1. Summary

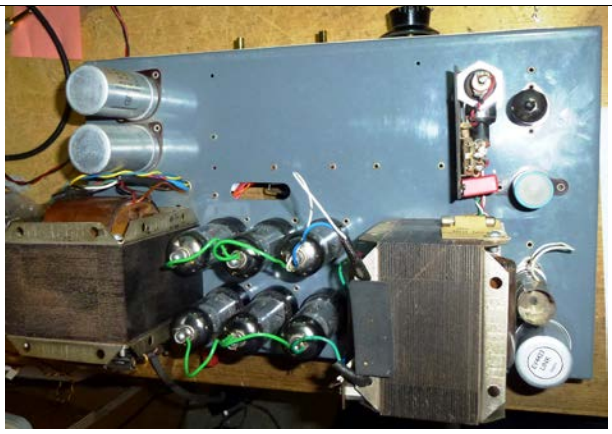
Valve PA Amplifier. eBay May 2013
Philips label – Model EV4437A – Serial No 1739

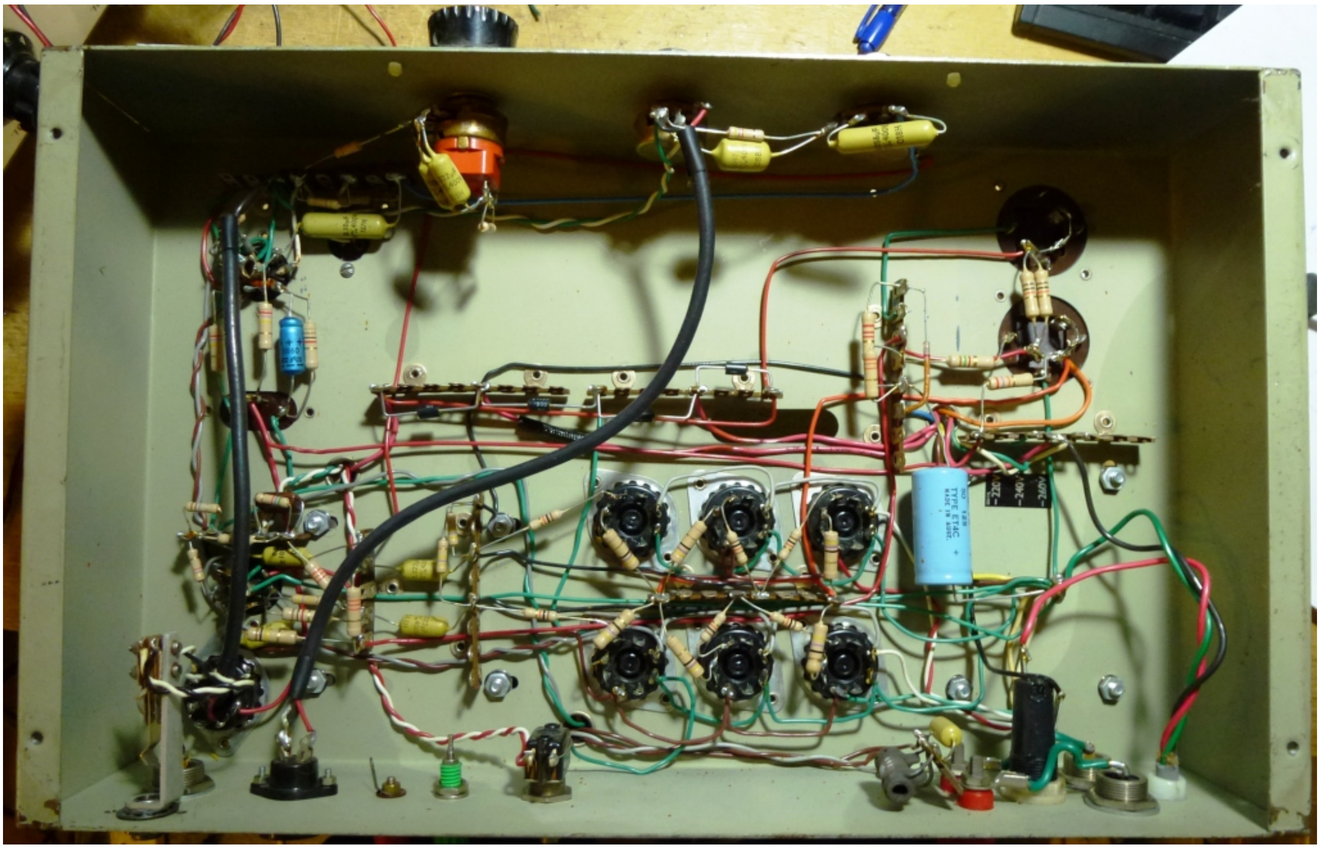
Two input, mono 120W amplifier with tone control and 25V/50V/100V line level outputs. 12AX7 preamps; 12AX7 driver and concertina PI; sextet 6CM5/EL36 fixed bias, push-pull output. OPT separate output feedback winding to driver/PI, and to monitor output. Both triodes in preamp with common bypassed cathode 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	2589. 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
Meter	Paton Model 30, No. 843 1W, dated 25 Oct 1971.

