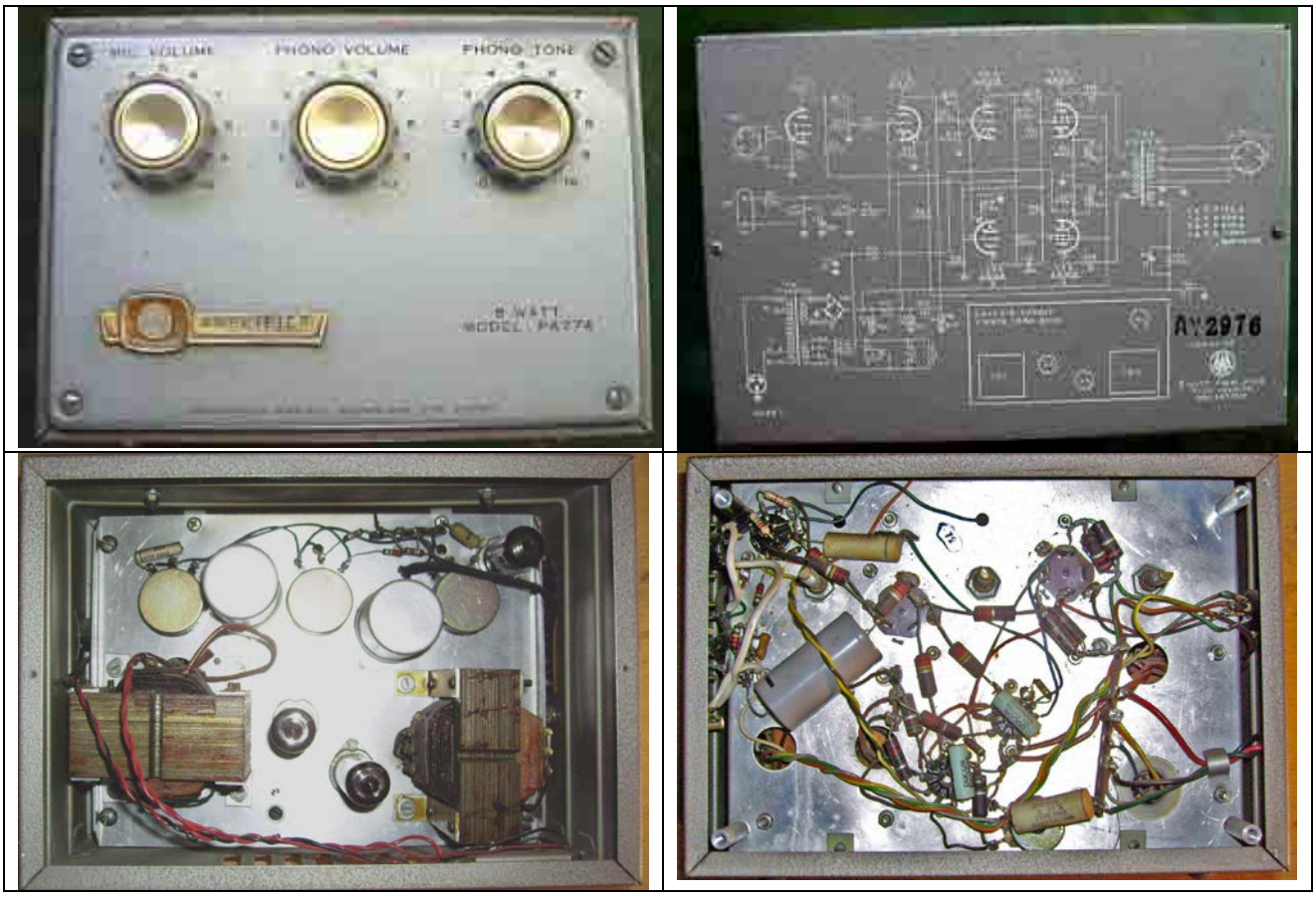
1. Summary

AWA 8 Watt Amplifier Type PA774, S.N. AY2976. eBay May 2009

1.1 Original design

One microphone and one P.U. input channel PA amplifier. Half 12AX7 amplifier for MIC channel. PU input summing into half 12AX7 summing amplifier. 6BM8 floating paraphrase splitter provides high gain to PP pentode output stage. Cathode bias push-pull 6BM8 output, with isolated secondary feedback winding taken to the 2nd stage cathode. 220V plate supply from FC442 bridge diode rectifier and capacitor filter. Plate supply fed direct to the screen supply. Cascading resistor/cap dropping to the splitter voltage supply, and again to the input amp supplies. 6.3VAC heater supplied to all valves, and hum cancelling feedback taken to cathode of V3B. Vol pot for MIC input. Vol pot for P.U. input. Tone pot for P.U. input. Output load settings 150/300/600/ 1200Ω from 5K PP transformer. Transformers marked with '60720' and '60195'. POTs are IRC marked with 59774T63 date codes suggesting 1963 manufacture. Modifications noted were: 2.5mm input jack added; 33uF 500V cap added across C9B. Problems included: Terminal strip cracked for AC termination. Cathode bias resistors degraded. Bridge rectifier MR1 (Westcode FC442) failed. C11A leaky. C9A,B high ESR.



