1. Summary

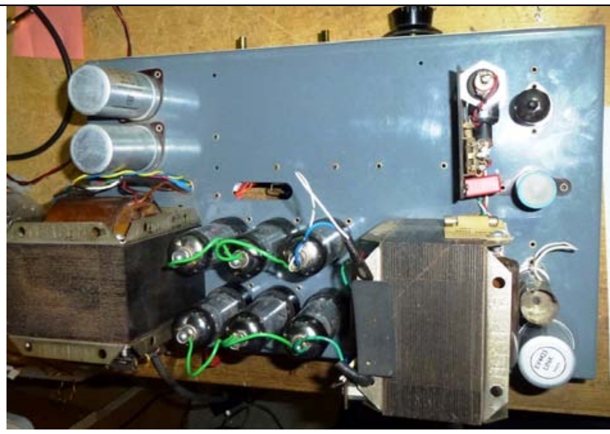
Valve PA Amplifier. $108.50 eBay May 2013
Philips label – Model EV4437A – Serial No 1739

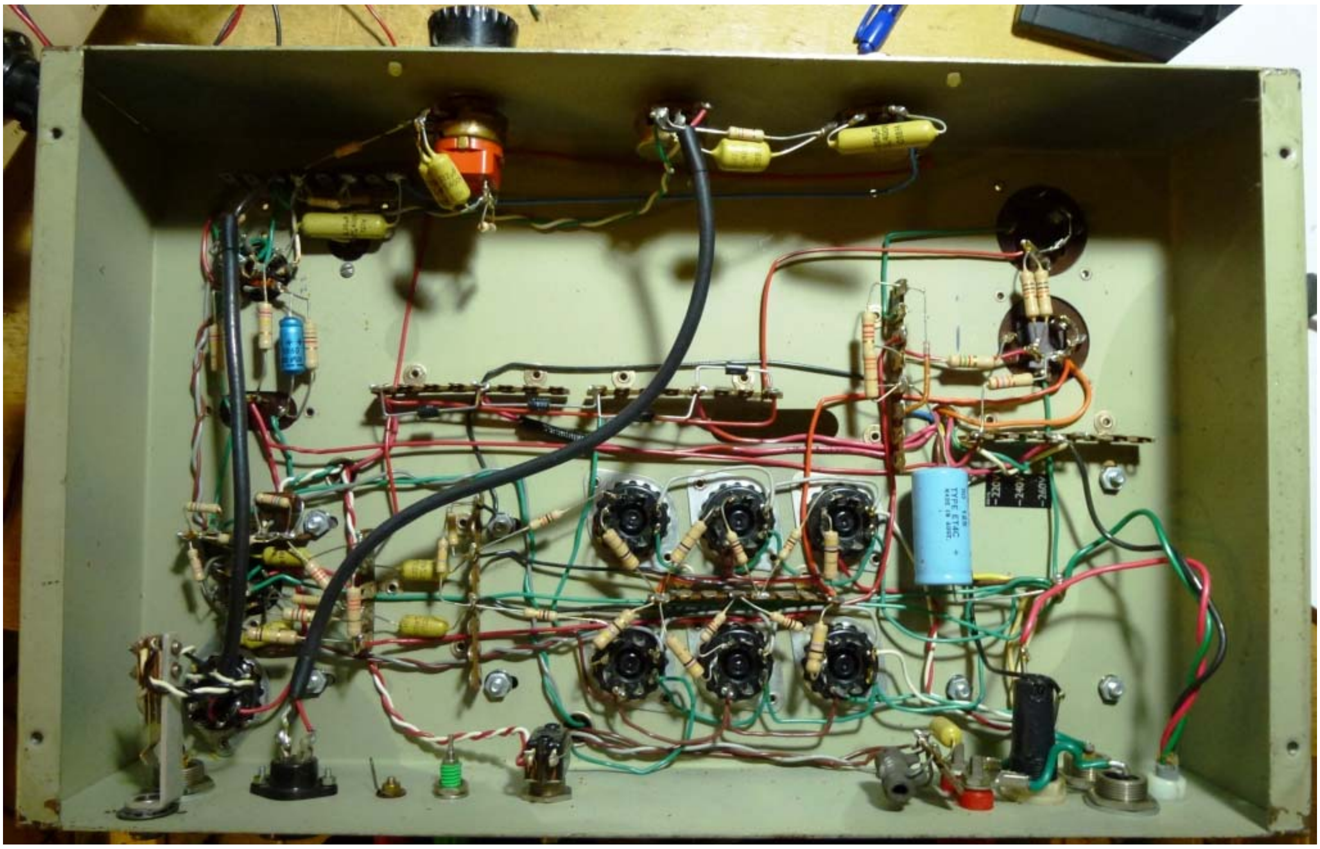
Two input, mono 120W amplifier with tone control and 25V/50V/100V line level outputs. 12AX7 preamps; 12AX7 driver and concertina PI; sextet 6CM5/EL36 fixed bias, push-pull output. OPT separate output feedback winding to driver/PI, and monitor output. Both triodes in preamp with common bypassed cathode resistor. LDR limiter from plate driven neon and output driven incandescent bulb. Parts info/markings:

