

Electrical Safety and Wiring for Repair Café Repair Coaches

19-Mar-2024 -1

As electrical Repair Coaches we encounter many wiring challenges during any given Repair Café session. We never know what customers will bring in for repair. Since it is impossible to document every type of repair the best we can do is apply basic electrical safety practices and wiring principles to every job.

Common electrical items seen at Repair Cafes are lamps, vacuum cleaners, blenders, toasters, coffee makers, tools, etc. Lamps need sockets, switches, wiring, and plugs replaced. The small appliances and tools need plugs replaced as well as cords replaced and internal wiring repaired. It is also common for customers to bring in rechargeable battery-powered items. These come with their own challenges since they involve chargers and batteries in addition to the item.

What follows in this document is basic information, guidelines, and practices to be used when servicing the electrical items brought to Repair Cafés. This is not intended as a tutorial. It is assumed that the reader has some DIY skills, is familiar with basic hand tools, and has, at least, a minimum understanding of electrical principles and how to use a multi-meter (DMM) for basic measurements.

All new electrical Repair Coaches, regardless of background, should work with an established Repair Coach for at least one session. This is so they can see how the Café process works and the Café can assess their technical as well as their people skills.

Every existing and prospective/new electrical Repair Coach needs to read this document even if they are a DIY veteran. This provides all of us with the same information. It gives RCs an opportunity to offer input to fine tune anything that needs updating.

Repair Coaches often collaborate on repairs. All of us have varying skill levels and it is common for two, or more, Coaches to work together on a repair. We help each other and learn from each other. That makes the Repair Café network better.

Ground Rules

We need to make safe repairs following accepted practices and using proper wiring techniques. It is necessary to use the proper wire type and gauge (size) for the job. For example, do not replace a damaged round shop vacuum cleaner cord with flat lamp cord even if they are the same gauge. Do not replace a 14 gauge cord with a smaller gauge, such as 16. That can lead to a fire.

Refuse to repair an item if you do not have an exact replacement part, or acceptable substitute, in stock or supplied by the customer. **It is not acceptable to “jury-rig” an electrical repair! REFUSE TO REPAIR UNSAFE ITEMS!** Examples of unsafe items are a heater with rust holes exposing the interior, any broken safety switches/thermostats, bypassed fuses/circuit breakers, etc.

Do not attempt a repair that is beyond your skill level! Confer with other Repair Coaches to determine if anybody can help you.

Basic Electrical Safety

- Remove all rings/bracelets/watches/long necklaces, etc. to avoid injury due to electrical or mechanical contact/entrapment.
- For additional safety, connect a portable GFCI to the extension/outlet strip you use at your repair table.
- Before starting a repair, and during a repair, **be sure the item to be repaired is unplugged**. There can be several power cords on your table so be certain that the power cord for your item is actually disconnected from power!
- Be careful sharing your outlet strip. **Your neighbor Repair Coach may accidentally plug in YOUR item’s cord and not his!**
- **DO NOT LET ANY CUSTOMER PLUG IN ANYTHING! You need to perform an evaluation prior to powering up any item.**
- Perform a visual inspection of the item and its power cord. Check for damage to the cord and plug, including the ground pin.
- Cord damage can include cracks in the insulation, missing insulation/exposed wires, stiffness/brittleness, etc. - **REPLACE**
- Plug damage can include cracks in the housing, missing pieces, exposed wires/screws, etc. - **REPLACE**
- If the plug on a 3 wire cord is missing the ground pin then **REPLACE THE PLUG.**
- Be sure all plugs **and** sockets are wired properly for hot (brass screw), neutral (nickel/silver screw), and ground (green).
- Check for short circuits between the plug prongs and between the plug prongs and the case.
- If the item has a 3 wire grounded power cord then check for continuity between the ground pin and the cabinet.
- Look for any damage to the item that makes the item irreparable (missing case pieces, exposed wiring, etc.)
- Use your phone to take pictures of the wiring connections for reference so you can be sure to replace the wires correctly.
- Check to be sure no wires are pinched or pulled when reassembling an item.
- **Always unplug power cords by pulling on the plug body, not the wire.**
- **Ask for help if you are unsure of how to evaluate and/or repair an item.**

Proper Wire Type and Gauge

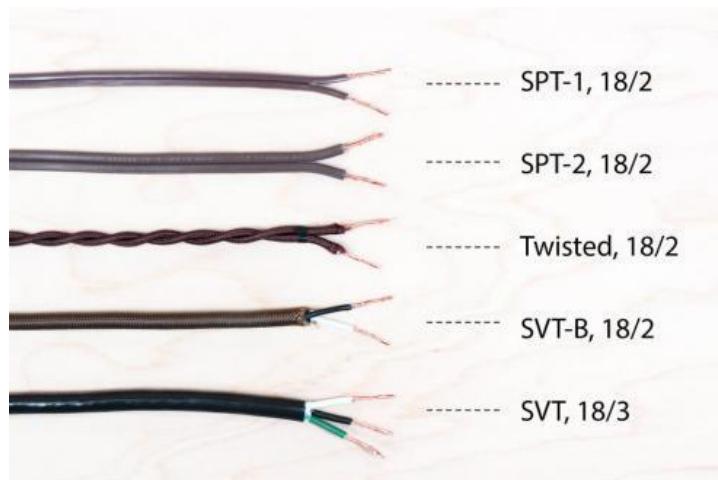
Several wire types will be encountered when dealing with lamps and appliances. Two of the most common are SPT and SVT.

