

About GEO Fex

GEO Fex DIY effects packages are designed with the musical effects experimenter in mind. GEO Fex offers the musical tinkerer the ability to work with and modify to his or her own liking circuits that accurately reproduce the technology of vintage effects.

GEO Fex packages reflect over two decades of research into effects technology and production techniques. The goal of the GEO Fex package is to make the sounds and circuits of a number of vintage effects available at a cost that is reasonable for the musical electronics enthusiast even when the enthusiast is making only one unit for himself.

As such, the emphasis is on achieving near-professional results in an at-home or in-garage setting. Modern toner-transfer technology allows the production of near-professional quality printed circuit boards one at a time by experimenters. Modern electronics mail-order suppliers can provide parts that were once very hard to find for the individual. The only missing part here is information - what was the circuit of a given vintage effect, and what special steps are needed to get the effect working right. This information is what GEO Fex all about.

GEO Fex packages reflect as closely as is known the original circuit of the vintage effect they are taken from. In some packages, the circuit was changed from the original in ways that make the GEO Fex package a better fit for modern musical effects practice - addition of true bypass switching, switch pop suppression resistors, and so forth. No changes are made that change the sound, which is, after all, the reason we do this.

GEO Fex packages have all been built and tested before you get them. They DO work, and they DO sound like the originals.

In some cases, detective work was needed to make the circuitry in GEO Fex packages available. Some of the vintage effects offered are so rare that none could be found for research, or the companies that provided them are no longer in existence. This meant quite a search for the underlying technical information in many cases.

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GEO Fex

Austin Treble Blaster

A Workalike of the Original

Dallas Rangemaster

Build a clone of the classic effect

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Austin Treble Blaster, a Dallas Rangemaster Workalike

The original Dallas Rangemaster has been little known in the USA, and underappreciated. Many guitarists have experimented for a long time trying to emulate some sounds common in recordings from Europe, without notable success. It turns out that the Dallas Rangemaster may have been the secret weapon. Network research and personal email have indicated that the Dallas Rangemaster was a key item in the sound Eric Clapton achieved in the Bluesbreakers album, Rory Gallagher's tone, and later Brian May. In the US, Tony Iommi noted in an interview that he used one for his work on the first Black Sabbath album.

What does this secret weapon do?

First and foremost, it's a treble booster. It provides gain of up to 24db at frequencies above about one to two kHz. It has about unity gain at the lowest normal guitar notes, and the gain about doubles with each octave. Since a doubling of level is a just-perceptible change in loudness, not a perceived doubling of loudness, this amounts to a fairly mild increase in level for higher notes, enough to make the guitar more "present". It shares this characteristic with other treble booster effects. If that was all that happened, there wouldn't be much excitement.

