# 1. Summary

Williamson Amplifier & matching Control Unit Preamplifier. $202 eBay Oct 2009
Australian manufacturer – unknown.

### *1.1 Original Main Amplifier*

Williamson Amplifier circuit – 1949 'new' version. Serial No 44530 (?)

The amp is the 1949 updated "new version" circuit of the Williamson amp circuit, except for the following subtle differences:

- Input coupling cap 0.1uF 200V.
- R1 = 1M2 (not 1M)
- R26 = 10k (not 4k7)
- R14, R19 = 220k (not 100k)
- R15, R20 = 2k2 (not 1k)
- C6, C7 0.1uF 400V (not 0.25uF)
- R25 = 2k+2k+2k connecting to terminals.
- OPT secondary with only 3 separate winding sections, and could be 8k (ie. not 10k)
- Humdinger rather than centre-tap for main amp heater.
- Additional preamp heater winding with its humdinger connected to bypassed divider off C5.
- C5 = 8u + 8u series with 220k bypasses
- C8 = 24u + 24u series with 270k&220k bypasses
- C9 = 24u + 24u series with 270k&220k bypasses
- HT supply to V1/2 via 3k5 5W dropper with 24uF 525V filter and 10k+10k 5+5W load, and also going to preamp.
- HT secondary windings with 135R 5W series resistors.
- Transformer primary with 200, 220, 240V taps, and secondary HT higher at 460V-0-460V.
- CH2 = 16H (not 30H at 20mA)
- CH1 = 8H (not 10H at 150mA)

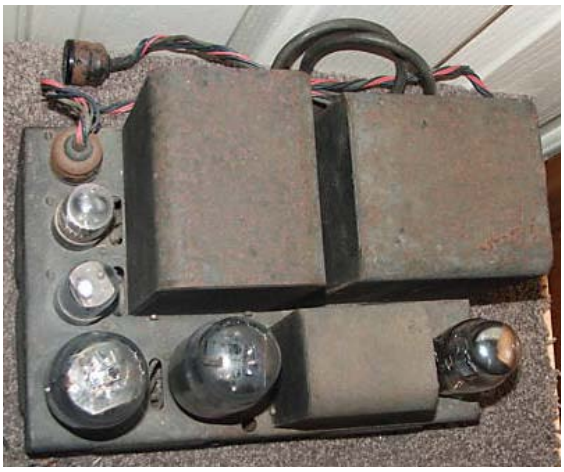
Some values are obviously nearest available: R4=500R; R10=410R.

**Components**

| | |
|---|---|
| Output Transformer | Assumed to be 10,000 PP primary; 2Ω, 2.5Ω, 2.5Ω secondaries; 677Ω DCR |
| Power Transformer | 200, 220, 240V Prim; V-0-V mA HT; 6.3V 4.5A; 6.3V 1A; 5V 2A. |
| Choke | CH1: ROLA Co. Melb, 16H |
| | CH2: ?, 8H |
| CAPs | Ducon Type ET2018, 24uF 525V (x5) |
| | Ducon Type ET1015, 8uF 525V (x2) |
| | Ducon Type ET2D, 8uF 525V (x2) |
| | Ducon Type MCT 49, 0.1uF 400V (x5) |
| | Ducon Type HS 201, 0.1uF 200V (x1) |
| | Ducon Type HS 415, 0.05uF 400V (x2) |
| POTS | IRC PG3 100Ω /W (x2) |
| Tubes | GZ32 Miniwatt R71 B8G (R7=GZ32, B=Mullard Blackburn, 1958 July) |
| | KT66 x2 HK 6, black base, coated, (GEC, HK=Oct 1952) |
| | 6SN7 x2 |

**Issues:**

No fuse or standby, and remotely switched. No protective earth. Old electrolytic and foil caps. Multiple chassis grounding. KT66 and GZ32 centre pins broken off. PT secondary supply higher than original design level. OT primary winding open-circuit.



