1. Summary

AWA 12.5 Watt Amplifier Type PA 1005, S.N. CZ1345. Mar 2021

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. 12AX7 floating paraphase splitter provides high gain to drive output stage. Cathode bias push-pull quad 6AQ5 output, with isolated secondary feedback winding taken to the 2nd stage cathode, and the splitter input cathode. 250V plate supply from voltage doubler 1N3195 diode rectifier and capacitor filter. Plate supply fed direct to the screen supply. Cascading resistor/cap dropping to the splitter, and again to the input amps. 6.3VAC heater supplied to all valves except input 12AX7 - which has heater powered as part of output stage cathode resistor. Vol pot for MIC input. Vol pot for P.U. input. Tone pot for P.U. input. Output load settings 40/60/120/200/315/630. Date codes suggesting 1969 manufacture.

PT: CD9
OT:33551 1 CD9
12AX7 Radiotron TM 12; ?
6AQ5 Radiotron R4 UC 3 (x4)
Diodes Radiotron 1N3195 (x2) (both megger ok at 1kVdc)
Caps: Ducon e-caps 4668, 4468, 4968, 0669 Hendon 019H, 108H, 029H
Anocap 4468
Resistors: IRC 69 O4
Chassis QC marks: 68

Condition: Original but dirty. Front fascia badge missing, and extra hole added. Rear fascia PU input changed to 5-pin. Line signal transformer ?XC?1501 factory fitted. Heater wiring around output stage roasted – fume marks under top cover – PT outer heater winding cover roasted – output stage top level sockets badly distressed and crumbly - suspected short circuit in heater path near 6AQ5s. All coupling caps tested good for capacitance and 500Vdc insulation.

1.2 Modified Design for Guitar Amp use

Inputs reduced to just one guitar input. MIC vol pot after 1st stage. PU vol pot after 2nd stage. Feedback only to PI stage cathode. Hum and noise minimised. 8 ohm Speakon socket output. Added protection.

2. Modifications

- Replaced AC input cable and internal AC wiring. No on/off switch. Added 275Vac MOV across primary. 250VAC primary winding used.
- Replaced diodes with UF4007, and filter caps with 220uF 160V with 150k bleeds.
- Removed Line signal transformer.
- Replaced 4 output stage sockets – only had 2 sockets with restraining clips.
- Disconnected P.U. input circuit from V1B.
- New e-caps.
- Valve socket chassis used for local ground, with star for main B+ and output stage.
- Individual 270Ω 2W screen stoppers.
- MOV across each OT primary half winding.
- Heater fixed humdinger replaced by 200R trimpot for protection, as no change in hum due to DC heated V1.
- Added 4x 24V 5W zeners in // across common cathode for over-voltage protection.
- Added 1N4004 between each common grid leak and common cathode of output stage for fault protection.
- Feedback taken only to PI input cathode, via rear panel bass full/cut switch used to disable feedback.
- Rewired output transformer secondary to 4x 8Ω in parallel.
- Speakon socket for 8 ohm output. Separated OT secondary windings at taps and connected the four middle windings (40-60; 60-120; 120-200; 200-315) in parallel to provide 8R output – the two outer windings (0-40, 315-630) are left open and unconnected. Earthed one side of output.
- Isolated 6.5mm socket input, switched to ground. Changed R1 from 2M2 to 1M, and added 10k grid stopper. Added 6.8uF cathode bypass to each V1 cathode.
- MIC vol wiper direct to 2nd stage. Added 150pF treble bypass across RV3 to equalise treble a bit.
- PU Tone moved to load 2nd stage output.
- Moved PU vol to output of 2nd stage, with wiper to PI via 220k grid stopper.
- 10R individual 6AQ5 cathode resistors for nominal bias checking (screen + plate).
- Added DB9 monitoring socket for common cathode voltage, 4x cathode sense, FS1/100, gnd with pin # as per 8x meter box.
- FS1/100 acts as B+ bleed. 99.4k+(1k//120k). 100k 2W.
- Shielded pair cable to Pots and front panel input and feedback circuitry.

To do:

- Could remove V1A or V1B cathode bypass to reduce gain.