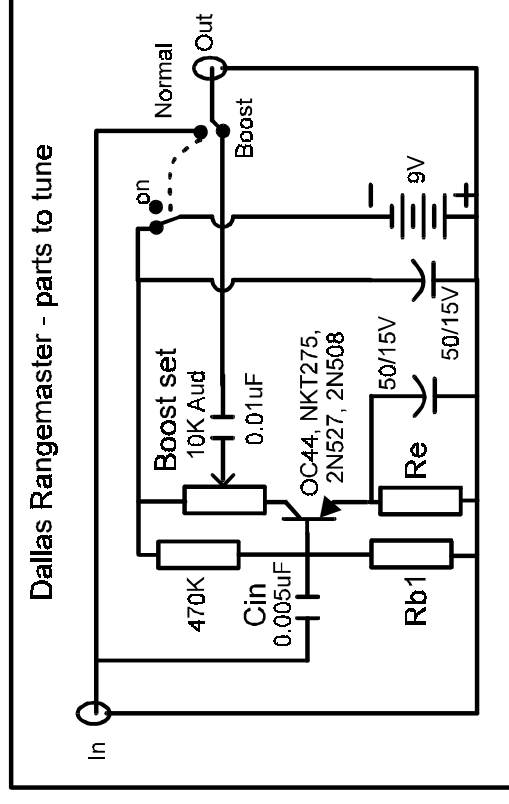
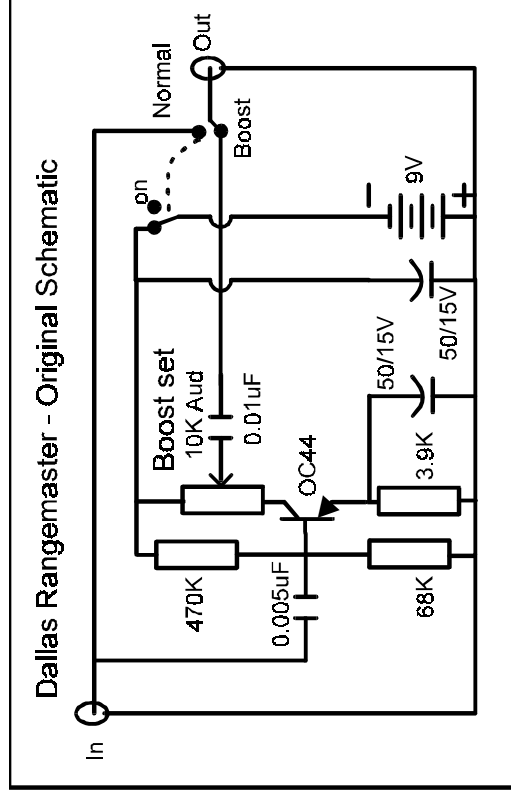
However, the Dallas Rangemaster has some other tricks. As a result of the use of germanium devices and careful biasing, there is a subtle distortion added, as well as a changeover to harder distortion on loud notes, and the built-in ability to overdrive a tube amp input for some more serious distortion. These effects get more prominent as frequency goes up, so there is a very characteristic note added by the Dallas Rangemaster.

So – how does it work?

The Austin Treble Blaster uses the same circuit as the original Dallas Rangemaster, so the comments apply to both circuits.

The Dallas Rangemaster/ Austin Treble Blaster couldn't be simpler. Referring to the original schematic, there is only one transistor, biased by four resistors. The 470K/68K series resistor provides a bias voltage to the base of the device, helping to set the static current in the collector. Since germanium transistors are used, the collector-base leakage also "helps" set the bias point as well. The 4.7K resistor, in conjunction with the input divider helps set and stabilize the bias point against drift and temperature variations. Its value and that of the nominal 68K base resistor are key to setting the bias point, so the exact values of these resistors should be set upon testing with the actual transistor to be used.

The collector resistor is just the output level control pot, a 10K unit with an audio taper. The "hot" lug is tied to the collector of the transistor, the "cold" lug tied to the battery supply, and the audio output taken from the wiper through the 0.01uF capacitor to the output switch. Some original Dallas Rangemasters used a 22K boost set pot, possibly as part of the tuning process to adapt a lower gain transistor to the circuit.



The original Dallas Rangemaster was intended for use only between a guitar and an amp, no other effects between them. As such, it did not use a "pull down" resistor at either input or output, as the guitar pulled down the input cap leakage, and the (presumably tube) amp input grid leak resistor pulled down

the output cap leakage, so there was no [klik] when it was switched. In modern setups, we cannot rely on those assumptions, so for my use I have added 2.2M “pull-down” resistors at both ends for maximum flexibility. The pull-down resistor have no audible effect, by actual test, other than keeping [klik] from happening. If you are a stickler for originality, you can simply leave these resistors off. The pull-down resistors are a practical necessity for use in a modern context with true bypass, which the original did not have.

Another quirk of the original is that there is a DC voltage across the volume control, which also serves as the collector load resistor. This means that it will inevitably scratch and crackle whenever the control is moved even if you use high-collar conductive plastic pots. This was OK in the time of the original unit, as the designer assumed that a player would set up this thing and leave it, not twiddling the control during a number. There are ways to “correct” this, but they complicate the design unduly, so I have chosen to leave them out, going with the original circuit. It will crackle when you twist the “boost set” control.

Digging deeper

The magic in the effect is all buried in the details of the biasing, the transistor characteristics, and what it does to a following tube amplifier.

