Vacuum Tubes

By: Oren Levy

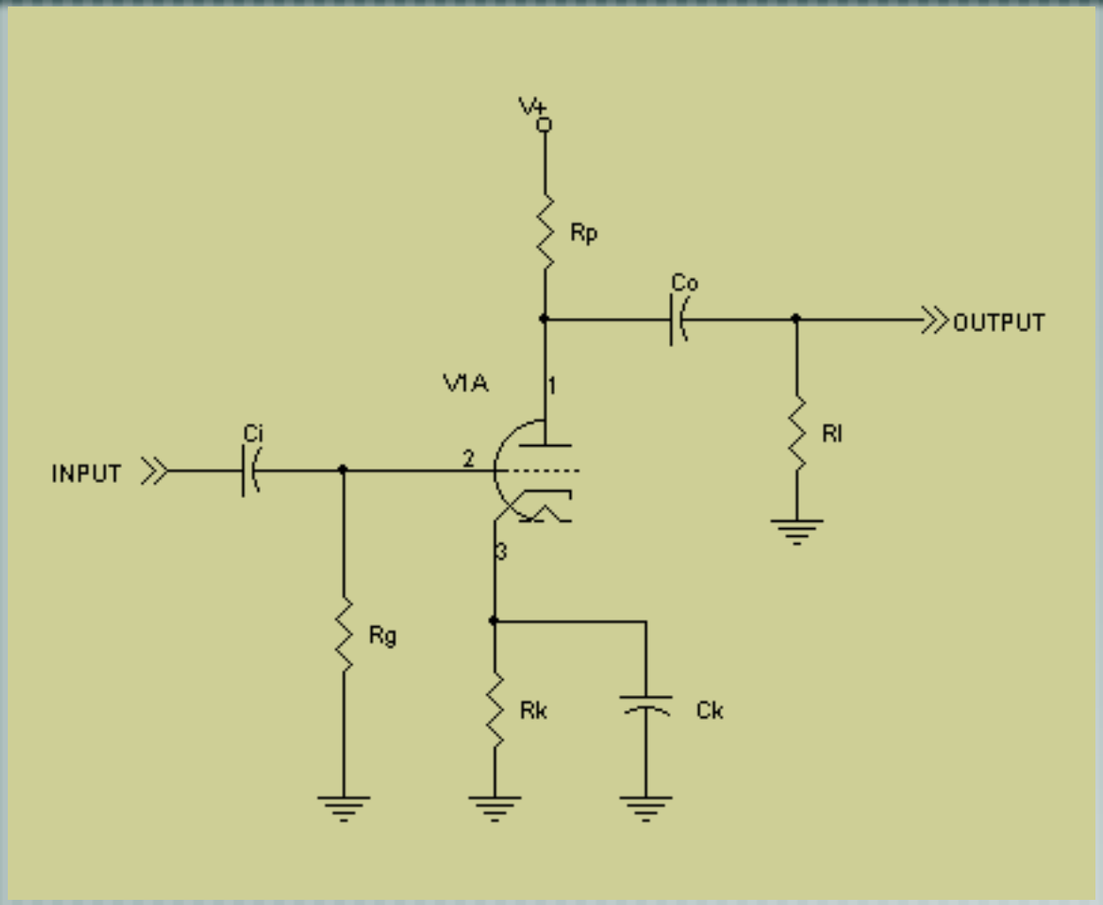
Thermionic Emissions

- The Cathode is heated up either directly or indirectly to the point that it omits electrons
- When electrons leave the Cathode, they go towards the positively charged Anode
- When electrons hit the Anode, they usually have enough force to knock off more electrons causing a secondary emission
- Suppressor grids held at ground prevent secondary emissions
- The tube’s vacuum is held between 10uPa and 10nPa to prevent other gas particles from impeding electron flow

Thermionic Emissions

- Originally tubes were designed to work with batteries where A, B, and C type batteries were all used for the various voltage within the tube
- AC voltage was not used with tubes at first due to their alternating property until proper transformers were developed
- Microphonics - when mechanical vibrations are turned into electrical noise

Common Cathode Amplifier



Gain: Av = (mu * Rp)/(Rp + ra)

