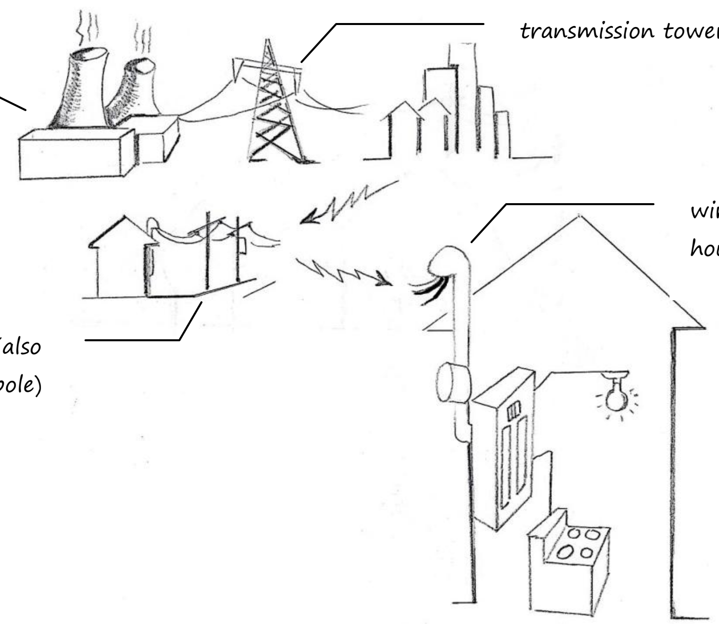
Contents

5 Electrical

5.1 Description

Of the various house systems the most mysterious is electricity usually because it is little understood. It is also the most dangerous potentially if not installed, repaired or used properly. We recommend any electrical work be performed by a qualified electrician. The following provides a general understanding of how electricity is distributed and used in a home.

Fig. 5.1



5.1.1 Service Size

The service size of homes is determined by how much electricity a home is expected to use also known as the *load* measured in *amperage* (AMPs). Electrical codes provide a set of calculations that determine the load.

In North American homes are equipped with 120/240 Volt, Phase 1, 3-wire arrangement.

Electricity is sent through transmission lines in *alternating current - an electric current that reverses its direction many times a second at regular intervals.*

This is different from a flashlight battery, for example, that uses *direct current - an electric current flowing in one direction only*

100 AMP: The most common service size provided to homes that are usually **under 3000-square-feet**. The usual exception is homes that employ electric fuelled units as the main source of heating (i.e. electric furnace or boiler, electric baseboard heaters).

200 AMP: Typically homes **over 3000-square-feet** or as described above that employ electrically fueled heating systems will be equipped with 200 AMPs. 125-150 AMP is also possible but less common.

60 AMP: Prior to the regular use (some would argue overuse) of outlets, lights and countless electrical appliances most homes were provided with a 60 AMP service size – generally pre-1960. Presently, unless the house is under 600 square-feet approximately, the 60 AMP service size is upgraded to a **minimum of 100 AMPs** to meet electrical demand and generally **required by most insurance companies**.

400 AMP: This service size is reserved for exceptionally large homes **over 5,000 square-feet** so less common (unless you reside in the Hamptons). Commercial or multi-residential buildings will often require a 400 AMP service size.

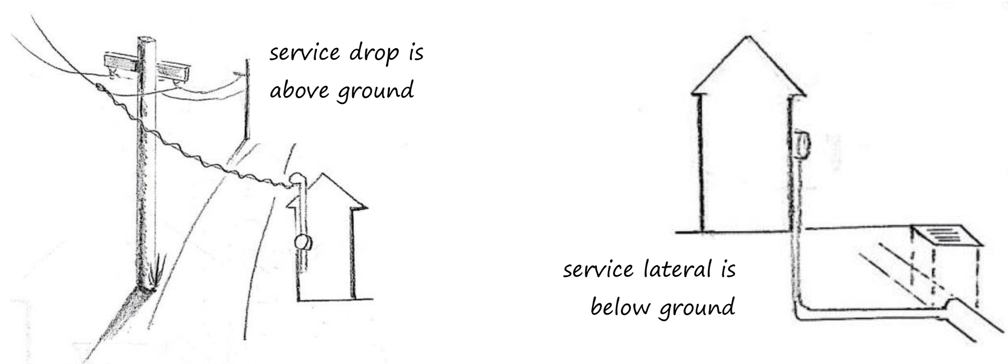
Other Service Sizes: 125 AMP or 150 AMP is also possible (common in some areas) and acceptable. 75 AMP, 80 AMP or 90 AMP services sizes may also be encountered though as described above will usually require upgrading to a minimum of 100 AMPs.

5.1.2 Service Entrance Cable

There are two ways a house is provided with electrical power – **above ground (service drop)** and **below ground (service lateral)**. The service can be located at the front or back of the house depending on the local electrical infrastructure.

The wires can be **aluminum** or **copper** and consist of three wires..

