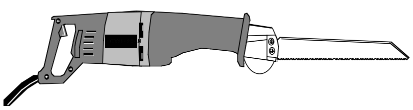
CONTENTS

CONTENTS

DRILLING AND NOTCHING OF *HORIZONTAL* LUMBER

Drilling holes in the framing lumber weakens the member. But we know holes and notches must be made to route the cable or conduit throughout the building.

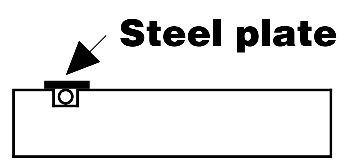
The installer must always observe the holes being made to assure they conform to the Code and they are not causing structural damage to the building.

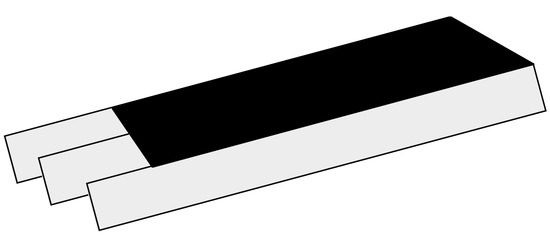


NOTCHING OF LUMBER

The rules for notching lumber comes from the Building Code. The rules apply to the *repetitive members*. A repetitive framing member such as studs, rafters and joists not over 4" in thickness and spaced not over 24" apart, at least 3 or more in parallel and joined together by a load.

The National Electrical Code in section 300.4(A)(2) permits cable or raceway to be laid in these notches if protected by a steel plate at least 1/16" to protect the cable or raceway from the penetration of nails or screws.



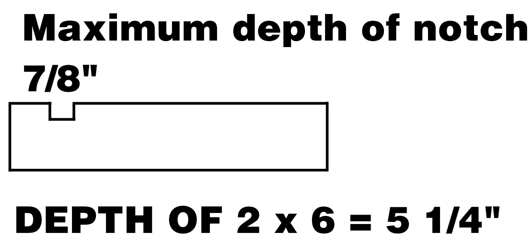


These floor joists are an example of repetitive members as there are at least three, they are 2 x 8 's, 16" on center, joined by a sheet of plywood to distribute the load.

To cut into a single timber or beam it must be detailed and approved on the drawing.

Do not cut into a timber or beam

The depth of the notch is allowed up to 1/6 of the depth of the member. A 2 x 6 has a measured depth of 5 1/4" x 1/6 = approximately 7/8" maximum depth of a notch.



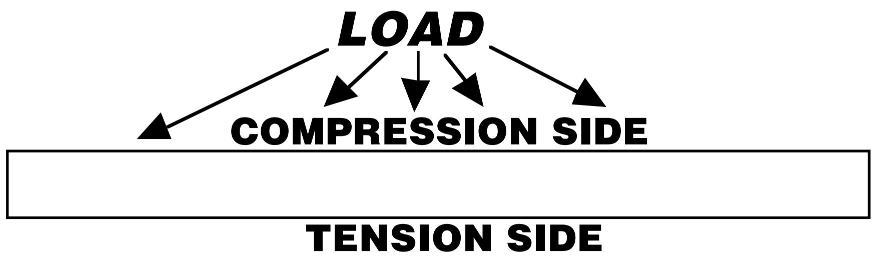
No notches are permitted in the *center 1/3* of the member, only in the outer 1/3.

A good rule to follow is the notch length should not be more than 1/3 the depth of the member. And only one notch at each end (outer 1/3) of the member.

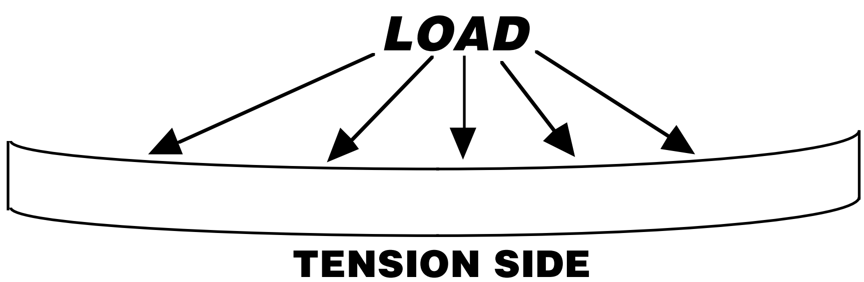
A 2 x 6 with a measured depth of 5 1/4" x 1/3 = 1 3/4" allowed length of notch.

• Bored holes are permitted in the center 1/3 if, NOT within 2" of the top or bottom and NOT to exceed 1/3 the depth of the joist.

A member has a compression side and a tension side. The compression side is the side where the load is on. The tension side is the under side.

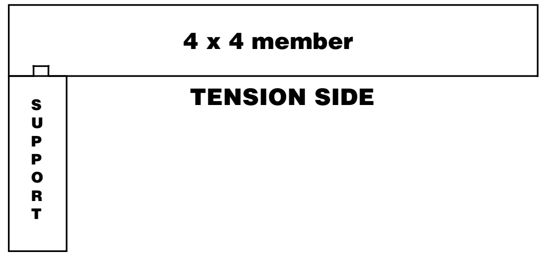


As the load is applied the tension is shown on the bottom side.



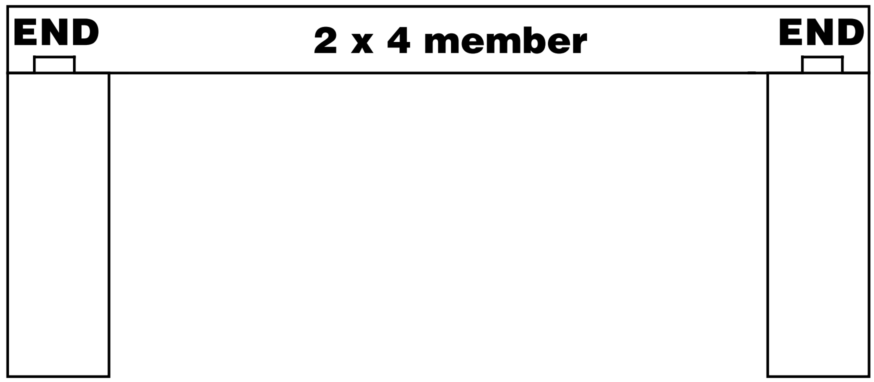
Notching is permitted on both the compression and tension side of 2-by's or 3-by's, but *NOT* 4-by's.

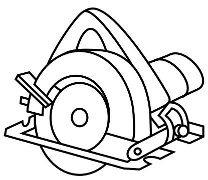
Notches are permitted on each end of a 4-by on the tension side where a support occurs.



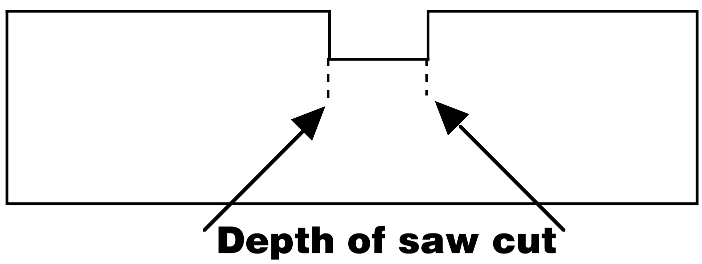
Notches at the end of members are permitted to be 1/4 of the depth, deeper than the 1/6.

Example: A 2 x 6 that measures 5 1/4" in depth a 1/4 = a notch depth of 1 1/4".



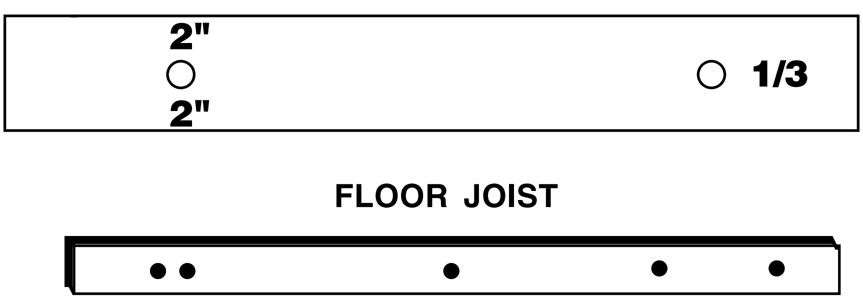


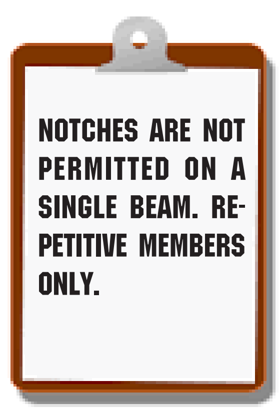
The cutting depth of the saw blade is considered into the maximum depth of the notch. Don't set the saw blade deeper than the maximum depth permitted.

