Wiring a Bathroom

Best practices for running wire, nailing boxes, and installing fixtures

Master Craftsman

BY CLIFF POPEJOY

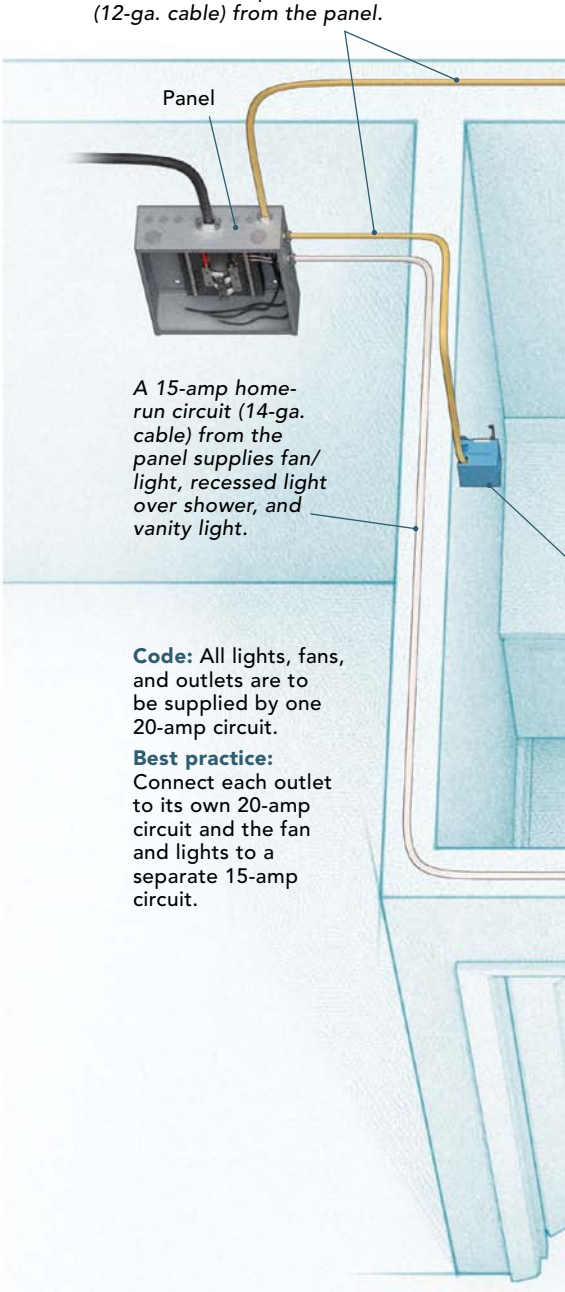
If you want to invest some sweat equity in the house or addition you're building, you might consider taking on the job of rough-wiring: installing boxes, running cable, and preparing the boxes before the drywall is hung. If the walls are open, it's a straightforward job, and most building departments allow homeowners to do their own wiring. The task of installing the main service panel is complex and is best left to a professional electrician, but you'll save money by doing the rest of the work yourself. And there's no better place to start than the bathroom, a space that's fairly dense with electrical needs but not overly complicated. Recently, I wired a small bathroom that was part of a new Habitat for Humanity house in Sacramento, Calif. The details of the job demonstrate the necessary steps for attaching boxes, running wire, and making the preliminary connections.

Circuit design and code requirements

As with all good building projects, you have to start with a plan. Usually generated by the architect or designer, a plan lists where the lights, outlets, switches, and other fixtures are to be located. It's also the best place to review the space's code-compliance.

The National Electrical Code (NEC) and the local codes that are based on the NEC allow the lights, fan, and outlets in one bathroom to be supplied by one 20-amp circuit, or for all

Cliff Popejoy got his start as a Habitat for Humanity volunteer and subsequently worked with other professionals to learn the rest of the trade. In addition to his residential and commercial work, Cliff is now the electrical-crew leader for the Sacramento, Calif., Habitat chapter. He says, "I've worked on many houses in which the electrical wiring is over a hundred years old and still functioning. I think of the men who did that work and their skill and labor. A hundred years from now, I hope some tradespeople, when they see my work, will think, 'This is good work. Whoever did this knew their craft, and cared enough to do it right.'"