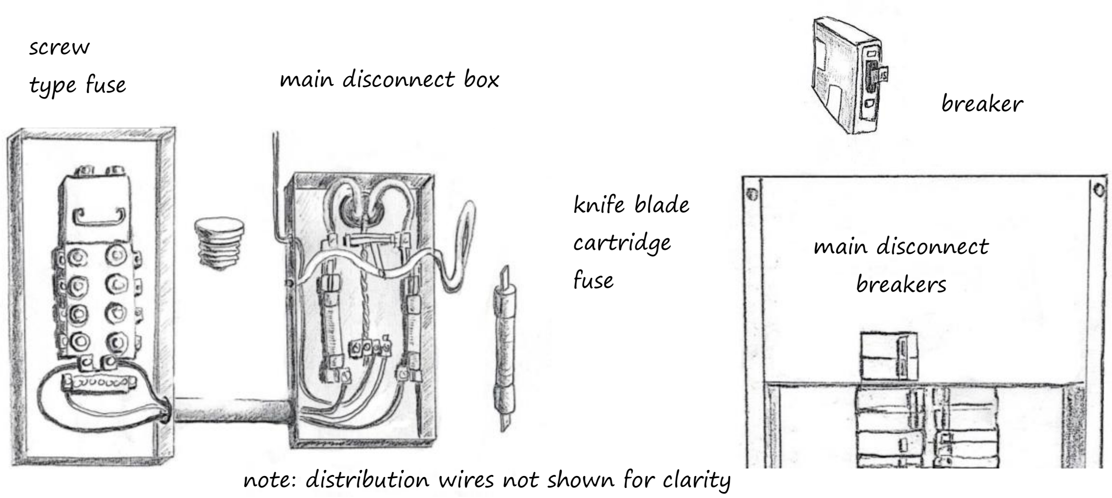
Fig. 5.2



5.1.3 Main disconnect/Service Box

This is the main switch that **disconnects (turns off) the electrical power** to the whole house and refers to the maximum amperage (AMP) the main disconnect is designed to handle. Every house is equipped with a main disconnect and can be an **individual service box** (fuse box) **or** part of a **combination breaker panel**. Sometimes a house can have both depending on the arrangement.
The most common ratings include 100 AMP, 200 AMP, 60 AMP and 400 AMP.

Fig. 5.3



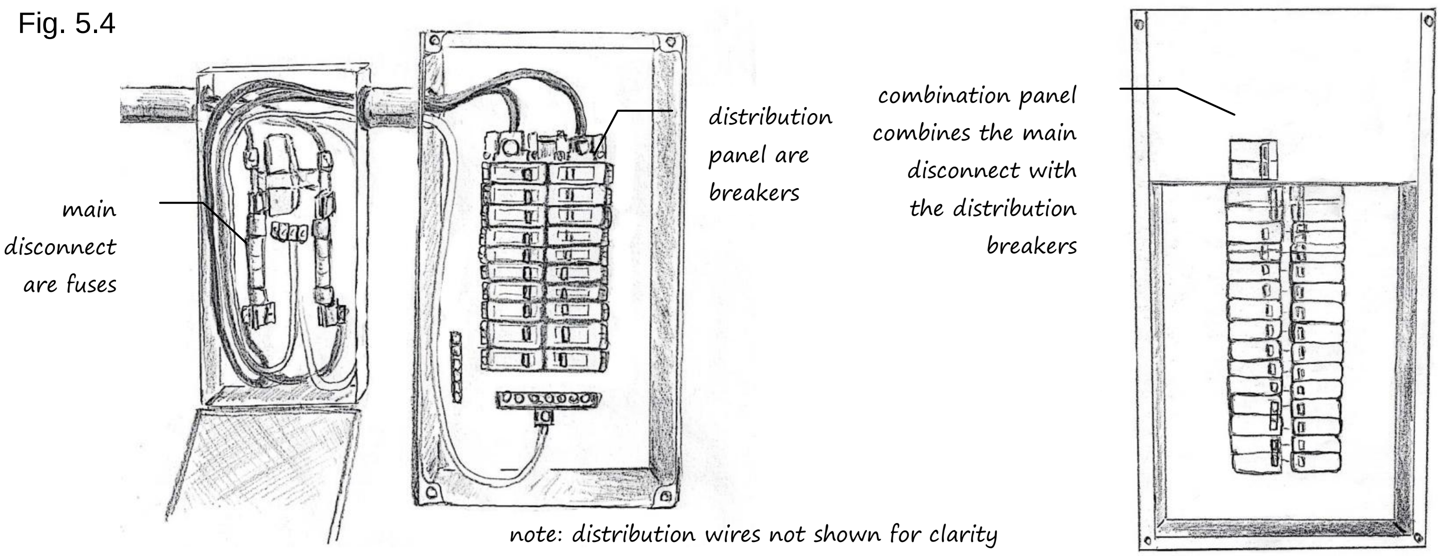
5.1.4 Distribution Panel

This is the ***hub*** from which all the wires are distributed to the house. A distribution panel can be equipped with **fuses or breakers**. Fuse panels are usually no longer being produced and often replaced with a breaker panel. Breaker panels are favoured by insurance companies.

Outlets and lights are provided with a 120 Volt circuit.