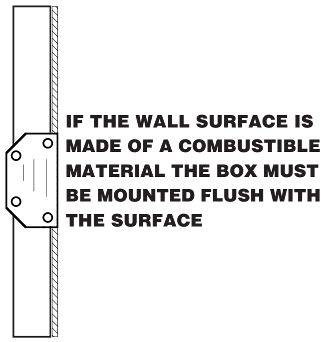


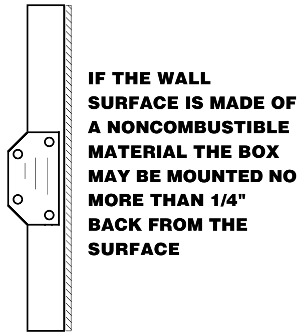
DRILLING OF JOISTS

Holes drilled in joists shall NOT be within 2" of the top or bottom of the joist, and the diameter of the hole shall not exceed 1/3 the depth of the joist.



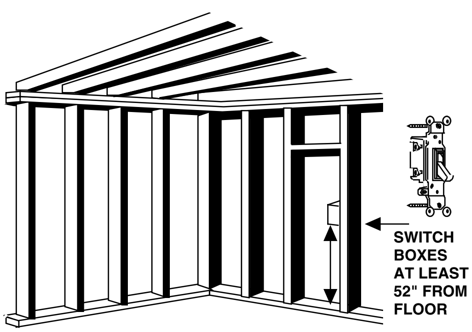


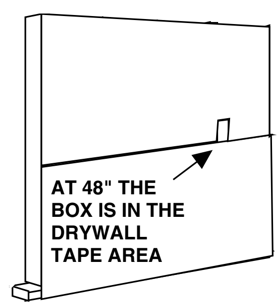


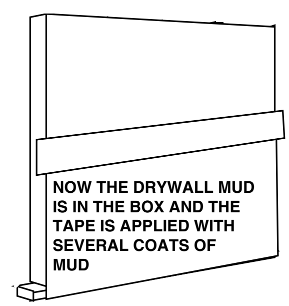


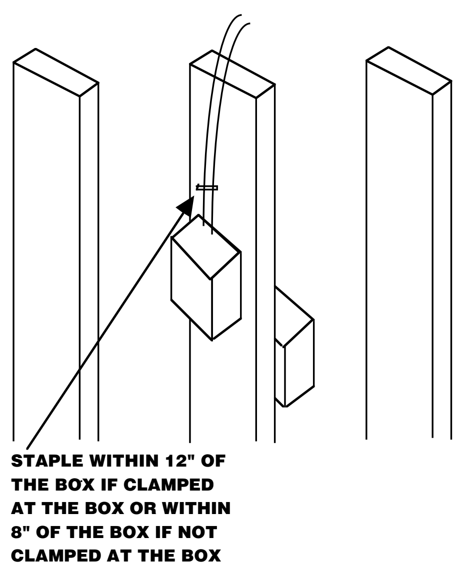
If the surface of the wall is to be of a combustible material such as wood, the boxes for outlets must be mounted flush with the finished surface. If the surface of the wall is to be of a noncombustible material such as dry wall, the boxes for outlets may be recessed in the wall not more than 1/4".

Some drawings show switch box mounting heights at 48" from the floor. Being an electrician over the years has caused me to disagree with this 48" measurement in some cases. When drywall is installed at 48" in height and 12 feet horizontally, the box will be located in the taped joint at 48". Same condition exists with the wall that has 4' x 8' paneling laid horizontally as a wainscot for protection of the lower half of the wall, the top trim molding will cover the box at 48". The bottom of the box should be at least 52" from the floor to stay clear of the 48" of the material being installed, otherwise the joint will fall at the box location. My experience has been when the joint compound is removed from the boxes the wire insulation gets damaged in the process.

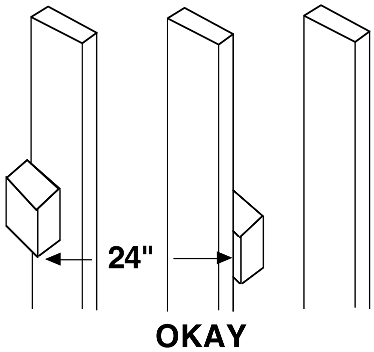








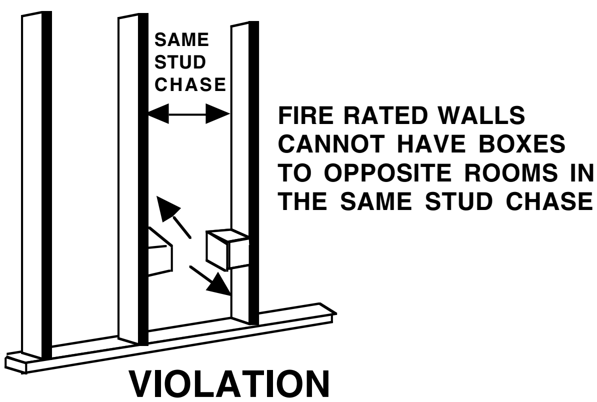
The cable must be stapled within 8" of the box if it is not clamped to the box or within 12" if it is clamped to the box, and must be stapled at no more than 4 1/2 feet of cable run. To avoid damage to the cable, the staples should not be driven too tightly against the cable. If the cable is ran through holes such as through the studs from box to box, it is considered supported and stapling is not necessary.

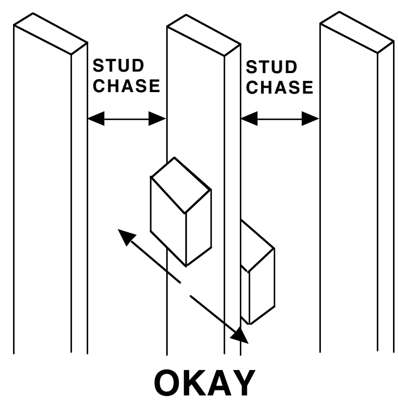


The Building Code requires outlet boxes on opposite sides of the fire resistant wall or the shaft enclosure shall be separated by a horizontal distance of not less than 24".

The exception is openings for electrical outlet boxes of any material are permitted provided such boxes are listed for use in fire resistant assemblies and are installed in accordance with their listings.

Back to back boxes or boxes in the same stud chase to opposite rooms are not permitted in fire rated walls. A good example would be a hotel room where a fire in one room could spread to an adjoining room through the boxes even though the wall is fire rated. Some codes permit boxes if in a different stud chase.

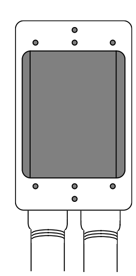




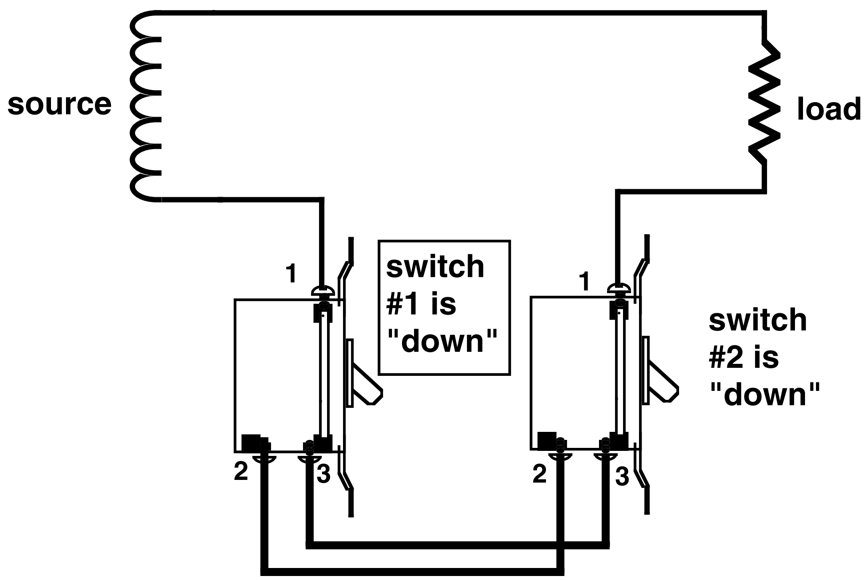
BOX SUPPORTS

Code section 314.23 requires a box to be rigidly and securely fastened in place.

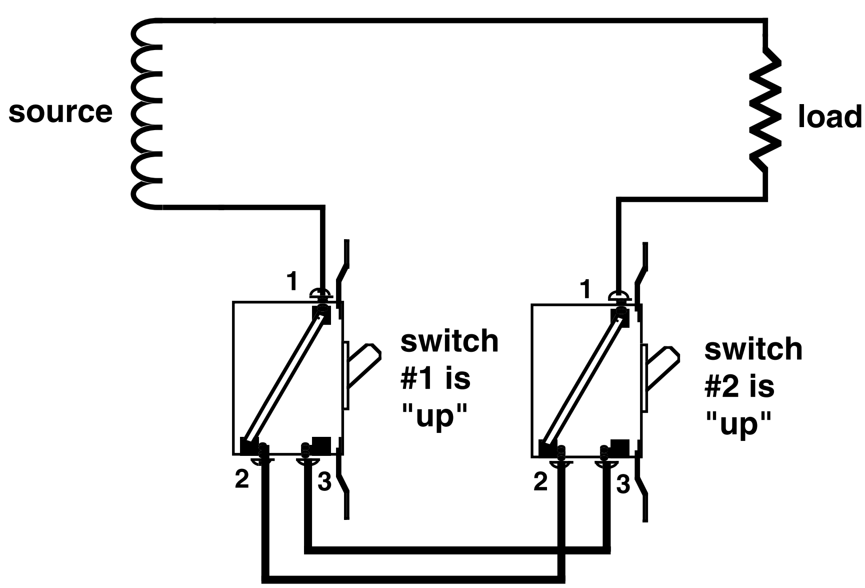
The violation I see everywhere in my travels is the violation of section 314.23(E). Boxes that contain **DEVICES** and are not over 100 cubic inches in size and have threaded entries or hubs shall be considered adequately supported where two or more **CONDUITS ARE THREADED** wrenchtight into the box hubs and each conduit is supported within 18" of the box.



