Lesson 9: Running Wire from the SEP

Once the electrical power has been directed from the yard pole into the service entrance panel, it is time to consider the proper procedures for wiring the agricultural structure and connecting power to the switches, lights, and convenience outlets. When initially planning the wiring of the structure, determining the number and type of circuits that will be established in the building is important.

Location of the SEP

As discussed in Lesson 6, the NEC requires that the SEP be as close as practical to the point where the wires enter the building. It should also be located near equipment that has a high electrical draw, such as water heaters or large motorized equipment. This practice will reduce the costs of wiring by shortening the length of the run for larger wire sizes. It will also reduce voltage drop.

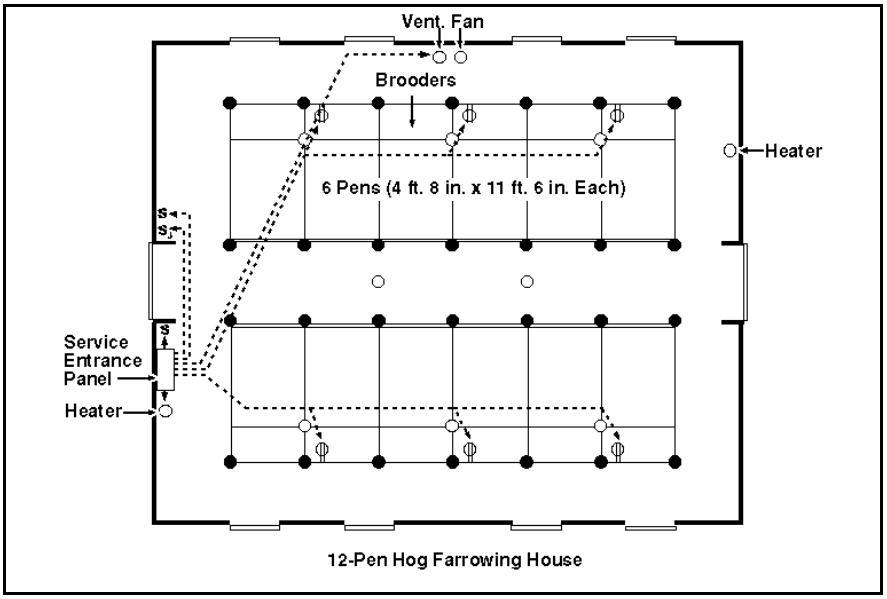
The SEP should be in an easily accessible location for three reasons. In an emergency, someone must be able to shut off power immediately. Also, ease of access to the panel is necessary if fuses blow or breakers are tripped. Finally, an easily accessible panel makes it easier to add circuits to the system.

Determining the Route of Each Circuit

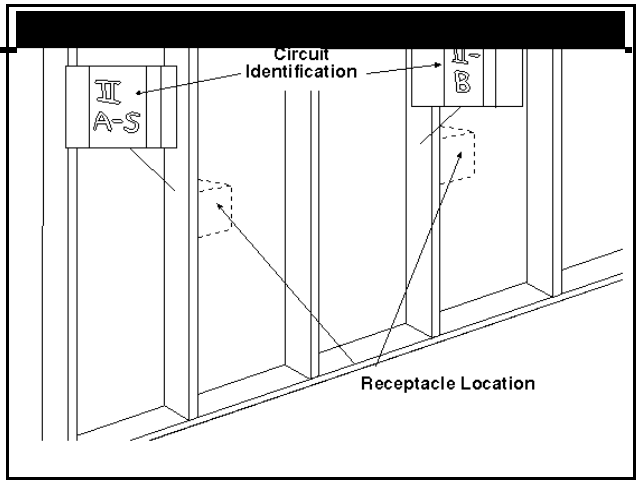
When the SEP is in place, the route of individual branch circuits can be planned. Because many different circuits may be used to control different outlets, lights, and pieces of equipment, carefully planning the path of each electrical circuit is important.