1.2 Modified Design for Guitar Amp use

Inputs reduced to just one guitar input – isolated 6.5mm socket with tip grounded; changed R1 to 1M and 22K grid input added; R2 and R9 changed to 2K2; switched R9 bypass; R11 changed to 100K. PU circuitry and summer removed. Single tone pot with 1kHz notch at min end and treble roll off at max end using existing 500K pot with 180mH. 100nF & 1k series LCR on wiper to gnd, and with 2k2 and 560pF on wiper to top, with 22k from wiper to 0V. Inductor made from ferrite

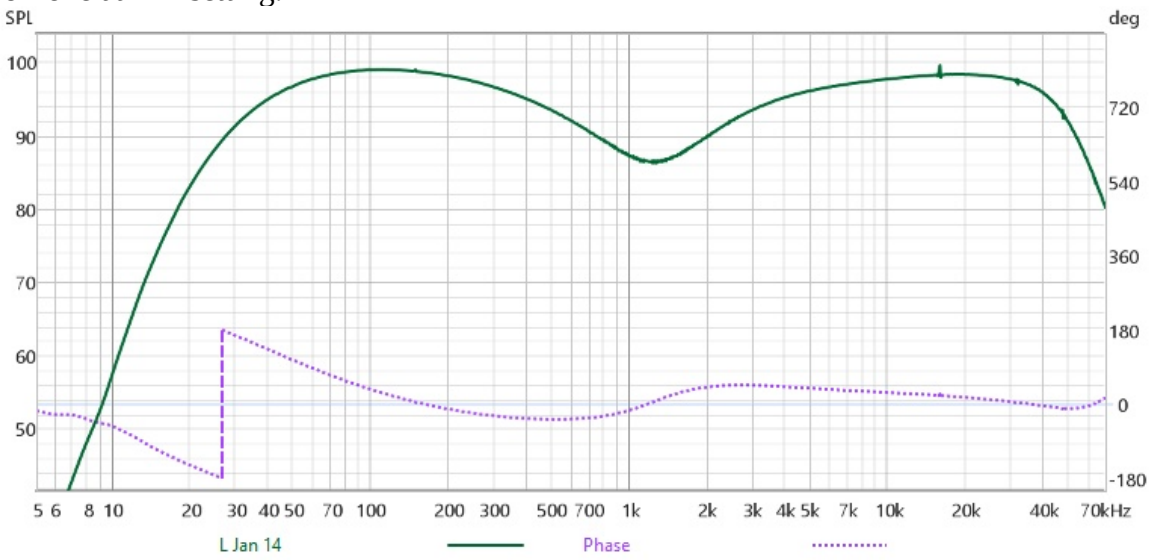
common mode choke with windings in series (DCR=4Ω), and mu-metal outer shell screening (due to proximity of PT). Gain pot with 22pF treble bypass. Make-up stage with cathode boost switch.

Replaced AC cable. AC fuse added. AC input OFF (mid), Standby (down), ON (up) switch added - 100k bleed resistor across Standby switch to provide some positive bias of electrolytics before normal on state. Added new RS204 bridge rectifier and 120uF 400V cap for main filter. Yellow LED for standby using heater through 1N4148 and series 390R.

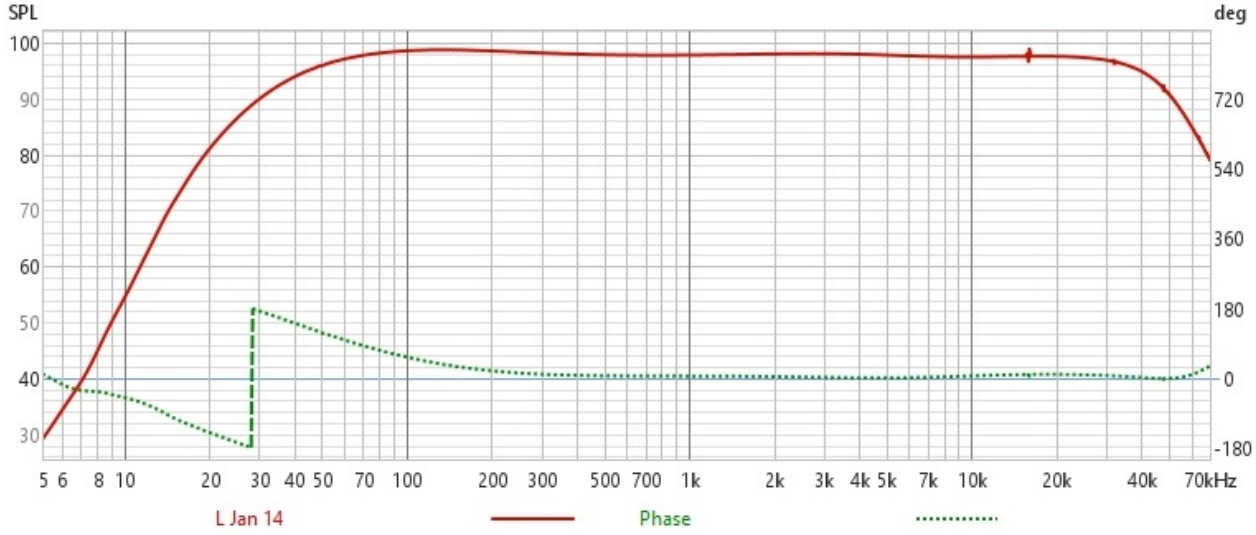
6.5mm phono locking socket for 15 ohm output, with switch to include 0R (up), 5R (down) or 10R (mid) series resistance (to match 5k transformer impedance) in series with 150R-to-300R output winding (ie. only using 15% of secondary 0-1200R winding). Removed orange and blue leads to power transformer primary. Removed other wiring taps on output transformer. Added 47k PRO2 across 0-1200R output winding of OPT to provide open-circuit loading ~0.2W dissipation at 8W output level. Added 330VDC MOVs across each OT primary half-winding.