It’s not widely understood, but all transistor gain decreases at low collector currents. Normally transistors are biased as close to the middle of their linear swing area as possible to get the biggest possible non-distorted signal out. If you bias a bipolar transistor near cutoff, the gain of the transistor is heavily dependent on the instantaneous signal in a way that compresses the signal more the closer to cutoff it gets. Even for signals that do not fully cut the transistor off, the signal is softly compressed more on one side than the other, which amounts to asymmetric distortion of the waveform since the compression is instantaneous.

This asymmetric distortion adds a sweet, liquid quality that gets more noticeable as notes are hit harder. Hit a note hard enough (or just use a high output pickup) and you can actually drive the transistor fully into cutoff, and get a changeover into harder distortion.

Germanium devices have more of this change of gain near cutoff than silicon ones do – bad for mainstream electronics, great for guitars. While silicon does this as well, and I have used the silicon device 2N3906 with moderately pleasing results, but germanium has more oomf.

Finally, the amplifier following the Dallas Rangemaster has a part to play in the tone. A vacuum tube input is usually biased with the grid more negative than the cathode, and in the case of the common 12AX7 preamp tube in most guitar amps, this is usually about 1 to 1.5 Volts negative. Whenever the grid is driven positive with respect to the cathode, the grid still affects the plate

current, but since electrons can now be absorbed by the now-positive grid, a grid current flows. The grid voltage, which controls the plate current, depends on whether the impedance driving the grid has a low enough impedance to supply the grid current. A high impedance source will be unable to drive the grid current, so the grid voltage will remain fixed at only slightly over zero volts, and the plate current will appear clipped for that part of the signal cycle where the grid is driven positive.

This leads to the curious fact that a low impedance source driving a tube grid will have a less distorted and more softly distorted plate signal than will a higher impedance source.

The Dallas Rangemaster has an output impedance no higher than the output pot resistance of 10K, and lower than that over most of the pot travel. This is substantially lower than the equivalent forward biased grid resistance of a 12AX7, so it can drive an input grid somewhat positive. The resulting distortion is smoother than a high impedance source would be. Note that amps that have series 68K resistors for “mixing” two inputs may not show the full benefit of this effect.

In terms of frequency response, I ran some measurements on the original unit. I had to measure the gain with an input of 10mv peak to keep the signal undistorted. The gain versus frequency is as follows:

Frequency (Hz)	Gain
80	~ 1
100	1.2
200	2.4
500	6
1000	10
2000	17
5000	29
10K	32
20K	30

This response is clearly just a simple RC high pass filter, and can be computed fairly closely with the approximation that the input capacitor works into the parallel equivalent of the 470K and 68K input resistors and the input resistance of the transistor. The transistor input resistance dominates this combination, being roughly 12K at the nominal DC bias current.

Turn on , tune in

The best parts of the sound from the Dallas Rangemaster are heavily dependent on the biasing point; germanium devices are notorious for device-to-device variation in gain. This fact probably accounts for the reputation that the Dallas Rangemaster has in Europe of being “uncopiable”. If you simply take a bag of parts of the right values including any old transistor with the right type number printed on it, you will almost certainly not have the device biased in the proper place to have the “sweet” distortion. The transistor may either distort too early or not clip at all on louder notes.

From what I’ve been able to see, the ideal biasing point for the Dallas Rangemaster’s sound effects seems to be to have the collector at between -6.8 and -7.1V with a -9.0V battery supply. This puts the static bias at a place that lets the soft cutoff distortion show through and allows a smooth transition to heavier clipping in cutoff with much louder notes. To get it biased there, you will need to mess with one or both of RB1 and Re. You may also have to get another transistor.

The Dallas Rangemaster ideally has a low-leakage germanium device with a current gain (Hfe) of about 75-100. These are not always available. If the current gain is higher, you will need to reduce the base bias by lowering the Rb1 value, as much as half to get -7V on the collector. If the current gain happens to be low, you may have to lower the emitter resistor, to no less than 2.7K; if that does not get the collector voltage in range, you may have to use a different value boost set pot. You can use a 25K pot if your transistor has a gain down to about 45. I would not use a device with an even lower gain; get another one.

