Replacing an Electrical Service

Upgrading service equipment increases safety and load capacity while bringing the house up to code

by Peitsa Hirvonen

If you're a GC and you ask clients what they would like to have in their newly remodeled home, they'll probably mention things like additional windows, granite counters, and new hardwood floors. One item they are unlikely to ask for is a new electrical service. But that doesn't mean they're not going to notice if you fail to advise them to replace obsolete or overburdened equipment.

They might not notice right away, but eventually they will — if breakers are always tripping, if there's insufficient capacity to add a spa or major appliance, or if their computer gets fried because the surge protector was plugged into an improperly grounded circuit.

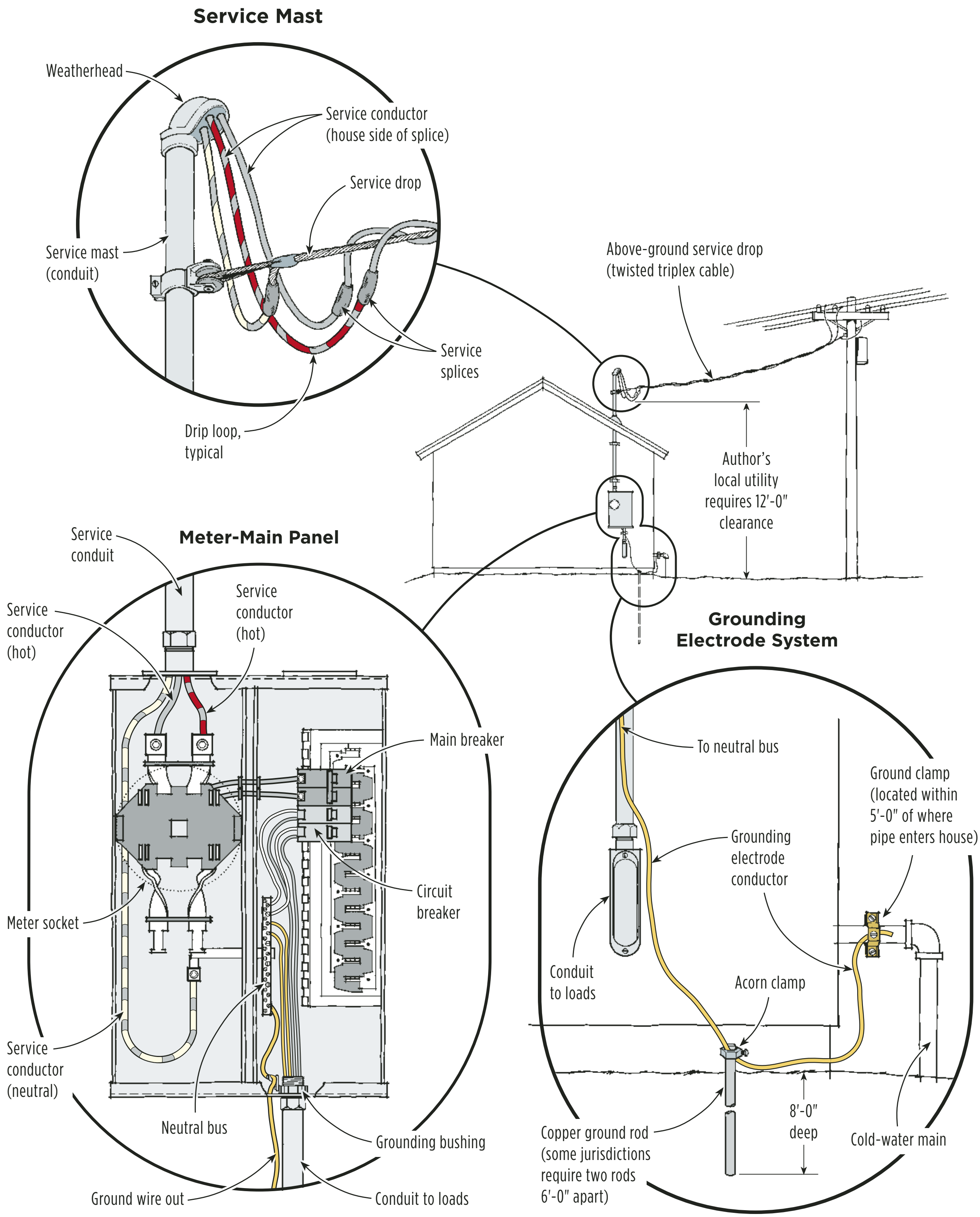
And they will definitely notice if someone gets electrocuted or the house burns down.