Boxes for switches, fixtures, and outlets

Plastic boxes are strong, inexpensive, and commonly used in residential work. Choose deep boxes with thicker walls; these high-volume boxes make wiring easier and safer because there's more space for heat to dissipate.

Product photos: Rodney Diaz. Drawing: Christopher Mills.

START WITH A CODE-COMPLIANT PLAN

An electrical plan is a map of fixture placement and circuitry that satisfies code requirements. Beyond ensuring a safe electrical rough-in, the plan is also the place where the comfort and convenience of the bathroom can be established through well-placed lights, fans, outlets, and switches.

Best practice: Mount vanity light 12 in. from ceiling to avoid interference from most mirror locations.

Code: One outlet must be GFCI protected and located within 36 in. of the edge of the sink.

Best practice: Install at least two GFCI outlets at the vanity, especially if there are two sinks, above the height of the counter.

Code: Bathrooms must have a window or fan for ventilation. Here, a fan/light combo also provides ambient light.

Best practice: Recessed fixture provides task lighting for shower.

GFCI outlets

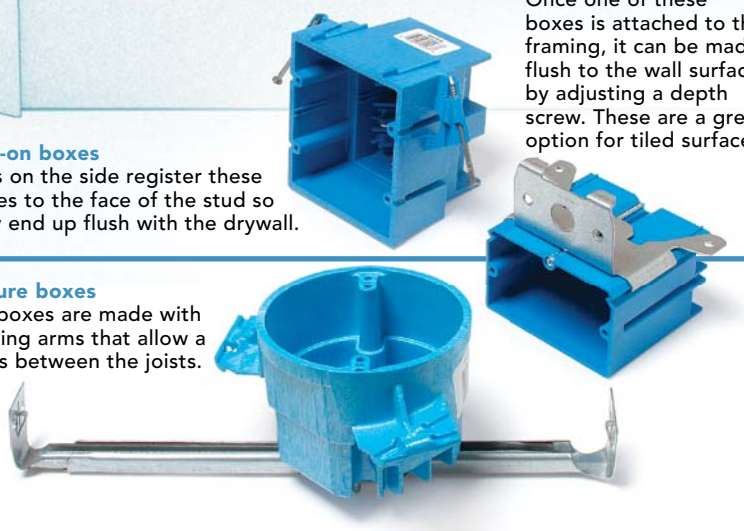
Best practice: Install switches for recessed light, vanity light, and fan within easy reach of the strike side of the doorway at a convenient height.

Adjustable-depth boxes
Once one of these boxes is attached to the framing, it can be made flush to the wall surface by adjusting a depth screw. These are a great option for tiled surfaces.

Metal boxes
These are usually used only when working with metal conduit or metal-sheathed cable, but because the vanity-light-fixture box location was on a stud, the author used a shallow, 3-in. metal pancake box to provide the necessary support.

Nail-on boxes
Tabs on the side register these boxes to the face of the stud so they end up flush with the drywall.

Ceiling light-fixture boxes
These light-duty boxes are made with adjustable mounting arms that allow a range of positions between the joists.



WHEN RUNNING CABLE, DRILL HOLES FIRST

Plan the route between the breaker panel and the switch or outlet box for each cable so that it has as few bends as possible. Starting at the box, drill a hole through the upper plate, then continue drilling along the circuit's route. To protect the cable from screw or nail damage, place holes as close to the center of the framing as possible, and never within 1¼ in. of the edge.

In control, and safe. *Brace the drill with both hands so that if the bit hits a nail, the drill doesn't suddenly sprain your wrist or knock you off your feet.*

TOOL OF THE TRADE

Ship's auger

The bit I like to use is a heavy-duty ⅝-in.-dia or ¾-in.-dia. ship's auger that's designed to cut through framing nails and costs about $20 to $25. Here, a 7½-in.-long bit for drilling studs and a 17½-in.-long bit for plates are from Bosch.

bathroom outlets in the house to be supplied by a 20-amp circuit. In the latter scenario, the bathroom lights and fans are connected to general-purpose 15-amp circuits. Either option is less than ideal.

