The Technology of the Tube Screamer

Introduction

The Tube Screamer series of distortion/overdrive boxes from Ibanez has a reputation that has led them to pass into musical urban myth. Helped along with Stevie Ray's use of them, the TS 808 and TS 9 have been sought after and traded up to astronomical prices. The other members of the TS family, the TS-10, the TS-5 and the TS-9 reissue have had a more troubled reception.

All the members of the TS family share a common technical design, with the similarities vastly overwhelming the differences. Later, I'll go over some of the things that DO make differences in these pedals, and some mods to effectively convert one to the other.

The TS series seems to be at its best when driving the input to a tube amplifier - that is, a triode grid connected to ground through a resistance of about 1M. All the TS series are capable of making their own distortion, but by itself, this distortion is much less interesting that what you get into a tube amp input.

Block diagram:

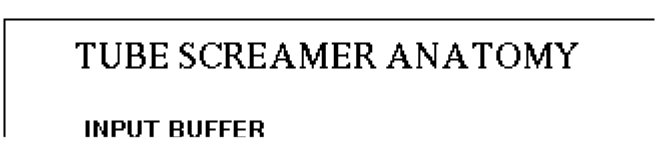
All of the TS series are so similar that a single schematic with asterisks and notes can cover them all. This simplified schematic breaks the circuit down into some simpler blocks. There are some housekeeping/utility stages which provide some common functions to several stages. The TS10 is the most different one, and the common bias voltage is higher. Then there are the ones that actually do the work:

- Input buffer
- Clipping Amp
- Tone/volume control
- Bypass switching
- Output buffer

Common/utility Stages

The 9V battery and external 9V input are common to all stages, as is the 4.5V generation stage, used as a bias voltage by all stages. The 4.5V section uses two equal resistors from +9V to ground. The junction of the two resistors sits at « the battery voltage and is decoupled to ground with a large value electrolytic capacitor to hold this point at an AC ground. The input jack switches the battery (-) terminal to ground in the normal power switching arrangement with a stereo jack. The exact value of the bias generation resistors varies somewhat from model to model, but this has no effect on the sound of the unit as long as the bias voltage is about 4.5V.

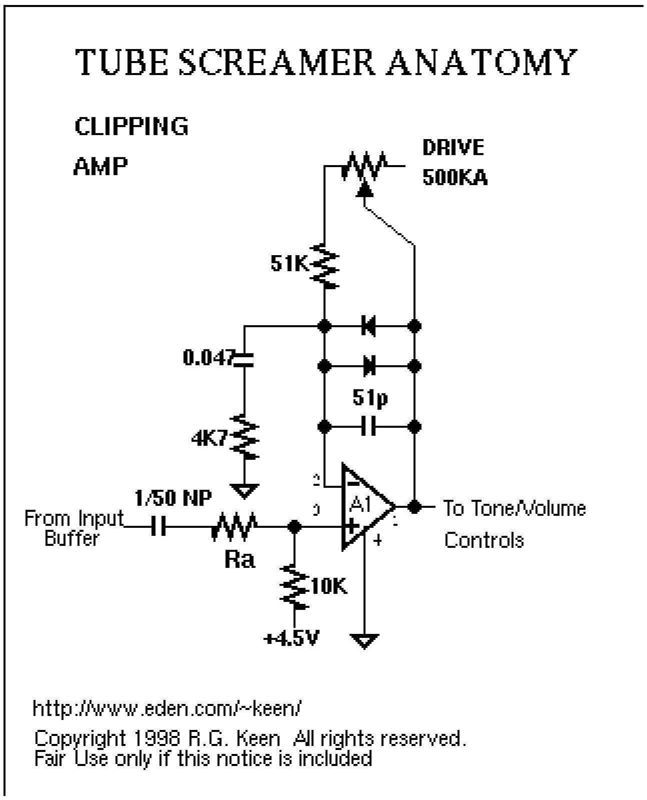
Input buffer stage



Referring to the schematic, the input stage is a plain vanilla emitter follower. The input transistor in the 808 and 9 is the 2SC1815, a cheap high gain, low noise transistor. I have seen a couple of other types in the other models, but the exact type of transistor has no significant effect on the sound. It is used to provide a gain of 1 (that is, no voltage gain) and a high input impedance. The base is tied to the common 4.5 V bias source through a 510k resistor, this forming essentially all of the input impedance. The input impedance of an emitter follower stage is the equivalent input biasing resistor in parallel with the input impedance of the emitter follower; this is the current gain of the stage times any emitter resistor. In this case the emitter resistor is 10K, and the typical gain of the 2SC1815 is 300, for an input impedance of 3M at the transistor base. Therefore, the 510K biasing resistor accounts for almost all of the signal loading at the input.