Need to Replace

As an electrical contractor, my company works mostly on existing buildings, and we never do anything without first checking the service panel.

The existing service could be so old it's completely unsafe, or it could be so close to capacity that adding any new loads — even small ones — could push it over the brink. Either condition would require a

Typical Overhead Service



service change (see sidebar, right), which nearly always means increasing the capacity of the service in amperes, and if the house is really old, taking it from 120 volts to 240 volts.

The "service" refers to all of the equipment between the utility splice and the main means of disconnecting power to the house — including the neutral bus and the grounding electrode system (see illustration, page 2).

Changing the service involves removing the old meter socket, the main disconnect, and often some distribution equipment, such as a fuse or breaker panel. This is followed by the installation of a new meter-main, which is a single metal enclosure containing a utility pull section, a meter socket, a main disconnect, and — in most cases — a distribution section.

Service Drop

In areas with above-ground power lines, the service drop is a twisted triplex cable that runs between the power lines and the house. It ends in a utility splice at the weatherhead, a helmetlike cover on top of a conduit. The wires on the house side of the splice — called service conductors — travel through a service conduit to the meter socket.

On older homes, the meter socket is in a separate enclosure, but on newer homes it's usually in the main panel.

In areas where the power lines are buried, there is a service lateral — an underground feed — running to the pull section of the meter-main.

The Local Utility

The NEC (National Electric Code) has a very specific set of requirements for the service. But strict as those requirements are, the utility's rules are often even more stringent.

For example, whereas the NEC allows the use of exposed service entrance cable and EMT for the service conductors, our utility requires 1¼-inch or

Figure 1. The author's company was hired to replace this original 1920s electrical service; it posed a hazard because it was old, undersized, not grounded, and in an outdoor ground-level wooden enclosure next to the driveway (above left). The service drop was connected to knob-and-tube wiring, which entered the building through holes in the wall. One of the hots was bent back and not connected (above right), so the house had only two-wire 120-volt service.

When to Change The Service

At the beginning of every job, the GC should consider whether the service needs to be upgraded.

Adding loads. A major remodeling project is likely to increase the loads on the electrical system. If you add any heating or motor loads, you should get the electrician to do a load calculation to see if the existing service has sufficient capacity.

Outdated equipment. Old three-wire (240-volt) 30-amp services are still around, and we've run into a few two-wire (120-volt) ones, too. We also encounter main disconnects with pull-out fuse blocks in the main/range configuration. Many people don't realize both fuse blocks must be removed to kill all the power to the house.

By code, you must be able to kill the power with no more than six movements of the hand — flipping six breakers or switches, or pulling out six blocks. A service with no main disconnect and six or more breakers will need an upgrade if you add any new circuits as part of the remodel — and all remodels should add circuits.

Sometimes the existing service has plenty of capacity, but the branch circuits are fused. There's nothing inherently unsafe about screw-in fuses; the problem is that homeowners or tenants can create a hazard by installing oversized fuses.

Faulty equipment. Another reason for a service change can be the three letters on the existing service: FPE, or Federal Pacific Electric. This company used to produce Stab-Lok panels, which are often found in homes built in the 1950s and '60s. The breakers that fit these panels (both the original and the aftermarket breakers) frequently fail, which can result in house fires or electrical shock.

larger rigid metallic conduit.

Utilities also have rules governing allowable distances from doors, operable windows, metal gutters, communications drops, gas service, and metal railings. In addition, they prescribe the height of the service drop above walkways, stair landings, and other areas of pedestrian access; higher clearances are required over driveways and streets.

It's important to understand what the utility expects. If there's anything unusual about the installation, we get a service rep to come out and approve the plan in advance.

The last thing we want is to complete an installation and have the utility people refuse to hook it up because they interpret the regulations differently than we do.

A Case in Point

Most of the photos in this story are from a project in which we replaced the original service on a house built in the 1920s. The drop contained three wires, but only two (a neutral and a hot) were connected, so the service was 120 volts rather than the usual 240 volts (a neutral and two hots).

This type of service is archaic but not uncommon in the older homes in our area. We replaced it because it was of insufficient capacity and was clearly unsafe (see Figure 1, page 3): Live metal parts were exposed in a ground-level outdoor wooden enclosure. A curious child could have opened the door and touched something live, and even an adult would risk electrocution by changing a fuse in the rain.

Most of the wiring was knob-and-tube. The entire house ran on two 20-amp circuits that, given the age of the wiring, should have been fused at 15 amps. They were actually fused at 30 amps; it's a wonder the house hadn't burned down.

