

UNIT V - ELECTRICITY

Lesson 9: Running Wire from the SEP

Competency/Objective: Describe how to run wiring from the SEP to a junction box, lights, and receptacles.

Study Questions

1. Where should the service entrance panel be located?
2. How is the route of each circuit determined?
3. How are the wires run through the building?
4. What tools are needed to wire a receptacle or light?
5. What is the function of a junction box?
6. What techniques are used when splicing wires?
7. How is a light circuit wired?
8. How are convenience outlet circuits wired?

References

1. *Agricultural Structures* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1999, Unit V.
3. Transparency Masters
 - a) TM 9.1: Wiring Diagram
 - c) TM 9.2: Labeling Receptacles
 - d) TM 9.3: Ceiling Runs
 - e) TM 9.4: Wall Runs
 - f) TM 9.5: Junction Box
 - g) TM 9.6: Connectors
 - h) TM 9.7: Wiring a Switch and Light
 - i) TM 9.8: Wiring a Switch Loop
 - j) TM 9.9: Wiring a Three-Way Switch and Light
 - j) TM 9.10: Series and Parallel Wiring
 - k) TM 9.11: Wiring a Convenience Outlet
3. Job Sheet
 - a) JS 9.1: Wiring a Three-Way Switch

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TEACHING PROCEDURES

A. *Review*

Lesson 8 described the proper methods for making connections at the service entrance panel. Lesson 9 will examine how branch circuits are planned and how wire is run through a structure. Switches, lights, and convenience outlets can then be installed.

B. *Motivation*

Show the students examples of light fixtures and convenience outlets so they can see the terminals used in wiring. Display the tools used in installing the different devices.

C. *Assignment*

D. *Supervised Study*

E. *Discussion*

1. Ask students where the SEP should be located within an agricultural structure. Discuss the factors that affect its location.

Where should the service entrance panel be located?

- a) As close as practical to the point where the wires enter the building
 - b) Near equipment that has a high electrical draw, such as water heaters or large motorized equipment
 - c) In an easily accessible location
 - 1) In an emergency, someone must be able to shut off power immediately.
 - 2) Ease of access to the panel is necessary if fuses blow or breakers are tripped.
 - 3) An easily accessible panel makes it easier to add circuits to the system.
2. Because a number of different circuits may control different outlets, lights, and equipment, the path of each electrical circuit should be carefully planned. Discuss the use of wiring diagrams; a sample diagram is provided in TM 9.1. Describe how circuits

and electrical devices can be labeled to distinguish between them, as shown in TM 9.2.

How is the route of each circuit determined?

- a) Two types of electrical circuits are considered when making a wiring plan.
 - 1) General circuits - circuits carrying 110-volt current and normally containing more than one electrical device
 - 2) Individual circuits - circuits carrying 220 volts of current and typically operate a single piece of equipment
 - b) The next consideration is which outlets will be connected to which circuit at the service entrance panel.
 - 1) A good rule of thumb is to avoid placing all the light fixtures in the same room or building on one circuit.
 - 2) The amount of electrical load placed on convenience outlets will determine their circuit needs.
 - (a) On a single circuit if the outlets in a room or building will have low usage, with one to two outlets used at any given time
 - (b) On different circuits if more than two outlets will be used at once or equipment with a high electrical draw will be used on a regular basis
 - c) A wiring diagram is useful when planning where branch circuits will run and what electrical devices will be connected to them.
 - 1) Mark the entry point.
 - 2) Add up the number of devices on the circuit and make sure sufficient amperage can be supplied.
 - 3) Repeat this process for each circuit.
 - d) Physically mount outlet boxes for lights and receptacles at each location, and label them on the diagram and within the structure for easy reference.
 - 1) Use Roman numerals for the individual circuit line.
 - 2) Letters designate the different outlet boxes.
 - 3) Switches are labeled with an S.
 - 4) Three-way switches are labeled S1 and S2.
3. Describe the techniques used when running wires through a structure. TMs 9.3 and 9.4 illustrate ceiling and wall wire runs.

How are the wires run through the building?

- a) Wire protection
 - 1) Avoid excessive bending of electrical conductors to prevent the insulation from cracking.
 - 2) Run wire inside of walls and ceilings to prevent physical damage.

- 3) Exposed wire runs or runs where damage may be a concern should have the conductor placed inside of a conduit.
 - b) General practices
 - 1) Conductors should run as straight as possible from the SEP to the individual outlets.
 - 2) As few splices as possible should be used.
 - 3) Wire runs should be as high and dry as possible.
 - c) Ceiling runs
 - 1) Ceiling runs are best because damage from traffic is minimized.
 - 2) They reduce wire damage because the wires are not located where water may collect or flow.
 - d) Floor runs - Noncorrosive conduits should enclose the wires.
 - e) Wall runs
 - 1) Drill a hole in the center of the wall studs that is large enough to accept the conduit or to allow the cable to slide through easily without friction and binding.
 - 2) Staple the wire along the side of a stud.
 - 3) Cut a notch in the side of the wall studs, and install a steel cover plate over the notch after the wire is in place.
 - 4) In structures where moisture will not be a factor, notch the bottom of the studs and run the wires along the bottom plate of the wall.
4. The use of the proper tools is essential to installing wiring efficiently and safely. Ask students to list the tools that they would use in wiring a light fixture or convenience outlet.

What tools are needed to wire a receptacle or light?

- a) Essential tools
 - 1) Wire cutters, either lineman's pliers, side cutting pliers, or needlenose pliers
 - 2) Cable rippers, which is used to remove the cable covering from the conductors housed in the cable sheathing
 - 3) Wire strippers for removing insulation from conductors
 - 4) Complete set of screw drivers
 - 5) Hammer
 - 6) Slip-joint pliers
 - 7) Level
 - 8) Tubing cutter for cutting conduit
 - 9) Conduit bender, which is used to bend or form conduit to turn corners
- b) Other tools
 - 1) Socket wrenches
 - 2) Drill motor and drill bits
 - 3) Adjustable open-end wrench
 - 4) Hand saw
 - 5) Electrical testing equipment

5. Sometimes branching a circuit is necessary. Discuss the use of junction boxes. TM 9.5 shows wiring within a junction box.

What is the function of a junction box?

- a) Used to protect the wires that are spliced together to branch circuits - Junctions are sometimes needed if a long electrical run is required or if no convenient outlets are available from which to branch power to different outlets on the same circuit.
 - b) Basically an outlet box with a solid cover
 - 1) The NEC states that all boxes must be dust tight and watertight.
 - 2) The NEC also requires that they be made of corrosion-resistant material.
 - 3) Junction boxes should be located where they are permanently accessible for repairs.
 - c) Connections in a junction box
 - 1) Insert the ends of the wires into the junction box through the knockouts.
 - 2) About 6 inches of each wire should pass through the knockouts.
 - 3) Connect black wires to black wires, white wires to white wires, and ground wires to ground wires.
 - 4) If the outlet box is metal, connect a separate piece of wire to the box and the ground wires.
 - 5) Clamp the wires securely to the box to prevent the splices from pulling apart.
6. Splices should be as sound as an unbroken conductor. Describe the different types of connectors that may be used. Different types of solderless connectors are shown in TM 9.6.