Large appliances that require more voltage such as stoves, dryers and air-conditioners are provided with 240 Volt circuits.

Fig. 5.4



Why have a distribution panel?

There are two main purposes of a distribution panel:

1. Electricity produces heat. The greater the demand for electricity the greater amount of heat produced in the wire. Since we don't want the wires overheating and potentially catching fire we have designed a system where the breaker (or fuse) detects heat and trips (shuts off) the circuit. In other words it is a **safety device**.

2. Provides the house with fuses or breakers that are connected to an individual appliance or several items such as lights and outlets. In other words in **separates and distributes** the electrical demand.

The most common ratings for distribution panels include 100 AMP, 200 AMP, 60 AMP and 400 AMP.

Why have differently rated breakers (or fuses)?

Breakers (or fuses) have a **rated size and must match the wire size** they are designed for. When a breaker (or fuse) size is greater than what the wire is designed for, the wire may overheat and cause a fire!

One reason we now use breakers versus fuses is because a larger fuse will often be installed (usually by the unsuspecting home owner) when it no longer functions (blown fuse).

Unlike breakers that can simply be re-set (switched back on) and rarely require replacement – which should be done by a qualified electrician anyway.

It should also be mentioned that fuses with a breaker like reset button are also available often called mini-breakers.

Please note that if a breaker (or fuse) requires re-setting or replacement often it may indicate a potentially hazardous condition that requires further evaluation by a qualified electrician

The different breaker (or fuse) sizes are also required to service the different amount (larger demand) of electricity required by the various house items such as ovens, air-conditioners, etc.

The most common ratings for individual breakers (or fuses) are 15 AMP, 20 AMP, 30 AMP, 40 AMP and 60 AMP.

Table 5.1

Rated Amperage (AMP)	Typical Use
15	outlets, lights-switches
20	air-conditioners, kitchen outlets, baseboard heaters
30	air-conditioners, clothes dryers
40	ovens
60 and up	panels

The most common **locations** for an electrical panel are the basement or garage and should always be easily accessible.

5.1.5 Auxiliary Panel(s)

As the name implies an auxiliary panel is an additional panel used when the main panel is full and/or is servicing another area of a house.

It can have the same properties as the main panel.

An auxiliary panel cal be located almost anywhere in a house but should be easily accessible.

5.1.6 Distribution Wiring

Copper: Metals are good conductors of electricity (electrons *flow* with relative ease). The most widely used metal is copper (a non-precious metal). Copper is ductile, malleable and provides good contact. It also does not corrode easily.

Aluminum: Aluminum wiring was installed in homes built approximately between the periods of 1960’s to 1970’s (due to the higher cost of copper during that time period). It was discovered, soon after its extensive use, that there were concerns:

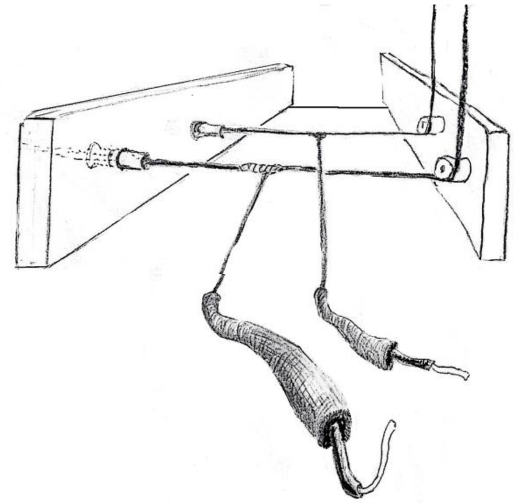
1. Due to heat the wires expand thus becoming loose or creep off terminal connections
2. Oxidizing increases the wire's resistance resulting in the wire overheating at the receptacle
3. During installation the wire is easily nicked resulting in the wire overheating at the receptacle

Aluminum wiring requires special maintenance and repairs that should be performed by a qualified electrician.

Knob-and-Tube-Copper: The standard form of wiring when electrical power became more common from about the late 1800's to the mid 1940's. Since this wiring is old and in many cases not well maintained or poorly modified it is usually replaced with modern wiring. Usually this type of wiring will also be replaced for house insurance purposes.

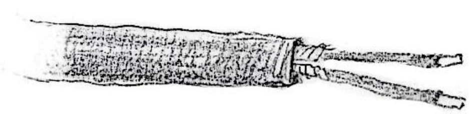
It can be identified by the ceramic knob and tube required to support the wiring. It also has the distinct condition of the hot and neutral wire being distributed separately.

Fig. 5.5



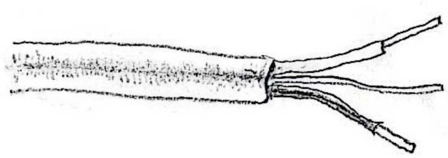
Ungrounded Wiring: This arrangement of wiring will have a hot wire (black) and neutral (white) wire but no ground wire and was used up until the 1970's.

Fig. 5.6



Grounded Wiring: Commonly known as Romex or Loomex wiring and is considered as the modern wiring. This type of wiring was installed since the 1970's that will have a hot wire (black) and neutral (white) wire and ground wire. It is considered safer due to the grounding potential.