Leaky devices can be a problem. Most modern DMM’s don’t really measure leakage, and the Icbo leakage shows up as a falsely high gain on a gain test. If you have tweaked your unit in and it still does not sound right, you may have a leaky transistor. If you show a “gain” of much higher than 150 upon testing, that transistor is probably either really too high a gain or too leaky to work well.

I recommend you do the actual tuning this way:

1. Build up your circuit by one of the methods shown later. Leave the Rb1 and Re resistors out, attaching a 100K and a 10K pot respectively on long wires for each.
2. Use a DMM and set these pots to the nominal 68K and 3.9K respectively, and make a temporary mark on the pot and shaft to note the pot rotation at these values.
3. Apply battery voltage and measure the collector voltage to ground. You would like to see -6.6 to -7.2V with a fresh battery (9.0 to 9.3V).

4. If the collector is too high (the transistor is too “off”) increase the Rb1 value. If you go very near the highest resistance before you get to -7V, reset the Rb1 pot to the 68K mark and inch the Re value down a bit, then try tuning the Rb1 value again.
5. If you go near the low end of the Rb1 resistor before you get to -7V, increase the Re value slightly.
6. Once you get to -7V on the collector, turn it off , remove the pots, being careful not to turn the shafts. Measure the resistances and solder in the nearest standard value fixed resistors.
7. If Rb1 is below 27K or above 82K, or if Re is below 2.7K or above 5.1K, your transistor either has the wrong gain or is too leaky to use, you’ll have to use another one.

Once you have tuned the bias point, you may have to tweak the input capacitor, Cin. This is nominally 0.005uF in the original Dallas Rangemaster. The exact frequency response of the very simple circuit depends primarily on the value of this capacitor and the input resistance of the transistor. In the originals I have seen, the input resistance of the transistor in parallel with the two biasing resistors tends to be about 12K, so a 0.005uF capacitor makes unity gain about 80 Hz, the frequency of the lowest note on a normally tuned six string guitar. Note that some transistors will require Cin of as much as 0.0068uF. Full boost is around 1-2kHz. Minor variations of the transistor gain do affect this response somewhat, but don’t make a huge difference in the sound.

If you make the capacitor smaller, the region of full boost, moves up, but the gain at the lowest notes goes down, as the pass band of the Dallas Rangemaster moves away from it, so the sound gets subjectively thinner. If you make the capacitor bigger, the passband moved down, so progressively lower frequencies are boosted. If you make the input capacitor much larger, say as much as 0.15uF, then almost all notes are boosted to full gain, and the result is only the soft distortion on all notes, which you may prefer. This is NOT the original Dallas Rangemaster sound, but you may prefer it for your purposes. For the original Dallas Rangemaster sound, stay within about +/- 50% of 0.005uF.

Building your own workalike

A circuit as simple as the Dallas Rangemaster is simple to build. Here are three ways to make your own Austin Treble Blaster. Obviously there are many other ways, but these are simple, cheap and effective. Choose a method to match your skill and interest levels.

A word about parts: The Rangemaster is a treble booster. You can also read that “hiss booster”. If you use vintage-mojo carbon composition resistors, you’ll feel

very original, but you'll also induce hiss. Metal film is much better for this one. The transistor may also be hissy, in which case, use another one.

Terminal strip method. This is most like the original construction of the Dallas Rangemaster. Procure six-lug terminal strip, such as a Mouser part number 158-1006. The lugs on either end of this strip serve as mounting and ground points, since they each have a foot that can be screwed into the chassis.