What techniques are used when splicing wires?

- a) Insulated solderless connectors (wire nuts)
 - 1) Strip back the wire insulation just enough for the wires to fit inside the connector.
 - 2) Lay the wires together.
 - 3) The method for connecting the wires depends on the connector selected.
 - (a) Threaded metal insert - Screw the connector onto the wires to be joined.
 - (b) Removable metal insert
 - (1) Remove the insert from the insulating shell.
 - (2) Slip the insert over the wires.
 - (3) Tighten the set screw in the insert to lock the wires in place.
 - (4) Screw the insulating shell back on over the insert.
 - (c) Spring-loaded - Screw the connector onto the wires to be spliced.
 - 4) Tape the conductors if necessary.
- b) Metal connectors for wires that are AWG 8 and larger

- 1) They have a collar with a set screw.
 - 2) Insert the wires into the connector.
 - 3) Tighten the screw.
 - 4) Wrap the connector and wires with electrician's tape.
7. Because most structures have some form of lighting, understanding how to wire lights and switches is important. Describe how different types of circuits should be wired. TMs 9.7, 9.8, and 9.9 show the wiring for a switched circuit, switch loop, and three-way switch. TM 9.10 can be used to illustrate series and parallel wiring. Hand out JS 9.1. The mock walls that students will use for wiring should be prepared before class period. They are made using 2" × 4" boards and should measure 2 feet by 2 feet.

How is a light circuit wired?

- a) Simple circuit
 - 1) Connect the black hot wire to a brass screw on the light fixture.
 - 2) Connect the white neutral wire to a silver screw.
 - 3) This system is impractical because the light cannot be turned on and off.
- b) Switched circuit
 - 1) A switch breaks the electrical circuit of the light fixture.
 - 2) White, black, and ground wires enter the switch box from the power source.
 - (a) Connect the white source wire to a white wire with a connector.
 - (b) Connect the black source wire to a brass screw on the switch.
 - (c) Attach a black wire to the other screw on the switch.
 - (d) At the light fixture, connect the black wire to a brass screw and the white wire to a silver screw.
 - (e) Connect a green ground wire from the light fixture to the ground wire from the source using a solderless connector.
 - (f) If the boxes are metallic, the ground wires are attached to the boxes with a piece of wire.
 - 3) 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.
 - (a) Connect the black source wire to a length of black wire with a connector.
 - (b) Connect this wire to a brass screw on the switch.
 - (c) Connect another black wire to the other brass screw on the switch.
 - (d) This second black wire runs back to the lighting box.
 - (e) Attach it using a connector to a black wire from the brass screw on the fixture.
 - (f) Connect the white source wire to a white wire from the light fixture using a connector.
 - (g) Attach the white wire to a silver screw at the light fixture.
- c) Three-way switch

- 1) Using a three-way switch, a light can be turned off and on from two different locations.
 - 2) Wiring a three-way switch begins at one of the switches.
 - (a) Connect the black wire from the power source to the common terminal on the switch.
 - (b) Connect a black wire to the switch on the opposite side from the black source wire.
 - (c) Connect a red wire to the other terminal on that side.
 - (d) Splice the white wire from the source to another white wire with a solderless connector.
 - (e) Make the appropriate ground connections at the switch.
 - 3) Next, the other wires are connected at the second switch.
 - (a) Connect a black wire to the common terminal of the switch.
 - (b) Attach a red wire to the terminal opposite the black wire.
 - (c) Connect a white wire to the other terminal.
 - (d) Make the ground connections in the box.
 - 4) The wires from the two switches meet at the light fixture.
 - (a) Connect the black wire from the first switch to the white wire from the second switch using a solderless connector.
 - (b) Splice the red wires together using a connector.
 - (c) Attach the black wire from the second switch to the brass screw on the fixture.
 - (d) Connect the spliced white wire from the power source to the silver screw.
 - d) Series and parallel wiring - Used when more than one light fixture is on a circuit
 - 1) Series wiring is an impractical system because the way the outlets are connected, if one light goes out, they all go out.
 - (a) The black wire from the source is attached to a terminal on the first fixture.
 - (b) A white wire then runs directly from the second terminal to the next lighting fixture and attaches to a terminal there.
 - (c) Another black wire runs from the second terminal on that fixture directly to the next fixture.
 - (d) This pattern continues through the series.
 - 2) Parallel wiring is the most common method of wiring multiple light fixtures.
 - (a) Jumper wires attached to each light fixture are spliced to the white and black wires from the power source.
 - (b) This system allows power to flow separately to each individual lamp on the same circuit.
8. Describe the process for wiring a circuit with one receptacle or several receptacles. TM 9.11 can be used to illustrate the wiring.

How are convenience outlet circuits wired?

- a) One receptacle
 - 1) Attach the black source wire to the side of the receptacle with the brass screw.
 - 2) Attach the white wire to the silver screw on the opposite side of the receptacle.
 - 3) Join the ground wires using a connector.
- b) Two or more receptacles on a circuit
 - 1) Connect the first receptacle as described.
 - 2) Connect another black wire to the other brass screw on the first outlet and to the brass screw on the second receptacle.
 - 3) Connect a white wire to the second silver screw on the first receptacle and the silver screw on the second.
 - 4) Follow the same procedure for any other receptacles on the same circuit.
 - 5) Make the appropriate ground connections.

F. *Other Activities*

Have students draw a diagram on a piece of paper showing how to hook a series of outlet receptacles to an on/off switch at the source. They should color code the different wires used.

G. *Conclusion*

The location of the circuits within an agricultural structure should be planned before running any wire to make sure that it is installed correctly. Once the wire is in place, light fixtures and convenience outlets can be installed.

H. *Answers to Activity Sheets*

I. *Answers to Evaluation*

1. c
2. a
3. e
4. d
5. b
6. b
7. d
8. d
9. a

10. Jumper wires attached to each light fixture are spliced to the white and black wires from the power source.

11. Threaded metal insert connector, removable metal insert connector, and spring-loaded connector
12. A wiring diagram
13. Answers may include any two of the following: drilling a hole in the center of the wall studs, stapling the wire along the side of a stud, cutting a notch in the wall studs and covering it with a steel plate, and cutting a notch in the bottom of the studs and running the wires along the bottom plate of the wall.
14. To protect the wires that are spliced together to branch circuits

Lesson 9: Running Wire from the SEP

Date _____

EVALUATION

Match the tools on the right with the description on the left.

- | | | |
|------------|-------------------------------|-------------------|
| 1. ____ | Used to cut conduit | a. Wire cutters |
| 2. ____ | May use lineman's pliers | b. Cable ripper |
| 3. ____ | Used to form conduit | c. Tubing cutter |
| 4. ____ | Used to remove insulation | d. Wire stripper |
| 5. ____ | Used to remove cable covering | e. Conduit bender |

Circle the letter that corresponds to the best answer.