A single handheld hair dryer can come close to overloading a 20-amp circuit all by itself, so I always put each duplex outlet on its own 20-amp circuit, and the vent fan and lights on one separate 15-amp circuit. If you're in doubt as to a circuit's capacity, do the load calculations to make sure you're not overloading it (see "How to figure circuit loads," p. 47).

All bathroom outlets must have GFCI (ground-fault circuit interrupter) protection. Most inspectors want to see outlets at or above the level of the counter, although the code does not specify height. Code does require a duplex outlet within 36 in. of the edge of each sink. If there is a double sink, put an outlet between them. Consider installing a pair of duplex outlets near each sink if, for instance, a hair dryer or curling iron are part of the morning routine. I strongly suggest running a separate 20-amp circuit for each outlet box, or even a 20-amp circuit for each duplex outlet. Here I installed two outlets, each on its own 20-amp circuit.

Even if the bathroom has an operable window (which is still code-approved as a venting option), install a vent fan. Vent-fan sizes are based on the amount of air the fans can exhaust, measured in cubic feet per minute (cfm). Fans should be sized according to building code, based on the square footage of the bathroom. Some fans incorporate a motion sensor and timer, while others have a humidity sensor (humidistat). If a fan doesn't have either one, control the fan with a manual timer that can be set for at least 60 minutes.

A bathroom needs good lighting

In a bathroom, light sources should use fluorescent or LED lamps to conserve energy. In some areas, they're required in order to meet the energy code. There should be both ambient and task lighting; the latter is especially useful at the vanity mirror and shower. A combined vent fan and light fits the bill for ambient lighting.

Avoid using recessed ceiling lights for vanity task lighting, because the strong downward light casts too many harsh shadows. Best practice is to eliminate shadows by mounting a fixture on each side of the mirror. At the very least, install a single long-bar fixture above the mirror that gives a strong, even light.

It's helpful to have task lighting in the shower area. Recessed lights with wet-location LEDs provide a strong source of illumination. The typical light-colored, reflective shower surfaces spread the light, so shadows are not an issue. Smaller 4-in.-dia. fixtures work well for a normal shower, but larger showers might need one or two 6-in.-dia. fixtures.

It's easiest to run one circuit at a time. *Keep track of each circuit by running one cable at a time. Although a tempting shortcut, it's never a good idea to run more than two cables through the same drilled hole.*

To run cable, feed it up into the joists and to the panel. Leave enough to reach the bottom of the panel, and work back, stapling the cable along its path. Back at the box, estimate about a foot of length beyond the box, cut it from the coil, and then feed the cable through the hole on the top plates and down the stud to the box.

No loose cables. *The NEC states that cable must be supported horizontally every 4½ ft. Insulated staples, plastic clips, and drilled holes provide the bulk of the support. Cable must also be supported within 9 in. of a box without clamps, or within 12 in. of a box that has clamps.*

The installation: Set up boxes first

When it's time to start work, I first check the door swings on the plan to make sure the light switches won't be hidden behind the door when it's open. Next, I place the outlet and switch boxes on the floor just below their intended location.

I like to start by mounting the outlet boxes over the vanity so that there is at least 1 in. or more (I prefer 2 in.) from the bottom of the box to the top of the backsplash. This ensures that there's no chance of conflict with backsplash installation. Here, the plans indicated a 36-in.-tall vanity cabinet with a tile counter and a standard 4-in. backsplash. I mounted the boxes at 45 in. from the floor to the bottom of the box.

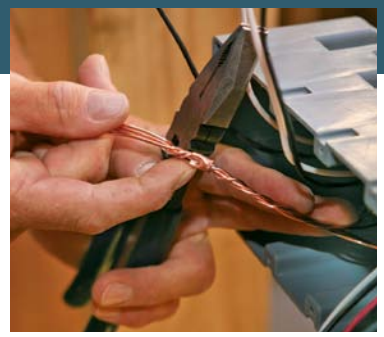
When outlets are to be located in the backsplash, I center their boxes in the vertical dimension. If the backsplash is tile, I try to work with the tile installer so that the box works well with the design.

