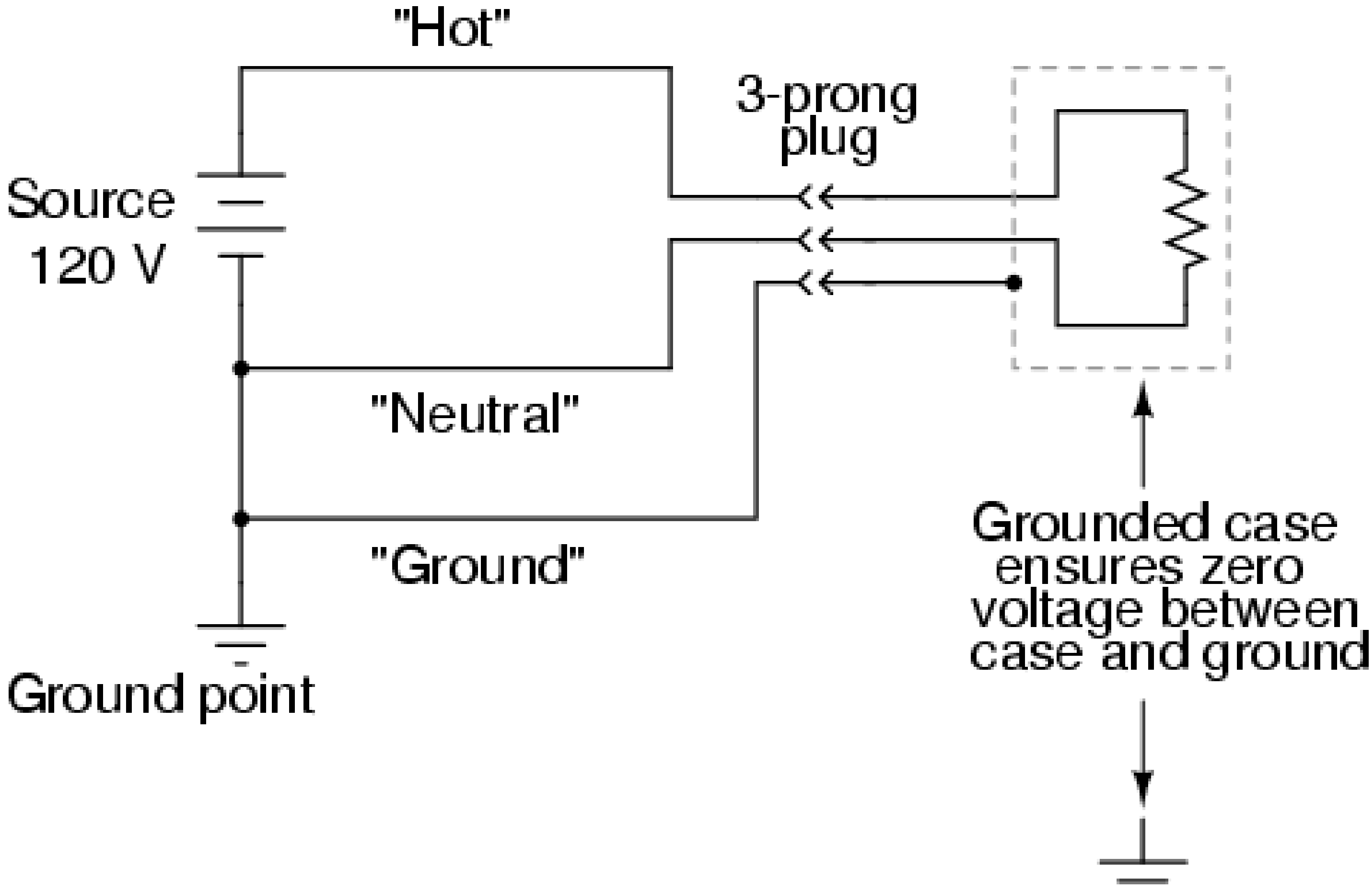

accidental contact
"Hot"
plug
Source
120 V
"Neutral"
Ground point
voltage between case and ground!

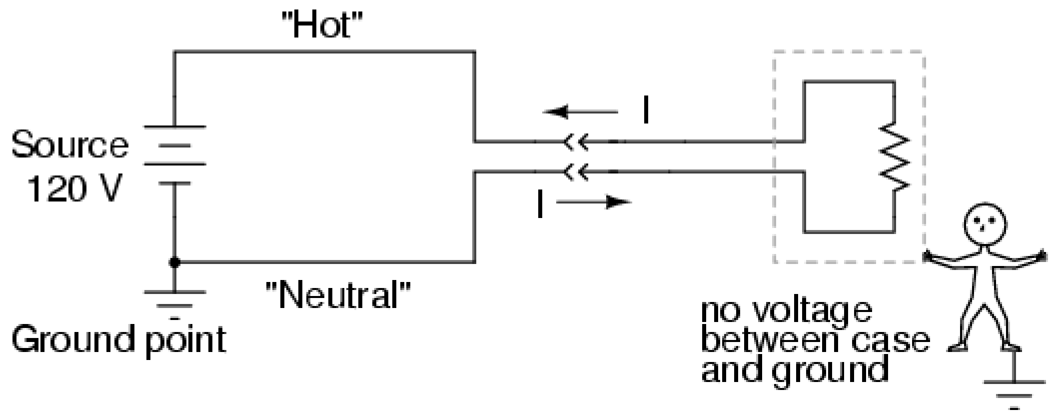

"Hot"
plug
Source
120 V
accidental
contact
"Neutral"
Ground point
no voltage between
case and ground!


"Hot"
plug
Source
120 V
accidental
contact
"Neutral"
Ground point
voltage between
case and ground!

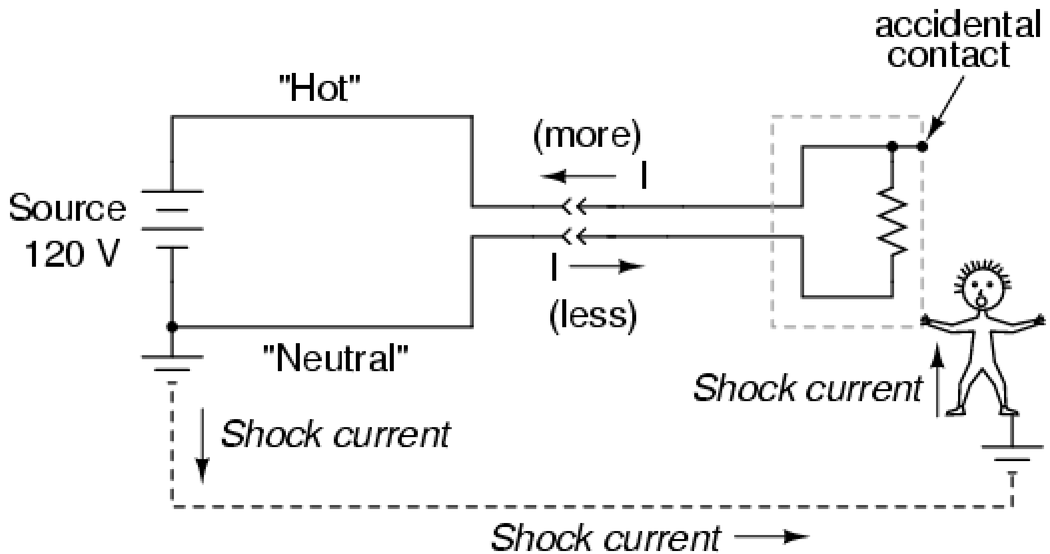


accidental ground path through tree (touching wire) completes the circuit for shock current through the victim.


"Hot"
3-prong plug
Source
120 V
"Neutral"
"Ground"
Ground point
Grounded case ensures zero voltage between case and ground

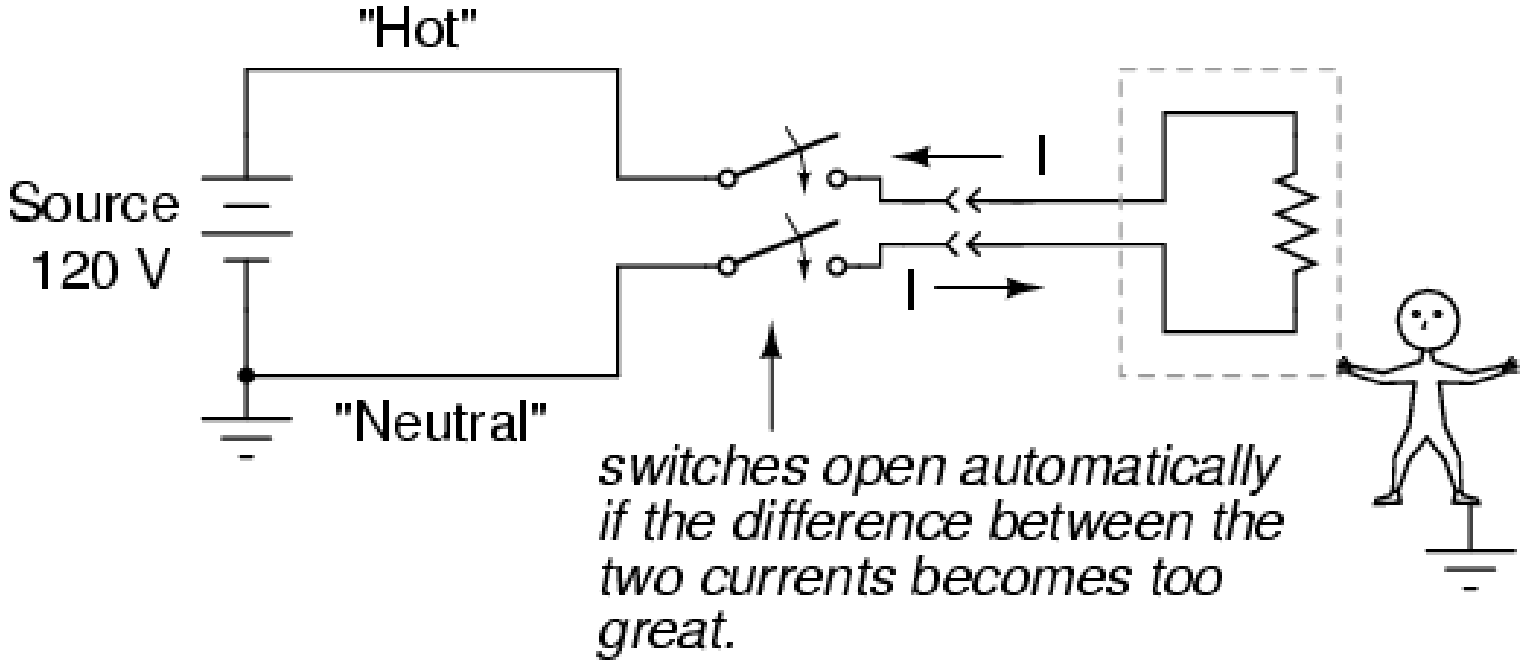


the current measured through the hot conductor
should be exactly equal
to the current through the neutral conductor,
because there's only one path for electrons to flow in the circuit.
With no fault inside the appliance,
there is no connection between circuit conductors
and the person touching the case,
and therefore no shock.

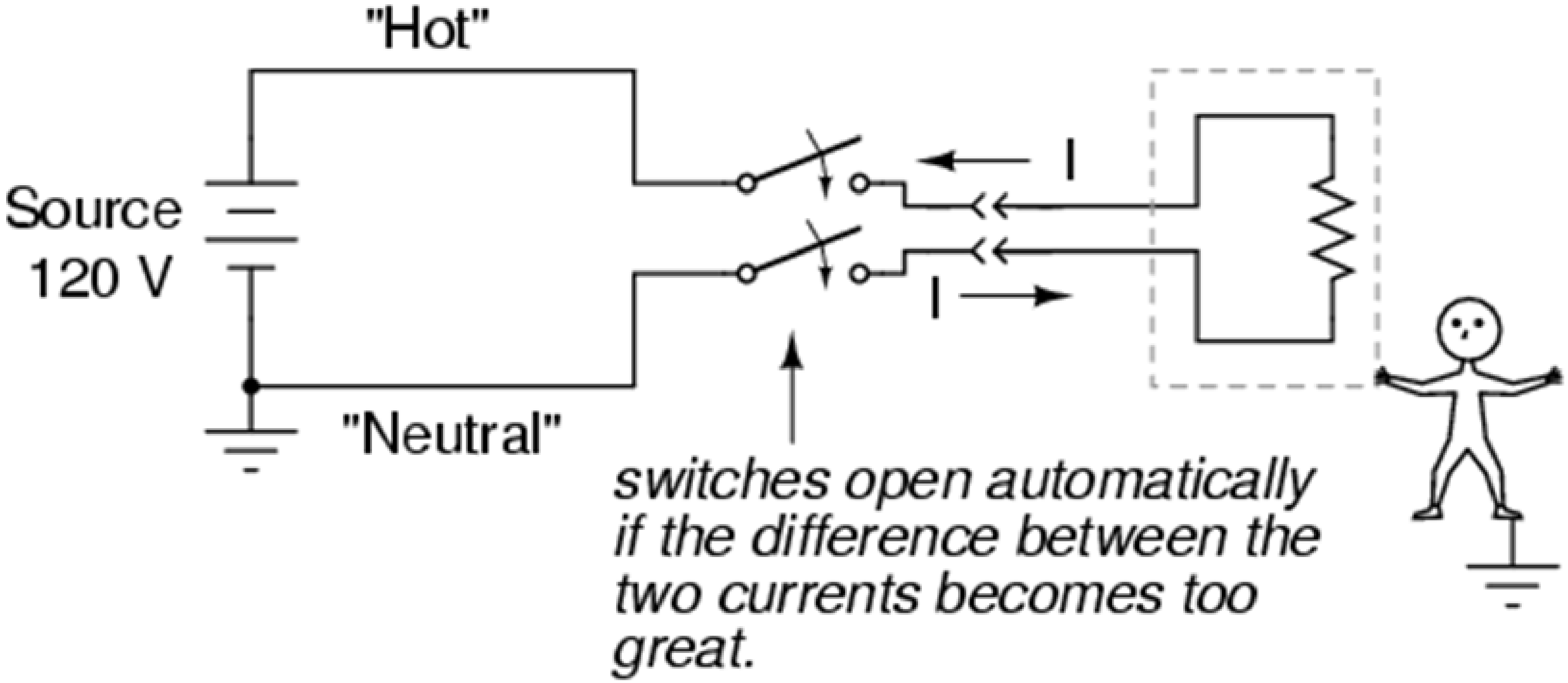


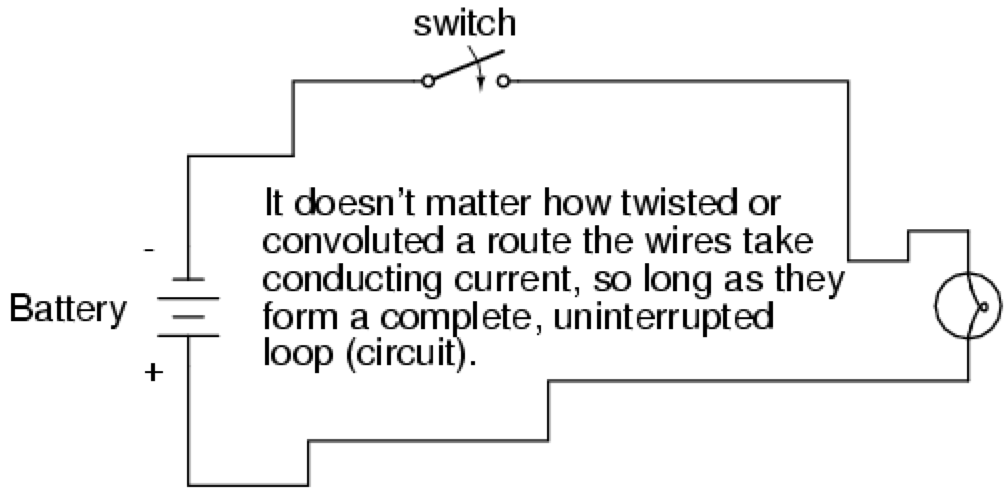
the hot wire accidently contacts the metal case, there will be current through the person touching the case.
The presence of a shock current
will be manifested as a difference of current
between the two power conductors at the receptacle:

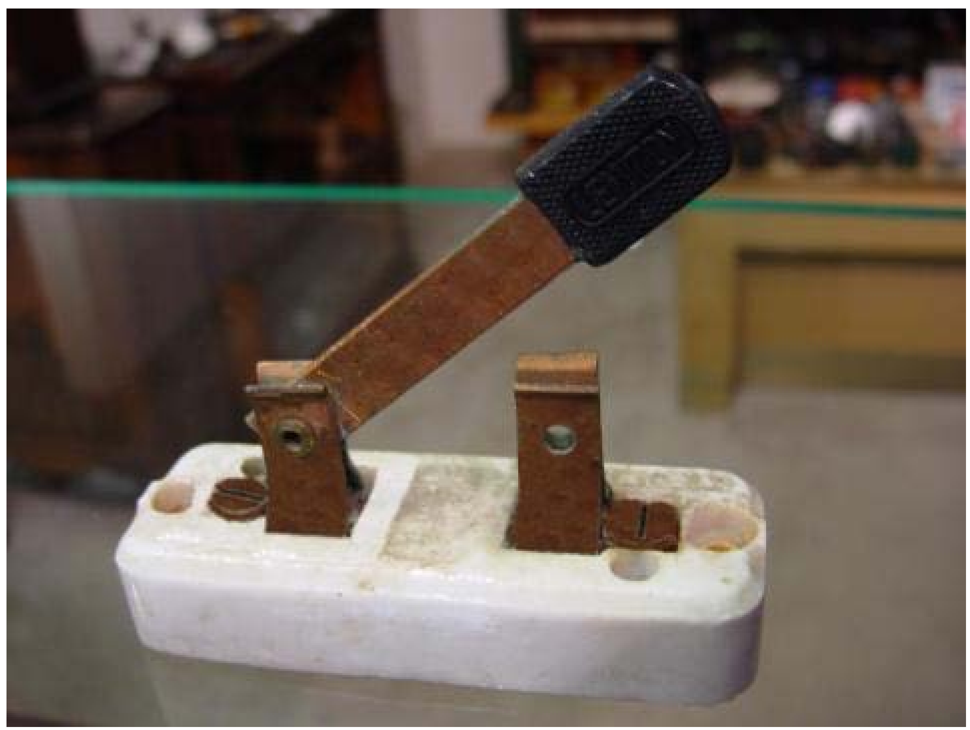
difference in current between
the "hot" and "neutral" conductors
will only exist
if there is current through the ground connection,
meaning that there is a fault in the system.



Ground Fault Current Interruptors,
or
GFCIs


"Hot"
Source
120 V
"Neutral"
I
I
switches open automatically if the difference between the two currents becomes too great.

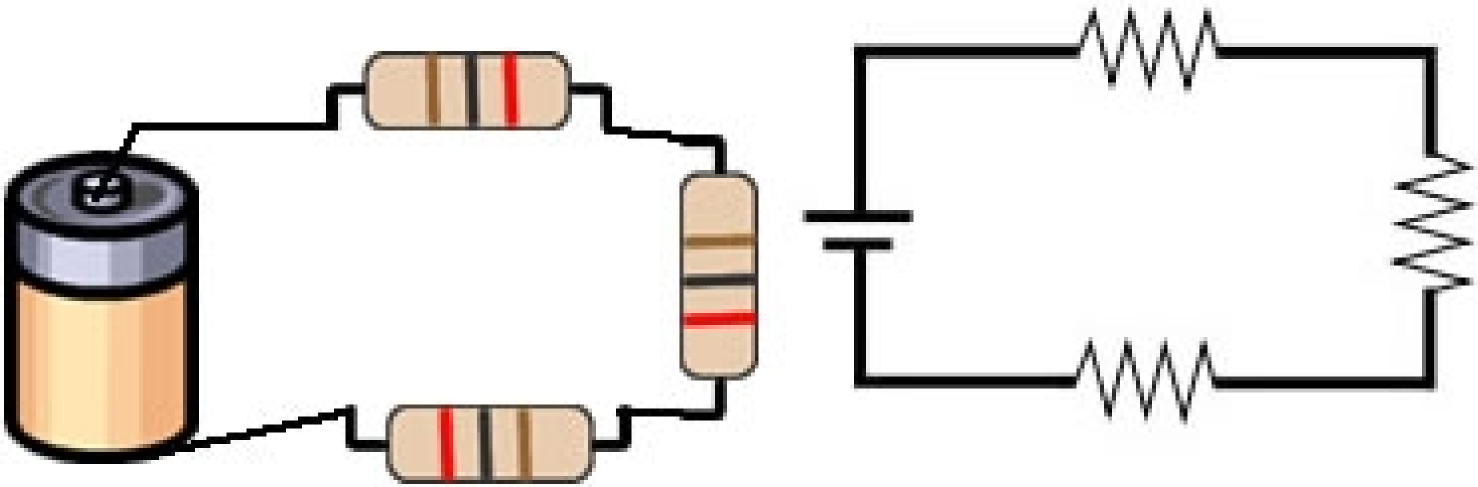

switch
-
Battery
+
It doesn't matter how twisted or convoluted a route the wires take conducting current, so long as they form a complete, uninterrupted loop (circuit).