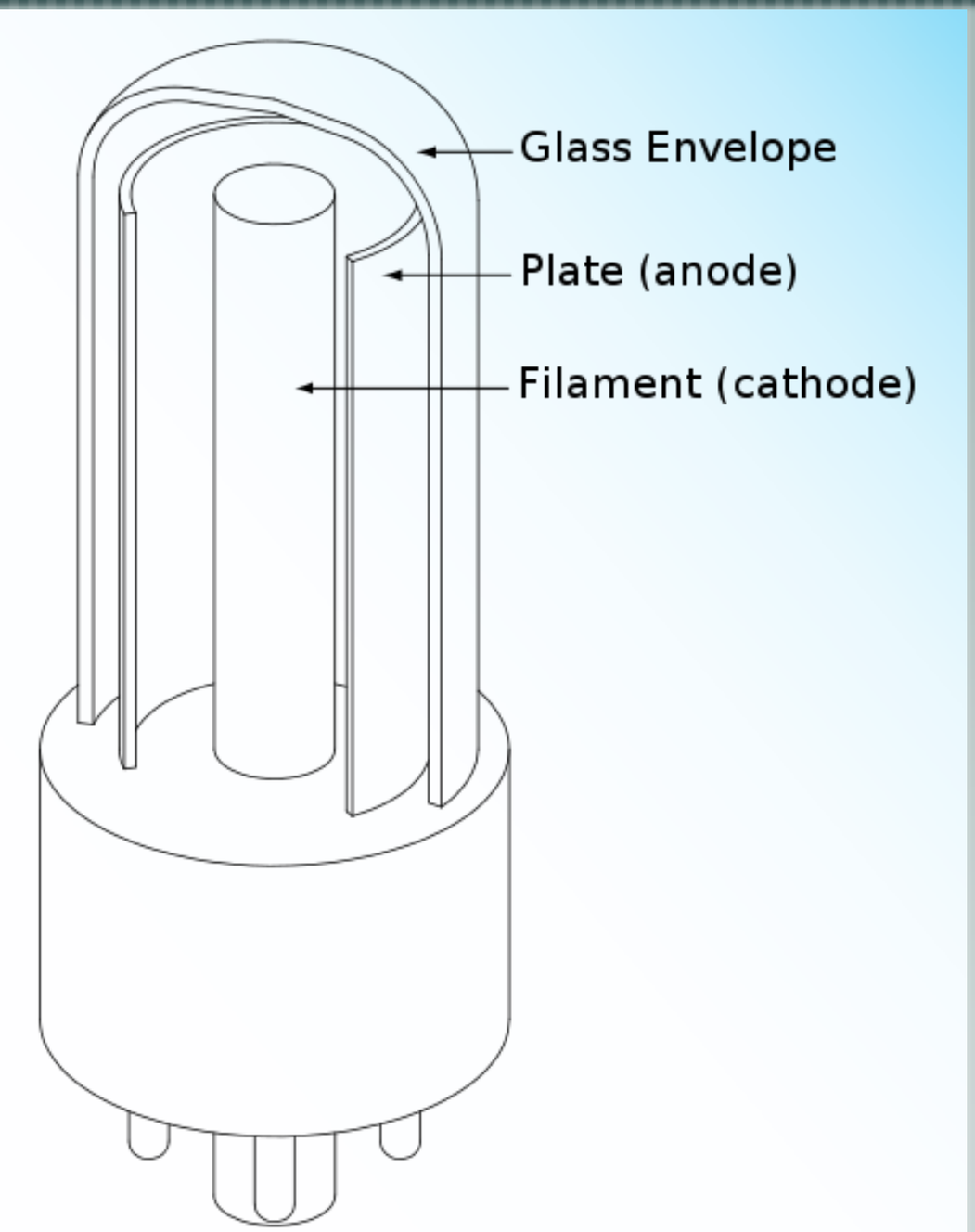
mu is the amplification factor

mu = gm * Rp

Rp = plate resistance

gm = transconductance (the ability to change the current in the tube by applying a voltage on the grid)

