# Tube Amplifier Debugging Page

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This page is designed to lead you through debugging a problem with a tube-type guitar amp. Just click on the appropriate links, making the appropriate tests as needed. This page fits older Fender and Marshall amplifiers best, especially in the sections relating to amplifier specific things like preamps, reverb and tremolo. However, the sections on power problems, hiss, and hum should work pretty well for any tube amplifier.

This page has proven useful to quite a number of people by the reports I've received. It's always possible that you'll find a bug in it, and I know that there are some situations that aren't covered, although I believe that over 90% of bugs are. If you find an error, or have a bit of debugging info to contribute, please email so I can include it.

## SAFETY WARNING AND DISCLAIMER

Read this warning before doing any of these operations. The life you save could be your own.

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Order of Suspicion

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Debugging Step #0 - Being Prepared

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Does your amp have....?

- No sound at all, not even faint hiss or hum, comes out of the speakers
- Faint hiss and/or hum comes out of the speakers
- Pops fuses
- Squeal at some or all control settings
- Putt - putts like a motorboat
- Hum
- hiss

- Popping sounds
- Unintentional and ugly distortion even when set for clean operation
- Low power or volume, or volume drops off
- Smoke or burning smell
- Intermittent operation
- Electrical shocks
- Reverb problems
- Vibrato problems
- Scratchy Controls

# Safety Warning

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Some tests necessary to debugging a tube guitar amplifier may require you to perform operations inside the amplifier with voltage on. These tests can be hazardous to perform if you do not know the specific methods to do them safely. Such hazardous tests are presented only for your information, and the author does not recommend that you should perform these tests, especially if you do not already have the skills and experience to do them without harming yourself, other people, or the amplifier you're working on. These skills are not things that you can safely learn by yourself from reading some text.

In some cases, I have used alternate non-hazardous tests before recommending hazardous ones in an attempt to avoid recommending a hazardous test, even where the most expeditious thing to do would be to open the box up and poke around in it. If you're an experienced technician, this may cause some of the testing to be clumsy and roundabout. This is often why.

This debugging page is not intended to teach you how to do these tests safely. If you need to do any test on the inside of the amplifer chassis, you do not already know how to do such tests safely, take your amplifier to a qualified service technician. Saving a few bucks is not worth endangering your life. A rough guide to some safety precautions can be found in the Tube Amp FAQ, although those guidelines are not in themselves sufficient training for safety procedures, either.

If you have any question in your own mind about being able to do any test safely, take the amplifier to a qualified technician, do not risk your life and health. The author assumes no liabilty, express or implied, for your actions or their consequences to your life, health, or possessions. Proceed at your own risk. Your action in performing any of the tests recommended by this page constitutes your acknowlegement of this warning, and your express assumption of all risks associated with any procedure, as well as indemnification and agreement to hold harmless of the author in any and all legal actions of any nature whatsoever arising from your actions.

# What to suspect first

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Not all things are equally likely to fail. Experience with tube guitar amps has shown that failures are most often in the following order of likehood:

1. Operator Error - a control or something is set or switched wrong.
2. Tubes - the most likely thing to have gone bad on a once-working amp; this is why they're in sockets!
3. Power Supply Components - they handle lots of power and get hot
4. Resistors and Capacitors - especially electrolytic capacitors
5. Mechanical Components
    - Tube Sockets
    - Switches
    - Switches
    - Cables, Cords and Jacks
6. Internal Wiring

Accordingly, suspect problems in that order. First make sure you are operating the amp correctly - master volume turned up, cords plugged in, etc, etc. Then suspect that a tube has failed, and so on.

# Debugging Step #0 - Preparation

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I would guess that you're here because of one of three reasons:

1. You're just curious
2. You're alert to the possibility that your amp might fail you at some critical time and you want to be ready to handle it well and easily
3. Your amp has already failed, you don't know what to do, and you're hoping to catch up by looking at what you should have done earlier.

Numbers one and two are good, laudable reasons to be here. You're a smart, forward-looking, prepared kind of person. Number three is where I'm going to have you being a religious convert next time. If you're part of group three and don't follow at least some of these recommendations, I think you're going to make some amp tech very happy during your life.

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## What can you do to be ready for the inevitable amp failure?

There is a **lot** of things you can do to be ready. These fall into two categories: knowlege you can have already learned for how to proceed, and objects you can have on hand just in case you need them. Let's take the knowlege first.

### The only good amp is a dead amp...

How does you amp act when the normal channel preamp tube dies?? Easy enough to find out - just pull it out, then listen to the amp. How about the reverb tube? Phase inverter? Shoot, what happens if one output tube dies?

A curiousity about tubes and a real advantage that they have over solid state devices is that a missing or failed tube will usually not cause any harm to the the rest of the amplifier. There are specific exceptions, notably shorted rectifier tubes and shorted output tubes; but you can safely, no harm to the amp, pull any tube out to listen for what it does to the sound.

If you'll spend an hour or so pulling a tube, listening to the results and noting what you can hear and what you can't, which controls work, which don't do anything anymore, etc., you'll already know what happens when tube XYZ dies.

This isn't perfect, of course. Most of the tubes in the preamp section of a guitar amp are dual triodes, and often only one section goes bad. Also, "going bad" doesn't always mean "totally dead". There's all kinds of things that mean only section one or two is bad, one side is noisy, one side is arcing, etc. But you CAN get some ideas.

Here's another idea - your favorite amp tech, who loves to see you walk though his shop door, will think you're crazy, but it makes a great deal of sense to beg for a couple of tubes that are KNOWN BAD. I bet he'll give you a few bad ones free, or at least save you some from repairs, perhaps in return for a six-pack worth of foaming mental lubricant. Just don't ask for shorted rectifier tubes or output tubes. If you can , get a set with a dead section 1, another with a bad section 2, excessive hiss, excessive hum, etc.

The reason an experienced tech can just listen to an amp, twiddle a few controls and make a doggone good guess about what's wrong is that he sees so many faulty amps and finds out what was wrong to cause them to act that way. You can't match your tech's experience in general, but you CAN know a lot about how your particular amp might go bad.