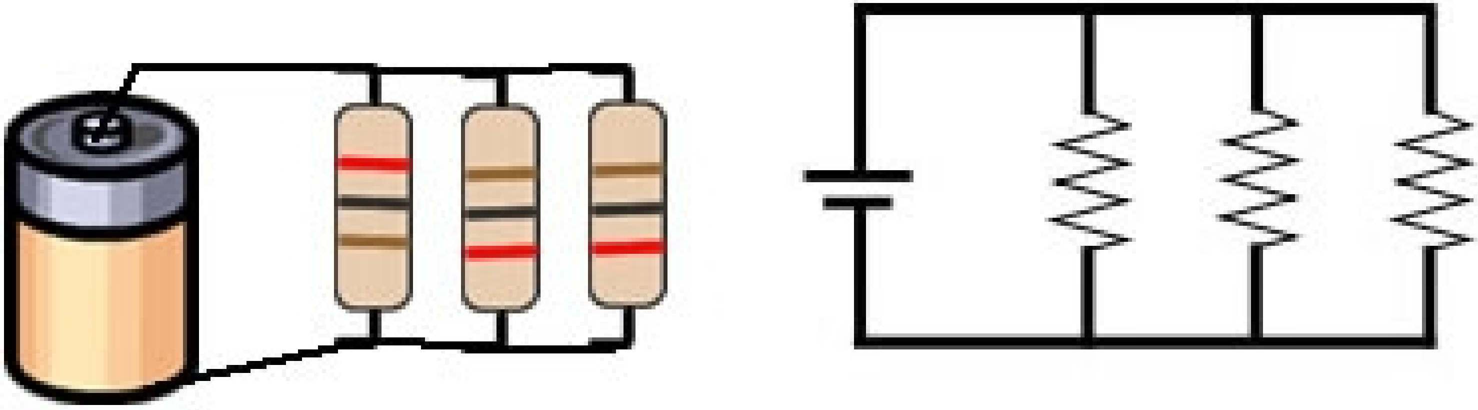
What is
a

SERIES PARALLEL
CIRCUIT?

Series Circuit



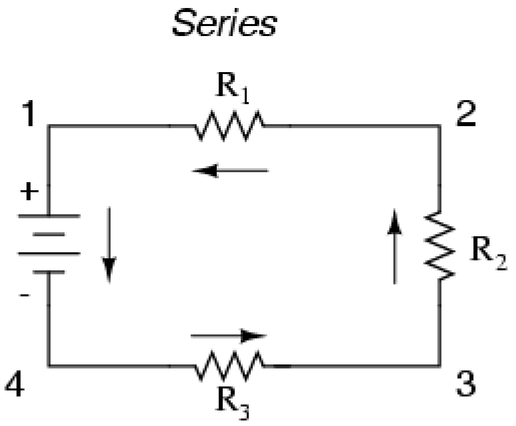
parallel circuit



With simple **series circuits,**

all components are connected end-to-end

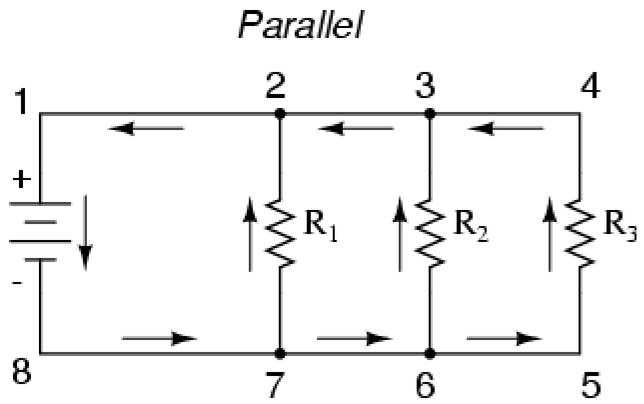
to form only one path for electrons to flow through the circuit:



With simple parallel circuits,

all components are connected between the same two sets of electrically common points,

creating multiple paths for electrons to flow from one end of the battery to the other:

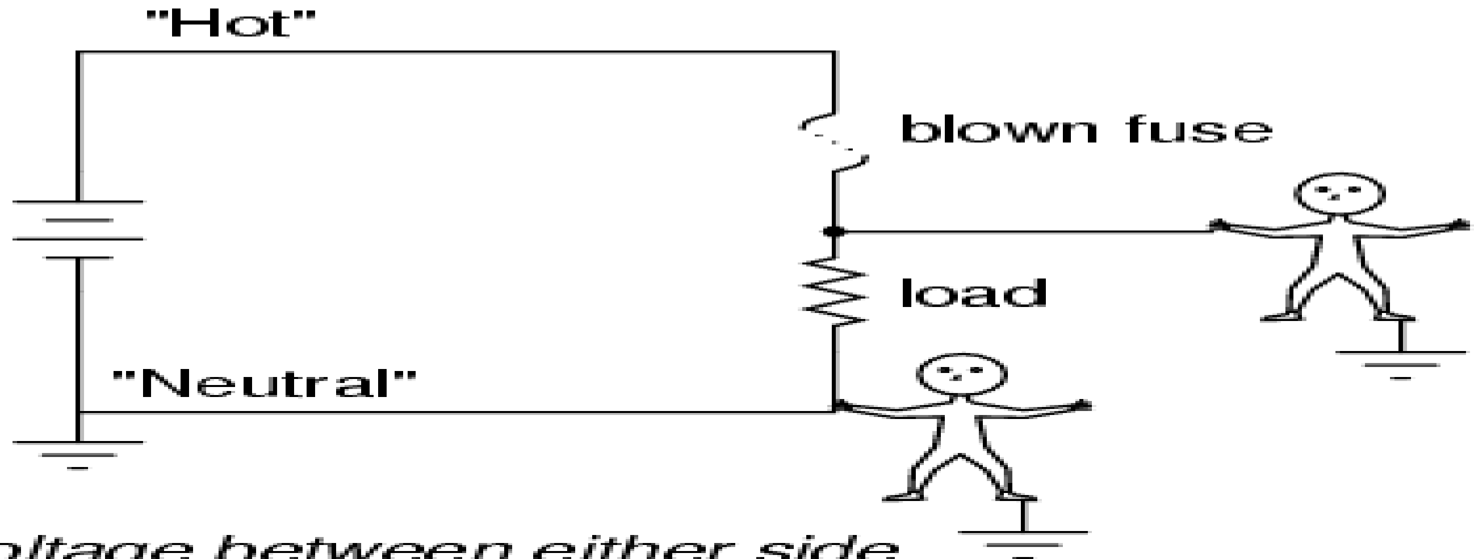


Series Circuits:

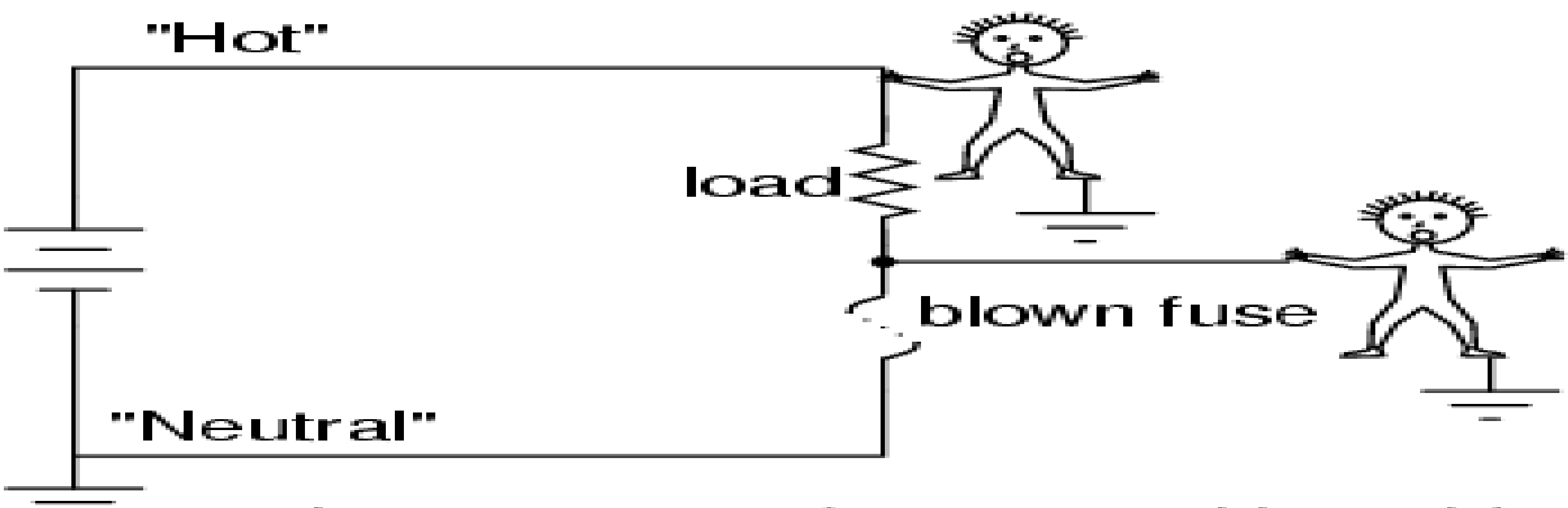
- Voltage drops add to equal total voltage.
- All components share the same (equal) current.
- Resistances add to equal total resistance.

•Parallel Circuits:

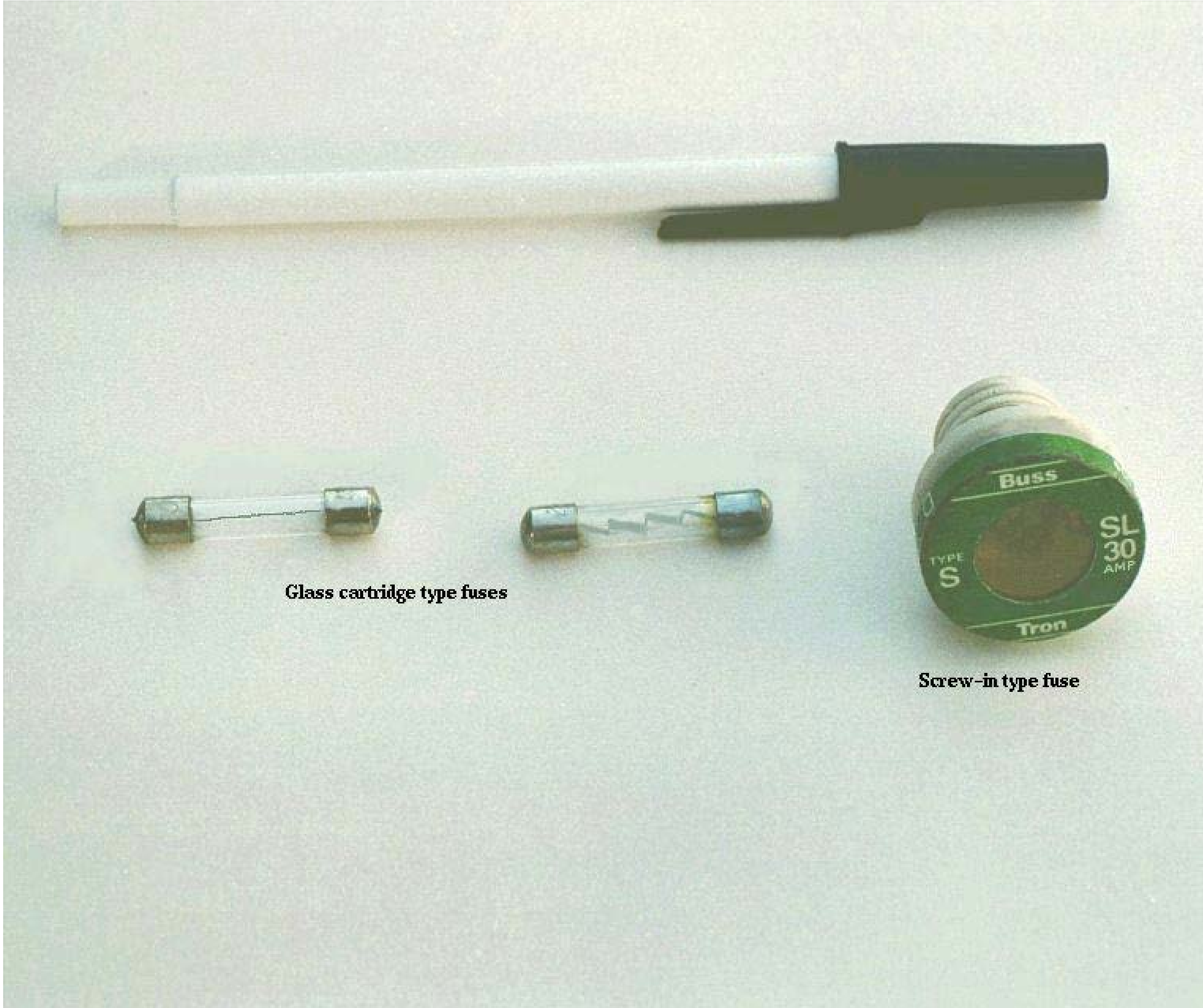
- All components share the same (equal) voltage.
- Branch currents add to equal total current.
- Resistances diminish to equal total resistance.



no voltage between either side of load and ground

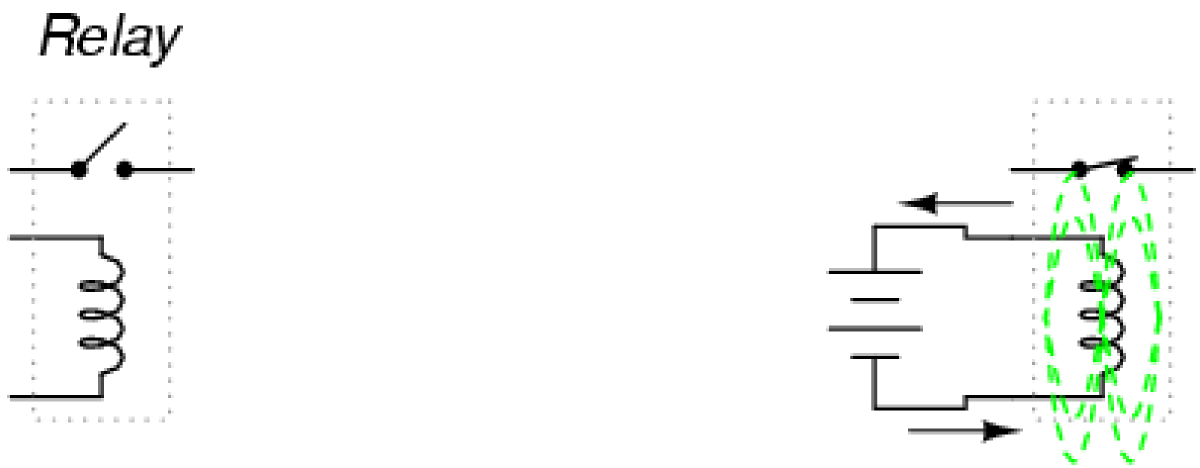


voltage present between either side of load and ground!



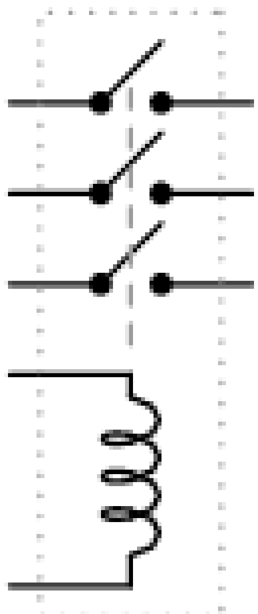
Glass cartridge type fuses

Screw-in type fuse

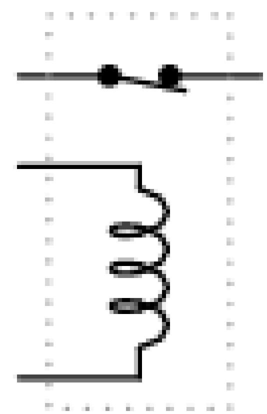


Applying current through the coil causes the switch to close.

Multiple-contact relay



Relay with "normally-closed" contact



Ohm's Law

	Resistance	Current	Voltage
Definition	The opposition to the flow of charges	The flow of electrons through a circuit	Potential Difference (the push behind electricity)
Symbol	R	I	V
Equation	$R = \frac{V}{I}$	$I = \frac{V}{R}$	$V = I R$

	Resistance	Current	Voltage
Label	Ω - Omega symbol	A - amperes	V - volts
Depends on	**The size of the wire.** Thick wire – Less resistance Thin wire – More resistance Long wire – more resistance Short wire- less resistance	The resistance in the circuit Greater resistance- less current Less resistance the greater the current	The voltage source Greater Potential difference = greater voltage

	Resistance	Current	Voltage
Label	Ω - Omega symbol	A - amperes	V - volts

Two symbols same meaning

	Resistance	Current	Voltage
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Symbol	R	I	V
Equation	$R = \frac{V}{I}$	$I = \frac{V}{R}$	$V = I R$

To obey Ohm's law means a conductor has a constant resistance regardless of the voltage.

- If you know two of the three variables you should be able to solve for the third.
- When using Ohm's law always use the 3 step form
  - 1. Write the equation
  - 2. Replace the known values
  - 3. Solve the problem
  - . Label with the correct unit of measurement.

Practice problems

In a circuit, 0.5 A is flowing through the bulb. The voltage across the bulb is 4.0 V. What is the bulbs resistance?

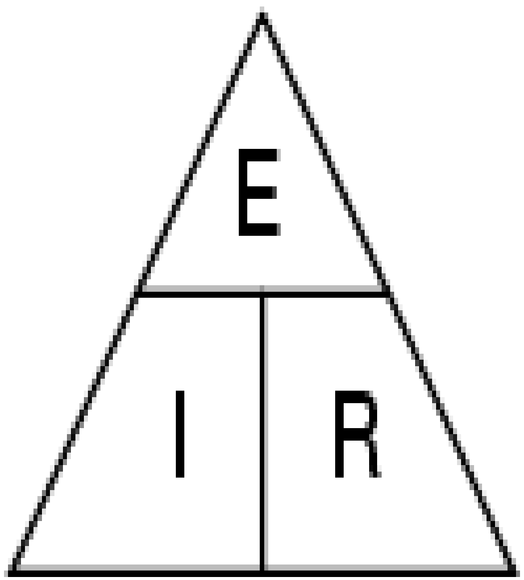
1. Write the equation → $R = \frac{V}{I}$
2. Replace the known values → $R = \frac{4.0}{0.5}$
3. Solve → $R = 8$
4. Label → $R = 8\ \Omega$

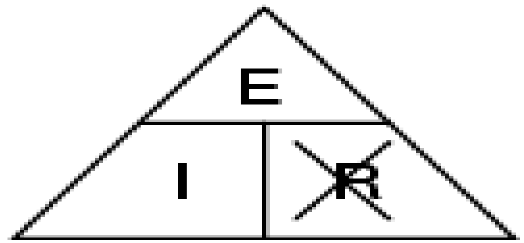
Practice problem

- You light a light bulb with a 1.5 volt battery. If the bulb has a resistance of 10 ohms, how much current is flowing?