3. Measurements

Voltage rail regulation. 240Vac mains

Rail	Idle 240V 0.27A
VS1	241V 2.36Vrms
VS2	197V ~20mVrms
VS3	167V
V1A plate	98V
V1B plate	107V
V2A plate	125V
V2B plate	130V
Heater 1	6.36Vrms
Sec HT	96Vrms
Cathode 9,15 14,12	14.7V 29.8+28.4mA (58.0) 27.4+32.6mA (60.0).
V1 heater	8.15V

Power transformer primary DC resistance: 45Ω.
Power transformer secondary DC resistance: 15Ω.

12VAC 50Hz nominal applied to output transformer 40R winding

Winding	Voltage rms	Turns ratio; Pri Impedance; Spec level; Notes
Pri P-P: BLU to Vi	154.9	1 ; Ω; N/A; appears to be 5k P-P
Sec: Feedback Winding	15.46	10.0; Ω; N/A Ω; 50Ω, based on 5k P-P
Sec: 40 to Com	12.39	12.5; 6,250 Ω; 40 Ω; 32Ω, based on 5k P-P
Sec: 60 to Com	18.54	8.35; 4,185Ω; 60Ω; 72Ω, based on 5k P-P
Sec: 120 to Com	24.7	6.27; 4,718 Ω; 120Ω;
Sec: 200 to Com	30.83	5.02; 5,044 Ω; 200Ω;
Sec: 315 to Com	36.8	4.21; 5,582Ω; 315 Ω;
Sec: 630 to Com	55.2	2.81; 4,961Ω; 630 Ω;

12VAC 50Hz nominal applied to 40 + 630 windings on output transformer

Winding	Voltage rms	Turns ratio; Impedance; Notes
Pri P-P: BLU to Vi	62.0	1 ; assumed to be 5k P-P
Sec: 40 to 630 windings	12.2	5.08; 194 Ω; based on 5k P-P
Sec: 40 to 60	2.44	25.4; 7.75 Ω; based on 5k P-P
Sec: 60 to 120	2.44	25.4; 7.75Ω; based on 5k P-P
Sec: 120 to 200	2.44	25.4; 7.75 Ω; based on 5k P-P
Sec: 200 to 315	2.44	25.4; 7.75 Ω; based on 5k P-P

Output transformer primary DC resistance: 162Ω plate-to-plate.
Output transformer secondary DC resistance: 4.2Ω 630 winding.
Output transformer secondary f/b DC resistance: 17Ω winding.

The effective impedance of the winding between the 40R to 60R, 60R to 120R, 120R to 200R, and 200R to 315R taps is 8R. These four windings were separated and wired in parallel, to give an 8R output – they comprise 45% of secondary winding turns. Checked for 100Vdc functional insulation.

Alternatively, the Com-40R, 40R to 120R, and 120R to 315R could be wired in parallel for a 32R output using 67% of secondary winding turns.

6AQ6 pairing (in descending order; total qty=17)
9,12 14,15 8,13 5,17 7,16 10 2 4,11 1,3 6
Nominal 7.2W dissipation is about 50% of max rated.

Power up causes stress on any 6AQ5 that conducts earlier than others, as common cathode bias voltage is constrained to be low - due to both 6AQ5 conduction timing differences and to initial cold V1 heater resistance.

Long term operation of V1 at low heater voltage may change its performance - so V1 and V2 are preferably swapped periodically.

