Build the "Real McTube II"

Overdrive/Distortion Tube "Stomp-box"

"The Real McTube" is a simple self-contained, one-tube circuit intended as an overdrive/distortion preamplifier. It makes use of the vacuum tube's relatively soft clipping characteristics to provide a fuzz-tone or overdrive sound with a warmer quality than afforded by most such solid-state devices. A dual triode is operated near the bottom of its characteristic curves to take advantage of the unique distortion of which such tubes are capable.

The project is intended for use with musical instruments, such as guitars and basses, to take advantage of the vacuum tube's distortion characteristics; as such it is not suitable for reproduction applications. If you're after high fidelity, consider my "quasi op-amp" preamp design instead.

The project is best assembled inside a closed case, stomp-box style, for ruggedness. However, there is no reason why you couldn't assemble it into other packages (even bread-board style). This is an ideal project if you have at least some electronics experience, but wish to break into the fascinating world of the thermionic vacuum tube.

History

of the "Real McTube" circuit

This project was originally published in *Electronics Now*, February 1999, based on a submission in 1997 of a circuit I put together in 1993. Since then, several individuals have made suggestions for expanding the text portion of the article, so here is an updated (Jan. 2001) version of this classic and useful design.

Back-issues of the Feb. 1999 issue of *Electronics Now* are still available from www.gernsback.com, should you wish to look over the original design. The schematic is also shown in Appendix I, for reference purposes.

A re-drawn version of the schematic (using European-style symbols) is available as a PDF file from www.soundcorecords.com/ ax84/media/ax84_m152.pdf.

A scanned copy of the original article (in jpeg format) is, as of this writing, still available members.xoom.com/aronnelson/mctube/.

THE REAL McTUBE

FRED NACHBAUR

Give your music a real "retro" sound with this vacuum-tube based preamplifier.

With the phenomenon of the "retro" movement in music electronics, there has been renewed interest in the vacuum tube. Several manufacturers are again building tube ampli-

Internet. Some of these are STF Electronics, 171 Springlake Dr, Spartanburg, SC 29302. Tel: 864-573-6677; SND Tube Sales, 5389 Ville Rosa La, Hazelwook, MO, Tel: 314-770-0119; Tube World, Inc., 2717 Superior

The first page of the original "The Real McTube" article

Features:

- High internal gain; A_V = 2400 max. (over 65 dB)
- 10:1 attenuator at output (-20 dB)
- 2-stage design
- Independent gain control at output of each stage
- Simple, low-cost power supply
  (using parts from two 12V "wall-warts")
- Very low B+ current demand (under 500 µA total)
- Low hum and noise
  (< 5mV. at max. gain; equivalent input < 2µV)
- Designed for 12AX7, but usable with any similar twin triodes
- Integrated bypass switch
- Readily customisable by changing component values to suit

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Article Index:

Contact

You may contact me regarding this project at fredn@netidea.com. I'd be happy to hear from you, and any bug reports or suggestions for improvement are always welcome.

Tube Designs by Fred Nachbaur
Precision Vacuum Tube Applications
The "Real McTube" II
Thermionic Overdrive Unit

Written Sept. 1997
Rev 1.1 Jan. 2001

THE REAL McTUBE

by Fred Nachbaur, Dogstar Music ©1997, 2001

1: INTRODUCTION

With the phenomenon of the "retro" movement in music electronics, there has been renewed interest in the vacuum tube. Several manufacturers are again building tube amplifiers and other devices, with claims of "vintage sound" and "warm tube distortion." Here's your opportunity to experiment with these interesting devices by building a tube pre-amplifier and distortion unit.

The differences between "The Real McTube II" and the original design are:

- The power supply has been modified to use the parts inside inexpensive and commonly available 12-volt, 500 mA. "wall-wart" DC power supplies. You will need two of these.
- Some users reportedly had trouble with excessive hum. This possibility has been greatly reduced by using DC for the tube filaments.
- The relay circuit for switching modes via an external foot-pedal switch has been replaced by an on-board push-on / push-off button switch, simplifying the circuitry and making the unit a self-contained "Stomp-Box".
- This construction article has been re-written and expanded, especially as regards to techniques for noise- and hum-avoidance. The topic of proper grounding has been covered in greater detail.

Cost will depend on how many parts you already have in your junk box, but it shouldn't exceed about $50 if you shop carefully. The crucial part, of course, is the 12AX7 or 12AX7A vacuum tube (and the 9-pin miniature tube socket to go with it). These are again quite commonly available, both from online sources and from many electronics jobbers. If you get stuck, call around to musical instrument repair shops that specialize in vacuum tube gear, but don't let anyone give you the "expensive because they're rare" line.