My next step on this project was installing the box for the task lighting over the vanity. I've found that if I locate the box 12 in. below the ceiling, either centered on the cabinet or on the sink, it usually avoids any conflicts with the height of most vanity mirrors. For a vanity that's more than 4 ft. long, a box mounted on each side of the mirror works well.

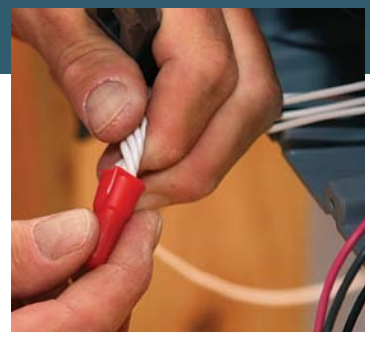
At the doorway, I mounted a deep four-gang box for holding the lights and the fan switches. For the sake

GET THE BOXES READY

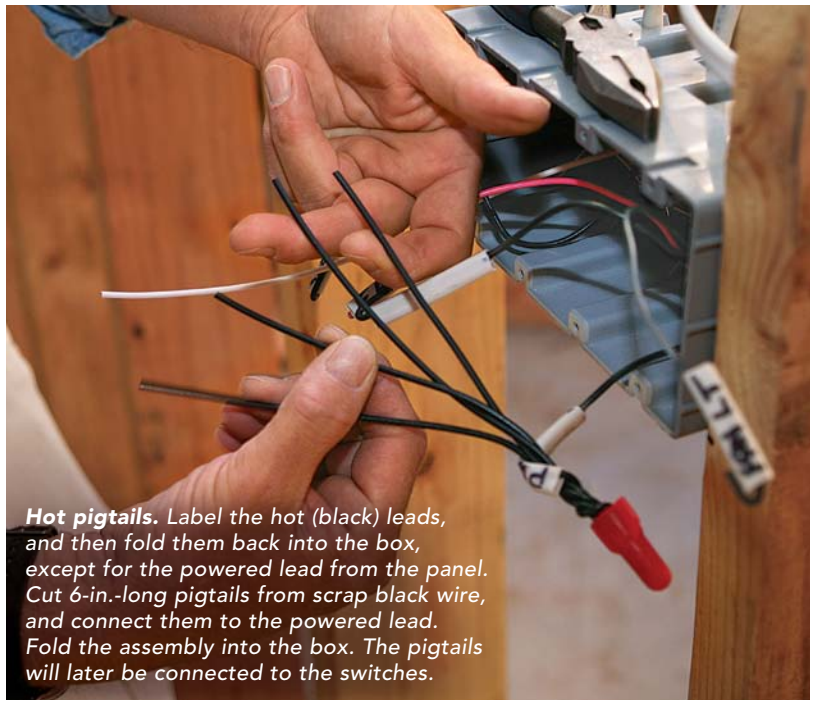
The last step in the rough-in process is to get the switch boxes and outlet boxes ready so they can be finished once the drywall is installed. The most complicated box to make up is the gang box of four fan and light switches that's powered by one home-run circuit to the panel.



All grounded. *Twist together the grounds, and secure them with a copper crimp sleeve so there's enough length for each to be connected to its switch.*



Neutrals next. *After trimming back ¾ in. of insulation on each wire, join the neutral conductors with a twist-on connector, and fold them into the box.*



Hot pigtails. *Label the hot (black) leads, and then fold them back into the box, except for the powered lead from the panel. Cut 6-in.-long pigtails from scrap black wire, and connect them to the powered lead. Fold the assembly into the box. The pigtails will later be connected to the switches.*

TRICK OF THE TRADE

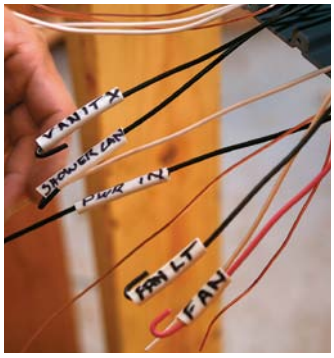
Strip jackets for 14/3

At each box, the jacket or sheathing has to be removed from the cable. You could use a utility knife, but the blade can nick the conductor insulation. You could also start a cut with a knife a few inches from the cable's end, then use the heavy thread that's encased in the 14/3-cable sheathing to slit the jacket, or use the bare copper ground wire as a rip cord. I like to use a special pair of stripping pliers (Klein, Ideal, or Crocks; about $25) that cuts the jacket but not the conductor insulation.

