1. Summary

Valve PA Amplifier. $82.20 eBay July 2009
Philips label – Model Code LBH1015/01 – Serial No 1080

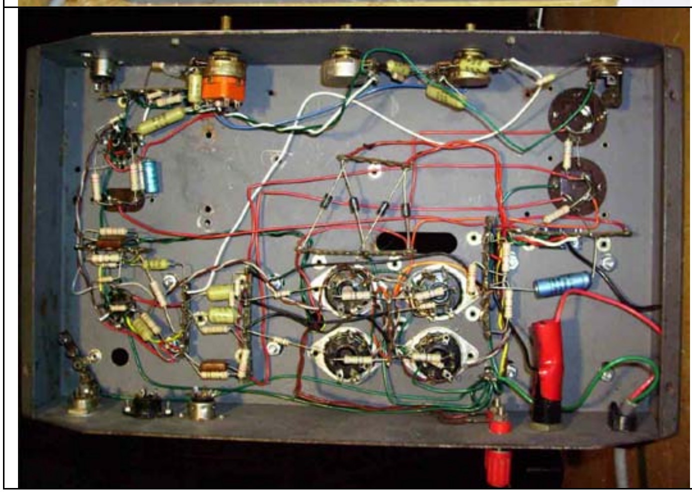
Two input, mono 60W amplifier with tone control and 50V/70V/100V line level outputs. Built circa 1970. 12AX7 preamp; 12AX7 driver/PI; quad 6CM5/EL36 push-pull output. OPT separate output feedback winding to driver/PI. Both triodes in preamp with common bypassed cathode resistor. Concertina splitter. Class B grid bias output stage.

Closely equivalent to 30W Philips model EV4435. Differences are no valve base selector (removed ?); Tuner socket is 5-pin DIN; PI circuit slightly tweaked; quad (not dual) 6CM5 used; tweaked OPT feedback values; upsized transformers. The OPT has a tag strip for the isolated feedback winding, and four other line level output terminals, and another isolated winding for local monitor speaker. Parts info/markings:

Power Transformer	No markings. 220;240;260 label under tagstrip.
Output Transformer	2638.
POTs	500k CTS/IRHC 45; 500k 45; 1MEG tap 100K CTS 45
Caps	Ducon ECT148, (24uF 450V x3) x2. Ducon 26uF 450V

Purchased condition: no 12AX7 valves; 3 added front panel holes and connectors; no base plate; no screws for holding top cover; input sockets un-wired; no tuner HT parts C1, R4; no microphone transformer (removed ?); Vol 1 pot a bit scratchy; front grill with one largish hole.

Reference websites:
http://members.chello.nl/m.janssen36/Amplifiers-with-valves.htm
http://www.peel.dk/Philips_amplifiers/index.html
http://home.alphalink.com.au/~cambie/EL36.htm
http://ozvalveamps.elands.com/awa.htm



2. Modifications

Done:

- Added extra insulation tube to mains wiring going to Tx.
- Added two 6.5mm insulated sockets in LHS front panel hole for guitar inputs – switched short to gnd with no plug inserted. High gain input (top) passes through additional cold-biased 12AX7 section.
- Moved Input 1 volume pot to between 10nF (increased to 22nF) output of tone circuit and input of driver/PI stage. Inserted send/return sockets after Vol pot, (3V3/3V3 + 10k clipper not connected on send) and .1uF return coupling. Added 1M grid leak and increased grid stopper to 470k to soften overdrive distortion to 12AX7 gain stage.
- Top input through 6k8/1uF cathode bypass 12AX7 with 270k anode. Output loading ~750k, with pot wiper connected to switch on bottom input. Bottom input to 1k5/50uF cathode bypass 12AX7 with 135k anode, and standard 68K and 1M grid input. Common HT of 285V.
- Moved Bass Cut pull switch to second triode output and using 5nF switched with 47nF.
- Tweaked driver cathode bias and PI DC bias to move idle bias into middle of each span (driver bias was too hot).
- Increased screen stopper from 47R to 47 + 330=380R to lower sag screen.
- Fixed bias from full-wave with series 470R, and pot trimmer.
- Matched V1-V4 for bias current at common bias voltage. Bias set at 10mA nominal as walkaway observed above 20mA.
- Added bias protection relay (Finder 40.52 48VDC) with series 1k resistor to increase sensitivity; connected HT secondary windings. Switched by standby switch.
- Reduced fixed bias grid leak from 470k to 220k, given that 0.5M is max level for single tube.
- Added 100R humdinger pot with +70VDC elevated heater bias.
- Added standby switch and indicator light in RHS front panel (intensity varied by bypass sw).
- Bypassed main VS1 electrolytic with 100uF 350V; 220uF VS2; 4.7uF VS3; 4.7uF VS5.
- MOV + 2k2 across each OT primary, and 1.2k resistor across output.
- Made new baseplate.
- Front panel meter (signal level) and backlight (6.3VAC bulb) added to cover leftover hole.
- Speaker output banana sockets changed to Speakon connector. 70V to 100V section of winding used (effective 14R loading for 1.75k PP primary) which is 30% of secondary 0-100V.