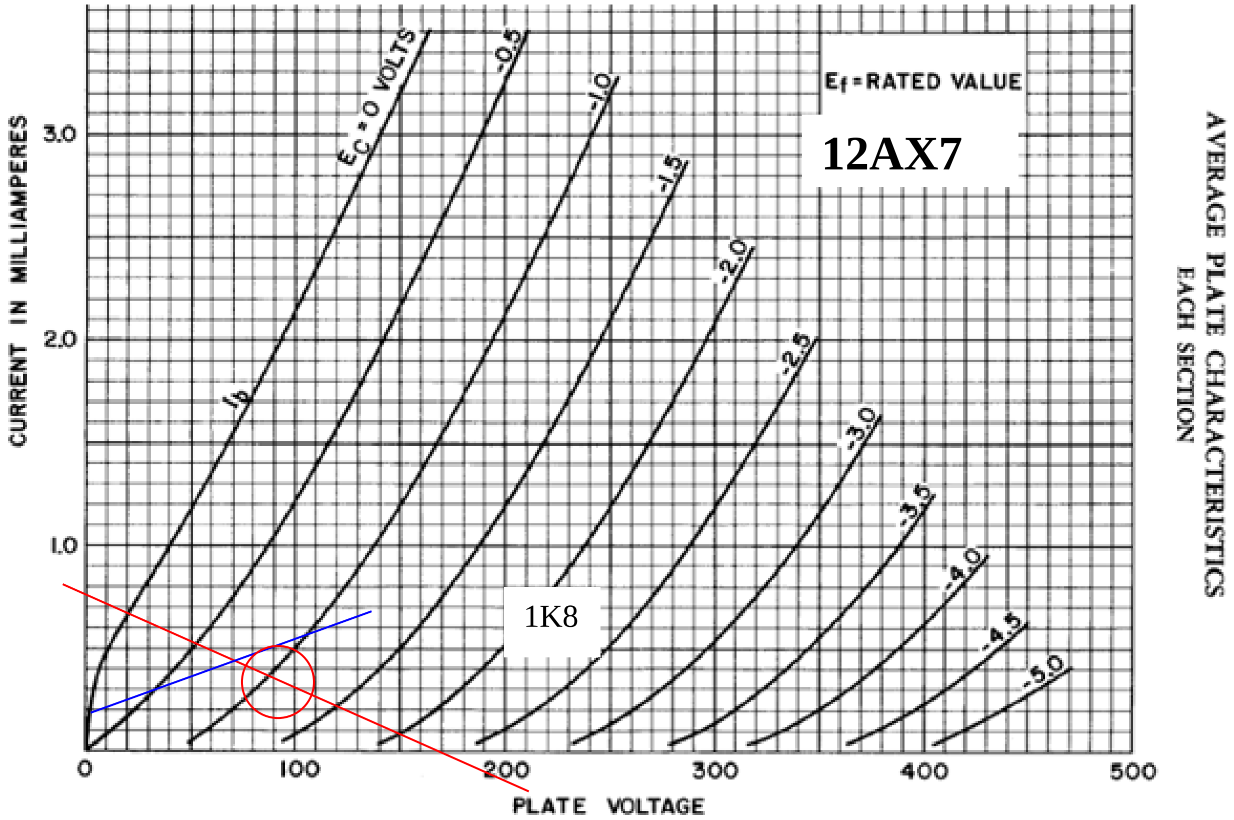
Output clean to 10W and soft limiting at 12.5W and then harder clipping at 14.5W max.