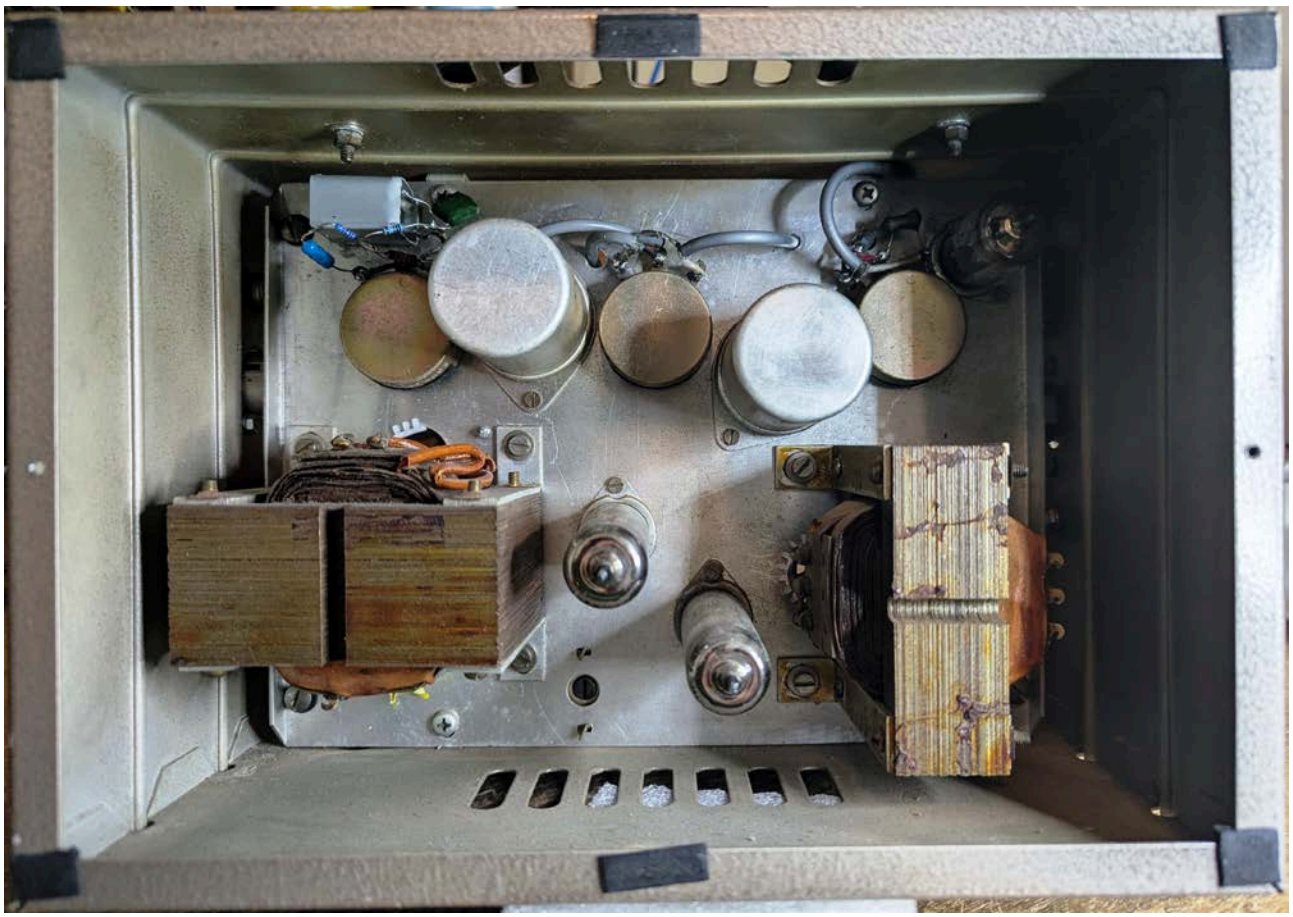
330R screen stoppers and 15K grid stoppers added to output pentodes. C4, C6 lowered from 22nF to 10nF to minimise blocking distortion.