Power Transformer	No markings. 220;240;260 label under tagstrip.
Output Transformer	2638. 1.15k PP; 0.14, 1Ω, 25-50-100Ω secondaries
POTs	500k IRC: K8, H8, A6
Caps	Ducon ET4C [4168, 0768 4068]; ECT148 [4368]; mustards [127H, 108H, 068H, 088H, 018H038H, 068H]; 50uF 25V 098H
Valves	6CM5 x6, Miniwatt DI C8I 880 (all same batch; DI=6CM5; C=Hendon works; 8=1968; I=Sept) 12AX7 x2, Miniwatt 513

Purchased condition: clean; slightly modified for university lab experiment (tone knobs replaced by locking presets; added earth 4mm socket; added speaker RC network; added 2 sockets for output); unsoldered speaker connection; V1 metal cover crimped to valve; scratchy pots.

Concerns: mains wiring; over-current protection; limiter loading on one side of PP; electrolytic and paper caps; no bias adjust; bias ripple; high gain from input.





Dating:
The 6CM5 and mustards appear to indicate 1968-9 build timing. The labels indicate 1966 model start.

2. Modifications

- Mains switch and 3A fuse in active. MOV across PT primary. Insulation on primaries.
- NTH13D160LA NTC thermistor in PT primary (16Ω cold) to support extra filter capacitance.
- 1.5A fuse in VS1 filtered DC line (practical option given AC winding configuration and relatively low DCV).
- HT diodes and PP stage 0V and bias 0V to VS1 and VS2 filter cap neg local star. New electrolytics: 2x 100uF (not 3x 24uF), and 3x 15uF (not 3x 24uF).
- Added 10R 0.6W cathode sense (poor mans fuse) to each 6CM5 (pin 8 to 1) – 1.2Wpk, 0.6Wmax square wave. Added common cathode 1R 2W for total bias current sensing.
- Added 6.5mm insulated socket in LHS front panel hole for guitar input – switched short to gnd with no plug inserted.
- Speaker output banana sockets disconnected. Neutrik Speakon connector added to 8Ω winding (25 to 50 taps) – grounded 1- terminal.
- Increased screen stopper from separate 47Ω to separate 47Ω plus common series 110Ω 20W to add 16V screen sag at 3x 50mA screen over-drive.