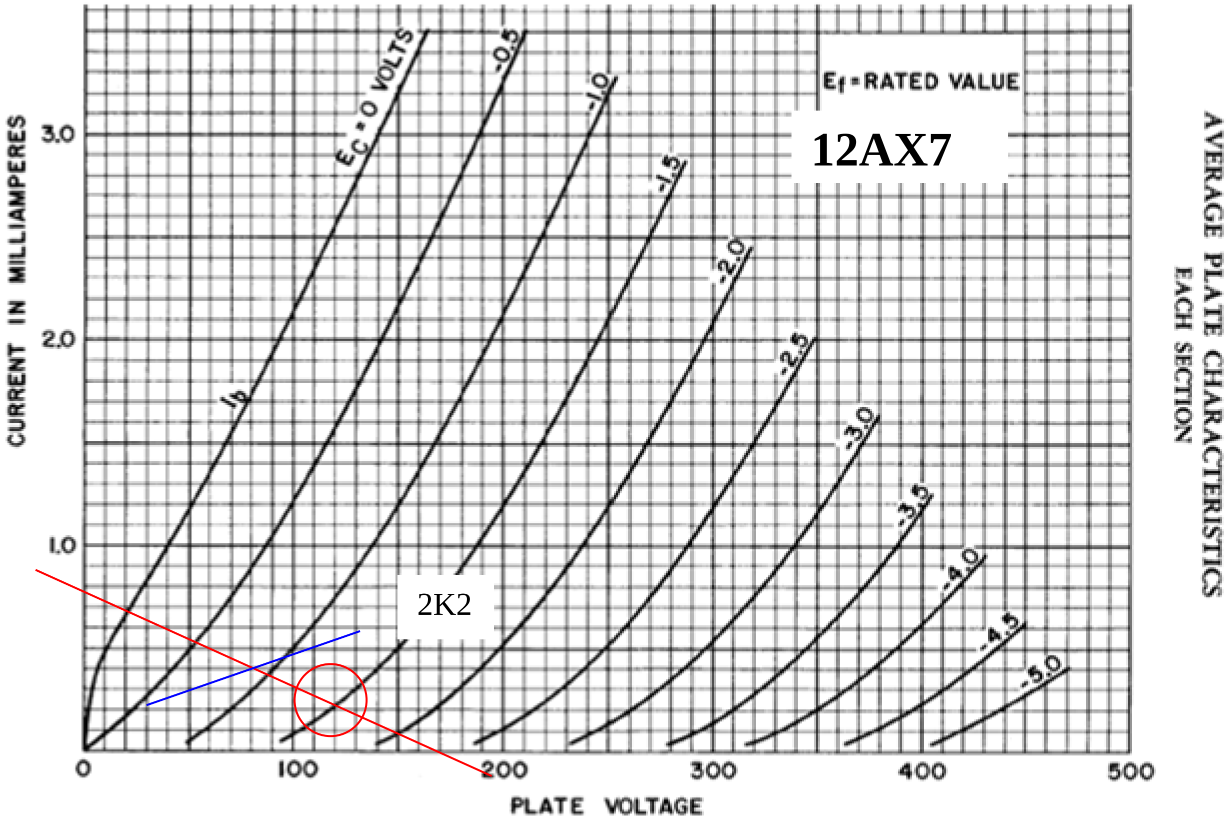
Feedback switch (rear panel) introduces 6dB NFB, and extends bass response noticeably and treble a bit.

4. Design Info

4.1 Input stage – 12AX7

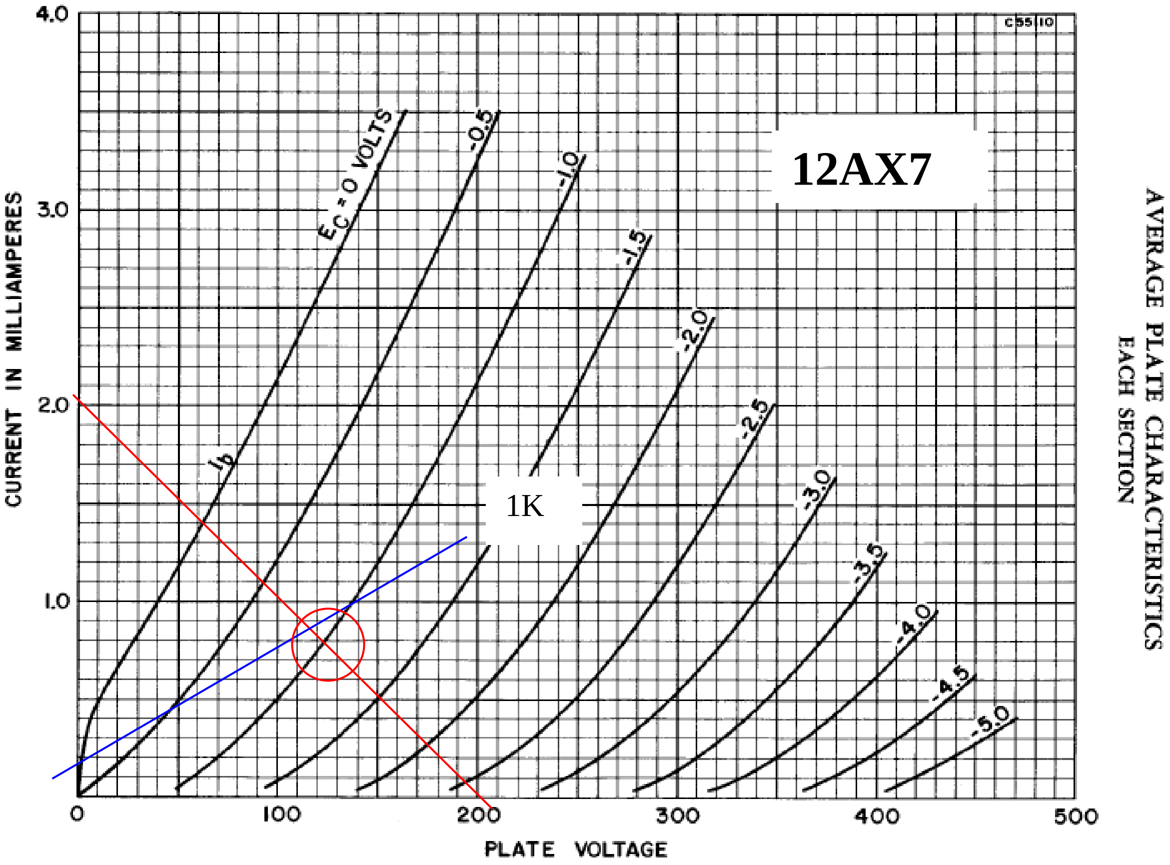
For the first half 12AX7, V1A, B+ = 167V; Va=98V; Rk=1.8k; RLdc=220k.
For the second half 12AX7, V1B, B+ = 167V; Va=107V; Rk=2k2; RLdc=220k.