This input stage is always connected to the input signal, not switched at all. Since complaints of "tone sucking" do not follow the TS9 and 808 around, apparently this is a high enough impedance to avoid loading guitar pickups too much like the common wah pedals do. Parenthetically, it's possible to avoid the "tone sucking" of the wah pedals by copying the TS series input buffer in front of them. Some people have expressed interest in converting the TS to a true bypass switching arrangement; I'll explain how to do that later.

The emitter follower output feeds two stages: a JFET through a 0.1uF capacitor, part of the "bypass" switching and the clipping stage, through a 1uF non-polarized electrolytic, a large enough value to not interfere with any guitar frequencies. In the TS10 only, there is an additional stage of emitter follower between the input buffer and the switching JFET.



Clipping Stage

The clipping stage is a fairly ordinary variable gain opamp stage with a few tricks to shape the amount of clipping and the frequency at which it occurs. The signal from the input buffer stage feeds the (+) input of the opamp section, so the output is in phase with the input. In all members of the TS family except the TS10, this is a direct connection from the coupling capacitor to the emitter of the input buffer. In the TS10 there is a 220 ohm resistor in series with the (+) input. In all models the input is biased to the 4.5V bias source with a single moderate value resistor, usually 10K; this seems not to make any difference in the sound. The gain of a noninverting opamp stage set up like this is [1+ Zf/Zi] where Zf is the equivalent impedance of the feedback network from the output pin to the (-) input, and Zi is the equivalent impedance from the (-) input to AC ground.

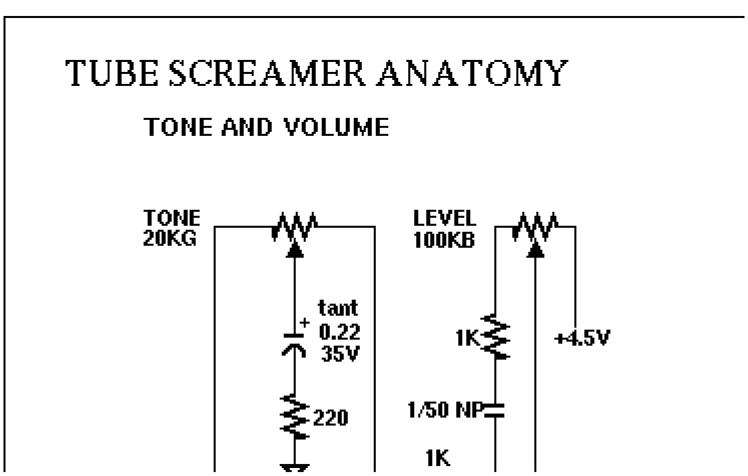
Zi is formed by the series resistor and capacitor from the (-) input to ground. This combination is frequency selective, in that the capacitor impedance is inversely proportional to frequency. At DC, the capacitor is an open circuit; it's impedance goes down as frequency goes up. At very high frequencies, the capacitor is effectively a short circuit, and the resistor is the sole determining factor in the gain, the capacitor impedance being negliglible compared to the resistor. At the point where the capacitor impedance equals the resistor, the gain of the entire circuit begins to fall off toward a gain of one. With the stock 4.7K resistor and 0.047uF capacitor, this frequency is 720Hz. Only notes and harmonics above this point get the full gain of the distortion stage, and everything below it gets pregressively less gain - and distortion. This fact probably accounts for the lack of "muddiness" of the distortion in the TS series as bass notes are clipped least.

Zf is the parallel combination of the clipping diodes, a 51pf capacitor, and the series combination of a 51K resistor and the 500K "Drive" control. Ignoring the diodes and capacitor for a moment, and assuming that the signal frequency is above the 720 Hz rolloff point of the Zi network, the gain of the clipping stage is (51K + drive control)/4.7K. This means the gain of the whole stage can be varied by changing the drive control setting between 1 + (551K/4.7K)= 107 (about 44db) and 1+ (51K/4.7K), about 12.

Going back to the clipping diodes now, the diodes have no effect until the signal at the output is greater than the threshold voltage of the diode. In the stock TS series, these are silicon signal diodes, with a turn on voltage of about 0.5 to 0.6v. As a diode turns on, the equivalent resistance of the diode goes down as the diode turns on harder. Effectively, there is a small range from about 0.4V to 0.7V (the exact voltages depending on the type of diode, the package, the doping, etc, etc.) where the diode resistance goes from an open circuit to a very low value, perhaps a few ohms for signal diodes. So as the diode turns on, the gain of the opamp stage changes, going down to just over 1 if the diode can be considered a short circuit compared to the 4.7 K resistor on the (-) input. Even if the Drive control is set for a gain of 100, the diodes conducting cause the gain to drop to 1 for only those portions of the signal where the product of the input signal and the gain exceeds the diode threshold. This means that the signal is "clipped" at the forward voltage of the diode; because there are two opposing diodes, this happens for both signal polarities.