6. Which of the following is used to indicate the circuit line in a label?
- a. Arabic numerals (1, 2, 3, etc.)
 - b. Roman numerals (I, II, III, etc.)
 - c. Letters (A, B, C, etc.)
 - d. Special symbols (S1, S2, S3, etc.)
7. Where should the service entrance panel be located?
- a. In the basement of a structure
 - b. Near the point where the circuits come together
 - c. In a corner of the building
 - d. Near where the wires enter the building
8. When wiring a single receptacle, the _____ is attached to the brass screw.
- a. White source wire
 - b. Green ground wire
 - c. Red hot wire
 - d. Black source wire
9. At a light fixture, the _____ is attached to the silver screw.
- a. White wire
 - b. Green wire
 - c. Red wire

- d. Black wire

Complete the following short answer questions.

10. How are light fixtures wired in parallel wiring?

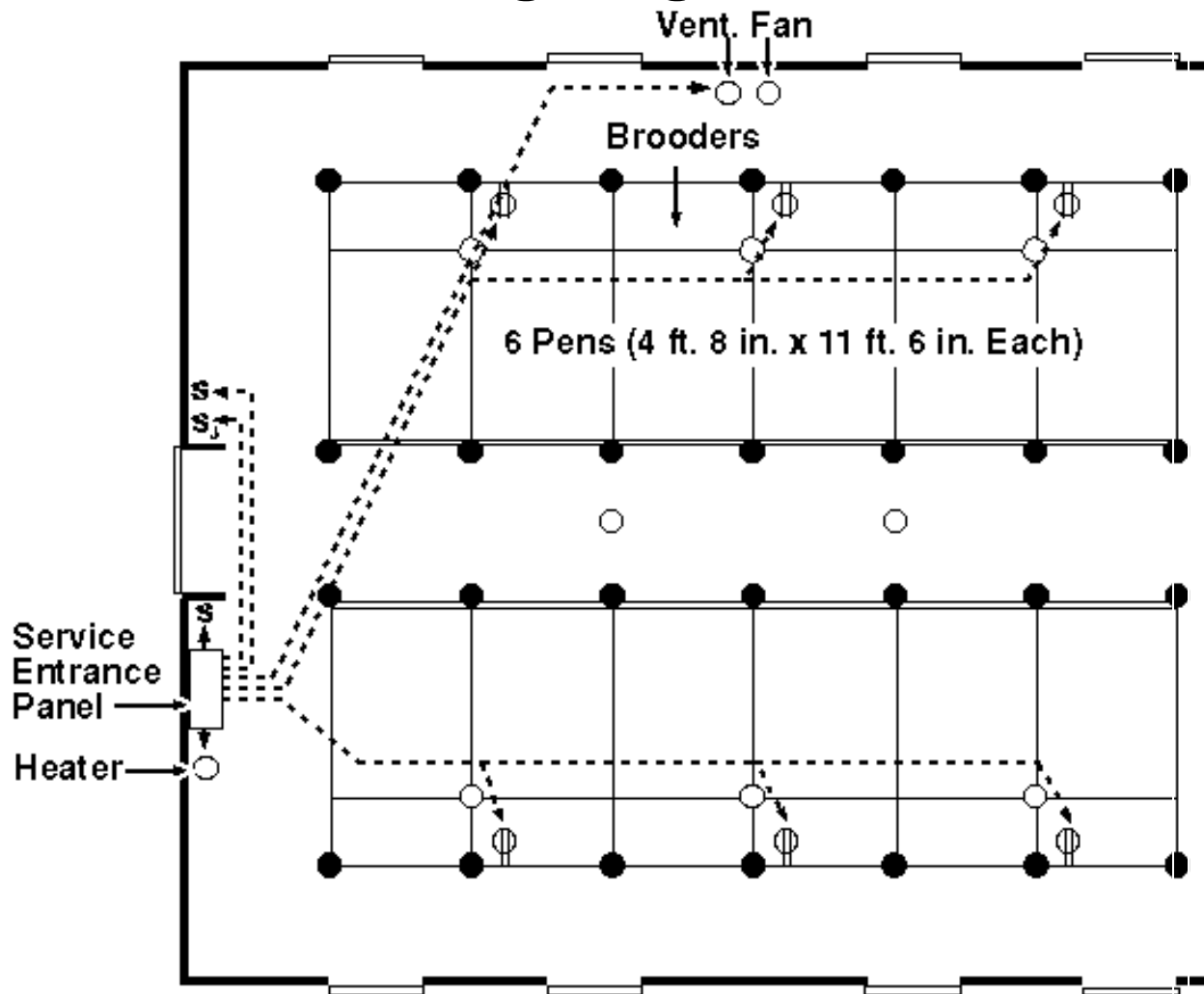
11. What are three types of solderless connectors?
 - a.
 - b.
 - c.

12. What can be used to help plan the path of branch circuits?

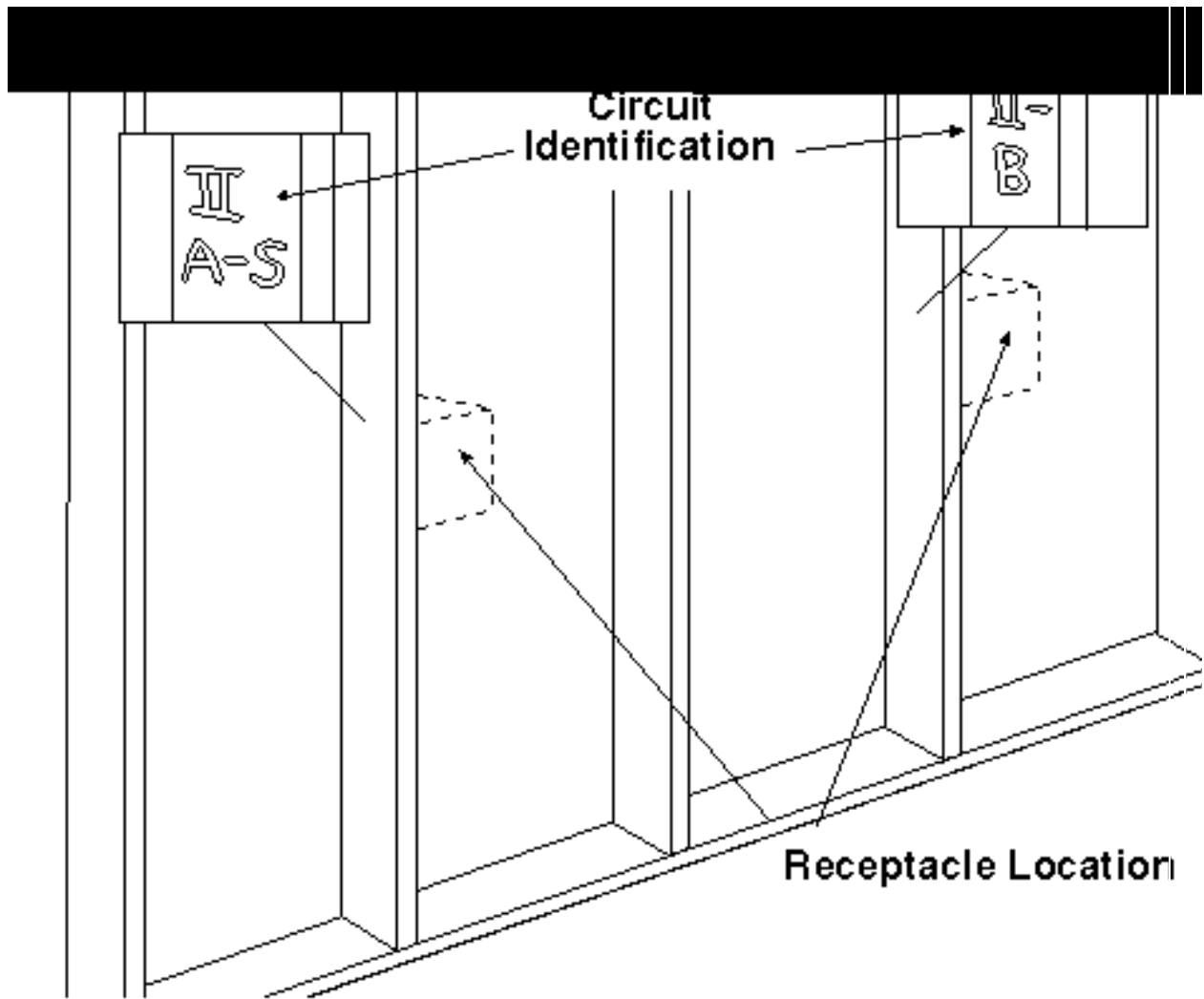
13. What are two ways wire may be run in walls?
 - a.
 - b.