4.2 Splitter stage – 12AX7

B+ = 197V. Va = 125V. Rk = 1k; RLdc = 100k.



4.3 Output Stage

In this Class AB push-pull output stage, two tubes are pushed into conduction and the other two tubes are pulled into cutoff, and there is a region of overlap where all tubes conduct equivalent levels of current. The cathodes are biased to +15V using a common cathode resistor. 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.

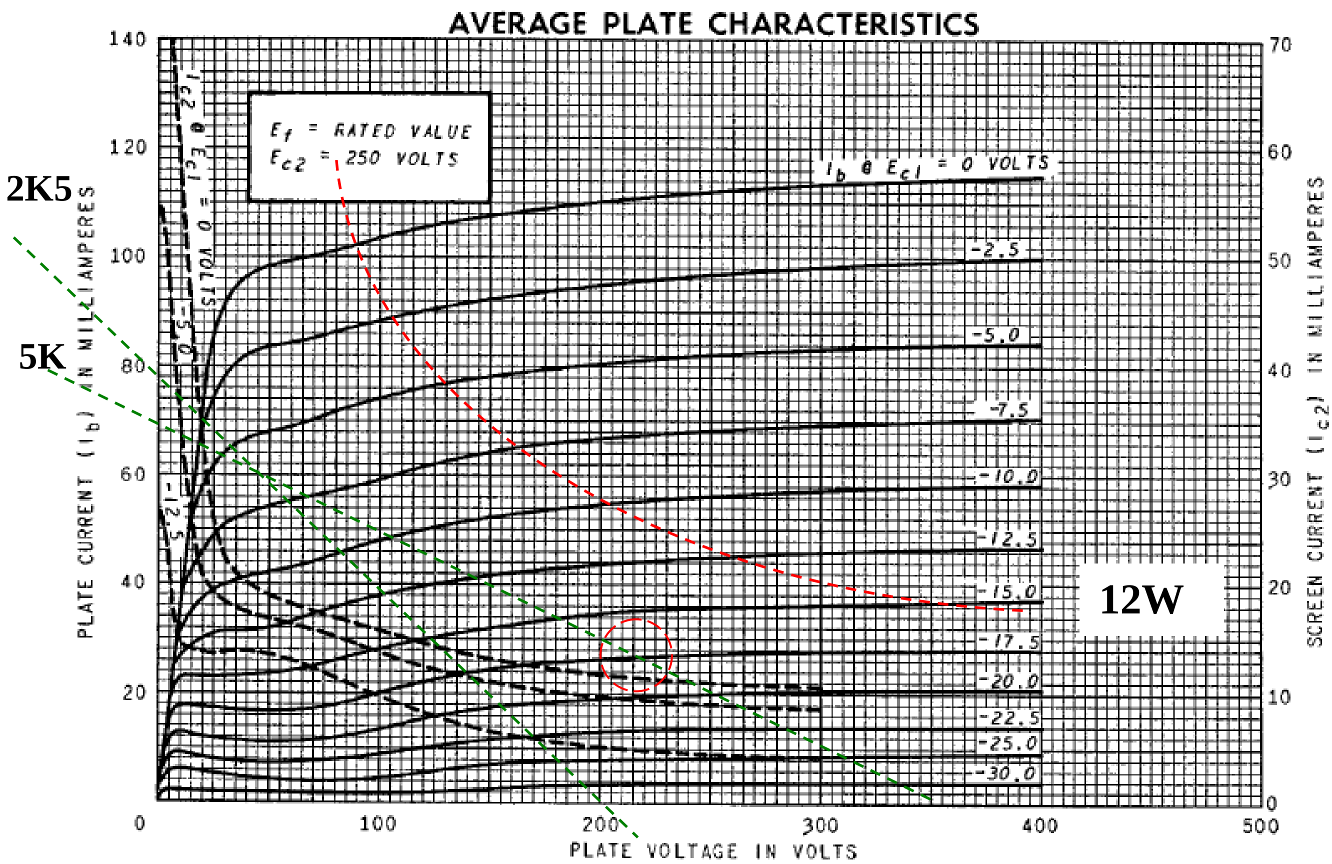
Exact replacement for 6AQ5 is 6HG5.