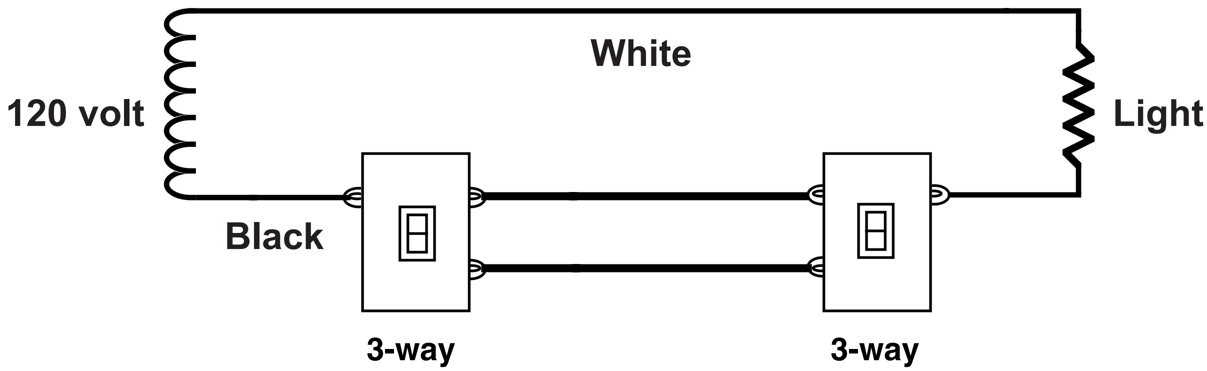
When switching switch **#1** from "up" to the "**down**" position the load now becomes **energized** as there is a complete circuit through terminal screws **1** and **3** on switch #1 and through terminals screws **3** and **1** on switch #2 and on to the load. By switching **either** switch #1 or switch #2 the load can be turned off.

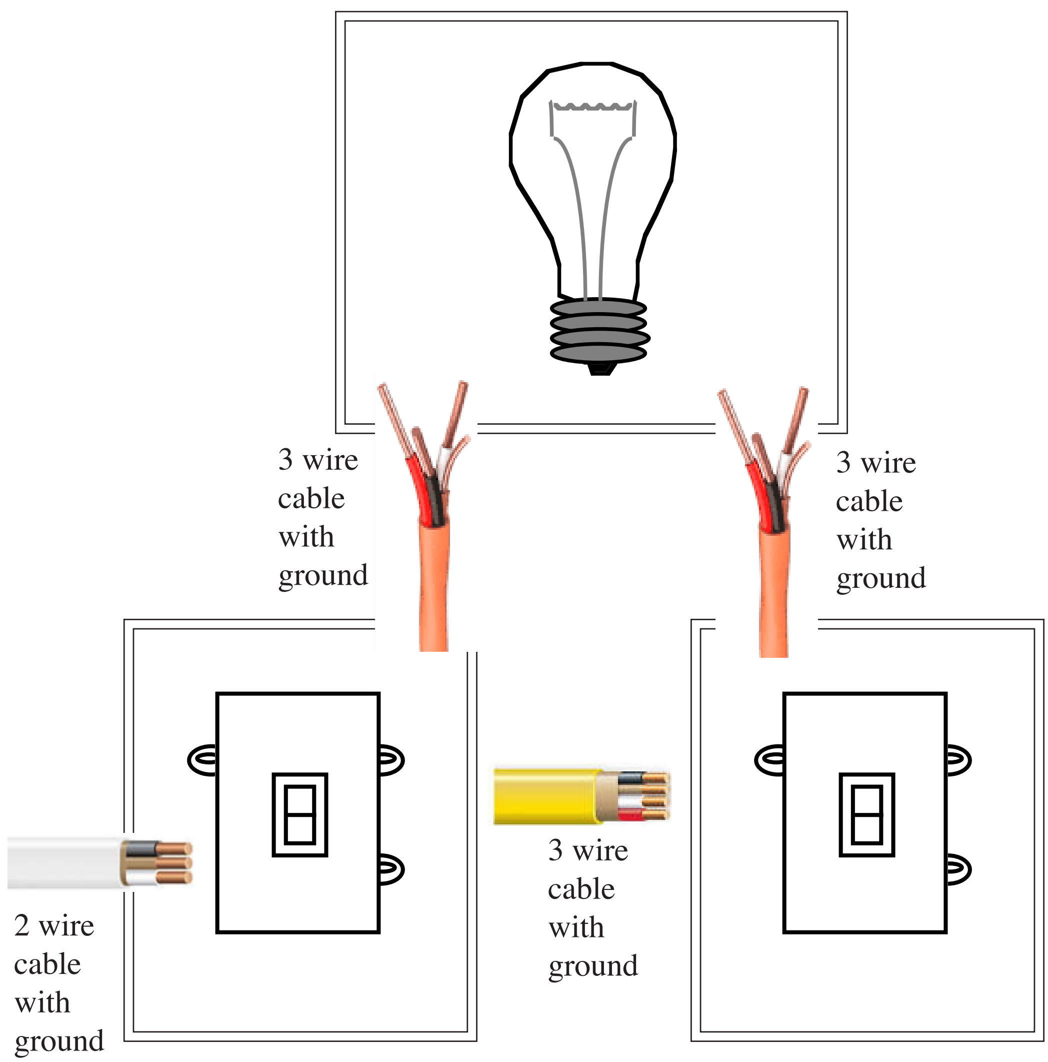


Turning both switches #1 and #2 to the "up" position will also **energize** the load as shown below. And by turning either switch the load can be shut off. It is very important for the student, at this point, to be able to trace a **complete** circuit from the source to the load through the action of the switches, terminals and wiring.



3-Way switch with one light

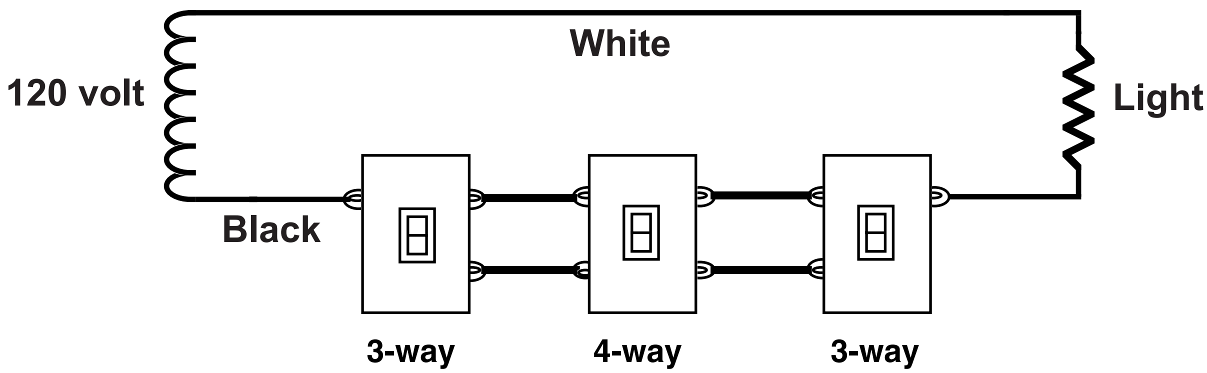




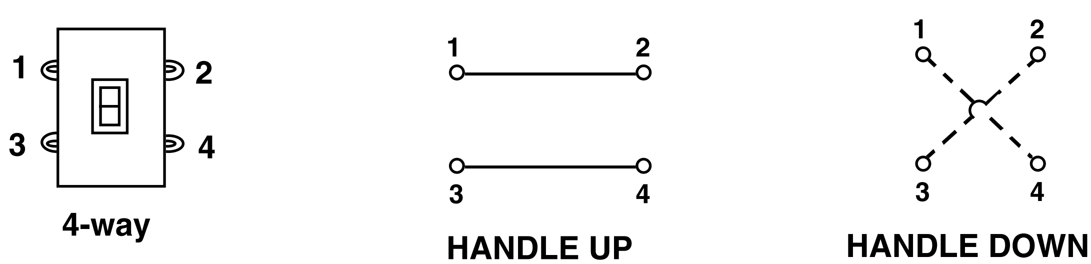
•Four way - A three-way switch has three terminals; a four-way has four. These control a light from two or three switch locations, such as at the top and bottom of a stairwell, at either end of a hallway, or in a large room with multiple entrances.