Memorizing the types isn't necessary, just be aware of the types so you know the differences and where to use them.

- **SPT-1/SPT-2:** Stranded, Parallel, Thermoplastic. **SPT-1**, thinner than SPT-2, is used in lamps because it fits easier in wiring pipe/fittings
- **SVT:** Service, Vacuum, Thermoplastic. Often used on vacuum cleaners and other small appliances.



<https://blog.1000bulbs.com/>

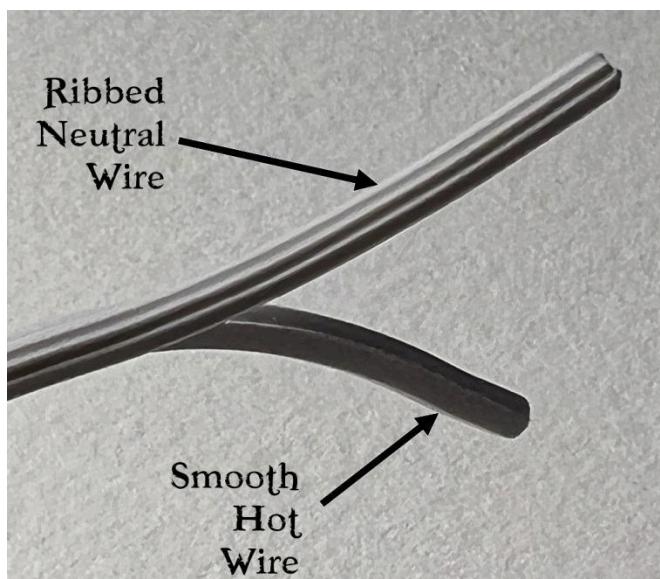


<https://www.instructables.com/>

For lamps we use **SPT-1, 18/2 cord**. That is the thinner flat lamp cord with an 18 gauge wire size. It fits in the lamp support pipe and wiring spaces easier than the thicker SPT-2, 18/2.

It is important to be able to identify the conductors (wires) in a cord so you know where to connect them. The chart below shows the wire colors used in the US vs international power cords. You may see both types during your repairs.

- For SPT lamp cord, the **ribbed conductor is the neutral (nickel/silver screw)** and the smooth conductor is hot (brass screw).
- SVT cords can be 2 or 3 conductors: hot/live (black/brown), neutral (white/blue), and ground/earth (green or green/yellow).
- Hot/Live = BRASS screw, Neutral = NICKEL/SILVER screw, and Ground/Earth = GREEN screw



<https://www.etsy.com/>



<https://www.etsy.com/>

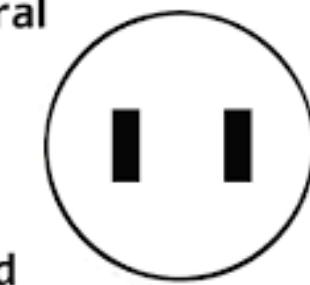
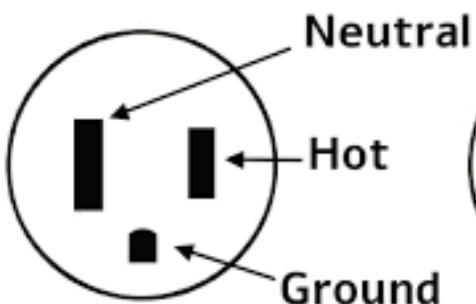
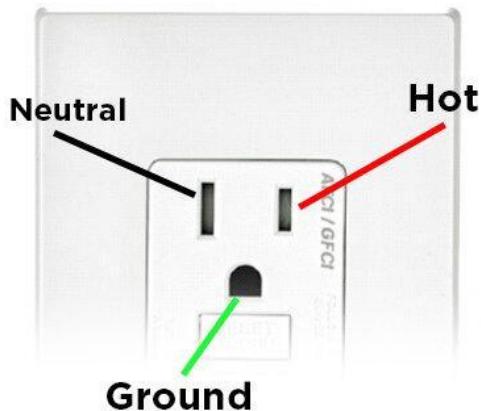
Outlets and Plugs

Outlet types:

Outlets and plugs come in many varieties but we are mainly interested in the ones we will see most often at a Repair Café.

Most power outlets and extension cord plugs and female connectors are polarized. That means the Neutral slot is wider than the Hot slot. If it is a 3-wire configuration, the outlet and the extension cord female connector will have safety ground jack and the plug will have a ground pin. You can see this in the picture on the left below.

Older outlets were non polarized so both slots were the same size and the hot and neutral couldn't be determined by looking at the outlet. This can be seen in the right picture. Polarized outlets and plugs were created as a safety feature and should be used when possible.



<https://blog.1000bulbs.com/>

<https://egrapevinestore.com/>



<https://homeinspectionmassachusetts.com/>

Plug Types

Common plugs are either polarized or non-polarized and can be either 2 wire or 3 wire. The 3 wire variety is always polarized due to the ground pin. Using a polarized plug is preferable because it maintains the neutral connection from the service panel (fuse or circuit breaker box) all the way to the lamp socket. This is a safety measure.