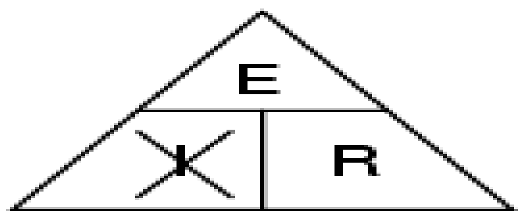
1. Write the equation → $I = \frac{V}{R}$
2. Replace the known values → $I = \frac{1.5}{10}$
3. Solve → $I = 0.15$
4. Label correct sig.fig → $I = 0.2\ A$

Quantity	Symbol	Unit of Measurement	Unit Abbreviation
Current	I	Ampere ("Amp")	A
Voltage	E *or* V	Volt	V
Resistance	R	Ohm	Ω

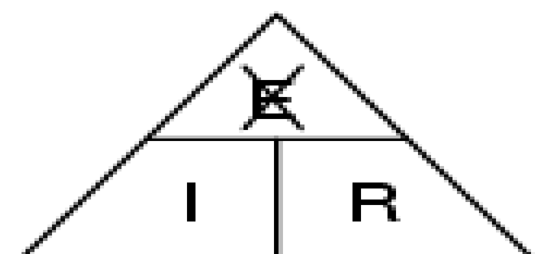




$$R = \frac{E}{I}$$



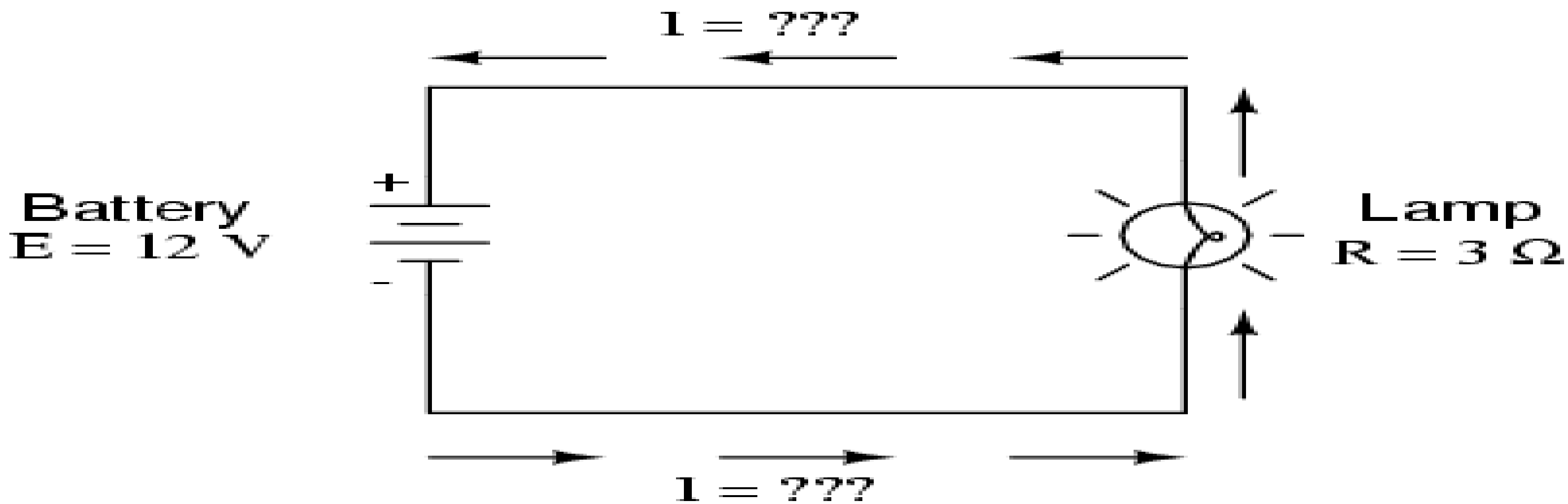
$$I = \frac{E}{R}$$



$$E = I\,R$$

$$I = \frac{E}{R} \qquad\qquad R = \frac{E}{I}$$

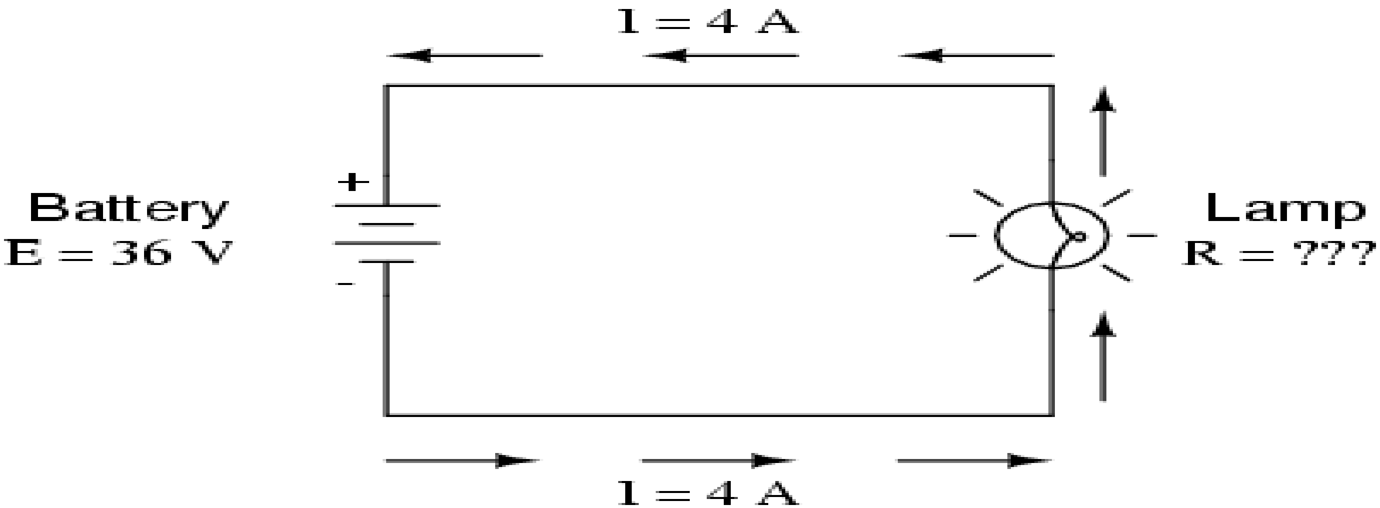
What is the amount of current (I) in this circuit?



$$I = \frac{E}{R} = \frac{12\ V}{3\ \Omega} = 4\ A$$

$$I = \frac{E}{R} \qquad\qquad R = \frac{E}{I}$$

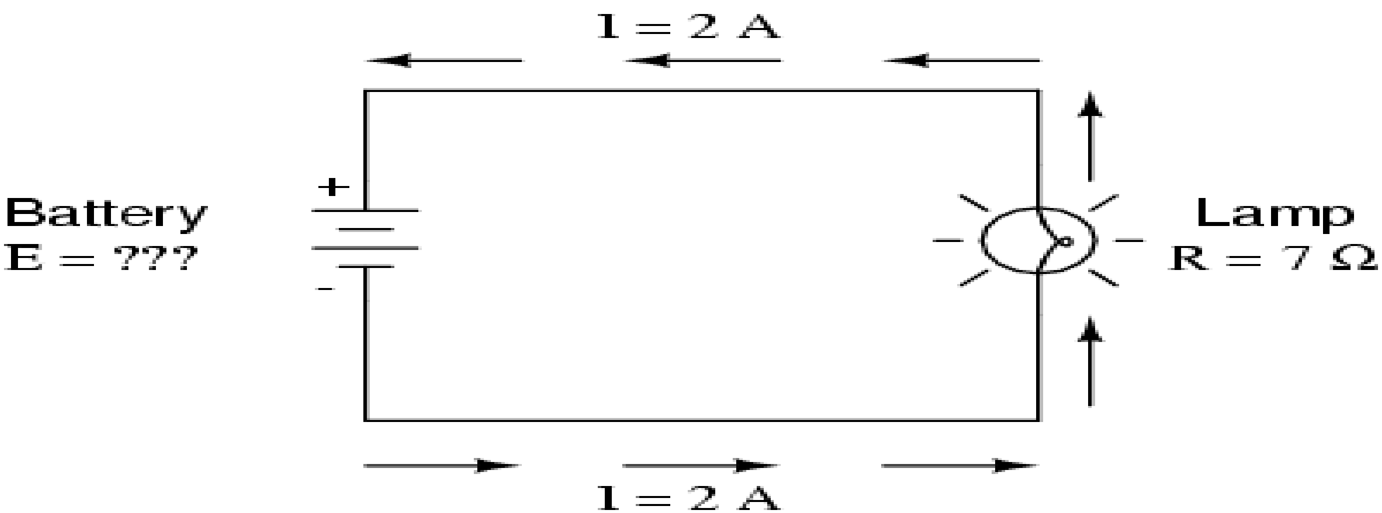
What is the amount of resistance (R) offered by the lamp?



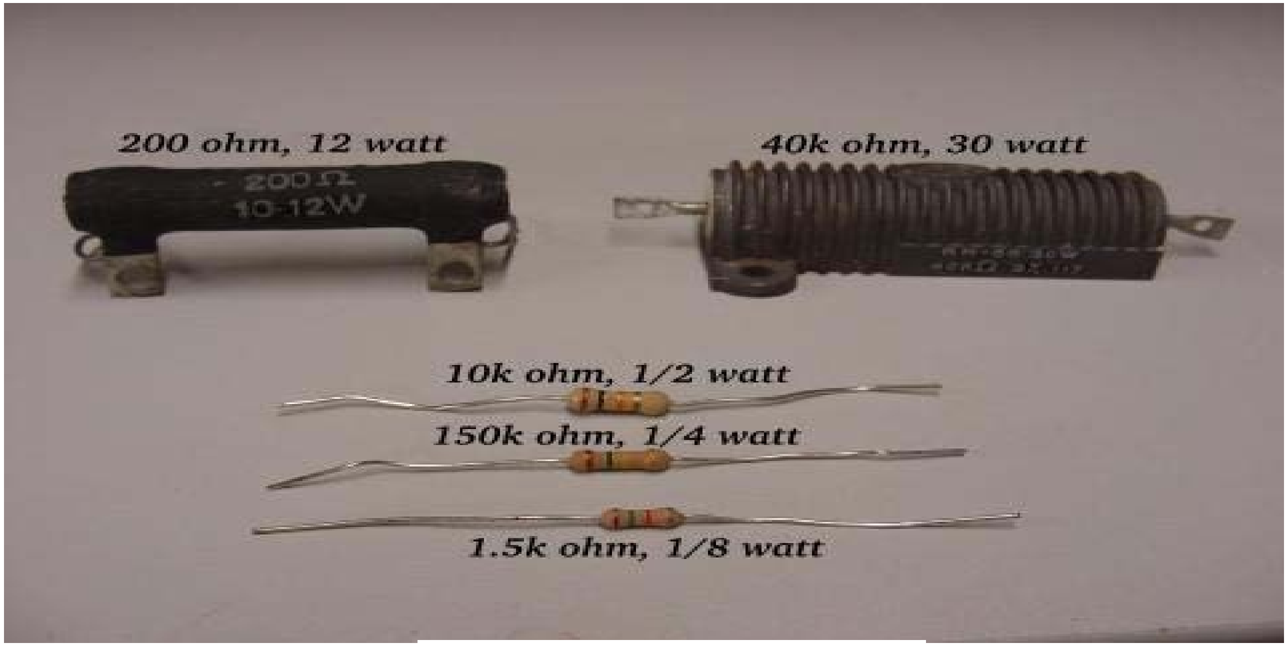
$$R = \frac{E}{I} = \frac{36\ V}{4\ A} = 9\ \Omega$$

calculate the amount of voltage supplied by a battery, given values of current (I) and resistance (R):

What is the amount of voltage provided by the battery?

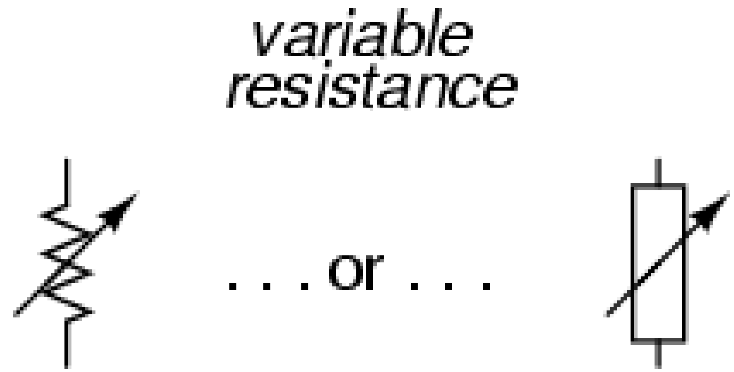


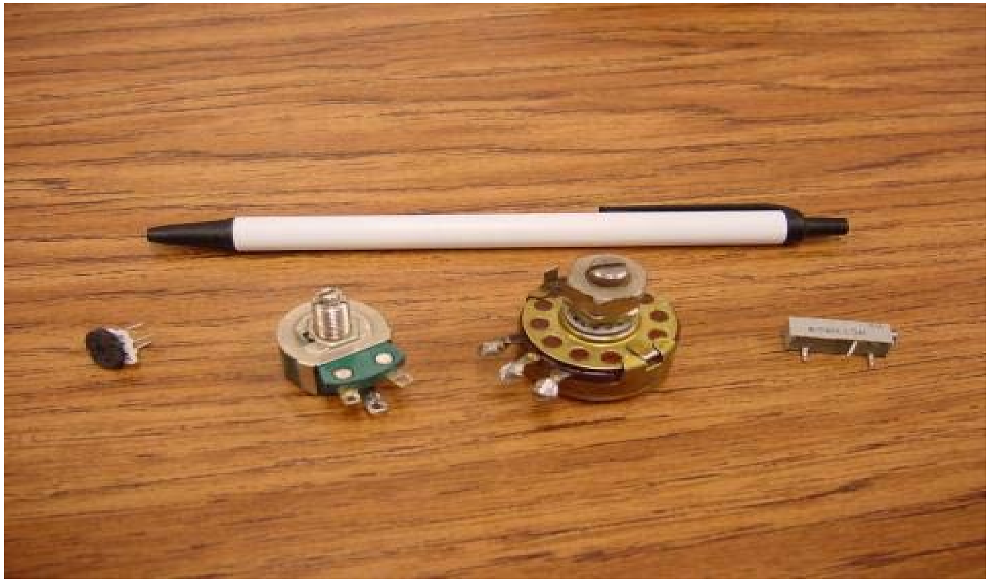
$$E = 1R = (2\ A)(7\ \Omega) = 14\ V$$



schematic symbol for a resistor looks like a small, rectangular box:

component symbol drawn with a diagonal arrow through it, that component has a variable rather than a fixed value. This symbol "modifier" (the diagonal arrow) is standard electronic symbol convention.

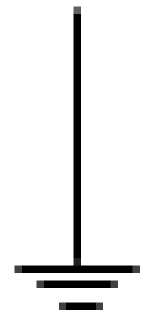




potentiometers

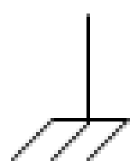
Variable resistors must have some physical means of adjustment, either a rotating shaft or lever that can be moved to vary the amount of electrical resistance.

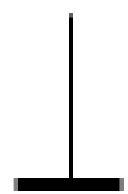
ground



A connection to earth. Used for zero potential reference and electrical shock protection.

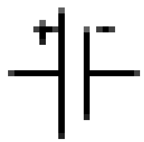
chassis

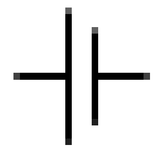




Connected to the chassis of the circuit.

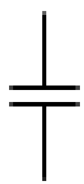
battery

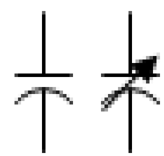




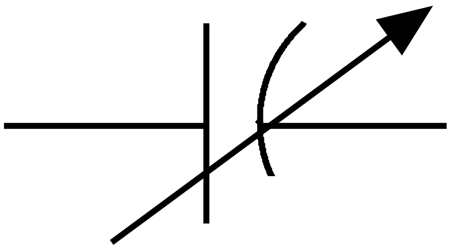
Supplies electrical energy. A battery is more than one cell.

capacitor

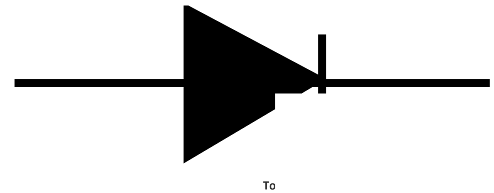




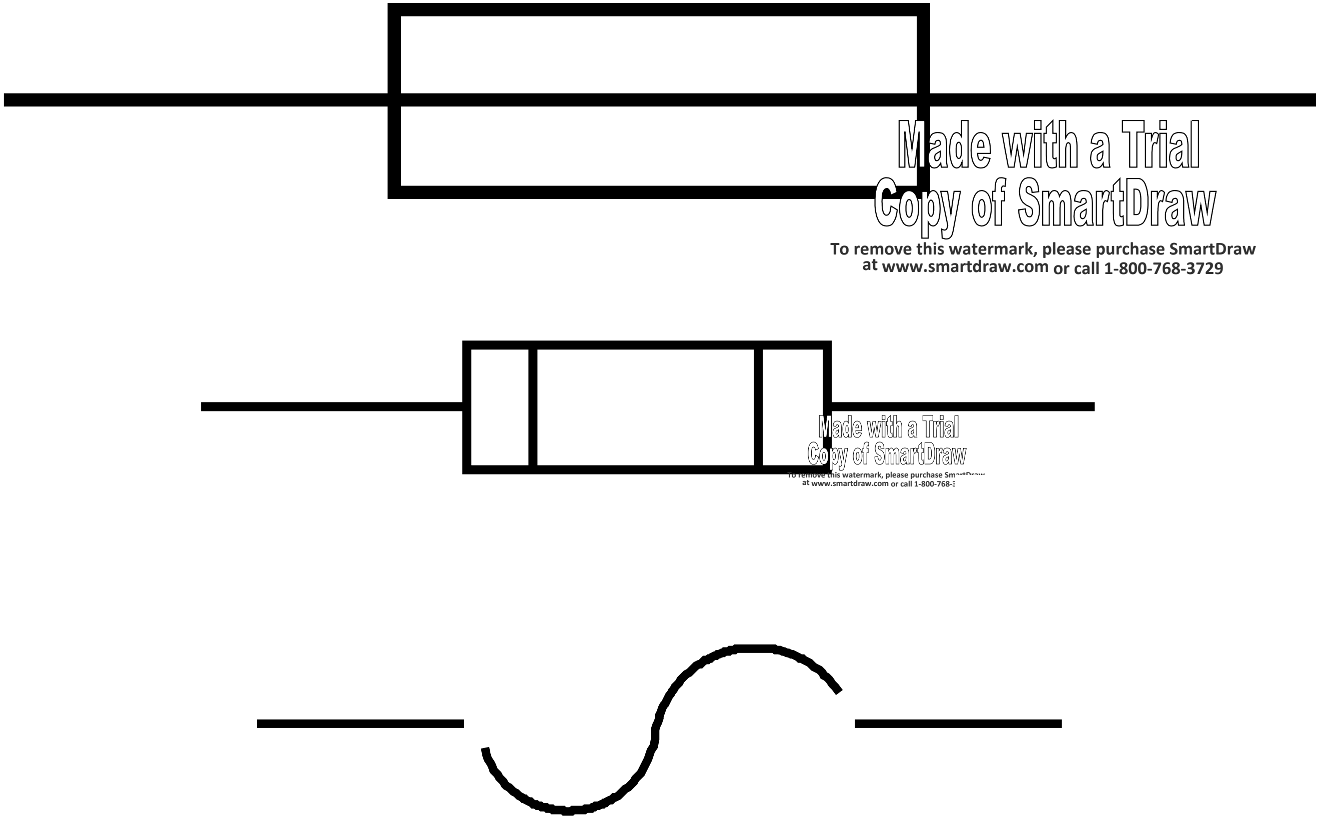
A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit.