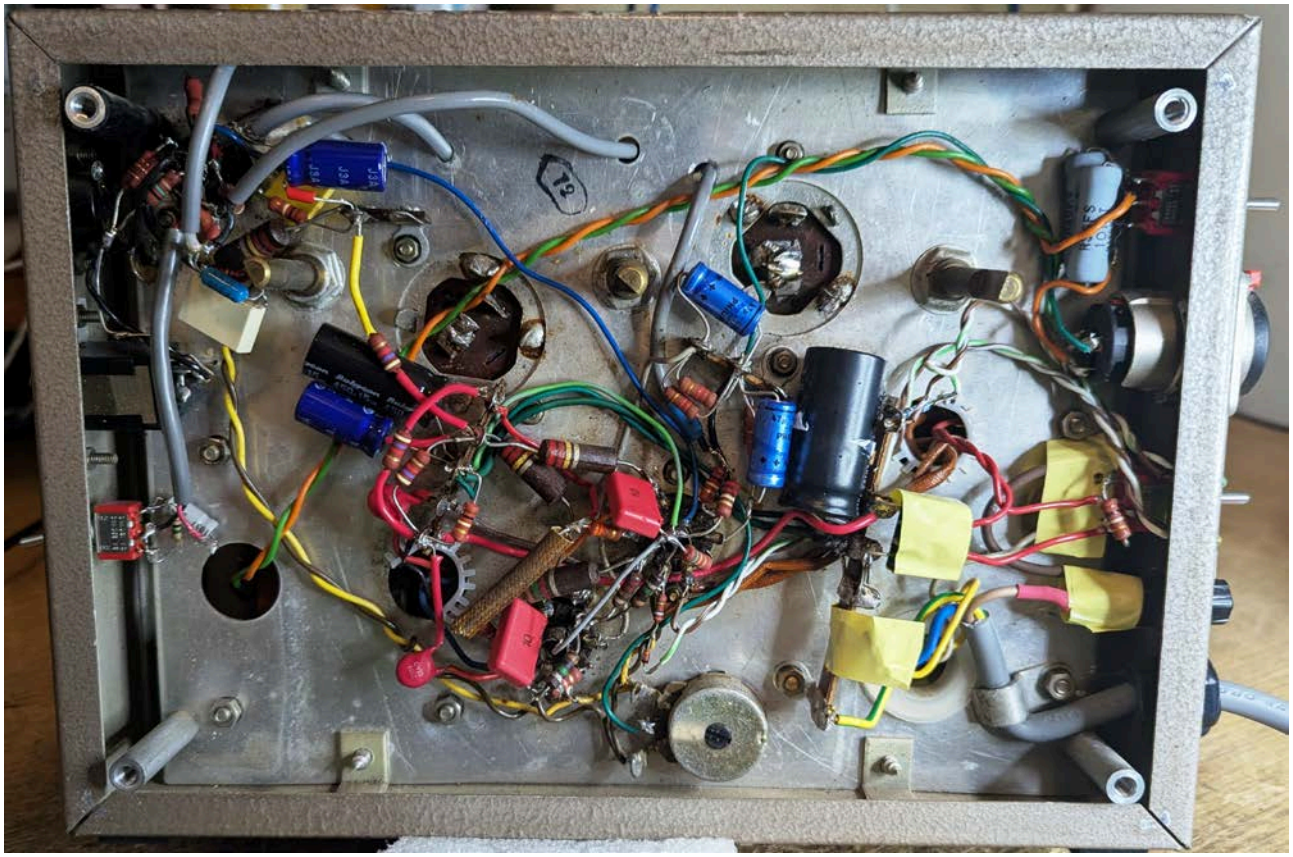
Phono Tone at min setting.



Phono Tone at 20% setting.







2. Measurements

Voltage rail regulation.

Rail	Idle	Cranked
VS1	244V (1.24Vrms)	
VS2	202V (30mVrms)	
VS3	233V	
VS4	227V	
Heater 1		
Sec HT		
Cathodes	18V, 18V (7W, 7W)	

Power transformer primary DC resistance: 59Ω.
Power transformer secondary DC resistance: 71Ω.