The classic 12AX7 was used in a wide range of vintage tube gear, mainly because of its relatively high gain and reasonable linearity. As tubes go, it is relatively quiet; notwithstanding the high degree of thermal noise inherent in all vacuum tubes, the 12AX7 (especially its European equivalent the ECC83) is at least mechanically constructed to minimize "microphonics," noise caused by mechanical vibration of its internal elements.

If you intend to experiment with different tubes to get "just that sound" also keep an eye out for type 12AU7 and 12AT7 (and their European cousins ECC82 and ECC81), as well as 12AY7 and 12AZ7. The 12AT7 and 12AZ7 will give comparable gain, but their clipping characteristics are a little different. The 12AU7 will give considerably less gain, and will therefore only be generally useful if the overdrive unit is placed later in your effects chain.

The "Tube Sound"

So what is it about tubes that make them sound different from solid state devices like transistors? There is really nothing mystical to this; in reality, their unique sound derives more from their shortcomings than from any other consideration. Being hot, bulky and expensive, manufacturers couldn't afford to make amplifiers with massive gain, which would have allowed them to use large amounts of negative feedback to linearize their response and reduce distortion. The exception was for applications such as studio monitors and similar high-end equipment. You only have to listen to such tube classics as Dave Brubeck's "Take Five" or Heart's "Dreamboat Annie" albums to hear for yourself that tube equipment can sound anywhere as good as, if not better than, top-end solid-state gear. (If you're interested in building a "middle-end" high-fidelity amplifier, check out my surprisingly simple yet capable RA-100 Reference Amplifer design.)

For musical instrument amplifiers, however, the inherent non-linearity and high degree of even-harmonic distortion of the "raw" tube amplifier (little or no negative feedback) contributes to the charm of its sound. "Warm" and "gutsy" are but two of the many adjectives used to describe the tube "sound."

This harmonic distortion is especially pronounced when a tube is overdriven. Unlike a transistor, which remains reasonably linear until it reaches cutoff (no current through the device) or saturation (maximum current through the device), a tube will exhibit a softer, more gradual bottoming-out at either extreme. This is especially pronounced at the saturation end, i.e. as the voltage across the tube approaches zero. There is no sharp saturation "knee", and any attempt to define the point at which a tube reaches saturation is strictly arbitrary.

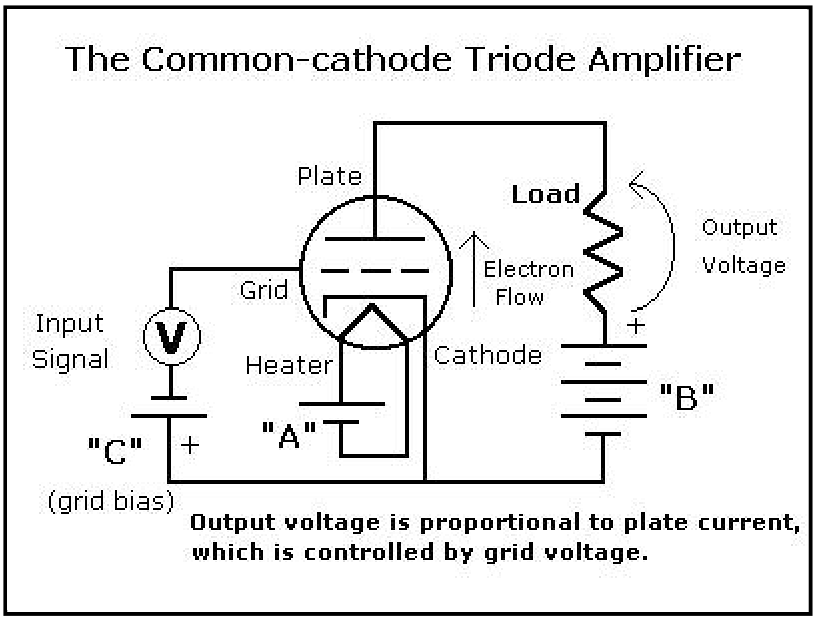
There are wide variances in these characteristics between tubes of a given family, and even between specimens of a given type. What's more, a tube's characteristics change as the tube ages. This can be a real nightmare if you're trying to design consistent, predictable gear using tubes. However, these factors all add up to the mystique of the vacuum tube for musicians and experimenters. I've known musicians who treasure old, worn-out, gassy 12AX7's because of the particularly dirty distortion of which they're capable.

The 12AX7 is but one of a whole family of dual triodes. Other devices in the family are the 12AT7, 12AU7, 12AY7, 12AZ7, (along with improved versions, indicated with an "A" suffix) along with numerous European equivalents. The filament (heater) requirements are all the same; either 12.6 volts (at around 150 milliamps) as suggested by the first two digits of the type numbers, or 6.3 volts (at 300 milliamps) depending on how the two filaments are connected. Another boon is that the pinouts for all of them are identical; going clockwise from pin 1, they all go Plate, Grid, Cathode (triode 1), Filament, Filament, Plate, Grid Cathode (triode 2), Filament centre. The circuit presented here will work with any of the tubes in this family, giving you the opportunity to experiment with different types to get the exact sound you're looking for.

