Make Your Own Voltage - Dropping Solid-State Rectifier That Looks Like a Vacuum Tube!

Here is how to build your own version of the *HardWay* FireFly 5Y3-FF rectifier.

(link to the FireFly Device page)

What it does:

- Plugs into your existing rectifier socket.
- Reduces the delivered voltage to your amp by 20-30 Volts.
- Controls inrush current.
- Provides "Sag" when the amp is pushed.
- Adds no noise to the amp.
- Looks like a glass vacuum tube, even has orange filament glow!

The build of this rectifier is fairly simple, but because you are building it inside a confined space (like building a ship inside a bottle), there is not a lot of room for messy soldering or poor lead dress. You should be capable with electronics, soldering, and electrical safety before embarking on the project. It's also a very good idea to "dry-fit" all the components into the tube before you start soldering.

The FireFly 5Y3-FF Rectifier.
The components are inside a silvered glass tube and mounted to a large metal/ceramic octal base.
A 6V amber wheat bulb lights when the rectifier is operating, giving the appearance of tube filament glow.

This rectifier was developed for the 5E3 Fender Deluxe amplifier, although it can be used in other amplifiers, and replace other vacuum tube rectifiers. The 5E3 Deluxe, like other vintage amps, suffers from high circuit voltages that shorten the life of tubes and capacitors and other circuit components. This is due to the higher modern line voltages compared to the line voltages available when these amps were designed – in the 1940s and 1950s wall outlets delivered about 110 VAC. Today's voltages are closer to 130 VAC.

There are numerous ways to reduce vintage amp voltages, but I think this is the best solution because (1) it doesn't modify the amp circuit in any way from its original design; (2) the original vacuum tube rectifier can be replaced in less than a minute, so the amp is back in "stock" form; and (3) The FireFly looks and acts like a  vacuum tube.

Parts List:

Here are the parts you will need to build a FireFly, a source, and an approximate price:

(1)	**Metal/ceramic octal base**, 1.57" OD.	*Antique Electronic Supply* P-SP8-477	$3.25
(1)	**38 x 200 mm glass test tube**.	*eBay*, Get more than one.	About $5.00
(1)	**Aluminum power resistor**, 500Ω, 50W	*Digi-Key* TMC50-500-ND	$12.54
(1)	**Miniature full-wave bridge** 0.9A 65V	*Digi-Key* B40C800G-E4/51GI-ND	$0.48
(2)	**Diodes**, 1N5408	*Mouser*, *Digi-Key*	about 7¢
(2)	**Disc capacitors**, .01/1kV	*Mouser, Digi-Key*	about 31¢
(1)	**Aluminum capacitor**, 1000 µF, 16 V	*Digi-Key* 493-1526-ND	$0.61
(1)	**Inrush current limiter**, CL90	*Digi-Key* KC009L-ND	$2.67
(1)	**Stainless basket strainer** 1¼ X 7/8"	*Hardware store*	Less than $4
(1)	**6V wheat bulb** with leads, amber	*eBay*	10 for $5
(1)	**Tiny Grommet**, .336 x .125"	Tiny *Grommet Store*	Not much
(1)	**Insulating Coating**, black	*GC Electronics*	$10
(~)	**High-temperature hook-up wire** 18AWG Solid		Meh.
(~)	**Spaghetti tubing,** black, (preferably) fiberglass tubing		Meh.

All the parts you will need…

Plus, this little guy.

Glass Tube Preparation:

The 1.5" OD heavy wall glass test tube will be much too long for our purposes, so we need to cut the end off so you have a domed end section that is 3 ¼" long. Use your preferred method of glass cutting, but make sure to file and smooth the cut end so that you don't lacerate yourself.

I silver the inside top 1¼" of the dome so that it looks like getter flash, but this is optional if you would rather not mess with dangerous chemicals. There are lots of "How-To" videos on YouTube which detail how to silver glass. One of the best videos is:

https://www.youtube.com/watch?v=hUX_cpFWNso

You can transfer the silver nitrate solution from your mixing vessel to the glass tube and let the reaction take place, without disturbing the glass tube. If it turns out a little uneven, that's ok, most tube getters aren't even, either. Paint the inside of the silvered section with high-temperature barbeque paint (black). This will prevent damage to the silver and prevent it from oxidizing.

Octal Base Preparation:

Remove all the pins from the base except for pins # 2, 4, 6, and 8. The pins are easy to remove by using a small drill bit and cutting the inside flange of the pin where it is swaged into the holes in the ceramic base. Once the flange is removed, a pair of needle-nose pliers can be used to wiggle the pins out.

