

# HOW YOUR HOUSE WORKS PART 2 THE ELECTRICAL SYSTEM

## FROM DAM TO DEN

Electricity is produced by generators—in principle, reverse electric motors. Unlike your power saw that converts electricity into torque, huge generators are set spinning by the power of wind, water, fossil fuels or nuclear energy. From the mechanical energy that goes in, we get kilowatts of electricity coming out.

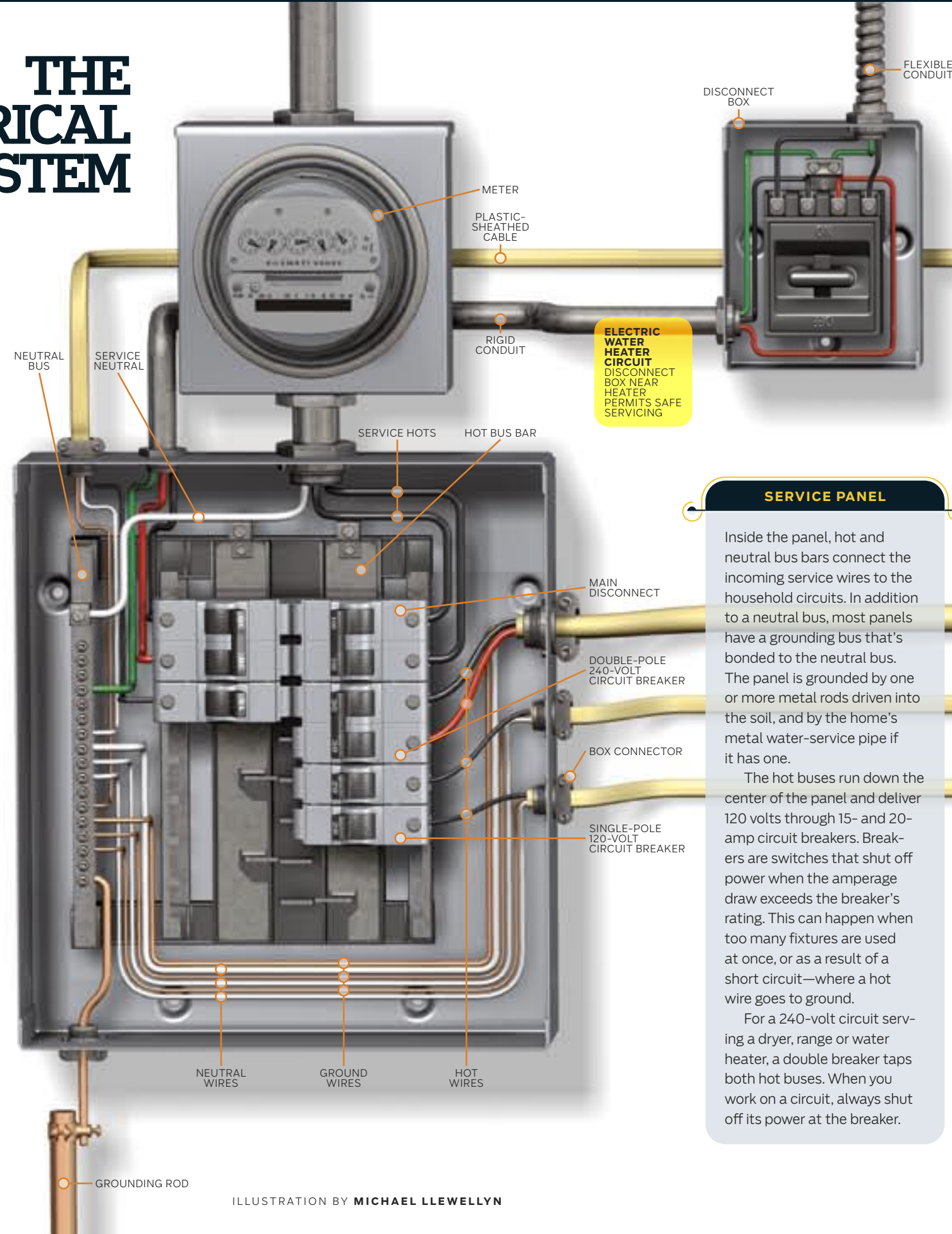
Voltage is the pressure that pushes electricity along a wire. And, those high-tension wires you see crossing the countryside carry a lot—500,000 volts and more. Step-down transformers at distribution stations and on utility poles reduce the voltage so it's suitable for household use.

Early systems supplied 120 volts and had two wires coming to the house: one hot and one neutral. These two wires, when run through a fixture or appliance, comprise a basic circuit. Although the electron flow in alternating current oscillates back and forth at 60 cycles per second, the hot wire is considered the power source and the neutral its return conductor. The amount of electricity drawn by the load is rated in amps.

Today, homes have three-wire service consisting of two 120-volt hots and a neutral, and can deliver 120 or 240 volts at 100, 150, 200 or 400 amps. The amperage determines the size of the service wires and number of breaker slots in the panel.