Purchased condition: clean; slightly modified for university lab experiment (tone knobs replaced by locking presets; added earth 4mm socket, speaker RC network, 2 sockets for output, 100mA meter with shorting switch on top); 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 2A 3AG fuse in active. MOV across PT primary. Insulation on primaries.
- NTH13D160LA NTC thermistor in PT primary (16Ω cold) to support extra filter capacitance.
- 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 – 20mA idle = 200mV. Added common cathode 1R 2W for total bias current sensing – 6x20mA idle = 120mV.
- Added 6.5mm insulated socket in LHS front panel hole for guitar input – switched short to gnd with no plug inserted. 47k grid stopper with 1M leak. Rear panel input socket and Mic socket and Mic transformer octal socket disconnected.
- Speaker output banana sockets disconnected. Neutrik Speakon connector added to 50Ω tap – to suit 2x16=32Ω speaker. 0 tap connected to feedback 0V node in preamp.
- Increased screen stopper from separate 47Ω 2W to also include common series 110Ω 20W to add 16V screen sag at 3x 50mA screen over-drive.
- Reduced mixer/grid-stopper to V1b from 470k to 470k//100k. Added 100k across Vol pot to load first stage. LDR as grid leak, with 7M5 feedback from tone cct.
- V2b cathode circuit changed to 820 and 390 to 0V, with 33k from mid-point, and feedback disconnected. V2b rail direct from VS3. VS3 with 390k bleed.
- V2a grid circuit now with 56k in series with 10nF, and 470k // 47k leak, and cathode increased from 1k to 1k27, to lower gain into PI stage.
- Varsi V150K10 200VDC 450pF MOV across 0-100Ω taps on OT.
- Fixed bias changed to full-wave with series 2K2 and 10uF filter, and then with 50k fail-safe trimpot and 47k divider to set bias, with 100uF final filter.
- Reduced fixed bias grid leak from 470k to 220k, given that 0.5M is max level for single tube.
- 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.
- Limiter RC loading on plate disconnected.
- GRN/WH heater pair feeds V1 and V2. Added 200R trimpot humdinger to GRN-WH heater, and disconnected white CT.
- Added output transformer half-primary MOV VE13 0421K protection, connected to first 6CM5 pair top-caps, and with B+ connection made in-line with RD wire.
- Added RXE050 PTC between 10Ω sense and each 6CM5 cathode for over-current protection.
- Added 1.25A IEC T 5x20 fuse to bridge link to 0V, and 315mA IEC T 5x20 fuse to 130V tap link to screen supply, and 1N4004 parallel to screen supply e-caps.
- Wired 8-pin microphone octal socket for display of 6x cathode currents. Either insert 6x 3VFS meter assembly into socket, or use extender octal-to-octal to meter assembly.
- Added 180k+1k8 bleed on VS1, and 120k+1k2 bleed on VS2.
- Changed 4-pin socket on rear panel to 5-pin monitor port for: gnd (1); common cathode sense (2); VS1/100 (4); VS2/100 (5). Cathode sense 6x20mAx1Ω = 0.12V [0012]
    - (pin 3 not used; common cathode sense shows on CS1 on 8-meter monitor).
    - VS2/100 ~1-2V low on 8x meter.
    - Common cathode 83mV displays as 0078 on 8x meter.

Grounding:

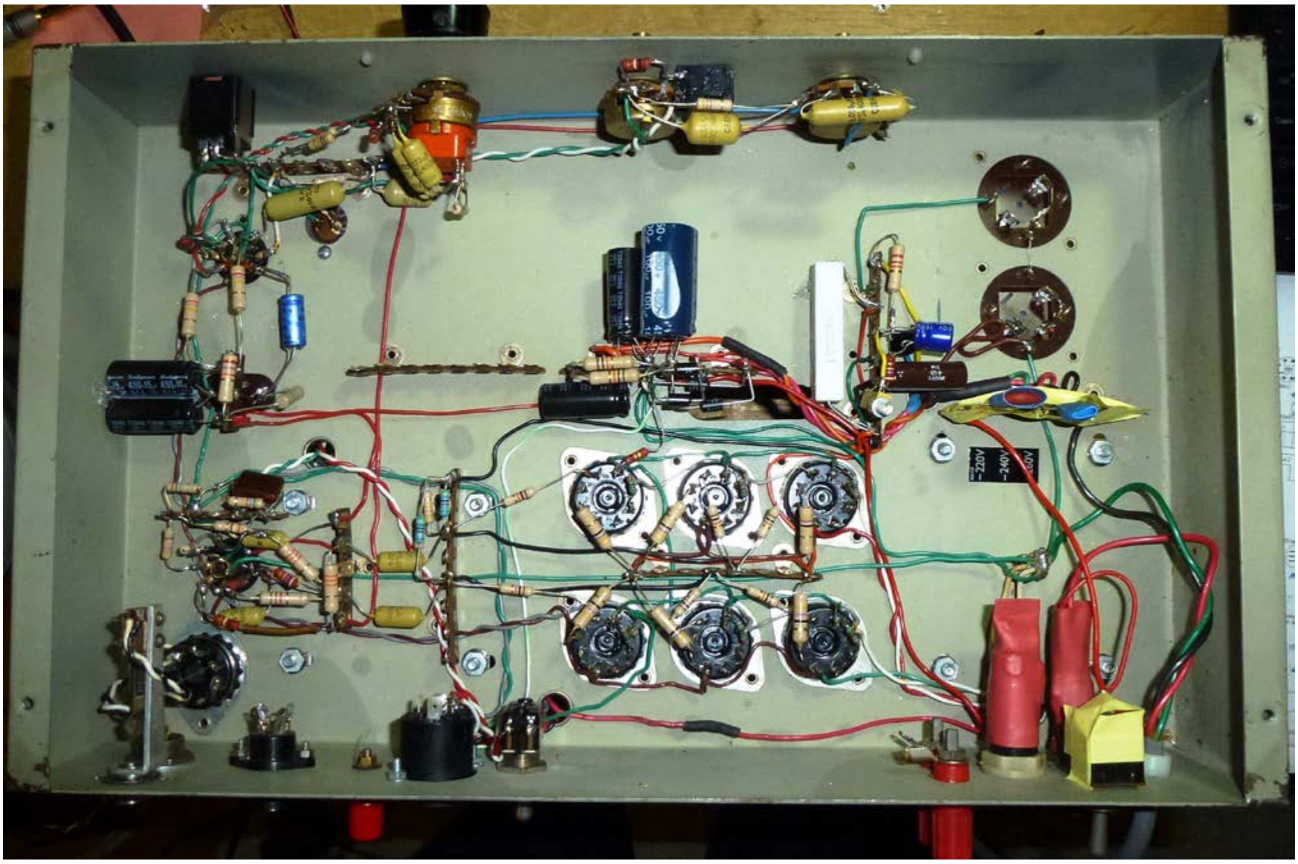
- Main chassis soldered node to: mains PE; brn T1 E.S.; tag strip riveted to chassis; preamp valve socket spigots and preamp; VS1-VS2 neg terminal; white heater CT; white heater CT.