14. What is a junction box used for?

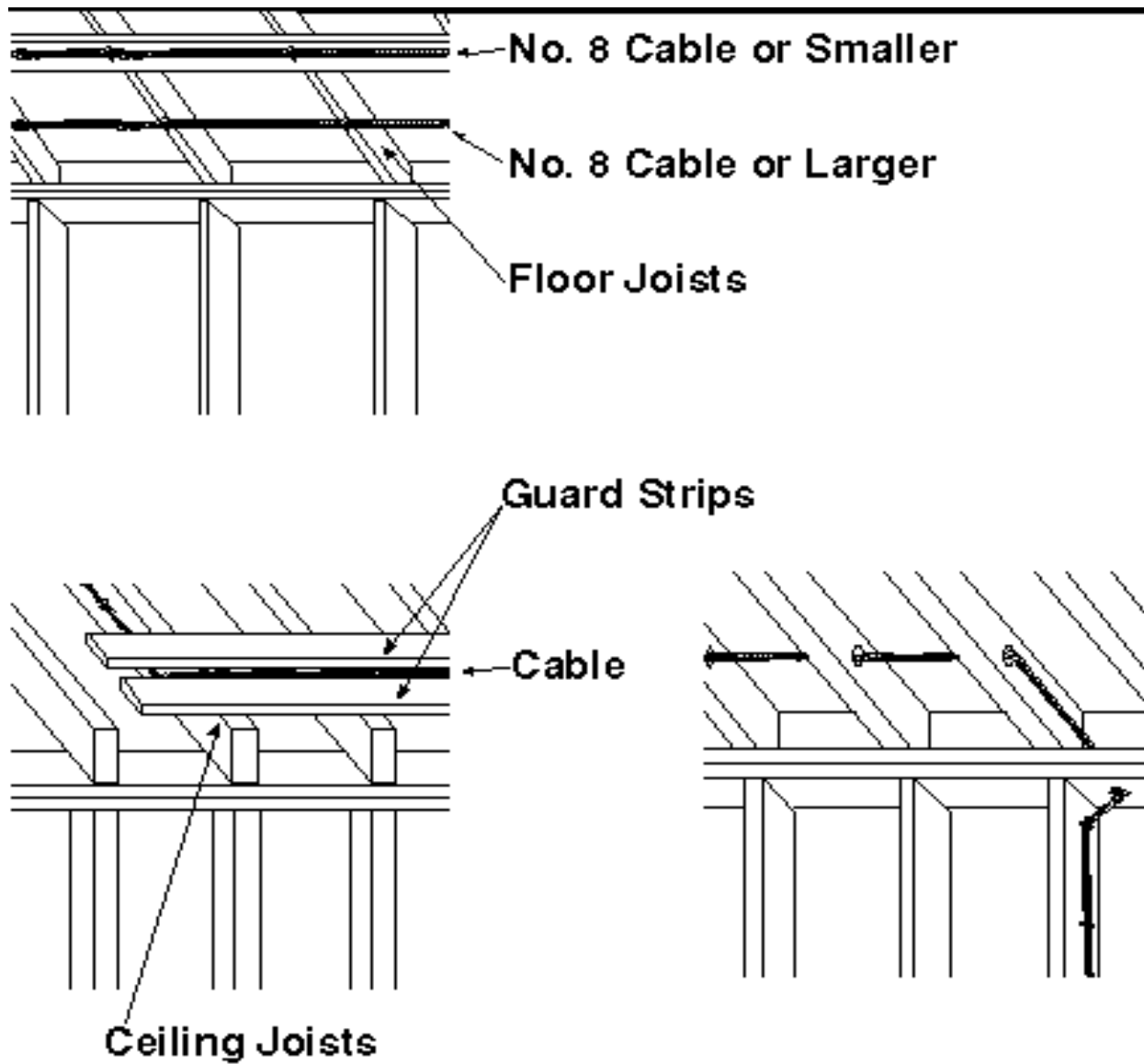
Wiring Diagram

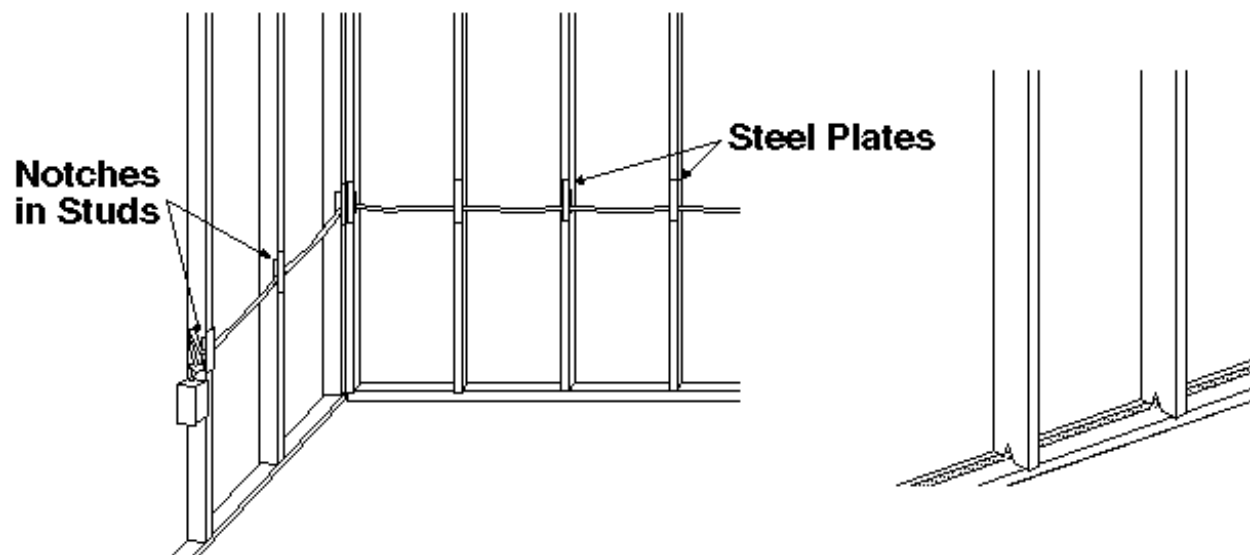
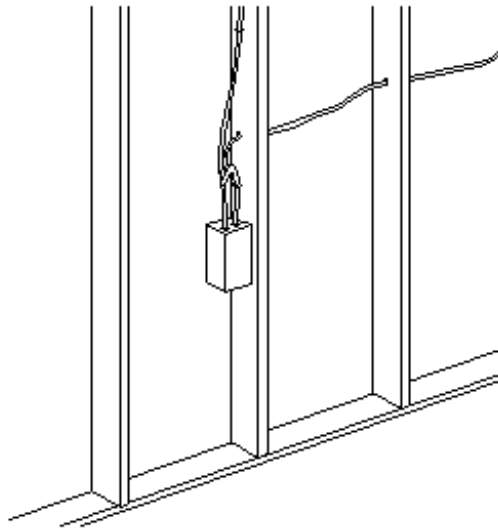


