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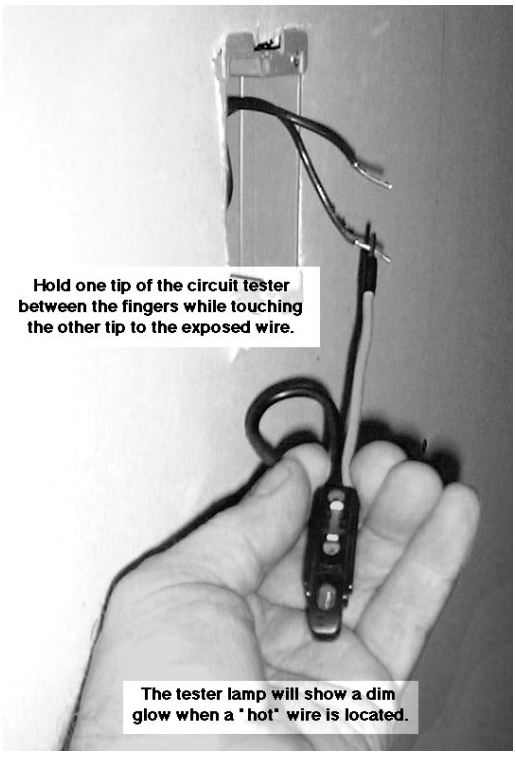
SWITCHES AND OUTLETS

While you should have a healthy respect for electricity, you don't need an engineering degree to do some basic electrical repairs in your home. Installing or replacing a switch or outlet – whether it is part of an existing circuit or is connected to a new circuit you have run from your service panel—is a relatively simple project for most homeowners.

Outlets should be installed in a **receptacle box** in the wall. The boxes may be made of metal or plastic; they can vary in size and in how they are attached to the wall. If there is a lot of movement when you pull the plug out of an outlet, the problem may not be in the outlet itself, but rather in how it is secured to the receptacle box or how the box itself is secured to the wall. On the other hand, if the prongs of the plug are not held securely in the outlet holes, or if the outlet no longer carries electric current from the wiring to the plug, then it's time to replace the outlet.

To install an outlet, you first need to identify the wires coming to it. Whether you have the older "knob-and-tube" style or newer wiring – wire in conduit, armored cable, or wire in plastic sheathing (commonly known by the trade name *"ROMEX"™*) – you should have a **"hot" wire** that brings electrical current to the outlet and a **"neutral" wire** that continues the circuit back to the service panel. Newer wiring systems may also have a third **"ground" wire** that serves as a safety device to prevent electric shock. In old knob-and-tube wiring (which is usually ungrounded), the hot and neutral wires often look identical. In newer wiring systems, the wires are usually color-coded; hot wires are usually black, (although some may be red, blue, brown, etc.), and neutral wires are white or light gray. The ground wire will be green or bare copper.

Even if you have a color-coded system, you should *always* make sure which is the "hot" wire and which is the neutral – it's possible that wiring mistakes were made previously. For testing, you can use an inexpensive **electrical circuit tester**, with two probes attached to a small neon bulb that lights up to identify the hot wire. (This test is done while power is coming to the outlet. A small resister in the tester protects you from injury from the electric current – just be careful not to touch any wires except with the tester.) Remove the outlet cover and, holding the tester as shown in the photo, touch a single probe to one of the wires, and then to the other, where each is attached to the outlet. The hot wire will produce a dull glow in the tester. Once you identify the hot wire, mark the neutral wire with a piece of white tape if it was not already color-coded.