Rail bleeds:

- VS1 180k+1k8+68
- VS2 110k+1k+120
- VS3 390k.

To do:

- 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.

Mains 240Vac.

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). The feedback windings are interleaved. Connection options are:
50-100 winding: 8Ω (29% of turns)
25-50 winding: 4.7Ω (22% 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 from 336 to 314V, and screen from 168 to 150V, with no feedback or 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.

Mains 220Vac 292V; 30V onset 240Vac 321V 159V; 31V onset

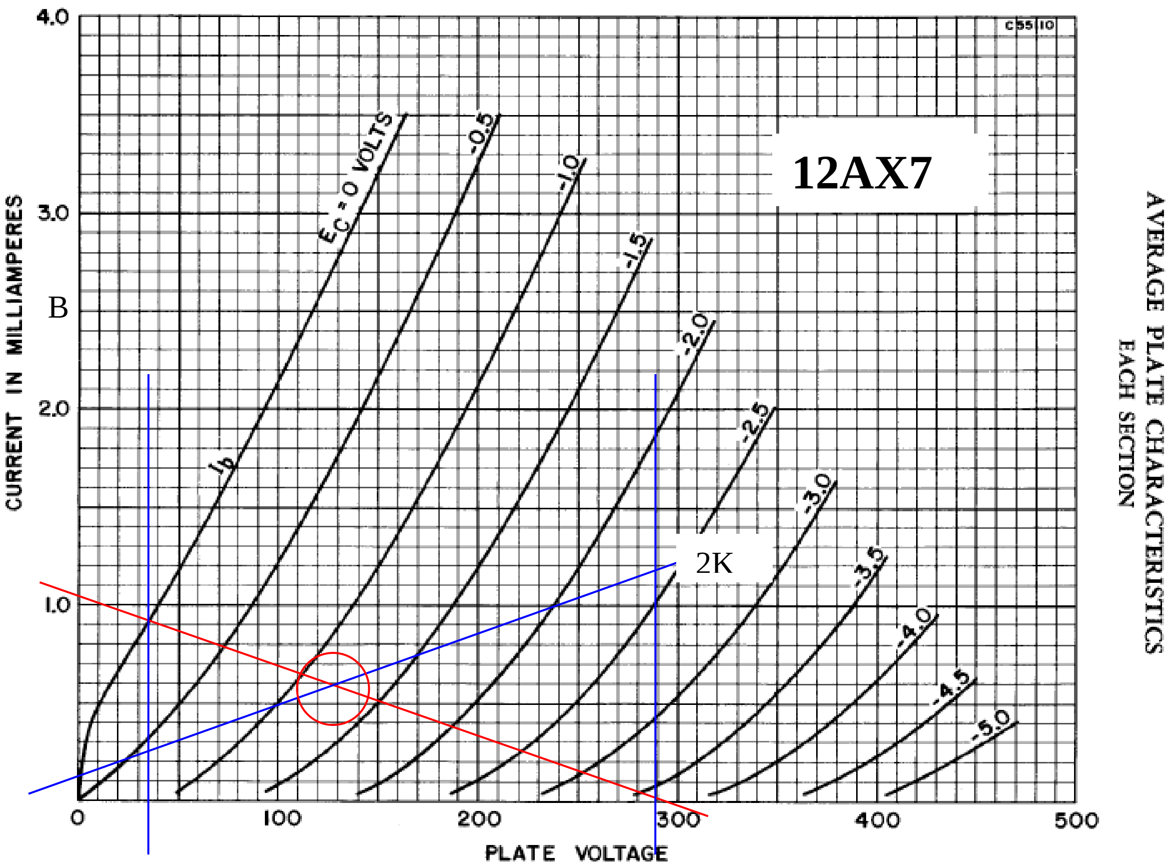
Mains current from 0.5A to 0.96A at 31Vac (32Ω, 30W).

58Vac cranked into 32Ω (105W); 288VS1. Mains 1.51A

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.