To do:

- Use 300mA fuse in series with 1R cathode sense, and shunt with a 10k (to bias valve to about 40V, 5mA, if fuse blows).
- Megger test on power transformer.
- Re-arrange secondary windings to 40R (for 32R loading) by splitting and then paralleling 0-50V and 50-100V windings.
- Philips insignia.
- Power level measurement and stage overloading.

3. Measurements

Rail	No valves	No valves; 1k2 on V1	Valves in; standby	Valves in; Idle 10mA
VS1	364V	335V (280mA; 93W)	42V	351V
VS2	182V	171V	11V	175V
VS3			39V	322V
VS4			V	280V
VS5			V	296V
VS6			-42.5V	-68V (-33.7V bias set)
VS7			4.8V	69V
Heater 1	7.0Vrms		6.6Vrms	6.5Vrms
Sec HT	260Vrms			
V1-V4				11.0,10.1 /11.0,9.7

Output power into 16.6Ω resistive load, sinewave input, modified circuit 14 Aug 09:
50Wrms before gross clipping. 95Wrms gross clipping.

The bias current on one of the 6CM5 appeared to thermally walk away above 20mA. So bias set at 10mA nominal.

12VAC 50Hz nominal applied to output transformer

Winding	Voltage rms	Turns ratio; Impedance for 1K8 pri; Spec level; Notes
Pri P-P: BLU to BRN	190	325V full output swing for 50/70/100V line outputs
Sec: WH to WH (flying)	0.31	613; Ω; 0.5V nominal level
Sec: 100V line (2-5)	58.2	3.26; 170 Ω; 160Ω ~ 1700Ω
Sec: 70V line (2-4)	41.5	4.585; 86 Ω; 80Ω ~ 1682Ω
Sec: Top (4-5)	16.6	11.45; 13.7 Ω;
Sec: Mid (3-4)	12.30	15.45; 7.5 Ω;
Sec: 50V line (2-3)	28.8	6.6; 41 Ω; 40Ω ~ 1742Ω
Sec: Feedback 10V, BLK to GRN (1-2)	6.00	31.67; 1.8 Ω;

If the full output was “100V” then the other outputs are 70V and 50V. Other amps show the outputs as 160, 80 and 40 ohm levels. So the primary is about 1700 ohm P-P, which is consistent with the datasheet standard Class B 3.5k PP. The 14 ohm nominal section of winding uses about 30% of secondary turns and can be used with 8 or 16 ohm speaker. An alternative is to separate the 0-40 and 40-160 ohm sections and connect in parallel for a nominal 32 ohm output (eg. 2x 16R Celestion 50-85W drivers).

Output transformer primary DC resistance: 62Ω plate-to-plate. The primary winding is interleaved around the secondaries.

Power transformer primary DC resistance: 7.5Ω, 0-240V.
Power transformer secondary DC resistance: 6 + 6Ω.

Dating:
The resistors and front panel label appear to indicate to me late 1960’s build timing, although I don’t have a good date for when that resistor type was first manufactured. The type/serial number label has hand written type number which appears to be LBH1015/01, but this could be inaccurate as the marking is poor. I see a listing for a Philips transistor amplifier with LBH 0251/10 dated 1975.