Two types of electrical circuits are considered when making a wiring plan. General circuits are those circuits carrying 110-volt current and normally containing more than one electrical device. Individual electrical circuits carry 220 volts of current and typically operate a single piece of equipment. Determining which type of circuit will be used and where the electrical devices will be placed within the structure is necessary. Remember, the placement of the SEP is partially determined by where the individual circuits with their heavier electrical loads will be placed.

The next consideration is which outlets will be connected to which circuit at the service entrance panel. A good rule of thumb is to avoid placing all the light fixtures in the same room or building on one circuit. With them all on a single circuit, if the overcurrent device that controls the lighting is triggered, the building or room will be in the dark, which may make it difficult to correct the problem. The amount of electrical load placed on convenience outlets will determine their circuit needs. If the outlets in a room or building will have low usage, with one to two outlets used at any given time, these outlets may be placed on a single circuit. If more than two outlets will be used at once or equipment with a high electrical draw will be used on a regular basis, the outlets should be split up on different circuits. Detailed planning can help avoid problems with blown circuits.



A wiring diagram (Figure 9.1) is useful when planning where branch circuits will run and what electrical devices will be connected to them. On the diagram, the entry point is marked first. The entry point is the point on the circuit where the wire attaches to the first electrical device on the circuit. The next step is adding up the number of devices on the circuit and making sure sufficient amperage can be supplied. This process is repeated for each circuit.



Next, outlet boxes for lights and receptacles are physically mounted at each location. They are labeled on the diagram and within the structure for easy reference. A code system based on the circuit used makes it easy to connect electrical wiring to the appropriate circuits and outlets. Figure 9.2 shows an example of circuit identification. One coding method involves using Roman numerals (I, II, III, etc) for the individual circuit line. Letters (A, B, C, etc.) designate the different outlet boxes. Switches are labeled with an S; if three-way switches are used, they are labeled S1 and S2. All outlet boxes and switches should be labeled prior to installing any wire for the branch circuits.

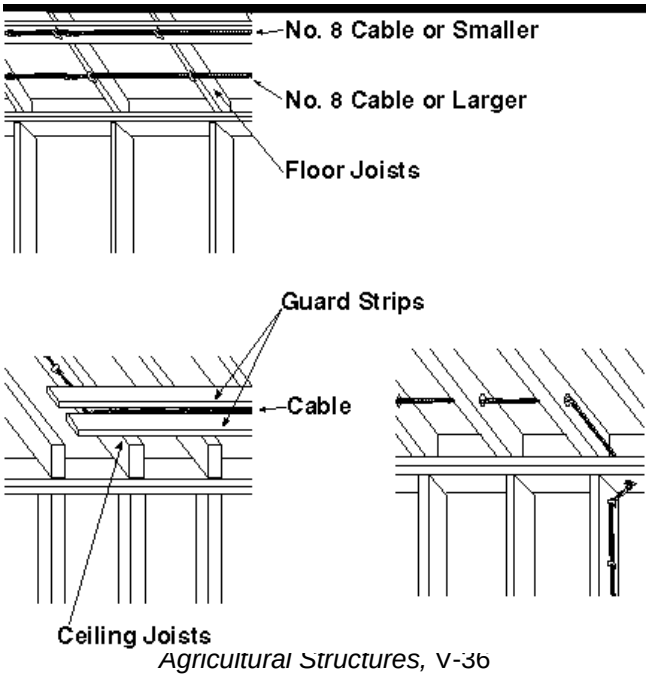
Running the Wires

Once the labeling is complete, wires can be run in the structure. Protecting the wire is an important consideration. Excessive bending of electrical conductors should be avoided to prevent the insulation from cracking, which could cause the wire to short out. Also, wire is run inside of walls and ceilings to prevent physical damage to the wires. Any exposed wire runs or runs where damage may be a concern, such as in walls where moisture damage could occur, should have the conductor placed inside of a conduit.

A few general practices should always be followed when running wire in a structure. Conductors should run as straight as possible from the SEP to the individual outlets. To reduce the possibility of system failure, as few splices as possible should be used. Wire runs should be as high and dry as possible.