- Reduced mixer/grid-stopper to V1b from 470k to 47k. Added 100k across Vol pot to load first stage.
- Added 56k to 47k divider to grid drive V2a to lower gain in to PI stage.
- Varsi V150K10 200VDC 450pF MOV across 0-100Ω taps on OT.
- Fixed bias from full-wave with series 2K2, and 50k pot trimmer.
- Moved Input 2 volume pot to act as a 1kHz scallop/notch filter connected to V1b output (prior to tone circuit so as not to load tone shaping). Relay coil G2R 12VDC as inductor, with series 47nF. Only impacts at end of pot rotation. Pot paralleled with 100k.
- Reduced fixed bias grid leak from 470k to 220k, given that 0.5M is max level for single tube.
- Limiter RC loading on plate disconnected.
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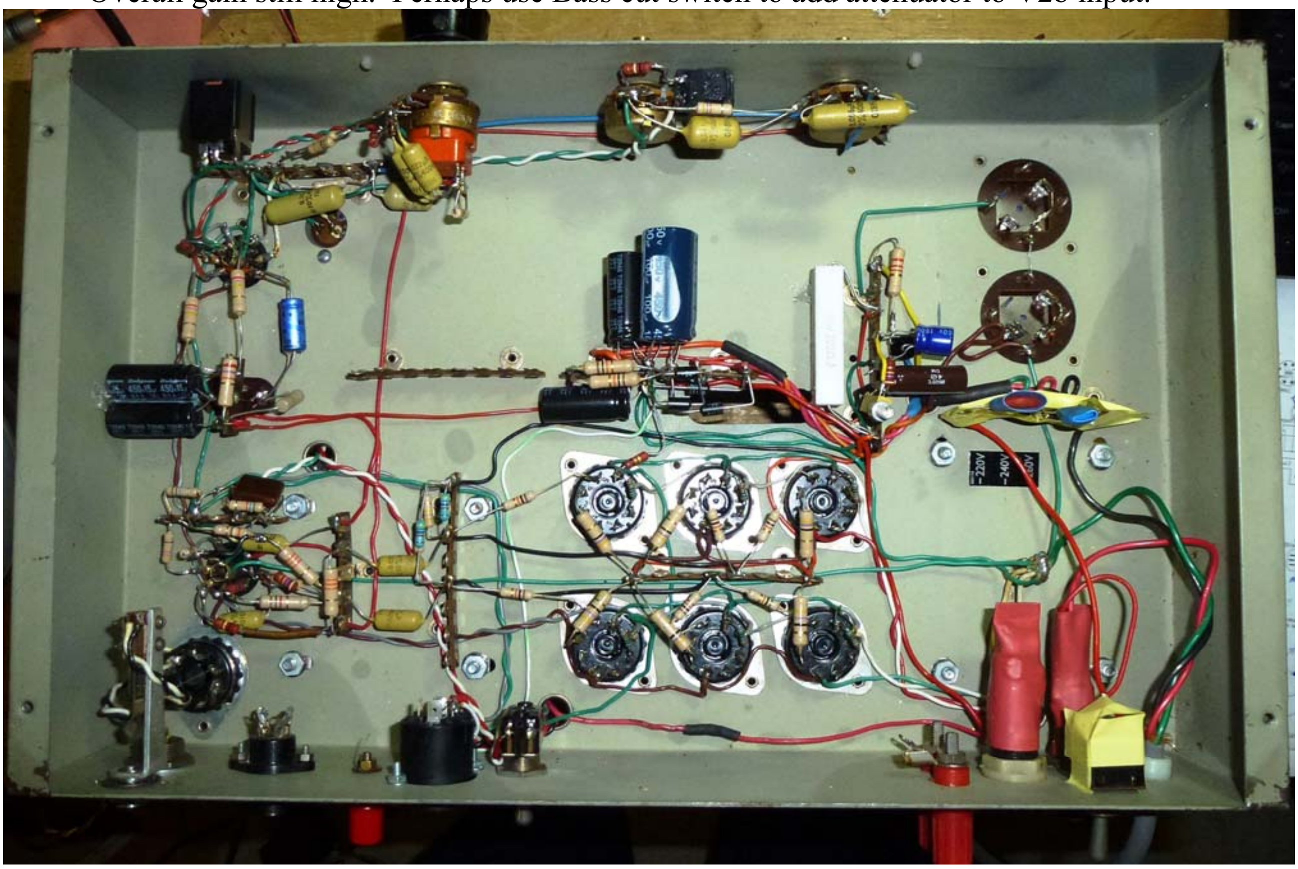
- Overall gain still high. Perhaps use Bass cut switch to add attenuator to V2b input.



3. Measurements

PT and OT primaries megger fine to chassis at 1kV.

Rail	Valves in; Idle 15mA av
VS1	336V 1.3Vrms
VS2	168V 0.6Vrms
VS3	312V
VS4	283V
VS6	-40V
VS7	-30V
Heater 1	6.6Vrms
Bias	34Vrms
V1-V4	18, 17, 17, 17, 13, 12mA

52VAC 50Hz nominal applied to output transformer half-primary

Winding	Voltage rms	Turns ratio; Impedance @1K15 pri; Spec level; Notes
Pri P-P: BLU to BRN	105.2	1.15kΩ 340V
Sec: 0-100	31.0	3.39; 99.9 Ω; 100V 1000 turns
Sec: 0-50	22.2	4.74; 51.2 Ω; 71V 716
Sec: 0-25	15.5	6.79; 25.0 Ω; 50V 500
Sec: FB	3.1	33.94; 1.0 Ω; 10V 100
Sec: wh-wh	1.18	89.15; 0.14 Ω; 3.8V 38

The datasheet standard Class B is 3.5k PP. An OT for a sextet is likely to be 3.5/3=1.17kΩ. The 0, 25, 50, 100 markings on the OT secondary terminals are impedance levels (not voltage levels). Connection options are:
50-100 winding: 4.7Ω (22% of turns)
25-50 winding: 8Ω (29% of turns)
50-100 winding plus FB winding: 14.7Ω (38% of turns)
50-100 winding plus FB winding plus wh-wh winding: 17.8Ω (42% of turns)

Output transformer primary DC resistance: 26Ω plate-to-plate. The primary winding is interleaved around the secondaries.