### *1.2 Original Preamplifier*

CONTROL UNIT. Using 6N8 and 12AX7 with switched tone controls. Output triode as cathode follower. Umbilical cable connection to main amplifier. Very similar to 1951'ish Leak RC/PA/U preamplifier (TL/12 Point One) format, with radio octal interface connector.

| | |
|---|---|
| POTs | Aerostat x1 Volume + power switch |
| Tubes | 6N8, Philips Miniwatt Made in Australia MT.6 Cm (old code MT=EBF80; C=Hendon factory, Australia ; m= batch 13 1954-56)<br>12AX7, RCA |
| Selector | MIC, LP, 78A, 78B, RADIO |

### *1.3 Dating*

The amp has a 1949 stamped ROLA choke. The other magnetics are pitch potted. Some resistors are 1940's full-body coloured, no resistors are 'newer' style. High Seal Ducons are earlier 'black end' types.

One 6SN7GT is Mullard, Made in Holland, 6J, carbon coated glass, base marked 45I ?6? Other 6SN7GT is Radiotron 'made in australia', 29. GEC KT66 date codes prior to 1969 were two digits using letters = year, month. The year started at A for 1945, and the months started at A for January, but the letters I and O were skipped. The change from black to brown base occurred around 1953, and to clear glass occurred in 1961.
http://www.altofidelity.com/link3.asp
https://www.tubeworld.com/kt66.htm
http://www.cathedralstone.net/Pages/GECKT66.htm
http://www.tubecollector.org/cv-valves.htm
http://forum.marstran.com/viewtopic.php?f=6&t=130

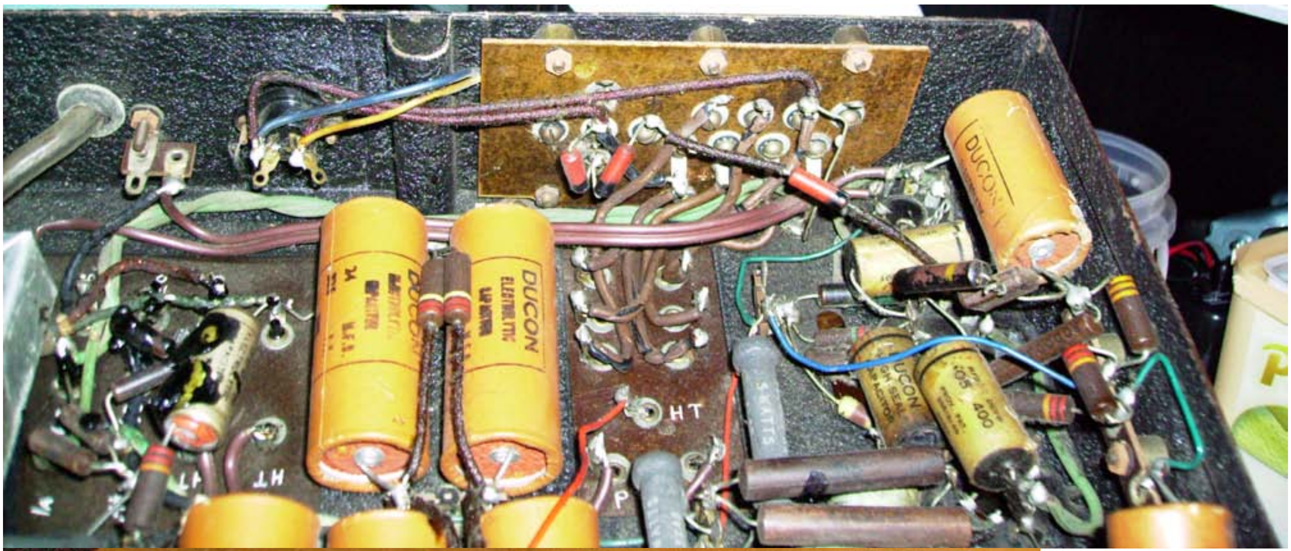
The main amp would indicate 1953'ish, based on choke, no newer resistors, and KT66 dates. The control unit selector types is consistent with 1950-1954.