4. Design Info

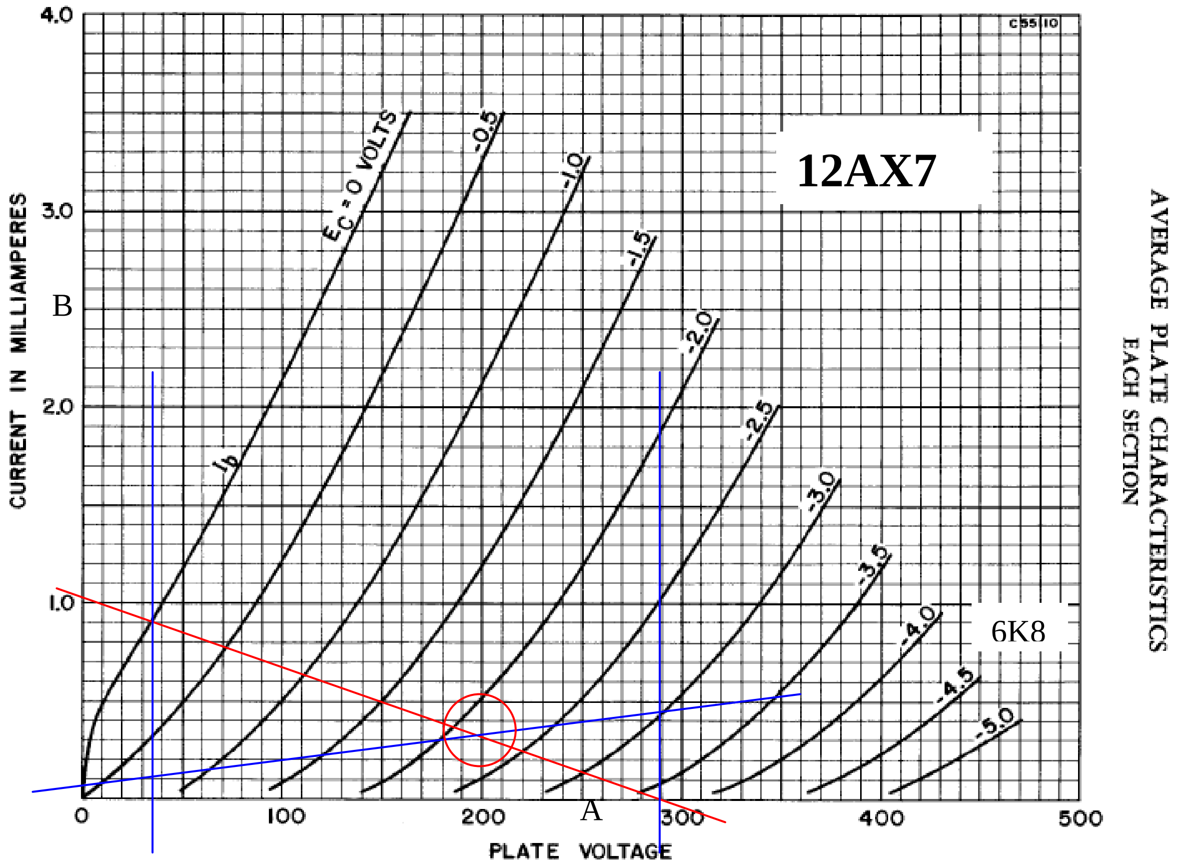
4.1 Input Hi-Gain Stage

For the first half 12AX7, V1A, VS5 = 285V; Va=200V [206]; Rk=6k8; Vk=2.2V [2.06]; Ia=0.3mA; RLdc=270k. Anode resistance Ra = ~30V/0.3mA=100k from 2V grid curve.

Voltage gain = u RL / (RL + Ra) = 90 x 195k / (195k + 100k) = 60; where RL ~195k (270k paralleled with 700k).

The input voltage swing limit is from the bias point at Vgk=-2.2V to Vgk=0V, which is about 4.4Vpp or 1.1Vrms. Referring to the loadline, the plate voltage would swing about 200V, from about 40V to 285V, with a mid-point of 200V [285-200=85V; 200-40=160V]. This gives a nominal gain of 160/2.2 ~ 70, which correlates with analysis above.

Cold biased for noticeable second-harmonic compression distortion on larger signals.