Conductors may be run through the floor or ceiling. Ceiling runs are best because damage from traffic is minimized. They also reduce wire damage because the wires are not located where water may collect or flow. Examples of ceiling runs are shown in Figure 9.3. If runs must be under flooring, noncorrosive conduits should enclose the wires.

Placing electrical runs in the walls is also common. Four approved methods are used to place electrical conductors within a wall; they are illustrated in Figure 9.4. The first method requires the drilling of a hole in the center of the wall studs. The hole should be large enough to accept the conduit or to allow the cable to slide through easily without friction and binding. Wire



can also be stapled along the side of a stud. A third method of running wire involves cutting a notch in the side of the wall studs. A steel cover plate is installed over the notch after the wire is in place. In structures where moisture will not be a factor, wire can be run in the walls by notching the bottom of the studs and running the wires along the bottom plate of the wall. This last alternative lessens problems with installing insulation later.

Tools for Wiring a Receptacle or Light

Gathering all the necessary tools is an important first step before installing anything. As with any construction task, the use of the proper tools is essential to working safely and efficiently.

Numerous tools can be used in electrical wiring. However, a few essential tools must be on hand to do a good job with installations.

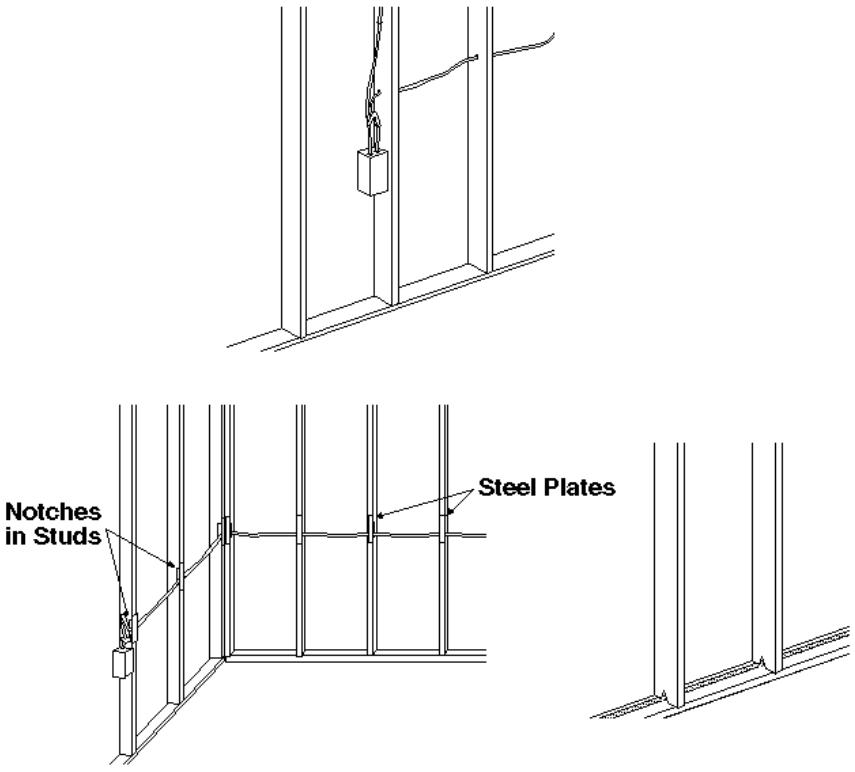
- Wire cutters, either lineman's pliers, side cutting pliers, or needlenose pliers
- Cable rippers, which is used to remove the cable covering from the conductors housed in the cable sheathing
- Wire strippers for removing insulation from conductors
- A complete set of screw drivers
- Hammer
- Slip-joint pliers
- Level
- Tubing cutter for cutting conduit
- Conduit bender, which is used to bend or form conduit to turn corners

Other tools can also be used to accomplish wiring tasks more efficiently. They include the following:

- Socket wrenches
- Drill motor and drill bits
- Adjustable open-end wrench
- Hand saw
- Electrical testing equipment