Power transformer primary DC resistance: 5Ω, 0-240V + fuse.
Power transformer secondary DC resistance: 8Ω.

Gain of V1a about 47 to top of pot, and no overload to well about 20V out.
Gain of V1b about 21 to input of V2b (removed) but depends on tone setting.

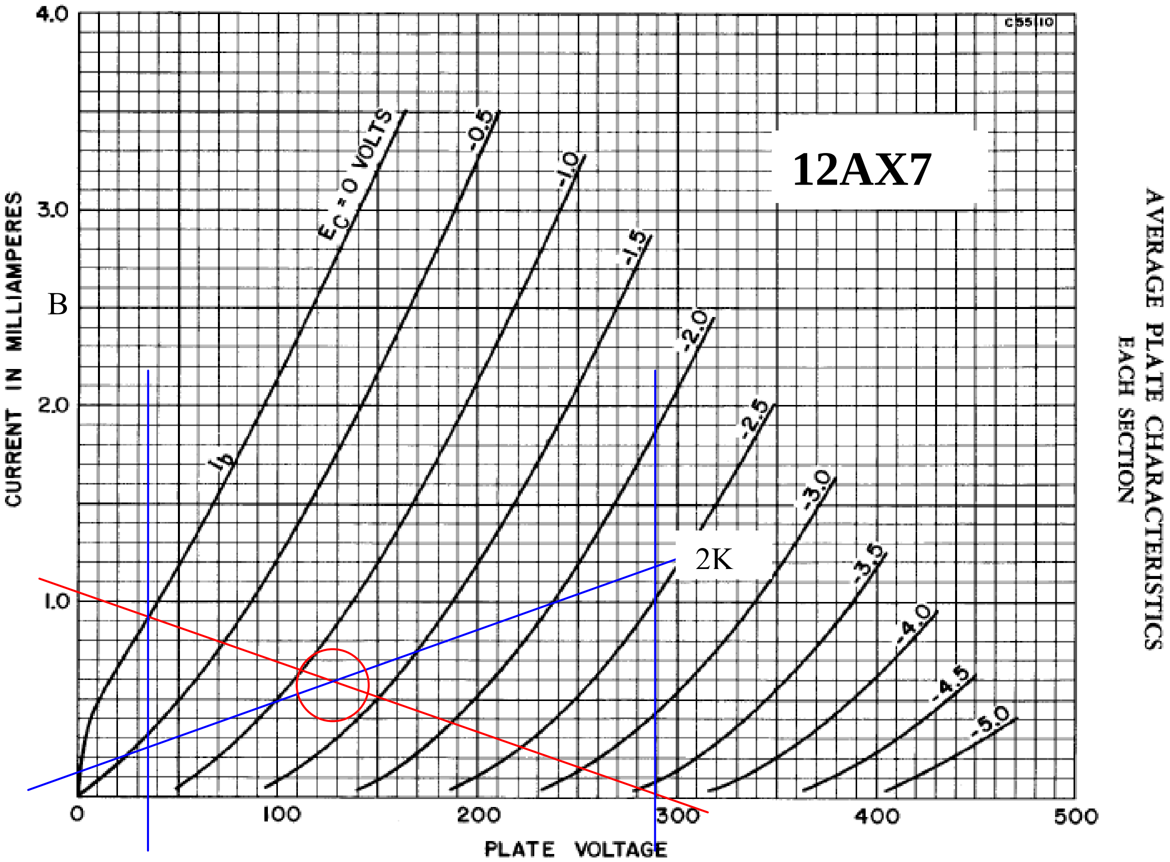
Cranked output to 109W in to 7.2Ω resistive load with VS1 sagging to 336 to 314V, and screen from 168 to 150V, with no feedback and output stage limiting. Clipping starts about 73W. May get a bit more with 8-9Ω loading. Cranked output with feedback similar.

Limiter (incandescent only) starts to attenuate above 10Vrms (95%), increasing to 80% at 15Vrms and 68% at 20Vrms (onset of clipping at 22Vrms), with transition time of about 100ms when limiter switched on. Ie. attenuates above 14W, with 35% reduction on a 30W level, and 55% reduction on a 55W level when the limiter was switched in.