You can spend some time swapping in a tube known to have a bad section 1 and seeing what it does; a bad section 2 to see what controls work and how, a known microphonic tube, a hissy, noisy tube, etc. You'll be amazed at how quickly you learn this stuff, and what you remember when your amp dies on stage. And your bass player will be A-M-A-Z-E-D.

If you get serious about being ready to fix your own, and you have taken the time to learn to do it safely, get:

- a Digital Multimeter (very serviceable ones can be had for under $30)
- a schematic for your amp

Make photo copies of the schematic, then start measuring the voltages on the pins of the tubes when the amp is not yet broken. When something fails, it's most often going to make the voltages somewhere be 'way off.

You catch the drift here - the more you know about how it acts when everything is OK, and about what failures in specific spots sound and act like, the easier fixing it is. You can even just pick your level of comfort. Anyone can swap tubes in and out, and that will catch most of the problems, very quickly.

## No problem, just plug one in...

Of course, when you know a little about what happens when the prefrontal megablaster tube dies, you'll be able to swap one in without missing a chord on stage - assuming you have another one, of course. Here's something to consider:

**tubes are expected to die. That's why they're in sockets.**

YOUR tubes are going to die someday,

given only that you keep using the amp, and if you don't keep using the amp, why are you reading this?

So - you're going to need replacement tubes someday. Why not get them when you have some time to bargain, shop for a good price, find good ones and interview them, get ones that you know will sound good, not no-name or used leftovers that the local tech happens to have when your amp dies in Western Mudflats, Montana?

Look inside your amp, and make a list of the different KINDS of tubes that you have. Chances are, there aren't all that many. Most even semi-modern amps use only 12AX7's for preamp tubes, most Golden Age amps use 12AX7 plus perhaps 12AT7 and/or 12AU7's in the preamp circuit, very old or rarer amps use the 6EU7 and/or others. It just can't cost that much to get one or two replacements of each kind as cheap insurance.

What's that? your amp uses a rare 7199, 12DW7, or some other esoterica? Well, what **WILL** you do when our friend the local tech in Western Mudflats tells you "...uh.... those are pretty rare these days. I think I can get some Chinese replacements for that here in three days ... maybe about $50 each, plus FedEx shipping. That OK?"? It's always going to be easier and cheaper to get them ahead of time. Not to mention less stressful.

OK, I see. You think they'll get lost or broken... well, how do you keep up with that guitar, those effects, cords, and amp?

What else, other than spare tubes? If you got this far, you probably have already guessed - anything that you can plug in easily without tools. This is probably just fuses and cords. A really dedicated amp maintainer would have a DMM in his gig bag or the bottom of his ampwith the spare tubes.

Output tubes are special - you MUST rebias the amp whenever a new set of output tubes goes in to be sure you didn't get a "hotter" pair that will run away and melt down on the old bias setting, maybe killing your power and/or output transformer in the process. However, nothing says you can't try a new pair before hand, perhaps with your local tech's assistance, and find a pair that is safe - that is, if the bias is not perfect, it is at least not harmful if you just sub in the new pair.

# No Sound At All

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- AC Power indicator light does not glow
- AC Power indicator glows

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If the speakers have only a modest hiss or hum coming from them, that indicates that the power amplifier section, speakers and speaker wires are OK, and that the fault is probably in the lower-signal sections of the amplifier.

- Preamp tubes bad
- Preamp power bad
- Input cord or connector is open or has dirty contacts; this can include the effects loop jacks, if present.
- Input jack dirty or corroded
- Open volume or tone control
- Open, shorted, or failing resistor or coupling capacitor
- Faulty signal wiring
- Dirty tricks - I actually saw this once. The clever-but-misguided spouse of a guitar buddy painted the tip of a friend's guitar cords with clear nail polish. All of them. That took a while to find...

# Fuse Blows

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Fuses blow quickly for massive overloads, like AC shorts to a grounded chassis. They blow with a some time lag - maybe only a second or two, up to minutes, as the overcurrent gets closer to the fuse's actual rating. Anything that uses enough power to cause the AC line current to exceed the rating of the fuse will eventually cause it to blow.

It is important to remember that a fuse NEVER blows without something else being wrong. It could be that:

- fuse is the wrong rating - replace it with the correct rating
- power tube shorted
- rectifier tube shorted
- power supply filter cap failing
- Carbon trails on the output tube sockets between the plate lug and the other electrodes, especially the heater electrodes.
- power tubes have lost bias or biased incorrectly
- power section of the amp is oscillating at too high a frequency to hear
- there is an ac wiring short or high leakage
- power transformer is faulty
- choke (if present) is shorted/leaking to chassis
- output transformer is faulty
- AC power wiring or B+ power wiring is faulty/shorted

# Squeals

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If it squeals, it's oscillating at a frequency low enough to hear. The single most common cause of this is a tube going microphonic. Try swapping tubes first; it's most often the first preamp tube if it actually squeals solidly instead of only when you hit a note that excites the resonance.

In most other cases, the squeal starts just after some pivotal event - the amp has just been repaired or modified, or new tubes put in, or has been dropped. That event is a clue. Think about what changed, then un-change it or tinker with whatever was changed.

Some causes of squeal:

- Tube going microphonic - most often first preamp tubes.
- Shorting contact on input jack (esp #1) not making contact; the "squeal" is from sound vibrations vibrating the chassis and the contact making and breaking contact repeatedly, making a little 'click' each time.
- Power tube shorted (this only happens for a short time - the amp squeals and then dies.)
- Lead dress - the leads carrying the signal around inside the amp have been moved around somehow so that the signal is causing internal electrical feedback. You can find this by running the amp with the chassis open and moving the wires around (gently! with a wooden stick) to see if the squeal changes or goes away. Once you locate the critical wire(s) you can figure out where they have to be to keep this from happening and tie them there. Another option can be to substituted shielded wire for the sensitive ones, with the shield connected at one end of the run only.
- If the amp has been modified, the squeal may be caused by poor lead dress in the modification, improper grounding in the modification, parts layout too close, or just that the new (usually higher) gain has pushed things over the edge. Higher gain makes a lot of things more critical, including grounding, bypassing, lead dress, and signal shielding.
- Wrong polarity/ incorrect hookup of a replacement output transformer.