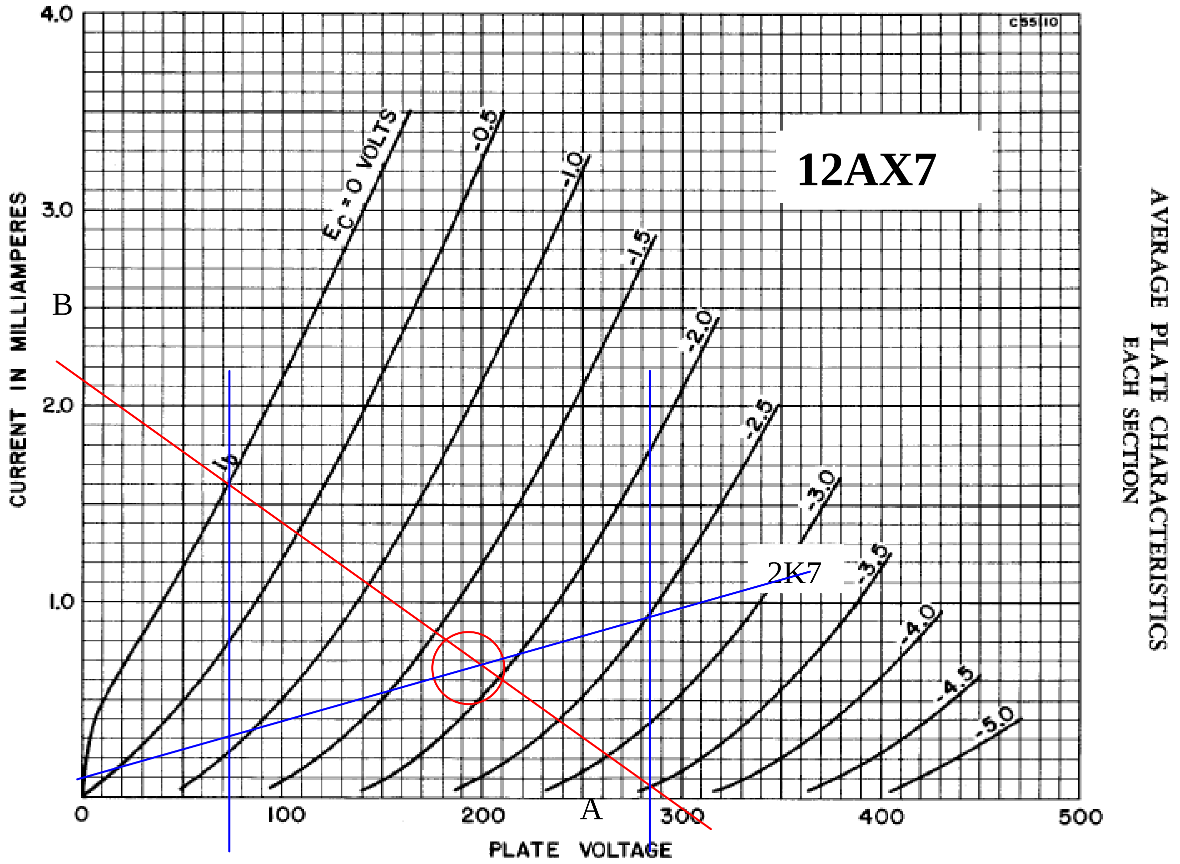
4.2 Input Normal-Gain Stage

For the second half 12AX7, V1B, VS5 = 290V; Va=195V [207]; Rk=2k7; Vk=1.8V [1.66]; Ia=0.65mA; RLdc=135k. Anode resistance Ra = ~30V/0.3mA=100k from 2V grid curve.

Voltage gain = u RL / (RL + Ra) = 90 x 100k / (100k + 100k) = 45; where RL ~100k (135k paralleled with 400k).

The input voltage swing limit is from the bias point at Vgk=-1.8V to Vgk=0V, which is about 3.6Vpp or 1.3Vrms. Referring to the loadline, the plate voltage would swing about 190V, from about 70V to 250V, with a mid-point of 190V [290-195=95V; 195-70=125V]. This gives a nominal gain of 95/1.8 = 50, which correlates with analysis above.

Mid-cold-biased for soft compression with normal input, and symmetrical compression (of un-compressed half-cycles) on high-gain input.