Choose one end and number the lugs one to six from that end, the starting lug being "1". Lug 1 will be the ground point for the circuit. In this order, insert components, dress and clip their leads, and finally once all components are in, solder:

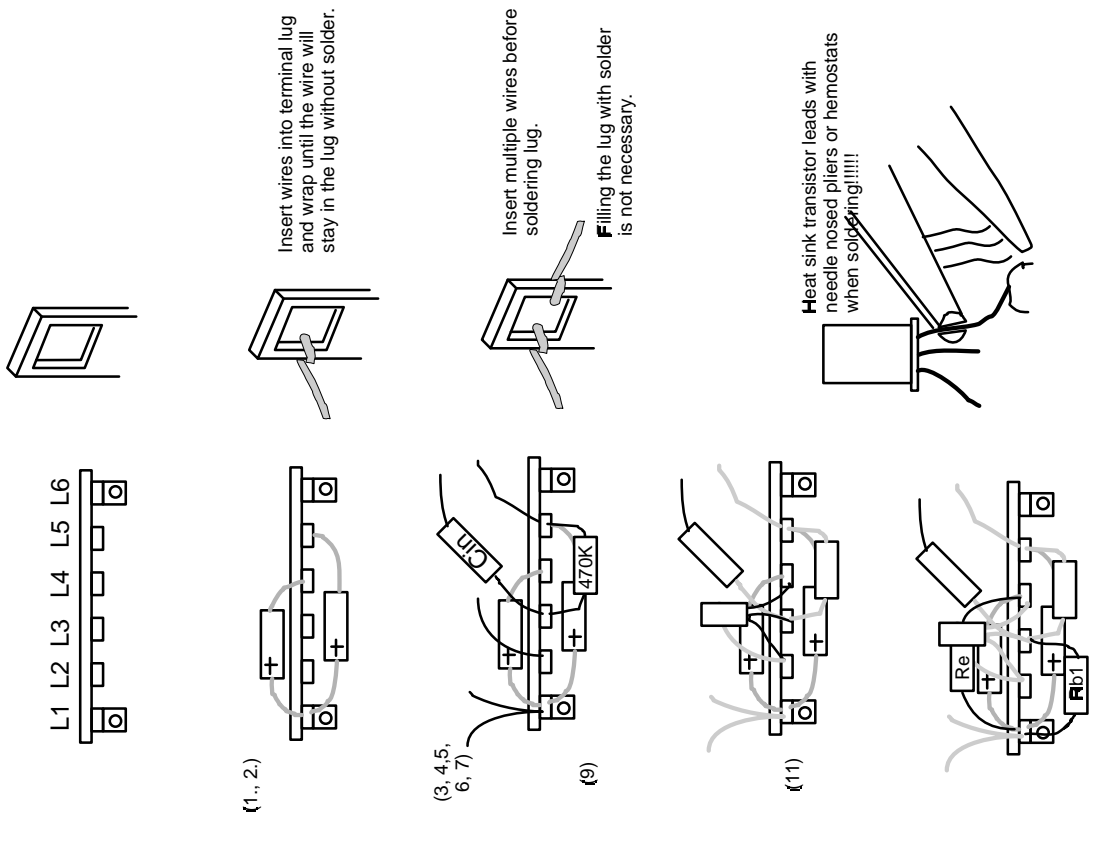
Note: if only one lug is specified, only one end of the component is connected.

1. 47uF(+ to L1): L1- L4
2. 47uF(+ to L1): L1 – L5
3. 470K: L3 – L5
4. Two ground wires: L1
5. Collector wire: L2
6. Input capacitor: L3
7. Power wire: L5
8. Solder the wires at the lugs.
9. Add the transistor, collector to L2, base to L3, emitter to L4. Use a heat sink between the solder joint and body of the transistor when you solder the device or you may ruin it! Note that you must heatsink the transistor lead each time you solder or unsolder a joint that connects to the transistor in the following two steps. This is important!!
10. Temporarily tack-solder the 100K tuning pot with wires from L1 to L3 and the 10K from L1 to L4, then perform the tuning process.
11. With the resistor values determined in the tuning process, insert the Re resistor from L1 to L4 and the Rb1 resistor from L1 to L3 and solder them in.
12. Position the terminal strip assembly in the box you're going to use and connect up the wires:
 - solder the ground wires to input and output jacks ground lugs
 - power wire to the "cold" lug of the boost set pot (the one that the wiper connects to when fully counter/clockwise)
 - collector wire to the "hot" lug of the boost set pot
 - base capacitor to the bypass switch
13. Solder the output capacitor from the wiper of the boost set pot to the bypass switch
14. Battery connector (-, black) wire to the bypass switch
15. Battery connector (+, red) wire to the input jack stereo signal lug

16. Bypass switch output wire to the output jack

If you like the idea of building the whole thing on a PCB instead of a terminal strip (musical legends aside, there is no advantage or disadvantage of point to point terminal strip versus PCB construction for this device) then you can make one either of two different ways.