Locating the New Service

The old service was on the side of the house next to a narrow driveway, but we couldn't put the new service there because there wasn't room to install protective bollards (3-inch steel pipes set in concrete) in front of the equipment, as required by the utility.

Instead, we decided to install the new service on the opposite side of the house; a utility pole was nearby and the exterior wall was far enough in from the property line to give us 36 inches (the code minimum) of clearance in front of the equipment (Figure 2).

Also, there was enough room under an existing window for us to install the panel

Figure 2. An electrician verifies that there will be the required 36 inches of clearance in front of the new panel within the property line.

Figure 3. With the new meter-main firmly bolted to framing, the electrician installs a vertical section of the service conduit (above left). To avoid running the service drop over the neighbor's property, it was necessary to run the conduit to the front corner of the building before turning it up and passing it through the roof overhang (above right).

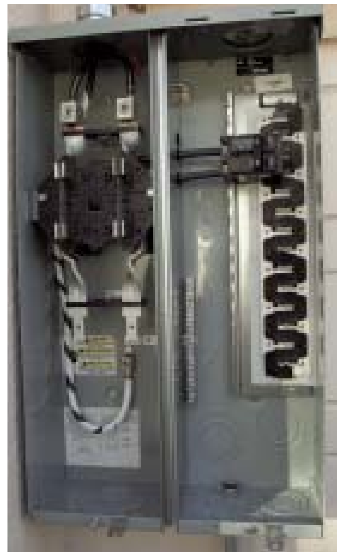


Figure 4. Gravity makes it easier to "pull" service conductors (left) by pushing them into the conduit from above. The electrician uses colored tape to color-code conductors so the utility knows which two to connect to the hots and which one to connect to the neutral (above left). Once the conductors are in the meter-main, the electrician connects the hots (red/black) to the line-side lugs, and the neutral (white) to a lug that ties to the neutral bus in the distribution section (above right).

and still comply with the utility's requirement that the centerline of the meter be no lower than 36 inches and no higher than 75 inches above grade.

We used a standard meter-main with distribution — a metal enclosure containing a meter socket, a main disconnect, and buses for branch circuit breakers. The plan was to bring the service conduit in from above and take conduit for the branch circuits out the bottom and into the crawlspace.

Mounting the panel. Since the equipment is heavy and supports a length of steel conduit, it's critical that the panel be solidly attached to framing members — not just siding. We typically fasten panels with 3⁄8-inch-by-3-inch lags or Simpson SDS structural screws. If the holes in the panel don't line up with framing, we drill new ones.

To prevent water intrusion, we run a bead of quality caulk across the top of the enclosure and down both sides.

Service Conduit Clearance

The service drop for this particular project could not hang over the neighbor's yard, so the periscope (the part of the mast above the roof) had to be at the front corner of the building (Figure 3, page 4).

To get the conduit there, we ran it up from the panel, turned it 90 degrees toward the street, then turned it 90 degrees up before passing it through the eaves. We extended the conduit 24 inches above the roof; if we had needed more clearance for the drop, we'd have made it higher.

In areas of pedestrian-only access, the NEC requires 10 feet of clearance between the drip loop and grade; our local utility requires 12 feet. If it's possible to meet this height requirement without penetrating the eaves, we extend the horizontal run of the service conduit about 18 inches past the building corner and install the weatherhead there.

In this case, we needed the height, so we penetrated the eaves and installed a roof jack over the conduit to prevent the hole from leaking. The utility required us to fasten the conduit to the wall within 3 feet of the hub at the top of the enclosure, once every 10 feet after that, and twice where it left the building wall. To clear a piece of trim, we spaced the service mast — conduit — off the wall by installing it over pieces of Unistrut.

Service Conductors

Once the panel and service conduit were in, we pulled the service conductors into the conduit. Since this was a 125-amp service, we used 1 1⁄4-inch conduit and #2 THHN (thermoplastic high-heat-resistant nylon-coated) copper conductors.

Copper vs. aluminum. The electrical code allows us to use aluminum service conductors, but we always use copper because it's more reliable.

Aluminum has more resistance than copper, and it also tends to oxidize, which creates even more resistance at connections. When the flow of current encounters resistance, the wire heats up and expands. When the flow drops, the wire cools and contracts. Over time, this activity stresses the connections between the service conductors and the lugs on the panel — sometimes enough to loosen them.

Applying an antioxidant compound to the connections can mitigate the problem, but in my view the added cost of using copper service conductors is a small price to pay to avoid future headaches.