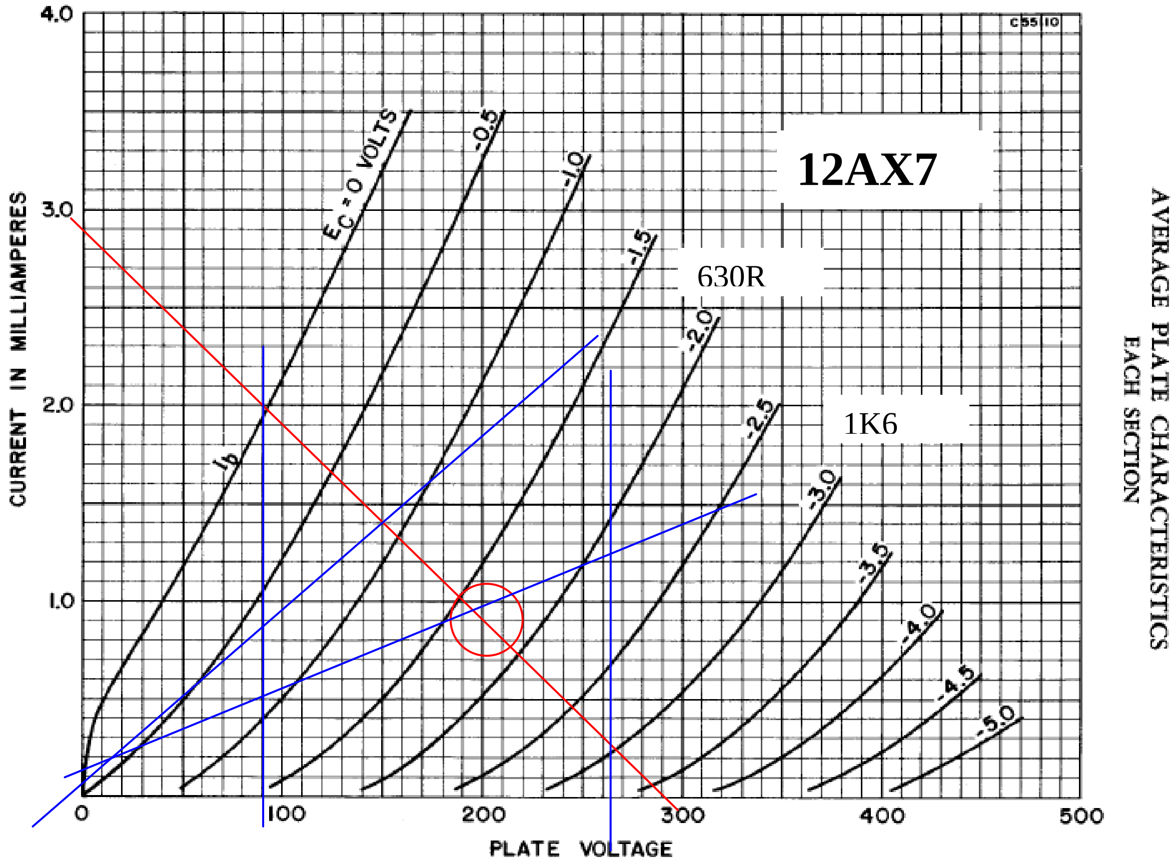
4.3 Drive and Splitter Stage

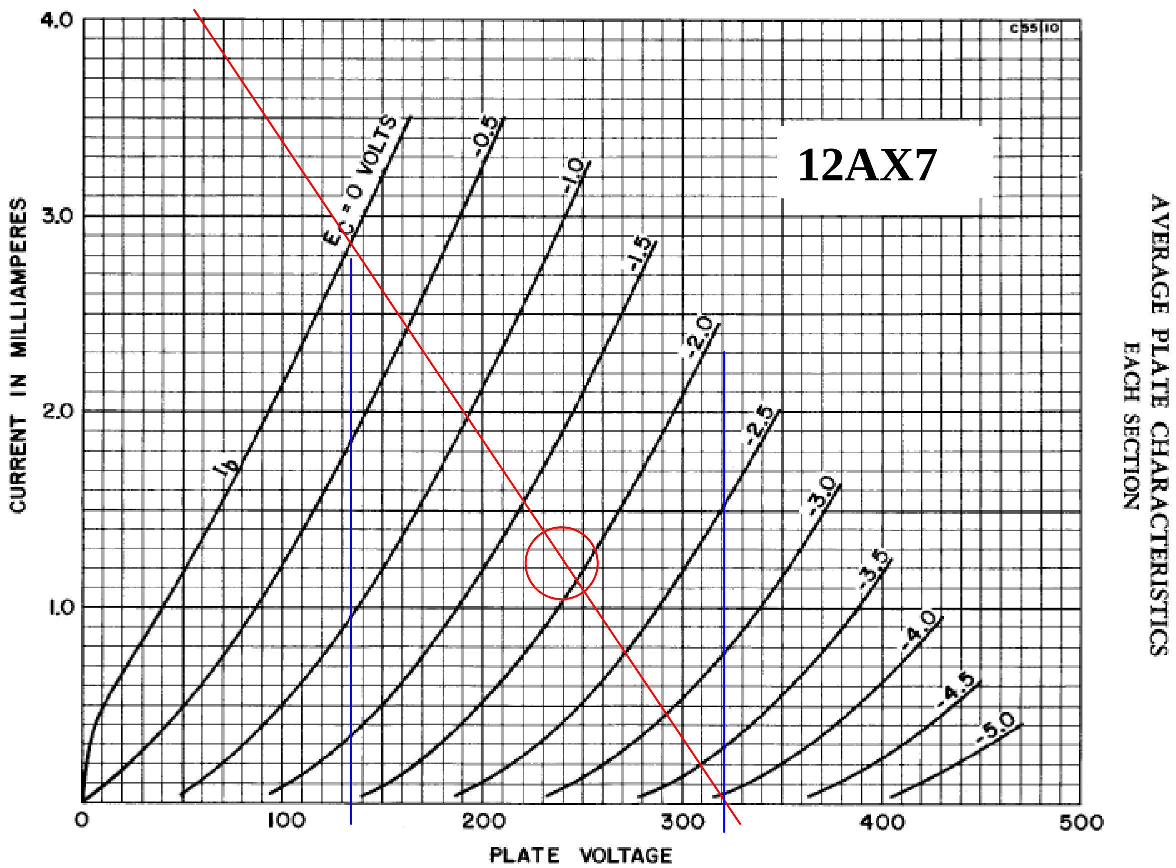
A concertina splitter, with direct coupled drive from first half triode. Gain of PI is a bit under one. Gain of driver has NFB to cathode from OPT output. The change from 22nF to 47nF coupling is probably due to the different drive characteristics of the bottom and top halves of the PI. The 1M5 direct coupling is just for dc biasing.