Fig. 5.7



Tinned Wire: This is essential copper wire that is plated with tin. The tin provides good soldering properties for connections.

Sheathing Materials: Sheathing refers to the 'jacket' that wires are wrapped in for protection and ease of installation.

None Metallic Sheathed: Wires are wrapped in non-metallic sheathing (plastic, cloth/paper). Modern wires are sheathed in plastic (nylon). Older wires up to approximately the early 1980's can be sheathed with cloth type materials.

The labeling on modern wiring will indicate where the wire can be installed.

Table 5.2

Plastic Wire Labeling	Uses
NMD –non metallic dry	Indoor use only
NMW –non metallic wet	Indoor and outdoor use
NMWU –non metallic underground wet	Used outside and underground

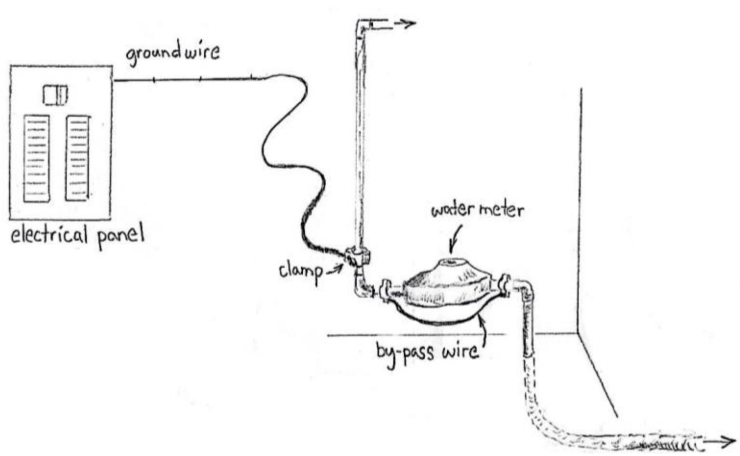
Metallic Sheathed: Also called BX, armour clad and flexible metal this type of wiring is well protected because of the metal sheathing. It is mostly used for commercial buildings. In homes it is used for furnaces and water heaters.

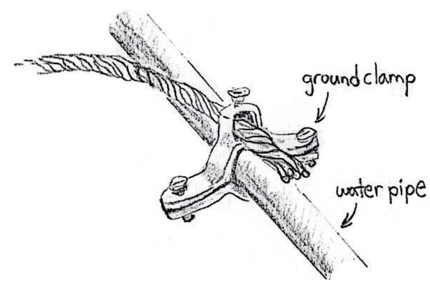
Fig. 5.8

5.1.7 System Grounding

An electrical system is grounded for safety purposes and as the name implies the earth is used as the grounding source. Essentially if there is an electrical leak in the system the grounding wiring carries the electricity to the ground where it becomes harmless instead of ‘charging’ the electrical device that someone might touch. Although the grounding system is not full proof it does reduce the risk of shock.

Fig. 5.9

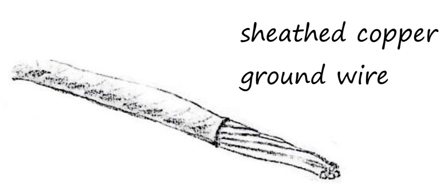




The grounding wire can be copper or aluminum and for many homes is connected to the metal water-main pipe that is buried in the ground. Grounding can also be done through a grounding rod.

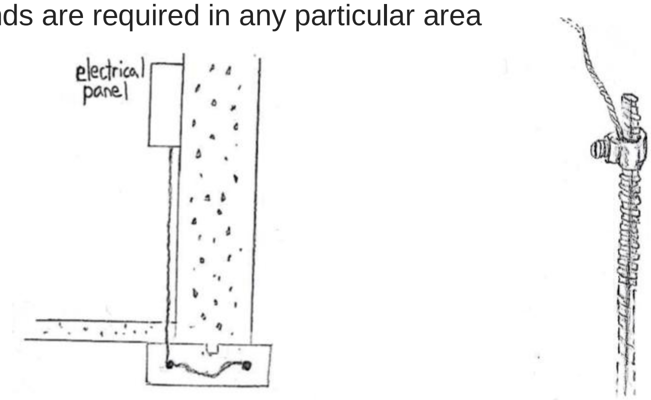
The grounding wire can be bare (no sheathing) or more common with modern building practices is plastic sheathed with a distinct colour such as green.

