

More musical instrument amps and other MI equipment

By Ron C. Johnson

Those of you who have been around the service business for a while are probably not surprised that tubes are still used extensively in guitar amps. And you've probably seen your share of tube circuits from the "old days" of television. On the other hand, some of you younger guys may find the idea pretty archaic. But, really, we're still using vacuum tubes as CRT's in televisions and monitors, so we're not all that far removed from the days of vacuum tubes.

Serviceing vacuum-tube amplifiers

As I mentioned in a previous article, many guitar amps still use tube circuits because musicians like the sound they get out of them. Solid state amps just seem to be too clean. Not enough texture, some would say. Whatever the reason, if you find yourself repairing musical instrument electronics you're going to run into tube amps.

Normally, the first thing I would say about tube amps is to be careful. Four hundred volt power supplies require some care and attention to avoid a shock. But anyone who works on televisions on a regular basis should already be aware of the danger of high voltage. Just the same, don't let your guard down just because you're working on an amplifier instead of a TV. The results of an electrical shock can run from mild discomfort all the way to electrocution and the dangers of secondary injuries can be just as serious.

A typical tube amp

The circuit shown in Figure 1 is a typical low power bass guitar amp made by Fender. This one only uses four tubes: two 7025's (dual triodes) and two 6V6GTA's (pentodes). Both of these are very common (or at least used to be when tubes were in general use). The 7025 is used as a signal amplifier and the 6V6's are power outputs. For those of you unfamiliar with

tube circuits, a few quick points follow.

Vacuum tubes work on the basis that, if you apply a potential between two metal electrodes in a vacuum, and then provide a source of free electrons (by the heating one of the electrodes), electrons will flow through the vacuum from the negative (heated) electrode to the positive.

The positive electrode is called the anode (or plate) and the negative electrode is called the cathode. The heater, or filament, is under or inside the cathode. It heats the cathode, releasing electrons which are attracted to the plate.

The vacuum-tube diode

A tube with two electrodes constitutes a diode. If the plate is positive and cathode negative, and there is a closed circuit between the two, external to the tube, current will flow. Within the tube, this current will be from positive to negative if you use conventional current flow, or vice versa if you use electron flow.

I personally use conventional current flow although some still prefer the other. If the voltage is applied in the opposite polarity no current flows. Because the current flows if the voltage is applied in one direction, but doesn't flow when the voltage is in the opposite direction, the vacuum-tube diode is a rectifier.

For amplification, vacuum tubes add at least one more electrode, (called a grid), between the anode and cathode. By applying a voltage to the grid, the current flow from anode to cathode can be controlled. If you're familiar with FET's you can easily catch on to tubes. A voltage on the gate (grid) controls the current flow (transconductance) of the device from drain (anode) to source (cathode).

The triode as amplifier

The circuit in Figure 1 shows the input signal applied to the grid of V 1 A, the first half of the first 7025 tube. We won't get into how to determine gain of the amp but the schematic conveniently tells us that with 3.5mV of signal in, there should be

195mV on the plate of the tube. The signal is inverted because, as the plate current is modulated, the voltage drop across the 100K plate resistor varies.

The output is capacitively coupled, with a relatively simple treble/mid/bass filter section and volume control before the next gain stage. Again, typical signal voltages are shown on this schematic. Notice that the grids of both stages are switched to ground through the input jack when nothing is plugged into the amp. This keeps noise from being amplified.

The output signal of the second stage is capacitively coupled to a difference amp made up of the two halves of V2. Although it may not look like it at first, this amp is very similar to the difference amp shown in a previous amplifier article. The signal is fed to the grid of V2A while the feedback signal is fed to the grid of V2B. Both cathodes are tied together and their common current flows (eventually) to ground.

The effect of negative feedback

If the cathode current of one side increases, the voltage of the other cathode increases as well. This decreases the potential from anode to cathode which reduces the current through that half of the tube. Decreased current means decreased voltage. It amounts to negative feedback. That's how the feedback voltage from the output can reduce the overall gain of the circuit.

Negative feedback also minimizes distortion and noise in the output stage. Assuming the input signal to the stage is clean, any distortion (or noise) which is added by the output stage is fed back to the input, out of phase. Since the distortion part of the signal is only found in the feedback, it is amplified (out of phase with the distortion added in the stage) and this subtracts out, leaving a clean output.