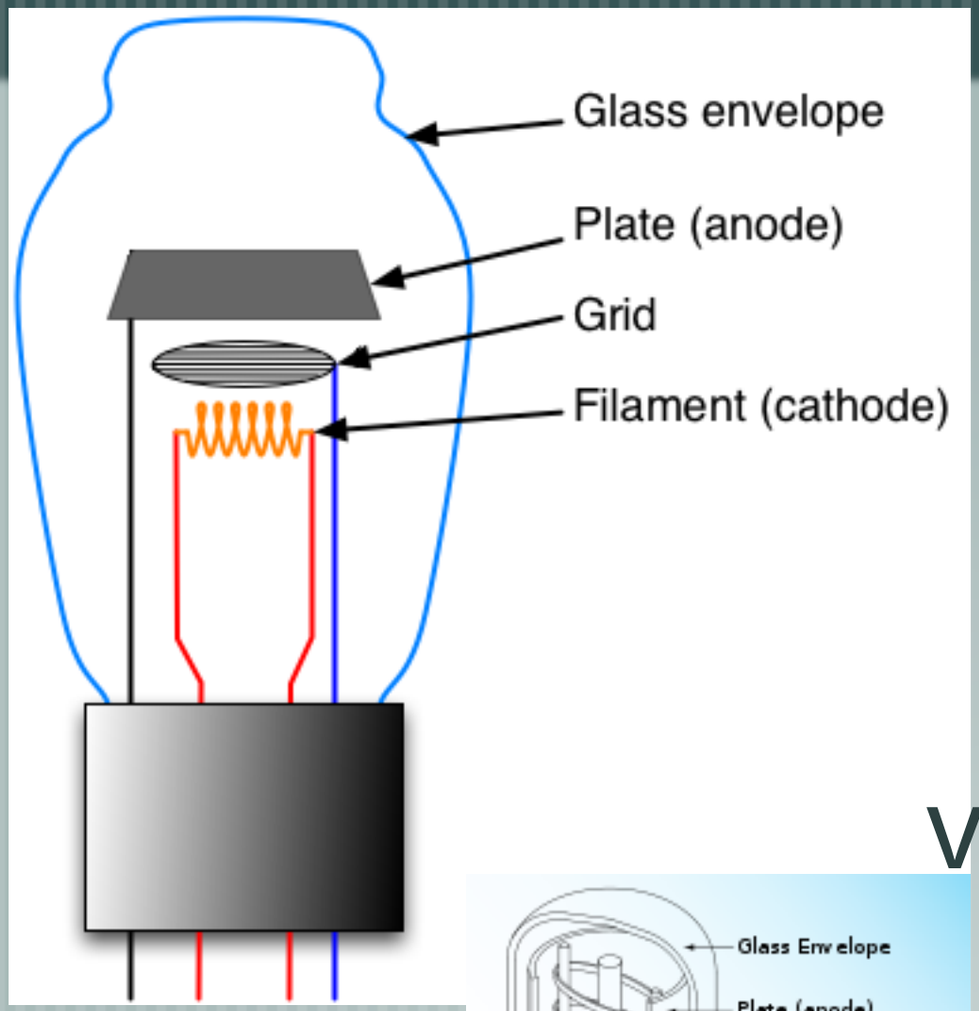
Diode

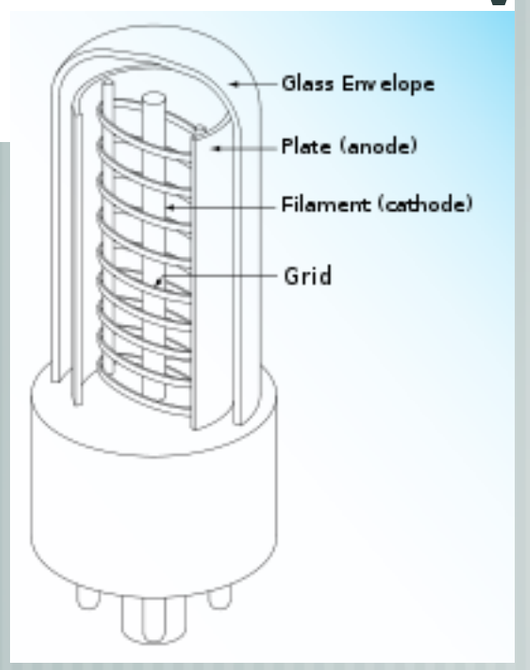


1. The filament heats up
2. Electrons are omitted
3. The positively charged plate attracts the electrons

Electrons only travel in the plate direction due to the charge difference between the anode and cathode

Triode

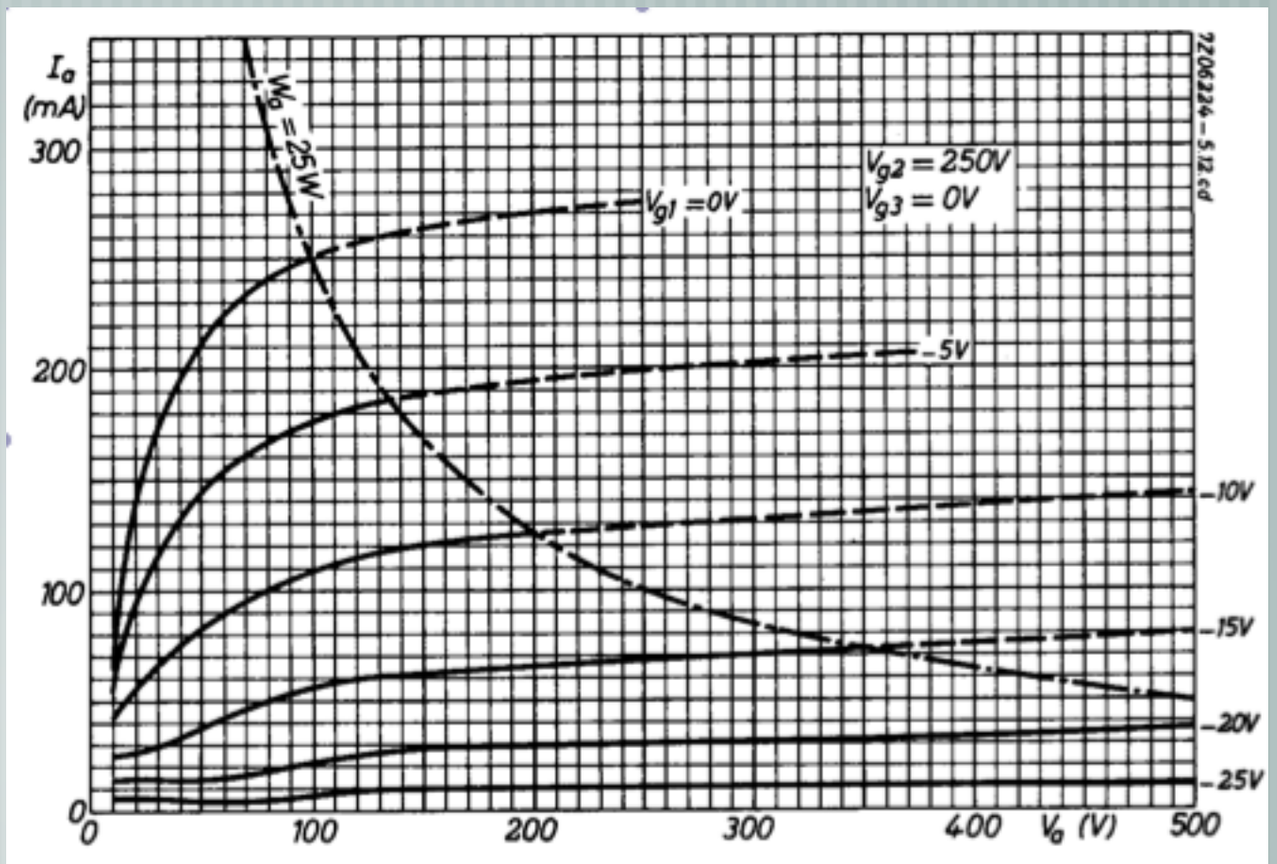




The triode includes the addition of the grid. The grid is charged with a voltage in between the cathode and the anode.