Fig. 5.10



Another form of grounding is Ufer (named after the consultant who first used it). It uses a concrete-encased (foundation) electrode to improve grounding in dry areas. Essentially the conductivity of the soil usually determines if Ufer grounds are required in any particular area

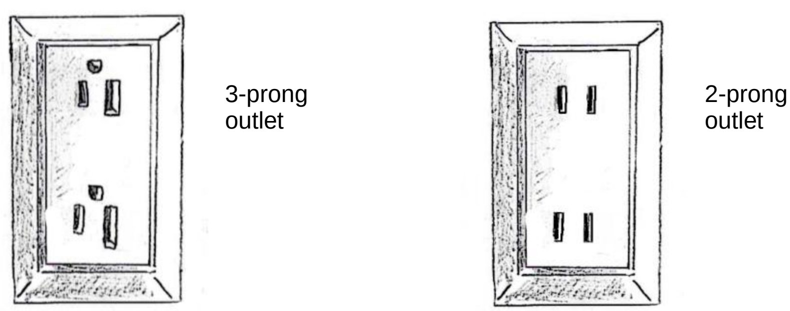
Fig. 5.11



5.1.8 Outlets

Outlets, also called receptacles, are used to power for our appliances. Older units' pre circa 1970's are ungrounded and can be identified by having only two slots at the face plate. All modern outlets are grounded and can be identified by the additional 'square-shaped' slot.

Fig. 5.12

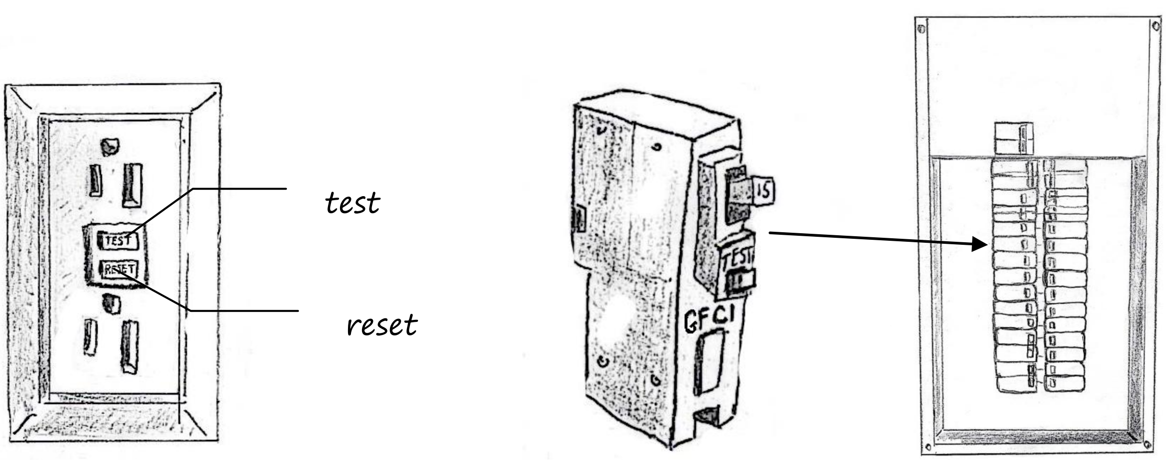


In older homes, pre 1960's, we did not have as many 'gadgets' therefore less outlets were required. In modern homes typically one outlet approximately **every 10-feet of wall length** is required.

5.1.9 Ground Fault Circuit Interrupter (GFCI)

GFCI's can be in the form of an outlet or breaker. A GFCI is a safety device that is mandatory under most electrical codes. It will have a test button and reset button that should be tested monthly.

Fig. 5.13



A GFCI is a device that stops the electricity when it detects it is flowing to an unintended path, possibly through water or through a person. It is used to reduce the risk of electric shock even though an electrical circuit is a properly grounded. The device is so sensitive that it can detect electrical ‘leaks’ as small as 5 milli-amperes which immediately disconnects the circuit.

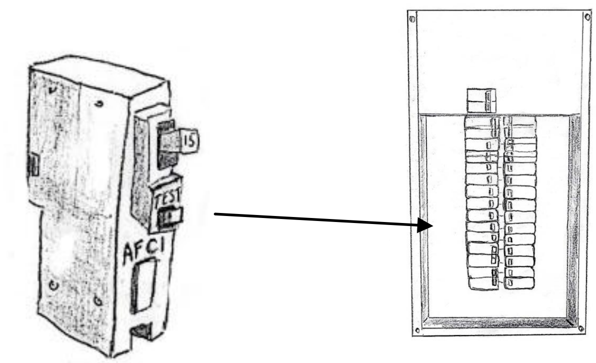
Breaker GFCI’s are located in the electrical panel. GFCI outlets can be located or used for the following purposes:

- Outside
- Bathroom
- Whirlpool Bath
- Kitchen
- Laundry Area
- Garage

5.1.10 Arc Fault Circuit Interrupter(s)

AFCI’s are special breakers (found in panels) that service bedroom outlets. They are designed to help prevent fires by detecting unusual electrical arcs and switching off the electricity.

Fig. 5.14



5.2 Limitations

A visual examination of the electrical system is performed. The electrical panel cover is removed and the interior of the panel is examined. A random sampling of outlets is tested with a circuit tester to determine if wiring connections to the outlet is correct. Under some conditions wall plates to outlets and switches are removed to observe the connections.

Main Disconnect Cover Not Removed: Typically the cover to the main disconnect is not removed since this is unsafe. Main disconnect fuse box doors can be opened if it does not require shutting the main switch off. Sometimes tags that have been installed by the electrical utility restrict opening the main disconnect door.