4. Design Info

4.1 Input Gain Stage

For the first half 12AX7, V1A, VS4 = 283V; Va=124V; Rk=1k (common); Vk=1.14V; Ia=0.59mA; RLdc=270k. Same for V1B. Little phase shift, so cathode current will nominally cancel.

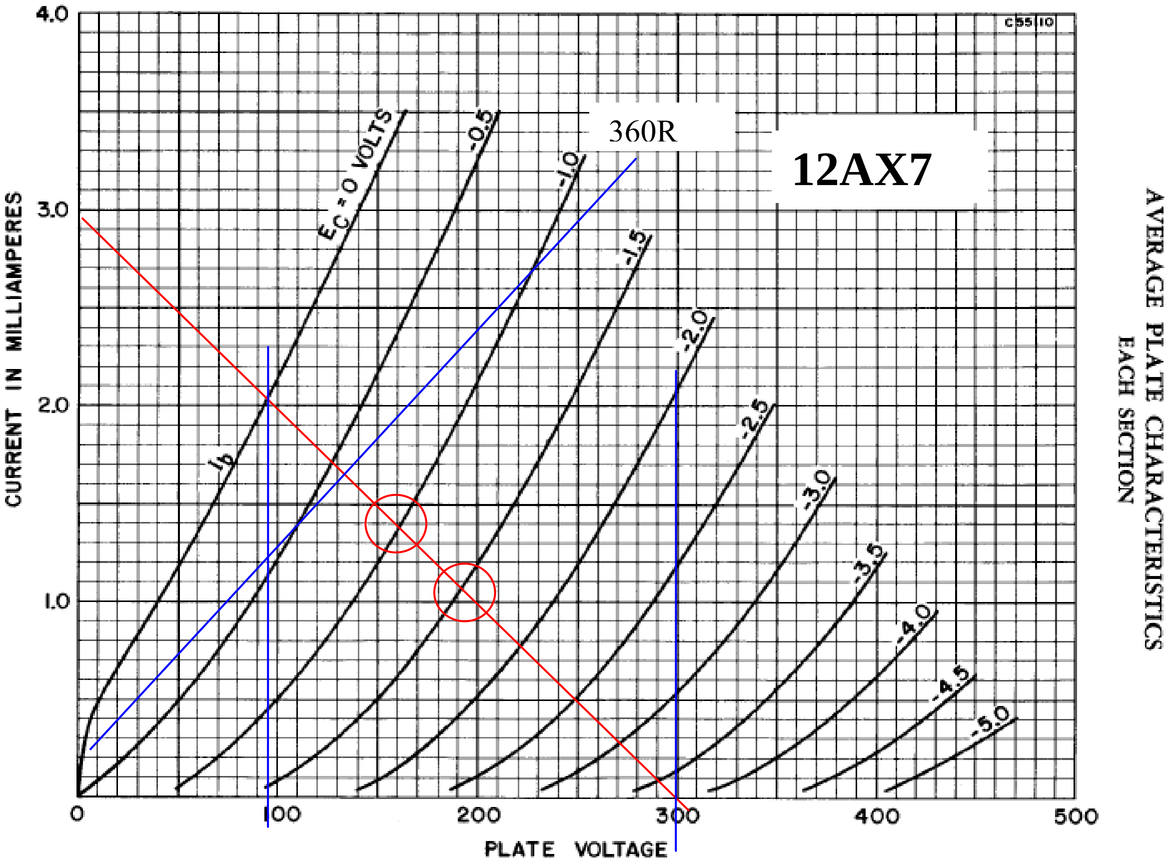


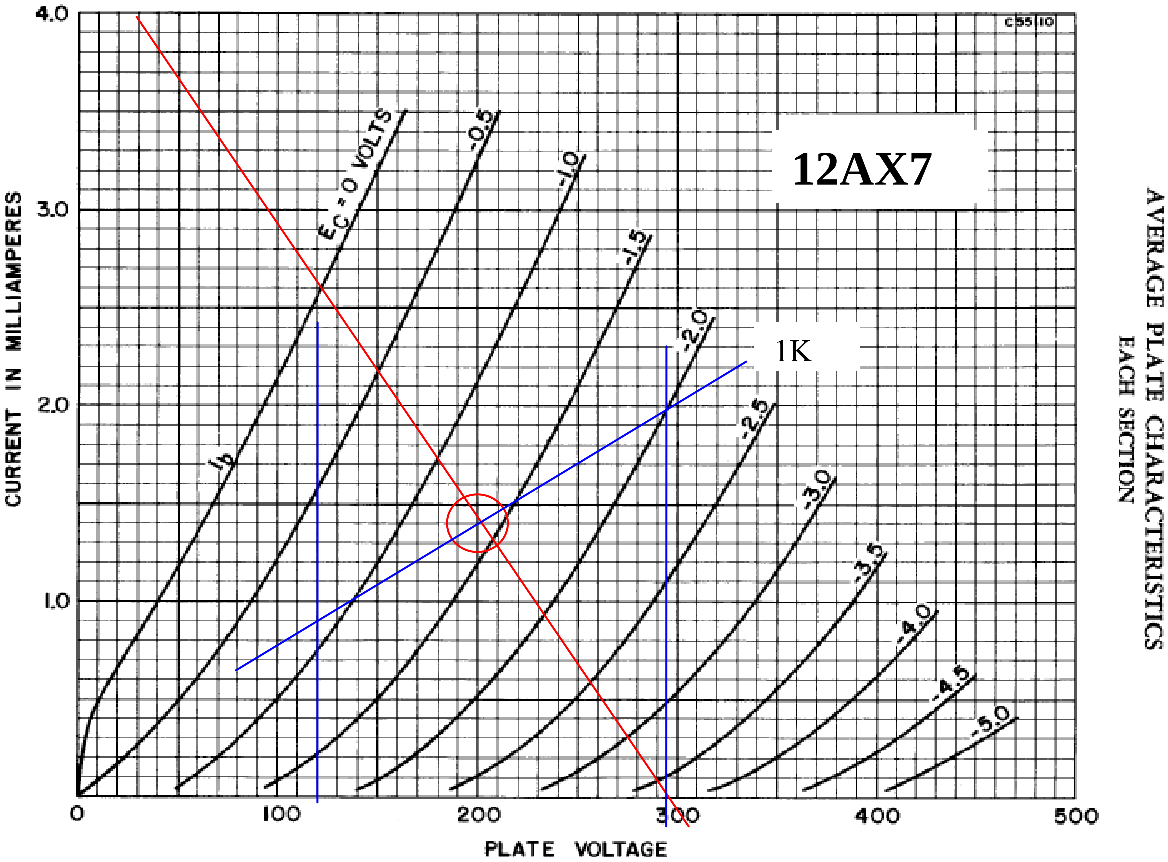
4.2 Drive and Splitter Stage

A concertina splitter using V2A, with capacitor coupled drive from V2B triode. Gain of PI is a bit under one. Gain of driver has NFB to cathode from OPT output.

V2B driver current is ~ (300-165V)/100k = 1.35mA.
V2A PI current is ~ (300-253)/33k = 1.4mA.
Effective lower leg resistance is 390//5k6 = 364, with voltage drop of 1.0V.

The voltage swing from the driver and PI is limiting before the output stage. Driver stage swing is increased by adding 820Ω (1.0mAx820=0.8V) V2B cathode resistance to increase cathode voltage to 1.6V (360x(1.0+1.3)mA=0.83V). PI stage swing is increased by increasing V2A cathode bias from 1k to 1.2k (idle current drops from 1.4mA to 1.3mA). Also could keep VS high by diode isolating from VS1.


4.0
3.0
2.0
1.0
CURRENT IN MILLIAMPERES
C55 10
360R
12AX7
EC = O VOLTS
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
Ib
0
100
200
300
400
500
PLATE VOLTAGE
AVERAGE PLATE CHARACTERISTICS
EACH SECTION


4.0
3.0
2.0
1.0
CURRENT IN MILLIAMPERES
C55 10
12AX7
1K
EC = O VOLTS
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
Ib
0
100
200
300
400
500
PLATE VOLTAGE
AVERAGE PLATE CHARACTERISTICS
EACH SECTION

4.3 Power Supplies

The power supply is full-bridge silicon diode BY127/800 and a 260-130-0 VAC centre-tapped secondary. 100uF capacitor input filter for VS1. Centre-tap 130VAC to 3x15uF capacitor input filter for screen VS2, but uses half the full-bridge to provide a full-wave rectified output.

The 34VAC bias supply modified to full wave rectifier but still with 2k2 series feed. Fail-safe pot added to set bias. Electrolytics on bridge output and after bias trimpot.