A "typical" guitar signal if there is sch a thing, can be expected to be in the range of 30 to 100mV for most pickups when the string is picked, trailing off as the note decays. For such signals, and especially in the lower notes, with the drive control turned down the sound out of the TS is fairly clean as the signal hardly breaks over the clipping diodes. With the drive control turned up, even a 30mv signal would be boosted to 3V if not limited by the clipping diodes, so there is enough gain here to give some distortion at least on the pedal's own to any reasonable guitar signal.

The small 51pf capacitor across the diodes acts to soften the "corners" of the clipped waveform somewhat. This softens the distortion somewhat. The action of the 51pf is most noticeable when the drive control is maxxed out, so it softens the distortion most when the gain (and distortion) is highest. Put another way, the capacitor's impedance goes down with increasng frequencies, so it starts cutting the gain of the stage when the impedance of the capacitor is equal to the resistance of the 51K resistor plus the setting of the drive control. This rolloff frequency is lowest in the audio range and most noticeable when the resistance of the drive control is highest.



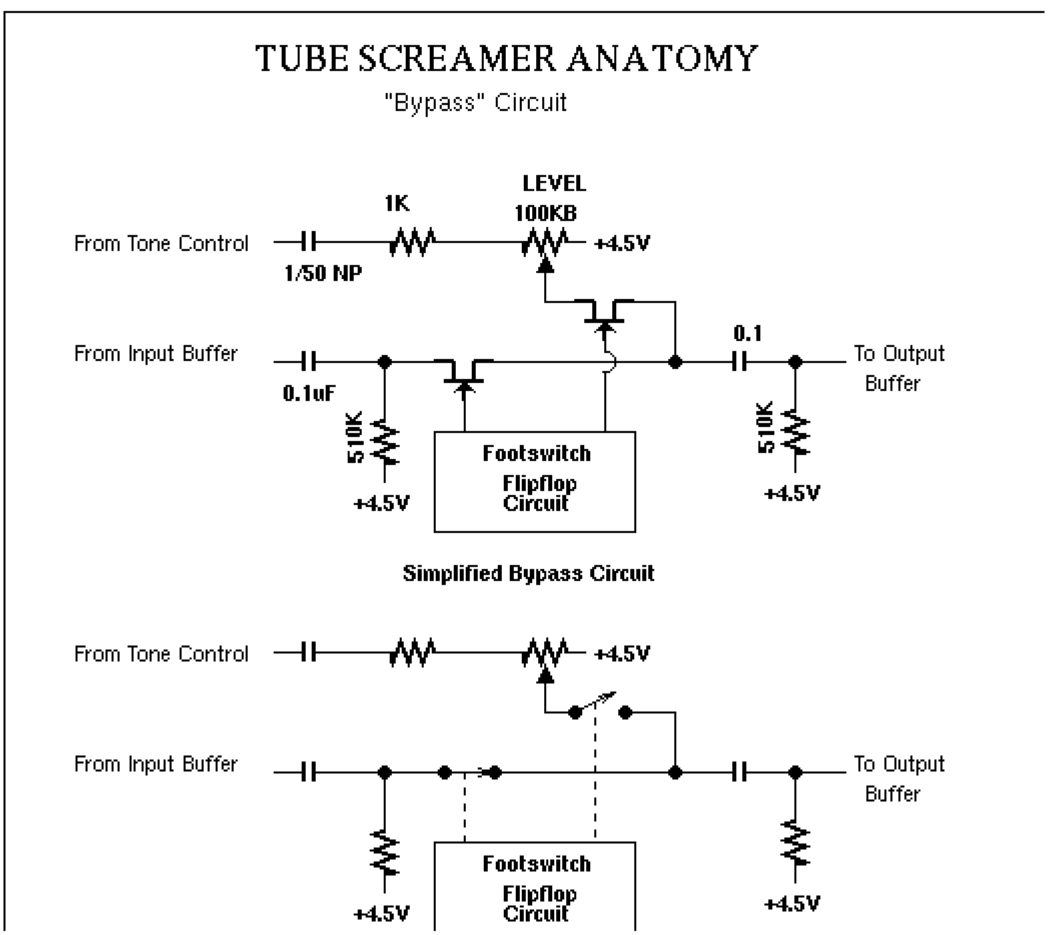
Tone and volume control stages

Cutting out harsh high frequency harmonics seems to be one of the underlying principles of the TS series. Following the clipping stage there is a 1K resistor leading to a 0.22uF capacitor to ground. This acts like a simple RC lowpass filter, with the rolloff point being 723Hz. This means that the output of this stage is down 20db (10:1) at 7230 Hz, and another 6db (20:1) at 14KHz, close to the top of the audio range. From this simple lowpass filter, the signal goes to the active tone control stage. The control is a 20K potentiometer strung from the (-) to the (+) input of the second opamp section. The wiper of the control is tied to a series RC combination to ground. This RC is a 220 ohm resistor and a 0.22uF capacitor. As a series network, at frequencies above the point at where the capacitive impedance is less than 220 ohms (which happens at about 3.2KHz), the network just looks like the 220 ohm resistor. At frequencies below that point, the capacitor impedance gets larger as the frequency goes down until at some point the capacitor impedance is large even compared with the full resistace of the tone control (20K); this happens at about 36Hz, below guitar frequencies.

The tone control operations are easiest to see if you assume that the tone control is at one end or the other of its range. When fully toward the (+) end, the capacitor shunts the frequencies above 3.2KHz to ground; when fully toward the (-) end, the capacitor shunts feedback frequencies above 3.2KHz to ground. This means that at the (+) side, the signal gets another -6db/octave high frequency rolloff, while when it's at the (-) side the signal finally gets some treble boost, +6db/octave above 3.2KHz. Note that the "boost" actually just levels off the -6db/octave induced by the 1K/0.22uF network ahead of the active control stage, so the treble is just not being cut any more above the turnover frequency for the tone control stage when fully at "treble".