Schematic shows total quad cathode current is (15.2V-8.2V)/56Ω = 125mA, or 41mA/valve. And dissipation is (245V-15.2V)*41mA = 9.4W. Max design centre is 12+2 = 14W.

As the output loading increases, the supply voltage VS1 to the output valve plates sags from about 245V towards 200V. Plate DC voltage will be lower than VS1 by an amount of 15V to ~44Vpk; ie. OPT half resistance of about 81Ω with a peak current of up to about 0.07+.07A, and 15V+19V(pk) cathode bias.

Screen voltage supply will also vary from about 245V towards 220V under steady-state heavy load. Screen voltage lower than VS1 by 8V due to the 270R stopper resistors at 30mA screen current per tube, plus additional 15V+20V(pk) cathode bias voltage increase. Max screen power dissipation is then up to 30mA x 220V = 6.6Wpk, and screen resistor peak is 0.35Wpk.

The 6AQ5 valve bias current allowed is 8.4W / (245-15-11V) = 38mA.



4.4 Power Supplies

The half-wave voltage doubler rectifier circuit uses a 95V HT winding for idle 125mA 250V B+.

Only one 6.3VAC secondary is available for heaters (4x0.45 + 0.3 = 2.1A). A 200R humdinger pot provide heater breakdown fusing to a 6AQ5 electrode.

The existing 375mA 3AG fuse is in the DC path, and only a bolted short is likely to cause fuse voltage to reach zero volts during mains cycles, so fuse is moved to HT winding. 200mA max anticipated load on VS1 has a 660mArms continuous secondary winding current. IEC60127-2 750mA Fast fuse for 110V secondary, based on hot start in to that max load.

Simulate period in PSUD2	10ms	50ms	continuous
Simulated RMS current	2.5A	1.9A	0.66A
Multiplier (based on 0.75A fuse rating)	3.3	2.5	0.88
IEC60127-2 Fast blow min limit multiplier	4	2.75	1

Primary side fuse is given as 0.5A. Need to confirm primary side idle and cranked current.