12VAC 50Hz nominal applied to output transformer 150R winding

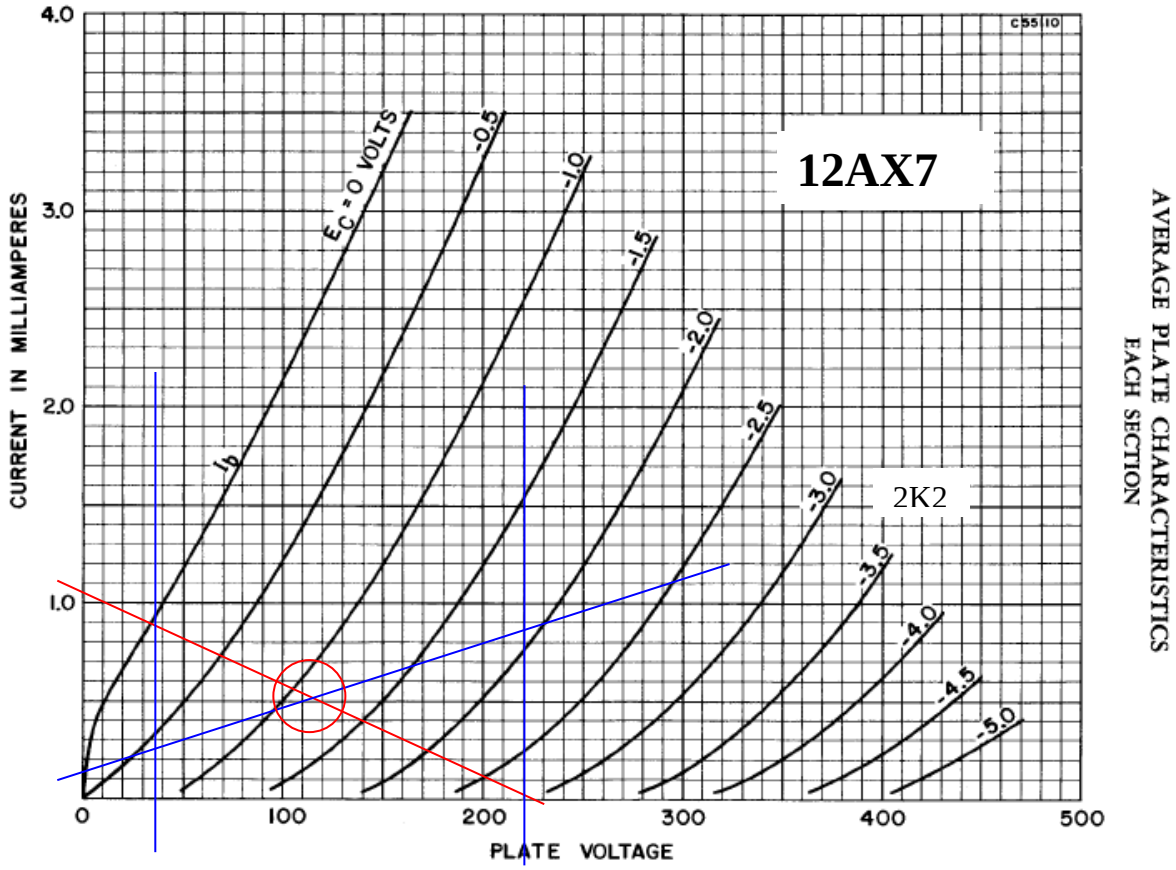
Winding	Voltage rms	Turns ratio; Pri Impedance; Spec level; Notes;	turns %
Pri P-P: BLU to Vi	70.92	1 ; ; N/A; appears to be 5k P-P	
Sec: Feedback Winding	7.04	10.07; N/A; 49Ω, based on 5k P-P	20.2
Sec: 150 to Com	12.33	5.75; 4,960Ω; 150 Ω; based on 150	35.5
Sec: 300 to Com	17.43	4.07; 4,970Ω; 302Ω; based on 5k P-P	50.1
Sec: 1200 to Com	34.79	2.04; 4,994 Ω; 1201Ω; based on 5k P-P	100
Sec: 150 to 300	5.04	14.07; N/A; 25.2Ω; based on 5k P-P	14.5
Sec: 1200 to 300	17.28	4.1; N/A; 300Ω; based on 5k P-P	50

Output transformer primary DC resistance: 153Ω plate-to-plate.
Output transformer secondary DC resistance: 18.2Ω 1200 winding.
Output 6Wrms cranked into 17Ω.