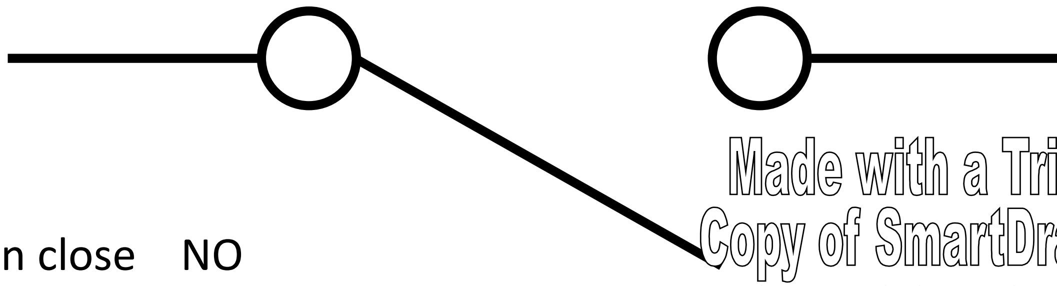
capacitor



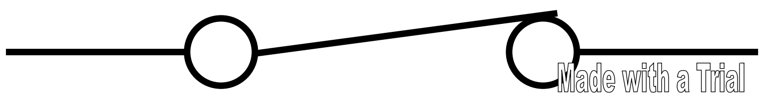
diode



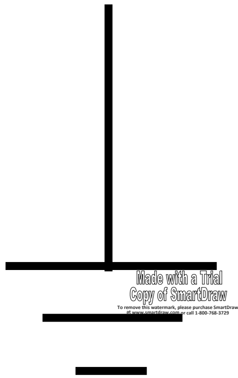
fuse



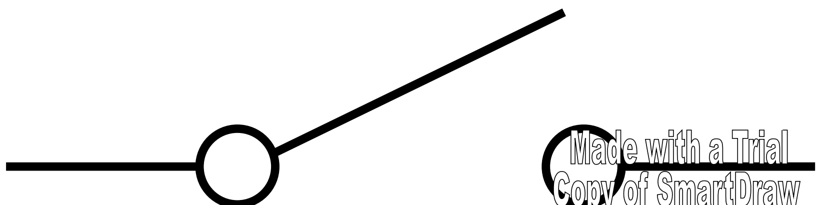
Make on close   NO



Brake on open NC



Earth ground



Single pole switch

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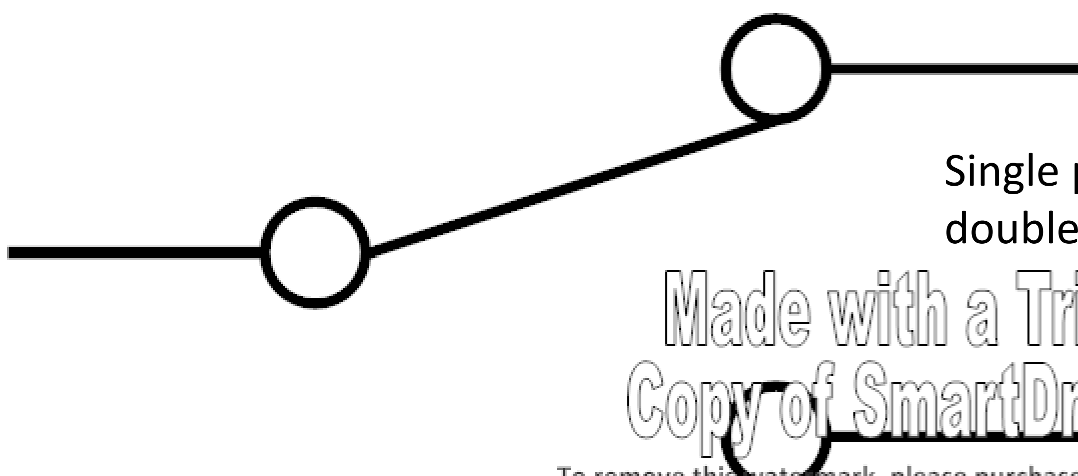

Single pole switch
double throw

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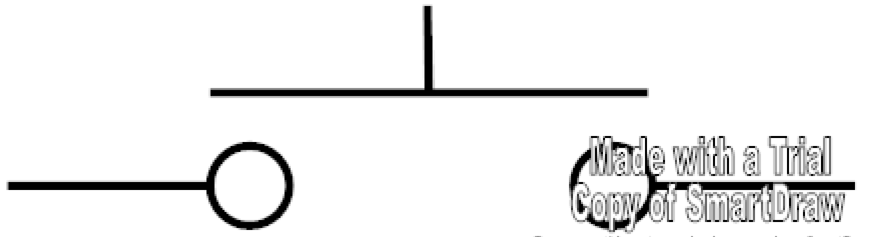
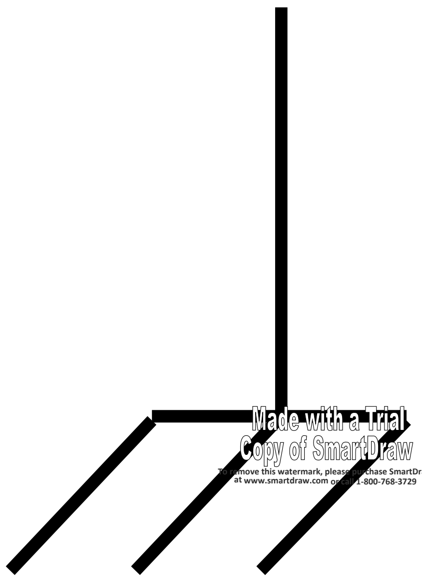
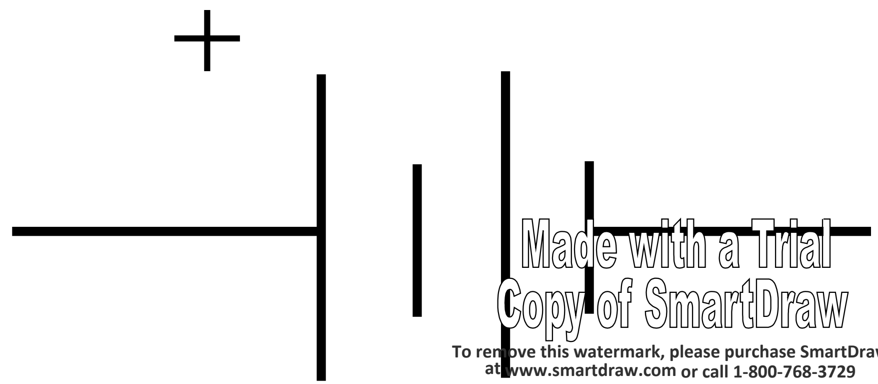


Push button



Chassis ground

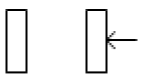


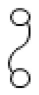
battery

circuit breaker

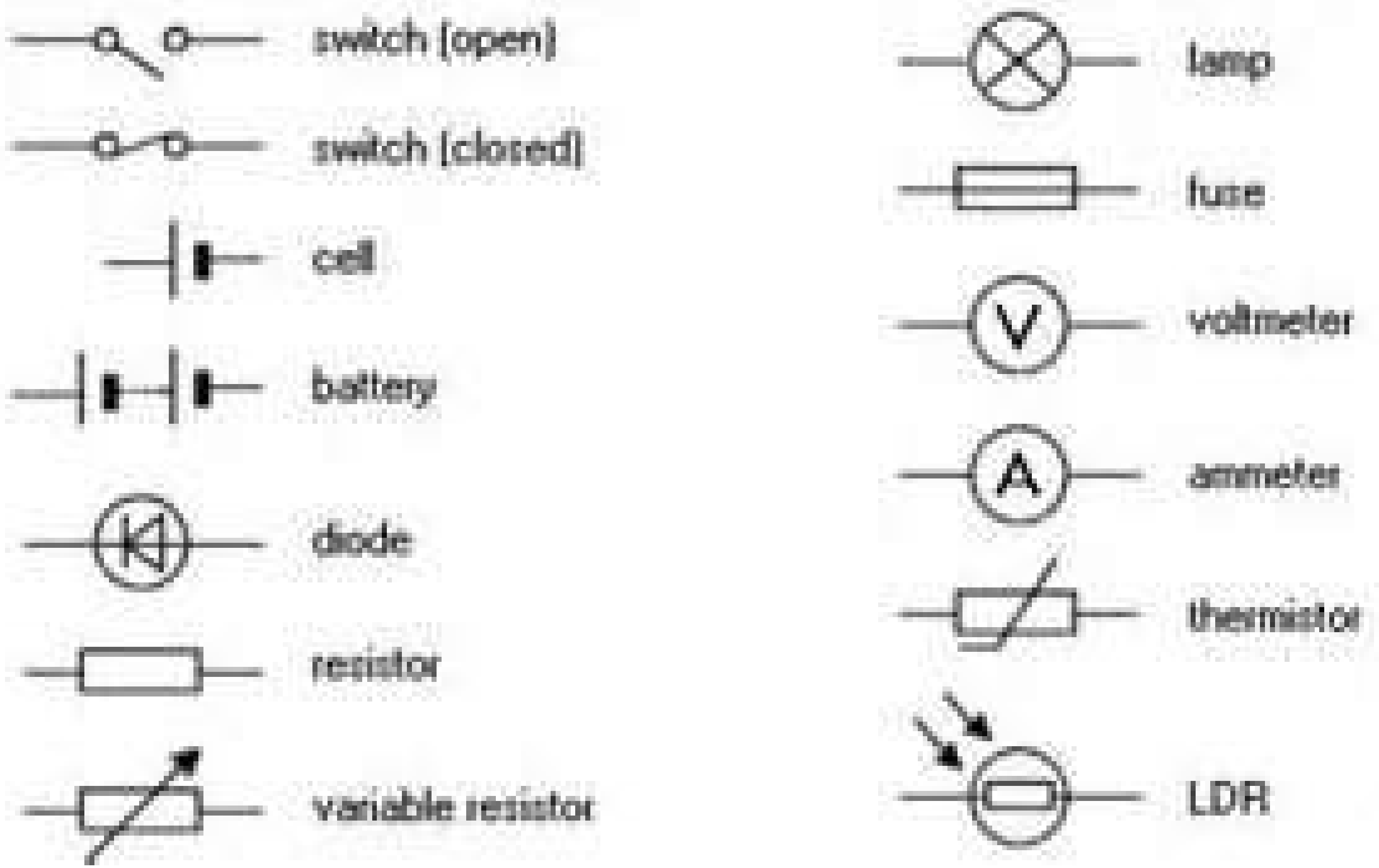
A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.

fuse

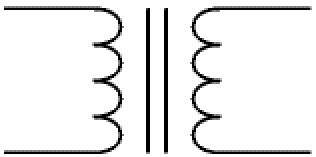




A type of sacrificial overcurrent protection device.

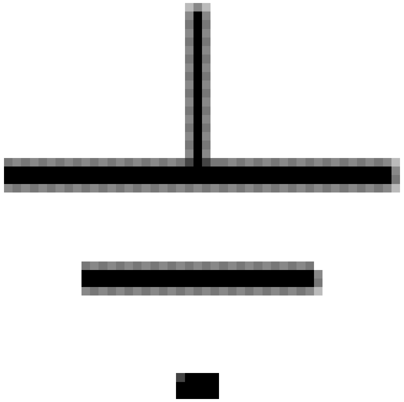

switch (open)
switch (closed)
cell
battery
diode
resistor
variable resistor
lamp
fuse
voltmeter
ammeter
thermistor
LDR

Transformer



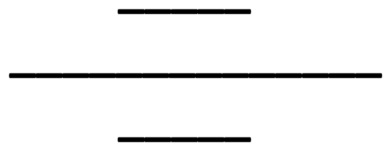
Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field in the core. There is no electrical connection between the coils.

Earth (Ground)



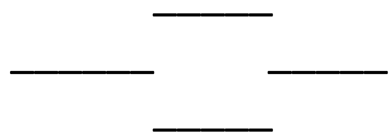
A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.

Fuse



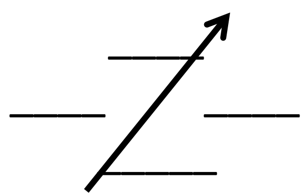
A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.

Resistor



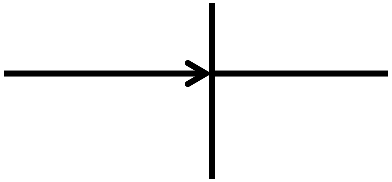
A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit.
Some publications still use the old resistor symbol:

Variable Resistor (Rheostat)



This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.

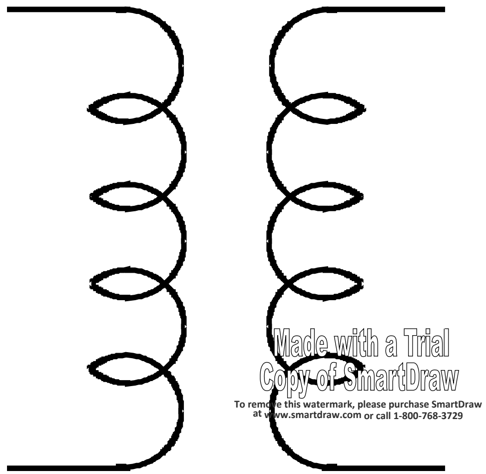
Diode



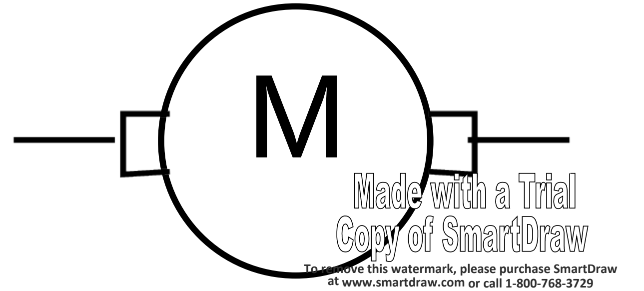
A device which only allows current to flow in one direction.

Inductor
(Coil, Solenoid)

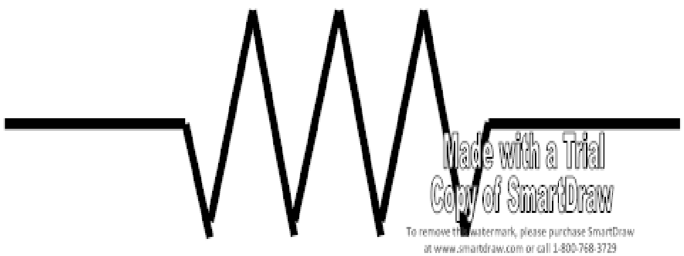
A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something.



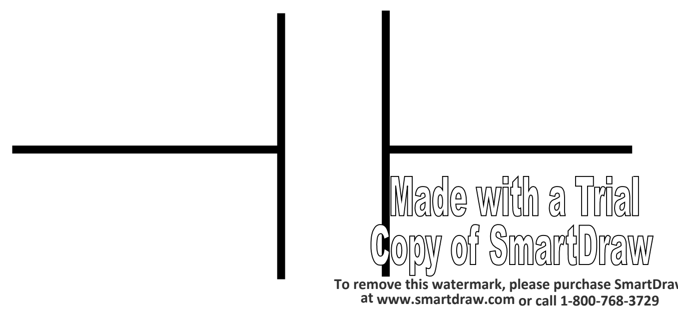
transformer



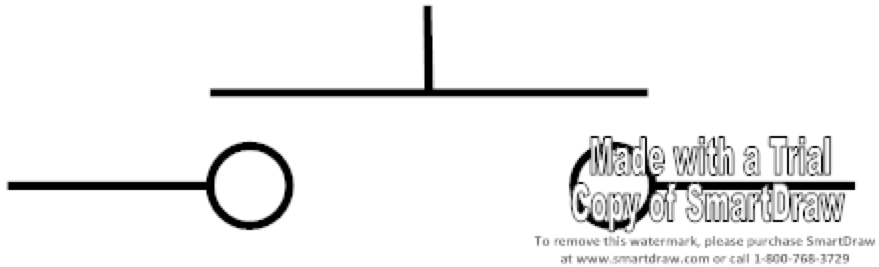
motor



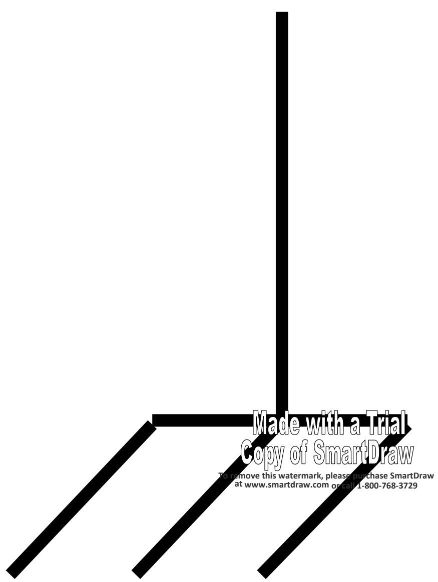
resistor



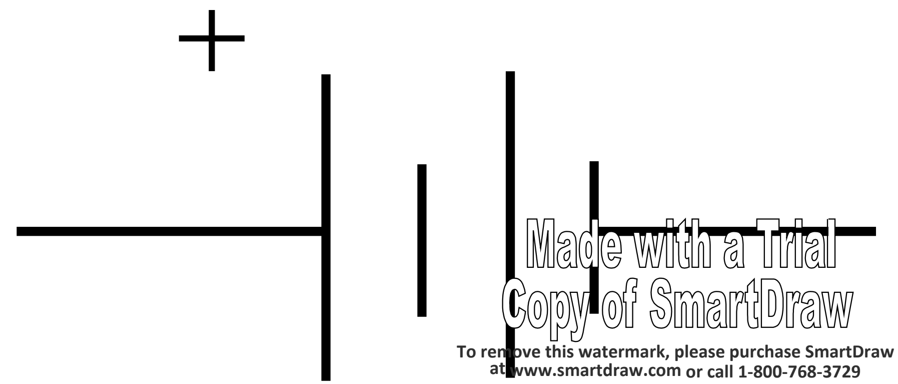
capacitor



Push button



Chassis ground



battery

Article 525 of the National Electrical Code covers the installation of portable wiring and equipment for carnivals, circuses, exhibitions, fairs, traveling attractions, and similar functions, including wiring in or on all structures.

If you use electric motors to circulate water in a tank that guests might touch,

Article 680 applies.
A key provision: 680.22(A)(1) permits a GFCI-protected single locking-type receptacle for a water-pump motor between 5 feet and 10 feet from the water

Overhead conductor clearances

Overhead conductors
must have a clearance of 15 feet
from amusement rides and attractions
(except, of course, for the conductors that supply power to the
ride or attraction) [525.5(B)].

For overhead conductors installed outside tents and concession areas,
the vertical clearance requirements of 225.18 apply [525.5(A)].

The minimums are:

- 10 feet above
finished grade, sidewalks, platforms, or projections
from which they might be accessible to pedestrians
for 120V, 120/208V, 120/240V, or 240V circuits.

- 12 feet
above residential property and driveways,
and those commercial areas not subject to truck traffic
for 120V, 120/208V, 120/240V, 240V, 277V, 277/480V, or 480V
circuits.

•

18 feet

over public streets, alleys, roads, parking areas subject to truck traffic,

driveways on other than residential property,

and other areas traversed by vehicles

(such as those used for cultivation, grazing, forestry, and orchards).

525.21 Disconnecting Means.

A means to disconnect each portable structure
from all ungrounded conductors shall be provided.
The switch shall consist of
no more than six enclosed switches
or circuit breakers
and shall located within sight of and
within 6 feet of the operator’s station.

525.20 **Portable Cords**.

Portable cords shall be size 12 or larger

Type G, PPE, S, SE, SEO, SEOO, SC, SCE, SCT, SO, SOO, ST, STO, STOO, W

or other types identified for extra-hard usage,

and must be of the grounding type.

The cord type is printed or embossed on approved cords.

Two-wire cords are not allowed.

Cables with a “J” in the type designation (such as Type SJT) are junior-hard-service rated

and are not permitted where subject to physical damage.

When used outdoors, cords shall be listed for wet locations and be sunlight resistant,

unless they are an integral part of listed portable equipment.

All cords shall be continuous and contain no splices.

Repair of the cord outer jacket only may be done

with heavy-wall heat-shrink tubing with proper adhesive or

by a vulcanizing process.

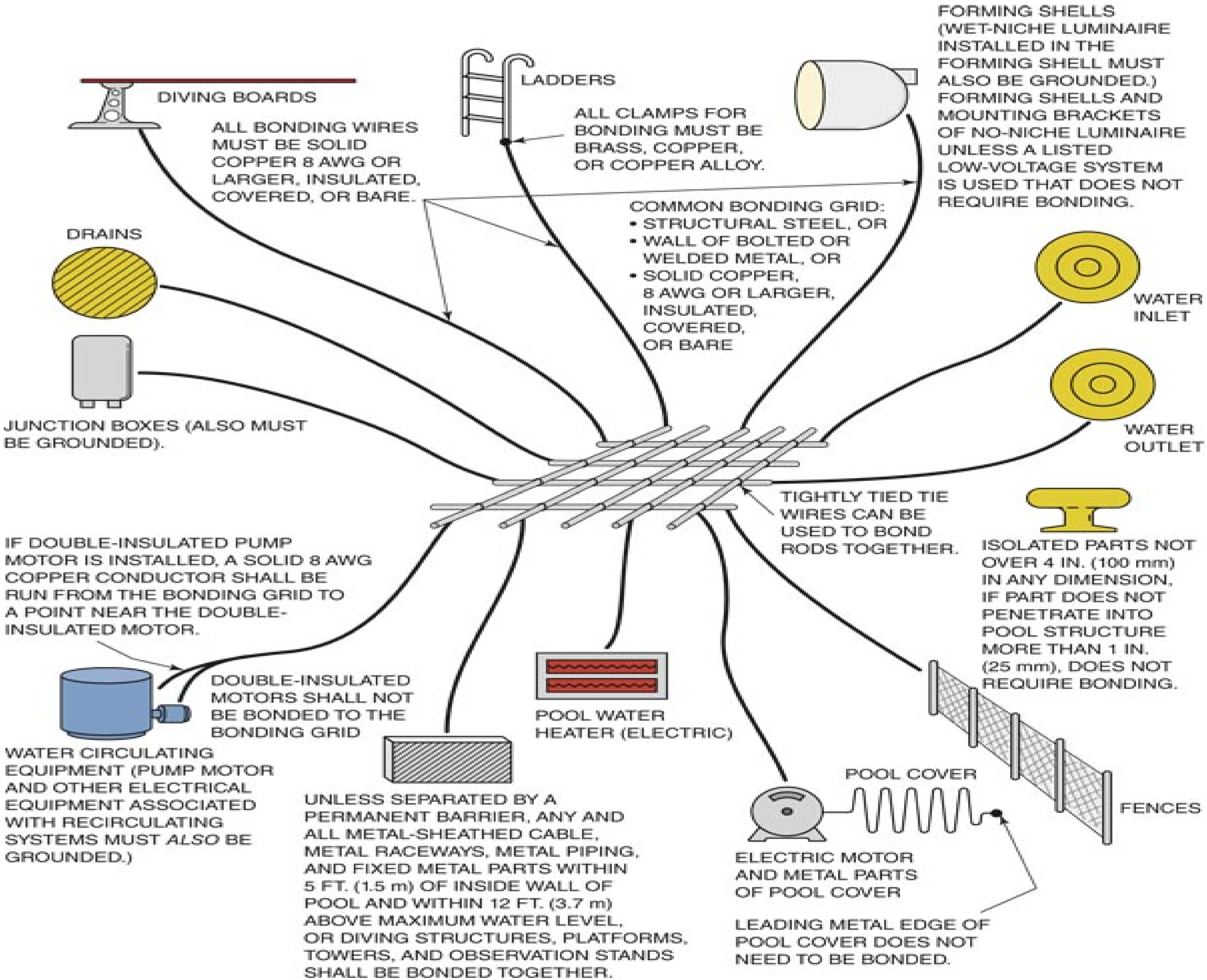
240.20 & 240.22 Overcurrent Protective Devices.
Motors and lighting circuits
shall have separate fuses or circuit breakers.