# Putt-putting sound or motorboating

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In an amplifier that has ever worked correctly once, motorboating is almost always a signal that the decoupling capacitors in the B+ lines of the preamp section are going high impedance, not decoupling properly. Replace the B+ decoupling capacitors at least for the preamp. Since the other capacitors are old, also, consider replacing ALL of the electrolytic capacitors in the amp (doing a cap job - see the Tube Amp FAQ at http://www.eden.com/~keen for info on the what and why of cap jobs.)

# Excessive Hum

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A good way to divide and conquer is to turn the volume control(s). If the hum changes levels as you do this, then the source of the hum is something that affects the stages of the amp before the volume control. A faulty, humming preamp tube can be isolated this way very quickly. Conversely, if the volume control does not affect the hum, the cause is somewhere after the volume control.

Faulty tube
: Tubes sometimes develop internal hum, for reasons known only to themselves. Do some tube swapping to locate the problem. Use the volume control test

Severely unmatched output tubes in a push pull amplifier
: Push pull amplifiers get by with less power supply filtering because they're supposed to cancel this ripple in the output transformer. The cancellation can be upset by output tubes that use different amounts of bias current, allowing the hum to be heard.

Faulty power supply filter caps

Faulty bias supply in fixed bias amplifiers
: A bias supply with excessive ripple injects hum directly into the grids of the output tubes. Check that the bias supply diode is not shorted or leaky, and then bridge the bias capacitor with another one of equal value to see if the hum goes away.

Unbalanced or not-ground-referenced filament winding

Defective input jack
: If the input jack is not making good contact to the guitar cord shield, it'll hum. Likewise, if the jack has a broken or poorly soldered ground wire, or not-very-good connection to the grounded chassis, it will cause hum. If messing with the jack changes the hum, suspect this.

Poor AC grounding
: In amps with two wire cords, defects of the "ground reverse" switch and/or capacitor can cause hum. A leaky power transformer can also cause this. It's especially bad when the ground reverse mess is already dicey.

Induced hum
: Placement of the amplifier near other equipment can sometimes cause it to pick up radiated hum from other equipement. Suspect this if the hum changes loudness or tone when you move or turn the amp. There is usually nothing you can do about this except move the amp to where the hum is less.

Poor internal wire routing
: If the signal leads inside the amp are routed too near the AC power wires or transformer, or alongside the high-current filament supply wires, they can hum. Sometimes using shielded cable for signal runs inside the cabinet can help. It is hazardous to do, but you can open the amp up and use a wooden stick (NOT A PENCIL) to move the wires around inside to see if the hum changes.

This is hard to do well and conclusively, since the amp will hum more just because it is open. BE VERY CAREFUL NOT TO SHORT THINGS INSIDE THE AMP.

Poor AC Chassis Ground at Power Transformer

A common problem is the main ground point to the chassis. The green wire (you DO have a three wire line cord, don't you?) ground to the chassis, the "line reverse" cap, the CT on the filament windings, the CT on the high voltage windings, and other things associated with power or RF shield grounding are often tied to lugs held under one of the power transformer mounting bolts. If this bolt becomes loose, or if there is corrosion or dirt under the lugs, you can get an assortment of hum problems.

Defective internal grounding

There are potentially lots of places that must be tied to ground in the internal wiring. This varies a lot from amp to amp. If one is broken loose or has a poor solder joint or poor mechanical connection, it can show up as hum. Note that modified amplifiers are particularly susceptible to this problem, as the grounding scheme that the manufacturer came up with may well have been modified, sometimes unintentionally. With the amp unplugged, open and the filter capacitors drained, carefully examine the wires for signs of breakage or mods.

Relay Coil Hum

If your amp is home-built, you may have used an AC-coil relay for some switching functions. If you used the filament AC for powering this relay, you can get an AC hum in the signal path induced from the coil. The cure is to run this relay from DC by rectifying and filtering the filament supply or changing to another type of relay that's less susceptible to causing hum. Of course, for homebuilt amps, there could be many hum-inducing problems.

# Excessive Hiss

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- noisy tubes
- Noisy plate resistors. The carbon composition resistors used on the plates of preamp tubes often go very noisy, especially in older Fenders. If swapping tubes does not fix the trouble, locate the circuit that seems noisiest by tube swapping, and then replace the plate resistors in that circuit with equal-value metal film or metal oxide resistors. You can use carbon comp if you can find them, but the problem is likely to recur.
- Noisy resistors in the B+ decoupling string, often around 10K in value
- Unusual: An ultrasonic oscillation can cause an intense insect-like hissing that sounds very much unlike normal hiss.
- Rare: leaky coupling capacitors or faulty controls
- Rare: a slight ongoing arc on the output tube socket(s)
- Rare: a bad solder joint somewhere in the signal chain
- Rare: internal arcing or noise in almost any part in the preamp section

A good way to divide and conquer is to turn the volume control(s). If the hiss changes levels as you do this, then the source of the hiss is something that affects the stages of the amp before the volume control. A faulty, hissing preamp tube will be turned up this way very quickly. Conversely, if the volume control does not affect the hiss, the cause is somewhere after the volume control. In general, the volume level of the hiss is an indicator of where the hiss is occuring - the louder the hiss, the more likely its source is near the input of the amp where the gain applied to it will be the greatest

The procedure of locating by removing one tube at at time working from the phase inverter/driver back towards the input until removing a tube no longer stops the hiss should then localize the problem to one tube's worth of circuitry.

# Popping Sounds

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Popping is almost always an arcing problem. The high voltage in the amp has found some path that cannot stand the high voltages and discharges suddenly through that path. The arc current is high, but cannot be sustained by the power supply, so the voltage drops a little, the arc extinguishes, and it takes some time for the power supply voltage to build back up to where the arc will start again.