The opamp is set up as a noninverting buffer, which just means that there is no net signal loss through the tone control stage, a gain of 1 - if you can find a frequency where there isn't otherwise a boost or cut from something else.

The volume control is fairly standatd, a 100K audio control with the output of the tone control stage connected to the "hot" lug, the "cold" lug connected to AC ground, and the signal taken from the wiper.



"Bypass" operations

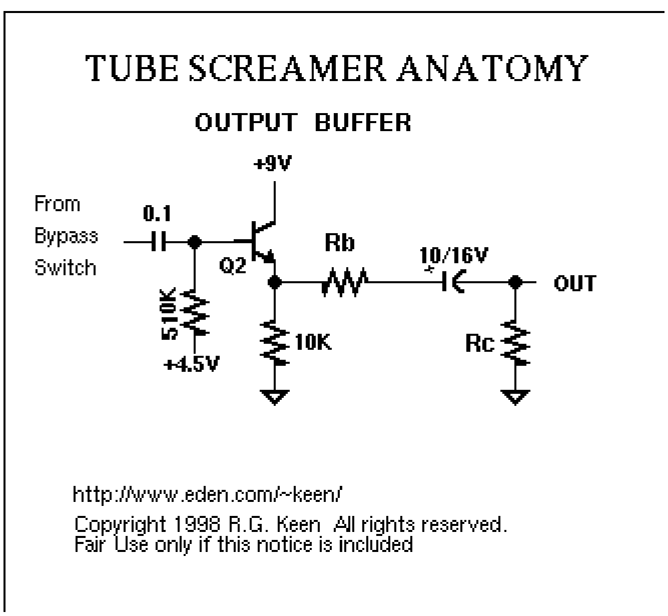
"Bypass" is a misnomer for the TS series. They all use JFET electronic switching, and all of them have at least the two signal buffers and a JFET switch (plus the additional emitter follower in the TS10) in series with the signal even when "bypassed".

I have deliberately super simplified the footswitching arrangement in the schematic, as this is the thing least likely to need modification. In addition I show a conceptual drawing for the switching, replacing the FETs with idealized switches.

The electronic switching is done by two JFETs, 2SK30A in early pedals and 2SK118 in later ones. These FETs are set up with both source and drain tied to the 4.5V bias source through high value resistors. Since they are N-channel devices, they are "on" and look like about a 100 ohm resistor when the voltage between gate and source is 0, and "off", looking like a multimegohm resistor, when the voltage from gate to source is negative. The gate of each fet is tied through a diode to the electronic switch control flipflop so the gate can be pulled to ground, which is -4.5V compared to the source. When the gate is allowed to float by the voltage on the other side of the gate diode being higher than the 4.5V on the source, leakage effects let the gate drift up to the 4.5v of the source over a period of a few milliseconds. This allow the switch to turn on softly with no audible click. An RC network on the outboard side of the gate diode does the same for the turn off.

The two JFETs are connected to out-of-phase outputs of a simple discrete flipflop made from two more NPN transistors. The flipflop is set up so it changes state once each time the "bypass" footswitch is pressed, and so it is "biased" to come up in the "bypassed" state. The actual footswitch is a sealed dome momentary switch, a fugitive from computer keyboard technology. The switches are available on the surplus market at very low prices. The two out-of-phase outputs (when one is high, the other is low, and vice-versa) are connected to the two gate control networks for the JFETs so that only one JFET is on at a time.