Drill a 1/8" hole into the ceramic center pin. Use a carbide drill, nothing else will cut the ceramic. Be prepared for failure, and have some spare bases on hand. We need this hole for ventilation, and besides, it makes the tube look like a Mullard.

Mark the inside of the base with the pin numbers. Trust me, you'll appreciate this later. *Refer to a pinout drawing of a rectifier tube like 5Y3-GT to be certain your pins are numbered correctly.*

Basket Strainer Preparation:

Drill a 1/8” hole in the middle of the basket strainer. There is already a hole there, so you are just making it wider. Insert the grommet into the hole. This insulates the basket from the circuit,

Aluminum Resistor Preparation:

Cut the mounting tabs off the resistor with a Dremel or another tool. Smooth the cuts with a file so it looks nice. This big power resistor is going to get very hot during operation – as hot as a vacuum tube. If you read the FireFly page on my website, you know that I tried to force ventilate the resistor with the **World's Smallest 5VDC Fan**. It worked quite well, but it added noise to the circuit that I couldn't seem to get rid of. Anyway, I subsequently found that the **Hole in the Pin** idea worked very well to control temperature, so I never went back to the fan. *(I have a bunch of these fans, which cost over $10 apiece, so if you want one to play with, I will sell you one for $5.)*

Using Ohm's law, you can decide what value of resistor to use to get the voltage drop you want for your particular amplifier. The 500Ω version I am using here is for a Fender Deluxe power transformer, and reduces the rectified voltage by 20 30 volts to the plate of the 6V6. Your mileage may vary, so check your amp's transformer secondary output voltage and current to your rectifier, either by direct measurement, which is probably best, or by using the values from the specification sheet for your transformer, and use these to calculate what resistance you need for the voltage drop you want.

Ohm's Law: **E = IR** (Voltage equals current (in Amps) times resistance (in Ohms)

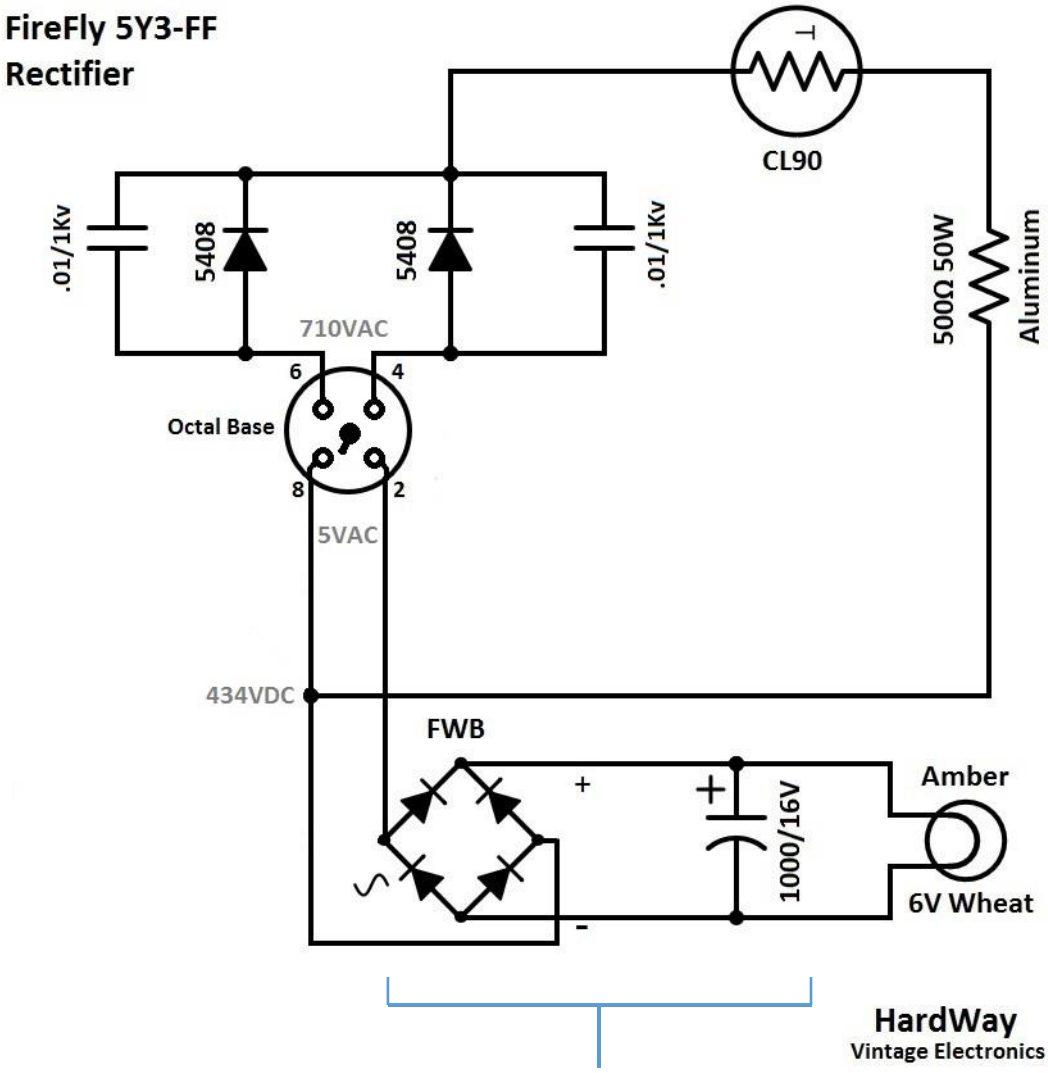
Therefore: If the current *at the power resistor* is 62 mA, and the Resistance is 500 Ohms,