2: BASIC TUBE THEORY

Vacuum tubes (or "valves", to use the more functionally descriptive British term) are "active" devices (as opposed to passive devices like resistors and capacitors) which, until the advent of solid-state devices, were the only viable means for constructing virtually everything electronic: from simple rectifiers, to amplifiers and oscillators, even logic circuitry. In principle, at least, anything that can be done with solid-state devices could be done using tubes. In practise, however, their size, power requirements, and speed limitations would make many of the devices we now take for granted (such as the computer on which you're viewing this document) impossible. Nonetheless, they still have an honoured place in today's world, as this project will hopefully demonstrate.

Probably the most important member of the family of vacuum devices we refer to as "tubes" is the vacuum triode. This is the simplest vacuum device that is capable of amplification; i.e. providing an output signal greater than, and roughly proportional to, an applied input signal. In this respect it is functionally analogous to the ubiquitous transistor.



Unlike transistors, however, tubes require at least two power supplies. Before the advent of universal home power, most electronic gear was operated on batteries. One battery (called the "A" battery) was needed for the low voltage, relatively high current supply to heat the tube's filament. Another (the "B" battery) was the high voltage, low current battery used to power the tube's plate circuit. This anachronism has persisted to this day; if you ever wondered why you hear of devices connected to "B+", now you know. In the early days, there was even a "C" battery, used to provide the negative grid bias for some circuits. This didn't persist for very long except in special radio applications because the negative grid bias can usually be obtained by using a cathode resistor, as in our circuit, or by other means.

Vacuum triodes are roughly analagous to field effect transistors (FETs). The "cathode" is analogous to the source, the "grid" to the gate, and the "plate" to the drain. Like FET's, tubes have a near-infinite input impedance, and a high output impedance. The most widely-used tube configuration (common cathode) is quite similar to the common-source FET amplifier configuration. But there the similarity ends.

Physically, a tube operates by heating the "cathode", one of the electrodes inside the vacuumized envelope. This causes electrons in the cathode to attain enough velocity to leave the surface, forming a "space charge" around the cathode. The positively-charged "plate" (also sometimes called "anode"), usually surrounding and concentric with the cathode, attracts this space charge, causing an electron current to flow through the space between the cathode and plate. If the plate is negatively charged, the space charge is repelled and no current flows; this is how the vacuum diode works. Such vacuum diodes were once almost universally used as rectifiers in power supplies, detectors in radio circuits, and similar applications.

In what's called a vacuum triode, there is another electrode called the "grid", placed between the cathode and the plate, consisting of a spiral screen of fine wire. The grid is normally biased negatively, so that it does not act as a secondary plate and draw current. Small changes in voltage on the grid cause significantly greater changes in electron current through the tube from cathode to plate, resulting in amplification.

As the tube was developed, additional grids were added to form first the "tetrode", which has a second grid (at a positive potential) to act as an intermediate "plate", resulting in a more constant-current characteristic. The problem with tetrodes is that the relatively high electron velocities caused "secondary emission" caused by electrons being bounced off the plate. The "pentode" overcame this by adding another grid (at a low potential) between screen and plate. The culmination of multi-grid mania was the "heptode", which is not a cool frog but rather a five-grid device once used extensively as the oscillator/mixer in home radio receivers.

When dealing with vacuum tubes, it can make sense to consider current flowing from the negative terminal to the positive terminal of the "B" supply, because that's what physically happens. This is called the "electron current" convention, and was what was taught in most technologist courses up until a couple decades ago. The problem with this convention is that the algebraic signs end up backwards in circuit design and analysis, so engineering courses thankfully used the opposite convention (called "conventional current flow") in which current is assumed to flow from positive to negative. This has the advantage in semiconductor circuits of making the arrows in diode and transistor symbols point in the right direction. When dealing with tubes, however, which convention you use is strictly a matter of personal preference.

Finally, I should point out that unlike transistors, tubes come in only one polarity because we only have one type of charge carrier - electrons. Unlike the solid state, no one has yet figured out how to make holes in a vacuum. I suppose it's theoretically possible to make tubes out of anti-matter to get "PNP" tubes, but storage and interfacing could be a bit of a headache. ;-)

3: HOW IT WORKS

(Refer to schematic provided separately)

120 volt AC power is applied via power on-off switch S1 to the primary of transformer T1 and "power on" indicator I1, a neon lamp with built-in series resistor. T1 is scrounged out of an inexpensive 12-volt, 500 milliamp "wall-wart" DC power supply.