The Function of a Junction Box

When wiring circuits, branching the circuit is sometimes necessary. Branching is splitting the circuit to allow power to run in two or more directions. A junction box is used to protect the wires that are spliced together to branch circuits. Junctions are sometimes needed if a long



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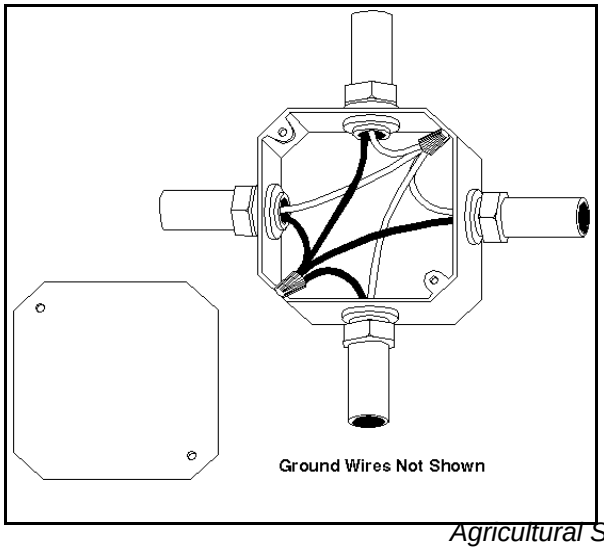
electrical run is required or if no convenient outlets are available from which to branch power to different outlets on the same circuit.

A junction box is basically an outlet box with a solid cover. The NEC states that all boxes in which splice connections are made must be dust tight and watertight. The NEC also requires that they be made of corrosion-resistant material. Junction boxes should be located where they are permanently accessible for repairs.

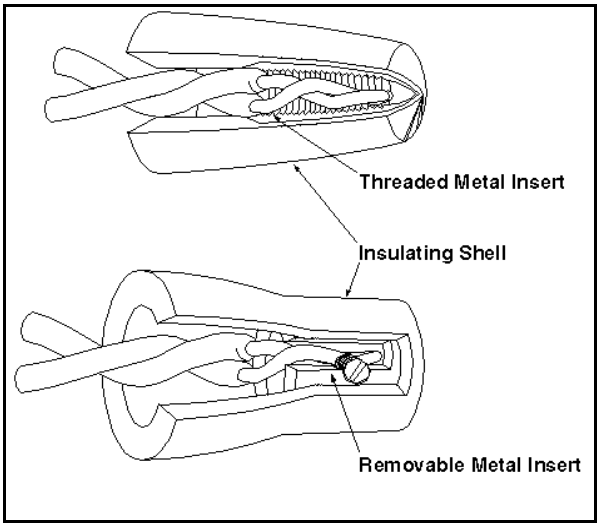
Connections in a junction box should be made carefully, paying attention to detail. The ends of the wires are inserted into the junction box through the knockouts, which are specially designed parts of the junction box that can be removed. About 6 inches of each wire should pass through the knockouts. When splicing conductors together, black wires are connected to black wires, white wires to white wires, and ground wires to ground wires. If the outlet box is metal, a separate piece of wire should be connected to the box and the ground wires. The wires should be clamped securely to the box to prevent the splices from pulling apart. A junction box is shown in Figure 9.5.

Techniques for Splicing Wires

For most electrical wiring, solderless connectors are used to splice wires. Several different types of solderless connectors are used, including threaded metal insert connectors, removable metal insert connectors, and spring-loaded connectors. These connectors are pictured in Figure 9.6. They all perform the same basic function of efficiently joining two or more wires.



Insulated solderless connectors, commonly referred to as wire nuts, are easy to use. To splice wires, the wire insulation is stripped back just enough for the wires to fit inside the connector. The wires are then laid together. The method for connecting the wires depends on the connector selected. With the threaded metal insert connector, where the insert is



contained in an insulating shell, the connector is screwed onto the wires to be joined. For the removable metal insert connector, the insert can be removed from the insulating shell. The insert slips over the wires, and the set screw in the insert is tightened to lock the wires in place. The insulating shell then screws back on over the insert. The spring-loaded connector is similar to the threaded metal insert in that it screws onto the wires to be spliced. Inside of the insulating shell is a cone-shaped spring that holds the wires together when screwed onto the wires.