Popping is often associated with the time when you flip the standby switch. In standby, the current drain from the power supply is less, so the voltage rises, causing more voltage stress. When the standby switch is thrown, the higher-than-normal voltage can break over things that stand the normal stress of operating voltage.

Tubes
: The tubes themselves will sometimes develop internal, intermittent arcs. Do some tube swapping. Start at the front (preamp) end of the amp and pull a tube, listen, pull a tube, listen. When you find one where pulling it makes the popping stop and a new tube makes it quit completely, you're done.

Arcing power tube socket
: The B+ may be arcing across the surfaces of the output tube sockets themselves. This is often the case when an amplifier has a lot of dust and dirt inside it. In some cases, the arc can be started by a few seconds of playing without a load on the amp, which causes large spikes on the plates of the output tubes. Contamination of the tube socket surface can let an arc get started, and the arc itself burns the surface of a plastic tube socket body. This leaves a carbon residue in the path of the arc, burned remains of the trail of the arc; the carbon residue is itself somewhat conductive, so in the future, there is a ready made path for the next arc. You have to replace the socket if this is the case.

Intermittent switch
: A switch, often the standby switch, can develop internal arcs

Intermittent breakdown of coupling cap or a popping resistor
: Sometimes a signal coupling capacitor just can't take it anymore, and it starts breaking down intermittently. Resistors, particularly those delightful, brown sound carbon composition ones, sometimes develop internal pops. Proceed as for tubes. In this case, a new replacement tube will NOT make the noise quit permanently, and you have to figure out which component is causing it.

Intermittent breakdown of output transformer or choke
: The filter choke, if your amp has one, and output transformer are connected to the highest voltages in the amp. If they are old (can you say "vintage"? I thought you could) and if they get hot, the insulation on the wires inside can start being intermittent. Internal shorts that clear will cause popping. Shorts that don't clear will pop a fuse, usually. Sometimes it'll just cause smoke.

broken resistor or capacitor or R/C lead/ wire

This is one where the problem is not caused from the B+ breaking down insulation. Mechanical damage can break a part and leave enough pressure on the pieces so it mostly makes contact and kind of functions. Vibration will cause it to open momentarily, causing a pop.

Heat from resistor or output tube melting solder

This is a fun one. Some of the power supply dropping resistors, output tube cathode biasing resistors or the connections on the output tube sockets themselves get so hot that they melt the solder that attaches the leads. Even more interesting is when they just soften it so it gets grainy and any vibration (speakers, anyone?) makes a cold, grainy solder joint. This bad joint can pop and arc, sputter, hiss, rectify AM radio, do lots of nead stuff. Once you find the bad joint, you'll also have to find out why it was so hot.

You can sometimes leave the amplifier turned on and turn out or dim the lights in your workroom, and see arcing happining. On pops that happen when the amplifier is touched or jarred, you can (gently, now) tap the chassis with a rubber hammer or wooden stick, being careful not to break anything or touch the amplifier with your hands as you do this. This often makes a mechanically-motivated arc happen, and you can see where it is, and deal with it when the lights are on. BE VERY CAREFUL NOT TO TOUCH THE INSIDES OF THE AMP IN THE DARK - THE HAZARDOUS VOLTAGES ARE JUST AS DANGEROUS IN THE DARK.

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Ugly sounding distortion can take several forms.

Harsh grainy sound

- Output tubes biased 'way too cold
- Rubbing or torn speaker cone
- Rarely, the amp can be oscillating ultrasonically and still get some sound through, with a harsh, ugly sound.

Sound cuts out or squawks on loud notes

- Failing coupling capacitor
- Failing plate resistor, cathode bypass cap, cathode resistor or grid resistor
- Intermittent ultrasonic oscillation

Muffled or constricted sound

- Failing preamp tube; find the offending section by tube swapping and see if a good tube fixes the problem
- Low signal tube bias is pushing it into saturation or cutoff. Measure operating voltages on the preamp tubes. The problem section will have tube pin voltages that are 'way off normal.
- Failing coupling capacitors from the preceeding stage.
- Failing plate resistor, cathode bypass capacitor, cathode resistor, or grid resistor
- Power supply problem; a dropping resistor may have drifted far from it's nominal value, changing the power supply voltage enough to cause this.

Faint out of tune sound on every note

Excessive power supply ripple, usually indicating that the power filter capacitors are going bad. This can also be caused by speaker cones and voice coils with problems so they just rub slightly, too.

# Low Power or Loss of Volume

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Faulty Preamp Tube

Faulty Power Tube(s)

Bad preamp cathode resistor

An unbypassed cathode resistor has drifted upwards (to 5K-10K or over)

Faulty phase inverter

If for some reason the phase inverter input side is good but the inverted side is bad, the power amp will still work, but power will be very low. This can be a bad 1/2 tube, a faulty socket contact, a broken or open plate resistor or coupling capacitor to the output tube, or a bad solder joint on any of these.

Open cathode bypass capacitors in preamp

if they go open, the stage they're in loses gain, but does not otherwise fail. If they short, it dramatically shifts the bias point, and may cause distortion as well as low volume.

Faulty vibrato circuit on neon/LDR vibrato Fenders

If there is a dummy plug in the footswitch hole, or a bad footswitch so the vibrato is always active, sometimes the vibrato tube turns on and stays on, not oscillating. This keeps the neon bulb on all the time, shunting lots of signal away. Same thing can happen if there is a shorted vibrato tube (rare) or a bit of wire or solder shorting the vibrato tube. Check the plate voltage on the vibrato tube to be sure it's oscillating.

High voltage isn't high enough for some reason

- Failing rectifier tube - try swapping in another one
- Failing power filter capacitors
- Failing or open series dropping resistor in the bypass networks leading to preamp stages
- Failing bypass capacitor - treat as in power filter caps.

Open screen resistors on power tubes

Amp cuts out or "goes dead" when the volume control is turned up higher than "X" or when you hit a specific note

You have a parasitic oscillation above hearing range. This can overheat an output transformer, and really needs to get fixed fast. It can often be fixed by tube swapping, but you often need an oscilloscope to see what's happening in the electronics.