Color-coding. Before pulling the wires, we typically mark them at each end with color-coded tape.

In a single-phase service, the phase legs are black and red; the neutral is always white. And when we install the wire, we leave enough extra at the weatherhead for the utility to form a drip loop and make the service splice.

Inside the panel, the hots terminate at the upper — or line side — lugs of the meter socket, and the neutral at its own lug (Figure 4, page 5).

Grounding System

Our next step was to build the grounding electrode system, which consisted of a copper ground rod wired to the service main and water line (Figure 5). Although we're allowed to use 1/2-inch rod, we use 5/8-inch rod because it's less likely to bend when we drive it.

The rod is driven into the earth near the panel and is supposed to go 8 feet deep. In some jurisdictions we're required to drive two rods 6 feet apart. We always add a second rod if we hit something and have to drive the first one at an angle.

The grounding electrode conductor is #6 bare copper wire. It should run as a continuous single piece (no splices), and it should connect to the following items:

- the neutral bus in the panel;
- a lay-in lug on the grounding bushing on the conduit that goes to loads;

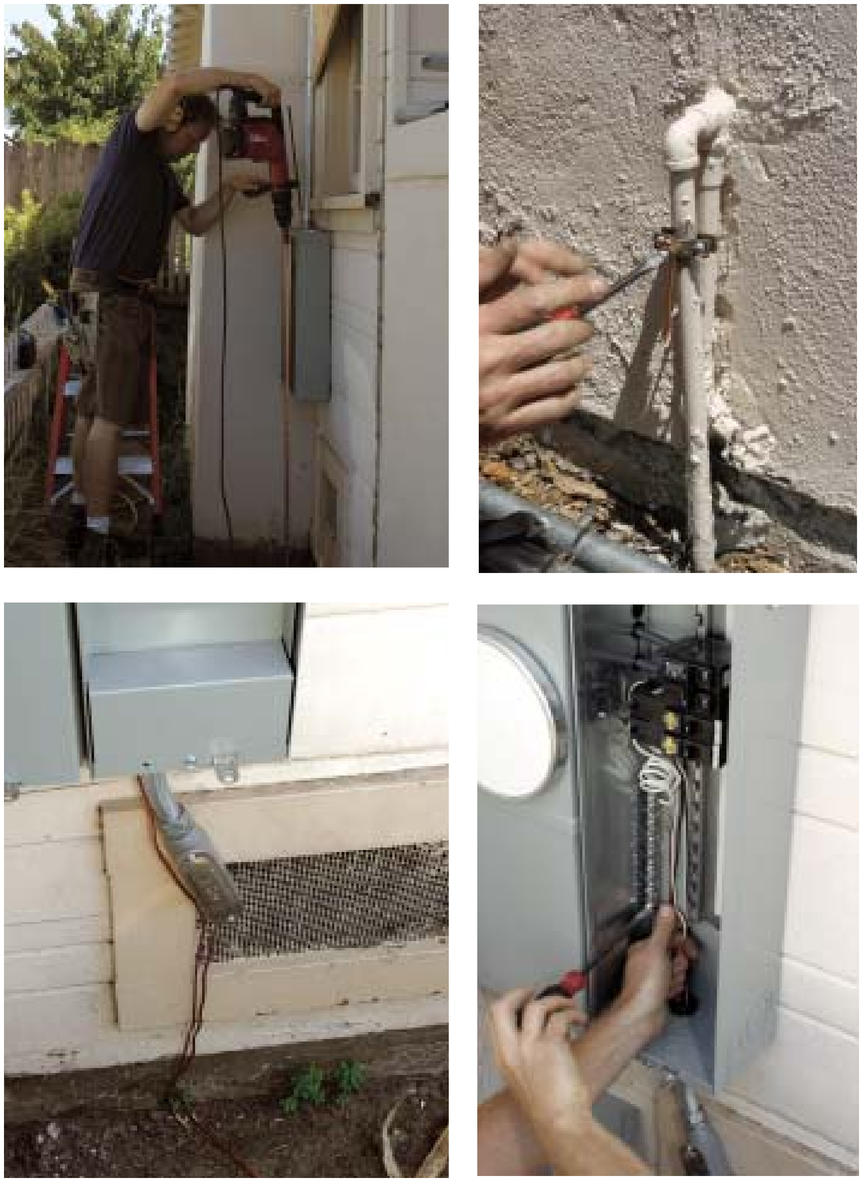


Figure 5. The electrician uses a rotary hammer with a ground-rod-driving attachment to drive a grounding rod into the soil (top left). He then runs a single grounding wire that connects to a clamp on the water main (top right), an acorn clamp on the ground rod (above left), a lay-in lug on the grounding bushing on the conduit to the loads (not shown), and the neutral bus in the main service (above right).