Fuse Block(s) Not Pulled: Fuse blocks are not removed since this will interrupt the electrical circuit servicing an area of the house.

Power off: When the power is off the Inspector is not permitted, unless permission is given, to turn the power on. Sometimes the power if off for safety reasons that the Inspector may not be aware of.

System Ground Not Visible/Not Accessible: Under some circumstances, typically due to storage or lack of access, the grounding wire termination point (i.e. at the water-main) is not visible. Since the grounding wire is typically hidden behind finished walls the continuity of the wire cannot be determined.

5.3 Observations/Recommendations

All electrical recommendations should be considered as high priority and safety issues that require attention by a qualified electrician.

5.3.1 SERVICE ENTRANCE:

Service drop (wires that connect to a house from the street electrical pole).
Service lateral (wires that connect to a house from an underground conduit)

Clearances: The wire from the street must be have proper clearance from the ground and not 'reachable' for example from area where normal activity occurs i.e. porch

Loose: Wires should be properly secured to the house usually with a ceramic attachment or directly to the mast.

Main Disconnect: Over fused unit (fuse is too big) can result in high temperature that can damage components due to overheating or can lead to fires.

Damage: Frayed wires or damaged/loose conduits require repair.

Drip Loop: Inadequate drip loop can result in a water infiltrating the conduit and panel resulting in damage or an electrical short.

5.3.2 SERVICE PANEL

The electrical panel is the ‘hub’ where all the wires of the house are connected to the main source of power.

A panel can employ fuses or breakers or a combination of both. Most modern installations employ a combination breaker panel.

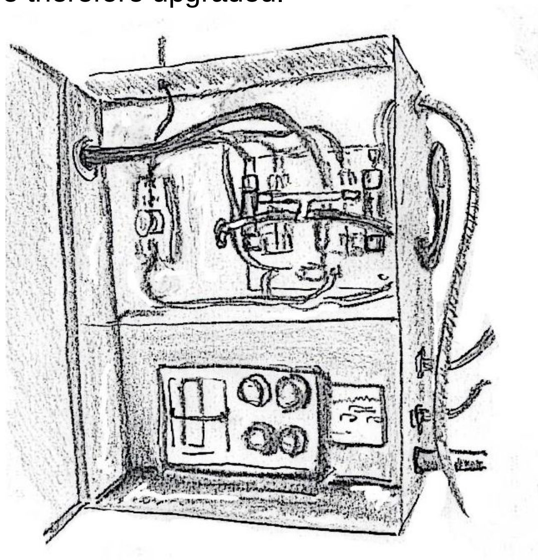
The most common panel rating (capacity) can be 60 AMP, 100 AMP, 125 AMP, 150 AMP, 200 AMP and 400 AMP. The rating can be determined from the specification label located on the removable panel cover.

The front of the panel cover should be labeled accurately.

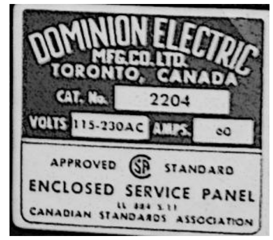
The most common locations for an electrical panel are the basement or garage and should always be easily accessible.

60 AMP service: The majority of homes require a minimum of 100 AMP service especially for insurance purposes. They are therefore upgraded.

Fig. 5.15



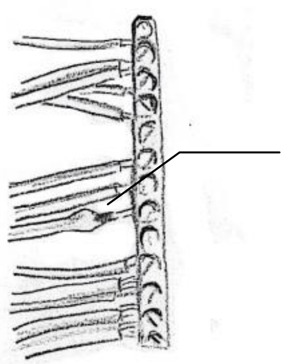
older 60 AMP panel as indicated by the data plate



Aluminum wire: This type of wiring can be identified by their 'silvery' colour. Aluminum wiring is prone to 'slipping' from connections and/or overheating which can lead to fires. They can also oxidize on the surface which can lead to overheating. Homes with aluminum wiring require inspection and maintenance by qualified electrician.

- panels should be rated for aluminum wiring
- wires should be coated with an anti-oxidant before connecting

Fig. 5.16

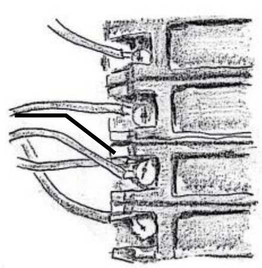


evidence of overheating aluminum wire inside of the panel

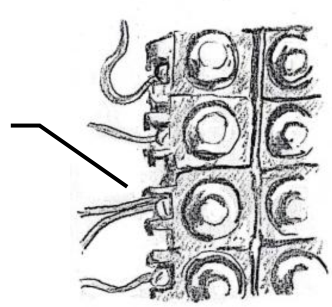
Double-Taps: This term applies to a breaker (or fuse) that has **more than one wire connection** inside of the panel. Although it is very common it is not permitted. The risk is that a breaker might be over fused which means it is connected to too many receptacles. This may lead to the breaker tripping (shutting off) on a regular basis. it can also lead to loose connections which may over heat.