# Smoke or Burning Smell

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There's good news and bad news. The good news is that it's easy to find the problem, at least the thing that is burning. Just unplug the amp, open up the chassis and look for what's burned, charred, or overheated looking. That's what's causing the smoke/smell.

The bad news is that in almost all cases, the part that is burning is a power handling component. These are ALL expensive. Worse, in some cases, the part that is burning is not what is causing the problem, and you still have to find what else is faulty.

In some ways, having smoke coming out of the amplifier is kind of a deviant, hard-headed version of having a fuse blow - something is eating too much power, it's just that the fuse for some reason is not blowing. This is especially suspect if the fuse blew, and you didn't have another of the right rating, so you stuck in a higher current rated fuse.

Possible causes are:

- Failing/shorted output tube - this can overheat the output transformer and/or power tranformer. More rarely, it can also overheat the choke, but usually the transformers go first.
- Improperly biased output tube.
- Failing bias supply on fixed bias amplifiers
- Failing cathode resistor bypass capacitor on cathode biased amps.
- Failing/shorted rectifier tube (or solid state diodes - they do fail, if rarely) can overload the power transformer as well as killing the power filter capacitors by letting AC through. A failing filter cap or shorted output tube can pull so much current that it overloads the rectifier tube, too.
- Failing power filter capacitor. These can sometimes get hot enough to literally explode or burn, as well as just quietly overloading the power supply and popping rectifiers and power transformers.
- Failing power transformer.
- Failing power filter capacitor
- Choke with a "soft" short between winding and core
- Failing output transformer

# Intermittent Problems

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Intermittent problems are some of the most frustrating ones to solve. The amp works fine until - something - happens, and then it acts up. Most of the effort in debugging this one is to make it act up so you can cause it to happen when you want, which will then in turn let you find the problem, and verify that you have really fixed it. Intermittents always mean that something is just at the very edge of failing and it takes the causing event to push it over. When the causing event or condition is not present, it works fine, or maybe will "reset" when the amp is turned off or cooled.

Notice carefully what makes the intermittent happen, if you can. Very common events that institute intermittent problems are:

- Mechanical vibration - it only happen when it's banged or shaken by being on top of speakers
- Heat (thermal stress) - something only edges over into failure when it gets hot
- Voltage stress, perhaps combined with heat

This one is probably only going to yield to the laundry list technique, so here goes:

- Failure only happens after a longish time of playing: this is most often thermal, as something fails when it gets hot enough. Good places to look:
    - Tube develops a problem when it gets really hot
    - Bad solder joint opens up when it gets hot enough
    - Resistor or capacitor goes bad when it's hot - these usually show signs of overheating to a visual inspection. Power tube screen resistors are a common place this happens.
    - Mechanically damaged part opens up under thermal stress. Broken resistor bodies can be held together by the lead's springiness and only open when they get hot. Capacitor leads may have the same problem, as can soldered wires and joints.
- Failure only happens when the amp is sitting on top of speakers
    - Bad solder joint or broken part
- Failure only happens when the amp is cold
    - Bad solder joint or broken part, or badly drifted resistor value.
- Failure only happens when the amp is taken off standby: Since the B+ voltage rises in standby, this often means that the higher voltage is preaking something over. This may take the form of the amp only coming on slowly after a delay when the switch is thrown, or of a squeal or pop after the switch is thrown, or ugly sounding distortion for a while until it "gets better"
    - Preamp decoupling capacitors
    - Signal coupling capacitors
    - Dirty, contaminated, or arcing tube sockets.

- Amp stutters or cuts out when driven really hard: overdrive is causing the output tubes to go into grid blocking after being over driven; this is caused by the signal causing a temporary bias shift.

Depending on how desperate you are, you might want to apply a shotgun technique: Methodically remelt **every single solder joint in the amp**, adding in a bit of rosin core solder as you do. A milder form of this would only remelt the ones in the circuits you suspect. This sounds horrible, but really doesn't take all that long. The worst part of doing this is that you never really find which one caused it, just that the problem quits.

I have a friend who repairs amps for a living and who said he once fixed an intermittent problem on a Fender where the amp was cutting out intermittently. He found that the wires to the output tube sockets had been put in the correct places but **never soldered!**

# Electrical Shocks from Amp

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If your amp gives you electrical shocks, you probably have leakage of AC voltage to the chassis, either accidentally or by design. Either way is dangerous.

Note that if your equipment is properly three wire grounded and working correctly, other equipment that is leaking may shock you when you touch both of them, leading you to think that your amp is the one that is leaking. You'll have to test both pieces to find out which one is leaky.

Your amplifier should have a three wire AC cord fitted for the AC power for safety reasons whether it originally had this or not. If your amplifier HAS a three wire cord and still shocks you, there is more than one fault in operation, possibly including mis-wiring of the building's AC power outlets - it does happen.

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**SAFETY WARNING**
If your amp is shocking you, you have to consider that the whole amplifier represents an electrical hazard to you, and might hurt or kill you under certain conditions. If you do not already know how to work on such faulty equipment safely, take the amplifier to a qualified service technician to fix.

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To determine whether your amp is actually leaking AC, use a multimeter set to a range that will read at or over 125VAC. Plug the amp in and turn it on. Measure the AC voltage between the ground ring on the input jack and a known AC ground point, such as the chassis of a piece of equipment which is properly three wire grounded. This voltage should be zero. If it is over a volt or two, either your amp has a leakage problem, which is why you're getting shocked, or the equipment you're using for a ground reference has a fault in it which leaves the chassis un-grounded (which is unlikely)

If the voltage you read is over 30VAC, you have enough leakage to be dangerous to your health.

## Finding the source of leaking AC

1. Unplug the amplifier. Turn the power switch on.
2. Measure the resistance of each flat prong on the AC cord plug to chassis ground. This resistance should be very high, but since you're getting shocked, probably isn't.