Original conditions:
Driver current is ~ (280-135V)/100k = 1.45mA; Vak ~ 135-0.92 = 134V. Effective Rk ~ 0.92/1.45=630.
PI idle current is ~ (321-285V)/33k = 1.1mA; Vak ~285-36= 249V.
Common cathode feedback node = 0.92V/390R = 2.4mA = (1.4+1.1).
DC bias current through 1M5 ~ (135-36V)/1M5 = 70uA

Tweaked conditions:
Driver current is ~ (293-182V)/100k = 1.1mA; Vak ~ 182-1.8 = 180V. Effective Rk ~ 1.75/1.1=1K6.
PI idle current is ~ (325-284V)/33k = 1.24mA; Vak ~284-42= 242V.
Common cathode feedback node = 1.75V/760R = 2.3mA = (1.1+1.2).
DC bias current through 1M5 ~ (182-42V)/1M5 = 93uA

The voltage swing from the driver is up to about 70Vpk from quiescent 165V.


12AX7
630R
1K6
AVERAGE PLATE CHARACTERISTICS
EACH SECTION
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_C = 0 VOLTS
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
I_b
4.0
3.0
2.0
1.0
0
100
200
300
400
500
C55110


12AX7
AVERAGE PLATE CHARACTERISTICS
EACH SECTION
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_C = 0 VOLTS
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
I_b
4.0
3.0
2.0
1.0
0
100
200
300
400
500
C55110

4.4 Power Supplies

The power supply is full-bridge silicon diode BY127/800 and a 260-130-0 VAC centre-tapped secondary. 3x24uF capacitor input filter for V1. Centre-tap 130VAC to 24uF capacitor input filter for screen V2, but uses half the full-bridge to provide a full-wave rectified output.

The 37-0-37VAC bias supply now has a 48V relay load, so extra diode added from un-used secondary half winding to give full-wave rectifier output. Original 37.5VDC bias level increases to 42.8V, but this reduces to 38.0V with standby relay on, and ripple is reduced. Fail-safe pot added to set bias.

A standby relay provides inherent bias failure protection, and switches the two outer secondary winding connections to the full-bridge. 470k resistors are placed across each relay contact to pre-charge the main supply capacitors (about 45V reached).

The heaters are taken to a +60VDC elevated reference through a 100R 2W humdinger pot.

4.5 Output Stage

Class B push-pull output stage with small region of class A overlap where both tube pairs conduct. The 1.8KΩ impedance plate-to-plate OPT (best estimate), presents each tube pair with 450Ω, and each tube with a 900Ω load impedance for effectively all signal currents.

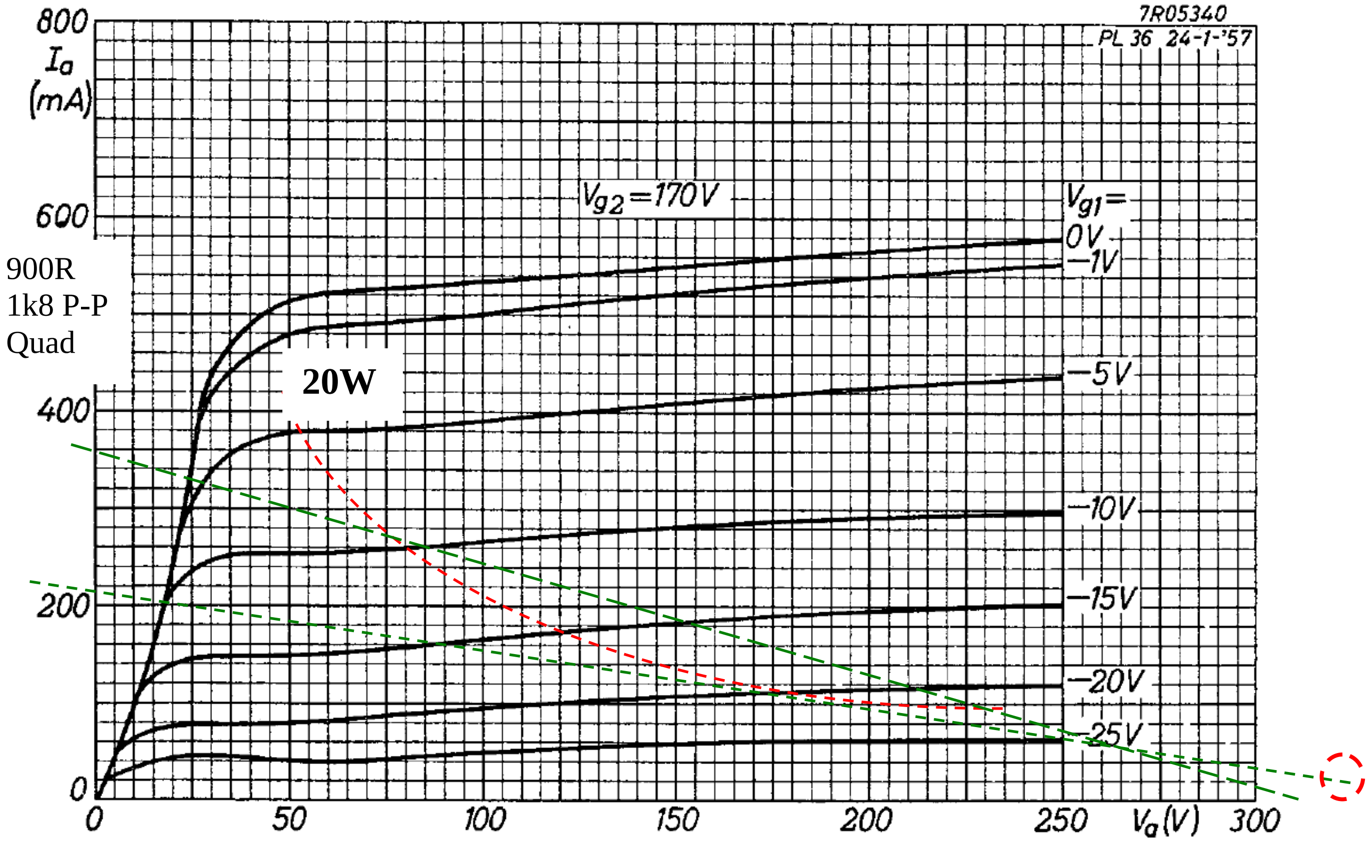
8-12W max for 350V anode is 23-34mA, but tubes set for 10mA nominal.