Lighting circuits shall be protected
at no more than 20 amperes.
Motors shall be protected
at not over 125% of full load current
or shall be thermally protected.

525.31 **Equipment Grounding.**

Equipment grounding conductors
shall be run with all feeders and branch circuits.

Exposed metal parts of electrical equipment shall be bonded,
and if cord connected,
the cord shall have a grounding conductor
and grounding type attachment plug.
Equipment that is listed and labeled as double insulated is permitted.
All grounding conductors in an enclosure
shall terminate in a common grounding bus or lugs.
The equipment grounding bar or
lug(s) shall be secured to the electrical enclosure
with screws or bolts used for no other purpose.
Approved means shall be used
to connect equipment grounding conductors to enclosures.
Equipment grounding conductors
shall be isolated from
grounded circuit conductors.



FORMING SHELLS (WET-NICHE LUMINAIRE INSTALLED IN THE FORMING SHELL MUST ALSO BE GROUNDED.) FORMING SHELLS AND MOUNTING BRACKETS OF NO-NICHE LUMINAIRE UNLESS A LISTED LOW-VOLTAGE SYSTEM IS USED THAT DOES NOT REQUIRE BONDING.
LADDERS
DIVING BOARDS
ALL CLAMPS FOR BONDING MUST BE BRASS, COPPER, OR COPPER ALLOY.
ALL BONDING WIRES MUST BE SOLID COPPER 8 AWG OR LARGER, INSULATED, COVERED, OR BARE.
COMMON BONDING GRID:
• STRUCTURAL STEEL, OR
• WALL OF BOLTED OR WELDED METAL, OR
• SOLID COPPER, 8 AWG OR LARGER, INSULATED, COVERED, OR BARE
DRAINS
WATER INLET
JUNCTION BOXES (ALSO MUST BE GROUNDED).
WATER OUTLET
TIGHTLY TIED TIE WIRES CAN BE USED TO BOND RODS TOGETHER.
IF DOUBLE-INSULATED PUMP MOTOR IS INSTALLED, A SOLID 8 AWG COPPER CONDUCTOR SHALL BE RUN FROM THE BONDING GRID TO A POINT NEAR THE DOUBLE-INSULATED MOTOR.
ISOLATED PARTS NOT OVER 4 IN. (100 mm) IN ANY DIMENSION, IF PART DOES NOT PENETRATE INTO POOL STRUCTURE MORE THAN 1 IN. (25 mm), DOES NOT REQUIRE BONDING.
DOUBLE-INSULATED MOTORS SHALL NOT BE BONDED TO THE BONDING GRID
POOL WATER HEATER (ELECTRIC)
WATER CIRCULATING EQUIPMENT (PUMP MOTOR AND OTHER ELECTRICAL EQUIPMENT ASSOCIATED WITH RECIRCULATING SYSTEMS MUST *ALSO* BE GROUNDED.)
POOL COVER
FENCES
UNLESS SEPARATED BY A PERMANENT BARRIER, ANY AND ALL METAL-SHEATHED CABLE, METAL RACEWAYS, METAL PIPING, AND FIXED METAL PARTS WITHIN 5 FT. (1.5 m) OF INSIDE WALL OF POOL AND WITHIN 12 FT. (3.7 m) ABOVE MAXIMUM WATER LEVEL, OR DIVING STRUCTURES, PLATFORMS, TOWERS, AND OBSERVATION STANDS SHALL BE BONDED TOGETHER.
ELECTRIC MOTOR AND METAL PARTS OF POOL COVER
LEADING METAL EDGE OF POOL COVER DOES NOT NEED TO BE BONDED.

525.11 Multiple Sources of Supply.

Where multiple separately derived systems
or services or both supply rides,
games, attractions or other structures
that are separated by less than 12 feet,
all sources shall be bonded
to the same grounding electrode system.

The bonding conductor shall be copper
and sized in accordance with Table 250.122
based on the
largest overcurrent device supplying the portable structures,

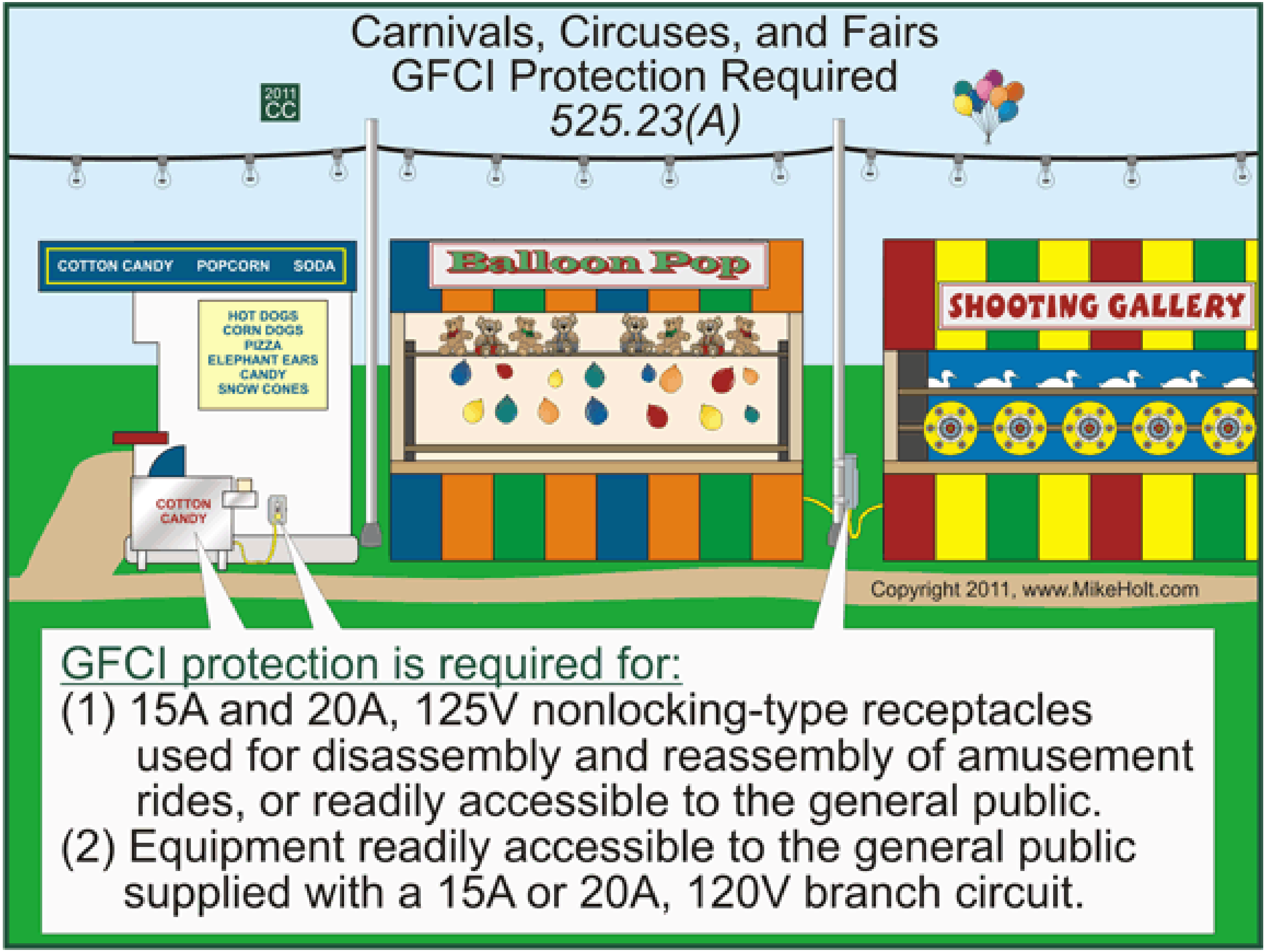
but not smaller than 6 AWG.

525.23 Ground-Fault Circuit-Interrupter Protection.

All 125-volt, single phase,
15- and 20-ampere receptacle outlets
that are in use by personnel
or readily accessible to the general public
shall have listed GFCI protection.
Manufactured cord sets
incorporating listed ground-fault circuit-interrupter protection
for personnel shall be permitted.
Egress lighting shall not be connected
to the load side
of a ground-fault circuit-interrupter device.

525.21 **Portable Wiring Inside Tents.**

Wiring for temporary lighting,
where installed inside tents and concessions,
shall be securely installed
and shall be protected from accidental breakage
by a suitable fixture
or lamp-holder with a guard.
Overhead lighting
may be installed with approved Type SO cord sets.
Festoon lighting
or cord sets shall be installed
at groundleast 10 feet above
where accessible to the public.


Carnivals, Circuses, and Fairs
GFCI Protection Required
525.23(A)
2011
CC
COTTON CANDY POPCORN SODA
HOT DOGS
CORN DOGS
PIZZA
ELEPHANT EARS
CANDY
SNOW CONES
COTTON
CANDY
Balloon Pop
SHOOTING GALLERY
Copyright 2011, www.MikeHolt.com
GFCI protection is required for:
(1) 15A and 20A, 125V nonlocking-type receptacles used for disassembly and reassembly of amusement rides, or readily accessible to the general public.
(2) Equipment readily accessible to the general public supplied with a 15A or 20A, 120V branch circuit.

525.5 **Overhead Clearances.**

A clearance of 15 feet

in any direction shall be maintained
from overhead conductors operating at 600 volts
or less and
any portion of an amusement ride or attraction.
No portion of an amusement ride or attraction
may be located under
or within 15 feet horizontally
of conductors operating
at over 600 volts.

Overhead conductors must have a 15 foot clearance from amusements attractions

Can not be located under or within 15 feet horizontally of conductors of 600 volts or more.

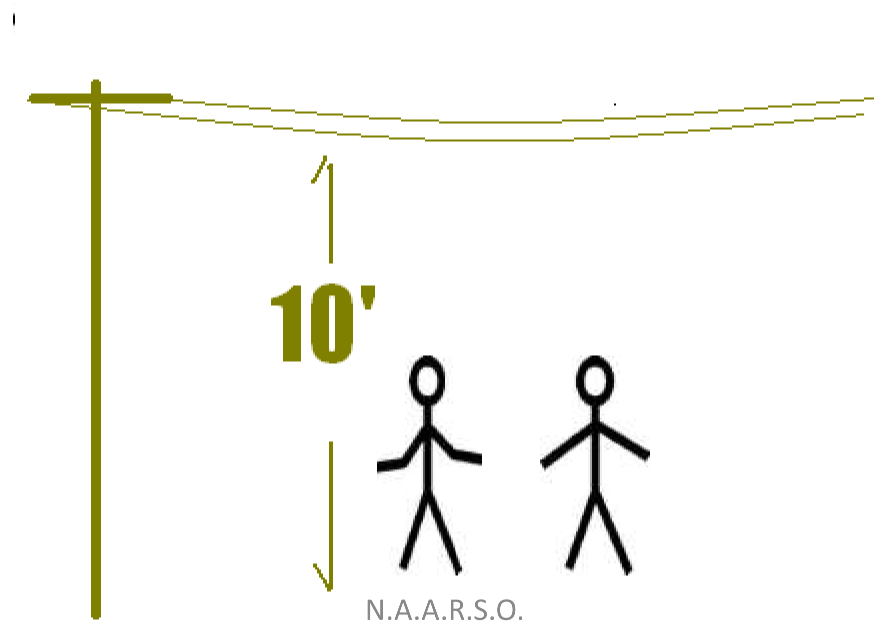
Conductor must be 10 feet or above grade

Conductor must be 12 feet or above property and driveways

18 feet for public streets and areas

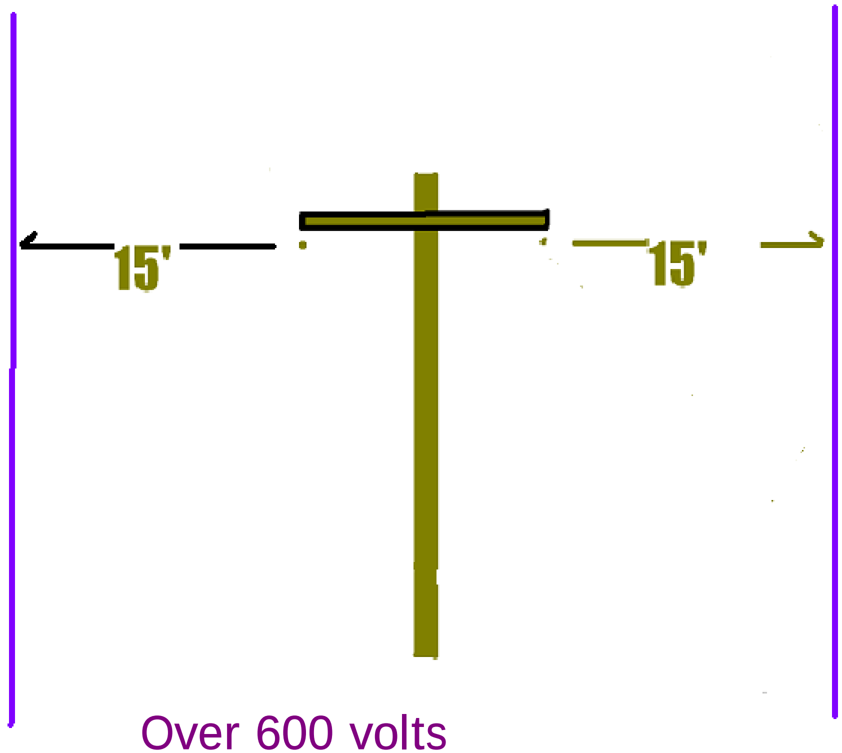
Overhead Conductor Clearances

- 10 ft above finished grade, sidewalks, platforms, or projections from which they might be accessible to pedestrians for 120VFor overhead conductors installed outside tents and concession areas, the vertical clearance requirements of 225.18 apply [525.5(A)] (Figure 525-2). The minimums are:, 120/208V, 120/240V, or 240V circuits.



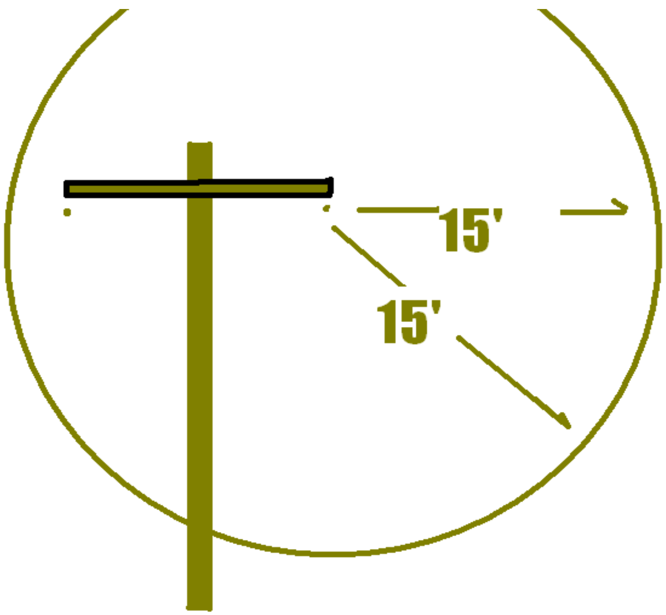
Overhead Conductor Clearances

Amusement rides or attractions shall not be located under or within 15’ horizontally of conductors operating in excess of 600 volts

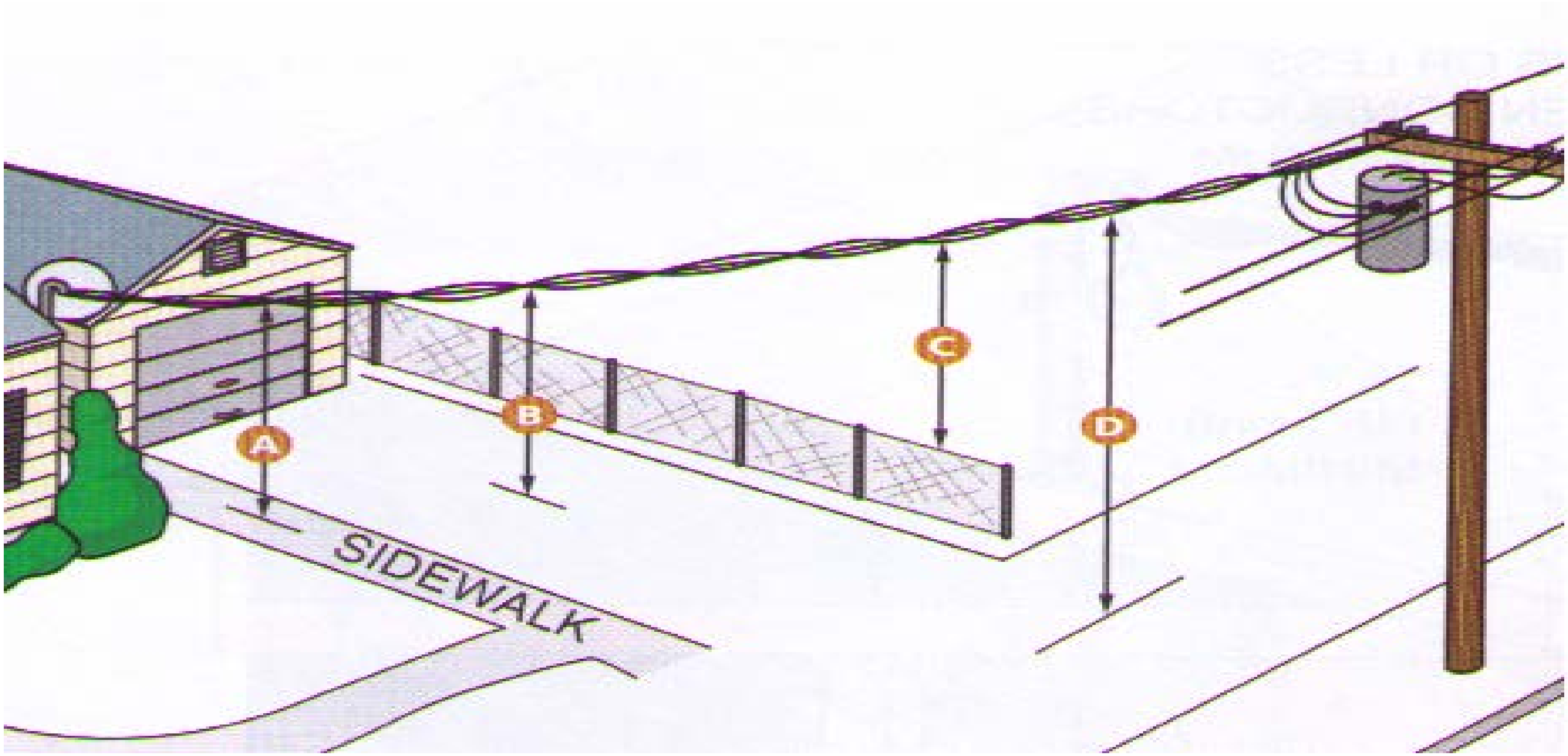


Overhead Conductor Clearances

- Overhead conductors must have a clearance of 15 ft from amusement rides and attractions (except, of course, for the conductors that supply power to the ride or attraction) [525.5(B)].



600 Volts or less



CLEARANCES FOR SERVICE
DROPS –
120/240 VOLT SINGLE PHASE:

A = 10 FT. (3.0 m) MINIMUM

B = 12 FT. (3.7 m) MINIMUM

C = 10 FT. (3.0 m) MINIMUM

D = 18 FT. (5.5 m) MINIMUM

445.13 **Generators.**

Generators or other power supply units
and the associated electrical distribution cords and panelboards
must be inspected at each engagement during the season.

Generators.

The conductors from the generator terminals
to the first overcurrent device
shall not be less than 115 percent
of the nameplate rating of the generator.
To establish ground,
the neutral terminal in the service equipment,
transformer truck,
or generator shall be connected
to an approved grounding electrode system
with a stranded copper grounding electrode conductor
sized not smaller than 4 AWG.
This conductor shall be installed without splice
from the grounding terminal
to the grounding electrode
shall be connected with approved clamps.