When using solderless connectors, taping the conductors may be necessary. If the correct amount of insulation has been removed, tape is not needed because the insulating shell of the connector will protect the bare wires. However, if bare wires are exposed, electrician's tape is wrapped around the connection to protect the wires.

When splicing wires that are AWG 8 and larger, different connectors are needed. For these situations, metal connectors are used. They have a collar with a set screw. To splice wires, the wires are inserted into the connector, and the screw is tightened to hold them in place. The connector and wires are wrapped with electrician's tape to protect the joint.

Wiring a Light Circuit

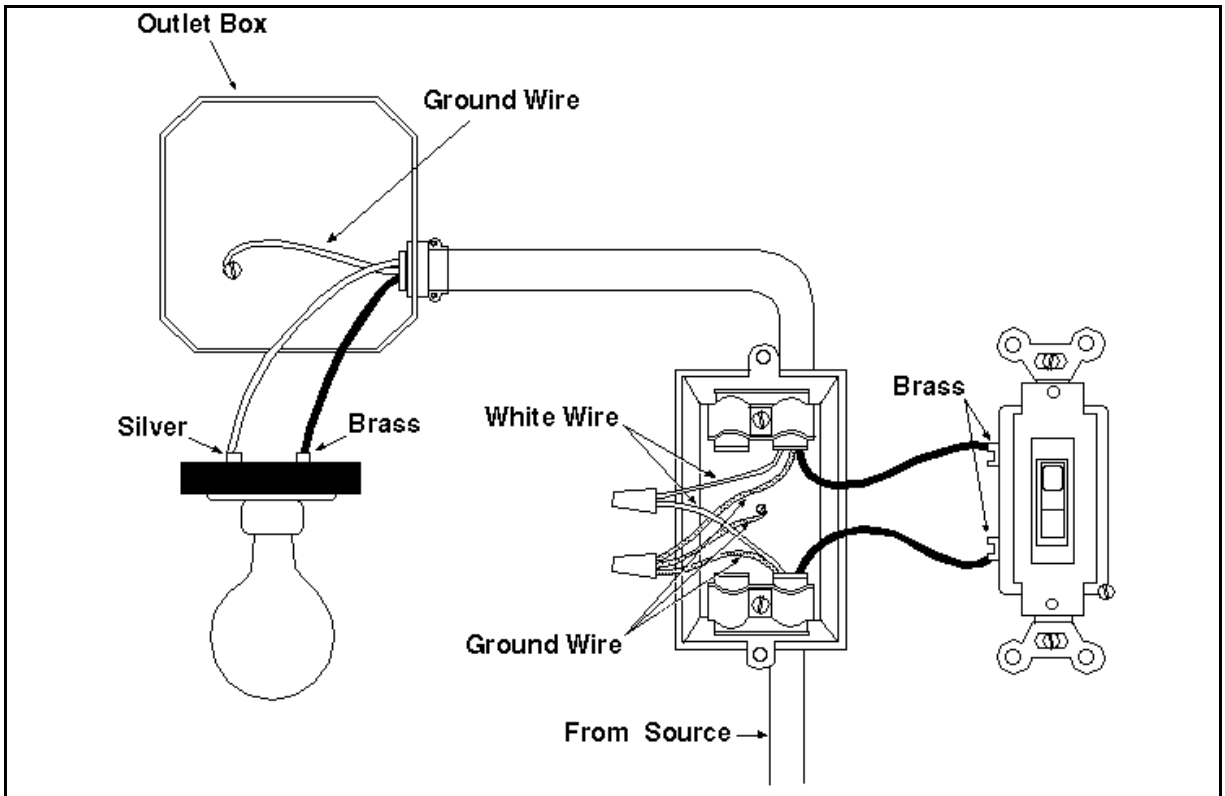
Almost every structure that has electrical power will have some form of lighting. Understanding the principles behind the proper wiring of lights and switches is necessary to efficiently and correctly connect these circuits.