One JFET is connected to the signal at the emitter of the input buffer transistor, and the other is connected to the output of the volume control. The other side of both JFETs connect to the base of the output buffer transistor. Because of the flipflop action, one and only one JFET is conducting signal at any time, so the output buffer gets only the buffered input signal or the processed signal through the clipping stage and tone controls, but not both. The buffered input stage signal is the sound you hear when the effect is "bypassed".



Output Buffer Stage

The output stage is again an emitter follower with a 10K emitter resistor, biased from the 4.5V bias source. At the output of the emitter follower is one of the few systemic differences between the members of the TS series. From the emitter of the transistor, there is a low-value resistor in series with a 10uF signal coupling capacitor, then a shunt resistor to ground. The following chart has the values of these resistors from model to model:

Model	808	9	9RI
Series res.	100	470	470
Shunt res.	10K	100K	100K

So how do these differences affect the sound?

To start with, the series resistance at the emitter limits the amount of drive available to drive an amplifier input (although not by much), and in concert with the series capacitor forms a voltage divider with the output shunt resistor and the input impedance of the amplifier plugged into it. This drops the available signal only a trivial amount, probably inaudibly so. The input resistance of a typical tube amp is most often 1M or over. This is not a serious contributor to the loading of the output follower.

However, the 10K shunt resistor load on the TS808 output does have an effect on the follower's operation. An emitter follower with a resistor load is often assumed to have a very low output impedance, which is true, as long as the signal is going up. However, when the signal is going down, the transistor can only turn off, and the signal is pulled down by the net loading, DC and AC on the emitter. The 10K shunt resistor effectively halves the emitter loading on the output buffer. This does two things; trivially, it reduces the input impedance of the emitter follower; more importantly it reduces the negative going output impedance of the stage by half to about 5K. This means that the output stage can drive the following stage off about twice as hard.

Can this account for the admittedly very subtle audible differences between the TS 9 and 808? It pretty much has to, as the operating current for both stages is the same, the series resistance is only trivially different compared to the forward biased input impedance of a triode grid (10's of K's for the typical duotriode input), and the voltage divider ratio difference between 100/10K and 470/100K is 0.990099 versus 0.995322, an inaudible amplitude difference.

In terms of differences among the models: the TS808, the TS9, and the TS9 reissue are in fact built on the same circuit board pattern. For these three, THE ONLY DIFFERENCES ARE THE OPAMP TYPE AND THE TWO OUTPUT RESISTORS. This is how the various conversions to "TS808 specs" are done - two resistors are changed in value, and the opamp maybe changed to another type. Conversions to "brown sound" or other mystical turbocharging are done by twiddling the values of the resistor and capacitor frequency determining components.

The TS5 is a circuit copy of the TS9, excepting the opamp and a few components in the bias supply section.

The TS10 is the "sleeper". Available on the used market for as low as $20 in working order, it differs from the TS9 In only a few ways:

- extra 220 ohm resistor in series with the (+) input of the clipping amp
- extra emitter follower in series from the input buffer amp to the JFET switch for the bypassed condition
- Different bias voltage for the input buffer transistor.

If you jumper the 220 ohm, clip out the extra buffer transistor and connect the jfet signal coupling cap to the emitter of the input buffer, and change one resistor in the input buffer biasing circuit, you have a working TS9 in the TS10 case. From there, two resistor changes get you an 808 circuit. Both of these assume that you'll change out what is probably a dreadful opamp.

The Opamp

The TS808, the TS9, most TS9 Reissues, and some of the 10's and perhaps a few 5's came with the "JRC4558" dual opamp. Most 10's, almost all 5's and a few 9 RI's came with other opamps. The JRC4558 is a dual opamp with "industry standard" pinouts which means that there are perhaps fifty different dual opamps from different manufacturers that will fit in the same holes and work.

There seems to be a difference in sound depending on what opamp is actually in the circuit. In fact, this may be the single biggest effect on the sound of the TS circuit. The JRC parts were undoubtedly chosen by the design engineer primarily because they were cheap. During the time the 808 was in production, the JRC was oneof the cheapest dual opamps on the market with acceptable audio performance. As such, it was used in huge volumes of Japanese audio equipment. The opamp is described in some Japan Radio Corporation (JRC...) literature as "an improved dual 741 type opamp with better noise, drive capability, and slew rate than the original 741 type opamps". Note that this is not saying much, as the 741 is a fairly abysmal audio part.

For some reason, the JRC4558's seem to be well suited to duty in the TS type circuit. JRC later changed its name to New Japan Radio Corporation and made parts titled "NJM4558". When you order these, you get parts that are labeled "JRC4558". By all reports, these sound as good as the original. The tube screamers made with 72558A are reported to sound abysmal. From the brave souls who took the suggestions in the tube screamer clone section over on GEO and put in a socket to swap parts, the following types of opamps DO seem to sound good.