Push-pull output

The output stage is a push-pull configuration: one side drives the output on the

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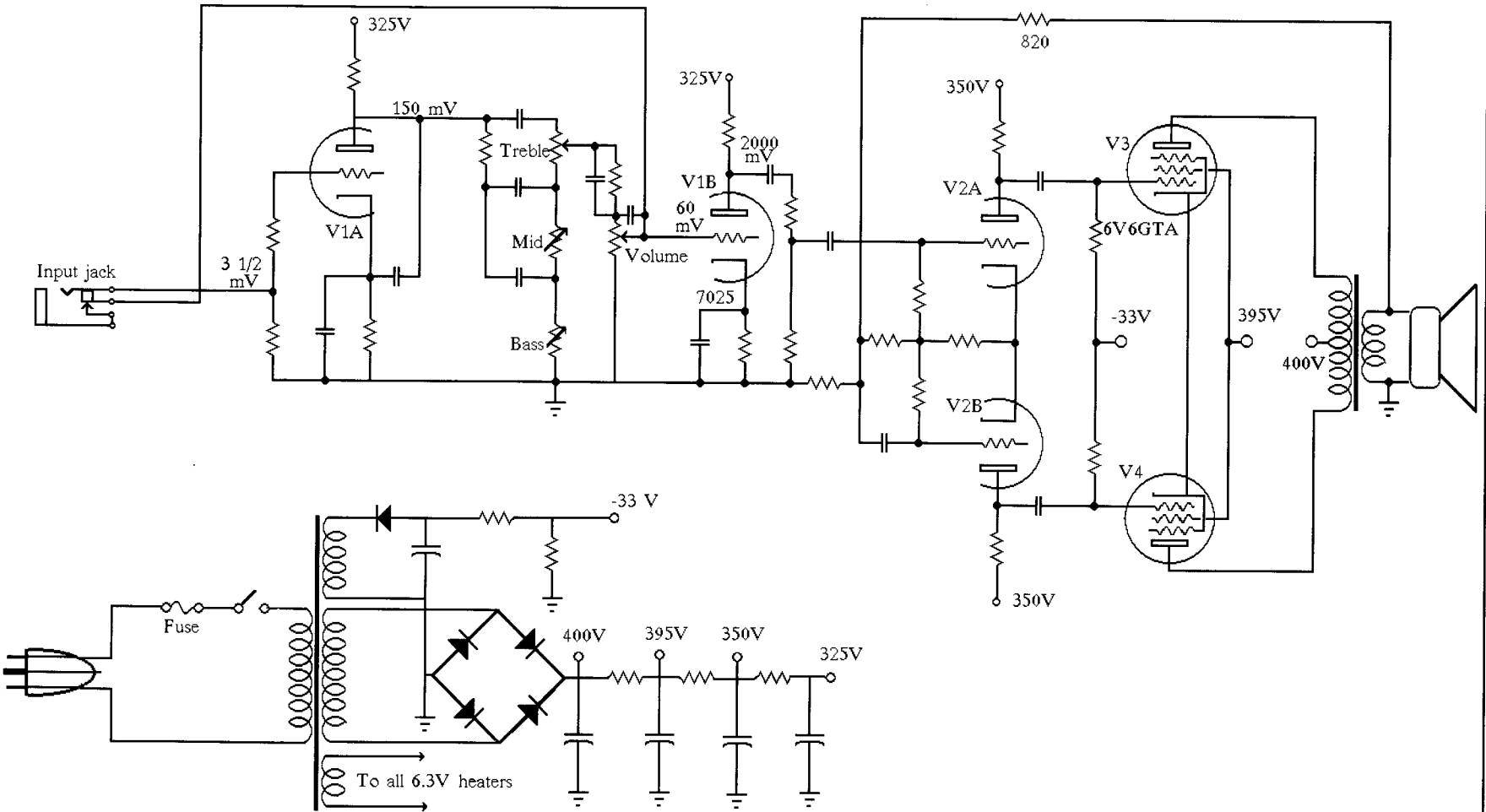


Figure 1. This is a schematic diagram of the circuit of a typical low power bass guitar amp made by Fender. This one only uses four tubes: two 7025's (dual triodes) and two 6V6GTA's (pentodes).

positive excursion of the signal while the other side takes care of the negative excursion. Notice the additional -33V power supply which sets a bias on the grids of each output tube.

The 6V6 pentode is a power tube. Its extra internal grids give it better drive capacity without the capacitive and grid limitations of the smaller tubes. In this case the 400V power supply is connected to the center tap of the output transformer. On each signal excursion current flows in alternate directions through the input windings inducing a current in the output windings which are connected to the speaker.

The transformer not only allows this bias arrangement but it matches the high impedance tube output circuit to the low impedance speaker load. The feedback signal is obtained from the output side of the transformer and sent back to the input of the difference amp to control the gain.