4-way switches have four terminals on them: two for traveler wires coming in, and two for traveler wires going out. The device will usually indicate which two terminals are for “incoming” and “outgoing” wires.

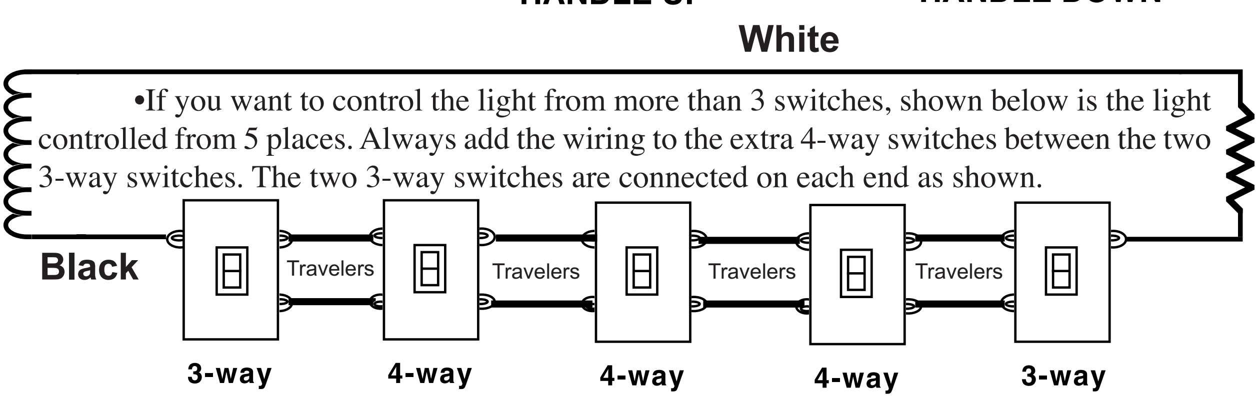
When a load is required to be switched from more than two switching points, a 4-way switch must be used in the circuit. 3-way switches are connected to the source and to the load with the 4-way switches connected in between.



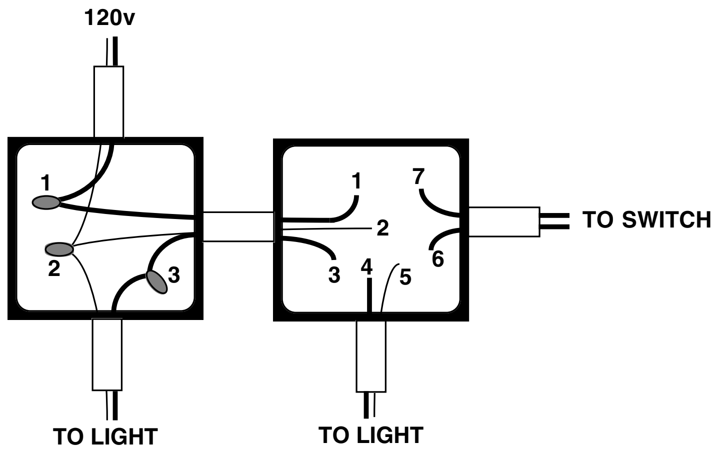
Don't confuse a 4-way switch with a double-pole switch. A double-pole switch will have "on" and "off" marked on the toggle. A 4-way switch has **no** "on" or "off" markings and is constructed so that the switching contacts can alternate their positions as shown below.



•If you want to control the light from more than 3 switches, shown below is the light controlled from 5 places. Always add the wiring to the extra 4-way switches between the two 3-way switches. The two 3-way switches are connected on each end as shown.



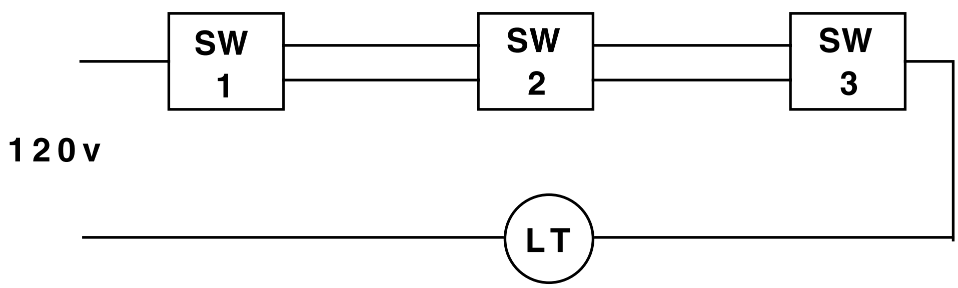
SWITCH EXAM



1. Which wires are connected together so the switch will control both lights?

(a) 1 to 5, 2 to both 6 and 7, 3 to 4 **(b) 1 to 7, 2 to both 5 and 6, 3 to 4**

(c) 1 to 4, 2 to 6, 3 to both 5 and 7 **(d) 1 to 6, 2 to 5, 3 to both 4 and 7**



2. The supply wire to SW1 should be the ____ wire.

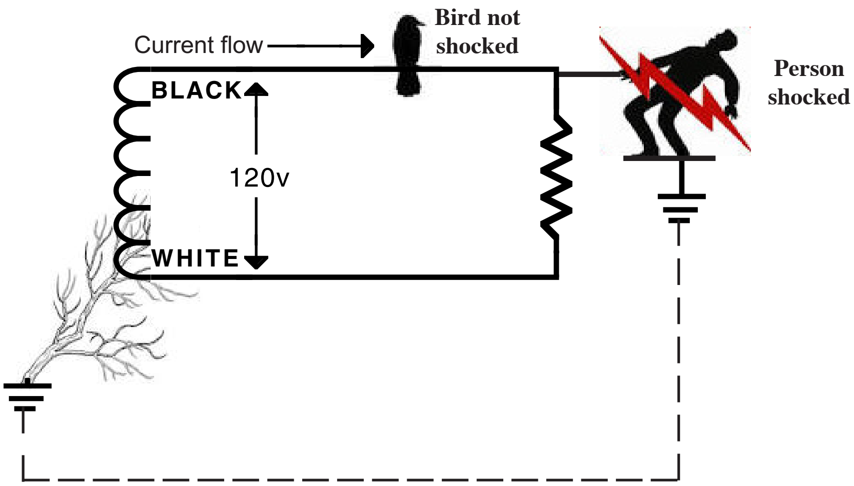
(a) white (b) green (c) bare (d) black

3. SW3 should be a ____ switch.

(a) single-pole (b) double-pole (c) 3-way (d) 4-way

4. SW2 should be a ____ switch.

(a) single-pole (b) double-pole (c) 3-way (d) 4-way

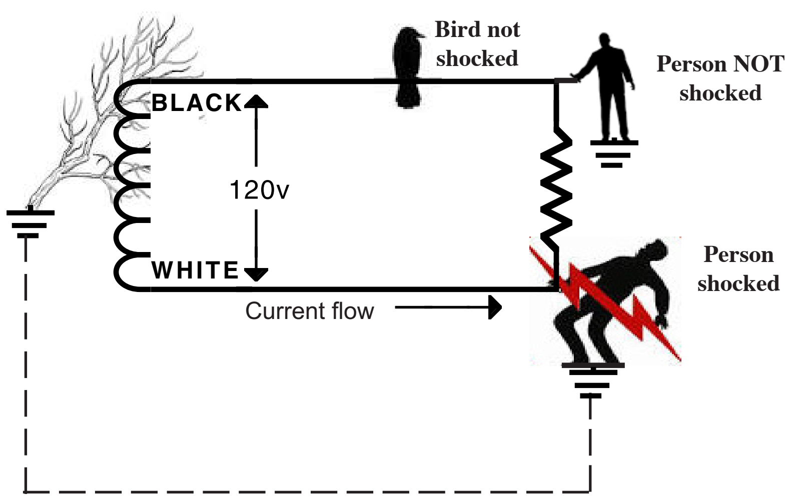


Accidental ground path created through the tree completes the circuit for shock current to flow through the victim.

However, this could all change with an accidental ground, such as a tree branch touching a power line and providing the connection to earth ground:

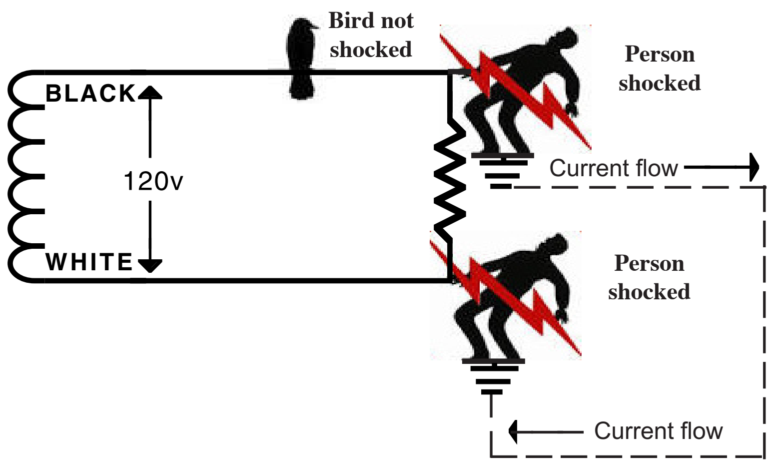
Such an accidental connection between a power system conductor and the earth (ground) is called a **ground fault**.