- new manufacture JRC4558D
- LM833
- RC4558, made by a couple of US firms
- TLC2202
- TLC2272
- OP275
- LT1214

What makes for a good opamp versus a bad one? I dug through the data books on the ones that people told me sound good, and came up with a common factor. The ones that sound good seem to all make a point that they recover from overdrive gracefully. I can hear you asking "what the devil does that mean for opamps?" It's like this - in a feedback configuration, an opamp's enormous gain keeps both inputs within a few millivolts of each other all the time, every nanosecond. When the opamp is driven to the point where the output is near a power supply voltage and cannot swing any further, the feedback is no longer keeping the inputs together, and one input is driven further toward a power supply than the other. This can cause some ugly things to happen. In some opamps, the output inverts polarity for a few microseconds. I'll leave it to you to imagine how ugly those little "blatts" sound. In other opamps, the recovery time from overload is slew rate limited; the output does not follow a multiple of the input, but "slews" at a fixed rate until it catches up to the amplified input. This also sounds bad.

While the clipping opamp is not driven into overload, I theorize that the sudden change of gain every time the diodes go into and out of conduction can cause a similar although briefer recovery period at each "corner" of the clipped waveform. In this period, you'd get non-harmonically related artifacts that would neve be very big (all that lowpass filtering, remember) but which would be audible as a harshness or edginess. While this is just a theory, it does seem to meet the only observed facts, and has predicted a couple of opamps that did sound good. You're free to come up with your own theory, of course, but I like this one. It has worked so far.

== This section has been updated based on newer information ==

There is some confusion at present over what is a true or "vintage" JRC4558. Several electronics suppliers list the JRC4558. These are sometimes listed in their catalogs as "NJM4558", but what you get are marked "JRC4558D". By all reports, the current manufacture JRC4558D's sound just as good as the ones current with the manufacture of the original tube screamers.

There were zillions of the real "JRC4558" made when it was current. They are still available in isolated caches of parts, although they can sometimes be hard to find. Does true "New Old Stock" matter? probably not. In addition, the JRC4558D was used in tons of Japanese audio equipment at about the same time, so a junky cheap Japanese stereo or clock radio could have several hidden inside it.

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The best thing to do, I believe, if you're hunting the Tube Screamer Holy Grail is to stick in an 8 pin socket on the board, noting the orientation of the original chip carefully, and then just plug in various dual opamps until you find one that conjures up images of your own personal guitar deity.

Maintenance problems in the basic TS series

The TS series as a whole has a couple of weaknesses that you should know about if you own one of them.

In the TS 808 and 9, and probably the TS10 as well, the external DC adapter connector is prone to craciking either the solder or the board where it's soldered on. This can lead to intermittent operation of the unit, as the normal battery power goes through there as well. To fix this, open the unit up and examine the power jack and board immediately around it. If you have solder cracking, ust remelting the solder with a touch of an iron and a little fresh rosin core solder will fix it right up.

If the board itself is cracked, just remelting the solder will temporarily fix it by bridging over the crack, but solder is a very poor mechanical material and it is likely to crack again through the solder. In this case, use a bit of resistor lead on the tracs, bent to shape and soldered in place for a ways back from the connector leads. It's a good idea to shape the resistor lead into a tight loop around the power connector leads for more support. Solder the resistor lead along it's entire length for 1/4" or so along the trace leading away from the connector. The resistor lead is tin/solder plated soft steel, and will mechanically support the connection.

It's not a bad idea to simply do this reinforcement in any case unless your soldering skills are not quite up to doing it without shorting out other traces.

The "bypass" switch module seems to be prone to failure and intermittency as well. This switch is a sealed keyswitch module, and inside is a dished metal dome that clicks over to make contact when the button is pressed. There is also a rubber ring inside that keeps things apart. The intermittency seems to come either from corrosion of the disk or contamination of the contact points from gook coming from the rubber part. My friend the amp tech actually takes the switch apart - if you're careful this can be non-destructive - and cleans the contacts up, getting rid of any loose debris. He claims a 70-80% success rate at doing this.

Of course, he's also sitting on a pile of replacement switches from the local electronics surplus house, too, so failures of technique are not fatal. The switches are not particularly hard to find or expensive if you have a good surplus outlet nearby. If you don't have this advantage but do have some electronics skills, you can put any one of a number of other miniature snap action ("tactile feel") switches in there if you can adapt them mechanically to the small circuit board and the activation spring from the foot treadle.