### *1.4 Commercial style Williamson Amplifiers*

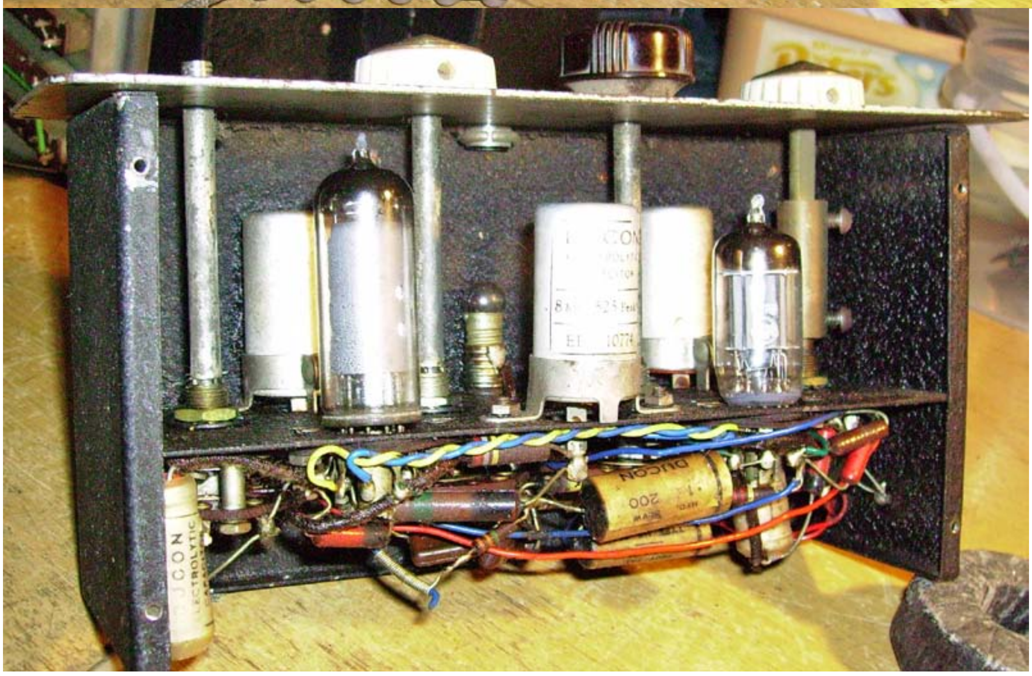
There were many commercial Williamson-style amplifiers and kits made from about 1948 and through the 1950's, but few know Australian versions. Australian interest appears to have moved rapidly to other options from the early 1950's due to Playmaster and Mullard designs that were widely popularised. Stinson's reference to 1948 Huckle Radio, and 1950 Audio Engineers amplifiers are the only know Australian Williamson-style commercial amplifiers.


VOLUME
LEVEL
MAX


DUCON
HT


DUCON
HT


DUCON
TYPE HS 201


DUCON

# 2. Modifications

- Replaced the power cable. Added primary fuse. Added primary MOV (431KD10).
- Added mains switch to main amp chassis – removed link to switch on control unit.
- Replaced HT electrolytics with poly caps – reduced cap size to standard Williamson levels (although choke values appear to be lower).
- Added secondary CT switch, with 150k bypass bleed resistor, and series fuse.
- Signal caps replaced - 'high seal' HS caps replaced by MKS4 'hidden' in Ducon carcass – for fun!
- WW 100Ω R17, R21 pot wipers cleaned. Break in one pot bridged. Resistor bypasses on R17 and R21 for fail-safe operation.
- Tuned humdinger on 6.3V 4.5A and 1A heaters with 50V elevated DC bias.
- Distributed star ground scheme, with chassis connection raised with 4.7R and // cap, and old switched AC mains wires used as chassis ground link to preamp.
- OT primary lead-in wires replaced from pitch to terminals.
- Added MOV-R network across each primary half winding.
- Added sense 1R for each KT66 cathode for idle setting.

# 3. Measurements

Voltage rail regulation.

| Rail | GZ32 only<br>10k6 VS2<br>50k VS4 | GZ32 only<br>6k VS2<br>50k VS4 | Minimal load* | Max Load<br>120R series |
|---|---|---|---|---|
| VS1 | 528V | 498V | | |
| VS2 | 520V (49mA) | 488V (81mA) | | |
| VS3 | 501V | 471V | | |
| VS4 | 401V (8mA) | 380V (7.6mA) | | |
| Heater 1,2 | | | | |
| Heater 3 | | | | |
| Sec HT | 459V | | | |
| Ripple C1 | | | | |
| Ripple C2 | | | | |
| Ripple C3 | | | | |

Power transformer primary DC resistance: 9Ω: 240V; 220V; 200V; 0V.
Power transformer secondary DC resistance: 90 + 94 = 183Ω.