3. If the resistance is very high, over 1M ohm, you have either
    - an intermittent short from the power transformer primary which only happens when the AC is on
    - capacitive leakage though the "ground reverse" switch
    - a short between one of the secondary windings and ground or
    - an intermittent short from the AC wiring, fuse, or ground reverse capacitor which only happens when the AC is on
4. If the resistance is lower than 1M ohm, there is a leakage path in the primary circuit.
    - unsolder the power transformer primary leads and measure the resistance to chassis from each one. A low resistance means that there is a leakage path from primary to the transformer core, and it must be replaced.
    - If the transformer shows high resistance to chassis from all primary leads, measure the resistance to chassis from each AC plug prong. A low reading indicates that the leakage is in the wiring path.
    - Measure the resistance of the AC "ground reverse" capacitor if your amp has one. A low reading means it is bad and must be replaced.
    - If you get high readings on all these primary AC points, unsolder and measure the resistance to chassis in turn of the high voltage windings, then filament windings, and of the filament windings to each other and the high voltage windings. A reading under 1M ohm on any of these indicates a defective transformer.

Be certain that you re-solder any wires you removed during the debugging.

# Reverb Problems

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- No reverb
  - Input or output cable to the reverb pan not plugged in
  - Failing reverb drive tube
  - Failing reverb recovery tube
  - Bad reverb tank: measure the resistance between the center and outside conductors on the RCA jack on the reverb tank. It should be less than 2K ohms for all types of Hammond/ Accutronics tanks, at both input and output sides. ManyFender amps may have a resistance of only 2-4 ohms at the input side. This is normal. Other amps may have higher input resistances, from several hundred ohms up to a couple of K. If the resistance is high, the tank is bad. You can look inside the tank to see if one of the little wires have come loose from the RCA jack; some tanks can be saved this way. If the little coils at the ends of the springs are open, get a new tank. Sometimes the delay springs break. You're welcome to try to solder/putty/glue them back together, but don't expect too much from this.
  - Very faint or thin reverb
    This is caused by too little signal getting through the reverb path.Could be:
    - Failing drive or recovery tube
    - Failing component making one of these tubes be biased incorrectly.
  - Hum from reverb
    - Open ground/shield on reverb cable
    - Dirty/corroded RCA jack/plug on reverb cable
    - Broken ground wire inside reverb tank
  - Hiss from reverb
    - drive or recovery tube going noisy
    - Resistor going noisy in drive or recovery tube circuit
  - Distorted reverb sound; failing drive or recovery tube or failing component making one of these tubes biased improperly
  - Crackling or popping sound from reverb
  - Squealing noise from the reverb, affected by the reverb control
  - Scratchy reverb control

# Vibrato (Tremolo)

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## No Vibrato

- Vibrato tube going bad, either the oscillator section or the driver section; swap it and see.
- Neon/LDR module going bad (Some Fenders)
- Broken/open resistor, capacitor, or wiring
- Faulty speed or intensity control
- Faulty vibrato footswitch , jack, or wiring

## "Ticking" Vibrato

- Fiberboard contamination: Dust, dirt, and junk can let the LFO signal leak into the audio path. Vacuum the dust and dirt away, and if it still persists, remelt the wax top and bottom with a hair dryer.
- Solder blobs from eyelets touching insulating board: Sometimes excess solder drips out the bottom of an eyelet and can intermittetly contact the insulating board, can cause ticking. Remelt the eyelets and examine the board underneath for any blobs dripped down.
- Funny ground on some SF Fenders; On one of the signal tubes, the cathode cap was placed on the tube socket, and wired to a ground lug on the vibrato cancel jack instead of across the resistor on the fiberboard. The vibrato shares this ground line, and can the vibrato current can cause audible ticking in the audio path. Rewire the cap to another ground or relocate it to the board.
- Poor Signal wire layout: signal wires run too close to vibrato leads can pick up the LFO signal. Move them around and see if the ticking goes away.
- Bad repair/replacement foot switch cable: the Fender footswitch cable is not two conductor; it's single conductor shielded, plus single conductor. The reverb wire is shielded, vibrato wire is not. This keeps vibrato out of reverb. If you retrofit with two conductor shielded, you get vibrato ticking onto reverb audio.
- Sharp tick in vibrato oscillator: On neon/LDR Fenders, on the neon bulb side of the module there is a 10M to one side of bulb, 100K to the bulb; from the 10M straight across the board is the gnd point of the LDR. Put a 0.02 cap from 10M/bulb to the ground point; this works by filtering the output of the oscillator.

# Scratchy Controls

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Controls go scratchy because the sliding contact inside the control makes intermittent contact with the resistive element, and you hear a little "gritch" every time it makes or breaks contact. This can be caused by:

- Old, worn controls
- Dust and dirt inside the controls
- Poor quality controls with bits of the resistor coming off inside.

You can sometimes restore a control to non-scratchiness by spraying contact cleaner inside the pot and turning the shaft rapidly to clean the dirt and stuff off the resistive element; however, the problem is likely to recur. Getting a new pot is the best fix. If you decide to try the spray cleaner trick, use one that leaves a lubricant on the surface to lessen the wear and make it longer until you have to do this again.

Scratchiness is a thousand times worse if there is DC across the pot, so you might check for that. DC across any pot except the bias pots is usually an indication that a coupling capacitor is leaking, so check for that.

# AC Power Indicator Does Not Glow

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This indicates either that the power indicator is burned out (which does happen...) or that there is no AC power reaching the indicator, which is usually wired directly across the power transformer or wired to one of the filament windings of the power transformer. No AC reaching the indicator is more likely than a burned out indicator AND no sound, so the fault may be one of these:

- Fuse blown
- Open primary in the power transformer in those amplifiers where the power indicator is on a secondary
- Power cord open - test it with an ohmmeter
- Faulty AC power switch - with the amp unplugged, test it with an ohmmeter.
- Faulty wire or solder joint in the AC power path. Test from AC plug prong to prong with an ohmmeter.
- Silly stuff like power cord not plugged in

All of the major items may be isolated by using an ohmmeter and tracing out the AC path from prong to prong of the AC line cord. No live voltage tests are needed at this level.