Signage on generators

Warning signs must be posted to indicate the danger of high voltage and to restrict access to qualified persons only.

The Generator

A fire extinguisher sized in accordance with the hazard shall be mounted, charged, tagged and readily accessible at the generator enclosure.

Class A - Wood, paper, cloth, trash, plastics

Solid combustible materials that are not metals.

Class B - Flammable liquids: gasoline, oil, grease, acetone

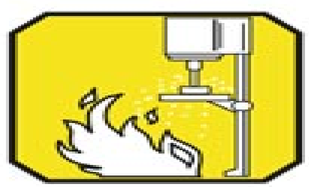
Any non-metal in a liquid state, on fire.

Class C - Electrical: energized electrical equipment

As long as it's "plugged in," it would be considered a class C fire.

Class D - Metals: potassium, sodium, aluminum, magnesium

Unless you work in a laboratory or in an industry that uses these materials, it is unlikely you'll have to deal with a Class D fire. It takes special extinguishing agents (Metal-X, foam) to fight such a fire.

CLASSES OF FIRES		
 CLASS A (GREEN)		• ORDINARY COMBUSTIBLES
 CLASS B (RED)		• FLAMMABLE LIQUIDS AND GASES
 CLASS C (BLUE)		• ELECTRICAL EQUIPMENT
CLASS D (YELLOW)		• COMBUSTIBLE METALS

EXTINGUISHER MARKINGS	
ORDINARY A COMBUSTIBLES (GREEN)	
FLAMMABLE B LIQUIDS (RED)	
ELECTRICAL C EQUIPMENT (BLUE)	


DANGER
HIGH
VOLTAGE

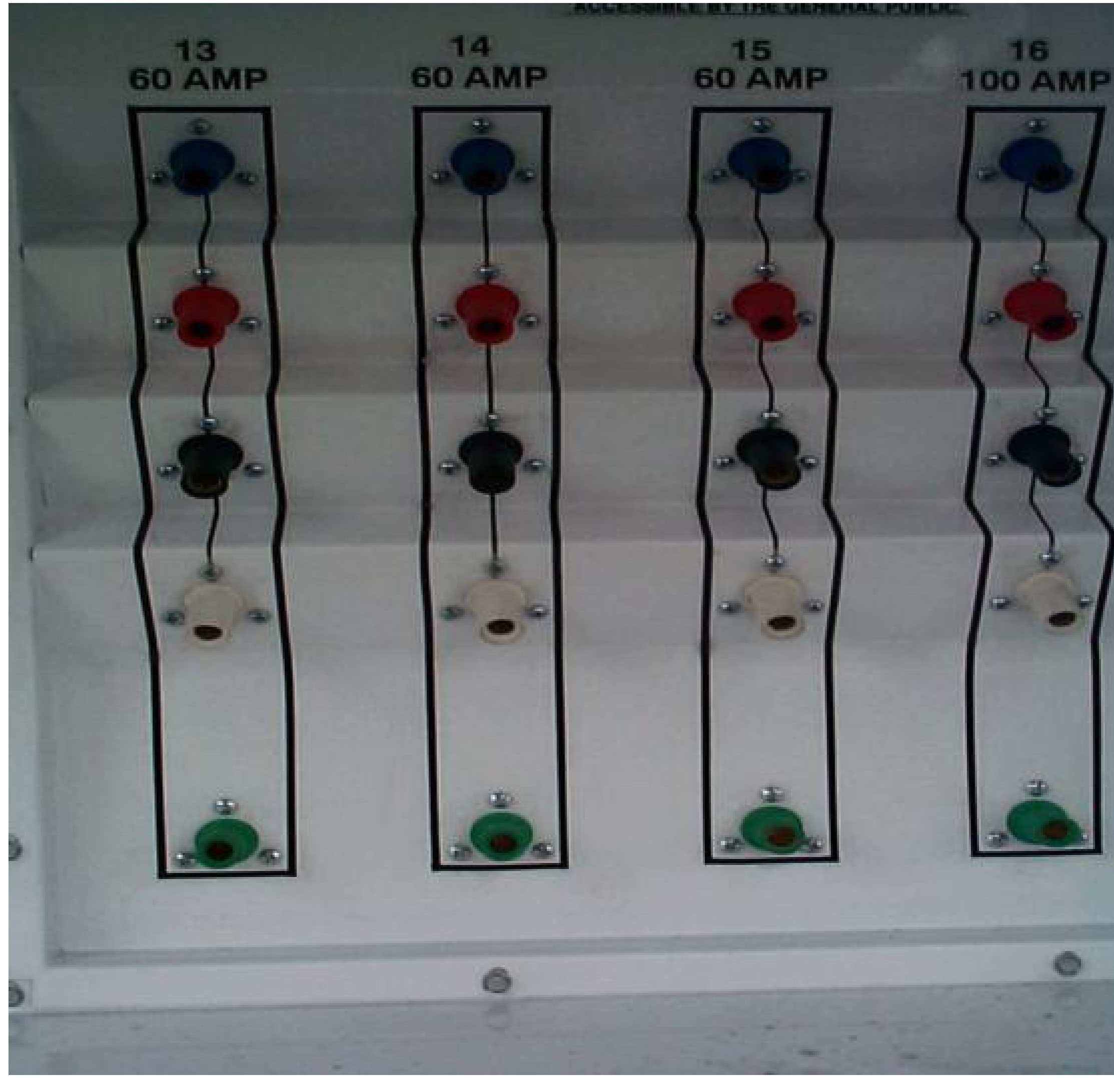
A. **Distribution and termination boxes shall be designed so that no live parts are exposed to accidental contact. Where used outdoors the boxes shall be of weatherproof construction (<u>*wooden distribution boxes prohibited*</u>) and mounted so that the bottom of the enclosure is not less than 6 in. above the ground. Such boxes shall be locked to prevent unauthorized opening Art 525-15(a) and <u>fenced if located in public areas</u>.**


CAUTION
ON 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 ON
OFF
OFF
1
60 AMP
2
60 AMP
3
30 AMP
4
60 AMP
5
60 AMP
6
30 AMP
7
30 AMP
8
30 AMP
9
30 AMP
10
30 AMP
11
30 AMP
12
30 AMP
13
30 AMP
14
30 AMP
15
30 AMP
16
30 AMP
17
GFCI
18
GFCI
19
GFCI
20
GFCI

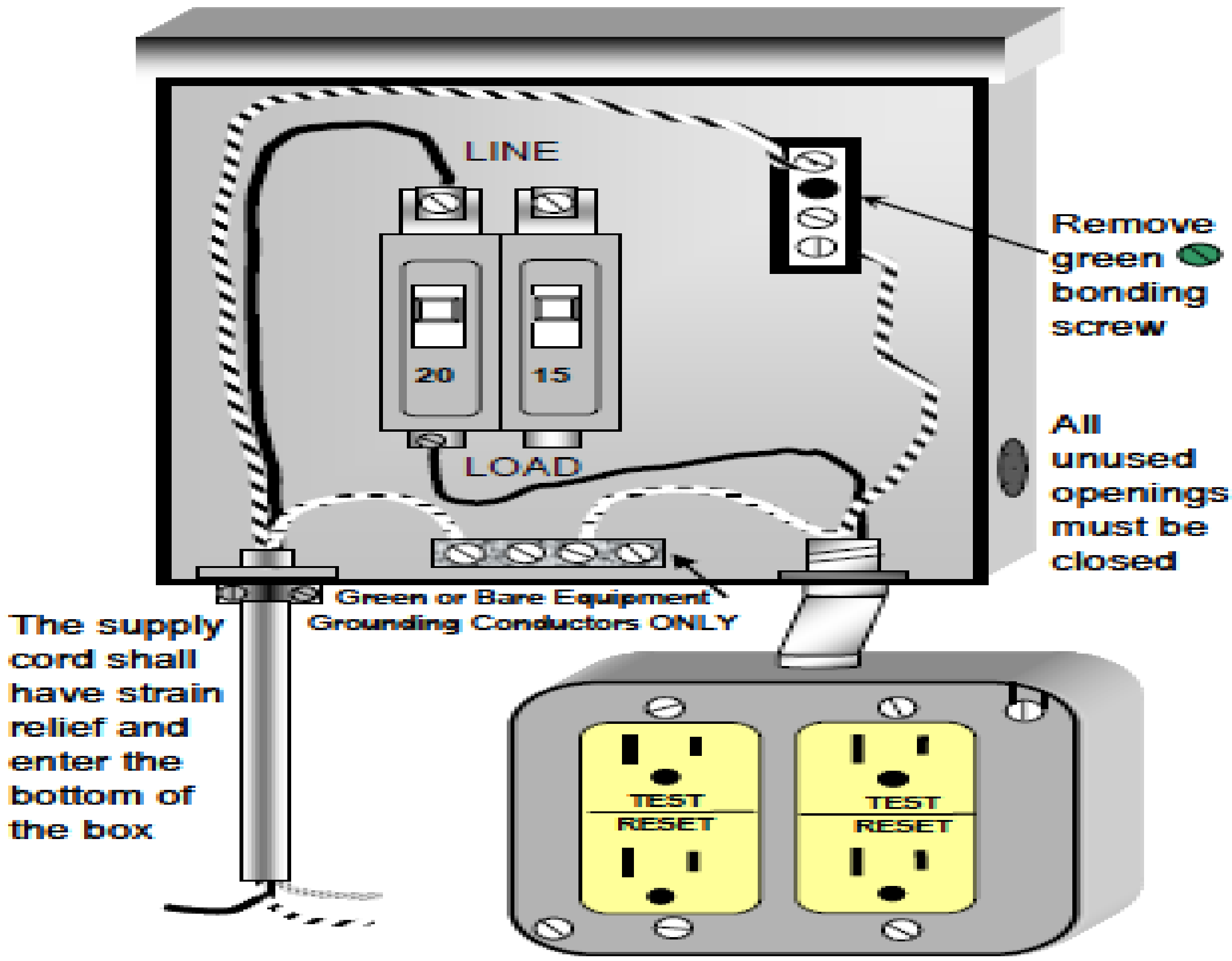
First connect - Last disconnect

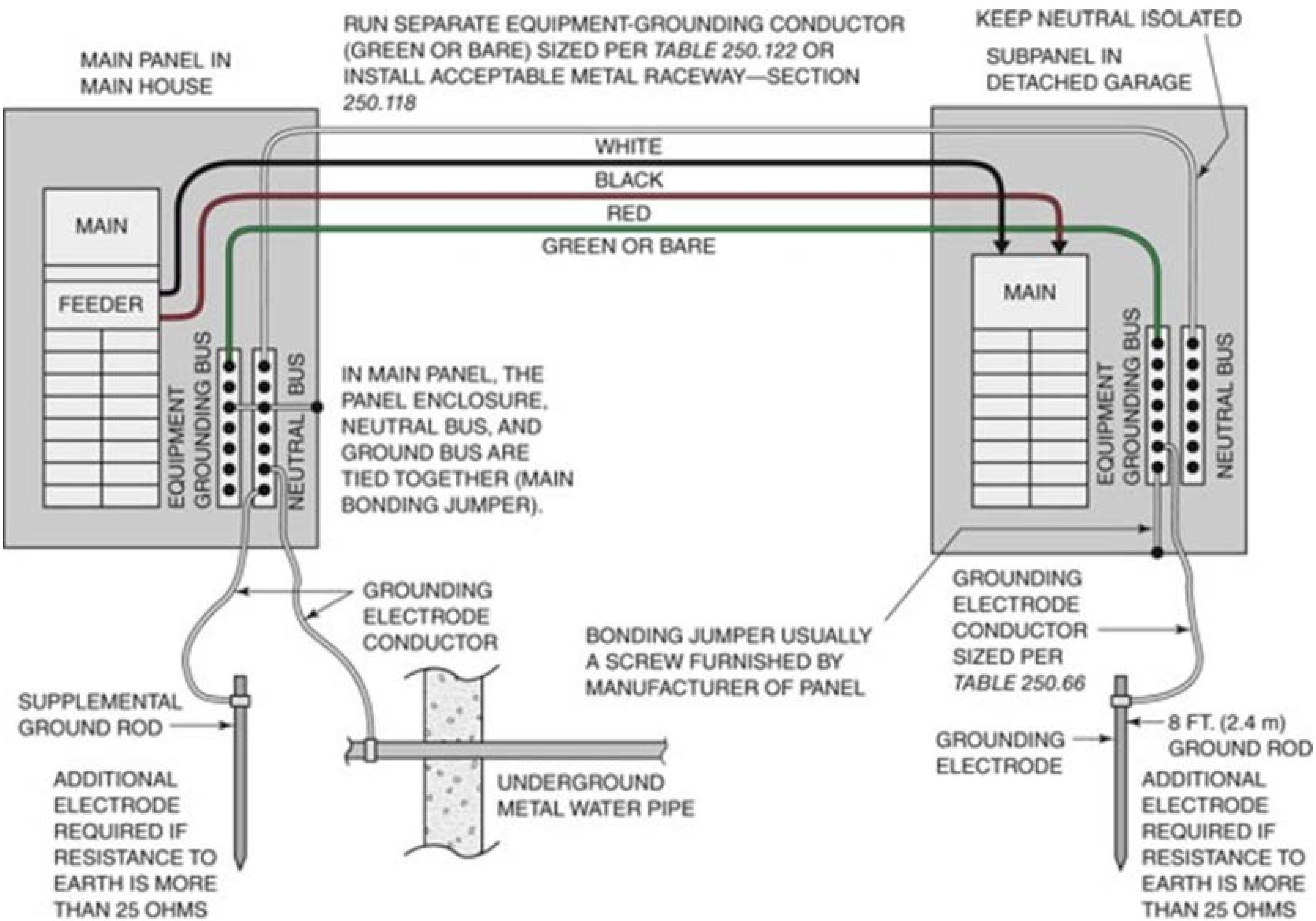
- Blue = hot
- Red = hot
- Black = hot
- White = neutral

- Green = ground



This diagram shows an example of an acceptable disconnecting switch for a typical concession unit.




RUN SEPARATE EQUIPMENT-GROUNDING CONDUCTOR (GREEN OR BARE) SIZED PER *TABLE 250.122* OR INSTALL ACCEPTABLE METAL RACEWAY—SECTION *250.118*
KEEP NEUTRAL ISOLATED
MAIN PANEL IN MAIN HOUSE
SUBPANEL IN DETACHED GARAGE
WHITE
BLACK
RED
GREEN OR BARE
MAIN
FEEDER
EQUIPMENT GROUNDING BUS
NEUTRAL BUS
IN MAIN PANEL, THE PANEL ENCLOSURE, NEUTRAL BUS, AND GROUND BUS ARE TIED TOGETHER (MAIN BONDING JUMPER).
MAIN
EQUIPMENT GROUNDING BUS
NEUTRAL BUS
GROUNDING ELECTRODE CONDUCTOR
BONDING JUMPER USUALLY A SCREW FURNISHED BY MANUFACTURER OF PANEL
GROUNDING ELECTRODE CONDUCTOR SIZED PER *TABLE 250.66*
SUPPLEMENTAL GROUND ROD
ADDITIONAL ELECTRODE REQUIRED IF RESISTANCE TO EARTH IS MORE THAN 25 OHMS
UNDERGROUND METAL WATER PIPE
GROUNDING ELECTRODE
8 FT. (2.4 m) GROUND ROD
ADDITIONAL ELECTRODE REQUIRED IF RESISTANCE TO EARTH IS MORE THAN 25 OHMS

Electrical Service Grounding

- Grounding Electrode (two)
- Continuous, no splices, meter bypass
- Copper ground wires and grounding conductor (corrosion resistant)
- Aluminum - insulated solid conductor
- Aluminum - insulated multi-strand
- Aluminum - bare vs. insulated (risk of corrosion, break in wire, loss of safe grounding

GROUND RODS and PIPES

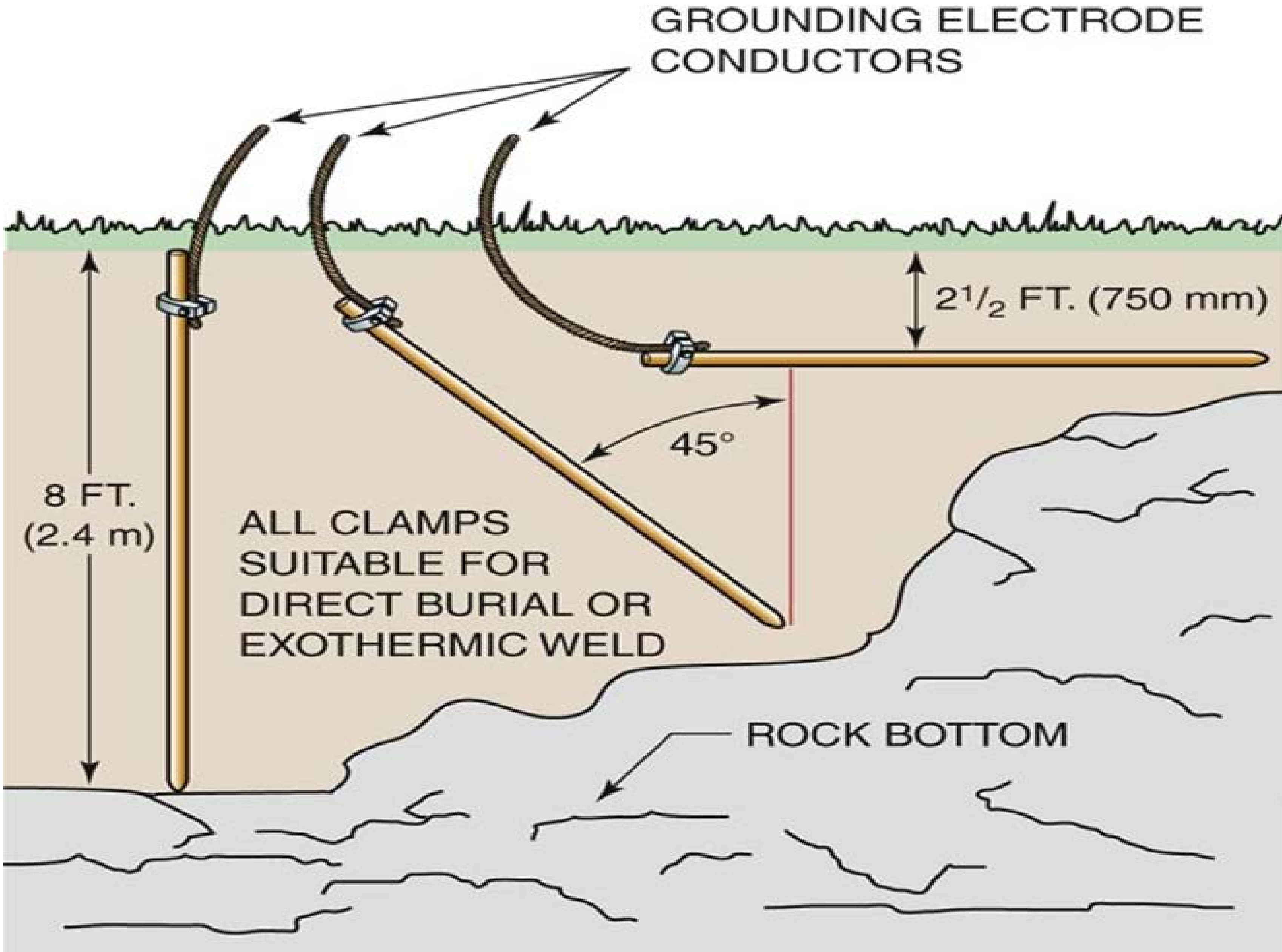
- Rods and pipes shall not be less than 8ft. In length.
- Non-ferrous rods shall be listed and shall not be less than ½” in diameter; 5/8” for iron or steel rods and ¾” for iron or steel pipe or conduit.
- Rods and pipes must have at least 8’ of their length in contact with the soil. Driven in at an angle not greater than 45 degrees or buried in a trench not less than 2 ½ ft. deep.
- The upper end of the electrode and electrode attachment shall be flush with the ground unless protected from damage.