CH1: ROLA Co. Melb; 16H at 17mA, 16H at 48mA, 11H at 78mA, DCR= 570Ω
CH2: 8.3H at 93mA, 7.2H at 160mA, 3.8H at 260mA, DCR= 94Ω

Output transformer – unknown manufacturer - potted
Secondary as three separated windings
20VAC 50Hz nominal applied to output transformer primary

| Winding | Voltage rms | Turns ratio; Pri Impedance; Spec level; Notes | | |
|---|---|---|---|---|
| Pri P-P: | | -; | 10,000Ω; | Assumed to be 10k |
| Pri P-HT: | 20.6 | -; | 2,500Ω; | N/A |
| Sec: #1 | 0.58 | 35.5; | 2,500 Ω; | 2Ω; |
| Sec: #2 | 0.647 | 31.8; | 2,500Ω; | 2.5Ω; |
| Sec: #3 | 0.647 | 31.8: | 2,500 Ω; | 2.5Ω; |
| Sec: #1+3 | 1.22 | 16.9: | 2,500 Ω; | 9.8Ω; |
| Sec: #1+2 | 1.23 | 16.7: | 2,500 Ω; | 9Ω; |
| Sec: #2+3 | 1.29 | 16: | 2,500 Ω; | 9.8Ω; |
| Sec: #1+2+3 | 1.87 | 11: | 2,500 Ω; | 20.7Ω; |

Output transformer primary DC resistance: 338+339=677Ω plate-to-plate.
Primary half windings have self resonances at 6kHz, 14kHz, 45kHz, 250kHz.

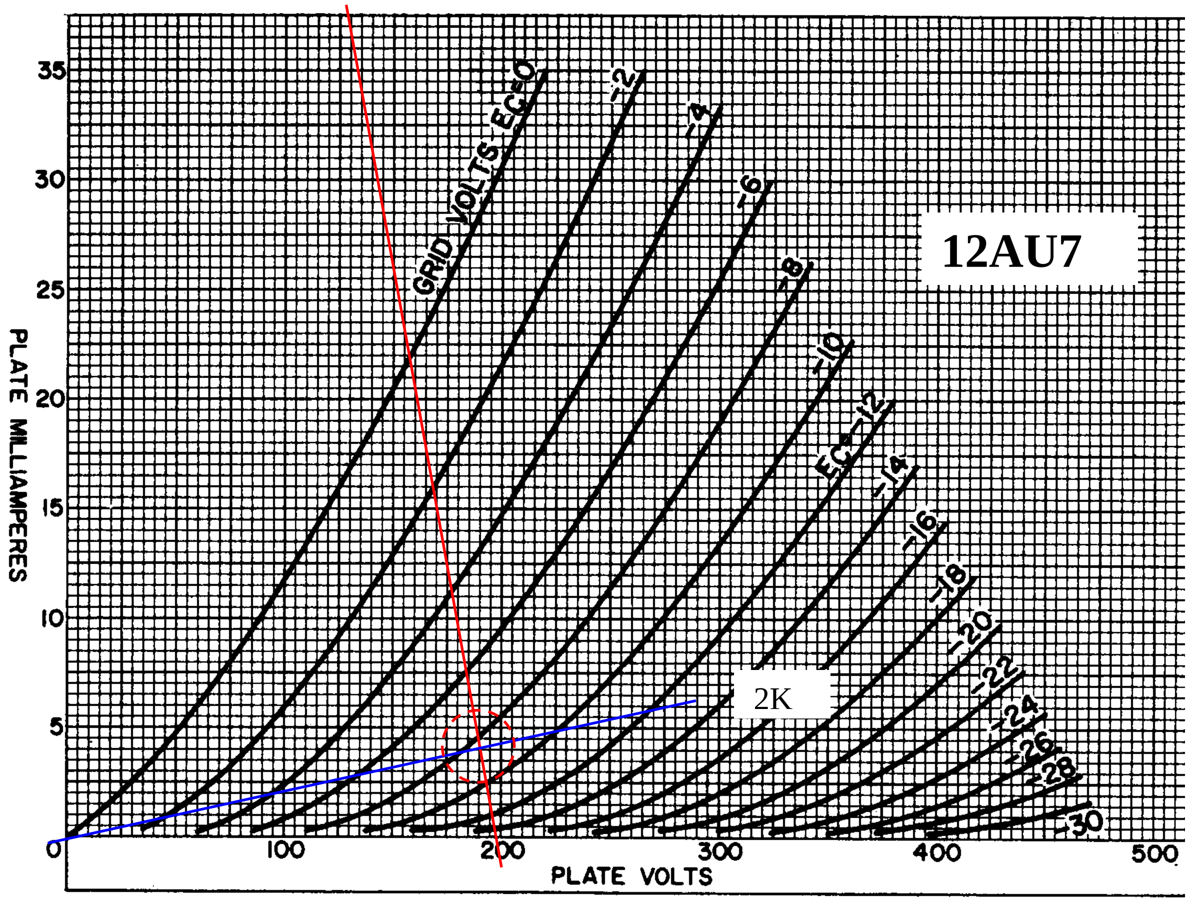
Primary could also be 8k PP, which would give 1.6, 2.0, 2.0 ohm sections, to allow 2, 8 and 16 ohm outputs.