It is also possible that the wall socket is not live. Plug some other AC powered unit into the socket and see if that unit works. If it doesn't, the AC power breaker may be open.

# Power Tube Shorted

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If the power tubes are relatively new or very old, or if the amp has been roughly handled when it was hot, a power tube may have an internal short. These shorts are rare in tubes past infant mortality and not yet worn out.

The whole trick here is to separate truly defective shorted output tubes from other flaws that will kill new, good tubes that you put into the amp.

Remove the power tubes, replace the fuse, and see if the fuse still blows when powered up with the power tubes out. If it still blows, the tubes are not your problem.

If the fuse does not blow with the power tubes out, check to see that the screen resistors are not open or burned, then, for fixed bias amps, ensure that there is an adequately negative voltage on the control grid socket contact with a voltmeter. In cathode biased amps, the grids will be held at ground, but for a fixed bias amp you should have -20 to -60 volts here, depending on what kind of output tubes the amp uses. In fixed bias amps, if you can't find a negative voltage on the control grid socket contact, YOU WILL PROBABLY KILL ANY NEW TUBE YOU STICK IN THERE. Check lost bias or incorrect bias to save killing a new pair of tubes, and if no trouble is found there, then suspect that the tube itself shorted.

Replace the output tubes with new ones, and place the amplifier chassis on a stable, uncluttered surface in a room you can darken. Be certain that you can turn the amp and room lights on and off without touching anything inside the amplifier for safety's sake. Turn the amp on and the room lights out, and watch the new output tubes like a hawk for signs of overheating. If the fuse does not blow again and there is no sign of red or orange glow other than the normal filament glow inside the power tubes after the amp heats up, the old tubes were the problem.

If you've had an output tube die, always be suspicious of a bad screen grid resistor and a bad input grid resistor; check the value and appearance of these every time you have a power tube fail. Particularly Fender's carbon comps go high resistance or cracked

Be sure to rebias for the new tubes.

If the fuse now blows again, or the new tubes glow red-orange on the plates, shut it down immediately and inspect all of the components and wiring around the tubes to find the problem that is keeping the tubes from being biased properly.

# Output Tube Biasing Problems

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Output tubes handle probably 85% of all the power used by your guitar amp. If they are biased incorrectly or if there is a fault in one of the biasing components, it can cause a number of power supply and output section problems. A failed biasing component that lets the grid assume the same voltage as the cathode will cause an output tube to act almost shorted. Tubes which are conducting too much bias current (older tube-techs would say these are "underbiased" or "biased too hot") can cause blowing fuses, excessive power supply ripple and 120Hz hum, burned out rectifier tubes and could in the long run kill an output transformer or power transformer. They overtax in general everything in the electrical path from the AC power plug to the output transformer.

You will need to know whether your amplifier is fixed bias or cathode biased. If you don't have a schematic make sure the amplifier is unplugged. Remove the output tubes and measure the resistance from the cathodes of the output tubes to chassis ground. If this is under 10 ohms, you have a fixed bias amp. If it is 50 ohms or more, you have an amplifier that is cathode biased. Between these two could be a flaw in the amplifier or could be one of the very rare amplifiers that use a combination of cathode and fixed bias.

There are relatively few causes of output tube bias problems. All of them involve the grid not being held at a negative enough voltage with respect to the cathode.

- In any amplifier:
  - If the output tubes have just been replaced with new ones, "infant mortality"/early dying of the new tubes.
  - Leaky/shorted coupling capacitor from the driver tube plate to the power tube grid. Note that the chances are that only one of the multiple output tubes will have this problem.
  - Dirty, corroded or just old tube socket not making good contact to the tube grid pin Note that the chances are that only one of the multiple output tubes will have this problem. Eagle-eye the socket hole contacts with a magnifier and try to see if they are corroded or dirty looking or maybe the contacts have lost their springiness, and don't make good contact. Try removing the tube, squirting a little tuner cleaner into each socket hole, then wriggling the tubes back in. You can also very gently pry the contacts out so they have more pressure on the tube's pins.
  - The socket could be broken.
  - Rarely, a very poor or inexpert rebiasing attempt by an unskilled technician.
  - Rarely, an output tube itself that is shorted grid to cathode Note that the chances are that only one of the multiple output tubes will have this problem.
  - Rarely, the resistance from the tube grid to its bias supply will be open. This can lead to "runaway" in power grid tubes. Measure the resistance from grid socket pin to bias supply

point in fixed bias amps or to ground in cathode biased amps and make sure that both (all) output tubes have the same nominal resistance - usually 100K to 220K, never more than 470K. If one grid has a lot higher resistance to ground or to the bias supply, there is a problem with the grid leak resistor on that tube.
    - Even more rarely, a wiring flaw in the wires getting the bias voltage to the grid. I have seen an amplifier that came from the factory with all of the wires inserted into the socket lugs and wrapped around the contacts, but not soldered. It worked that way for 20 years, and had intermittent troubles the whole time.
- In fixed bias amplifiers:
    - If the tubes have just been replaced with new ones, failure of the owner to get rebiasing done, or "infant mortality"/early dying of the new tubes.
    - Failure of the bias section of the power supply, especially the adjustment pot or the bias supply filter cap
- In cathode biased amplifiers:
    - If the output tubes have just been replaced with new ones, "infant mortality"/early dying of the new tubes.
    - Leaky/shorted cathode resistor bypass capacitor
    - Rarely, a noninductively wound cathode resistor with an internal short
    - Rarely, a broken or incorrect wire.

# Coupling Capacitor Problems

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The biasing of any tube stage depends on having the signal coupled into the grid of the tube at the proper DC level. A leaky coupling capacitor lets current through from the preceeding stage and upsets the DC bias, usually turning the tube on so hard that no signal can pass through it. A power tube with a leaky or shorted coupling capacitor may blow fuses cause low power or excess hum, or kill transformers. A preamp tube will just cause little or no signal to pass through or ugly-sounding distortion of the signal that does get through.