As the output loading increases, the plate supply voltage VS1 sags from 350V, due to supply regulation (335V @ 90W loading on VS1). 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 31Ω (ie. peak current of up to about 2x0.3=0.6A).

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.

Each valve has an ‘off’ period for 50% of time where the average plate dissipation is approaching zero W. As such for design, the max average dissipation during the ‘on’ period can target up to 2 x 10 = 20W per tube, and can extend dynamically beyond 20W level if needed. Assessing the EL36/PL36 plate curves, as no known 6CM5 curves are available, shows the simple plate load line starting at crossover of 10mA at VS1=350V (nominal level), and experiencing plate loss extending dynamically above 20W, and extending to the knee for gate voltage about -5V and anode current of ~300mA. This loadline will move lower under heavy loading as VS1 sags and OPT resistive loss increases. The plate curves would compress from the 170V screen level towards the peak.

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 = 0.6 x 0.6 x 1k8 / 8 = 81W. For this maximum signal condition, the rms OPT current draw is likely about 2 x 190mA (64% of peak), and the average VS1 power consumed is 320x0.38 =122W, and the OPT loss is $(0.38)^2$ x 62Ω = 9W, so the tube plates dissipate 122 - 81 - 9W = 32W, or just under 10W each.



4.6 HV breakdown

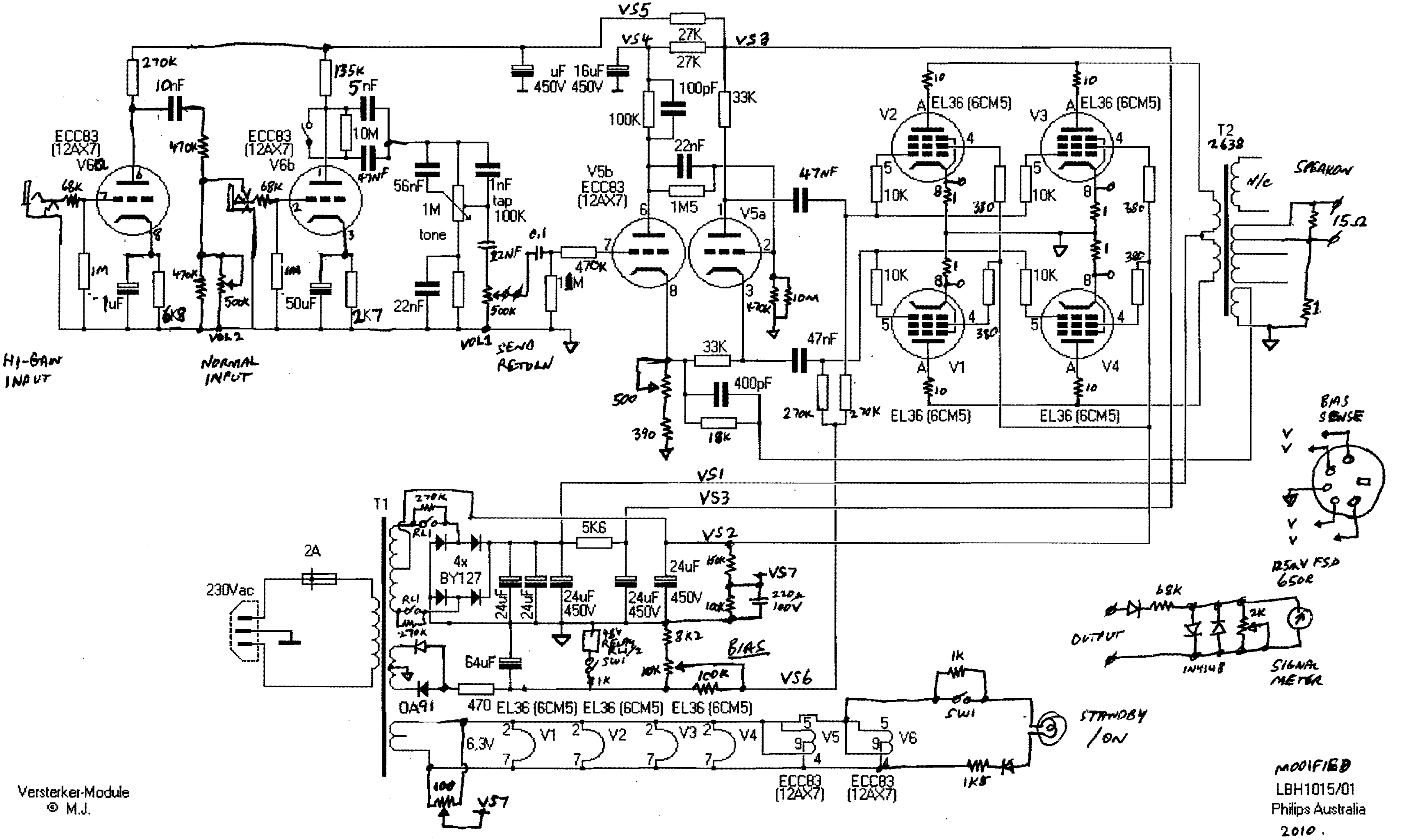