Fig. 5.17

double tap on a breaker



double tap on a fuse



Overfused: Fuses (and breakers) that are too big will allow more electrons to flow through and therefore allow more heat than the wire is designed for which can lead to fires.

Openings/Missing Cover: The panel box is designed to contain heat and sparks that can lead to fire therefore must not have any openings.

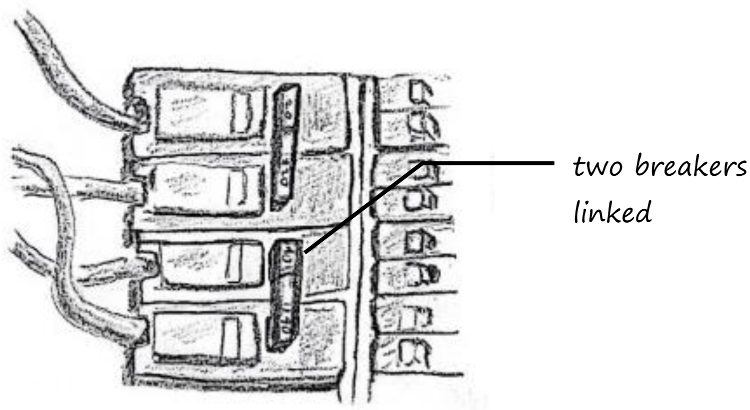
Loose: Loose or poorly connected wires will restrict ('bottleneck') electrons from flowing that can lead to overheating.

Rust: Rusting components will inhibit electrons flowing which can lead to overheating.

Old/Obsolete panels: These typically require replacement with modern panels especially if renovating. In some cases can be considered as unsafe or recommend upgrading for insurance purposes. A 60 AMP panel is an example.

240 Volt Links: Some appliances (dryers, air-conditioners, ovens) require two breakers for extra power (240 volts). As such these breakers must be 'linked' so that they both switch off together. For older fuses we use fuse blocks.

Fig. 5.18



We also link split receptacles. These are two 15 amp circuits that are connected to one outlet in the kitchen. In recent years this arrangement has been replaced with one 20 amp circuit that requires a GFCI outlet if located within 1 meter of the sink.

Undersized Panel: A panel will have a label indicating the maximum amperage allowed for the main disconnect breaker. The breaker size must not exceed the maximum AMP rating. This can result in the panel overheating.

Location/Access to Panel: A panel should be readily accessible for service or to shut power off in an emergency and when servicing electrical components. Generally panels are located in basements and garages and should be at eye level. The sides and fronts of a panel should have approximately a 3 foot clearance.

Crowded Panels/Auxiliary Panels: Too many wires in a panel can lead to overheating. As well the wires run the risk of being in contact with the front cover which can strain connections. If applicable an auxiliary panel can be installed and the excess wires redirected.

Overheating: This can often be identified by scorching inside the panel or to its components. Recently with the use of a thermal imaging camera overheating can be identified though this method is not part of a regular home inspection in accordance with the Standards of Practice.

Overloaded Circuits: This implies that a breaker (or fuse) is connected to too many electrical devices such outlets and lights. This can result in the fuse 'blowing' (or breaker tripping) often due to overloading (too much heat) which is at best a nuisance. Overall it is difficult to determine unless living in the house. However older panels with limited space can be suspected of having over fused circuits. This is especially common in older homes where additional outlets and lights have been installed but the panel not upgraded and no new wires installed. Double-tap circuits might also be overloaded.

Damage: Panels or components within the panel that are damaged may not perform adequately and therefore require immediate replacement.

5.3.3 BRANCH WIRING:

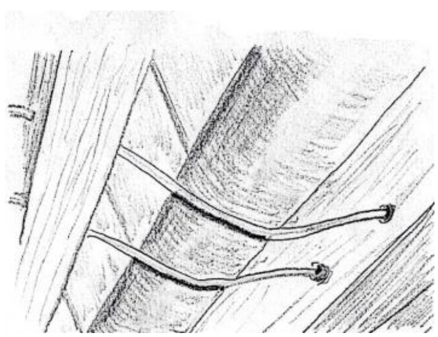
As the name implies the wires branch out through the house providing power to the electrical devices such as lights, outlets and appliances. Naturally since the wires are located inside the wall and ceiling areas the majority will not be visible.

Common defects include the following and due to the potential danger associated with electricity repairs should be performed immediately by a qualified electrician.
Damage/Loose/Exposed/Abandoned wires: All these conditions are unsafe and require immediate repairs.

Wire Support : Wires should be secured properly. Wires require a minimum support of approximately every 4 feet and should not be accessible in finished areas of a home. Wires visible in finished areas of a house can indicate armature installations. Wires are generally secured or supported or secured to the house framing.

Wire Duct/Pipe Contact: Wires should not be in contact with metal supply ducts or piping. This is potentially a shock hazard and/or can lead to undue overheating of the wire. It is common to find wires running through return ducts as long as they are not in contact with the metal.

Fig. 5.19



Extension Cords: These are generally designed for temporary purposes therefore should not be used as a permanent source of power.