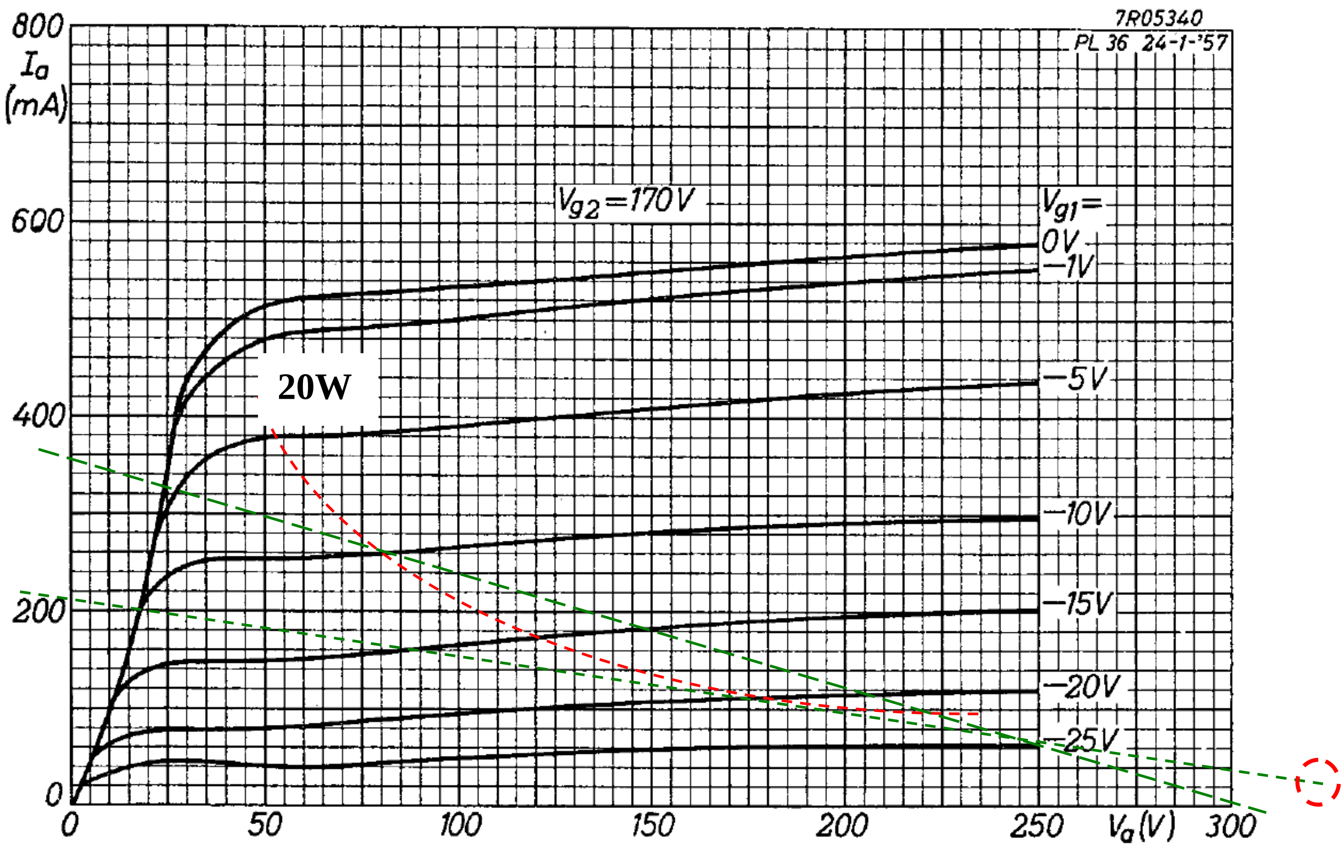
4.4 Output Stage

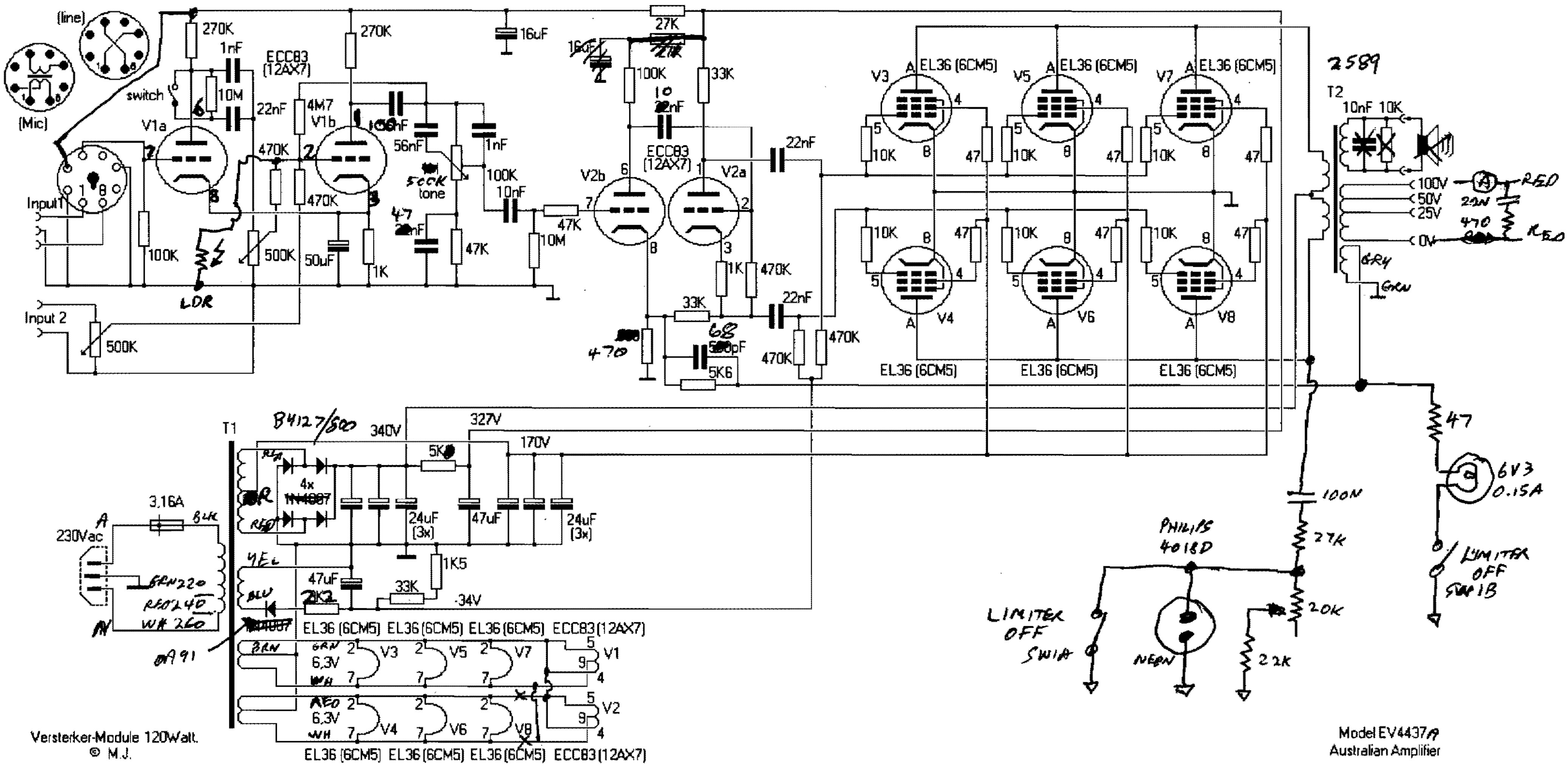
Class B push-pull output stage with small region of class A overlap where both tube pairs conduct. The 1.15KΩ impedance plate-to-plate OPT for the sextet presents each tube with 850Ω, and each tube with a 1,700Ω load impedance for effectively all signal currents. 8-12W max for 350V anode is 23-34mA, but tubes set for 15mA nominal.

As the output loading increases, the plate supply voltage VS1 sags from 336V to 314V at onset of clipping, due to supply regulation. The voltage at the plate will be effectively lower than VS1 at high output loading by an amount up to ~17V due to OPT half resistance of about 13Ω plus 1Ω sense (ie. peak current of up to about 3x0.33=1A), and 10Ω individual sense.

The screen supply voltage VS2 is nominally 50% of VS1, and will also sag a bit under screen current loading at high output loading. Screen current level increases as Vg approaches 0V, possibly to over 40mA, with drop across each screen stopper resistor up to ~13V.

Assuming the loadline sags to about 300V level (from 340V) and a peak plate current of 300mA is achieved, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.9 x 0.9 x 1k15 / 8 = 116W. For this maximum signal condition, the rms OPT current draw is likely about 3 x 190mA (64% of peak), and the average VS1 power consumed is 320x0.57 =182W, and the OPT loss is $(0.57)^2$ x 26Ω = 8W, so the tube plates dissipate 182 - 116 - 8W = 60W, or about 10W each.





(line)
(Mic)
Input1
Input 2
V1a
ECC83 (12AX7)
V1b
V2b
V2a
EL36 (6CM5)
T1
T2
230Vac
3.16A
340V
327V
170V
-34V
LDR
tone
switch
Versterker-Module 120Watt.
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Model EV4437A
Australian Amplifier