3. Design Info

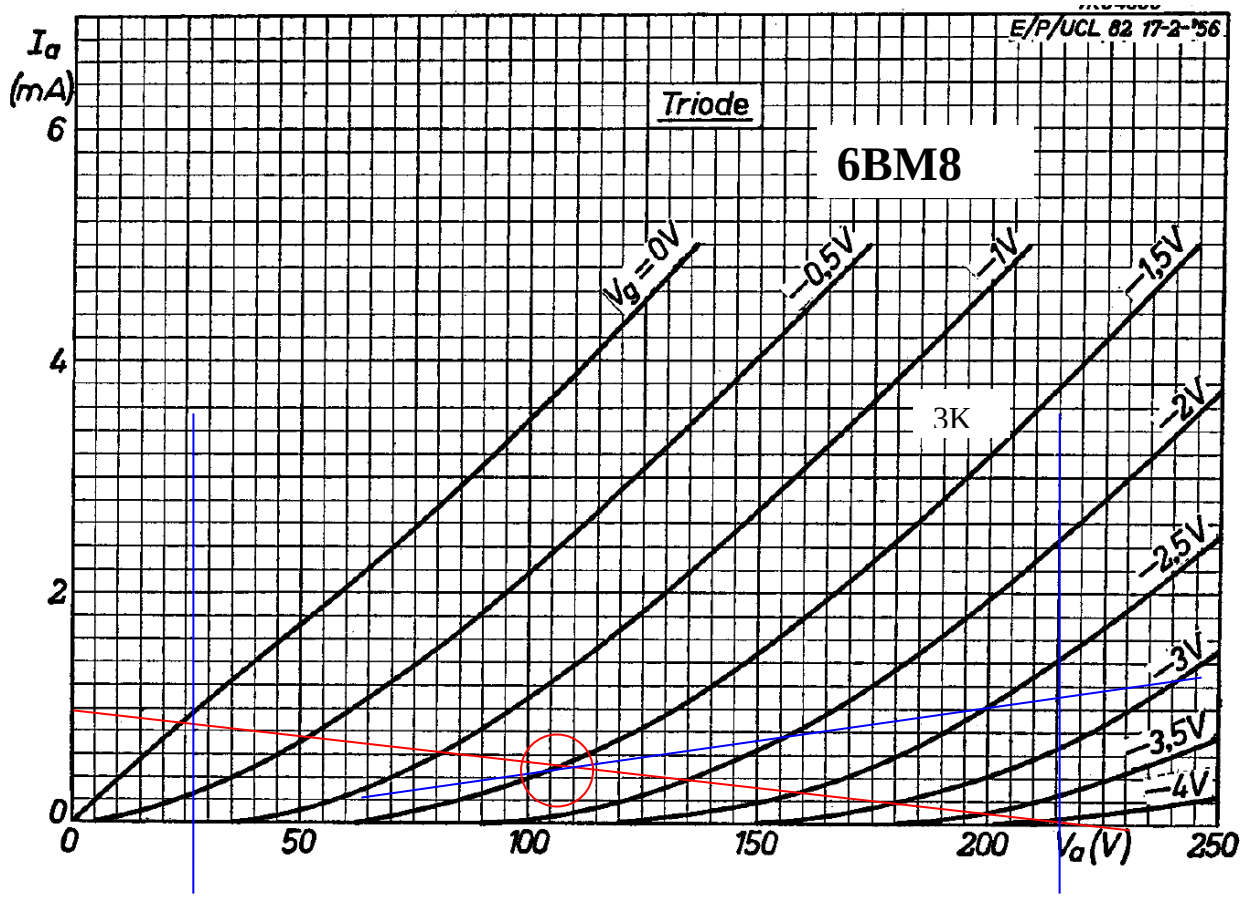
3.1 Input stage – 12AX7 - modified

For the first half 12AX7, V1A: supply voltage VS4 = 227V; Va=V; Rk=2k2; Vk=V; Ia=mA; RLdc=220k. Second half is quite similar.



3.2 Splitter stage – 6BM8 Triode

Cathode-coupled paraphase configuration phase splitter. Signal going into the grid of V2A makes a same-phase signal on the cathode and an opposite phase (and larger) signal on its plate. Triodes V2A and V3A share a common cathode resistor so when V2A is biased further into conduction, its increased cathode current raises the voltage of both cathodes so V3A is biased further out of conduction and so V3A plate signal varies with opposite phase of V2A plate voltage. If the voltage on plate of ‘A’ is larger than plate voltage of ‘B’ then grid of ‘B’ is driven harder, and so forces plate voltage of ‘B’ larger to equalise.



3.3 Output Stage

In this Class AB push-pull output stage, one tube is pushed into conduction and the other tube is pulled into cutoff, and there is a region of overlap where both tubes conduct equivalent levels of current. The cathodes are biased to +18V using separate common cathode resistors. The 5KΩ impedance plate-to-plate OPT presents each pair of tubes with a 1.25KΩ load impedance (with a matched secondary load) for signal currents in Class B region, and 2.5K in Class A region.

The supply voltage VS1 to the output valve plates is about 245V. Plate-cathode voltage will be lower than VS1 by an amount up to ~20V; ie. OPT half resistance of about 76Ω with an idle current of 0.03A, and 18V cathode bias. As the output loading increases, the supply voltage VS1 to the output valve plates sags to about 220V [check]. Plate DC voltage will be lower than VS1 by an amount up to ~34V; ie. OPT half resistance of about 76Ω with a peak current of up to about 0.12A, and 25V cathode bias.

Screen voltage supply VS2 will vary from about 200V towards 180V under steady-state heavy load. Screen voltage lower than VS2 by 18V at idle, and ~ 35V due to the 330R stopper resistors at up to 30mA screen current per tube, and the cathode bias voltage. Peak screen power dissipation is then up to 30mA x 150V = 4.5Wpk, and about 180 x 0.008 = 1.4W average.