12-Pen Hog Farrowing House



Ceiling Runs

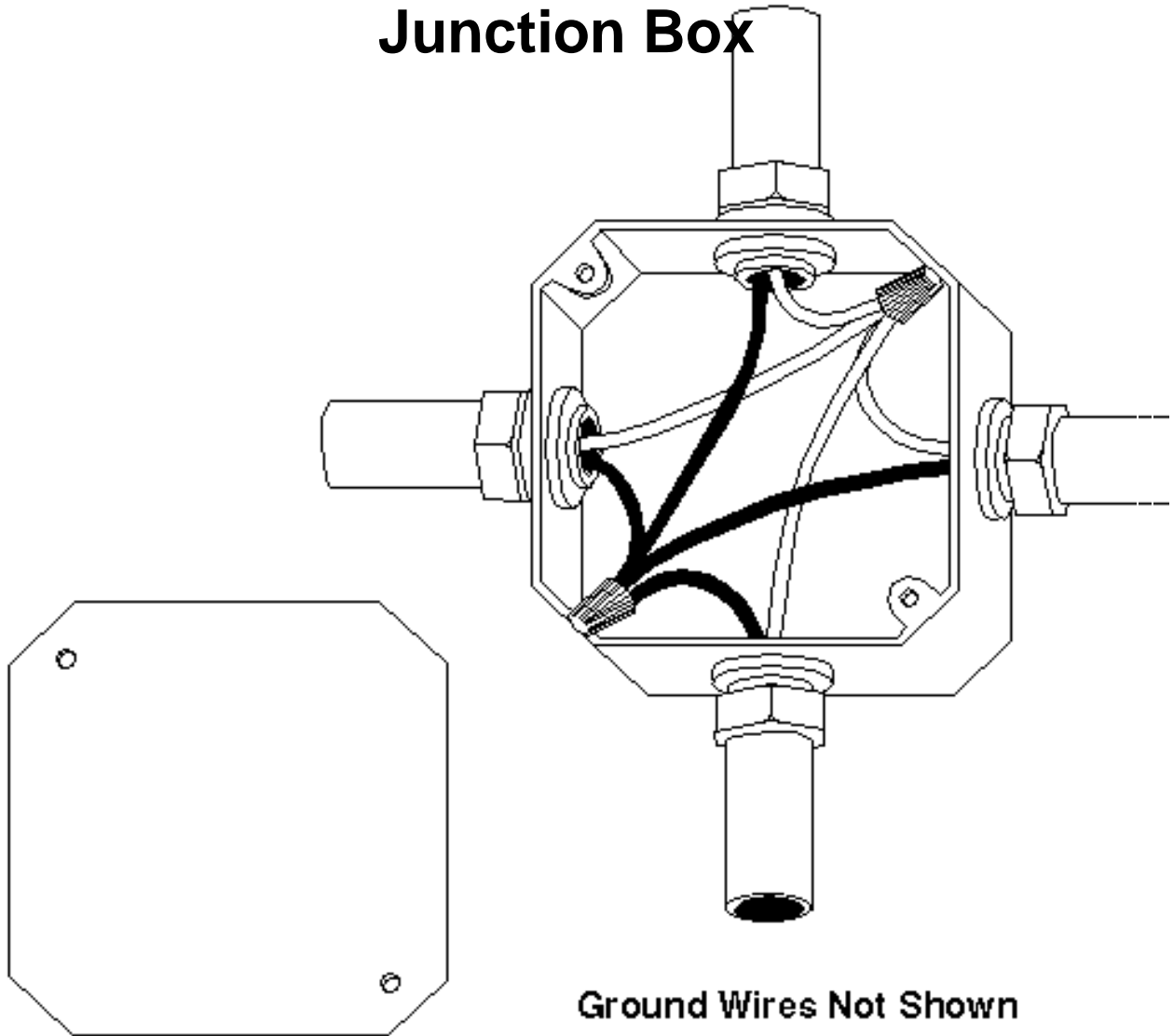




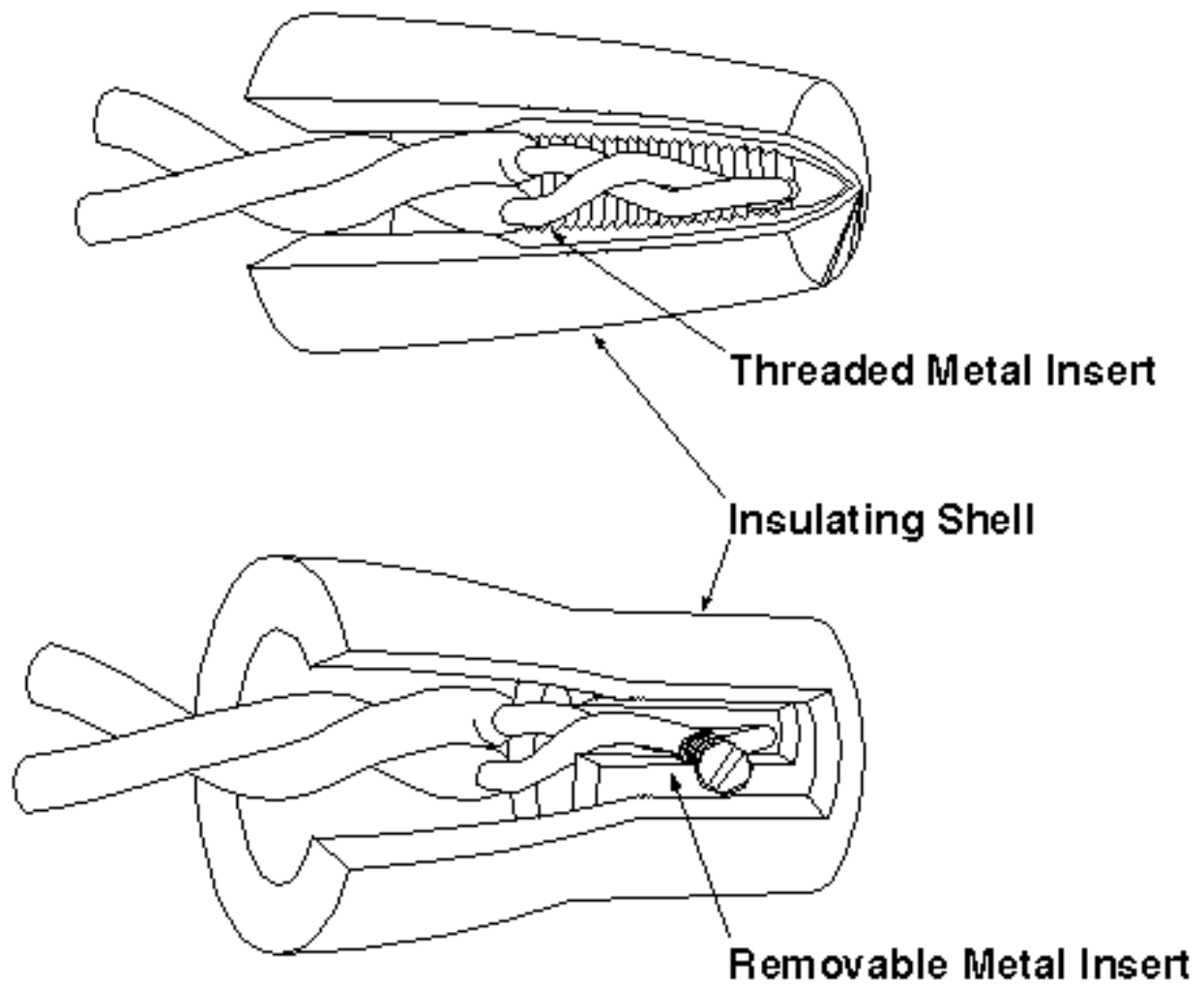
Wall Runs

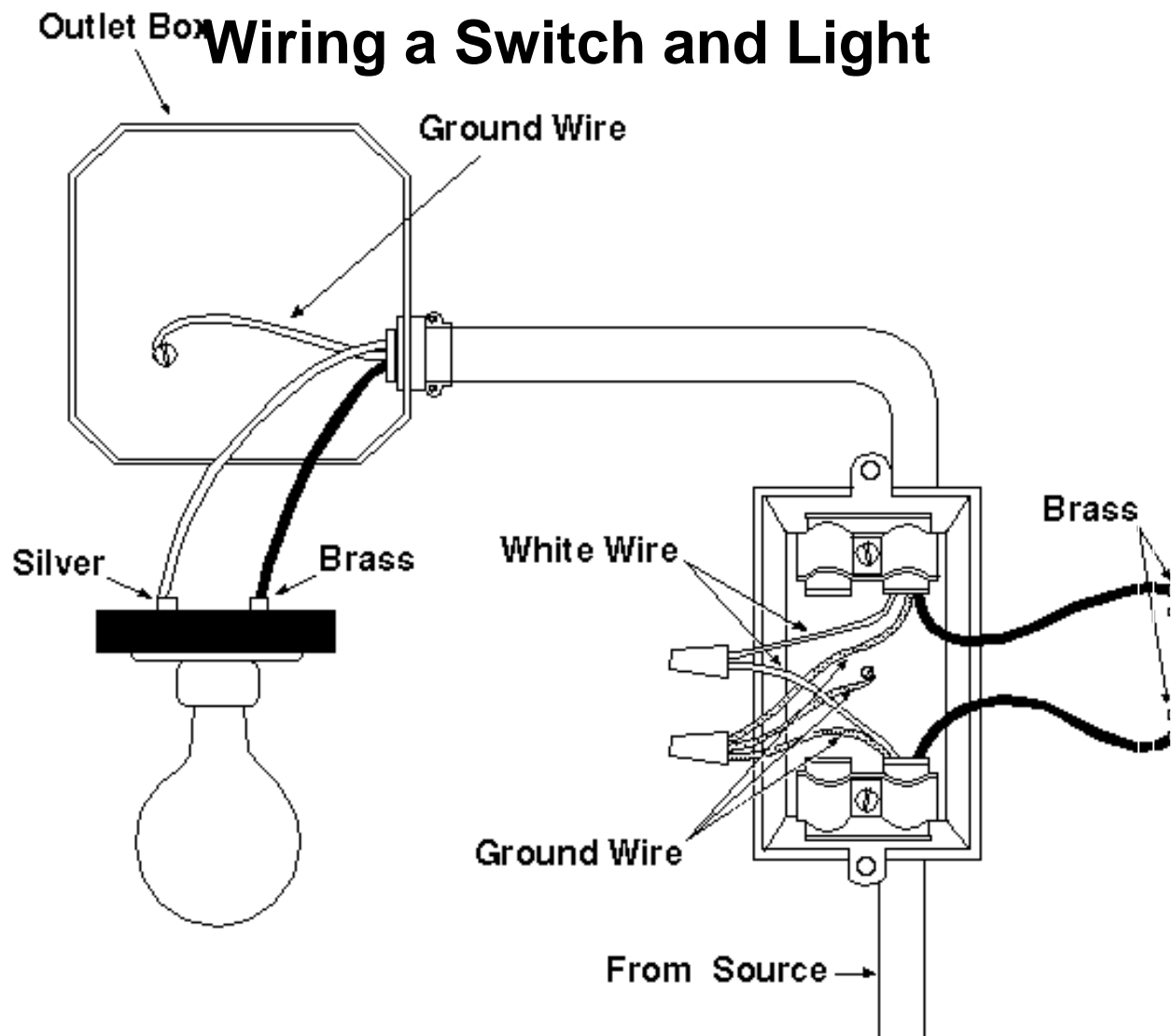
TM 9.5

Junction Box

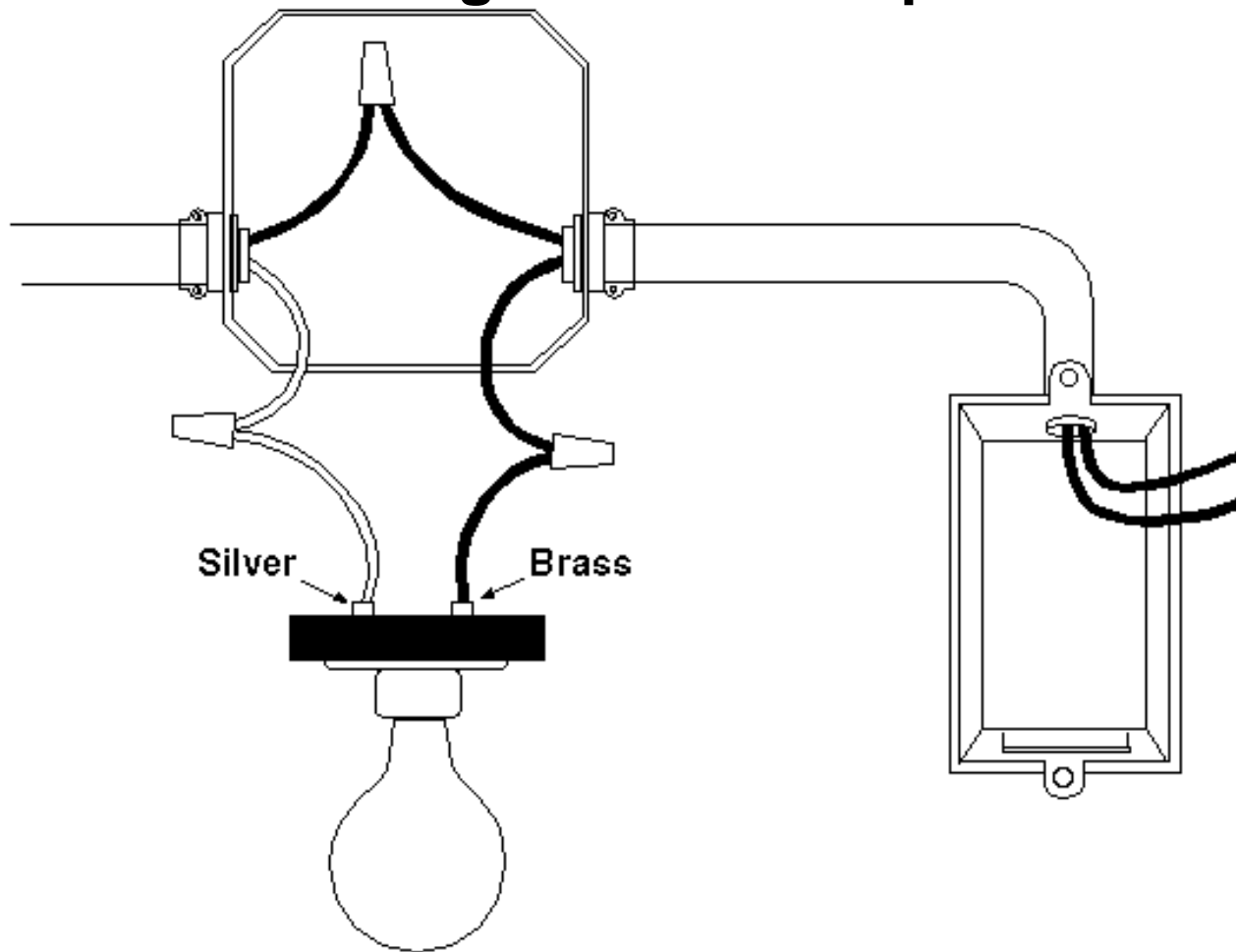


Connectors

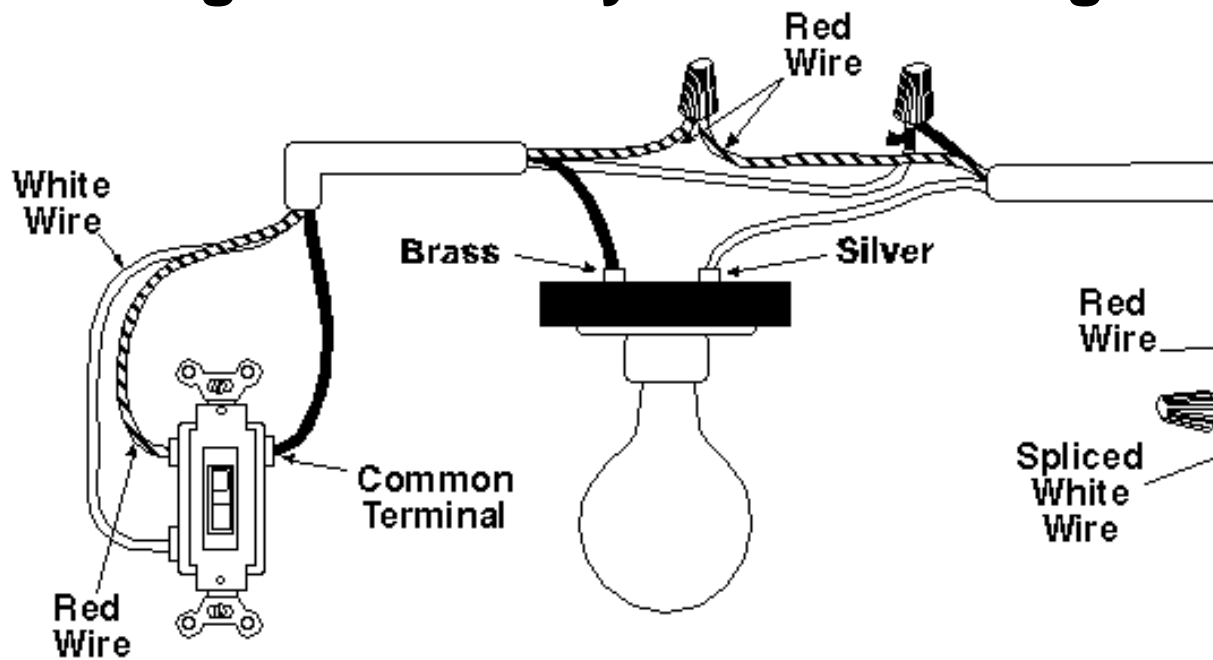




Wiring a Switch Loop



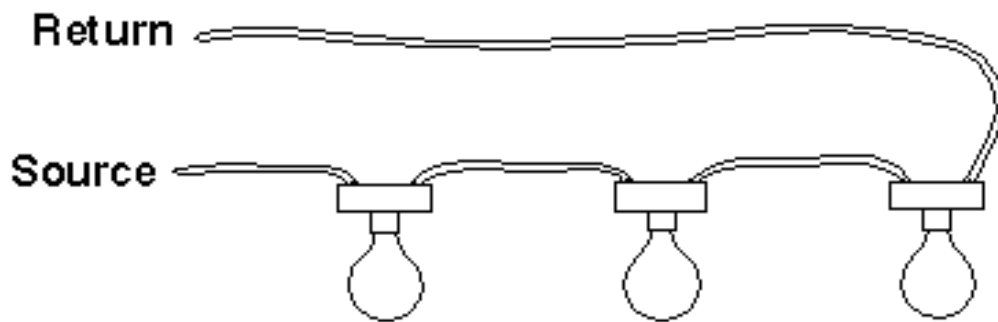
Wiring a Three-Way Switch and Light



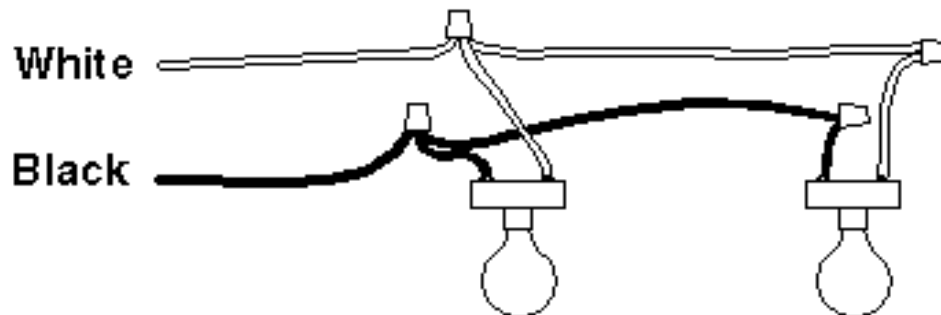
Note: Ground wire

Series and Parallel Wiring

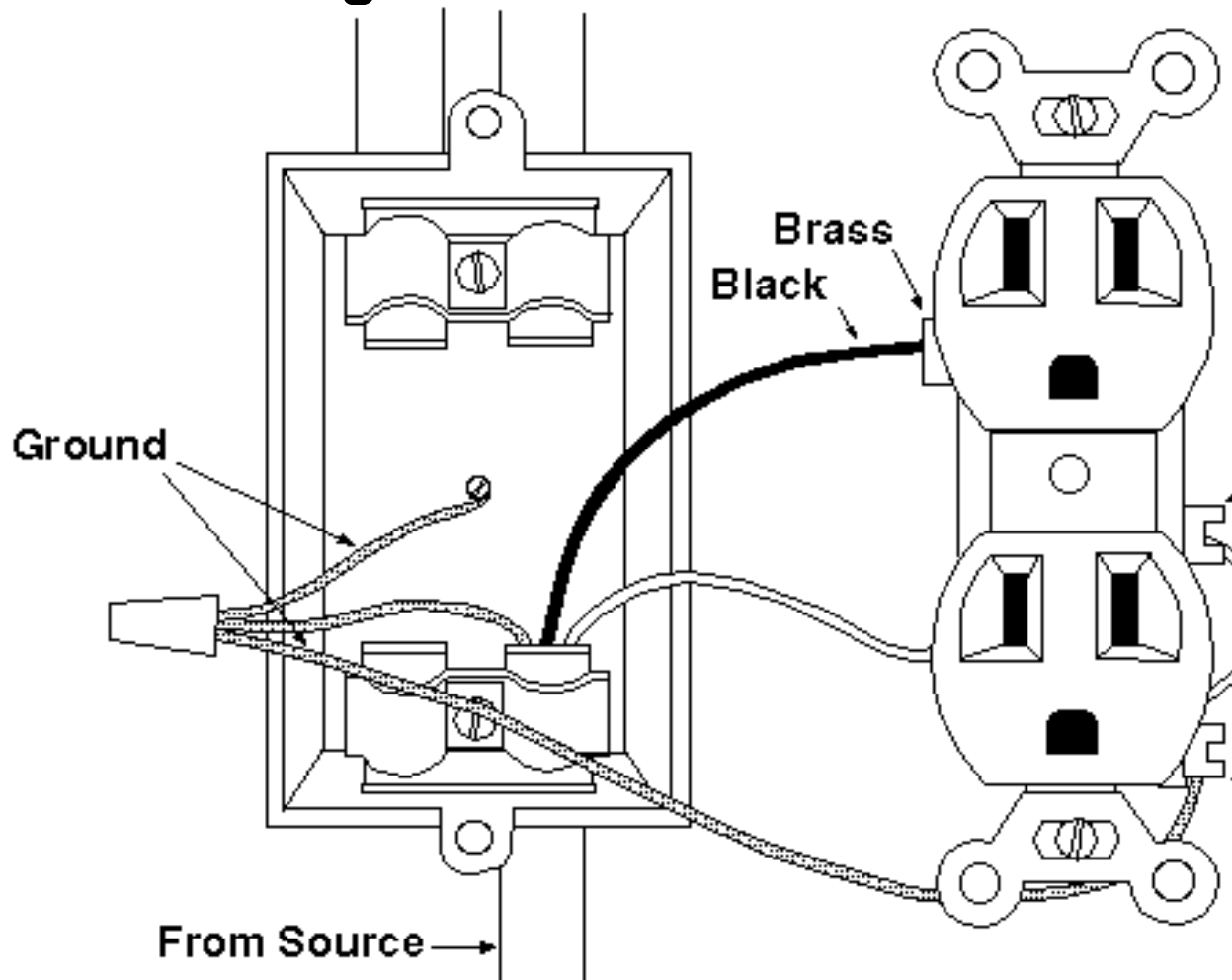
Series Electrical Connection



Parallel Electrical Connection



Wiring a Convenience Outlet



Lesson 9: Running Wire from the SEP

Name _____

Wiring a Three-Way Switch**Objective:** Wire a three-way switch to a light.**Materials and Equipment:**

Mock wall with two switch boxes and one light fixture already attached