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.



Accidental ground path created through the tree completes the circuit for shock current to flow through the victim.

With a tree branch contacting the top wire, **that wire becomes the grounded conductor in the circuit**, electrically common with earth ground. Therefore, there is no voltage between that wire and ground, but full (high) voltage between the bottom wire and ground.



As mentioned previously, tree branches are only one potential source of ground faults in a power system. Consider an ungrounded power system with no trees in contact, but this time with two people touching single wires:

With each person standing on the ground, contacting different points in the circuit, a path for shock current is made through one person, through the earth, and through the other person. Even though each person thinks they're safe in only touching a single point in the circuit, their combined actions create a deadly scenario. In effect, **one person acts as the ground fault which makes it unsafe for the other person**.

This is exactly why **ungrounded** power systems are dangerous: the voltage between any point in the circuit and ground (earth) **is unpredictable because a ground fault could appear at any point in the circuit at any time**. The only character guaranteed to be safe in these scenarios is the bird, who has no connection to earth ground at all!

By firmly connecting a designated point in the circuit to earth ground ("grounding" the circuit), at least safety can be assured at that one point. This is more assurance of safety than having no ground connection at all.

Human Contact With Earth

Dirt is not a very good conductor (at least not when it's dry).

It's too poor of a conductor to support continuous current to a load.

It takes very little current to injure or kill a human being, so even the poor conductivity of dirt is enough to provide **a path for deadly current** when there is sufficient voltage available, as there usually is in the branch circuit.

Some ground surfaces are better insulators than others. Asphalt, for instance, being oil-based, has a much greater resistance than most forms of dirt or rock. Concrete, on the other hand, tends to have fairly low resistance due to its intrinsic water and electrolyte (conductive chemical) content.

Concrete is made up of four main ingredients: water, Portland cement, aggregates, and air.

Asphalt, black or brown petroleum-like material that has a consistency varying from viscous liquid to glassy solid. It is obtained either as a residue from the distillation of petroleum or from natural deposits.

Though dirt is a poor conductor, it can conduct enough current to injure or kill a human being.

Current flows from one voltage to a different voltage, and it is often a ground connection of some kind that allows current to flow through a person's body when the person is touching a conductive portion of a circuit. If the absence of a ground connection means that there is zero potential difference between portions of a person's body, no current will flow, and shock will not occur.

Rubber-soled shoes do indeed provide some electrical insulation to help protect someone from conducting shock current through their feet. However, most common shoe designs are not intended to be electrically “safe,” their soles being too thin and not of the right substance.

Also, any moisture, dirt, or conductive salts from body sweat on the surface of or permeated through the soles of shoes will compromise what little insulating value the shoe had to begin with. There are shoes specifically made for dangerous electrical work, as well as thick rubber mats made to stand on while working on live circuits, but these special pieces of gear must be in the absolutely clean, dry condition in order to be effective.

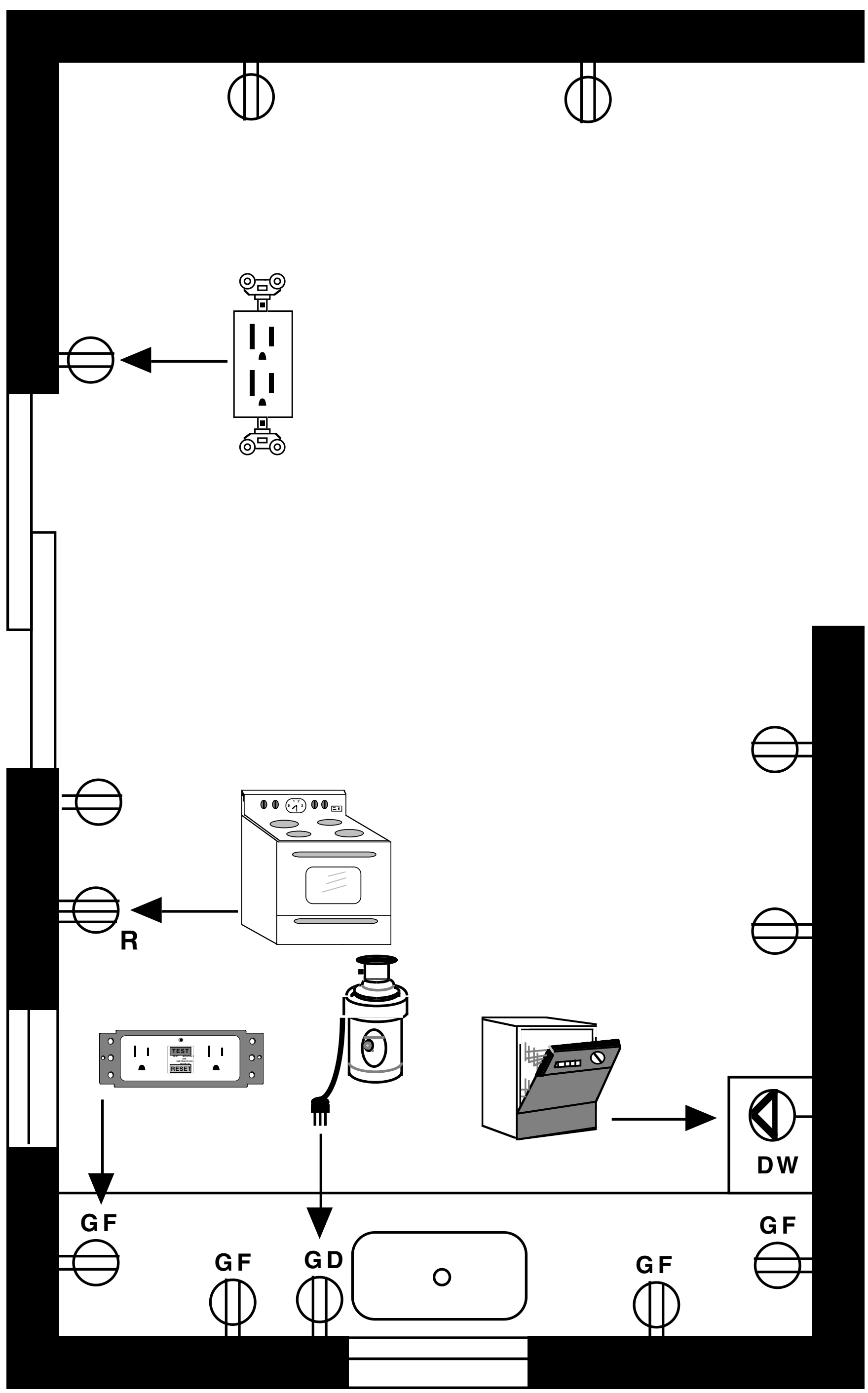
Suffice it to say, normal footwear is not enough to guarantee protection against electric shock from a power system.

Hand or foot contact, insulated with rubber: **20 MΩ typical**.

Foot contact through leather shoe sole (wet): **5 kΩ to 20 kΩ**.