- A polarized 2 wire plug has a wide blade for the neutral and a narrow blade for the hot so it can be plugged in only one way.
- A non-polarized 2 wire plug has two narrow blades and can be plugged in either way. Can't visually identify neutral or hot.
- A 3 wire grounded plug is always polarized because the ground pin allows it to be plugged in only one way.

Polarized and non-polarized 2 wire plugs:

A polarized plug is on the left; larger neutral blade circled in red. A non polarized plug, on the right, has two blades of the same size.

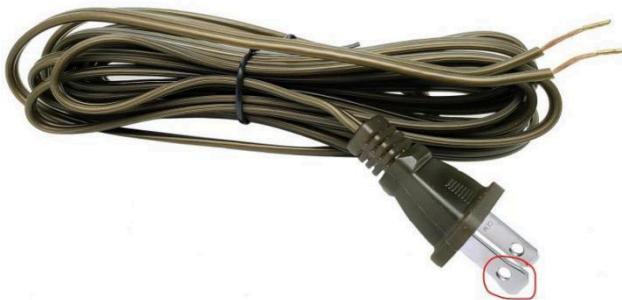


<https://www.homedepot.com>



<https://www.mylampparts.com/>

Below is a lamp cord set with molded polarized plug; neutral blade circled in red. Repair Cafés stock these in brown and white, the most popular colors. They also stock spools of SPT-1, 18/2 wire in brown and white as well as polarized plugs in the same colors.



<https://antiquelampsupply.com/>

When rewiring be sure to connect the ribbed (neutral) conductor to the silver/nickel socket screw and plug screw (if you are making your own cord from spooled wire).

If you encounter a vintage socket, or any socket, where you can't identify the neutral screw then use your DMM (Digital Multi Meter), on the ohms setting, to check which screw has continuity to the threaded shell of the socket.

Below is a polarized 3 wire plug. Note the safety ground pin.

DO NOT CUT OFF/REMOVE THE SAFETY GROUND PIN SO IT FITS IN A NON-POLARIZED SOCKET! THAT CREATES A SHOCK HAZARD!



<https://www.homedepot.com>

Bulb Types

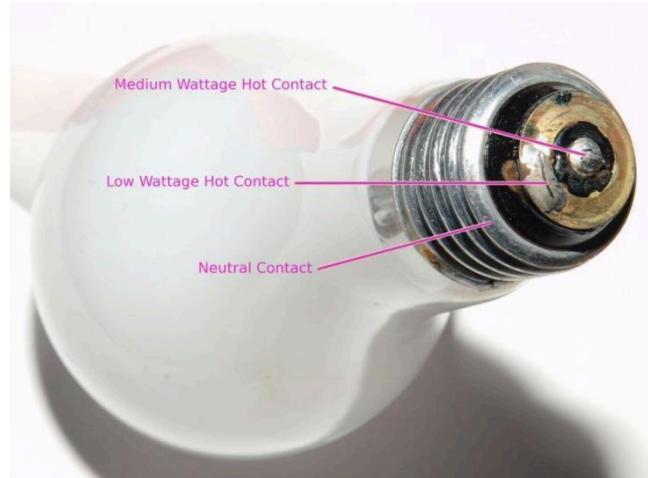
The most common bulbs we encounter are LED and incandescent in the “standard” shape and size as well as candelabra. The larger bulbs come in the on/off one wattage type and 3-way. A larger bulb, Mogul, looks just like a standard bulb just larger. The base looks the same as a standard bulb in either on/off or 3-way versions and is primarily used only in floor lamps.

On the left below is a standard on/off bulb. Note the single silver contact at the center of the base.

On the right is a 3-way bulb. They will have a description such as 30/70/100 watts or the equivalent if it is a LED bulb. Note the ring contact surrounding the center contact. The center contact is for the medium wattage (70) while the ring contact is for the low wattage (30). The 3-way socket will connect both the center contact and the ring contact to combine the low and medium wattage to get high (100).

Note: There is no danger of fire or short circuit if you use a single wattage on/off bulb in a 3-way socket. The same is true if you put a 3-way bulb in an on/off socket. The bulbs and sockets are designed to prevent a short circuit.

The only side effects of using a single wattage bulb in a 3-way socket is that you will only get one level of light and have to rotate the switch several times every time you want to turn the light on and off. Using a 3-way bulb in an on/off socket will only light the medium wattage setting of the bulb.

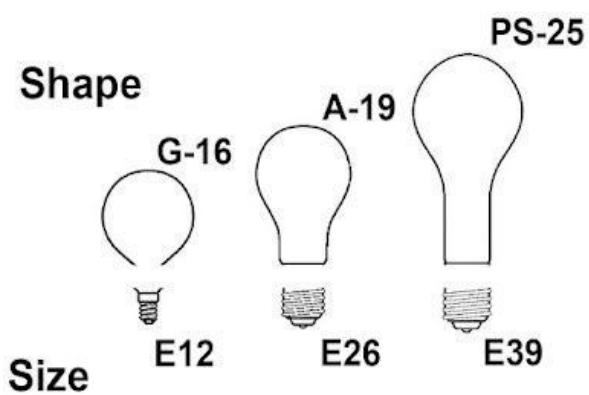


<https://www.walmart.ca/en/ip/23W-LED-Light-Bulbs-150W-Equivalent-3000K-Soft-White-E26-Base-A21-2500-Lumen-Bright-LED-Bulbs-4-Pack/PRDOWQHPA3EHL7Y>

<https://en.wikipedia.org/>

Candelabra bulbs, on the left below, have a smaller base than the above bulbs and are usually smaller than the standard bulbs. The common “night light” bulb is an example. Candelabra-based bulbs are often found in two bulb fixtures where one standard bulb is at the top and the smaller bulb is in the base.