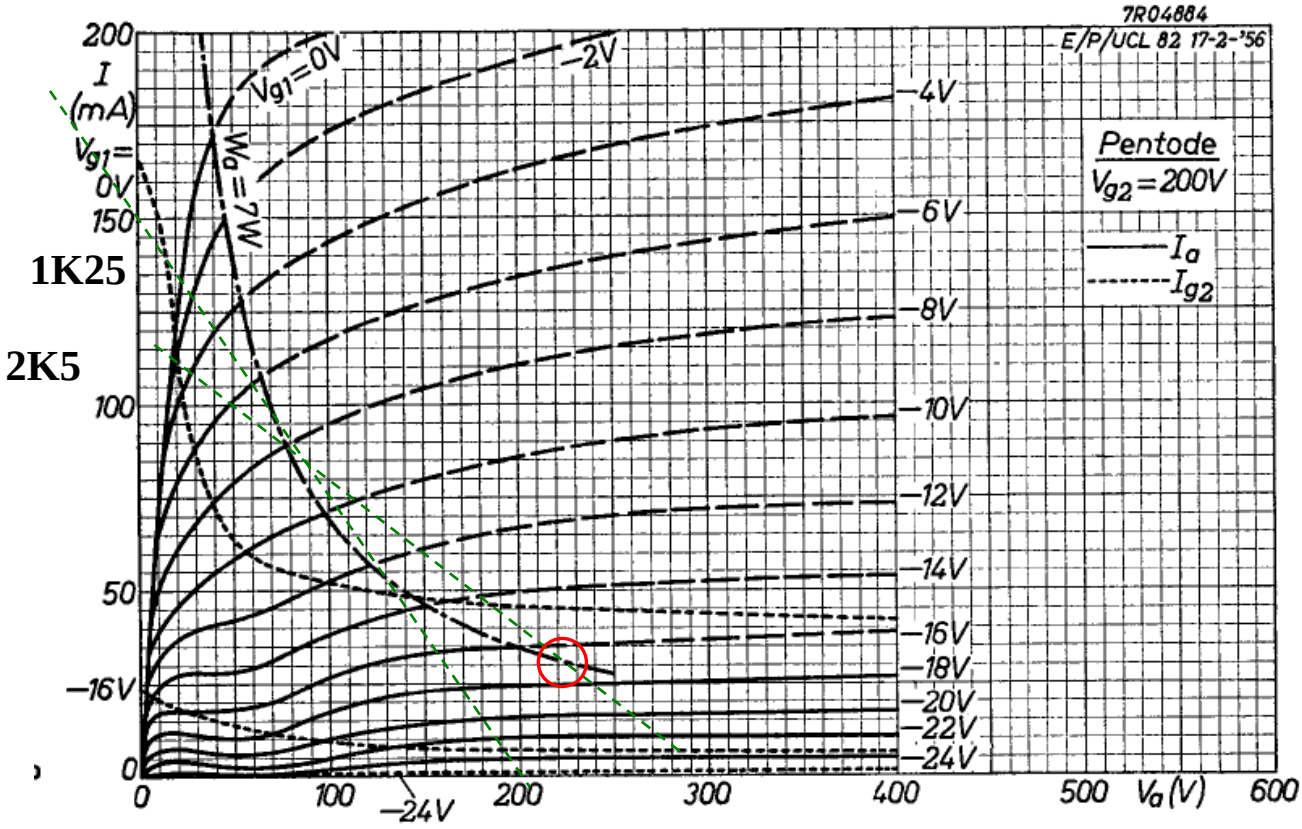
The maximum output valve bias current allowed is dependant on the maximum recommended plate dissipation of 7W, + 3.2W for the screen, for the 6BM8: Ibias(max) = Pd / Vb = 7W / (220-20V) = 35mA.

Assessing the 6BM8 plate curves, which shows the 7W constant power contour, indicates how the amp will dynamically exceed plate max design dissipation levels. Note that these curves are for a

200V screen level, with no compression influences, and the load lines are for 2.5K (5K P-P transformer push-pull) moving to 1.25K.

For a peak plate current of 130mA, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.13 x 0.13 x 5k / 8 = 10.5W. For this maximum signal condition, the rms OPT current draw is likely about 83mA (64% of peak), and the average VS1 power consumed is about 230x 0.083Arms =19W, and the OPT loss is about $(0.083)^2$ x 153Ω = 1W, and cathode bias loss is $(0.083)^2$ x 300Ω = 2W so the tube plates dissipate 19 - 2 - 1 - 6= 10W, or just under 5W each, which is ok.

Cathode bias trimmed to 30mA nominal with 600R resistance and nominal 18V bias. However, general comment is that common bias sounds better, but then valves would need to be better matched.