The (nominal) 12 volt AC output of T1 is rectified by a full-wave bridge rectifier (D5-D8), which can be individual diodes salvaged from the same "wall-wart" supply, or if you prefer you can use an encapsulated button-style full wave bridge assembly. The resulting 120Hz pulsating DC is then filtered by the network consisting of C3, R2 and C4. The drop across R2 also reduces the filtered DC voltage to about 13 volts, to supply 150 milliamps of relatively clean DC power for the tube's heater. This results in a significant reduction of AC hum as compared to the original "Real McTube", which used AC to directly heat the tube's filaments.

The 12 volt AC output from T1 is also coupled into an identical transformer T2, wired "backwards."

This steps the voltage back up to about 110 VAC for our plate supply. DO NOT omit this transformer! Although the circuit will work if you derive the 120 VAC directly from the line, you could seriously injure or even kill yourself or somebody else. (If that's not enough disincentive from isolating your B+ supply, you can also ruin the gear to which an unisolated piece of equipment is attached!) Diodes D1-4 full-wave rectify our B+ voltage. As is the case with D5-D8, these can either be four discrete 1N4004 diodes, or a 400V 1A button-style full-wave bridge module. (Note that in this case it's not usually possible to use the diodes from the "wall-wart", as they're usually 1N4001 or 1N4002 units, not capable of withstanding the higher AC voltage.) Capacitor C1 filters the resulting pulsating DC, and the network composed of R1 and C2 add a pole of low-pass filtration to reduce ripple. The end result is about 140 volts DC under load to power the plate circuits of our preamplifier.

The input signal from J1 is coupled to the grid of the first stage via capacitor C5. Input resistor R3 acts as a "grid-leak" to prevent any electrons accumulated on the grid from piling up on C5; the resulting negative voltage would eventually cause our tube to approach cut-off. The value was chosen to be high enough to not cause any significant loading on the input signal, while being low enough to assure that the grid is "biased" very near to ground potential.

R4 is our plate load resistor. The varying plate current flowing through this resistor causes a voltage drop proportional to the change in current. R4 therefore plays a major part in defining the voltage gain of our amplifier stage. Experiment! (Suggestion; to prevent possible damage to the tube and/or power supply, don't go lower than about 22K for R4 or R6.)

The plate current also flows through cathode resistor R5, causing a much smaller voltage drop across it. The result is that the cathode is slightly positive with respect to ground, and since the grid is approximately at ground potential, it follows that the grid will be negative with respect to the cathode. This is how we get the necessary negative grid bias, obviating the need for a third power supply. This scheme also helps to stabilise the circuit against changes in line voltage, tube aging, etc. by adding a bit of DC feedback. For instance, if line voltage drops, causing a decrease in plate current, the bias voltage will decrease also, tending to buck the decrease in plate current.

Capacitor C7 "shorts out" any signal component, eliminating the negative feedback (for AC) that would otherwise result. This has two major effects: first, it maximizes voltage gain, making it easier to achieve overdrive. Secondly, it eliminates any reduction in non-linearity distortion which would defeat our purpose in getting "that tube sound." Again, experiment. Remove C7 - you'll have less gain, but see how much cleaner the tube sounds? Short the cathode directly to ground - see how much dirtier the sound gets as the grid is driven into conduction?

The signal output at the plate of the first stage is coupled into a similar stage by capacitor C6 and GAIN control RV1. The component values in the two stages were chosen more or less experimentally to suit my own tastes. I suggest that you use these values as a starting point, and ... again ... experiment.

The output of the second stage is routed through an attenuator consisting of R8, R9 and "OUTPUT" control RV2. The accumulated gain after the second stage is so high that the absence of an attenuator would make it ridiculously difficult, if not impossible, to adjust the controls for varying degrees of overdrive, let alone balance the overdrive signal with the unmodified signal when in "bypass" mode. The wiper of RV2 is the output of our circuit, which passes via the contacts of bypass switch SW-2a to output jack J2. The other pole of the switch (SW2-b) is used to light LED1 to indicate that the overdrive / distortion mode is enabled. When SW-2 is in the other position, the output jack is connected directly to the input, effectively bypassing the entire circuit. (The 1 megohm of loading by resistor R3 will be negligible, and the net effect is as if the circuit isn't there at all.)

4: BUILDING THE REAL McTUBE II

The original "Real McTube" was built into a 4 x 6-1/4 x 2" plastic "minibox" with an aluminum lid for the controls, because I wanted a unit that was as small and portable as possible. Admittedly, the layout was a little tight. So for the second incarnation, I used a 6 x 5 x 1.5" aluminum box salvaged from an old telephone relay unit. While the overall volume is about the same, the geometry made for a less cramped assembly. As in the original, the tube socket was mounted on an L-shaped metal sub-chassis about 2x2". Biasing and coupling components were soldered between the socket and conventional phenolic terminal strips. The terminal strips and tube sockets were secured to the chassis using small bolts and nuts.