## SAFETY FIRST

Always check with local code authorities before starting a project. Get permits and inspections when required, use insulated tools and work with the power off. And, stay out of the service panel if you're not comfortable there—you can still do the circuit work while a licensed electrician handles the panel.



**ELECTRIC WATER HEATER CIRCUIT DISCONNECT BOX NEAR HEATER PERMITS SAFE SERVICING**

## SERVICE PANEL

Inside the panel, hot and neutral bus bars connect the incoming service wires to the household circuits. In addition to a neutral bus, most panels have a grounding bus that's bonded to the neutral bus. The panel is grounded by one or more metal rods driven into the soil, and by the home's metal water-service pipe if it has one.

The hot buses run down the center of the panel and deliver 120 volts through 15- and 20-amp circuit breakers. Breakers are switches that shut off power when the amperage draw exceeds the breaker's rating. This can happen when too many fixtures are used at once, or as a result of a short circuit—where a hot wire goes to ground.

For a 240-volt circuit serving a dryer, range or water heater, a double breaker taps both hot buses. When you work on a circuit, always shut off its power at the breaker.

## WIRE/CABLES/CONDUITS

The larger the wire, the more current it can carry. Therefore, circuit wire size is directly tied to breaker capacity. Wire that's too light for its breaker may carry too much current and become a fire hazard. Use 14-ga. wire for a 15-amp circuit, 12-ga. wire for a 20-amp circuit, and heavy 10-ga. wire for a 30-amp electric dryer circuit.



Most residential wire comes in multiwire cable—two or more insulated wires in a plastic sheath. The size and number of wires in a cable is marked on the sheathing. A 14-2-g cable, for example, contains one black hot wire, one white neutral wire and a noninsulated ground wire. Cables with additional hot wires, such as 14-3 or 12-4, are often used in lighting circuits.

Where wiring must be exposed, as on a concrete basement wall, it should be encased in thin-wall metal conduit. Flexible metal conduit can be used in semiprotected areas. You can pull cable through conduit, but it's easier to use individual wires.

Type UF cable has wires encased in a solid plastic strip, and it can be buried underground. Direct-bury cable needs the protection of conduit as it enters and exits the ground, however.

## GROUND VS. NEUTRAL

The bare ground wire and the neutral wire are not the same thing. The neutral wire is current-carrying even though it's on the ground side of the load. The bare wire is for safety. It carries current to ground, which causes the breaker to trip, if there's a short circuit in the appliance or fixture.



**ELECTRIC DRYER CIRCUIT**

## SWITCHES/RECEPTACLES

Single-pole switches are used to control lights from one location. To control a light from two places, you need two three-way switches and three-wire cable. Four-way switches are available for three switch locations. Beyond these, there are dimming switches, double-toggle switches that fit into single boxes, lighted switches that let you know if a remote light is on, and timer switches for programmed control.

Standard receptacles are rated at 15 or 20 amps. The 20-amp version is used most often in dedicated appliance circuits. A 15-amp receptacle is allowed in a 20-amp circuit because a single receptacle is unlikely to ever carry 20 amps. All modern receptacles are designed to be grounded, but ungrounded versions are still made for older, ungrounded circuits. Don't replace an ungrounded receptacle with a grounded one because it implies a protection that isn't there.



**THREE-WAY SWITCH** and **20-AMP RECEPTACLE**

**SWITCHED CIRCUIT SWITCH CONTROLS FIXTURES AFTER IT; HOT WIRE IS ALWAYS SWITCHED.**

## GFCI SAVES LIVES

GFCI (ground fault circuit interrupter) protection is required in any potentially wet situation, including garages, unfinished basements and near sinks. It protects against the chance of electrocution by sensing a current leak and cutting power within about 1/40 of a second. Protect an entire circuit with a GFCI breaker, or use a GFCI receptacle that protects outlets after it.

## LAMPS & LIGHTS

There are all sorts of incandescent lamps, from porcelain fixtures to decorative floor and ceiling models. New bulbs with electronic circuits provide the same light with less energy. Fluorescent and halogen fixtures are also more efficient than standard incandescents, but each has its peculiarities.