EL34 Pentode Tube

Used for power amplification
Indirectly heated element

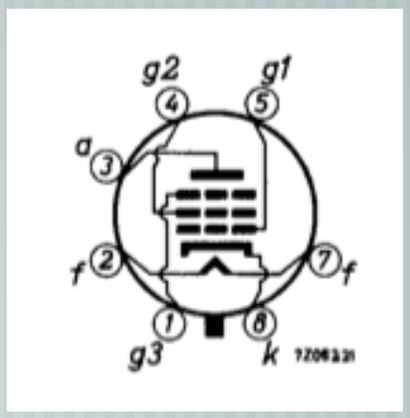


EL34 Pentode Tube

Class A:
Supply Voltage 256V
Anode Voltage 250V
Grid Voltage -14.5V

Maximum Voltages:
Supply Voltage 2000V
Anode 2000V
Grid Voltage 800

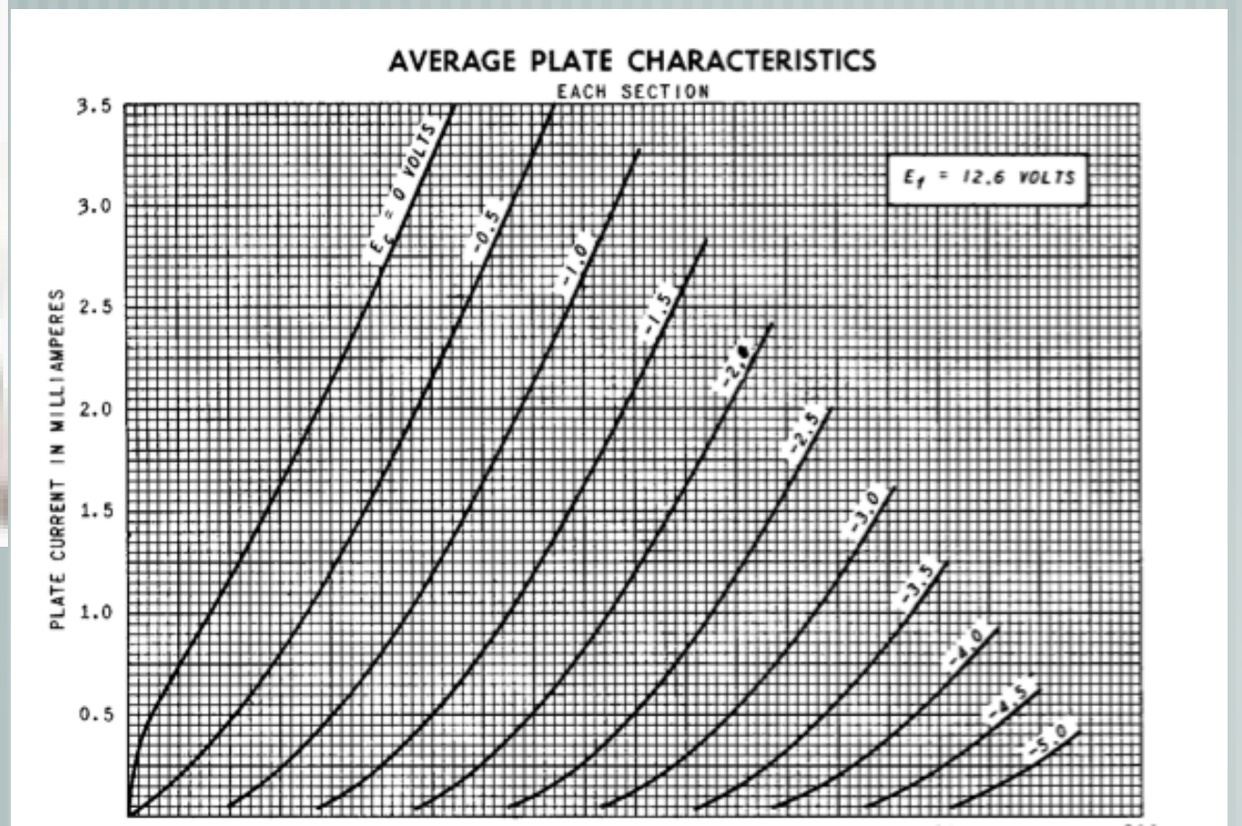
Class B (Push Pull):
Supply Voltage 425V
Anode Voltage 420V
Grid Voltage -38V



12AX7 Dual Triode Tube

Used in the pre-amplifier section

Has the highest gain from the 12Ax7 group without sacrificing microphonics.