Wiring a switched circuit, as shown in Figure 9.7, is relatively simple. White, black, and ground wires enter the switch box from the power source. The white source wire is connected to a white wire with a connector. The black source wire is connected to a brass screw on the switch. Another black wire is attached to the other screw on the switch. At the light fixture, this black wire

Before wiring any type of light circuit, the wires must be inserted into an outlet box. Six inches of the insulation is removed before inserting the individual wires into the box. Box connectors, or special connectors that attach to the electrical box and clamp the conduit in place, hold the wires in place as they enter the box.

The most basic light circuit is the simple circuit. For this circuit, the black hot wire connects to a brass screw on the light fixture. The white neutral wire connects to a silver screw. The electrical flow through the fixture and the attached lamp provides light. This system is impractical because the light cannot be turned on and off.

A switched circuit allows a light to be turned off. In a switched circuit, a switch breaks the electrical circuit of the light fixture. When the switch is open, it interrupts the flow of electricity and turns the light off. When the switch is closed, electricity flows through the circuit, creating light.



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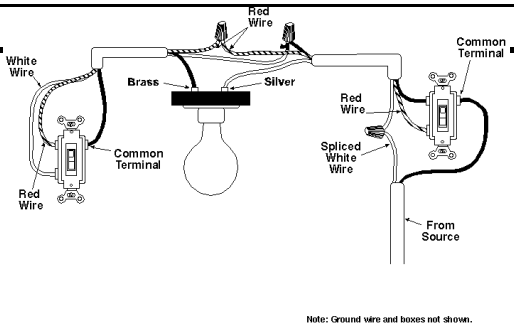


is connected to a brass screw and the white wire to a silver screw. A green ground wire from the light fixture is connected to the ground wire from the source using a solderless connector. If the boxes are metallic, the ground wires are attached to the boxes with a piece of wire.

In a switched circuit, the power may be brought from the source to the light fixture box rather than to the switch. A switch loop is used to carry the electricity to the switch. In a switch loop, a pair of black wires brings the power to the switch from the lighting box and carries it back to the light, as illustrated in Figure 9.8. The black source wire is connected to a length of black wire with a connector. This wire is connected to a brass screw on the switch. Another black wire is connected to the other brass screw on the switch. This second black wire runs back to the lighting box. It is attached using a connector to a black wire from the brass screw on the fixture. The white source wire is connected to a white wire from the light fixture using a connector. The white wire is attached to a silver screw at the light fixture.

The wires from the two switches meet at the light fixture. The black wire from the first switch is connected to the white wire from the second switch using a solderless connector. A connector is also used to splice the red wires together. The black wire from the second switch is attached to the brass screw on the fixture, and the spliced white wire from the power source is connected to the silver screw. A completed three-way switch is pictured in Figure 9.9.

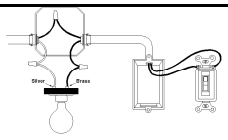
Series and parallel wiring are two methods used for wiring two or more light receptacles together. These methods are used when more than one light fixture is on a circuit. They are illustrated in Figure 9.10.

A three-way switch controls another type of lighting circuit. Using a three-way switch, a light can be turned off and on from two different locations. The wiring requires the use of a three-wire cable with black, white, and red conductors plus a ground wire.

Wiring a three-way switch begins at one of the switches. The black wire from the power source is connected to the common terminal on the switch, which is the side of the switch with one terminal screw. A black wire is connected to the switch on the opposite side from the black source wire. A red wire is connected to the other terminal on that side. The white wire from the source is spliced to another white wire with a solderless connector. Appropriate ground connections are made at the switch.

Next, the other wires are connected at the second switch. A black wire is connected to the common terminal of the switch. A red wire is attached to the terminal opposite the black wire, and a white wire is connected to the other terminal. The ground connections are then made in the box.