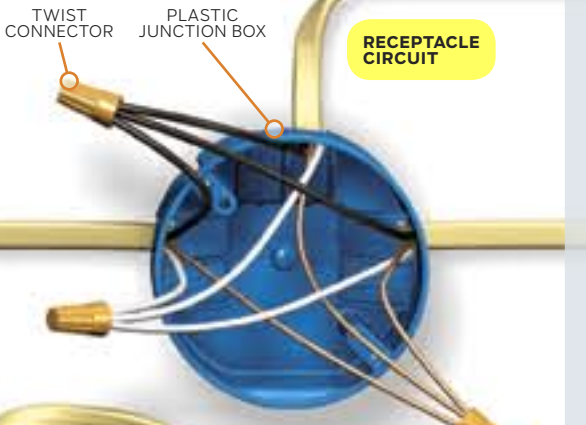
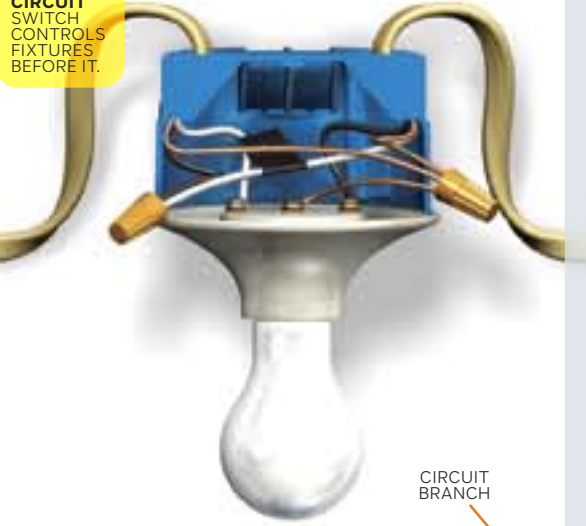
Fluorescents provide broad, even light that's five to six times brighter than an incandescent of similar wattage. And their lamps average over 9000 hours of service, compared to 1000 hours for incandescents. On the downside, their ballasts can start buzzing and are expensive to replace.

Halogens make good accent lights. A low-voltage halogen uses just 12 volts and its 20-watt bulb can outshine a 40-watt incandescent. They burn hot, however, and they're generally more expensive.



**COMPACT FLUORESCENT BULB** and **ELECTRONIC ENERGY-SAVING BULB**

**SWITCHED CIRCUIT SWITCH CONTROLS FIXTURES BEFORE IT.**



## ELECTRICAL BOXES

A variety of electrical boxes, both plastic and metal, are sold in home centers. Single-gang boxes are the most common. They hold a single switch or receptacle and are nailed directly to framing. Two-, three- and four-gang boxes are also available. Plastic boxes do not need to be grounded; metal boxes do and have grounding-screw holes for this purpose.

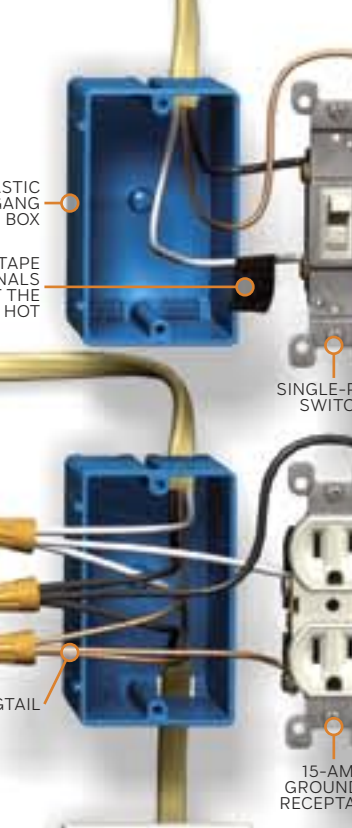
Codes limit the number of wires allowed in each box size, so install the deepest boxes you can get. You can count all ground wires as one, but all hots and neutrals must be tallied individually. Look for the wire capacity stamped into the back of each plastic box. For example, a 3 1/2-in. single-gang box will hold 11 14-ga. wires, nine 12-ga. wires or eight 10-ga. wires. Cut-in boxes are quick and easy in retrofit situations because they don't need to be nailed in place. Instead, they have tabs that grip the back side of wallboard. Outdoor boxes are made of seamless cast metal or plastic, and are designed to protect against moisture intrusion.



**CUT-IN BOX** and **OUTDOOR BOX**

## ASSESSING CAPACITY

When adding a new circuit or extending an existing one, you'll need to determine its capacity. Here's a useful rule of thumb. Assign each light and receptacle box a value of 1.5 amps. At that rate, a 20-amp circuit will support 13 boxes, while a 15-amp circuit will support 10. Dedicated circuits, like those serving dishwashers or bathrooms, can't be extended.



**PLASTIC SINGLE-GANG BOX**, **BLACK TAPE SIGNALS THAT THE WIRE IS HOT**, **SINGLE-POLE SWITCH**, **15-AMP GROUNDED RECEPTACLE**, and **COVER PLATE**

## FOUR TECHNIQUES SIMPLE TOOLS AND TASKS

### TESTING VOLTAGE



When you shut off a breaker, use a voltage tester to make sure there's no power at the receptacle. Place a probe in each slot. If the light glows the circuit is still hot.

### TESTING POLARITY



In an outlet, the shorter slot is the hot side and the longer slot is neutral. Check for correct wiring by connecting the hot side and the ground. The tester's light should glow.

### STRIPPING WIRE



Use a wire stripper to quickly strip the plastic sheathing from wire. The stripper has notches that match common wire-gauge sizes. It also cuts wire.

### BENDING WIRE



Wire strippers have holes in their jaws for bending wires to fit terminal screws. Insert the wire through the hole and twist the tool to form a neat, smooth bend.