Mods and Modified Versions

Conversion to TS808 - this seems to be a perennial hot one. Simple... just locate the 470 ohm and 100k resistors on the output buffer transistor, tracing back from the output jack, and replace them with a 100 ohm and a 10K. Bang, instant 808. If you're doing this to a TS 10, short out the 1K resistor leading to pin 3 of the dual opamp as well. A variation of this mod is to add more bass response as in the next mod. This is sometimes referred to as making it have a "browner" sound.

More bass - remember that 4.7K/0.047uF network on the (-) input of the clipping amp? To give yourself more bass, increase that cap to about 0.1uF. The (-) input is pin 2.

More distortion - everybody's favorite. No problem here. If you want more distortion, lower that 4.7K to get more gain when the drive control is maxxed out. If you don't also want to change the bass/treble response, you will need to change the capacitor as well. If you half the resistor, double the capacitor to keep the same overall frequency response.

It is theoretically possible to just use a higher value pot in the drive control, but you're unlikely to find a replacement for the micro-sized pots used in the original case. This is a possibility if you rip the circuit board out of the original box and install it in another box of your own choosing. This is not as crazy as it sounds, especially for the potato-bug TS5 as the plastic case is essentially useless no matter how good the circuit sounds. This leaves room for a true bypass switch as well.

Note that if you take the step to go to a box that lets you use different pots, you can also add switches for other functions like changing the bass response by switching in another capacitor, switching in other gain resistors or pots for various degrees of gain, or other tone control pots for changing the treble response.

Note that in going to higher gains, you will inevitably increase the noise in the output. This may be curable to a degree by changing the input transistor to a quieter part (MPSA18 or 2N5089 is good) as well as swapping to a more modern and quieter opamp like the LM833 or both.

Sweeter distortion - the stock units use a pair of silicon signal diodes, which look identical to the 1N914/1N4148 devices. If you change one of these diodes, chances are that the resulting pair will not clip at the same voltage for positive and negative signals, giving you asymetrical clipping, and the resulting even order distortion. If you pick something close, like maybe a silicon power diode like the 1N400x series for the second diode, the resulting second harmonic will be very subtle, not audible as an octave effect at all, just a "sweeter" or more liquid tone.

You can try a number of things like putting one germanium (1N34A from Radio Shack works) diode in series with one of the silicons to add a bit more threshold voltage to one side. A more radical treatment would replace one of the silicons with three germaniums; even more radical would replace one of the silicons with TWO silicons. These last will start to make an octave effect just barely audible at some notes on the guitar neck.

I've even heard of using LED's in there for the clipping diodes. Go wild here.

True bypass - to get untainted sound when the effect is bypassed, guitarists like true bypass switching. One way to get this simply is to make a true bypass box external to the effect, and just use short cords to connect the original effect up to it. If you are dexterous and can mechanically get a DPDT stomp switch inside the TS box, you can convert it to true bypass. This conversion is simple in concept. The two switch JFETs are pulled off the circuit board. The one from the input buffer is ignored, the drain and souce holes for the one at the volume control are shorted with bit of wire. This disables the electronic switching and makes it permanently "on". Then the external DPDT switch is wired for true bypass around the whole mess. There are diagrams for bypass switching on my web page at http://www.geofex.com/.

Parts Substitutions - If you just want to tweak the existing TS pedals, a good place to start is replacing the 1uF/50V NP electrolytic capacitors with 1uF/50V polyester film capacitors and the 0.22uF tantalum capacitors in the tone control section with 0.22uF film capacitors as well. The film caps are a little larger but there is room if you put some work into finding miniature parts. Mouser Electronics stocks suitable parts if you substitute a pair of 0.47uF caps for the 1uF electrolytics.

The electrolytics have a large dielectric absorption and cause a muffling of the sound. Ceramic caps are reputed to cause a harsh graininess, so are not a good choice for replacements.