Only requires either a 12.6 or 6.3V heater voltage

mu = 100

gm = .0016 A/V

Rp = 62,500

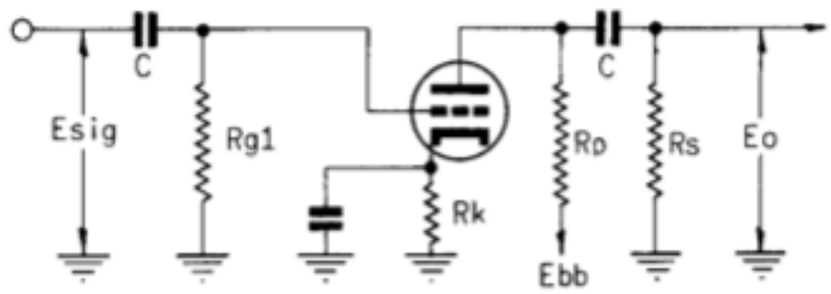
12AX7 Dual Triode Tube

Maximum plate voltage 300V
Maximum grid voltage 50 V
Maximum heater voltage 180 V

CLASS A RESISTANCE-COUPLED AMPLIFIER

EACH SECTION

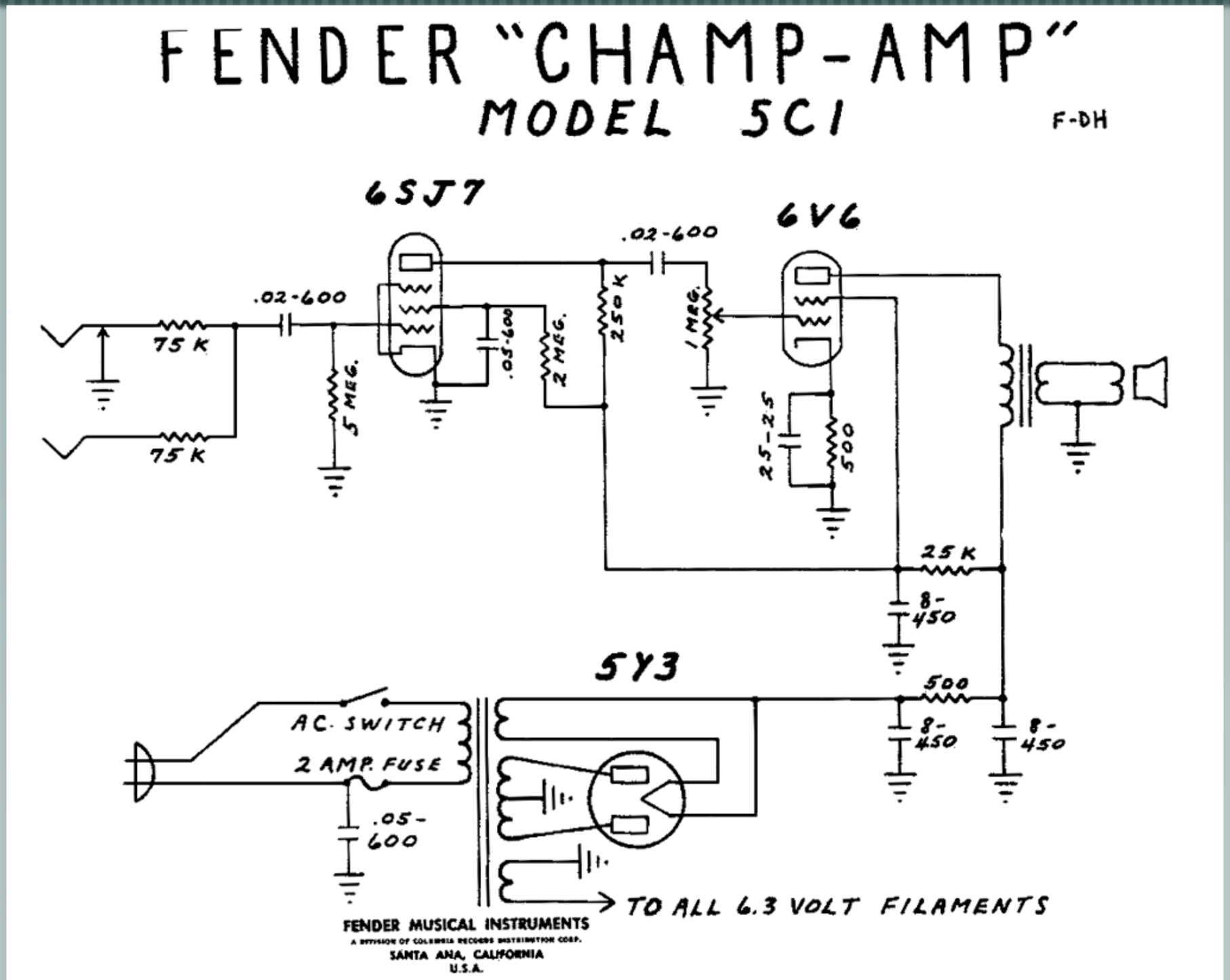
R_p Meg.	R_s Meg.	R_{g1} Meg.	Ebb = 90 Volts Rk	Gain	Eo	Ebb = 180 Volts Rk	Gain	Eo	Ebb = 300 Volts Rk	Gain	Eo
0.10	0.10	0.1	1700	31	5.0	1000	40	15	760	43	30
0.10	0.24	0.1	2000	38	6.9	1100	46	20	900	50	40
0.24	0.24	0.1	3500	43	6.5	2000	54	18	1600	58	37
0.24	0.51	0.1	3900	49	8.6	2300	59	24	1800	64	47
0.51	0.51	0.1	7100	50	7.4	4300	62	19	3100	66	39
0.51	1.0	0.1	7800	53	9.1	4800	64	24	3600	69	46
0.24	0.24	10	0	37	3.9	0	53	15	0	62	32
0.24	0.51	10	0	44	5.4	0	60	19	0	67	41
0.51	0.51	10	0	44	5.0	0	61	17	0	69	35
0.51	1.0	10	0	49	6.4	0	66	21	0	71	41