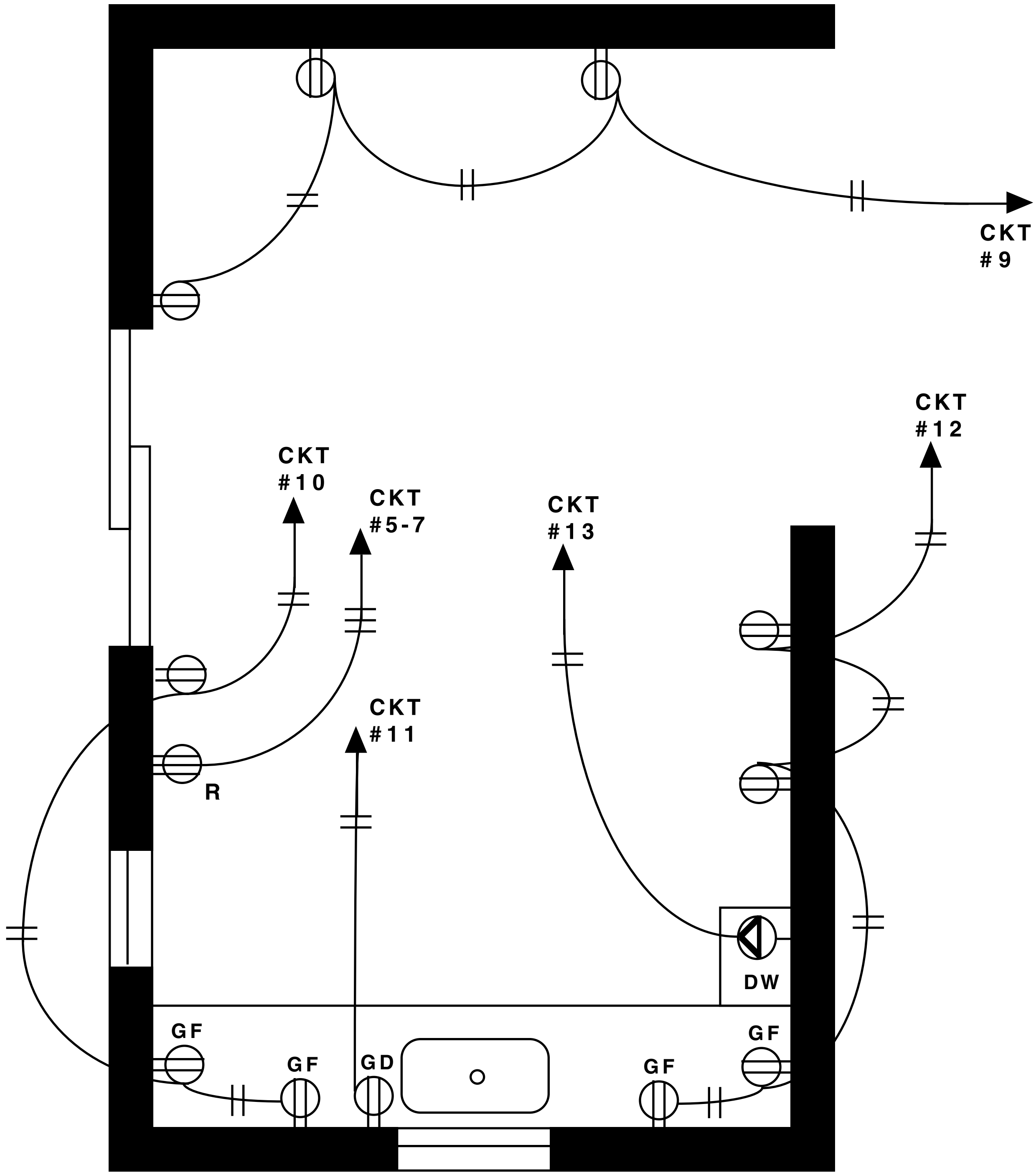
As you can see, not only is rubber a far better insulating material than leather, but the presence of water in a porous substance such as leather greatly reduces electrical resistance.

Now you can see the symbols being used in the floor plan to indicate the type of outlets. The range has a special 3-wire outlet, the receptacles within 6 feet of the sink are required to be ground-fault protected, the disposal has a separate receptacle, the dishwasher has a special outlet.



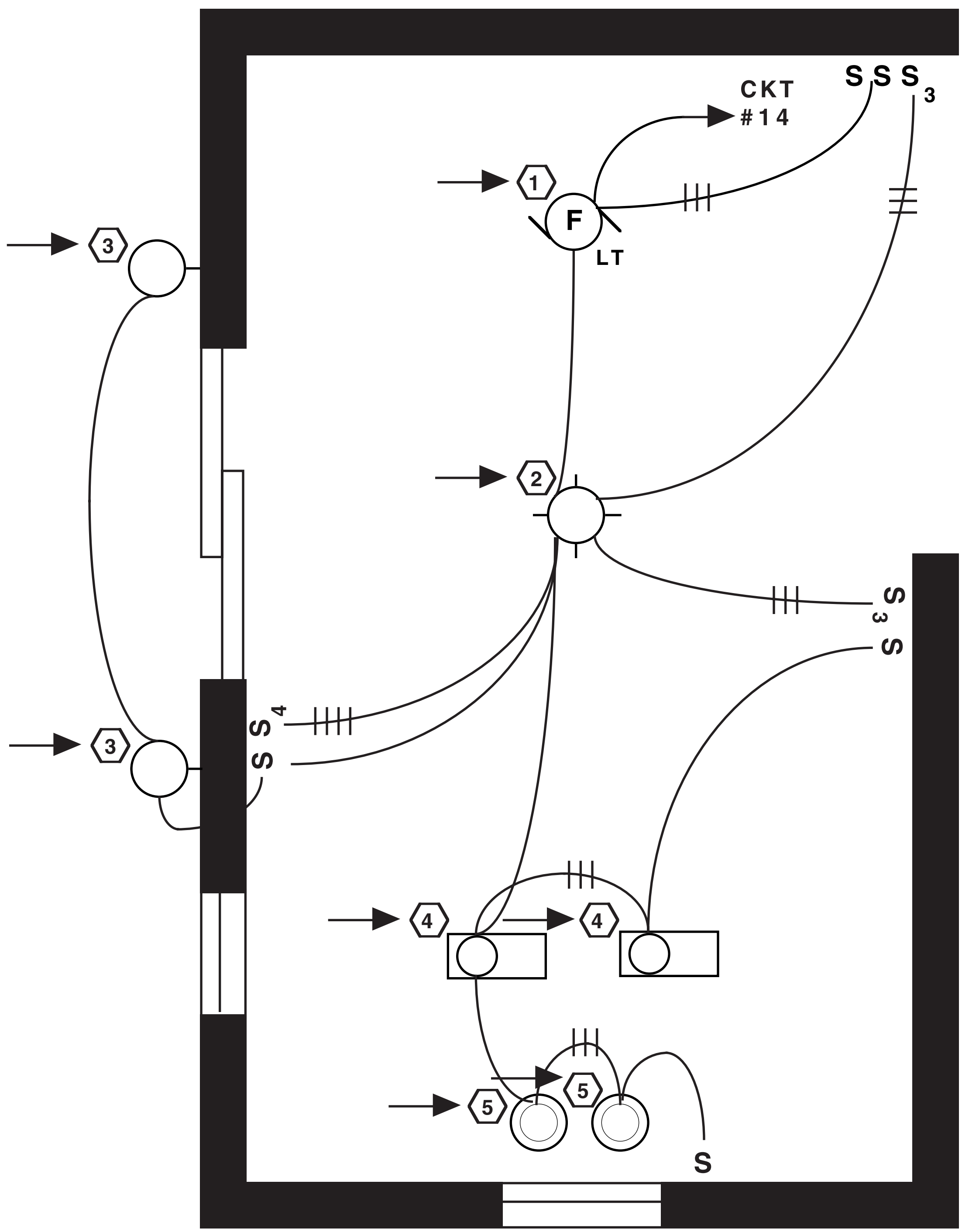
This floor plan shows six circuits (homeruns). Three for the small appliance outlets, one for the dishwasher, one for the disposal and one for the range. The two slash marks indicate a two-wire circuit, the three slash marks on the range cable indicates a three-wire cable.

Often designers will omit the two slash marks from the drawing, after adding the switches and lighting outlets, the drawing can become cluttered with several lines. To avoid confusion, the cable with NO slash marks is a two-wire cable, any cable with MORE than two-wires will be noted with slash marks.

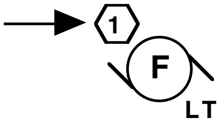


The kitchen lights are not allowed on the 20 amp small appliance circuits, so a separate circuit #10 is run for the lights.

The ceiling fan-light combo has two single-pole switches (one for fan and one for light) with a 3-wire cable to the fixture. The ceiling light is controlled from three locations by using two 3-way switches and one 4-way switch. The other lights are controlled by single-pole switches. •NO slash marks indicates 2-wire cable.



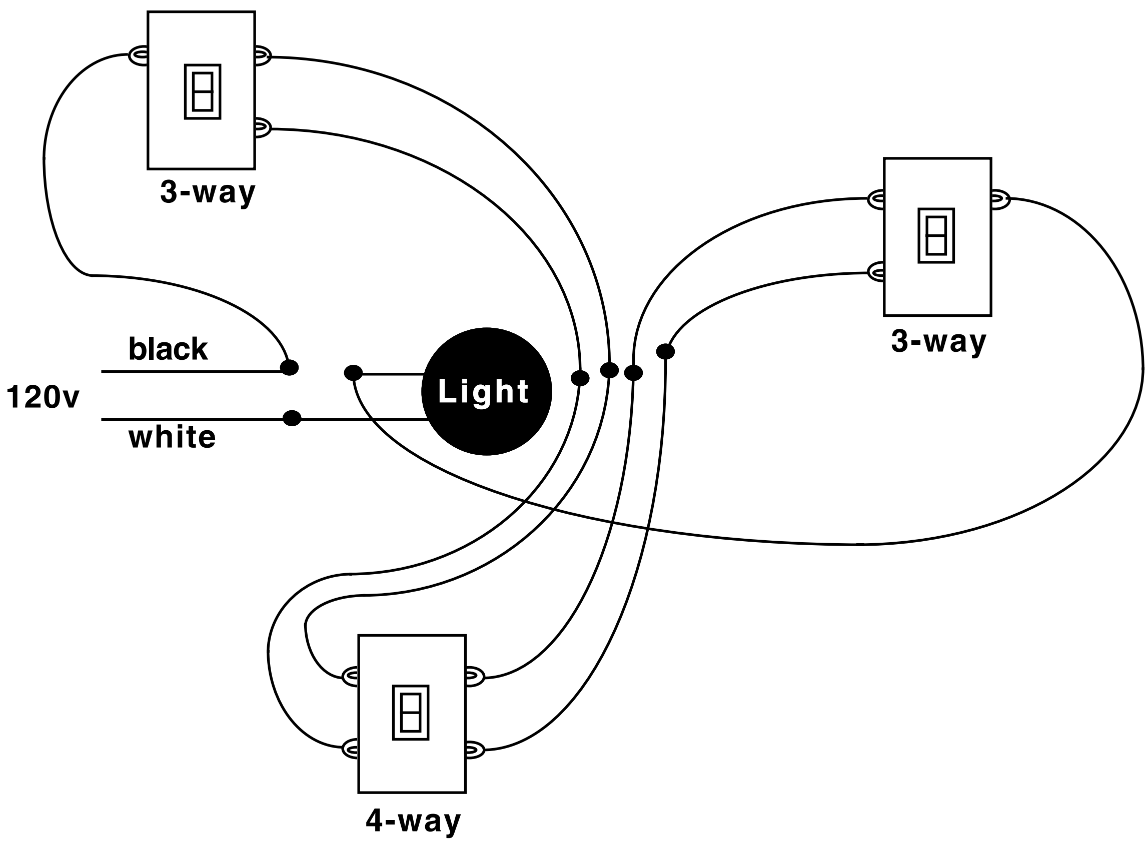
A lighting fixture schedule is a very helpful part of the electrical drawing.