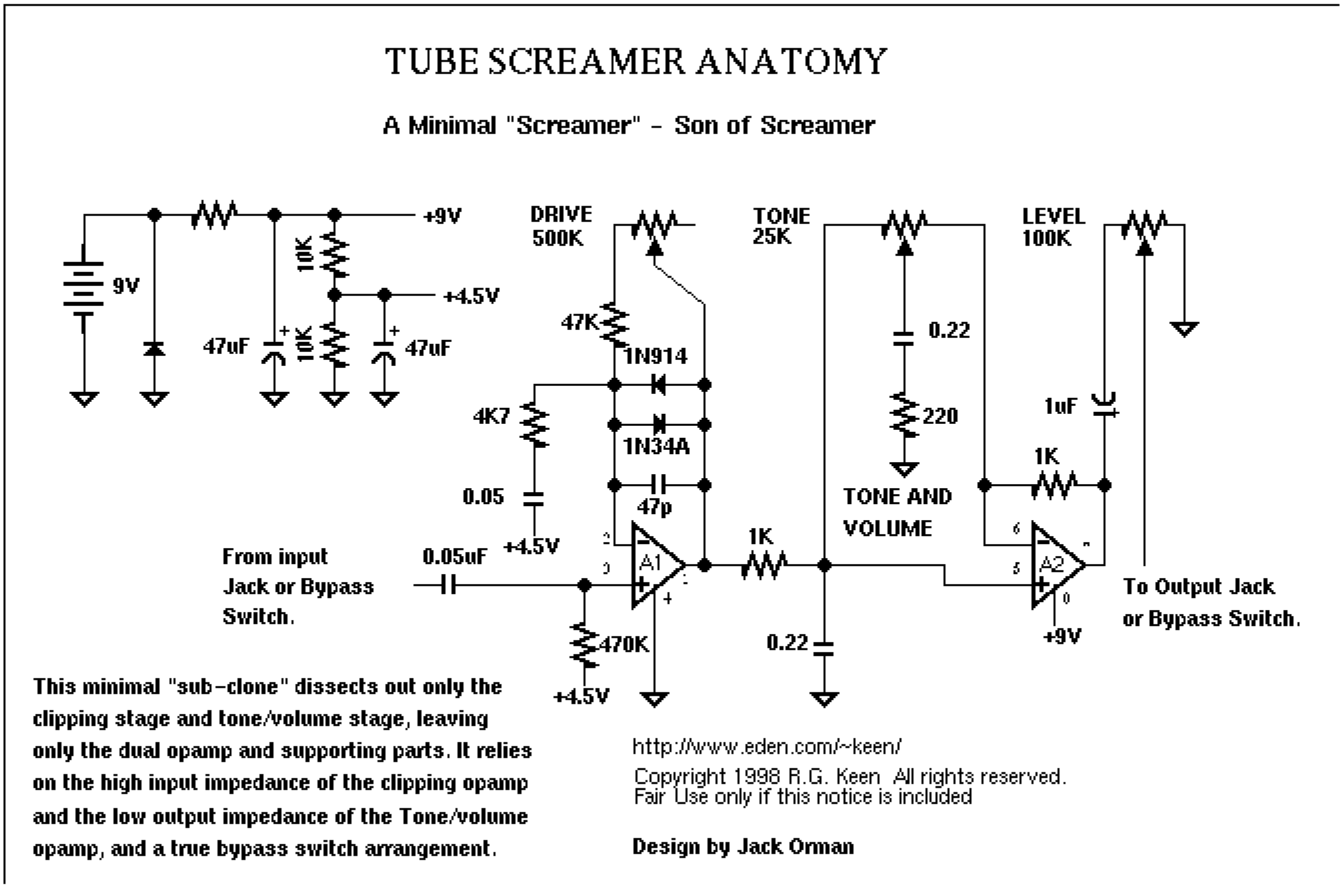
Send in the Clones

There are several clones or semi-clones of the TS series on the market. The schematic of the signal path of the TS series on my web page, as I mentioned, and it is entirely reasonable to hand wire one, using a DPDT stomp switch for bypass and applying your own personal Guitar God Mods along the way.

I also have a stripboard (Vero-board) layout there if you'd like to use that board technology, as well as toner transfer sheets to iron on a circuit board for the TS circuit. In these versions, I used the whole audio path, input and output emitter followers and everything. They fit nicely inside the Hammond 1590BB cast aluminum box, and come with wiring diagrams to wire the box up.

I used the emitter followers for both the toner sheet versions and for the vero board versions in case there was some subtle effect from them being there, on the theory that those folks who claim to hear sonic differences between the 808 and 9 can't ALL be wrong. Strictly speaking, if you do a good job of setting up the biasing for the clipping opamp with a high value resistor of about half a meg or so instead of the 10K that is used in the stock unit, the input emitter follower is probably not needed.

If you decide that the 808/9 folks are all wet, the output one isn't either, and if you delete these and use the DPDT stomp switch, you come up with a single chip version that is remarkably easy to build. Mark Amundson proposed this idea to me about a year and a half ago, using a CMOS opamp for the relative softness of the clipping that CMOS based amps give.



Jack Orman seems to have rediscovered this concept later to come up with his "Son of Screamer" article, which does not use the CMOS opamp.

If you decide that the magic might be in that output buffer, you can also just leave off the input buffer with appropriate circuit changes.

If you want to experiment with either of these, you can use either the toner layout or the veroboard layout, and just leave the input and output followers off, using instead a 510K biasing resistor at the (+) input to the clipping amp, and returning the volume control "cold" lug to ground instead of to the bias voltage, as some models of the TS series do.

Apparently the good sound of the TS series has not been lost on the boutique effects makers. Reportedly, there are a number of TS clones available in that market.