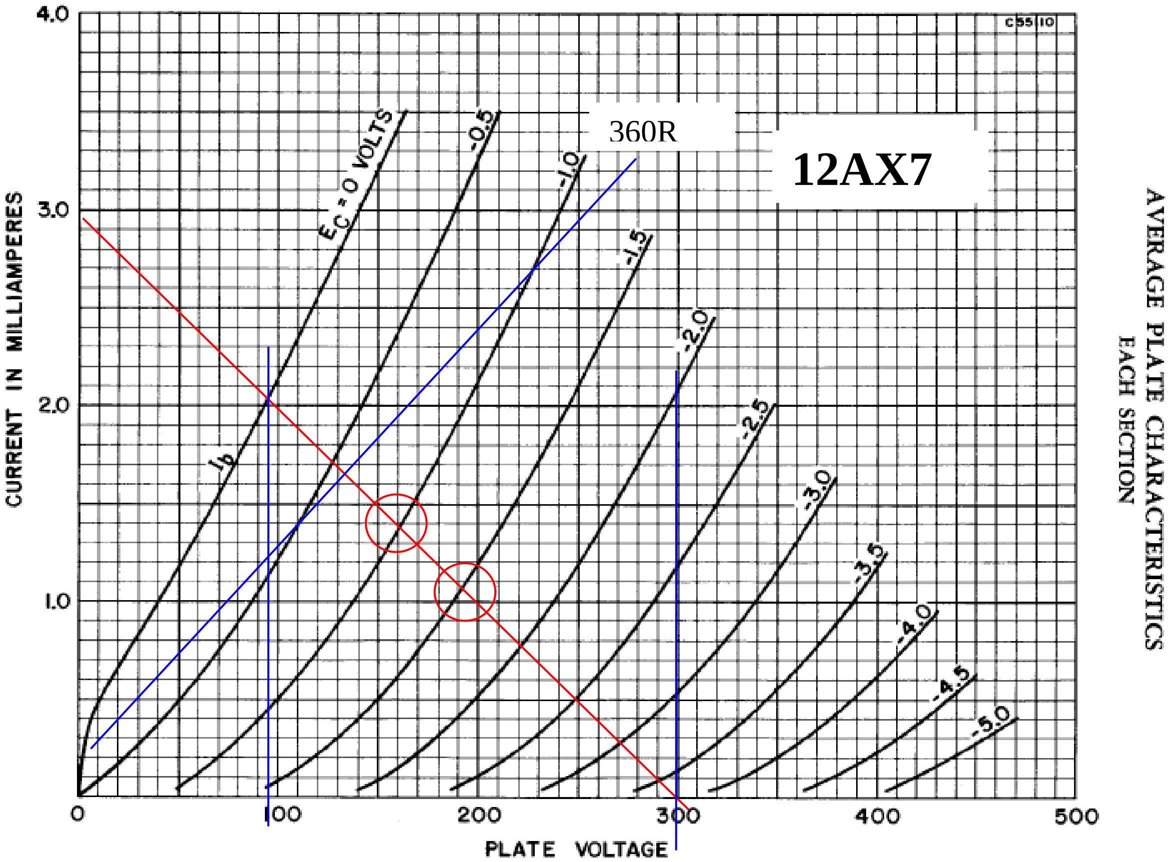


4.2 Drive and Splitter Stage

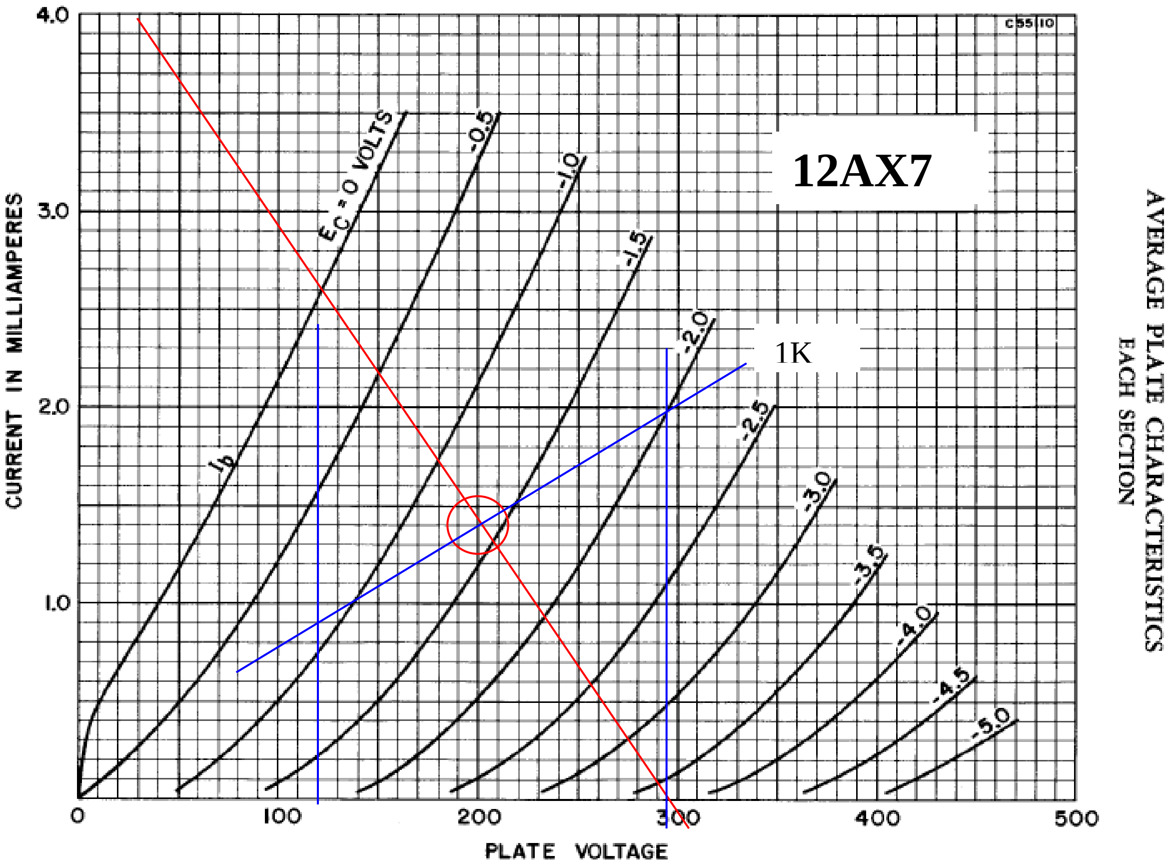
A concertina splitter using V2A, with capacitor coupled drive from V2B triode. Gain of PI is a bit under one. Gain of driver has NFB to cathode from OPT output.

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.