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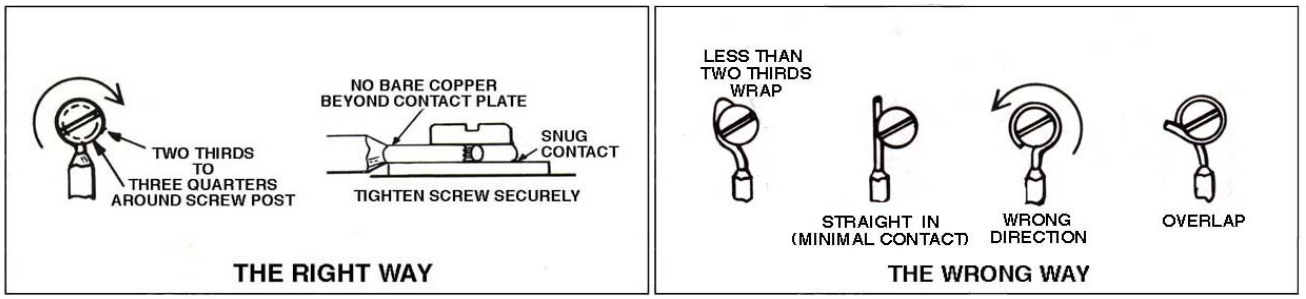
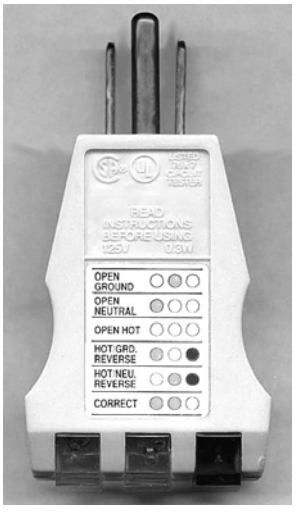
Now that you have identified the wires, turn off the power to the circuit that you're working on. Then, **test again,** to make sure that none of the wires is still carrying current. If you are replacing an existing outlet, you can now remove the mounting screws that hold the outlet in the receptacle box and pull it out. Unscrew the wires from the screws on either side of the existing outlet and discard it. (In some outlets, the wires may not be connected to screws, but may have been "back-wired" into push-in connectors on the back of the outlet; in such cases, cut the wire where it enters the outlet with wire cutters, removing as little wire as possible.)

To connect the hot wire to your new outlet, first make sure you have enough bare wire to wrap about 3/4 of the way around the terminal screw on the side of the outlet. (If necessary, use a wire stripper to remove about 5/8" of the plastic sheathing from the end of the wire.) Then, attach the *hot wire* to one of the *gold screws* on the outlet. Using needle-nose pliers, make a loop in the wire and wrap it around the screw as shown in the illustration below. (The loop should wrap clockwise, in the direction you'll be turning the screw, so that you don't unwrap the wire as you tighten the screw down to secure the wire loop.) Next, attach the white *neutral wire* to one of the *silver screws* of the outlet in the same manner. It is very important to match the right wire to the right color screw; reversing this **polarity** can damage some electronic equipment and create a shock hazard.



Occasionally, you may find two sets of wires attached to an existing outlet. Before you work on it, use a circuit tester to make sure *both halves* of the outlet are turned off – they may be connected to two different circuits (i.e., to create a "dedicated" circuit that powers just one appliance), and both circuits will need to be turned off. In these cases, the small tab connecting the two halves of the outlet will have been removed (you'll need to use your needle-nose pliers to snap off the tab on the replacement outlet); on each half, a hot wire is connected to the gold screw and a neutral wire from the same circuit to the silver screw. In other cases, the two halves of the outlet will be part of the same circuit, with the second pair of wires continuing on to the next outlet on the circuit. In this situation, there will be a black wire leading to one of the gold screws, and a continuation of the black wire leading from the other gold screw. In the same way, a neutral wire will lead to one of the silver screws, and a continuation of the neutral wire will lead from the other silver screw.

If you have a ground wire coming from your service panel, you can install a grounded outlet. The ground wire from the service panel enters the receptacle box and is then joined in a **wire nut** with additional "pigtails" of ground wire: one that connects to the green grounding screw on the outlet, and another that is secured by a grounding clip or screw to the box itself (this second pigtail is only used with metal junction boxes). If the ground wire is insulated with green plastic, the ends of the wire should be stripped before they are screwed together in the wire nut; the wire nut itself should be the appropriate size for the wire you're connecting. (Note: If you don't have a ground wire, a **ground-fault circuit interrupter** will provide some protection from electric shock – *see separate handout.* Do not install any other three-prong outlet where there is no ground wire.)