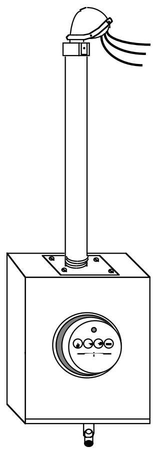


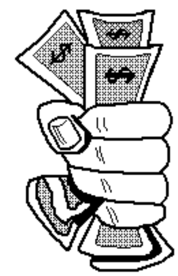
It shows the type by an indicator box. The fixture schedule lists the quantity, manufacturer and item number, type of mounting and even the lamp required for the fixture.

LIGHTING FIXTURE SCHEDULE H - 6677					
Symbol	Type	Quantity	Manufacturer #	Mounting	Lamps
F LT	1	1	Blowtime Inc. f-47338	surface	4-60w
	2	1	Brightlite Co. L-s 23975	surface	100w
	3	2	Outdoor Lumens R-72w	wall	60w
	4	2	Quicklite Inc. F-5649	surface	2-40w WW
	5	2	Intense Lighting R-1275	recessed	60w

Shown below is the ceiling light which is controlled from three locations, which requires four wires from the 4-way switch to the ceiling outlet box, three wires from each 3-way switch to the ceiling outlet box, and a 2-wire cable which is the 120 volt source wire.





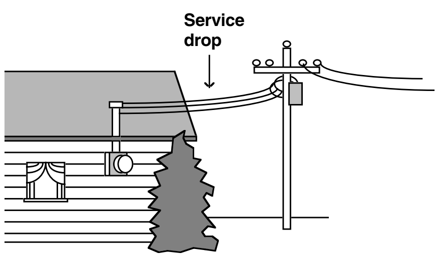


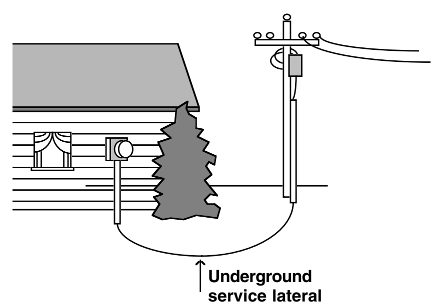
The location of the service to a building is extremely important as this is where the big money is spent.

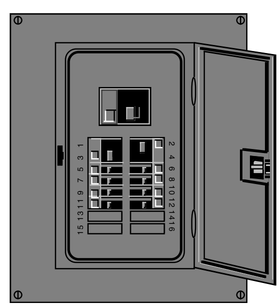
The service can be overhead or underground. The key in a residence is to locate the service and panelboard close to the heaviest loads. The heaviest loads would be the highest wattage appliances such as the range, water heater, clothes dryer, air conditioner, electric heat, etc.

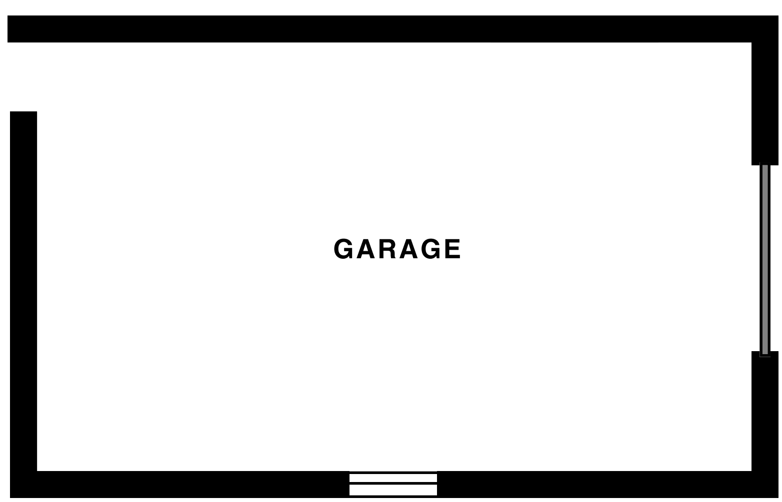
These appliances require the larger size cable which is the money factor. Always try to keep these circuits at a minimum distance from the panelboard.

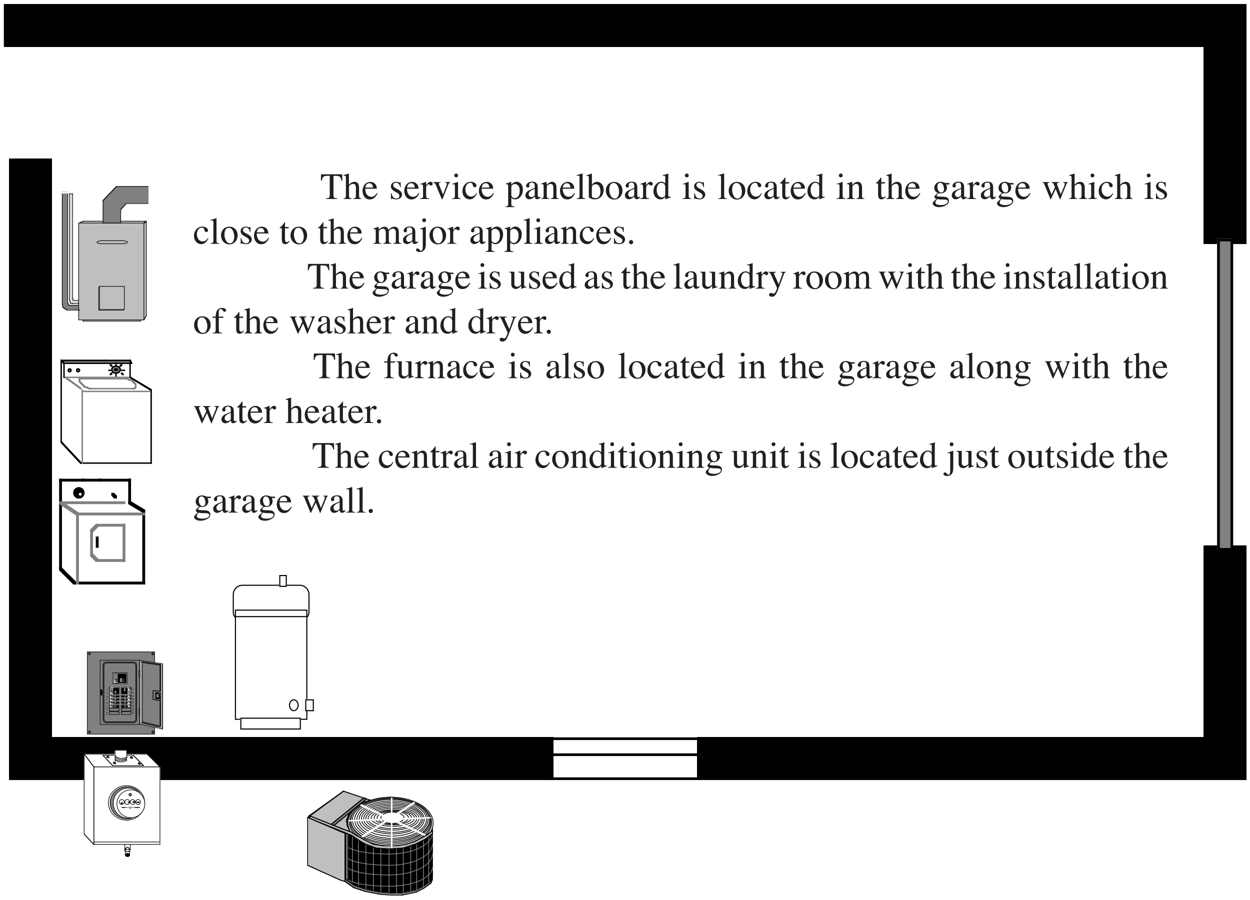
A garage that is close to the kitchen is an excellent location for the panelboard.