Figure 6. If the house has a gas line, the water pipes must be bonded to it. This is usually done at the water heater because both pipes are accessible there. A single length of grounding wire is connected to clamps on the water lines into and out of the heater (above left), then to a clamp on the gas line. The electrician installs a grounding clamp on the gas line (above right) after scraping off paint to ensure metal-to-metal contact.

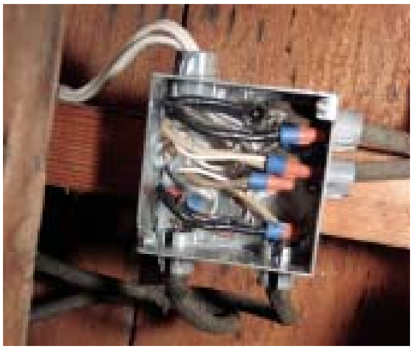


Figure 7. The electrician transfers the existing loads by disconnecting the knob-and-tube wiring from the fuse "panel" and running it to a junction box in the crawlspace, where it's connected to Romex (above). From there, the Romex runs to the other side of the house, exits the wall through a piece of conduit, and enters the bottom of the service panel (right).

- an acorn clamp on the ground rod;
- a ground clamp on the water main located within 5 feet of where the pipe enters the house.

By code we're required to bond the water pipes in the house to the gas pipe. This creates a larger grounding system and ensures that any existing circuits mistakenly "grounded" to a gas pipe are connected to something that actually *is* grounded (Figure 6).

We normally bond the gas and water pipes at the water heater (if it's gas) because all of the pipes are accessible there.

The wire runs between the gas line and the water lines at the heater; it's necessary to connect to both the cold-water inlet and the hot-water outlet, because if dielectric unions were used, the pipes downstream from the water heater might not be grounded.

Identifying Circuits

Before shutting down power, transferring loads, and demoing the old service, it's critical to check the existing circuits. If something isn't working, we want to know about it before making any changes; that way, it's clear we didn't cause the problem.

We also want to find out which wires are neutrals. Wires often aren't color-coded in old knob-and-tube systems, so when we find the neutrals, we mark them white. If we forget to identify them and accidentally hook up a hot and a white (120-volt) as two hots (240-volt), we could fry whatever is plugged into that circuit.

When changing out an old 240-volt service, we mark the phases black and red, based on testing before we shut off the power. Never rely on somebody else's colors. That person could have run a black to a red phase on a multiwire circuit. If, at the new panel, you connect both of them to the black phase, you could be loading the shared neutral with twice as much current as it can handle — which could torch the house.

Transferring Existing Loads

This house had only a couple of circuits, so when we removed the original service we were able to reroute the wires from the existing loads to a junction box inside the crawlspace. There we connected them to Romex, then ran the Romex to the other side of the house and fed it through a conduit into the service panel (Figure 7, page 7).

Since both circuits served more than one room and included bedrooms, we wired them to AFCI (arc fault circuit interrupter) breakers, which we then installed in the distribution section of the panel. Eventually, more circuits will be added, and only the bedroom circuits will be on AFCI breakers.

If we had been replacing a newer service — one with a metal enclosure — we would have stripped out the interior and treated it like a giant junction box. We would have run Romex between breakers in the new panel and existing loads in the old enclosure.

Figure 8. Once the loads have been transferred to the new panel, the electrician labels the circuits (top left) and installs the cover. Since the house was occupied and it was going to be some time before the utility could show up and make the final connection, the author's crew supplied temporary power by running Romex between the existing service drop and the new service conductors (top right). Later, the utility came out, removed the jumpers and existing service drop, and connected the new service drop (above).

Final Steps

Once the old loads were transferred to the new panel and we'd labeled the panel to indicate which rooms the circuits served, we reinstalled the cover and called for an inspection.

Sometimes, if we're lucky, we can get the utility people to show up, install the meter, and reconnect the house on the day we call (Figure 8).

But often it's difficult to make this happen, so if the home is occupied and the homeowners need the power interruption to be short — they work from home, say, or have medical equipment — we may leave the old service connected and temporarily heat up the new one with a jumper. That way, we can move branch circuits one at a time, which means the only one that's off is the one we're working on.

We also might use a jumper to power the house until the utility is able to show up and make the permanent connection. Keep in mind, though, that not every utility will allow you to install jumpers, because doing so requires connecting to a live service drop.

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