Below is a bulb size comparison chart. The E12 is a candelabra, the E26 is standard, and the E39 is a Mogul.

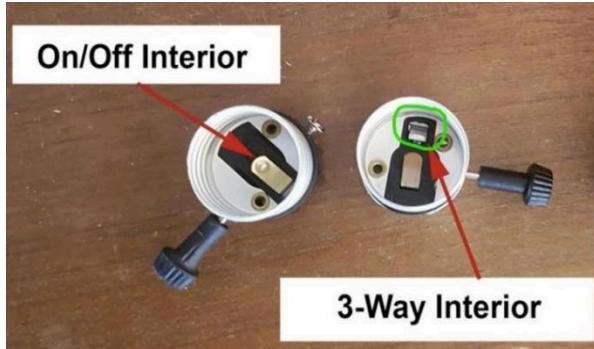


Lamp Sockets

Lamp sockets come in several varieties. The most common are: on/off, 3-way, 3 terminal/2 circuit (NOT 3-way), and keyless (no switch). The types of switches on sockets are turn knob, pull chain, and push on/off.

It is important to properly identify the terminals on a socket so that it can be wired properly:

- On/off and 3-way sockets have two terminals: hot (brass), and neutral (silver).
- Three terminal sockets have a brass (hot), silver (neutral), and black. The black terminal is for the hot wire of the second bulb in the fixture, usually at the base of the fixture. This is detailed below.
- Keyless sockets can have two or three terminals depending on whether they are on/off or 3-way. The latter uses a separate switch. Details follow.



<https://www.lamppartsrepair.com/>



<https://www.instructables.com/Wiring-Sockets/>

On/off and 3-way sockets have 2 screws: brass and silver.

A 3-way socket looks like an on/off socket but has an extra contact, circled in green in the picture above. This extra contact mates with the low wattage ring on the base of a 3-way bulb. The center contact is for medium wattage. The switch selects the ring for low, the center contact for medium, and both the ring and center contacts for high. It has 2 screws: brass and silver. It is wired the same as an on/off socket.

The interior of a 3 terminal/2 circuit (NOT 3-way) socket looks like a standard on/off socket **BUT** has 3 screws: brass, silver, black. The black screw is for the hot wire for the second bulb, usually a candelabra type, located in the base of the lamp. A picture of the bottom of a 3 terminal socket is below. The wiring diagram using this socket is provided later in this document.



<https://www.ebay.com/item/163645459127>

The interior of a keyless socket can look like an on/off or 3-way socket depending on the type of bulb to be used in the lamp. If it is an on/off type it will have 2 screws: brass and silver. The 3-way type will have three screws: brass, silver, black. This socket will have an **external 3 wire, two circuit switch** to control the socket. A wiring diagram is provided later in this document.

On the left is an on/off keyless socket. The one on the right is a 3-way keyless socket. Note the extra contact for the 3-way bulb.

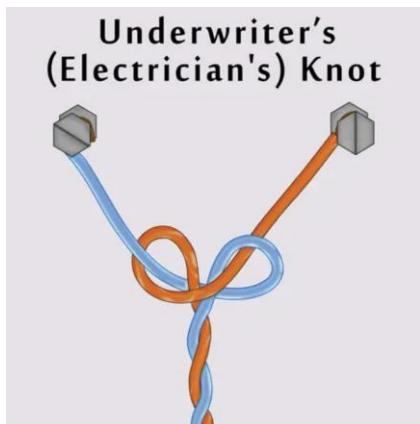


<https://www.vacuumsrus.com>

<https://www.ebay.com/item/153822474588>

Wiring Lamp Sockets Properly

Begin wiring a socket by splitting the lamp cord about 3 inches. To prevent the wire from being ripped off the socket terminals due to the lamp cord being yanked, a special knot, known as the Underwriter's Laboratories Knot aka UL Knot, is tied in the lamp cord at the base of the socket. The two-color graphic below shows how to loop the wires to form this knot.



<https://www.101knots.com>



<https://www.walmart.com/ip/3-Way-Lamp-Socket-Replacement>

Once the UL knot is formed, pull the ends tight, and cut the wires so that they are about 1" long. Next, using wire strippers, strip approximately 5/8" of the insulation off of each wire. You can see this in the left photo below.

It is critical to properly attach the wires to the socket terminals so they do not short circuit to another wire or any part of the socket or lamp. The stripped end of the wire must be twisted clockwise tightly and formed into a clockwise loop as shown in the left picture. The loop is placed under the screw head with the wire strands facing clockwise and the screw is tightened clockwise as seen in the right picture. Be sure to tuck all of the strands under the screw head.