then the Voltage drop is .062 X 500 = 31 Volts. Close enough.

This resistor is also what provides "Sag" when the amp is pushed. It is not exactly the same as sag from a vacuum tube, but in the current range in which the amp operates it is very close.

The perforated metal basket is an important component for thermal control; it gets hot along with the resistor and helps radiate heat.

Schematic:



The full wave bridge and filter capacitor are only required if you plan to use a tiny 5V cooling fan; the wheat bulb can use AC.

ASSEMBLY:

OK; be neat, methodical, and patient. Workmanship counts. Refer to the schematic frequently.

The 1N5408 diodes have thick leads which fit nicely in the hollow pin of the base. They go into pins 4 and 6. Have both diode stripes (cathodes) facing up, away from the base. Dry fit them first, and make sure the leads are very straight - they are going to be structural support for some other components. You may want to cut ¼" from the leads of the anodes of the diodes so they sit closer to the base, but when the lead bottoms out in the pin, there should be at least ¼-½" space between the body of the diodes and the floor of the base.

Bend the leads of the diodes so that the diode body is offset from the pin and aligned closely with the inside edge of the base. You must make room for the big resistor which will be centered in the middle of the base. Again, dry-fit things and adjust as needed.

Bend the cathode ends of the diodes at right angles towards each other. Cut off the overhanging ends of the leads. Solder the two parallel leads so you have a nice, neat line of solder across the join. Now solder the .01/1kV capacitor in parallel to each diode. Use more or less the full length of the leads, but be sure to insulate them with fiberglass tubing. Solder the cap leads close to the diode body. Use a heat sink on the diode lead being soldered, next to the body of the diode. The cap leads are long because you are going to bend the leads so that the caps surround the central aluminum resistor, later. (Remember dry-fitting).

Cut a 4½" length of 18AWG solid wire and straighten it. Strip one end, and insert it into pin #2. You can solder this wire now. If you are unfamiliar with soldering hollow pins, the best way I have found is to heat the outside of the pin with your iron at 700˚ F. Flow the solder through the hole in the end of the pin so that the wire is well-involved. If the solder forms a blob on the end of the pin, you can file it off later, just make sure the diode lead is well-soldered into the pin.

Cut a length of *bare* 18AWG wire about an inch long. This wire solders to the eyelet on the end of the aluminum resistor. Center the resistor vertically over the middle of the base and bend the wire so that it can be inserted into pin #8, and the eyelet of the resistor is directly over the vent hole in the center pin you drilled earlier. The eyelet should be flush with the center pin hole. Don't solder it yet.

Make another 4½" length of straight 18AWG insulated solid wire (it can be a different color) and solder it to the resistor wire you just made, at the point where it bends to enter #8 pin. This wire is vertical, just like the wire you soldered to pin #2. Solder the assembly of resistor and wire into pin #8. Now you can bend the disc capacitors connected to the diodes around the resistor, even with the plane of the resistor, but not touching it. Trim any protruding wire ends and adjust the assembly so the resistor is centered, straight, and looks nice.