4.5 Protection

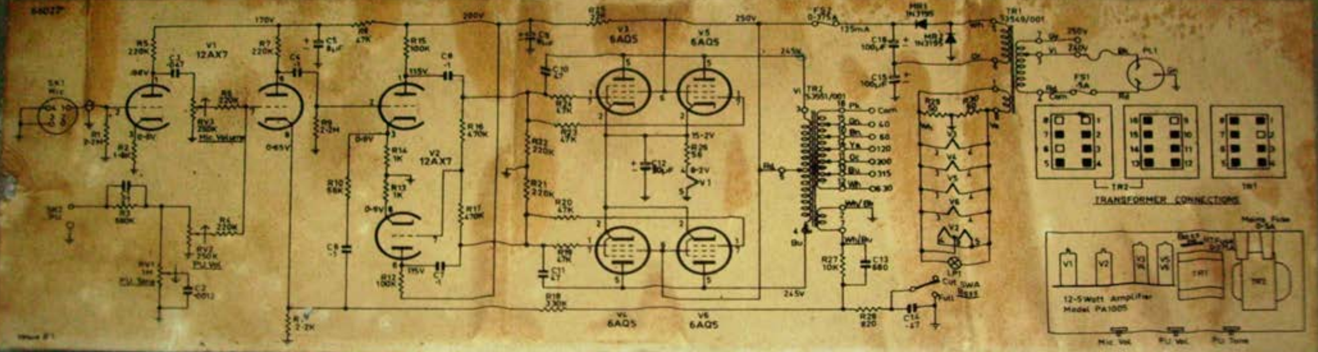
A 354Vdc 1mA, 90pF 7mm disk MOV type 2502 is placed across each primary half winding to dampen any overshoot.

An open-circuit 12AX7 V1 heater may cause the output stage bias voltage to rise, and may stress the coupling cap voltage rating and the 200V Vhk limit of the 6AQ5. A cranked output stage may cause the output stage bias voltage to rise, and may stress the coupling cap voltage rating and the V1 heater voltage. V1 heater voltage would exceed 12.6V+10% when common cathode voltage exceeds about 13.8+8.4 = 22.2V. Four parallel 24V 5W 1N5359 zeners act in series with each cathode 10Ω sense, and existing V1 heater, to constrain bias voltage. Max total continuous Zener current is about 300mA, with zeners soldered to chassis tab for cooling.

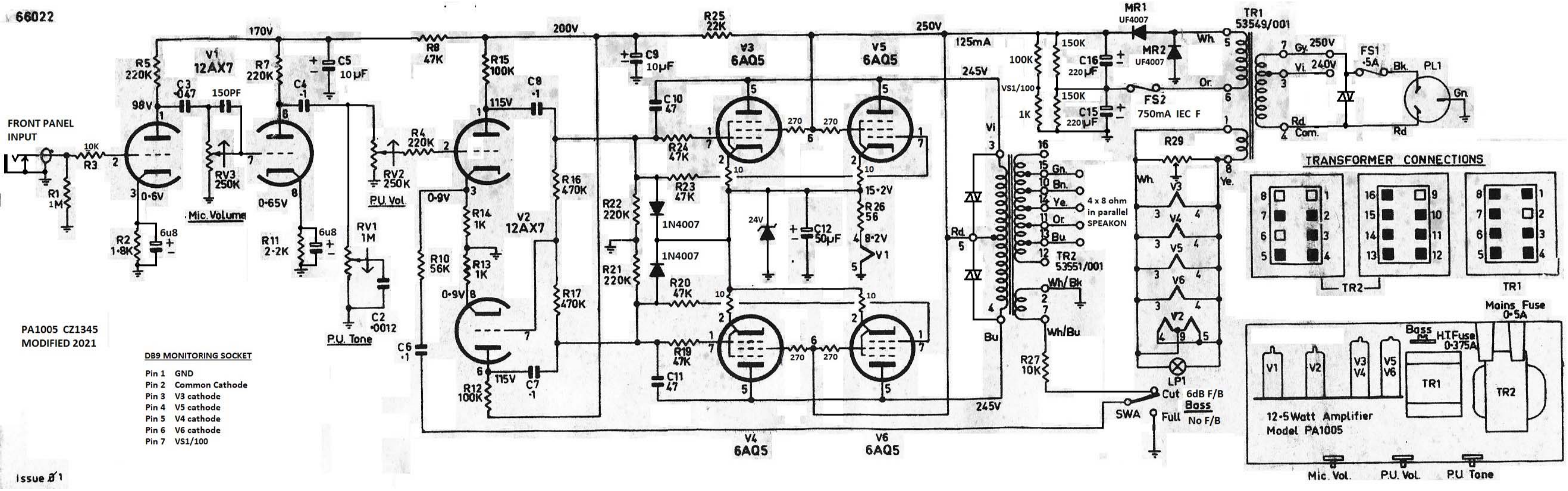
A bolted short from a 6AQ5 screen to cathode would have the highest fault current (as no screen stopper) and could cause a cathode current of about 900mA, and a HV winding current of about 2.2A (and secondary side fuse should fail) and raise cathode voltage to 120V and diode current to 1.5Arms. Adding a 270Ω screen stopper and 10Ω cathode current sense would supress the max winding current to 1.3A, and cathode current to 440mA, and raise cathode voltage to 62V and diode current to 0.9Arms. 24V Zener protection of the cathode would increase fault current levels.