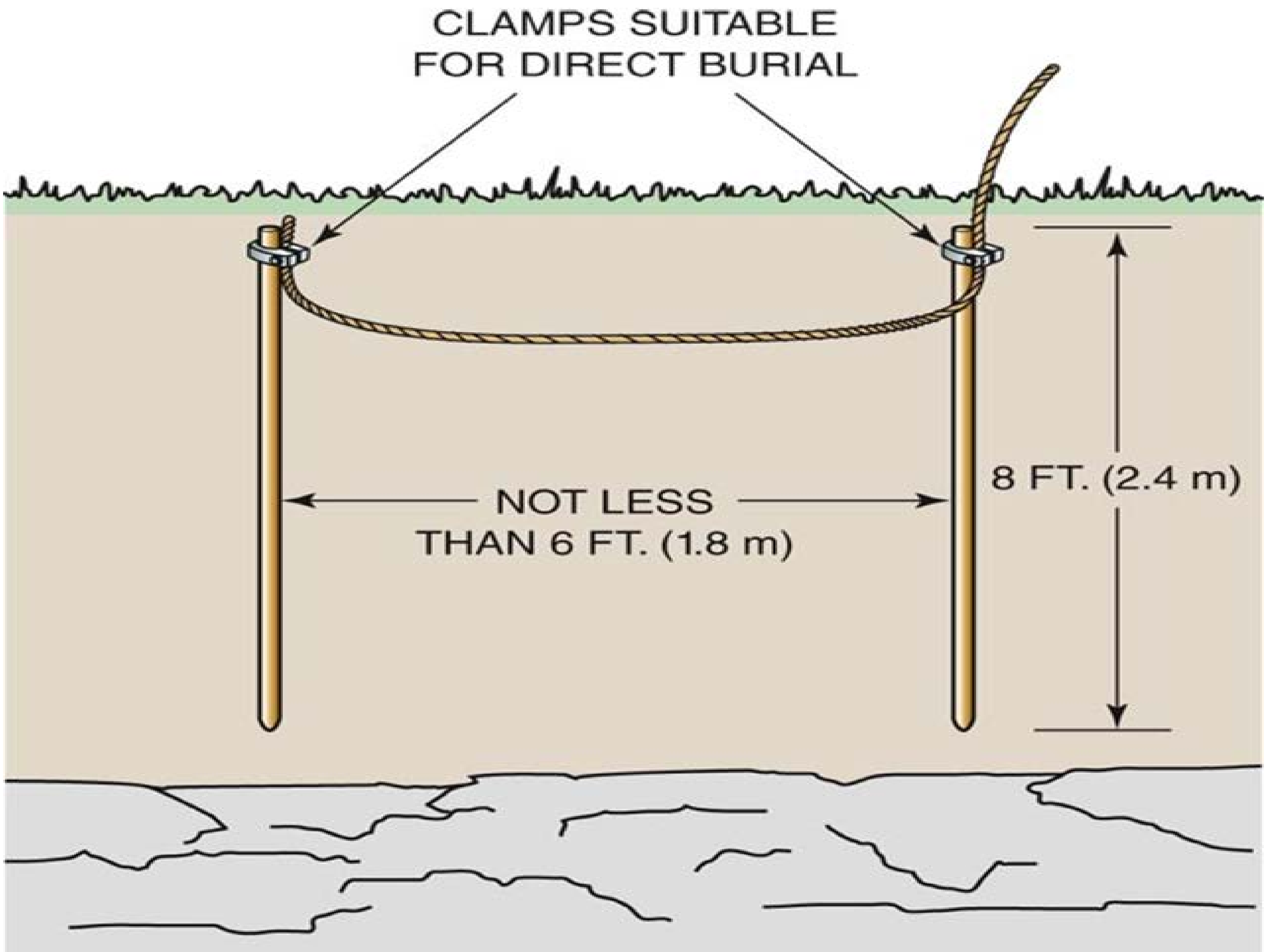
(Art 250-52 (c) (3) and (d))

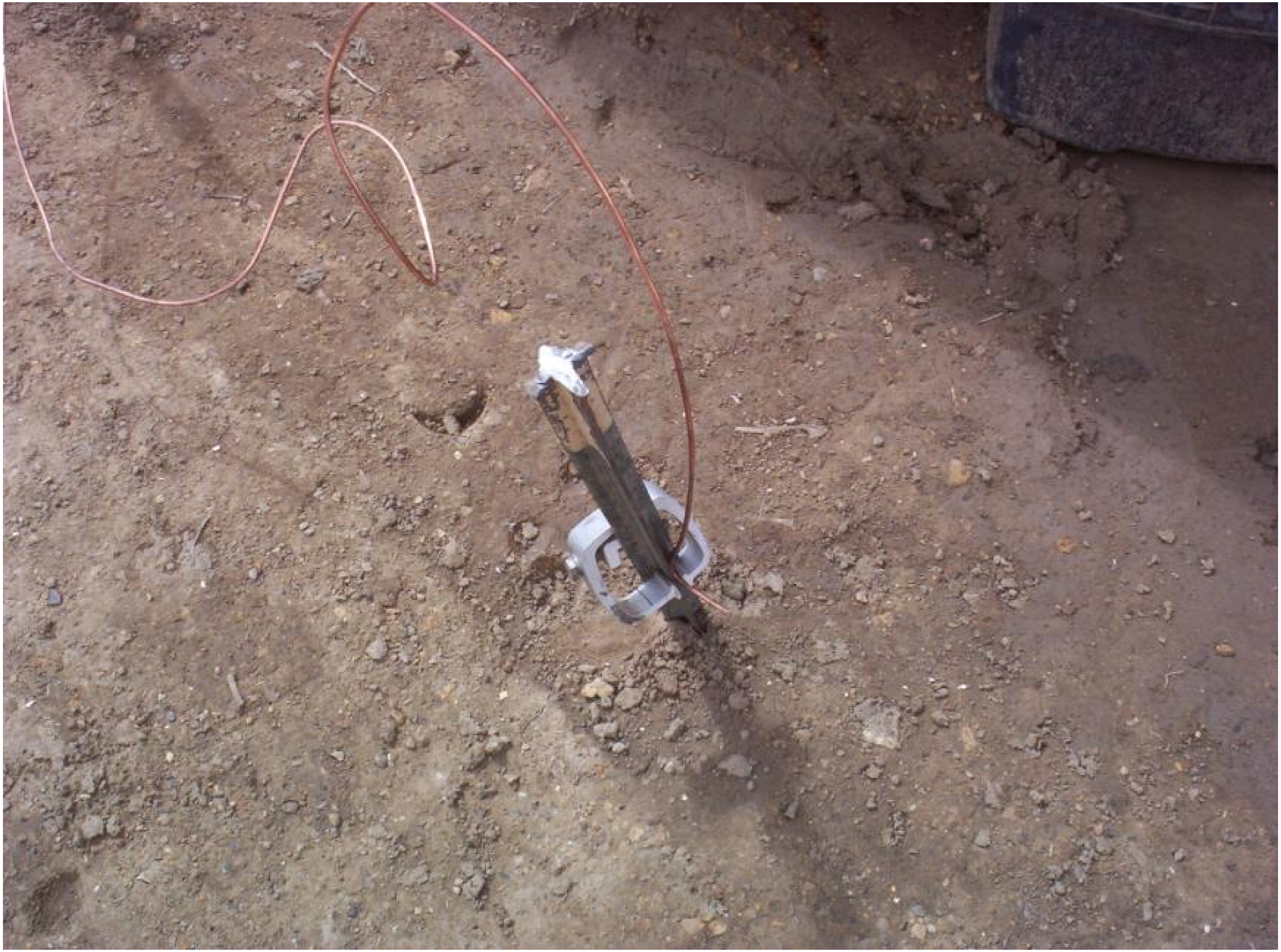
Table of Electrical Ground Wire Sizes

- Ground Gauge CU (Copper) Service Size

#8	to	100A
#6	to	125A
#4	to	165A
#3	to	200A


GROUNDING ELECTRODE CONDUCTORS
2 1/2 FT. (750 mm)
45°
8 FT. (2.4 m)
ALL CLAMPS SUITABLE FOR DIRECT BURIAL OR EXOTHERMIC WELD
ROCK BOTTOM

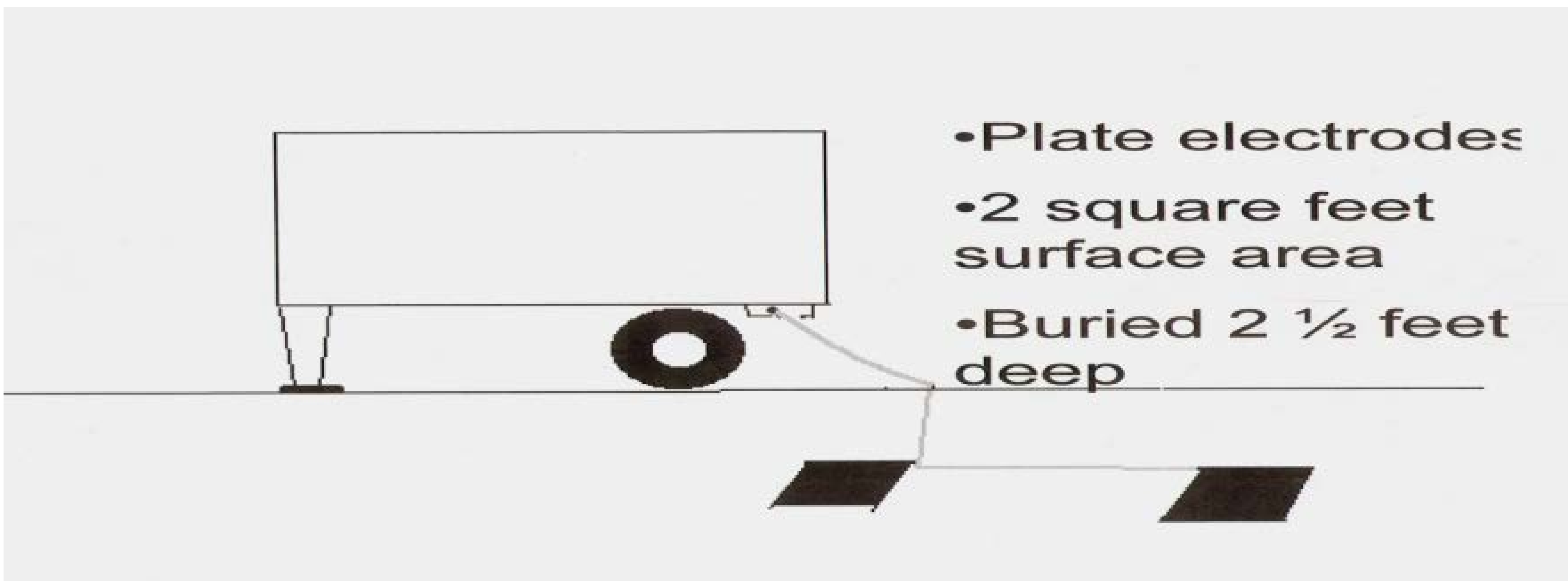

CLAMPS SUITABLE
FOR DIRECT BURIAL
NOT LESS
THAN 6 FT. (1.8 m)
8 FT. (2.4 m)



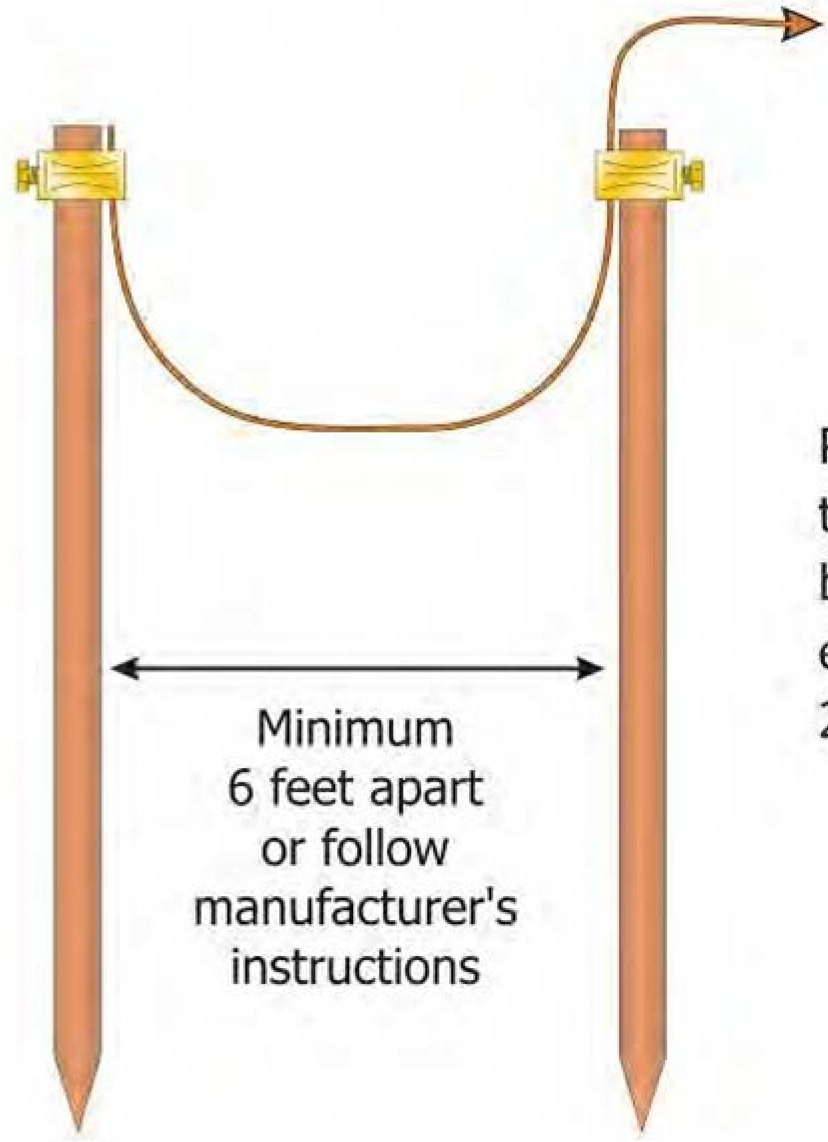

BALDOR
GENERATORS
TS25
FRANK'S
P0509150007
BAL
GENER
P0509150007

<u>PLATE ELECTRODES</u>

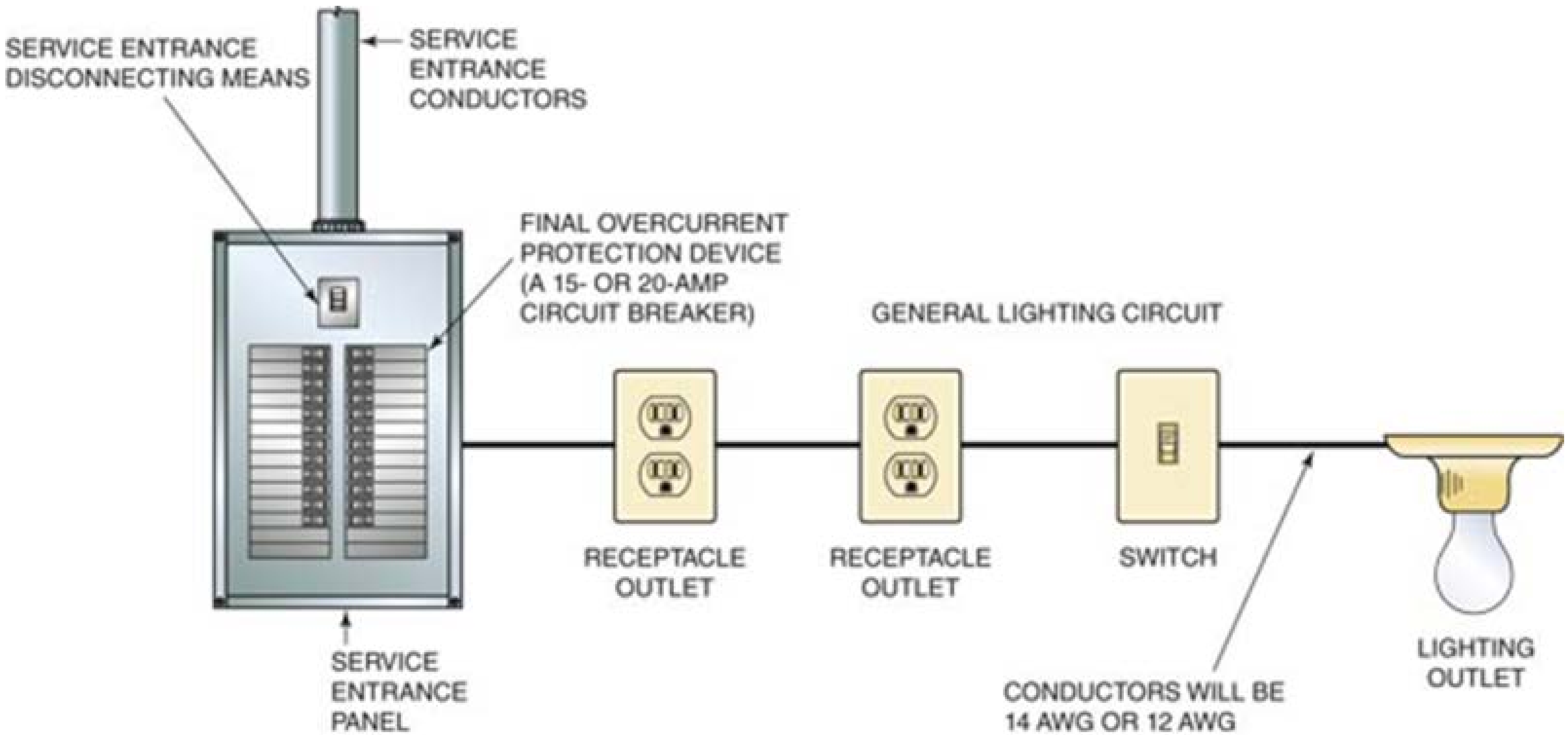
•In lieu of rods and pipes for grounding electrodes, plate electrodes may be used provided they are not less than 2 square feet of surface area in size and at least on quarter inch thick.
•Plate electrodes shall be buried not less than 2 and ½ feet below the surface.
Art. 250-52 (d)

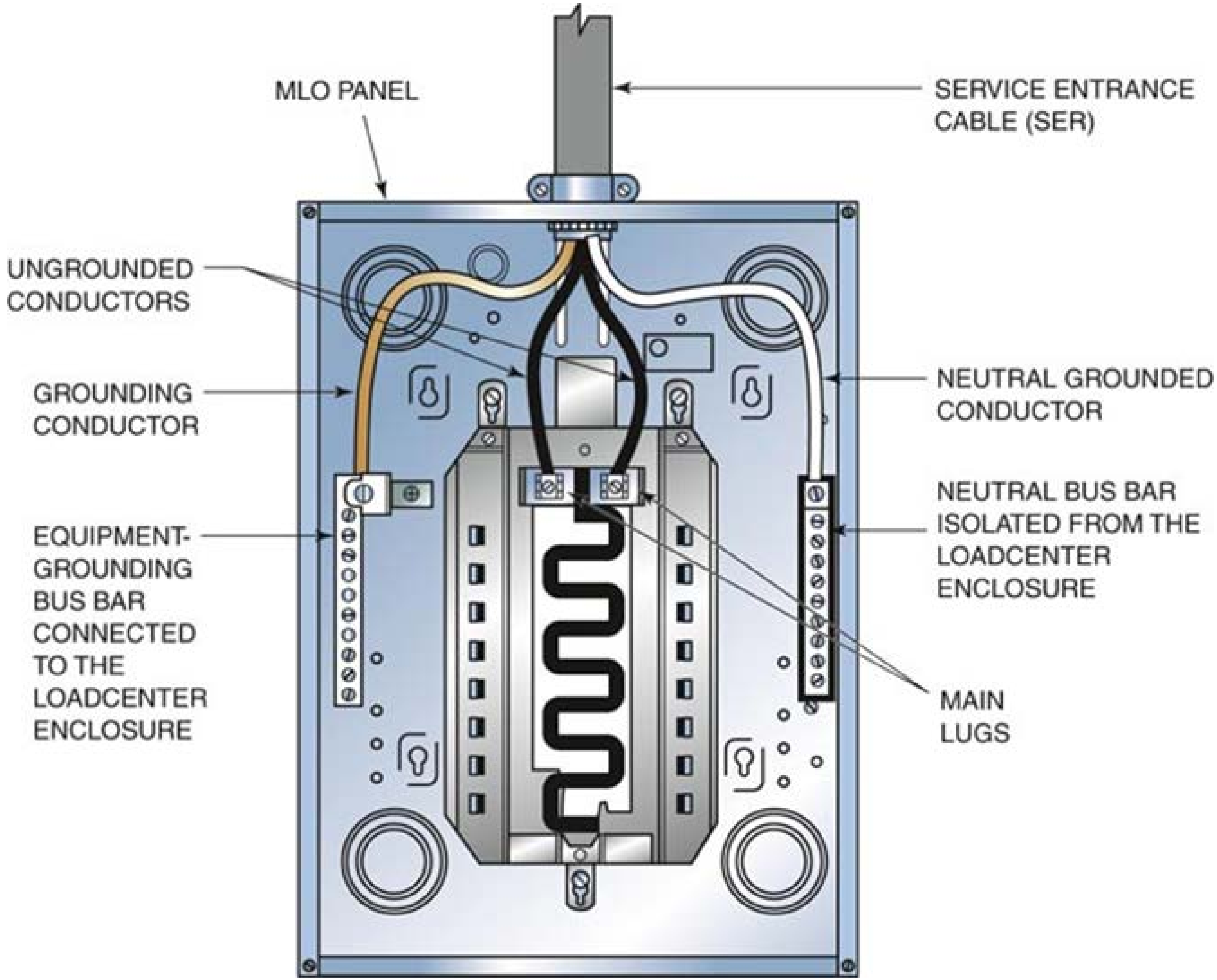


Resistance of Rod, Pipe, and Plate Electrodes



Rod, pipe, or plate electrode that exceeds 25 ohms must be augmented by an additional electrode of a type specified in 250.52(A)(4) through (A)(8)