<https://www.instructables.com/Wiring-Sockets/>

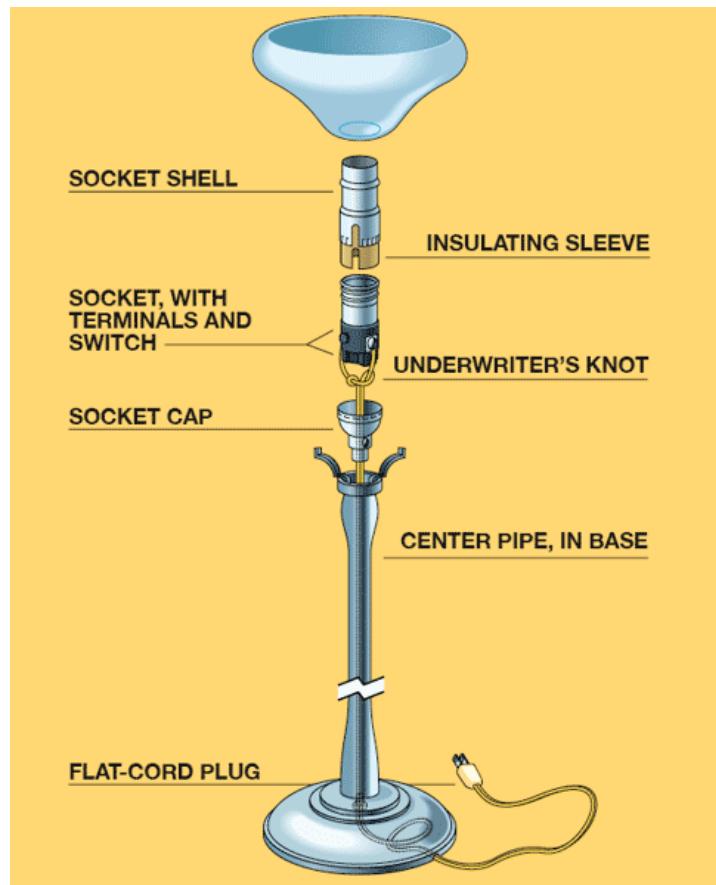
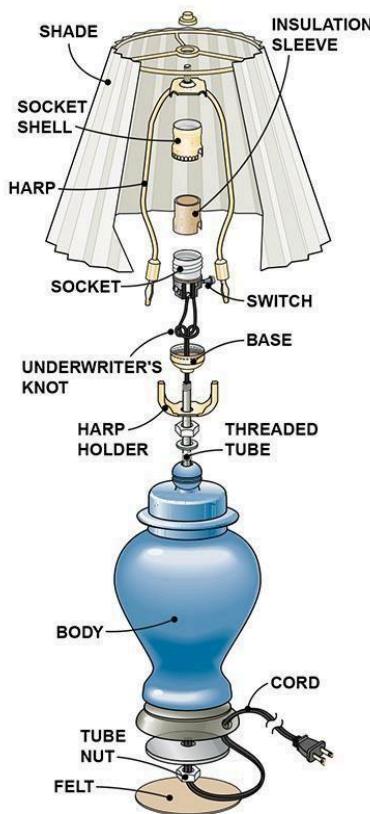
The following pictures show two examples of **HOW NOT TO WIRE** a lamp socket.



<https://www.instructables.com/Wiring-Sockets/>

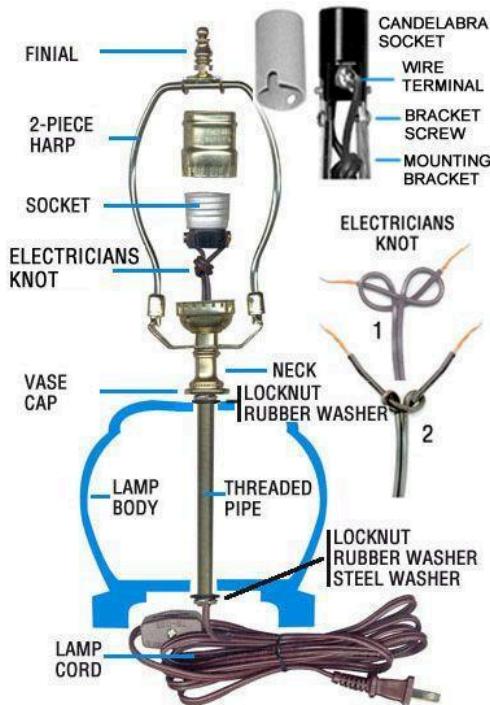
Rewiring Basic Single Bulb Table Lamps and Floor Lamps with an On/Off or 3-Way Socket

Using the socket wiring information from above, follow the lamp diagrams below to disassemble a lamp to replace the socket. Most lamps will look something like these.