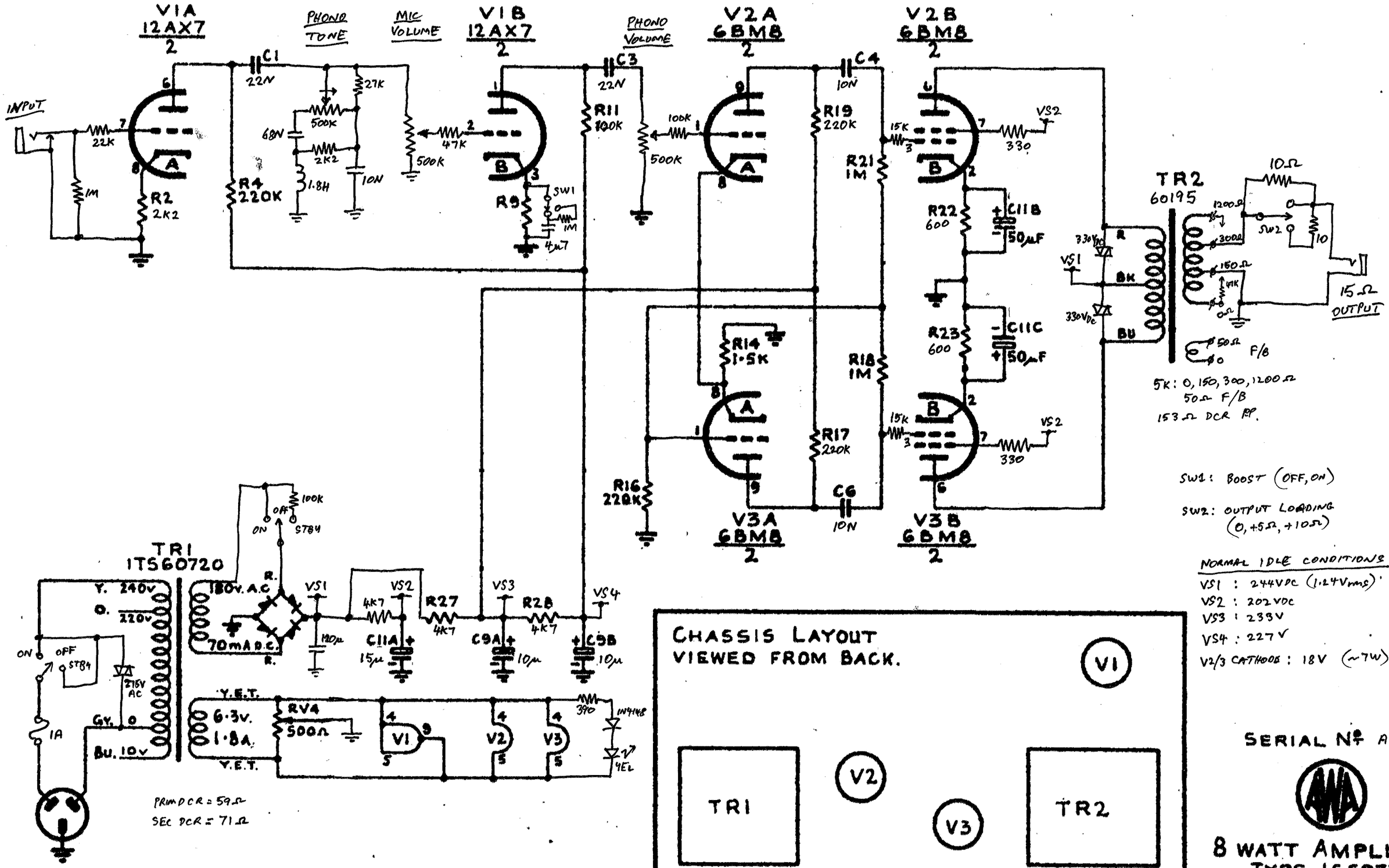
3.4 Power Supplies

The full bridge rectifier circuit uses a 200V secondary HT winding. Only one 6.3VAC secondary is available for heaters. Heater loading is 0.3A + 2x 0.78A = 1.8A.

C11A is replaced with a 120uF 400V cap. The ripple voltage across V1 is mainly 100Hz, at a measured level of 1.24Vrms at idle.

Bleed: 100k on VS1.

Distributed star 0V with one link to chassis at power supply.


V1A 12AX7 2
PHONO TONE
MIC VOLUME
V1B 12AX7 2
PHONO VOLUME
V2A 6BM8 2
V2B 6BM8 2
INPUT
C1 22N
C3 22N
C4 10N
22K
1M
R2 2K2
R4 220K
68N
500K
27K
2K2
1.8H
10N
47K
500K
R11 100K
100K
500K
R19 220K
R21 1M
15K
330
VS2
R22 600
C11B 50µF
R23 600
C11C 50µF
R18 1M
R14 1·5K
R17 220K
R16 220K
C6 10N
V3A 6BM8 2
V3B 6BM8 2
SW1
1M
4µ7
TR2 60195
10Ω
1200Ω
300Ω
150Ω
47K
SW2
10
15Ω OUTPUT
330VDC
VS1
BK
BU
50Ω F/B
5K: 0, 150, 300, 1200Ω
50Ω F/B
153Ω DCR PP.
SW1: BOOST (OFF, ON)
SW2: OUTPUT LOADING (0, +5Ω, +10Ω)
TR1 1T560720
Y. 240V
O. 220V
180V. A.C.
70mA D.C.
VS1
VS2
VS3
VS4
4K7
R27 4K7
R28 4K7
C11A 15µ
C9A 10µ
C9B 10µ
100K
OFF
ON
ST84
215V AC
ON
OFF
ST84
1A
Gy.
Bu. 10V
Y.E.T.
6·3V. 1·8A.
RV4 500Ω
V1
V2
V3
390
IN4148
4EL
PRIM DCR = 59Ω
SEC DCR = 71Ω
CHASSIS LAYOUT VIEWED FROM BACK.
TR1
V2
V3
TR2
V1
NORMAL IDLE CONDITIONS
VS1 : 244VDC (1·24Vrms)
VS2 : 202VDC
VS3 : 233V
VS4 : 227V
V2/3 CATHODE : 18V (~7W)
SERIAL Nº A42976
8 WATT AMPLIFIER
TYPE IG59774
DRG. 59774C1
PA 774