SERVICE ENTRANCE
DISCONNECTING MEANS
SERVICE
ENTRANCE
CONDUCTORS
FINAL OVERCURRENT
PROTECTION DEVICE
(A 15- OR 20-AMP
CIRCUIT BREAKER)
GENERAL LIGHTING CIRCUIT
RECEPTACLE
OUTLET
RECEPTACLE
OUTLET
SWITCH
LIGHTING
OUTLET
SERVICE
ENTRANCE
PANEL
CONDUCTORS WILL BE
14 AWG OR 12 AWG

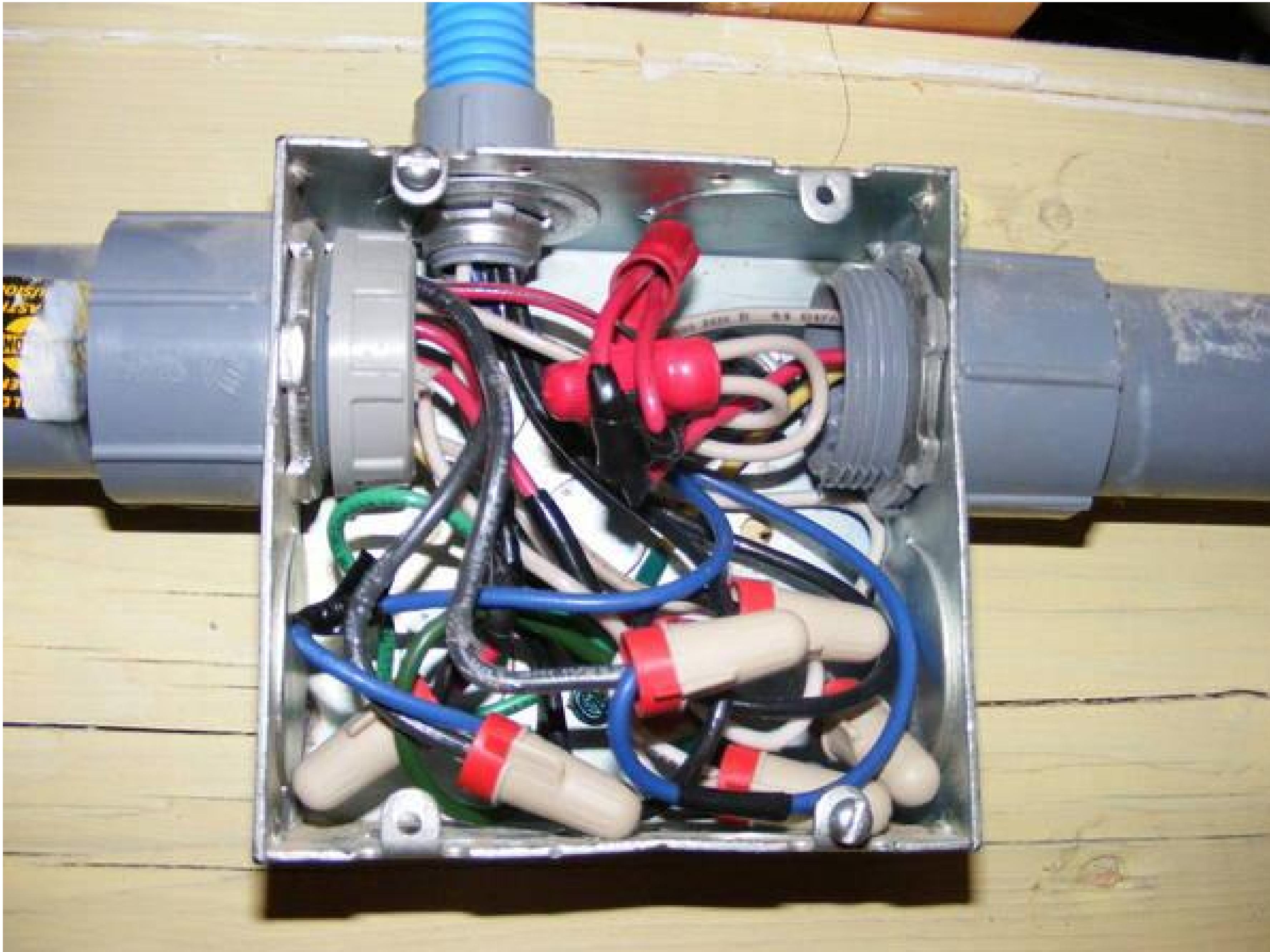

MLO PANEL
SERVICE ENTRANCE CABLE (SER)
UNGROUNDED CONDUCTORS
GROUNDING CONDUCTOR
NEUTRAL GROUNDED CONDUCTOR
NEUTRAL BUS BAR ISOLATED FROM THE LOADCENTER ENCLOSURE
EQUIPMENT-GROUNDING BUS BAR CONNECTED TO THE LOADCENTER ENCLOSURE
MAIN LUGS


GENERAL DUTY SAFETY SWITCH
DANGER / PELIGRO
SAFETY SWITCH


SQUARE D
ENCLOSED
CIRCUIT BREAKER
DANGER
WARNING:


ON
OFF


Thereifixedit.com

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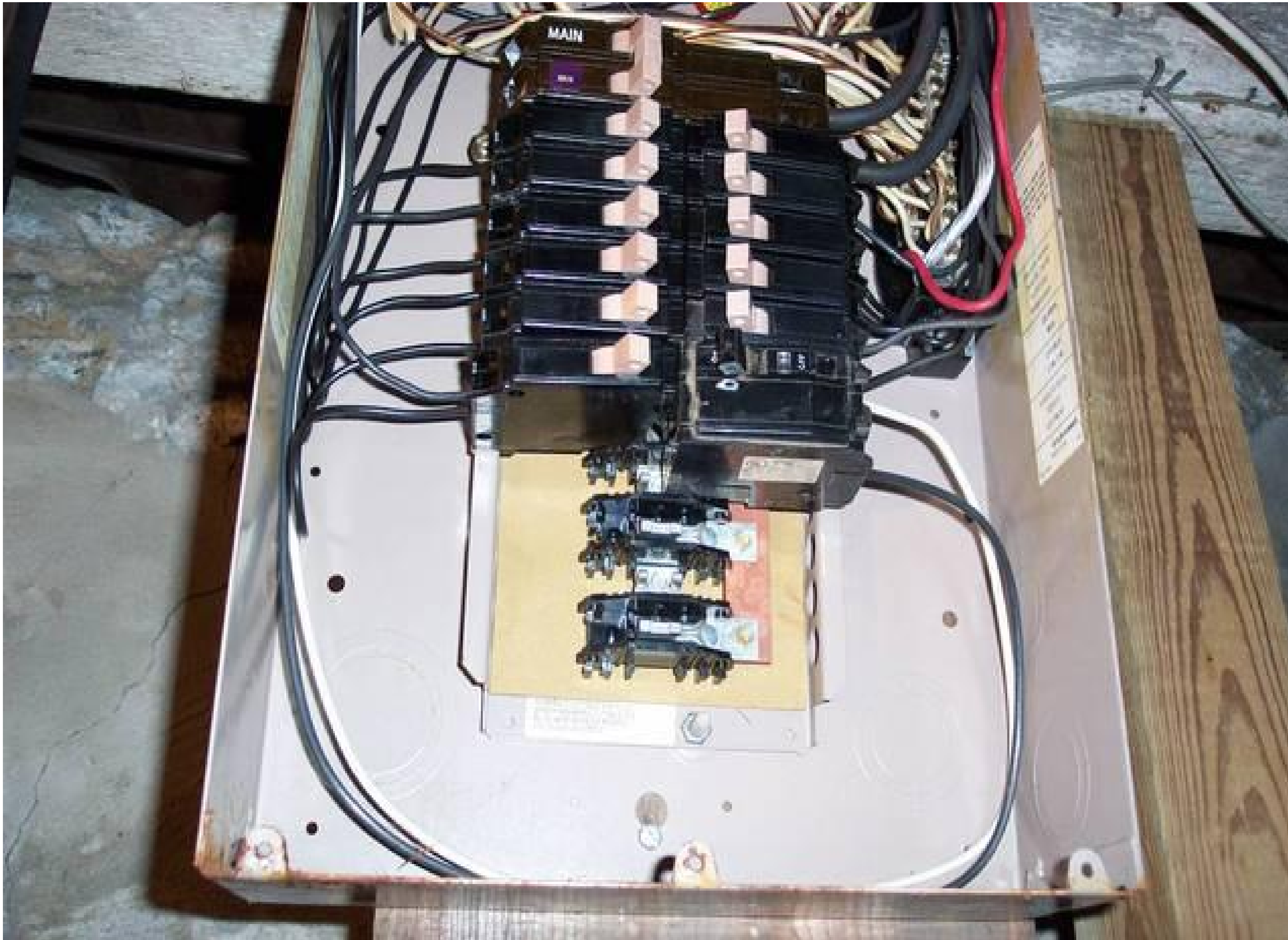
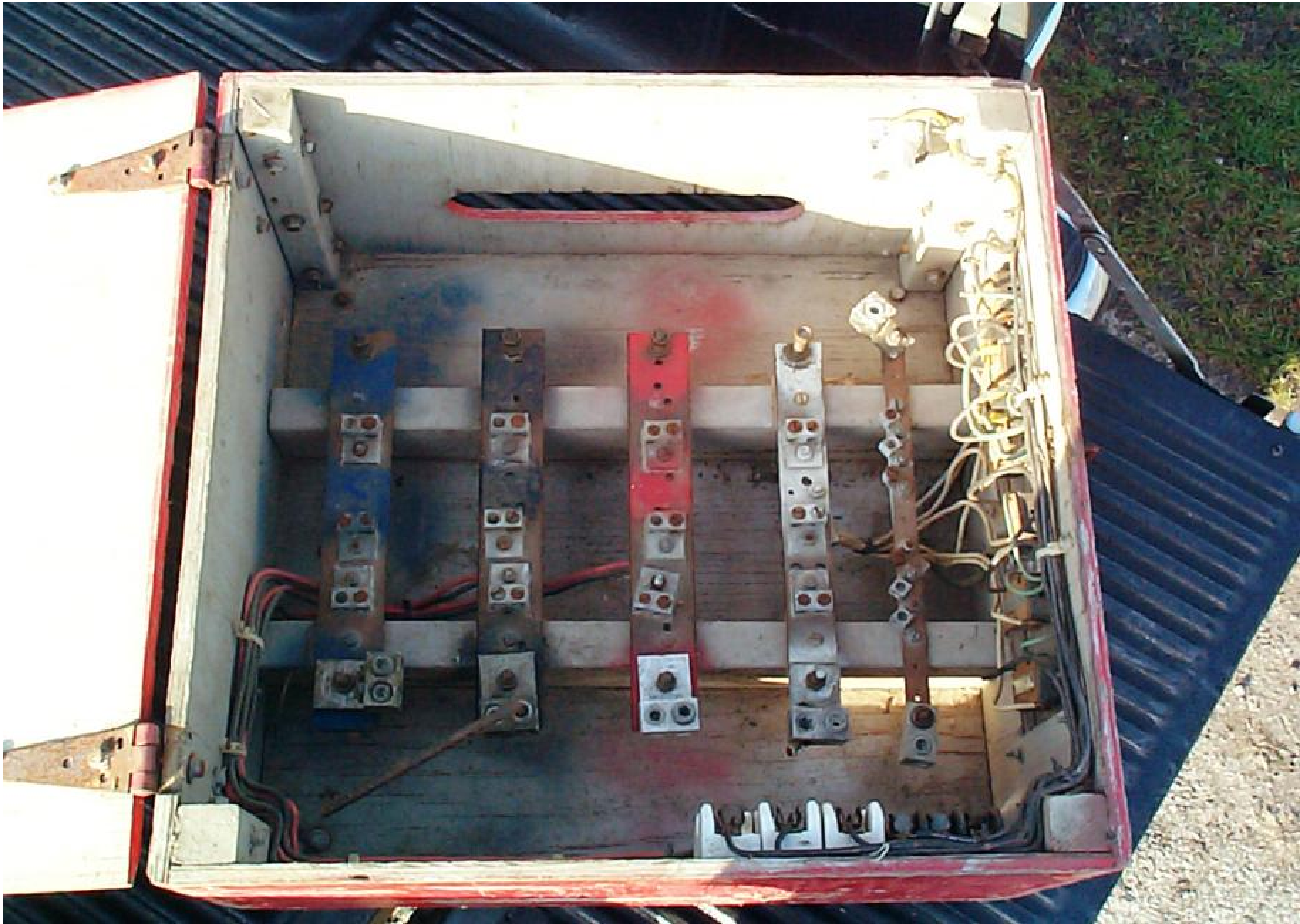
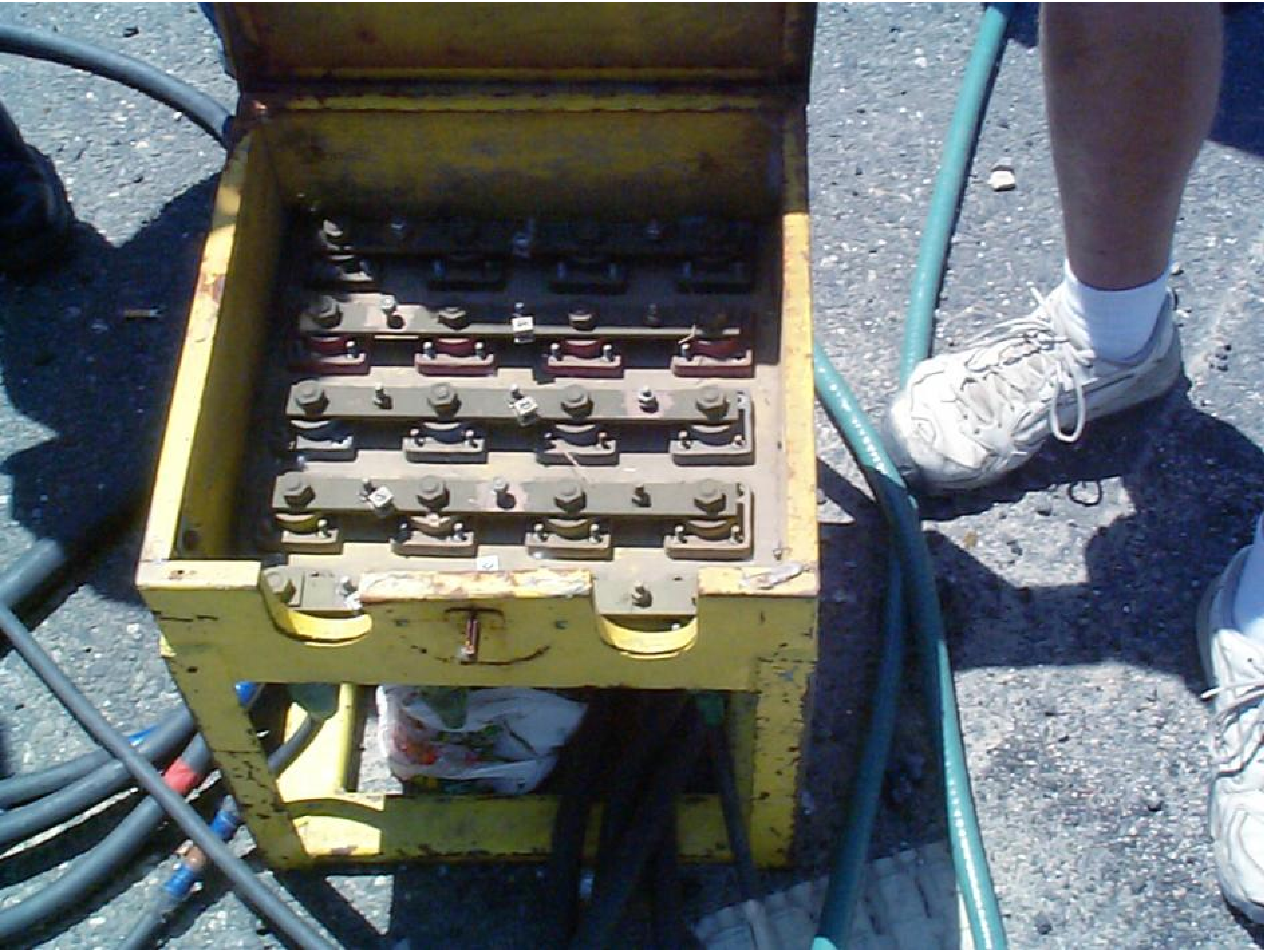

MAIN

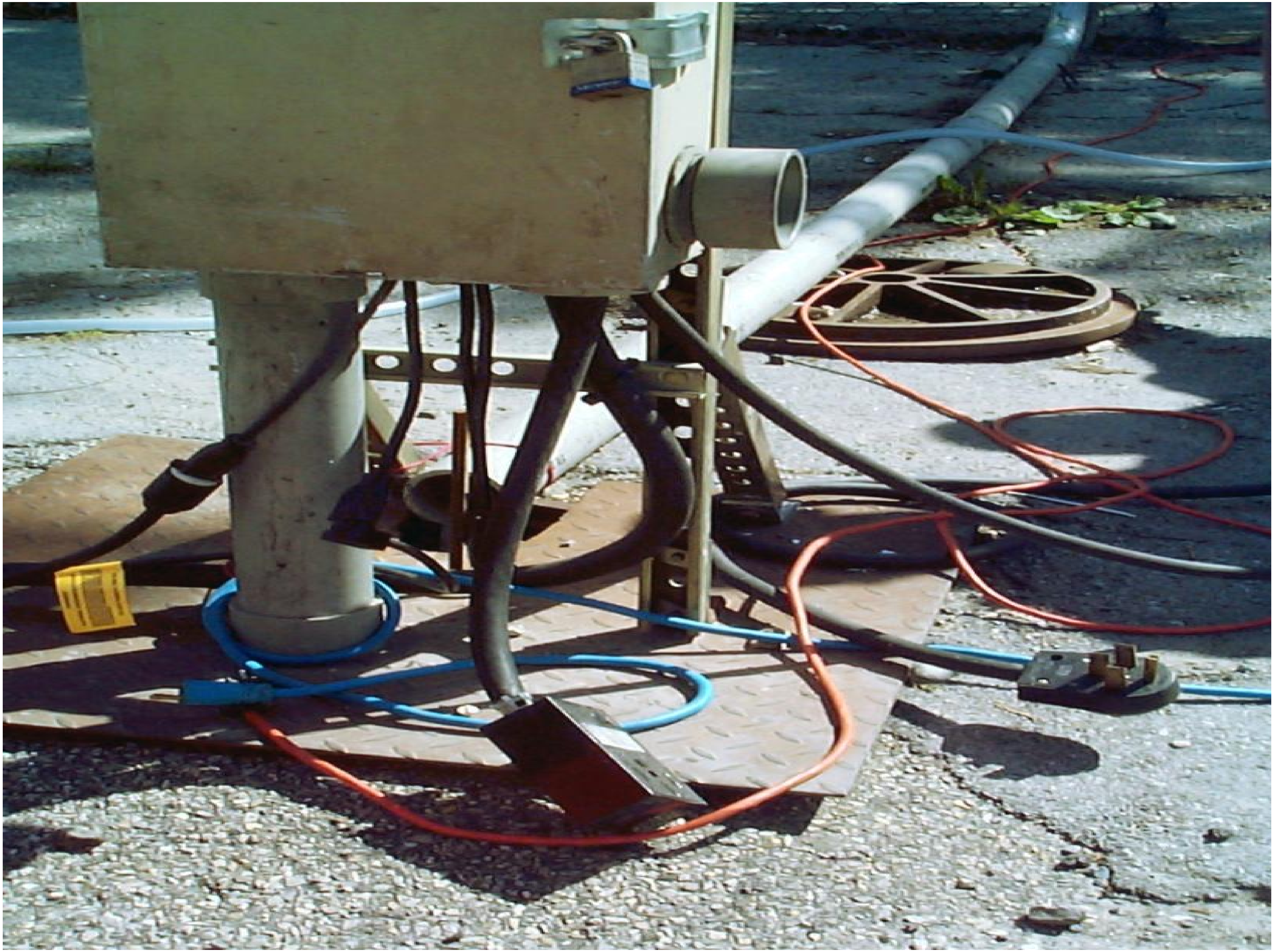

10

Wood distribution box

Open bus bars & no overcurrent protection







- Proper matting on midway