If the B+ rail shorts to ground, due to a flashover, or insulation breakdown, then 1A fuses in the transformer outer secondary windings would provide gross failure protection by de-energising VS1, and possibly VS2.

4.7 Output Level Meter

A "SIGNAL" meter with 650Ω resistance and 125mV FSD was used with 2k bypass trim pot and series diode rectifier and series resistance Rs to give FSD from a ~16Vrms level from the 50V output winding. (16/2)x490/Rs = 0.125 hence Rs = 33k. But only needed 6k8 – probably due to distortion and doubt about 16Vrms.

4.8 Send / Return Effects

Vol control output has up to 1Vrms output, so worthwhile adding 9V1 zeners directly across to pk limit. Use 400mW zeners to keep parasitic capacitance low. Take return direct to same point. Add 0.1uF poly in series with 47k gate input.



VS5
VS4
27K
VS3
27K
uF 450V
16uF 450V
100pF
33K
100K
100K
22nF
1M5
V5b ECC83 (12AX7)
V5a
47nF
270K
10nF
135K
5nF
10M
47nF
ECC83 (12AX7)
V6a
ECC83 (12AX7)
V6b
68K
470K
56nF
1M
tone
1nF
tap 100K
22nF
0.1
470K
1M
1M
uF
6K8
470K
500K
1M
50uF
2K7
22nF
500K
VOL2
VOL1
HI-GAIN INPUT
NORMAL INPUT
SEND RETURN
500
390
33K
400pF
18K
47nF
270K
270K
470K
10M
V2
EL36 (6CM5)
V3
EL36 (6CM5)
10
10K
380
V1
V4
EL36 (6CM5)
EL36 (6CM5)
T2
2638
SPEAKON
N/C
15Ω
BIAS SENSE
VS1
VS3
VS2
VS7
VS6
T1
270K
RL1
2A
230Vac
4x BY127
5K6
24uF
24uF
24uF 450V
24uF 450V
24uF 450V
220u 100V
100K
8K2
BIAS
10K
100R
64uF
48V RELAY RL1/2
SW1
1K
OA91
470
EL36 (6CM5)
EL36 (6CM5)
EL36 (6CM5)
6.3V
V1
V2
V3
V4
V5
V6
ECC83 (12AX7)
ECC83 (12AX7)
1K
SW1
1K5
STANDBY /ON
100
VS7
68K
2K
125mV FSD 650R
OUTPUT
1N4148
SIGNAL METER
Versterker-Module
© M.J.
MODIFIED
LBH1015/01
Philips Australia
2010.