Unlike the original version, all components were mounted onto the top case-half, which eliminated wires between the two halves, making assembly and testing a lot easier. The photo shows the finished project, and can be used as a guide in your own implementation.

You may prefer to leave yourself a bit more space for experimenting, in which case I suggest a larger box. With a single 12AX7, heat is not a big consideration so you don't have to worry about ventilation. Orientation of the tube doesn't matter either; the 12A?7 family can operate in any orientation (not necessarily a given for all tubes!)

Be careful about wiring, especially in the comparatively high-voltage plate circuits. Be sure to use capacitors that will stand the voltage. I suggest staying away from "carbon composition" type resistors, especially for R4 and R6; otherwise you can get another classic tube sound - lots of hiss.

Some comments on the power supply: as mentioned earlier, the Real McTube II uses two inexpensive DC "wall-wart" power supplies, rated at 12 volts DC at 500 milliamperes. Larger units will work just fine should you happen to have a pair of 800 mA. or 1000 mA. units in your junkbox, but will require appropriately more real-estate in your project box.

There are two good ways of opening the plastic case in order to retrieve the transformers. The first method is to carefully cut around the seam using a hacksaw. Be careful you don't cut too deep, or you might damage the transformer. The other way is to squish the wall-wart in a shop vise to break the weld along the seam. This appears to work best if you clamp it diagonally, corner-to-corner; first in one direction, and then in the other. If the ones you happen to have don't respond well to this approach, use the first method.

You will probably even be able to use the little rectifier/filter PC boards inside the wall-warts. If yours have four diodes, that's perfect. If they have only two, this means they're using a centre-tapped power transformer which requires a slightly different circuit approach; see the alternate power supply schematic in Appendix 2 if this is the case. Note: both transformers have to be the same type; i.e. you can't use a two-diode wall-wart and a four-diode one together.

For the low-voltage rectifier, you can even re-use the diodes that come on the board (D5-D8). For the high-voltage rectifier bridge, however, you'll have to change the diodes to units with a higher voltage rating (1N4004 - 1N4007), since the ones in the wall-warts are typically only low-voltage 1N4001 or 1N4002's. You can also use the existing pads to mount the first filter capacitor. For the low-voltage supply you could even use the existing capacitor, though I suggest changing it to a 2200 µF unit (the ones supplied are usually only 1000 µF).

If you're lucky (as was I), you might get boards that already have a place for a second capacitor, wired in parallel with the first. This can be used to advantage in the high-voltage supply by installing both 33 µF 160V filter capacitors right on the board, cutting the trace connecting the positive ends, and bridging the trace with the 2.2k resistor R1. I don't recommend this for the low-voltage supply, since the considerably larger resistor R2 won't fit as well.

Note when wiring up the power supply that transformer T2 (the high-voltage step-up transformer) is wired backwards; what used to be its primary is actually our secondary winding. If you lose track of which winding is which, look at the size of the wire; the low-voltage side will be wound with considerably thicker wire. It's these thicker wires that are connected to each other in this project.

I recommend testing (and debugging, if necessary) the power supply first. At the low-voltage DC output (no load) you'll typically read about 15-16 volts DC. At the high-voltage output you'll read about 150 volts under no-load conditions. Be careful about accidental shorts; the transformers used in these wall-warts won't tolerate much abuse before they burn themselves out. (If you want to improve your odds, you can put a 1/16 Ampere fuse in series with the AC input. Since these transformers are designed to self-destruct under fault conditions, the fuse isn't needed for safety reasons, but might well save you a transformer if you make a wiring error.)

OK so far? Next wire up the filament lines. The output from the low-voltage supply should connect to pins 4 and 5 (which is which doesn't matter) of the tube socket, with the wires twisted together. At this point the tube should light up when you energize the power supply. At this point you can also wire up the LED and its dropping resistor R10. Note that your voltage between pins 4 and 5 will now be in the range of 12-13 volts, and the high-voltage supply will also be dragged down (generally to about 145 volts). To avoid an unpleasant surprise as you're working on this or any tube circuit, discharge the high voltage capacitors **after** turning off the unit and unplugging it from the wall socket. The best way to do this is to clip-lead a 10K resistor between the positive and negative terminals of the power supply, and leave it on for several seconds before proceeding with your work. (Don't forget to unclip it before applying power again!)