12AX7
360R
AVERAGE PLATE CHARACTERISTICS
EACH SECTION
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
EC = 0 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
1.0
2.0
3.0
4.0
C55110



12AX7
1K
AVERAGE PLATE CHARACTERISTICS
EACH SECTION
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
EC = 0 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
1.0
2.0
3.0
4.0
C55110

4.3 Power Supplies

Mains primary with NTH13D160LA NTC thermistor (16Ω cold;) to increase PT 5Ω primary DCR. Max NTC current rating of 2.0A at 25C. With current below 0.5A (25%), the NTC resistance is circa above 6Ω (see Murata NTH catalog R44E-3), so may impact regulation.

The power supply is full-bridge silicon diode BY127/800 and a 260-130-0 VAC centre-tapped secondary. 200uF 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 bridge neg link to 0V is fused to allow VS1 of 326V at a max dc load of 3x190=570mA. PSUD2 indicates 1.15Arms continuous fuse current, and a 1.25A T IEC fuse.

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current		5.7A		2.35A	1.5A	1.15A
Multiplier (for 1.25A fuse rating)		4.6		1.9	1.2	0.92
IEC 60127-2 **T** min limit multiplier		10		4.0	2.75	1

The screen supply 130V tap is fused to allow VS2 of 160V at a max dc load of 3x40=120mA. PSUD2 indicates 310mArms continuous fuse current, and a 315mA T IEC fuse.

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current		1.1A		0.48A	0.36A	0.31A
Multiplier (for 315mA fuse rating)		3.5		1.5	1.2	0.98
IEC 60127-2 **T** min limit multiplier		10		4.0	2.75	1

A 315mA F IEC fuse is likely not appropriate.

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current	1.4A		0.69A			0.31A
Multiplier (for 0.315A fuse rating)	4.5		2.2			0.98
IEC 60127-2 **F** min limit multiplier	4		2.75			1

A 1N4004 in parallel with screen supply e-cap is needed to avoid reverse bias if bridge neg link fuse blows.

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.

GRN/WH heater pair with 3x 1.2 + 2x 0.3 = 4.2A. RD/WH heater pair with 3x 1.2 = 3.6A. Each with CT to chassis gnd. Modified by disconnecting GRN/WH CT and adding humdinger pot with wiper to chassis gnd (or elevated).

4.4 Output Stage

Class B push-pull output stage with small region of class A overlap where all tube sides conduct. The 1.15KΩ impedance plate-to-plate OPT for the sextet effectively presents a 3k5 PP impedance per pair of tubes, so each tube with 1k7Ω load impedance for small signal, reducing to 850Ω class B for larger signal currents. 8-12W max for 350V anode is 23-34mA, but tubes set for 15mA nominal. Given the loadline likely falls below the knee, using a lower speaker impedance than rated may be worthwhile (ie. use tappings for 15Ω with an 8Ω speaker, or use 25Ω tapping for 15Ω speaker, or use 50Ω tapping for 2x16 = 32Ω speaker), as that would push the class B loadline more towards the knee.

As the output loading increases, the plate supply voltage VS1 sags from 336V to 314V at onset of clipping, due to supply regulation (including the added primary NTC). The voltage at the plate will be effectively lower than VS1 at high output loading by an amount up to ~18V due to OPT half resistance of about 13Ω plus common 1Ω sense (ie. peak current of up to about 3x0.33=1A), plus 10Ω individual sense, so 14+3.3=17.7V.

The screen supply voltage VS2 is nominally 50% of VS1, and will also sag a bit from mains primary regulation and under screen current loading at high output loading. Screen current level increases as Vg approaches 0V, possibly to over 40mA, with drop across each 47Ω screen stopper resistor up to ~2V, and 13V across common series 110Ω from 3x40 = 120mA.