A bolted short from 6AQ5 anode to heater would force about 1A through an OT primary and the humdinger. Using a 200Ω 0.6W tuned humdinger would reduce the fault level a bit, and the humdinger would hopefully act as a poor man's fuse.

A positive 6AQ5 grid from excessive grid leakage or an internal fault could force all 6AQ5 to conduct. A 1N4007 from each common grid leak to the common cathode would limit positive grid voltage to about 0.5V, and add typically about 10pF shunt, and up to about 30pF at Vgk=0V peaks, and limit the fault current to just one 6AQ5. A 1N4007 has very low leakage current during normal operation (<0.1uA or >300MΩ loading).



V1
12AX7
V2
12AX7
V3
6AQ5
V5
6AQ5
V4
6AQ5
V6
6AQ5
TRANSFORMER CONNECTIONS
12·5 Watt Amplifier
Model PA1005
Mic Vol.
PU Vol.
PU Tone



66022
FRONT PANEL INPUT
R3 10K
R1 1M
R5 220K
98V
C3 ·047
150PF
V1 12AX7
170V
R7 220K
C4 ·1
C5 10µF
RV3 250K
Mic. Volume
0·6V
0·65V
R2 1·8K
6u8
R11 2·2K
RV1 1M
C2 ·0012
P.U. Tone
RV2 250K
P.U. Vol.
R4 220K
R8 47K
200V
R15 100K
115V
C8 ·1
0·9V
R14 1K
R13 1K
V2 12AX7
R10 56K
R16 470K
R17 470K
C6 ·1
R12 100K
C7 ·1
R25 22K
C9 10µF
C10 47
V3 6AQ5
V5 6AQ5
250V
125mA
245V
R24 47K
R23 47K
R22 220K
R21 220K
1N4007
1N4007
R20 47K
R19 47K
C11 47
270
24V
C12 50µF
15·2V
R26 56
8·2V
V4 6AQ5
V6 6AQ5
Rd.
Vi
Bu
Gn.
Bn.
Ye.
Or.
Bu.
4 x 8 ohm in parallel SPEAKON
TR2 53551/001
Wh/Bk
Wh/Bu
R27 10K
SWA
Cut 6dB F/B
Full No F/B
Bass
MR1 UF4007
MR2 UF4007
100K
150K
VS1/100
1K
C16 220µF
C15 220µF
FS2 750mA IEC F
Wh.
Or.
TR1 53549/001
Gy. 250V
Vi. 240V
Rd. Com.
FS1 ·5A
Bk.
PL1
Gn.
Rd
R29
Wh.
Ye.
V3 V4 V5 V6 V2
LP1
TRANSFORMER CONNECTIONS
TR2
TR1
Mains Fuse 0·5A
Bass
H.T.Fuse 0·375A
12·5Watt Amplifier Model PA1005
Mic. Vol.
P.U. Vol.
P.U. Tone
PA1005 CZ1345
MODIFIED 2021
DB9 MONITORING SOCKET
Pin 1 GND
Pin 2 Common Cathode
Pin 3 V3 cathode
Pin 4 V5 cathode
Pin 5 V4 cathode
Pin 6 V6 cathode
Pin 7 VS1/100
Issue 01