Series wiring is an impractical system except for special purposes because the way the outlets are connected, if one light goes out, they all go out. Series wiring is primarily used in situations where a burned out light needs to be addressed immediately. To install a series system, the black wire from the source is attached to a terminal on the first fixture. A white wire then runs directly from the second terminal to the next lighting fixture and attaches to a terminal there. Another black wire runs from the second terminal



on that fixture directly to the next fixture. This pattern continues through the series. If one lamp burns out, it breaks the circuit, thus cutting off electricity to all the lights on the circuit.

Parallel wiring is the most common method of wiring multiple light fixtures. In parallel wiring, jumper wires attached to each light fixture are spliced to the white and black wires from the power source. This system allows power to flow separately to each individual lamp on the same circuit. If one lamp burns out, the other lamps will still receive power for lighting.

Wiring Convenience Outlets

Convenience outlets provide electrical connections for tools and equipment. Therefore, wiring them properly in the electrical circuit is necessary. Outlet receptacle devices are easy to install and can be connected in a series. These receptacles can be controlled with switches.

Wiring a receptacle circuit begins with attaching the black source wire to the side of the receptacle with the brass screw. The white wire is attached to the silver screw on the opposite side of the receptacle. The ground wires are joined using a connector. A wired receptacle is illustrated in Figure 9.11.

The procedure for wiring two or more receptacles on a circuit is more complicated. The first receptacle is connected as described.

Another black wire is then connected to the other brass screw on the first outlet and to the brass screw on the second receptacle. A white wire is connected to the second silver screw on the first receptacle and the silver screw on the second. The same procedure is followed for any other receptacles on the same circuit. The appropriate ground connections should then be made.

Summary

Planning the location of circuits and equipment to be installed is useful. Not only does a wiring diagram identify how electrical runs will be laid out but also where electrical outlets will be installed. Once the plan is finalized, the proper tools to do the job should be gathered together. Lights and receptacle outlets can be then be installed using the proper techniques.

Credits

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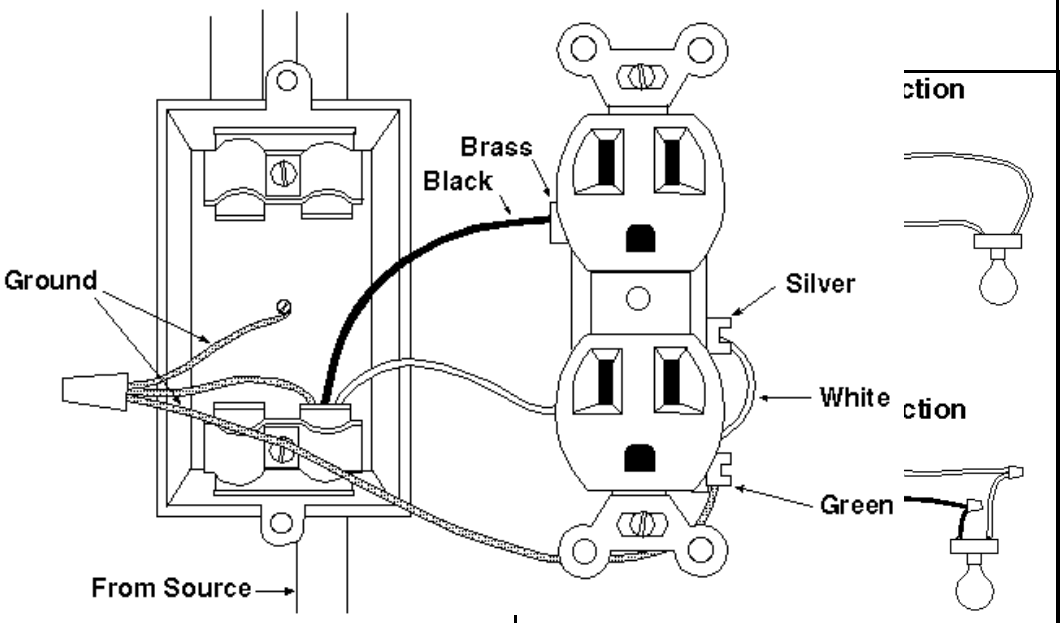

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