Trim one end of the CL90 so that it is about 1" long. Insulate the leads of the CL90 with fiberglass tubing, leaving ¼' or so bare wire at the ends. Solder the short lead to the cathode

end of the diode in pin #6. The remaining lead bends at a 90˚ angle and heads upstairs like the wires in pins #2 and #8. Bend the CL90 around the resistor, as you did with the disc capacitors. It's OK if the CL90 contacts the side of the resistor, because once the resistor heats up it will transfer heat to the CL90, which will reduce the CL90's resistance, which is what we want to happen when the rectifier is operating. Solder the free end of the CL90 to the upper eyelet of the resistor. Put a dab of insulating goo over the eyelet.

OK, now you can start the second level of the ship in a bottle.

1.
Place the open end of the metal basket over the resistor. The resistor eyelet should enter the grommet, but it probably won't go all the way through it, although it's ok if it does. Run the two vertical wires through any other two holes in the basket. Insert the grain-of-wheat bulb through a hole in the basket, about half-way into the basket. Put a blob of insulating goo on the wires where they enter the basket hole to keep the bulb in place.

Hey! You can skip step #2 if you do NOT plan to use a tiny DC fan for cooling. Just connect the wheat bulb leads to the 5 VAC wires (pins #8 & #2). Polarity doesn't matter.

2.
Shorten the two 5VAC wires (pins #8 & #2) as needed and solder them to the **~** leads on the miniature bridge. Polarity doesn't matter. Shorten the bridge leads as needed also, you want the bridge to be flat and close to the top of the basket. Solder the **+** lead of the 1000 µF capacitor to the **+** lead of the bridge, and the capacitor **–** lead to the **–** lead of the bridge. The leads should also be shortened so that the whole assembly is close together and compact, sitting on top of the basket, and not overlying the edges of the basket. Now solder the leads of the grain-of-wheat bulb to the **+** and **–** leads of the bridge. Polarity doesn't matter.
3.
We are about done. Go around with the insulating goo and cover the 5408 diode leads, the bridge leads, and any other bare wire that has the potential to touch something it shouldn't. Your lead dress should be so good that none of these wires are near anything else, but this is an extra measure of security.
Make sure everything is neat and straight and even. Once we seal the glass tube you won't be able to adjust anything ever, ever again.

Trial fit the glass tube over the assembly. It should fit easily with no rubbing and have solid contact with the base. If not, adjust things until it is correct.

Before you seal the glass tube, *triple* check your connections, referencing the FireFly 5Y3-FF schematic. Check all your solder joints and lead dress.

Check for shorts with a DMM. You should not measure any resistance between any of the pins #2, 4, 6 or 8. If you do find some resistance between any two pins, something is bad wrong. Fix it.

The best sealant I have found for the tube-to-base seal is red RTV high-temperature sealant.

4.

Run a bead along the inside edge of the base and a *little* up the sides. Then carefully insert the glass tube, twisting it a bit to spread the sealant around. Don't make a mess. Get it where you want it, and then leave it alone for at least 24 hours.

You are done, except for testing. Good for you!

Does your FireFly look like this?

WARNING:

The voltages in an amplifier can kill you. *An amp can kill you even if it is off and unplugged*. You must be qualified to work inside an amplifier. If you are not, or if you have any doubts about your ability in this regard, get a qualified technician to do the testing for you.

5.

TESTING:

If you have a Variac, good. Install the FireFly into the rectifier socket of your amp. ***Handle it by the base, not the glass tube.*** Plug your amp into the Variac. Start your Variac at low voltage and bring it up in steps to normal line voltage (~122VAC). Check the output voltage of the rectifier (pin #8), and watch out for smoke or other unusual activity. If you don't have a Variac, you can just plug in the amp and check voltages and pay attention to any alarming smoke and noise. Almost certainly you have completed the project perfectly and you won't have any problems.

The voltage at pin 8 should be considerably less than it was with a vacuum tube rectifier. How much? Well, in my 1957 Fender Deluxe, with a wall voltage of 125VAC, a 5Y3-GT rectifier tube delivers 382 VDC to the plates of the 6V6s (Yikes!), and the cathode resistor drop is 22.2 Volts.

When I replace the 5Y3-GT with the FireFly, the plate voltage is 352 VDC and the cathode resistor drop is 20.3V. That's a 30V drop of plate voltage. Just right!

You will want to check the bias of your amp after installing the FireFly.

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Thank you, and

Best Regards,

Don Hayward

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