Servicing

Tube circuits are actually pretty easy to troubleshoot. There are two dc power supplies here: the 400V main supply and the -33V bias supply. The 400V supply uses a full wave bridge while the negative supply uses a single diode for half-wave rectification. Each has its own transformer winding.

Watch for bad power supply caps which will cause large levels of ripple on the supply rails. Also, make sure the tube filament voltage is present. This 6.3Vac is provided by a separate output winding on the power supply transformer and is connected to each tube.

Tubes, of course, can fail. They tend to be somewhat fragile, especially in an amp that is hauled around to gigs. Sometimes the internals come loose and the tube goes "microphonic". Even though it amplifies, the slightest vibration will be amplified as well. In extreme cases the vibrations from the speaker itself will feed back causing the amp to howl.

The positive aspect of tubes is that they are easily replaced and can be tested if you have a tester available. I wouldn't trust a tube tester too far though.

Signal tracing

Signal tracing through a circuit like this is fairly easy as well. You need to know which pin is which on the tubes. I have an old GE tube manual which lists most

of the common tubes, their specs and pinouts. Schematics like this one give typical signal levels which is helpful. Watch out for open capacitors, shorted or open rectifiers in the power supply, and dirty, intermittent potentiometers in the volume and tone control circuits. Also look for signs of abuse. It's fairly common to find dried residue of beer and soft drinks inside the chassis.

The newer tube amplifiers have tube sockets mounted on printed circuit boards. The older ones still have point to point wiring between sockets. These can be a nightmare to troubleshoot and worse when you're soldering or desoldering components. Usually, the easiest way to remove a component is to cut it out and then remove the solder and the ends of the component leads.

Well, that's a pretty sketchy overview of a typical tube amp but hopefully it will help somebody to feel more comfortable tackling one for the first time.

Mixing boards and effects

Sound mixing boards are another kind of musical instrument equipment that you'll see quite often probably because they receive a fair amount of use and abuse. They run from small four channel microphone mixers to large road consoles with 32 or more input channels, monitor and effects mixes, and several submixes.

The features on these are limitless. Some have built in "phantom power" (a technique of simplexing dc power out to condenser microphones), clipping indicators, LED bargraphs, solo and cue switching, and so on. Ultimately, they all do basically the same thing. They take audio signals and route them to various outputs while controlling their levels.

One of the common problems with mixers is dirty or damaged potentiometers. Each channel has a volume "fader" or linear potentiometer which adjusts the main output level of that channel. Each channel will have several other rotary potentiometers which adjust equalization (tone) in several ranges, signal level to monitor and effects busses, input signal trim controls (to avoid overdriving the input circuitry), and other controls depending on the complexity of the board.

Cleaning noisy controls

Inevitably you'll have to clean up noisy potentiometers using spray cleaners. I

recommend you find the best kind available and use it liberally. Unfortunately, these pots wear out and eventually cleaning them won't help. You'll have to replace them. Also I've only had limited success trying to clean linear faders. These have to operate smoothly and can't create any noise.

Usually trying to clean faders results in a quiet but sticky action which the customer won't accept. Keep a good stock of replacement faders for the brand of mixer you repair. They are expensive but necessary to do the job right. You'll also find that, often, these faders can only be obtained from the manufacturer of the equipment as they have been specifically manufactured for that product.

Locating noisy components

Another common problem with mixers is noise generated somewhere on the board. This can be caused by bad filter caps in the power supply, leaky signal caps or leaky transistors or op amps. The frustrating part of troubleshooting these problems is in trying to find the source of the problem.

A heat gun and some freeze spray can be handy here as some noise problems are caused by thermal defects in components. Warm up the suspected area (not too hot) and then spray individual components. Sometimes this will show up a bad one. Dirty connections and cracked circuit boards are common sources of problems here as well. Just moving the equipment around, or flexing the printed circuit board, will show up some problems.

Although the newer (and more expensive) mixers are being engineered for easier servicing, you'll find half the job on some repairs is just getting the thing open. Besides removing lots of screws you often have to remove all the knobs and nuts from the potentiometers before you can get to the solder side of the printed circuit board. For one particular brand and model I used to have a special, home-made "puller" just to get the knobs off without damaging the mixer.

Finally, don't always believe what the customer tells you about a mixer. Mixers are complex pieces of equipment and sometimes the problems are caused by the operators themselves. So insist that the customer gives a detailed explanation of the problem and then check it carefully yourself before tearing the board apart to start testing. ■