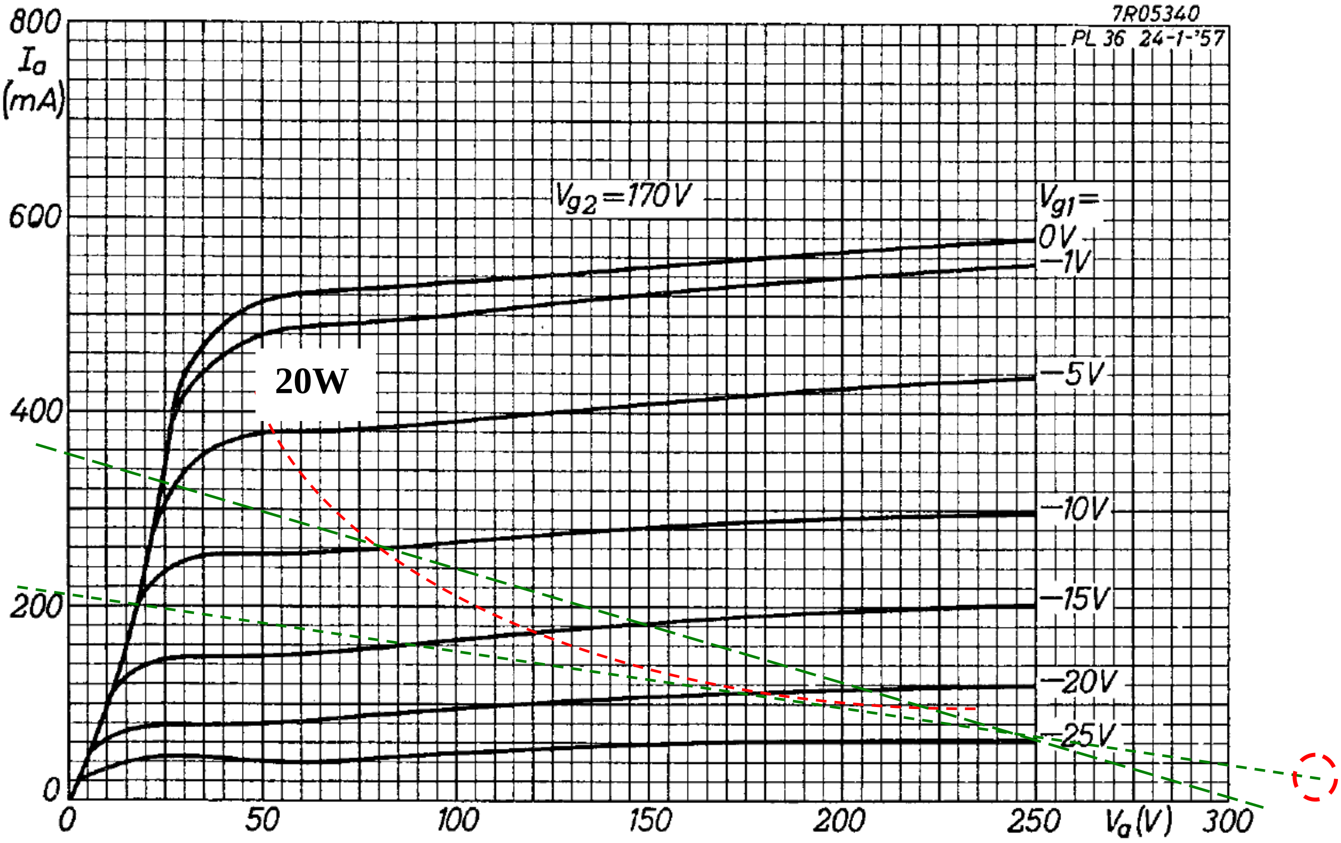
Assuming the loadline sags to about 300V level (from 340V) and a peak plate current of 300mA is achieved, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.9 x 0.9 x 1k15 / 8 = 116W. For this maximum signal condition, the rms OPT current draw is likely about 3 x 190mA (64% 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.

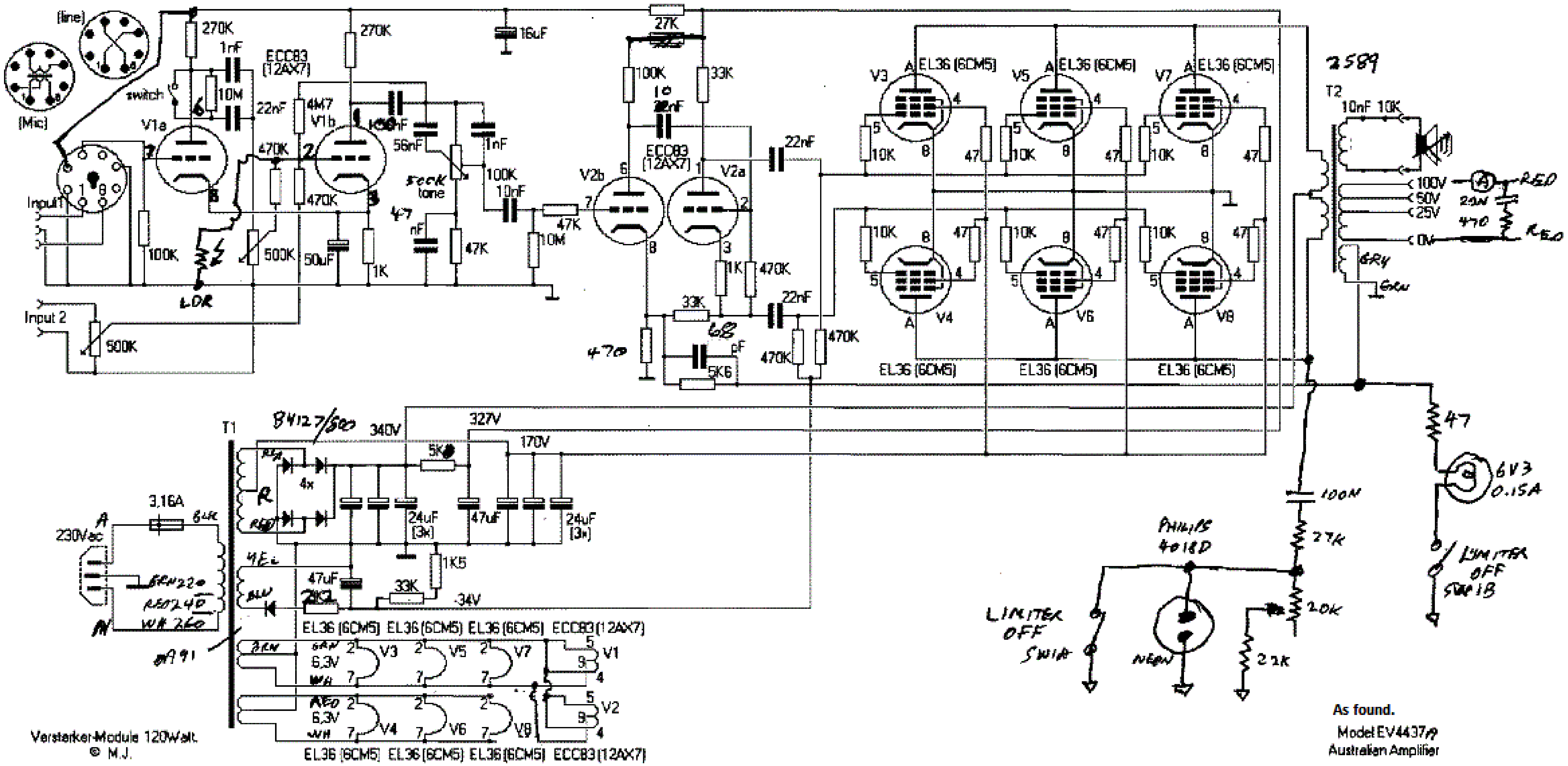
A 6CM5 fault from a screen to cathode short has a high prospective current limited by cathode and screen resistance of circa 1+10+47+110 = 168Ω. A screen to anode short has a high prospective current limited by OPT primary winding and screen resistance of circa 13+47+110 = 170Ω. Given a forcing voltage of 160V, the prospective fault current could be circa 1A. For the short-to-anode scenario, a VS1 in-line 1.5A fuse would not blow. For the short-to-cathode scenario, a cathode 10Ω 0.6W sense would dissipate circa 10W, and so would smoke, but may not open. In either fault scenario, a screen 47Ω 2W sense would dissipate circa 47W, and so would smoke, but may not open.