## Output Tubes

Output tubes biasing comes in two major flavors - cathode biasing and fixed biasing. Output tubes need a lower grid resistor than preamp tubes, usually 100K to 470K. The grid is tied through this resistance to either ground (in cathode biased amps) or a negative voltage supply (in fixed bias amps). If the capacitor that couples the AC signal to this grid is leaky or shorted, it conducts the DC from the plate of the preceding stage into the grid. This upsets the biasing and causes the tube to conduct 'way too much current.

In all cases, you must determine whether the coupling capacitor is leaky. A quick way to test the capacitor is to unplug the output tubes, connect the (-) lead of your multimeter to chassis ground, and use the (+) lead of your multimeter to measure the voltage on the socket contact that corresponds to the grid. You must know whether your amp is cathode biased, in which case the grid contact must be at zero volts, not positive at all.

If your amp is a fixed bias amp, the grid contact(s) in the socket(s) must be at a negative voltage, -15 to -60Vdc. If they are more positive than -15, you probably have a leaky coupling cap.

If either of these tests indicate a leaky or shorted coupling cap, open the chassis, determine the value of the suspected coupling capacitor, and replace it with another of the same or higher voltage and capacitance rating. Then button the amp back up and see if the voltage on the socket contact for the grid has changed.

It's best to make this substitution with a capacitor you don't mind leaving in if that was NOT the problem so you don't have to go back and pull it back out.

It is possible to unsolder the grid end of the coupling capacitor, turn the amp on and measure the DC voltage from the unconnected end of the capacitor to ground with an analog voltmeter. If you only have a Digital Multi Meter (DMM), connect a 1M ohm resistor from the free end of the capacitor to signal

ground, then measure the voltage across the resistor. If this voltage is even 1V, the capacitor should be replaced; the capacitor is leaky. This is a definitive test, but you do have to have the amp open and powered on, and so it is a more hazardous test.

## Preamp tubes

For all tubes except cathode follower stages and output tubes in guitar amps, this means that the grid of the tube is tied to ground through a high (over 470K, often 1M) resistor. Cathode follower stages have their grids tied either directly to the plate of the tube driving them or to a fixed positive voltage.

The tests for a leaky coupling cap in a preamp tube are the same as for power tubes, except that you have to know which tubes may be direct coupled cathode followers. A direct coupled cathode follower stage will have it's grid tied directly to the plate of the driver tube ahead of it, no coupling capacitor at all. This is only the case for some older Fender Bassman models and a number of Marshalls. If you find a tube socket with a high (could be 100V or more!) positive voltage on it's grid contact, unplug and open the amp, and drain the B+ capacitors. Then look at the grid circuit in question. If there is a capacitor between it and it's driving circuit, the coupling capacitor is bad. If it is connected by either a wire or a resistor to the driving circuit, it is direct coupled and the high grid voltage is not a defect.

For all stages that are not cathode followers, the voltage on the socket pin for the grid should be dead zero, not positive even a fraction of a volt.

Replace coupling capacitors with at least 600v rated capacitors regardless of their original ratings unless you simply can't get such caps.

If neither of these fixes the problem or materially changes the symptoms, back up a step and make another guess.

# Preamp Tubes Problems

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This topic is still under construction.

If you suspect that a preamp tube is going or has already gone bad, the most expeditious way to find it is to have a new, known good spare tube to swap in until you find the problem. Just swap in the new, good one and see if the problem is corrected. If you put a new known good one in, and the problem does not change, then the tube you replaced was not the problem - or at least not THAT problem.

Easter-egging (hey! I wonder why they call it that...) with a good tube is the highest likelihood practice to hit a fix quickly.

"OK," I can hear you saying, "but I don't have a spare preamp tube!" Shame on you. All right, maybe there's something we can do. There are usually several preamp tubes of the same kind inside most amps. Try swapping a pair of them, noting which tube is which so you don't lose track of which one you suspect. It should be vanishingly rare for TWO preamp tubes to go bad at once. You'll usually be able to tell if the problem moves around when you move one particular tube, or if it stays the same no matter what you do. If it stays the same, you don't have a tube problem, you have trouble with the circuits around a tube.

# Power Supply Filter Capacitor Problems

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There are a limited number of ways for the power supply filter capacitors to be bad. All of the tests on power filter capacitors must be considered hazardous since they may store deadly amounts of voltage and charge even with the amplifier unplugged.

Any time you suspect power filter capacitors, do the following: With the amplifier unplugged and the chassis open, connect one end of a clip lead to the metallic chassis. Clip the other end of the lead to a 10K 1/2W or larger resistor. Holding the resistor with an insulating piece of material, touch the free end of the resistor to each section of the power filter capacitors for at least 30 seconds. Then:

- Visually inspect the capacitor(s) for any signs of bulging, leaking, dents and other mechanical damage. If you have any of these, replace the capacitor. Also note the condition of any series dropping resistors connected to the capacitors to see if they have been damaged by heat. Replace them if they have.
- Use an ohmmeter to measure the resistance from the (+) terminal of each capacitor to the (-). This should be over 15K ohms, preferably much over that. If you get less than that on any capacitor, unsolder that capacitor and remeasure just the capacitor. Under 15K indicates a dead or dying capacitor; replace it. If the resistance is now much higher with the cap unsoldered, there is a low resistance load pulling current, not a faulty capacitor. Always check all of the power filter capacitors while you're in there. If one is bad, consider replacing them all (see "Cap Job" in the Tube Amp FAQ)
- If there is no obvious mechanical problem and the resistance seems high enough, temporarily solder a new, known good capacitor of at least as high a capacitance and voltage across the suspected capacitor or section., then plug in and try the amplifier again. If this fixes the problem, turn the amplifier off, unplug it, drain the filter capacitors again, and replace at least the bad section if not all of the filter capacitors.

If you are replacing a multisection can, get a replacement can with multiple sections matching the original before you remove the original capacitor. Once you get it, make yourself a note of the symbol on each terminal of the old capacitor, such as square=1uF/450V, triangle=20uF 450V, etc. and then clip the old terminal with the symbol off the old can. Remove the old can, mount the new one, and use the symbol chart and lugs still on the leads to make sure you connect the right sections up in the new capactor.