As an added measure to prevent shorts, you can finish by wrapping electrical tape around all four sides of the outlet, covering the terminal screws and bare wires. Then, neatly push the wires

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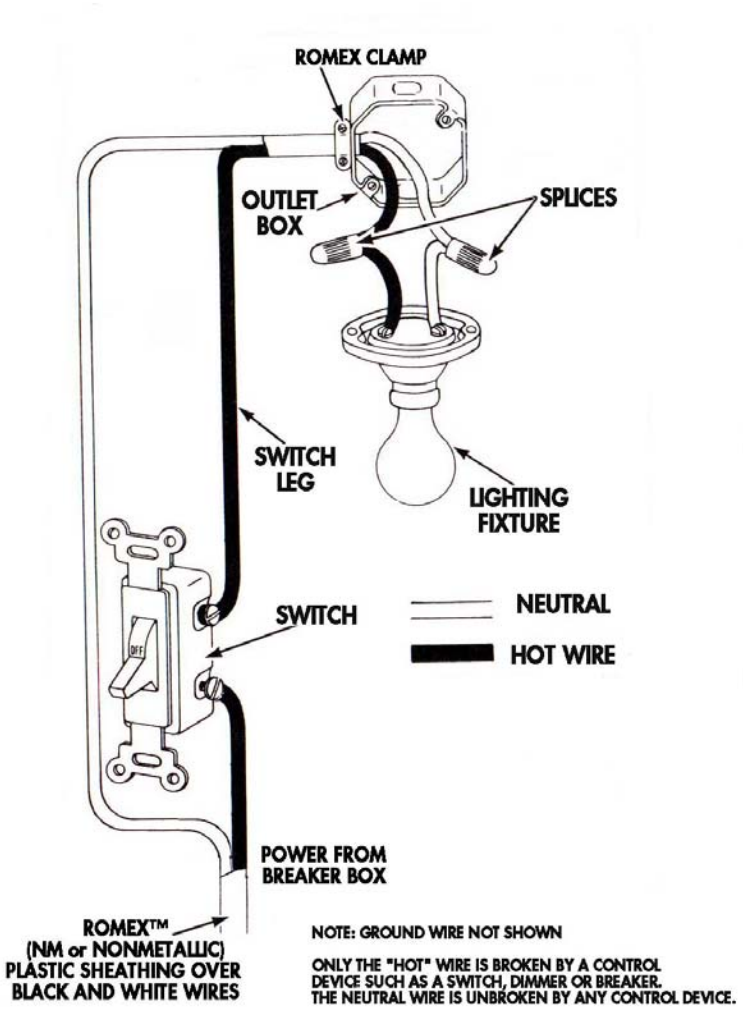
and the outlet into the box. Tighten the mounting screws, replace the cover plate, and turn the power back on. On a grounded outlet, you can confirm that the polarity and grounding are correct by inserting an inexpensive **three-prong circuit tester** into the outlet and checking the resulting light pattern.

Replacing a **single-pole switch**, where there is only one switch controlling a light or other fixture, is also a simple task. (It is not uncommon for switches to go bad.) Switches don't have a neutral wire – there will be a hot wire coming to the switch, and a continuation of the hot wire leading away from the switch *(see illustration);* when the switch is in the "off" position, it interrupts the flow of electricity through the hot wire to the light or outlet it controls. Some switches will also have a green ground terminal screw.

When you have removed the faceplate and identified and marked the hot wire, turn off the power to the circuit; use an electrical tester, as described above, to ensure that you have the power turned off before you continue. Then, take the old switch out of the junction box that holds it in the wall, unscrew the wires attached to it, and discard it. Attach the hot wire to one of the screws on the new switch, and the continuation of the hot wire to the other screw, making your connections as shown in the previous illustration. If there is a ground wire, attach it to the green grounding screw on the switch; if there is no grounding screw on the switch, attach it to a metal junction box with a grounding clip or screw, or, with a plastic box, to the metal switch bracket. Finally, insert the wires and the switch into the box, replace the mounting screws and faceplate, and restore power.



If you have a single-pole **dimmer switch**, the wiring is done in the same way as with traditional on/off switches. Dimmer switches should be grounded; attach the ground wire to the metal receptacle box or, with a plastic box, to the metal dimmer bracket.

Wiring **three-way switches** is a bit more complicated; you will want to see our *separate handouts* for these devices.