For the short-to-cathode scenario, a PTC in each cathode (between sense resistor and cathode) may need to withstand up to 400mA at 50% duty cycle (depending on loadline into knee), and may sit in an elevated ambient temperature due to location at the tube socket and if it is soldered in-line with a 10Ω sense.

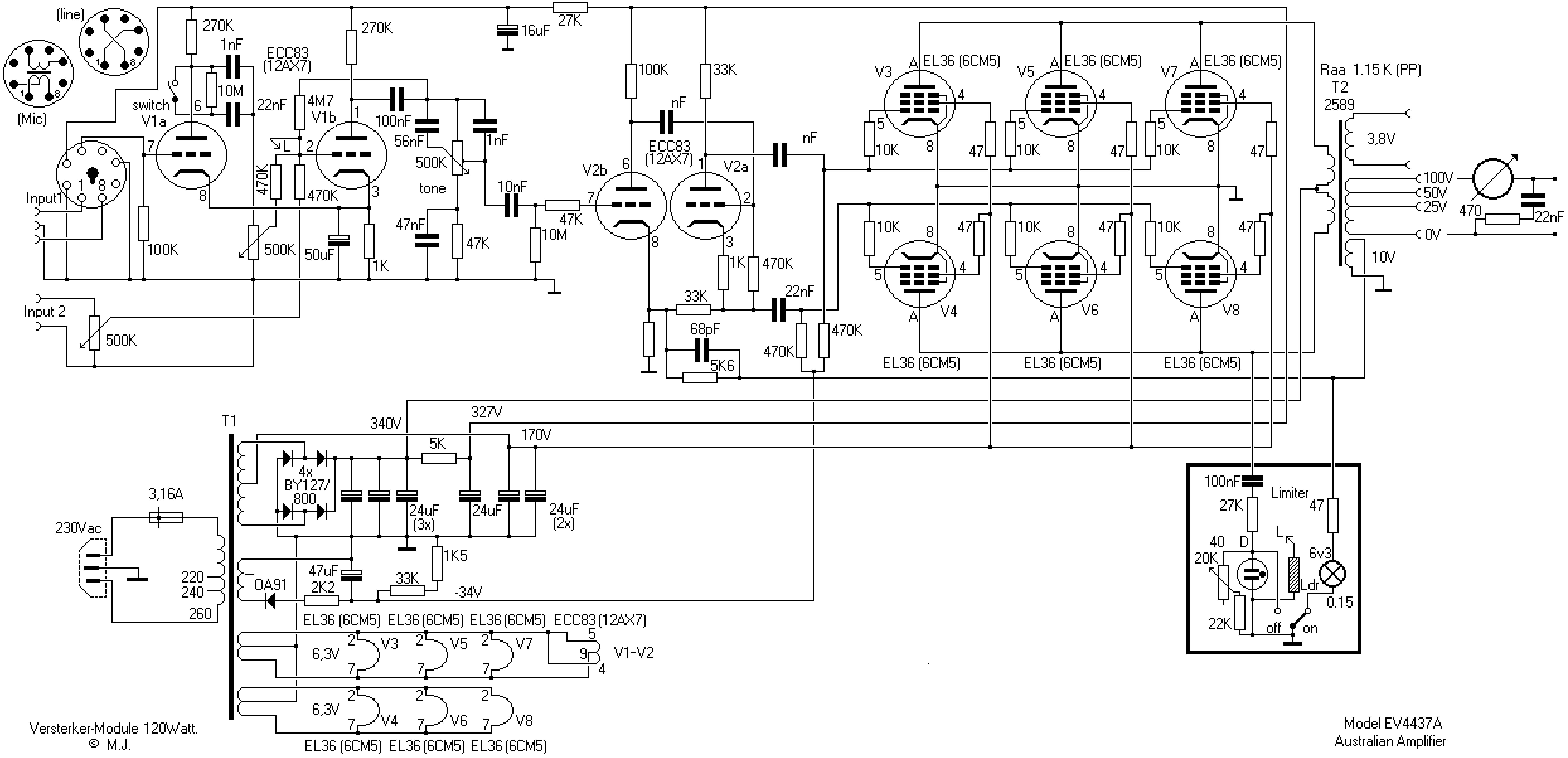
An RXE050 with a 0.5A HOLD rating (ie. circa 50% HOLD margin) has a nominal cold resistance below 1Ω, and would trip for a continuous fault current above 1A in 40 secs at 20°C. At a likely higher ambient temperature the Hold and Trip current ratings are lowered and could be nominally derated to 80% if local ambient reached 40ºC, and to 60% at 60ºC.

If the PTC trips, then the fault current characteristic (where an increase in Vk would lower the available forcing voltage) would likely reach a thermal equilibrium in the 'trip' region with a significantly constrained fault current level. The PTC part could fail and open if the equilibrium voltage exceeds the nominal 72V part rating, although that is likely a benefit as an indicator and for its 'fusing' action, and the amp would continue to operate.