Exterior Wires: Wires located on the exterior of the house must be rated for this purpose. They are labeled as NMW (non-metallic wet) or NMWU (non-metallic wet underground). Interior grade wires are prone to degradation of the sheathing due to harsher conditions on the outside. Armoured cable (AC) also called BX (brand name) should generally not be used on the exterior since they are prone to rusting.

Bonding Wires: This refers to a wire that is connected from a gas pipe to a copper water supply pipe. Often located above or near the gas water heater. It is a bare copper strand wire clamped to each pipe. Since the copper water supply pipe is grounded with the water-main (assuming it is grounded) the gas pipe is bonded therefore allowing for any build-up of electrons in the gas pipe to be dissipated safely to the ground. The intent is to avoid heat or sparks that may ignite the gas inside the pipe.

Dedicated Circuits: Certain appliances require dedicated circuits. This means they cannot be used for any other use. An example is the breaker (or fuse) connected to a fridge. An outlet (receptacle) used for a fridge should not be used for other purposes. If you observe lights blinking momentarily this may indicate a circuit (breaker or fuse) not dedicated to the fridge. This happens when the fridge compressor is activated for cooling. 220 volt circuits such as dryers, air-conditioners and ovens are dedicated circuits.

Knob & Tube: In the majority of cases knob and tube wiring must be abandoned and replaced with modern wiring. Home owners should be aware that this can be expensive.
Often poor connections are made with modern type of wiring that lack junction boxes.

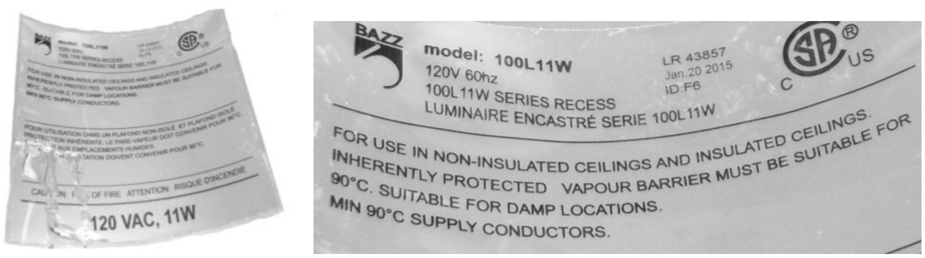
Aluminum: This type of wiring can be identified by their 'silvery' colour. Aluminum wiring is prone to 'slipping' from connections and/or overheating which can lead to fires. They can also oxidize on the surface which can lead to overheating. Homes with aluminum wiring require inspection and maintenance by qualified electrician.

- panels should be rated for aluminum wiring
- wires should be coated with an anti-oxidant before connecting

5.3.4 ELECTRICAL DEVICES

Light(s): Loose light fixtures require repair. Lights located in insulated ceilings must be rated for that purpose and require a proper housing to allow for proper heat dissipation. Labels inside of the housing will indicate this. Labels may also indicate the proper type of light bulb and maximum wattage.

Fig. 5.20 Pot light label



Ungrounded Outlet(s): These are common for homes built up to the 1960's since the distribution wiring did not have a ground wire. Naturally two prong outlets are ungrounded since they are connected with wires that have no ground.

In older homes the three prong outlets should be tested with a receptacle (outlet) tester to determine if they are grounded. Adding a GFCI (ground fault circuit interrupter) in place of a regular outlet is one way to make this condition safer. Of course replacing the ungrounded wire with a grounded wire is the preferred.

Cover Plate(s): Cover plates to outlets and switches are required to contain the connection within the junction box.

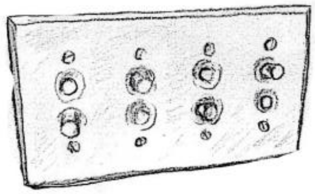
GFCI: Ground Fault Circuit Interrupters are required in areas where outlets are prone to wet conditions. Since water is a good conductor this is a safety device to automatically 'switch off' the power to an outlet should it come in contact with water. They are mandatory on the exterior, washrooms and kitchen outlets within 3 ft of a sink. They are also required for whirlpool bathtubs.

Miswired Outlet(s): Outlets have connections specific to the hot (black) wire, neutral (white) wire and ground (bare) wire. When the wires are not in the proper connection an outlet will be miswired.

A reverse polarity outlet is an example of a hot wire connected to the silver connection which is meant for the neutral wire and a neutral wire connected to the brass connection meant for hot wire.

Switch(es): Loose and damaged switches require repair. Older switches like 'push button' units are considered **obsolete** and should be replaced. These types of switches will typically indicate the **presence of knob and tube wiring**.

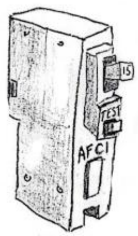
Fig. 5.21



Ceiling Fan(s): Loose and damaged fans require repair.

AFCI: Arc Fault Circuit Interrupters have recently become a requirement for bedroom outlets. They are installed to the breaker panel.

Fig. 5.22



Junction Box: When two wires are connected they must placed inside of a junction box. The junction box must be secured and capped so that the connection is not exposed.

Fig. 5.23