1 12-2 NMC cable, 16 inches long

2 12-3 NMC cables, 30 inches long

2 three-way switches

Light fixture

Solderless connectors

Three-prong plug

Screw driver set

Wire strippers

Cable rippers

Procedure:

1. Strip off six inches of the cable sheathing on one end of the 12-2 wire and both ends of the 12-3 wires.
2. Strip back 1 inch of insulation on all exposed wires. Bend hooks in the wires that will be connected to the switches or light fixture.
3. The 12-2 wire will be the power source. Attach the bared end of the 12-2 wire to one switch box with a box connector. Hot, neutral, and ground wires without sheathing should be in the box.
4. Using box connectors, attach one end of each of the 12-3 wires to a switch box and the other ends to the light fixture box.
5. At the first switch box
 - a. Attach the black wire from the 12-2 cable to the common terminal of the switch.
 - b. Attach the black wire from the 12-3 cable to the terminal opposite the black source wire.
 - c. Connect a red wire to the third terminal.
 - d. Connect the white source wire to another white wire with a connector.
 - e. Connect the ground wires with a connector. With metal outlet boxes, run a 6-inch jumper wire from the ground wires to the box and attach it with a ground clip.

6. At the second switch box
 - a. Connect the black wire from the 12-3 cable to the common terminal of the switch.
 - b. Connect a red wire to the terminal opposite the black wire.
 - c. Connect the white wire to the other terminal.
 - d. Make the appropriate ground connections.
7. At the light fixture box
 - a. Using a connector, connect the black wire from the first switch with the white wire from the second.
 - b. Connect the red wires with a connector.
 - c. Connect the black wire from the second switch to the brass screw on the light fixture.
 - d. Connect the white wire from the first switch to the silver screw on the light fixture.
 - e. Make the appropriate ground connections.
8. Remove 1 inch of the sheathing from the unconnected end of the 12-2 wire.
9. Open the three-prong plug casing and attach the 12-2 wire to the mounting screws, connecting the black wire to the brass terminal, the white wire to the silver terminal, and the green to the green.
10. Close the plug casing.
11. Have your instructor inspect all the connections.
12. Attach the switches and light fixtures to the boxes.
13. Place the cover plates on the switches.
14. Obtain a light bulb from your instructor and insert it into the light fixture.
15. Plug in the cord. Test the workings of the three-way switch.