7R05340
PL 36 24-1-'57
800
I_a (mA)
600
400
200
0
V_{g2}=170V
V_{g1}=
0V
-1V
-5V
-10V
-15V
-20V
-25V
20W
0
50
100
150
200
250
V_a(V)
300

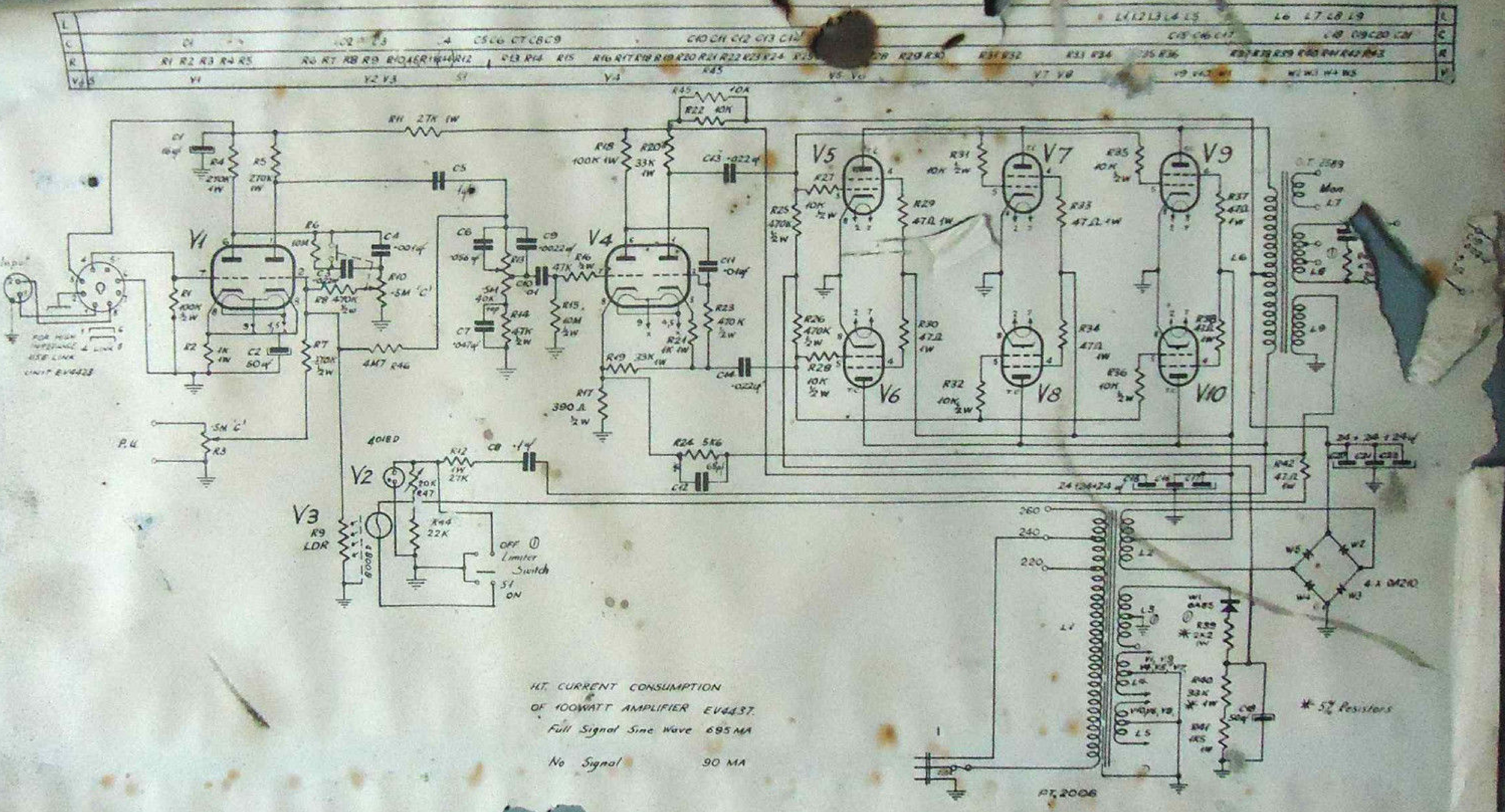


(line)
(Mic)
switch
Input1
Input 2
LDR
ECC83 (12AX7)
V1a
V1b
V2a
V2b
270K
1nF
10M
22nF
4M7
100nF
56nF
1nF
500K tone
100K
10nF
470K
100K
500K
50uF
1K
47K
10M
47K
16uF
27K
100K
33K
22nF
EL36 (6CM5)
V3
V4
V5
V6
V7
V8
10K
47
T2
10nF 10K
100V
50V
25V
0V
RED
GRY
GRN
2589
33K
68
pF
5K6
470
1K
470K
T1
84127/500
340V
327V
170V
5K0
3,16A
230Vac
BLK
GRN 220
RED 240
WH 260
4x
24uF (3x)
47uF
1K5
33K
-34V
2K2
BLU
6,3V
47
6V3 0.15A
100N
27K
PHILIPS 4018D
20K
22K
NEON
LIMITER OFF SW1A
LIMITER OFF SW1B
Verstarker-Module 120Watt.
© M.J.
As found.
Model EV4437/A
Australian Amplifier



Versterker-Module 120Watt.
© M.J.

Model EV4437A
Australian Amplifier


V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
Input
P.U
LDR
Limiter Switch
OFF
S1
ON
O.T. 2589
PT. 2006
260
240
220
4 x OA210
* 5% Resistors
H.T. CURRENT CONSUMPTION
OF 100WATT AMPLIFIER EV4437.
Full Signal Sine Wave 695 MA
No Signal 90 MA