Once the power supply is working, wire up the ground lines. The grounding method is very important in minimising hum and noise. Tie all grounds to a common point **not connected to the chassis**. Connection to the chassis is accomplished at the input and output jacks **only**. The following points should each have their own direct wire run to the central grounding point (one of the ungrounded terminals on your terminal strip): This terminal should be fairly close to the tube socket, so that the resistors from the tube socket to ground will reach without having excessive length.

1. V1 (12AX7) tube socket pin 9 (with a wire link to the centre-post if the socket has one).
2. Negative lead (B-) of the high-voltage plate circuit power supply.
3. Ground lead of the input jack J1.
4. Ground lead of the output jack J2.
5. Ground legs of the two volume potentiometers. Looking at the pot from the back, with the three legs pointing upward, this will be the terminal on the left.
6. Resistor R3. Solder the other end to pin 2 of the tube socket. Looking at the bottom of the socket, the pins are numbered clockwise from the empty space.
7. Resistor R5. Solder the other end to pin 3 of the tube socket. Also wire capacitor C7 between these two points, negative end to the ground lug.
8. Resistor R7. Solder the other end to pin 8 of the tube socket. Also wire capacitor C8 between these two points, negative end to the ground lug.
9. Finally, be sure that there is a good connection to the chassis at the two input/output jacks.

All signal lines, i.e. the lines to the input and output jacks, gain potentiometer RV1, and to the stomp-switch contacts, should be good-quality shielded cable. (These runs are shown on the schematic with little ground "rings".) RG174 is a good choice, should it be available to you. If not, use any decent shielded audio cable. Keep other component leads as short as is practical, mounting the components as close to their associated tube socket pins as is practical. The input to the first stage is especially critical; we're dealing with a very high input impedance and low signal levels, and hum and noise pickup is a real concern.

Finally wire up the rest of the components between the tube socket and the rest of the circuit, using the terminal strip to provide support for components such as R4 and R6 (connect to the B+ terminal), C5, C6, C8, and R8. R9 gets connected directly across the output level pot RV2. Again test the power supply before plugging the tube into the socket. At pins 1 and 6 you should read about 145 volts DC relative to ground. Between pins 4 and 5 you should again read 15-16 volts DC. (The reading to ground will be indeterminate with the tube out of socket.) At all other pins your should read 0 volts relative to ground.

If all is well so far, unplug the unit and plug the tube into its socket. (Careful, the filter capacitors will carry a residual charge under these conditions. To re-iterate, short them to ground via a 10K resistor for several seconds any time you work on the unit after having powered it up.) Monitor the B+ voltage at the positive end of C2 and turn the unit on. You should see the heaters start to glow. After about 10 seconds the B+ voltage should sag a bit as the triodes start conducting. The B+ voltage at the positive end of C2 should drop no lower than 135-140 volts DC.

Read the voltages on the pins of the tube again. If you used the component values suggested, your readings should be in the vicinity of the table below:

Pin	Description	Voltage
1	Plate A	+108 VDC
2	Grid A	-0.001 VDC
3	Cathode A	+1.5 VDC
4,5	Filaments	6.3 VDC
6	Plate B	+60 VDC
7	Grid B	-0.1 VDC
8	Cathode B	+0.7 VDC
9	Filament	0 volts

If the plate voltages are excessively low, or if either of the grids are positive with respect to ground, power down right away and find your problem. Same goes if you see blue flashes in the tube, or smell anything unusual. Be sure that you used good quality mylar or similar capacitors for C6 and C8, with at least a 150 VDC voltage rating.

Assuming that the voltages check ok, power off again and connect the output of the pre-amp/ distortion unit to your amplifier, and the input to your instrument. Turn GAIN and OUTPUT to minimum, and power up. Slowly bring up the controls until you hear signal. Congratulations! You're on your own from here!

4a: Using the Real McTube II

What sound you get from your guitar or other instrument via The Real McTube will depend greatly on the settings of the various controls; specifically, the volume and tone controls on your axe, and the GAIN control. The OUTPUT control has little or no effect on the sound, and is used primarily to balance the volume of the sound with or without the effect engaged.

Note that both stages are inverting amplifiers; the overall phase of your signal will therefore not change. However, how you adjust your controls will determine what portion of your signal gets clipped. The first stage will tend to clip more on negative half-cycles as the tube reaches cutoff (remember our discussion earlier regarding cutoff versus saturation). The second stage, however, will tend to clip more on positive half-cycles, since it sees an inverted signal at its input. By carefully balancing your instrument controls and GAIN, virtually any distortion sound from a mild, "warm fuzzy feeling" sound, to a hard "monster metal shred- head" sound, rife with odd-harmonic distortion, can be attained.

A compressor before the Real McTube will make it easier to get consistent sounds, but will also greatly affect the change of sound with varying dynamics. If you have multiple effects, play around with the various combinations. Where you place The Real McTube in your chain of effects will have a lot to do with the sound you end up with.