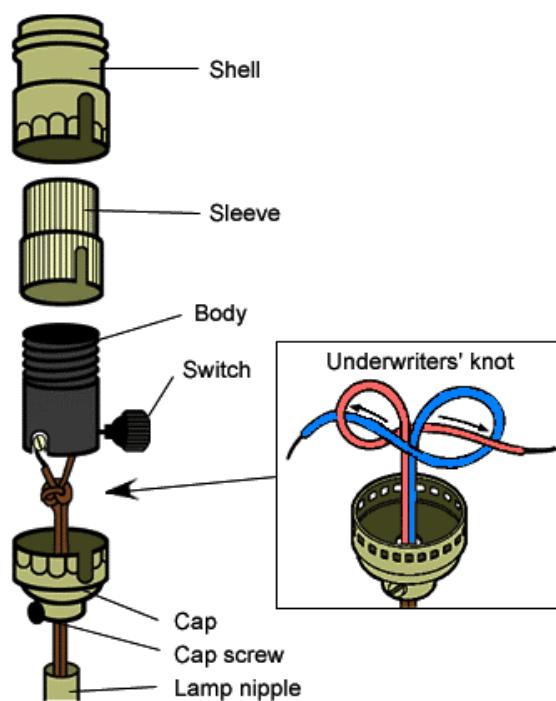


<https://www.familyhandyman.com/electrical/electrical-repair/>

<https://www.thisoldhouse.com/electrical/21016561/how-to-rewire-a-lamp>



<https://www.nationalartcraft.com/wireguide.htm>

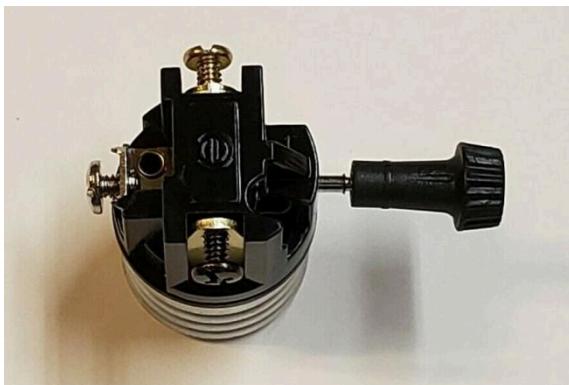


<https://www.copper.org/consumers/copperhome/DIY/>

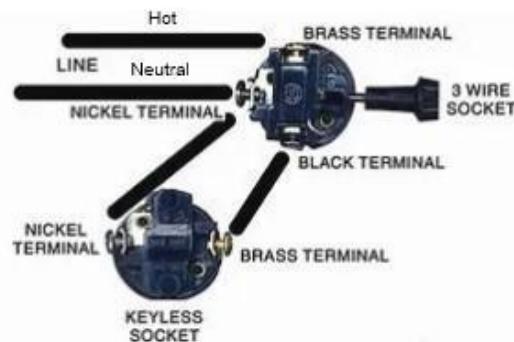
Rewiring Lamps with Two Bulbs (Top and Bottom) Using a Three Terminal/2 Circuit (NOT 3-Way) socket

These lamps typically use a standard bulb at the top and a small candelabra (night light) bulb in the base. The 3 terminal switch on the socket at the top has several positions that turn on the top bulb, the bottom bulb, and then both bulbs simultaneously. The fixture itself is usually assembled similarly to a standard table lamp.

The picture on the left, below, shows the base of a three terminal/2 circuit switch. The black terminal, for the keyless candelabra socket is at the bottom front. The brass, hot, screw is at the top and the silver, neutral, screw is at the left. To the right is a complete diagram showing how the switch is wired into the lamp. **Note that the Neutral wire from the line cord AND the bulb in the base are BOTH connected to the nickel terminal of the switch.**



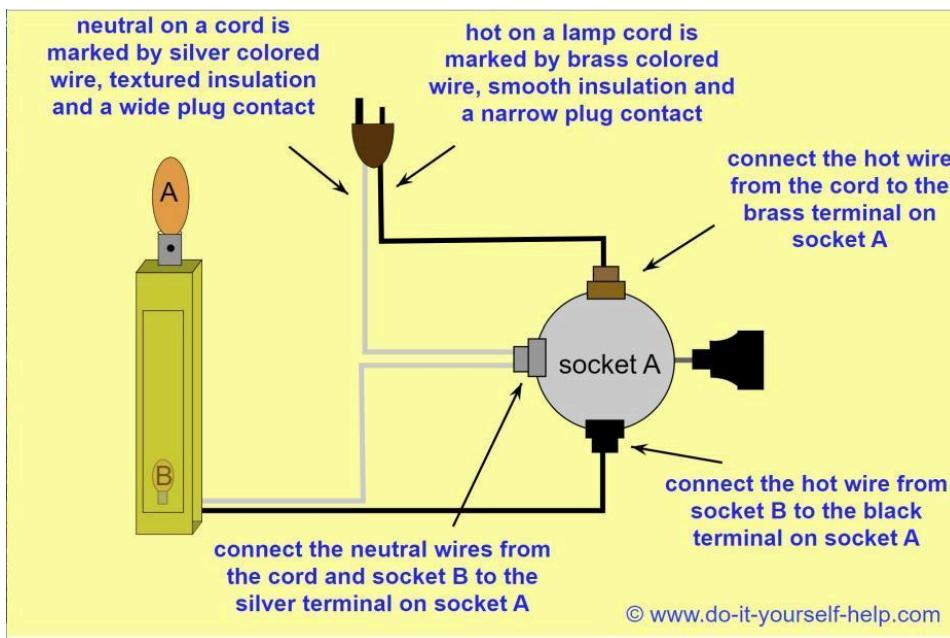
J&J LAMP PARTS <https://i.ebayimg.com/images/g/LtsAAOSwea5cdeCA/s-l500.jpg>



<https://diylightingsupplies.com/>

Below is an annotated graphic detailing the wiring of a lamp with a three terminal/2 circuit switch and two bulbs.

The top socket is a standard 2-way, on/off, socket. The bottom socket is usually a candelabra.