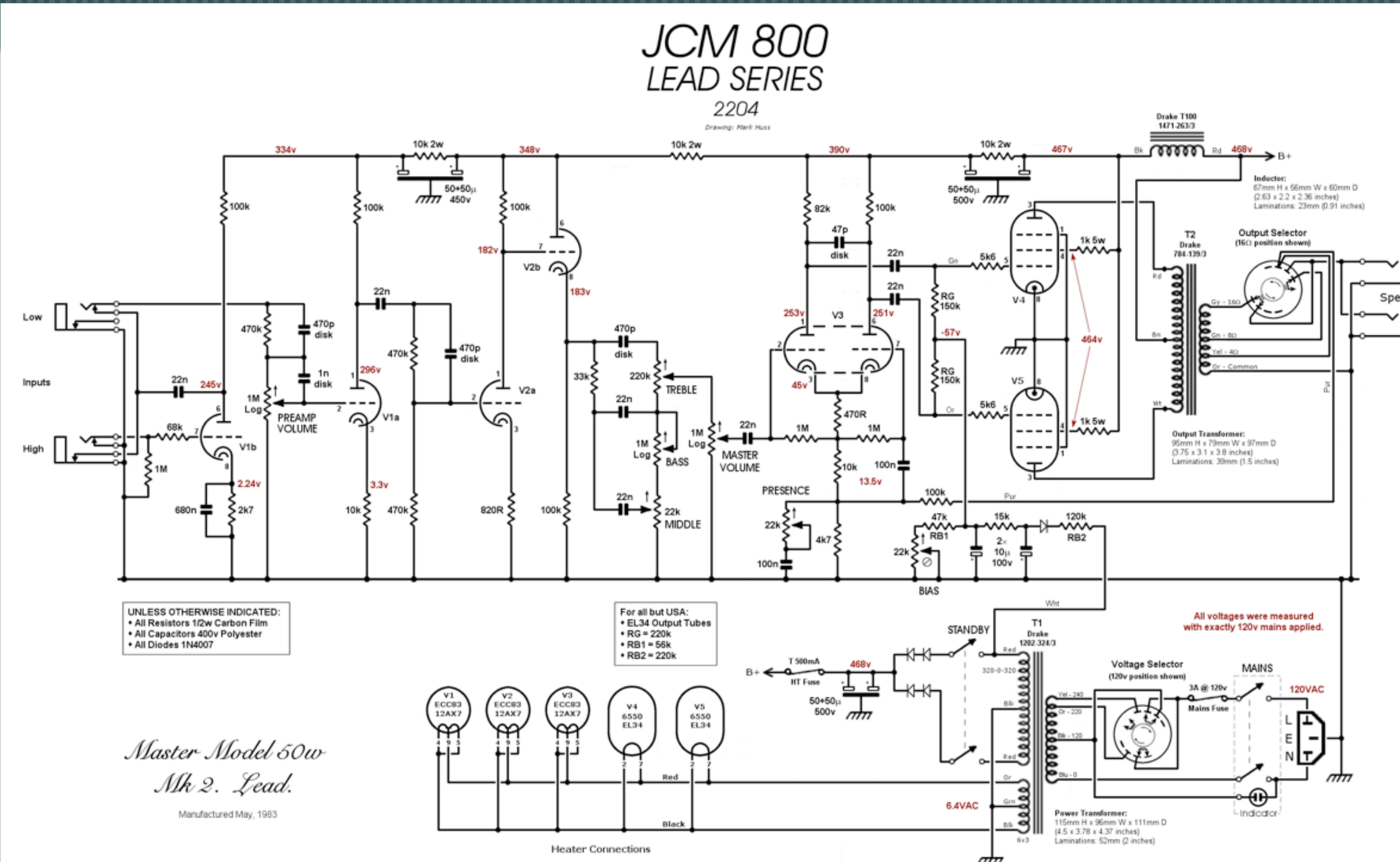
Note: Coupling capacitors (C) should be selected to give desired frequency response. Rk should be adequately by-passed.

Notes: 1. Eo is maximum RMS voltage output for five percent (5%) total harmonic distortion. 2. Gain measured at 2.0 volts RMS output. 3. For zero-bias data, generator impedance is negligible.