TRICK OF THE TRADE

Label cables

If I'm bringing more than one cable into a box, or bringing cables to the panel, I label the function of the cable on the jacket with a black marker. After stripping off the jacket, I slip it over the hot (black) lead.



of appearance, I set this box at the same height as the vanity outlets.

I located the vent-fan box between the ceiling joists, close to the shower and the toilet. I prepped the box by removing the most easily accessed knockout before nailing the arms to the joists, remembering to orient the fan's duct fitting in the direction of the flex-duct run.

The last fixture to install is the recessed light above the shower. Like the fan, the fixture's mounting arms can be adjusted to move the light's position between the joists.

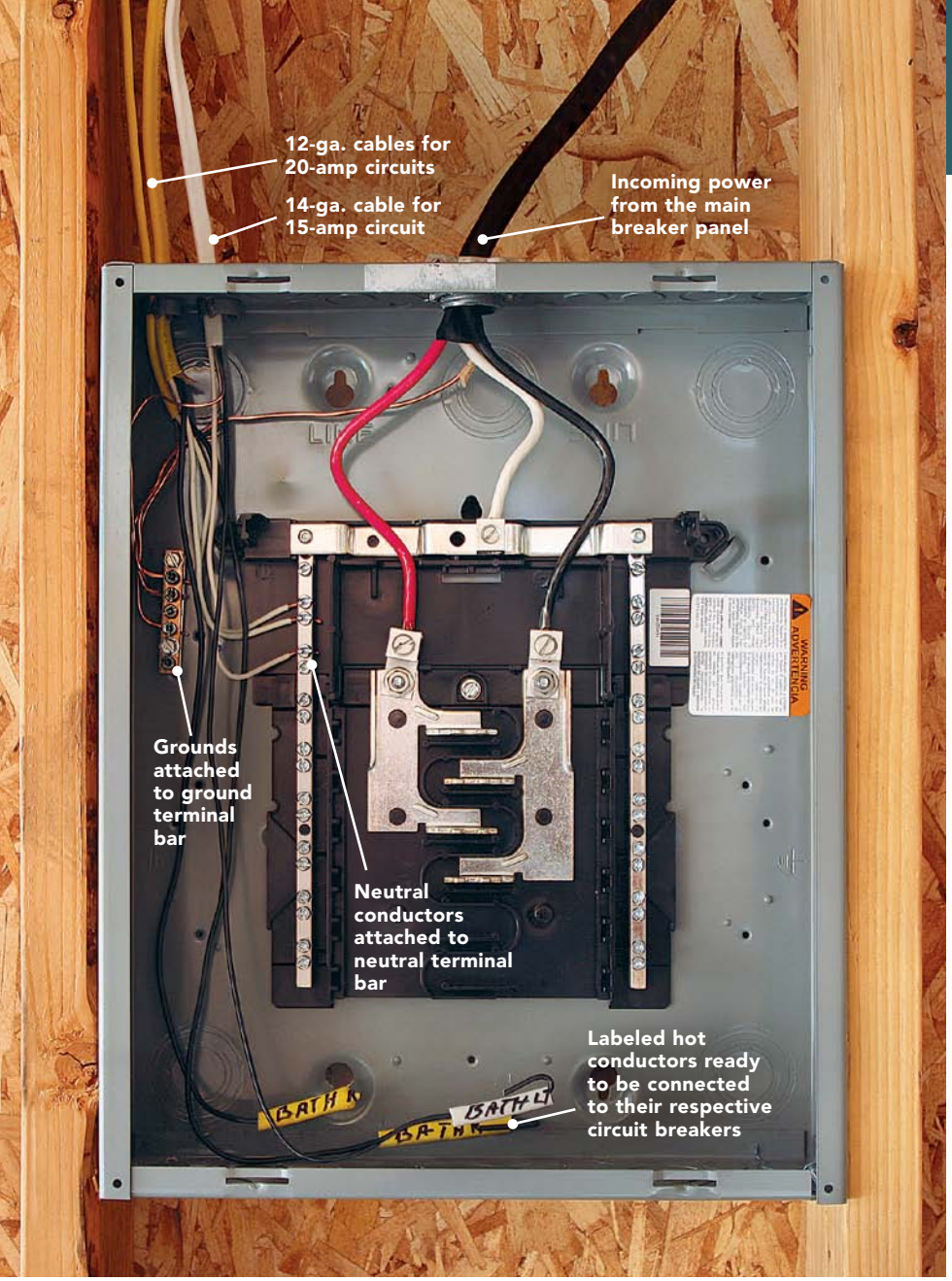
Running cable to the boxes

Nonmetallic-sheathed cable (NM-B) is the standard for residential work. The most common types, 12-ga. (yellow sheathing) and 14-ga. (white sheathing), are available with either two or three insulated conductors plus a ground. The lighter 14-ga. is used for 15-amp circuits, and the heavier 12-ga. is used for 20-amp circuits.

Before I start to pull cable, I trace the cable paths, called home runs, from the bath back to the panel. On this job, the bath was powered from a subpanel. These particular home runs are for each 20-amp outlet and for the circuit that powers the lights and fan, which are all switched from one box. After checking for potential obstacles and planning the route with the fewest turns, I started drilling holes and pulling cable.

I use a right-angle drill with a 17½-in.-long ship's-auger bit to drill the holes in the plates above each box or fixture and in subsequent joists or blocking. When drilling through plates, I stay as close as possible to the center. Any hole that's closer than 1¼ in. to the edge must be protected by a nail plate. I keep the holes in joists toward the middle as well. Modern I-joists have precut knockouts in the OSB web for running wire, which is a real time-saver.

Many people start with running the cable through the hole on the top plate above each box, but that creates a



PREP THE PANEL

All circuits terminate at the breaker panel. (In this instance, the bath was powered by a subpanel.) Cut grounds and neutral conductors to length, and secure them to their respective terminal bars. After labeling the hot conductors, don't cut them to length; just fold them into the box.