Wiring a Vintage Floor Lamp with Four Bulbs and Two Switches

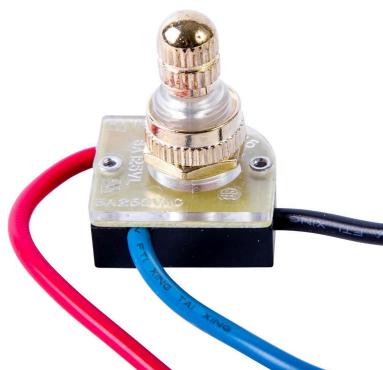
This is one of the more difficult wiring jobs because it entails connecting thirteen (13) wires from four bulbs and two switches. At the top of the fixture there is one socket with a switch that can be a 3-way or on/off type. It can use either a Mogul (large base) or standard, Edison, base bulb. Use your phone to take clear pictures of the connections when disassembling the lamp.

Below that there are three lamp sockets usually positioned at 120° increments around the center pole of the fixture. The picture on the left, below, shows a disassembled lamp with the wires exposed.

A special **3 terminal, 2 circuit rotary, pull chain, or push switch** that controls these three lamps is normally located on the center of the pole near the attachment point for the three lamp sockets. An example of a rotary switch is shown below, on the right.



<https://diylightingsupplies.com/>

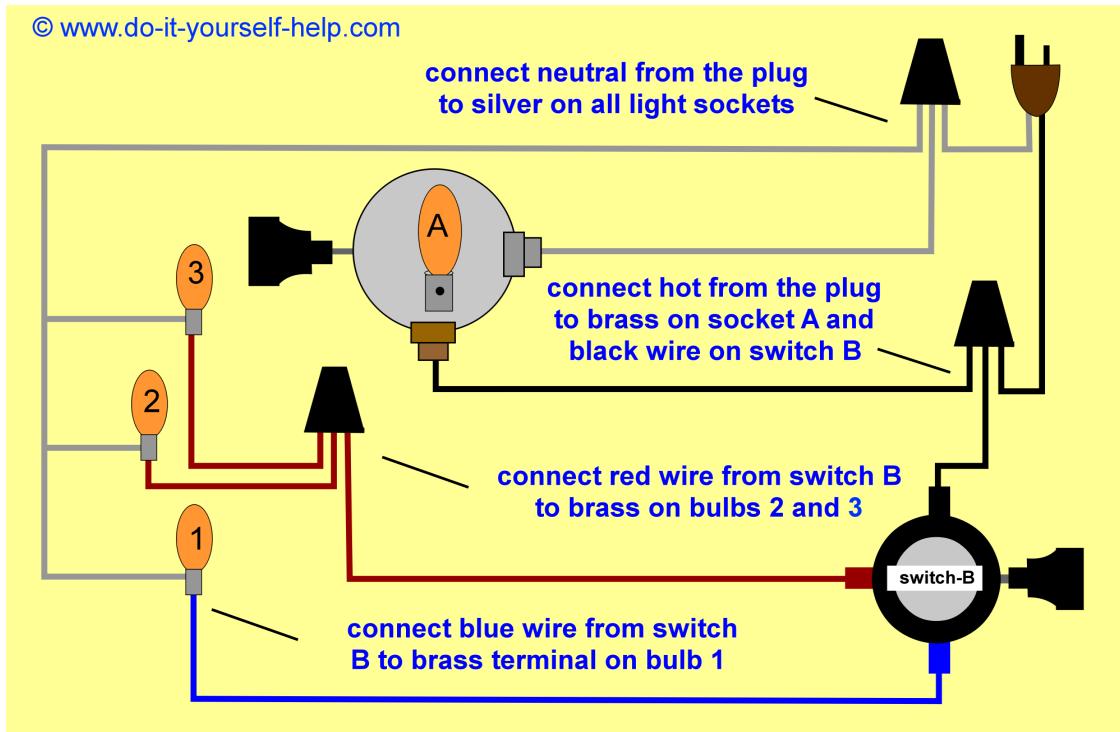


<https://www.walmart.com/ip/Gardner-Bender-GSW-68>

The annotated graphic below should help you to rewire this type of lamp fixture.

Be careful to use the correct color wires from the rotary switch marked "switch-B" in the diagram:

- The BLUE switch wire is connected to the HOT side of ONE lamp.
- The RED switch wire is connected to the HOT side of THE OTHER TWO lamps.
- The BLACK switch wire is spliced to the HOT wire from the top lamp socket AND the SMOOTH wire of the line cord.
- All of the neutral wires are connected together to the RIBBED conductor of the line cord.



Wiring a 3-Way Keyless Socket with a 3 terminal, Two-Circuit Switch

This isn't a common lamp socket but it has been included because one might show up at a Café.

It uses a 3-way keyless socket so the interior will look just like a regular 3-way socket but without a switch. In the left picture below you will see the extra contact, circled in red, that is for a 3-way bulb.

The center photo shows the bottom view of the socket and the three terminals, brass, silver, and black.

This type of lamp uses a **3 terminal, 2 circuit switch** to control the socket and is shown at the right.