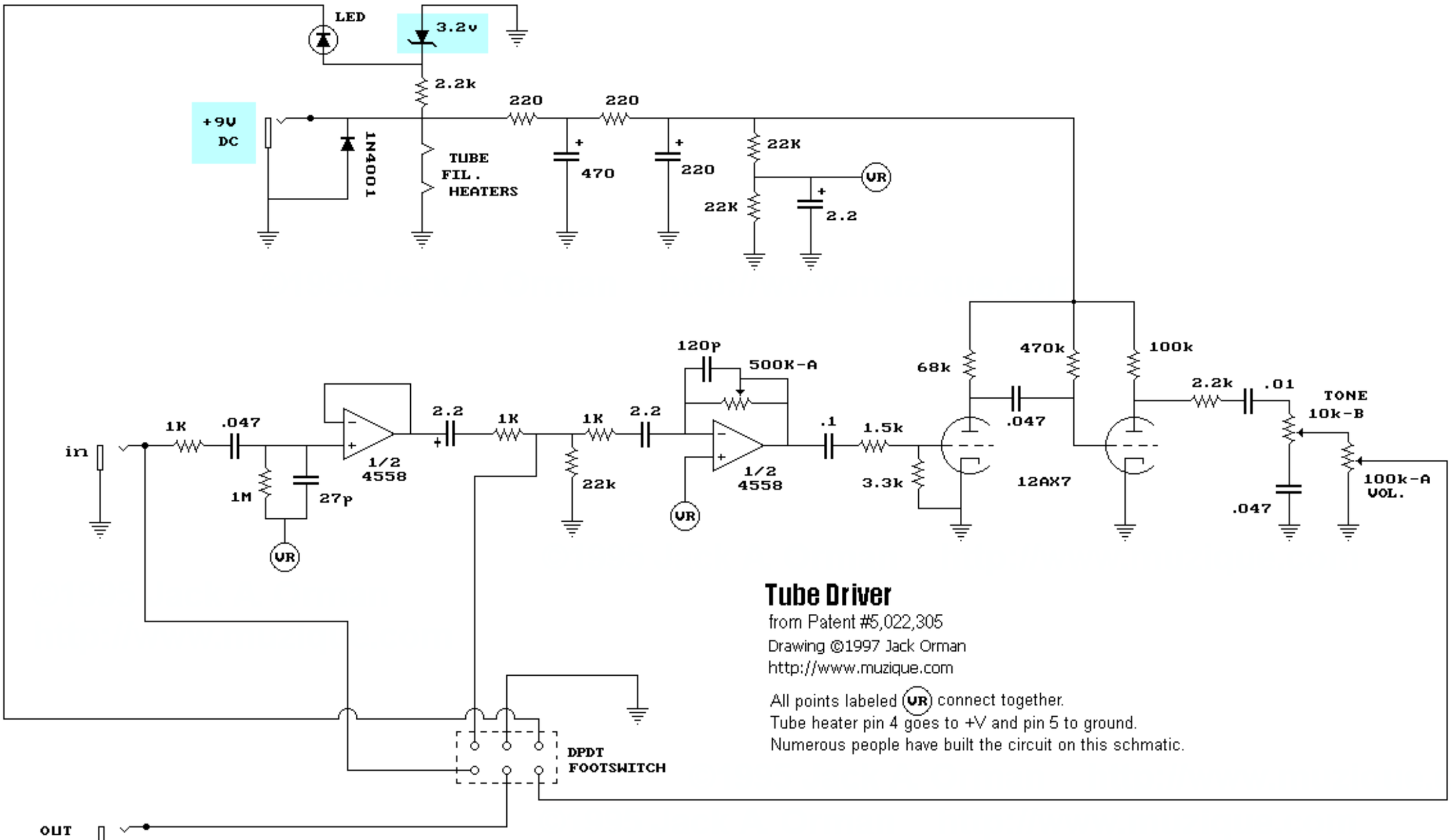
Fender Champ 5c1



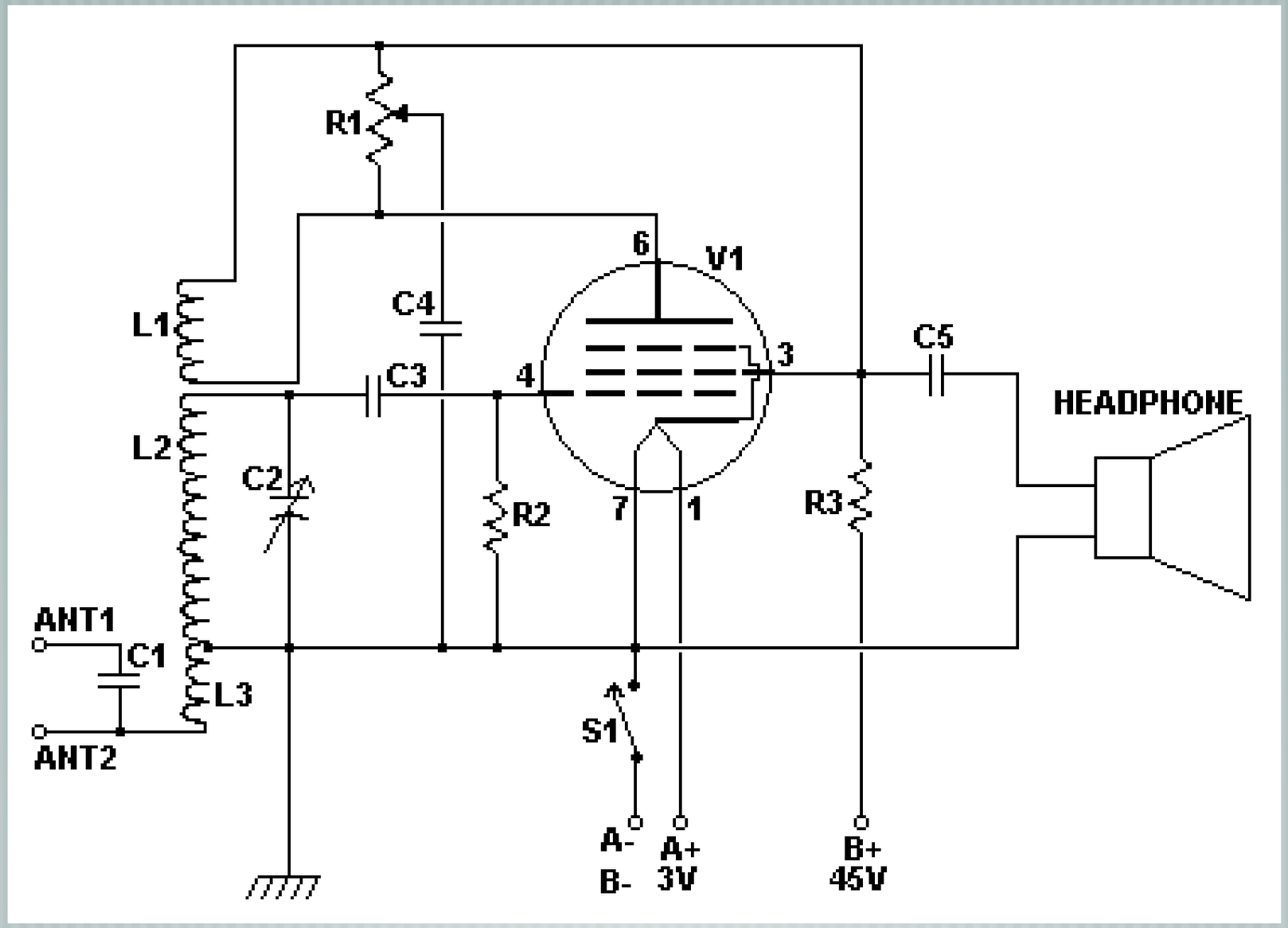
Marshall JCM 800



Battery Powered Tube Circuits



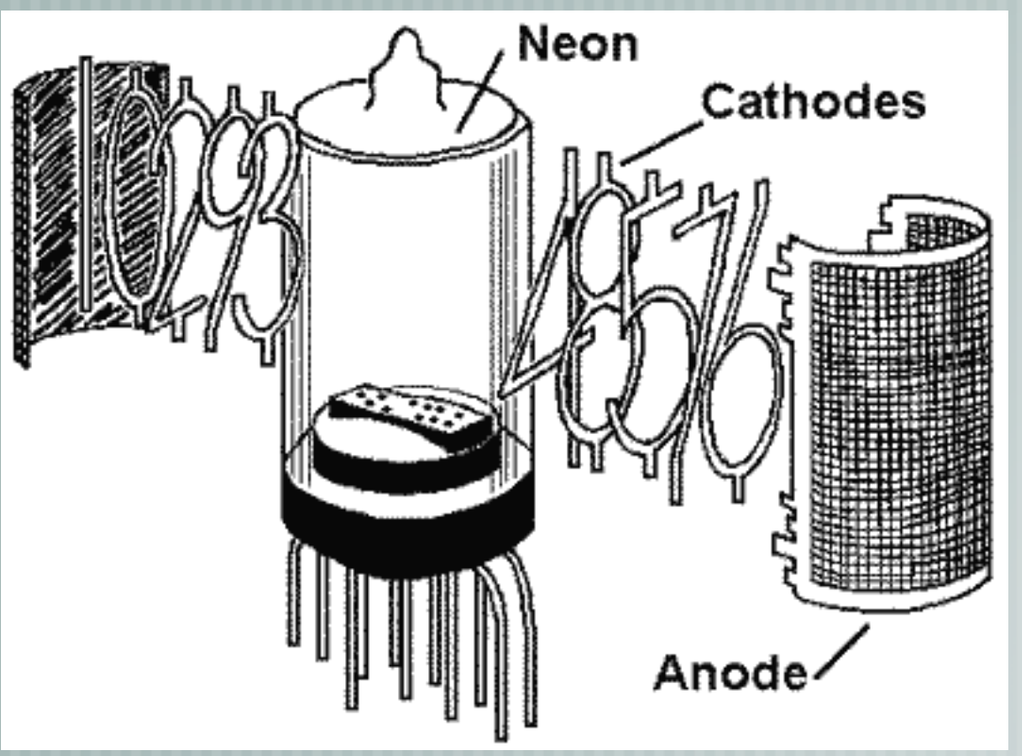
Single Tube Radio using 6A4



Nixie Tubes

QuickTime™ and a
GIF decompressor
are needed to see this picture.

Contain one surrounding Anode and one Cathode for each number



Contain Neon Gas

Require 170V to operate

Colossus