How to figure circuit loads

Here's an example that illustrates how to calculate a circuit load. A 15-amp bathroom lighting circuit is powering two bathrooms that have the following loads:

- **Two wall sconces, each with four bi-pin-base CFLs that draw 0.39 amps each: 8 × 0.4 amps = 3.2 amps**
- **Two combo fan/light units, each drawing 1 amp: 2 × 1 amp = 2 amps**
- **Eight recessed-light fixtures with 75w halogen incandescent lamps. A 75w lamp draws 0.625 amps (75w/120v): 8 × 0.625 amps = 5 amps**

TOTAL AMP LOAD 3.2 + 2 + 5 = 10.2 amps

lot of friction and makes pulling the cable difficult. I've found that the easiest way to run cable is to place the roll on the floor at the switch or outlet box and then feed the cable up into the framing and to the destination (fixture, fixture box, or panel). To ease the pulling process, I run no more than two cables through a hole. When the cable is threaded through the drilled holes, I leave enough surplus at the panel, then retrace the cable's path, stapling as I go. When I get back to the roll, I estimate the length I need to get back to the box, cut the cable, and then thread it through the top plate and staple it to the stud.

Finalize the process

With the cable cut to rough length and stapled up, the next step is to make up the boxes. Holding the cable next to the box, I cut it so that when it's routed into the box, there's about a foot of cable extending from the box. I strip back the jacket so that when the cable is in place, it will extend ¾ in. into the box. With a screwdriver, I spread open a clamp on the top of the box and pass the cable through, then neatly fold the conductors back into the box. Cables routed into fans and recessed cans are connected to the fixtures' leads.

For multiple gang boxes powered by a home run to the panel, the grounds are connected together, as are the neutral conductors. The hot conductors feeding each fixture are labeled and tucked into the box. Separate pigtails connected to the supply lead and the grounds will ultimately be assigned to their respective switches.

At the other end of the circuit, I route cable into the breaker panel. I connect the grounds and neutrals to their respective terminal bars, then label the hot conductors and tuck them into the box to await their later connection to the breakers. □

Photos by Charles Bickford, except where noted.