You might want to reduce the values of coupling capacitors C6 and C8. As you can verify using an oscilloscope, these will have a considerable effect on the exact nature of the transients that occur during clipping distortion. Lower values will give a reedier quality, the higher values as shown in the schematic result in a fatter sound. The circuit is extremely forgiving; take the opportunity to experience the fascinating, frustrating, flexible and highly subjective world of the vacuum tube amplifier.

5: PARTS LIST: THE REAL McTUBE II

rev. 01/01

(Parts with Mode part numbers available from your local Mode distributor.)

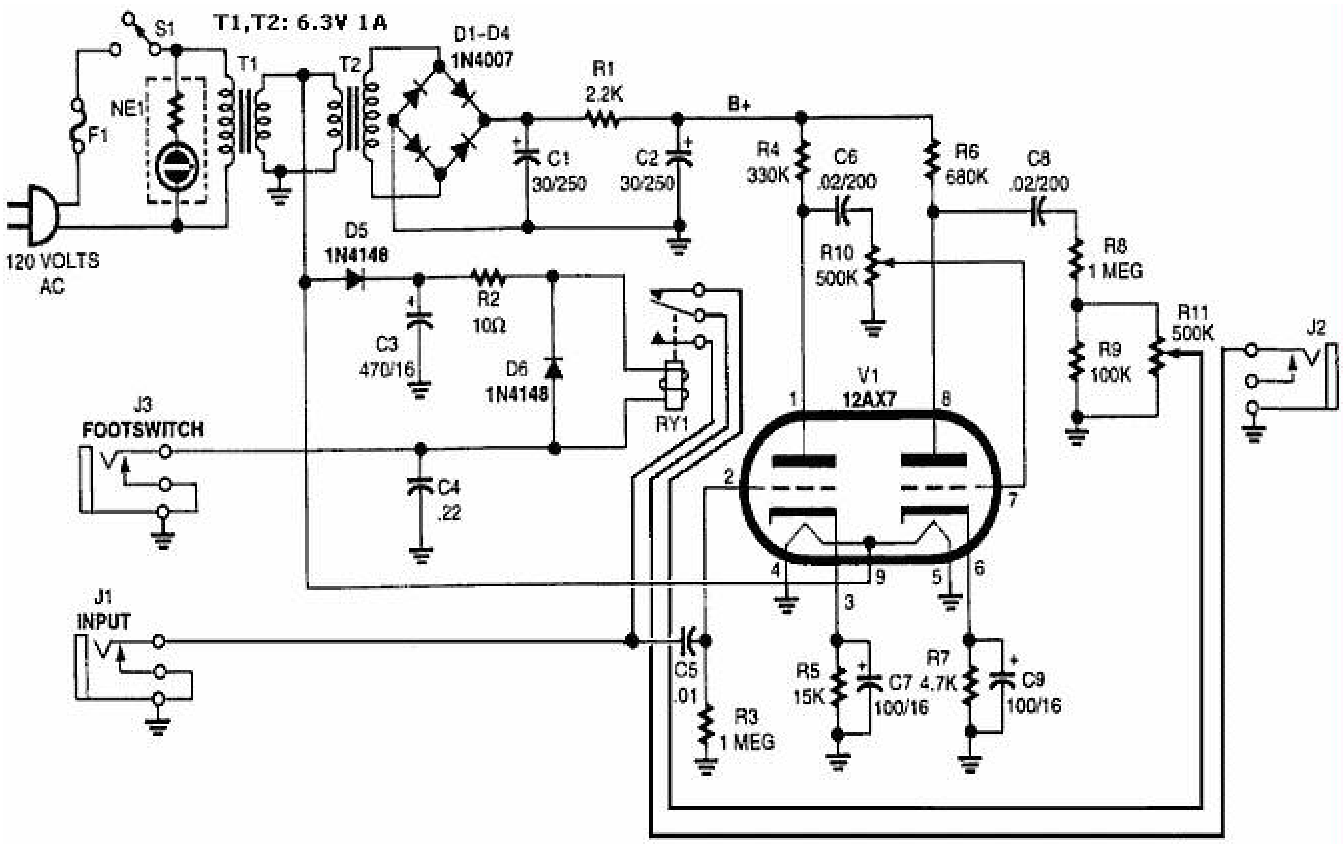
PART	DESCRIPTION	NOTES
C ------		**CAPACITORS**
C1, C2	33 uF. 160 V electrolytic	cer/mylar unl. noted
C3, C4	2200 uF, 16V electrolytic	
C5	.01 uF 100V	
C6, C8	.02 uF 200V	
C7, C9	100 uF 6V electrolytic	
D ------		**SEMICONDUCTOR DIODES**
D1-4	1N4004 or better silicon rectifiers	(or substitute 400V, 1A full-wave bridge module)
D5-8	1N4001 or better silicon rectifiers	(or substitute 50V, 1A full-wave bridge module)
I -----		**NEON PILOT LAMP**
I 1	125 VAC Red neon pilot	Mode 55-442-0
J ------		**JACKS**
J1	1/4" phone jack w/ switch	Mode 24-681-0
J2	1/4" phone jack	Mode 24-680-0
R -----		**RESISTORS**
R1	2.2 K	1/4 5% unless noted
R2	12 ohm, 2W	
R3, R8	1 megohm	
R4	330 K, 1/2W	
R5	15 K	
R6	680 K, 1/2W	
R7	4.7 K	
R9	100 K	
R10	470 ohm, 1/2W	