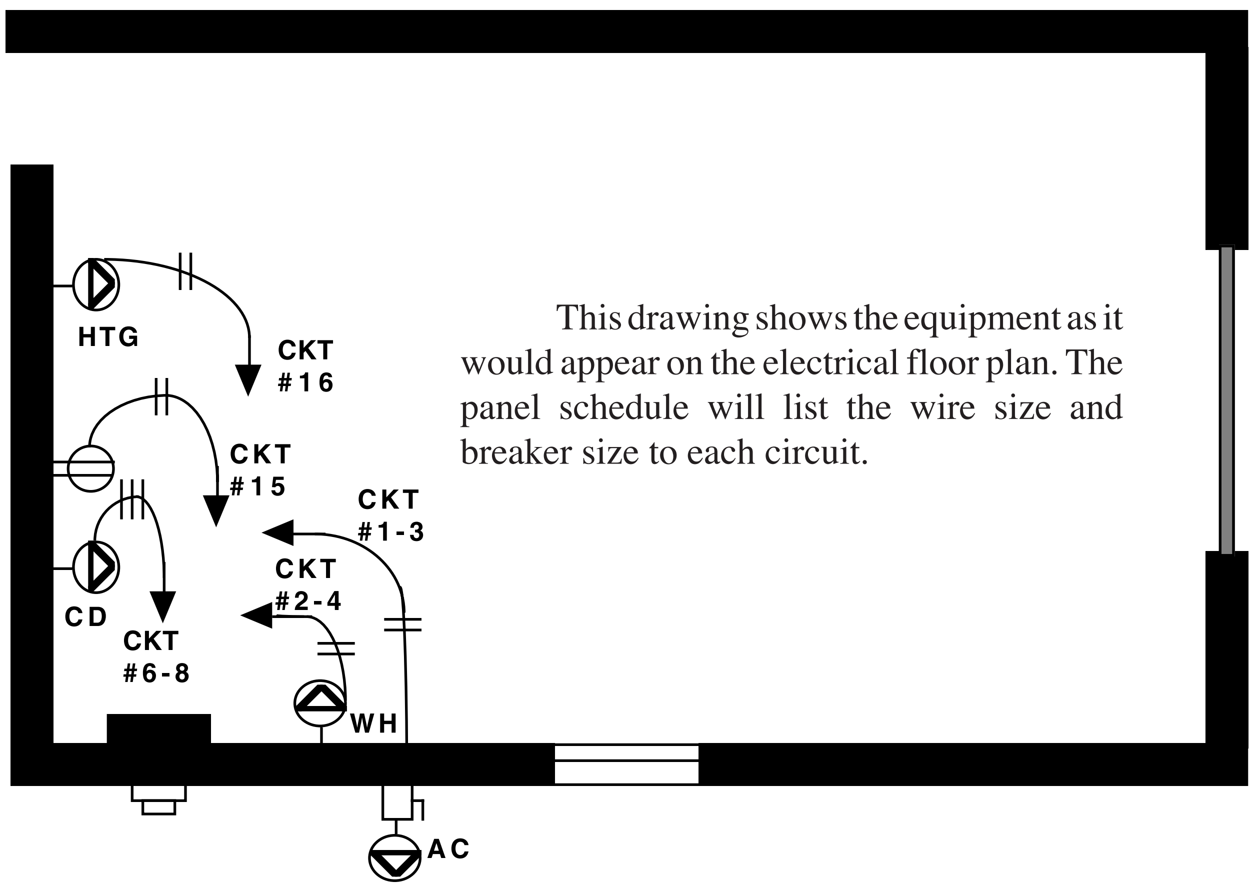


The service panelboard is located in the garage which is close to the major appliances.

The garage is used as the laundry room with the installation of the washer and dryer.

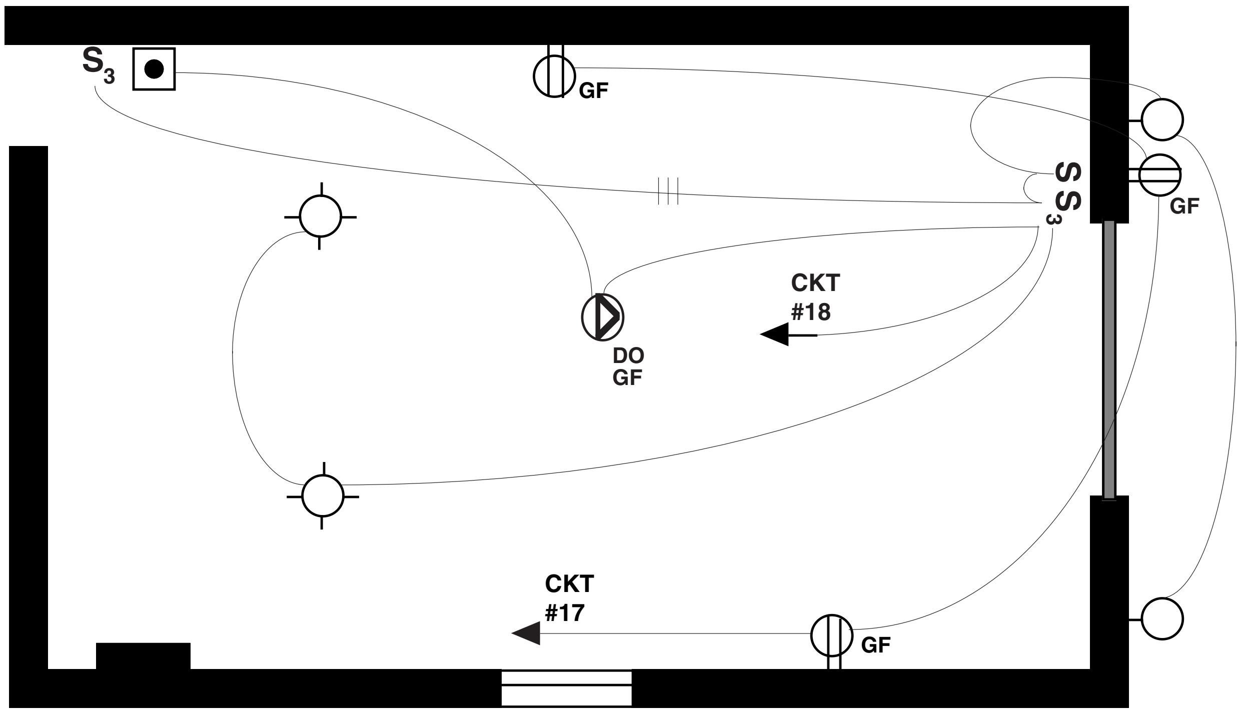
The furnace is also located in the garage along with the water heater.

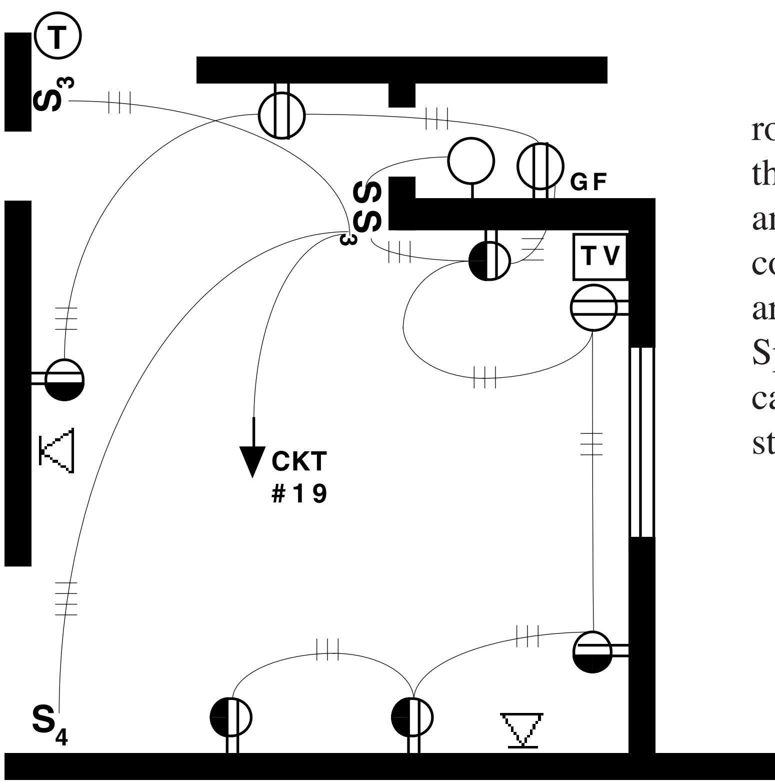
The central air conditioning unit is located just outside the garage wall.



This drawing shows the equipment as it would appear on the electrical floor plan. The panel schedule will list the wire size and breaker size to each circuit.

This drawing shows the remaining outlets in the garage. Circuit #17 is a required GFCI circuit to the receptacles. Circuit #18 is feeding the lights and overhead door opener which is GFCI protected.





Circuit #19 feeds the living room which is an area of the house that is lightly loaded. Two 3-ways and one 4-way switch is used to control the split-receptacles which are used in place of ceiling lights. Special wiring is required for the cable TV, telephones and thermostat.