Terminal Strip Method



Trace-your-own PCB method. Clean a suitable sized board blank of all traces of oil, dirt, and oxidation with a scouring cleanser and dry. Tape a bit of carbon paper over the board blank and over that tape the Trace Your Own board layout. Trace the layout onto the copper with a ball point pen. Then, remove the layout and tracing paper, and using a suitable etch-resist pen (Radio Shack sells them) ink in the pattern directly on the copper, trying to make it match the original layout. You can touch up any goofys by scraping the marker off with a sharp pointed knife for small mistakes or by wiping the board blank clean with a solvent and starting over for big errors. Once you're satisfied with the layout pattern, etch with your favorite etchant. Note that the Trace-Your-Own pattern is intended for top side soldering; you will solder parts on the copper side of the board. Note that using this method you will have to use the miniature 16mm control for the boost set pot to have enough room inside the recommended cast aluminum box, as the parts sit slightly higher than in ordinary pin-in-hole boards.

Standard drilled PCB method. Using the Toner Transfer Pattern, copy the layout to your favorite toner transfer medium (I prefer Techniks Press-N-Peel Blue) and iron it onto a board blank cleaned as above. Drill the holes in the pads and stuff the board as indicated.

The wiring diagrams and assembly diagrams for the PCB approaches apply to both PCB methods.

[Note: 11/24/98 PCB layouts will be added shortly]

Parts List and Suppliers

Part	Description	Mouser PN	M \$	Qty
OC44 [1]	PNP Germanium transistor	N/A- alternates available from GEO		1
47uF	Al Electro Cap	140-XAL16V47 (axial) -OR- 140-XRL16V47 (radial)	0.25 0.07	2
0.005 to 0.01uF	Capacitor, film see text			1
0.01uF (10nF)	Capacitor, film,	140-PF2A103K	0.14	1
4.7K nominal	1/4W resistor – see text		0.07	1
68K nominal	1/4W resistor – see text		0.07	1
470K	1/4W resistor	29SJ250-470K	0.07	1
2.2M optional	1/4W resistor	29SJ250-2.2M	0.07	2
10K “B”	Audio Taper Pot	313-4000-10K	1.74	1
1590B [3]	Box, Cast Alum. [3]	546-1590B	8.53	1
DPDT [4]	DPDT stomp switch [4]	N/A, alternates available from GEO	10.00 to 16.00	1
1/4” jack 1-ckt	Mono phone jack	16PJ023	1.22	1
1/4” jack 2-ckt	Stereo phone jack	16PJ081	1.31	1
Terminal strip [5]	Terminal strip, six lugs	158-1006	0.57	1
#22 - #24 AWG	9v battery clip stranded hookup wire knobs	12BC092	0.38	1
				1

Notes:

[1] OC44 was the original part number. This part is available only by the sheerest chance anymore. You can use most PNP germanium types if you can find on with a gain between 65 and 100, adjusting as noted in the text. Actual prototypes with type number NKT275, 2N527, 2N508, 2N404, and 2SB75 have worked very well. The replacement part ECG158 works well sometimes if you can get the right one. See if you can get the guy at the service counter to let you poke the leads through the plastic bag and test the gain at the counter before buying.

[2] These values are determined by experiment in the tuning of the pedal. You will need a 100K and a 10K pot temporarily for the tuning process.

[3] The Hammond 1590B is a comfortable fit for this effect. You can also use the Eagle equivalent, the Mouser part number 400-4591, which is a bit cheaper at \$7.35.

[4] Mouser does not have suitable stomp switches. The Carling 317P is the old standard, and is available through Stewart Macdonald Luthier supply for about \$17. Another usable one is the “Arrow” DPDT available through GEO for \$8.50 at the time of this writing.

[5] The terminal strip should only be bought if you are doing the hand-wired version. It is not needed for the PCB versions.