<https://www.ebay.com/item/153822474588>



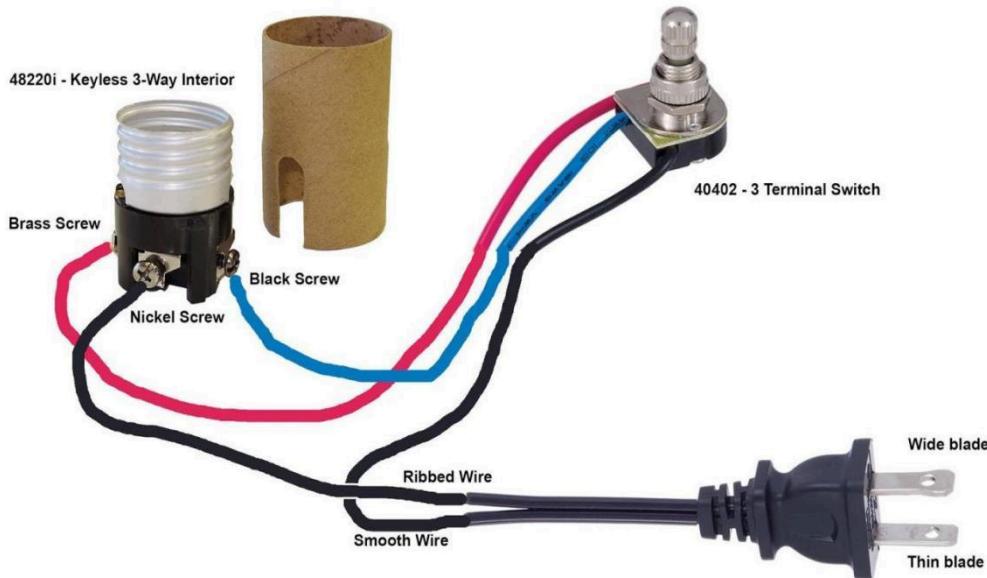
<https://www.walmart.com/ip/Gardner-Bender-GSW-68>

The annotated graphic below will guide you through the repair.

Be careful to note where the colored switch wires are connected:

- RED switch wire to brass socket screw
- BLUE switch wire to black socket screw
- BLACK switch wire spliced with a wire nut to SMOOTH (hot) line cord wire

The **RIBBED (neutral)** wire in the line cord is connected to the **nickel/silver socket screw**.



<https://antiquelampsupply.com/products/keyless-3-terminal-socket-interior-e26-medium-base>

Removing a Broken Bulb from a Socket

SAFETY FIRST:

- UNPLUG THE LAMP / TURN OFF THE POWER
- VERIFY THE POWER IS OFF - USE CIRCUIT TESTER
- USE EYE PROTECTION
- WEAR HEAVY GLOVES
- BE CAREFUL OF GLASS SHARDS

Equipment / Tools / Materials needed:

- Eye protection
- Gloves, preferably leather - resistant to broken glass
- Needle-nose pliers (2 pairs, if available)
- Fixture/Lamp chain pliers (optional)
- Circuit tester
- Strong trash bag (to hold glass shards)

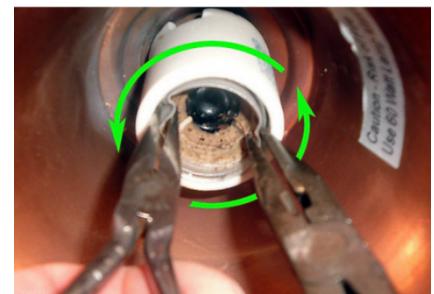
Remove And Clean Up the Glass

Put on gloves and eye protection. **VERIFY THAT POWER IS SHUT OFF!**

Using gloves, carefully snap off any bits of glass still attached to the base and discard in strong trash bag. Prevent flying shards!

Using Needle-Nose Pliers

Use needle-nose pliers to grip the metal edge of the bulb base as shown in the left picture. Bend the edge inward slightly for a better grip and start **turning counter-clockwise as shown in the center picture**. Sometimes **using a second pair of needle-nose** pliers on opposite sides of the broken base as shown in the right picture **can make it easier to turn the base counter-clockwise**.



<https://diyhomerepair.info/handyman-misc-jobs/remove-broken-bulb-base.htm> <https://prettyhandygirl.com/4-ways-remove-broken-light-bulb/>

The other way to use needle-nose pliers is to open the jaws wide enough to engage the walls of the bulb base. Then, with two hands maintaining the wide-open jaws, **rotate counter-clockwise** and the bulb should come out.

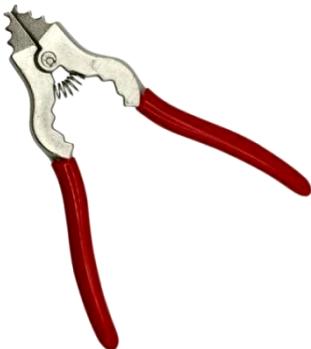
Eventually, the base will come out, either by turning or by being removed in pieces. Be patient and be careful not to damage the socket in the process.

Using Fixture/Lamp Chain Pliers

The primary use of fixture/lamp chain pliers is to open and close links in decorative lamp chain. An alternate use is for removing broken bulb bases from sockets.

Unlike needle-nose pliers that close their jaws when the handles are squeezed, these pliers open their jaws. Insert the tip of the closed jaws of the pliers into a broken bulb base. Squeeze the handles sufficiently so that the pliers make a firm grip on the sides of the bulb base. **DO NOT DEFORM THE BULB SOCKET!** Rotate the pliers counter clockwise to remove the bulb base.

A picture of fixture/lamp chain pliers is on the left. On the right, lamp chain pliers are being used to remove a broken bulb.



https://www.amazon.com/dp/B00CKBYD3FD?psc=1&ref=pxy_yo2ow_dt_b_product_details



<https://www.lamppartsrepair.com/2014/07/bulb-base-stuck-in-lamp-socket.html>