RV -----		**POTENTIOMETERS**
RV 1, RV 2	500K, Log taper	available from Radio Shack
SW -----		**SWITCHES**
SW-1	SPST sub-mini toggle (power)	Mode 42-230A-0
SW-2	DPDT on-on PB switch (bypass)	Mode 44-123-0 or 44-250-0
T ------		**TRANSFORMERS**
T1, T2	Power Transformers	as from Mode 68-125-1, 68-125P-1, etc.
V ------		**VACUUM TUBE (VALVES)**
V1	12AX7A, etc. (see text)	dual triode

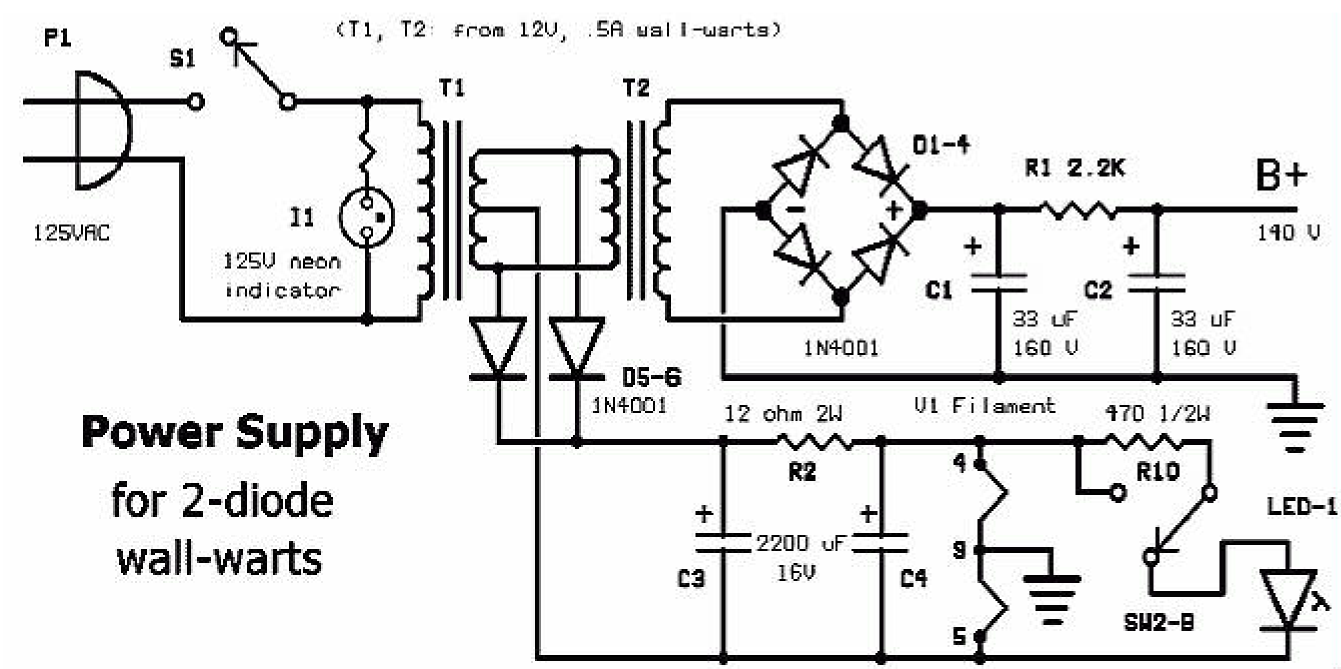
MECHANICAL PARTS

Steel or aluminum enclosure
AC power cord and plug (Mode 31-021-0)
strain relief for power cord
9-pin miniature chassis-mount tube socket
sub-chassis for tube and socket
2 pot knobs (several types available from Mode)
mounting hardware (nuts, bolts, washers)
terminal strips
hookup wire
shielded cable
cables to instrument and amplifier

5: APPENDIX I: The original Real McTube Schematic



APPENDIX II: Alternate Power Supply



End of article.