R1=1.32M; R2=34.4k; R3=50k; R4=560; R5=19.4k; R6=18.9k; R7=18.6k; R8=490k; R9=490k; R10=420; R11=52.6; R13=51.5k; R14=200k; R15=2.2k; R16=97; R18=100; R19=220k; R20=2.2k; R22=152; R23=95; R24=103.

Repaired parts: R11; C1, C3, C4, OPT, R4, R14, R19, 3k5 5W (replaced with 3k3 5W), 10k 5W, 10k 5W (2x10k replaced with 3x 6k8 4W).

## 4. Control Unit

Matching black crinkle finish. 500k volume control with AC power switch.

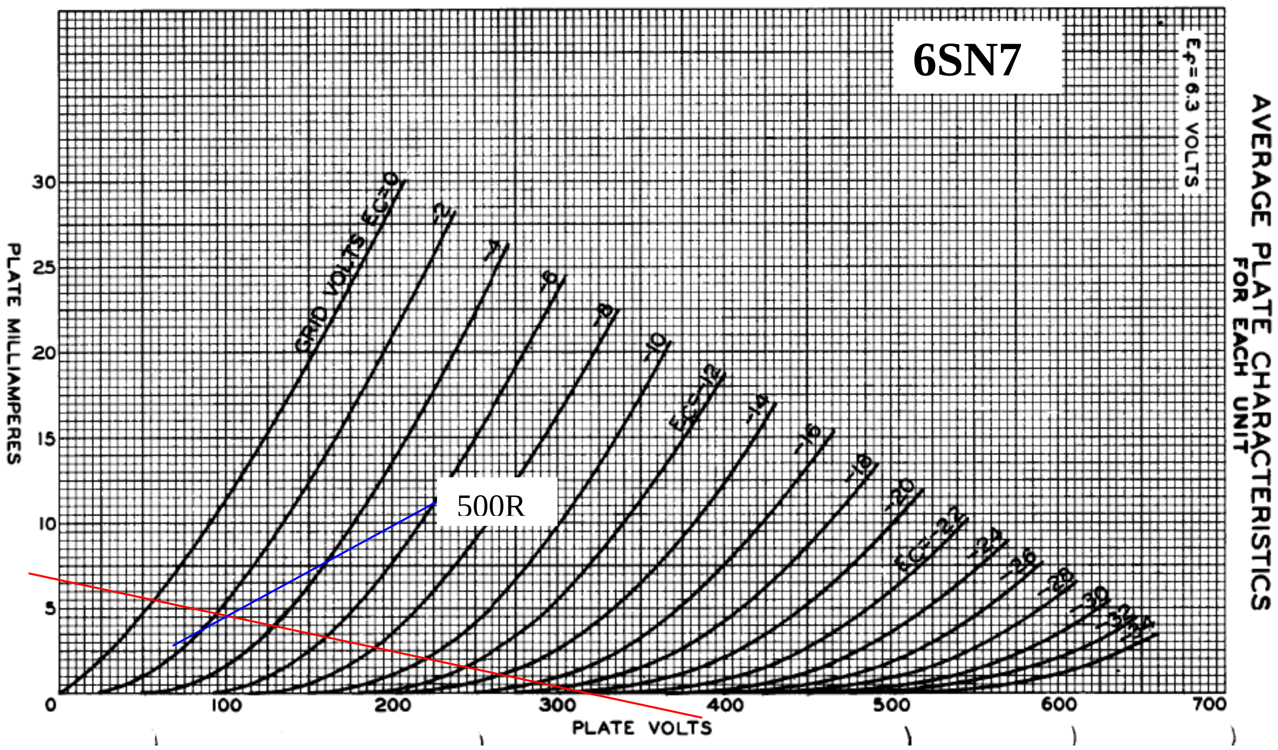


# 5. Design Info

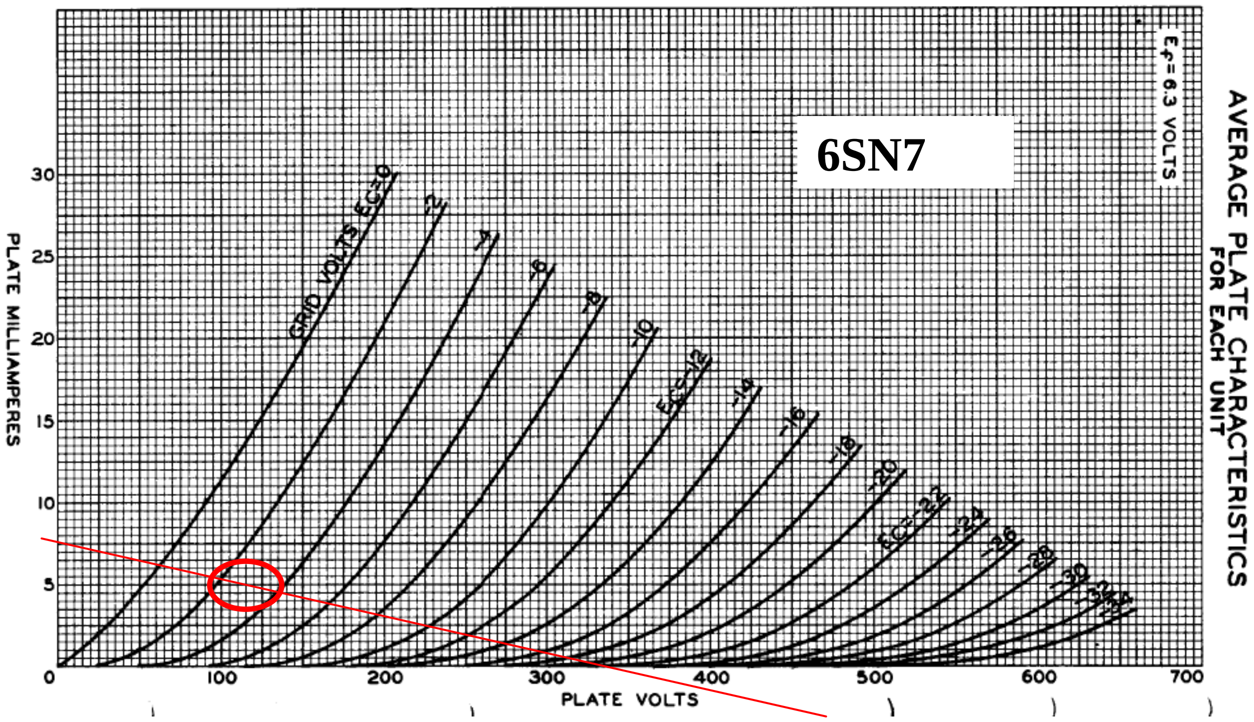
### *5.1 Input stage – 6SN7*

Supply voltage is 320V; load resistance is 47k; and cathode resistor is 500R. The plate voltage Vp axis intercept is 320V for no plate current, and the plate current Ip axis intercept is 320V / 47KΩ = 7mA. The gate-cathode voltage Vg1 operating point varies with plate current through the 500Ω gate-cathode resistance with the characteristic shown on the graph as a line passing through Ip=4mA for Vgk=-2V, and through Ip=10mA for Vg1=-5V. The nominal biased operating point at Vg1=2.0V.

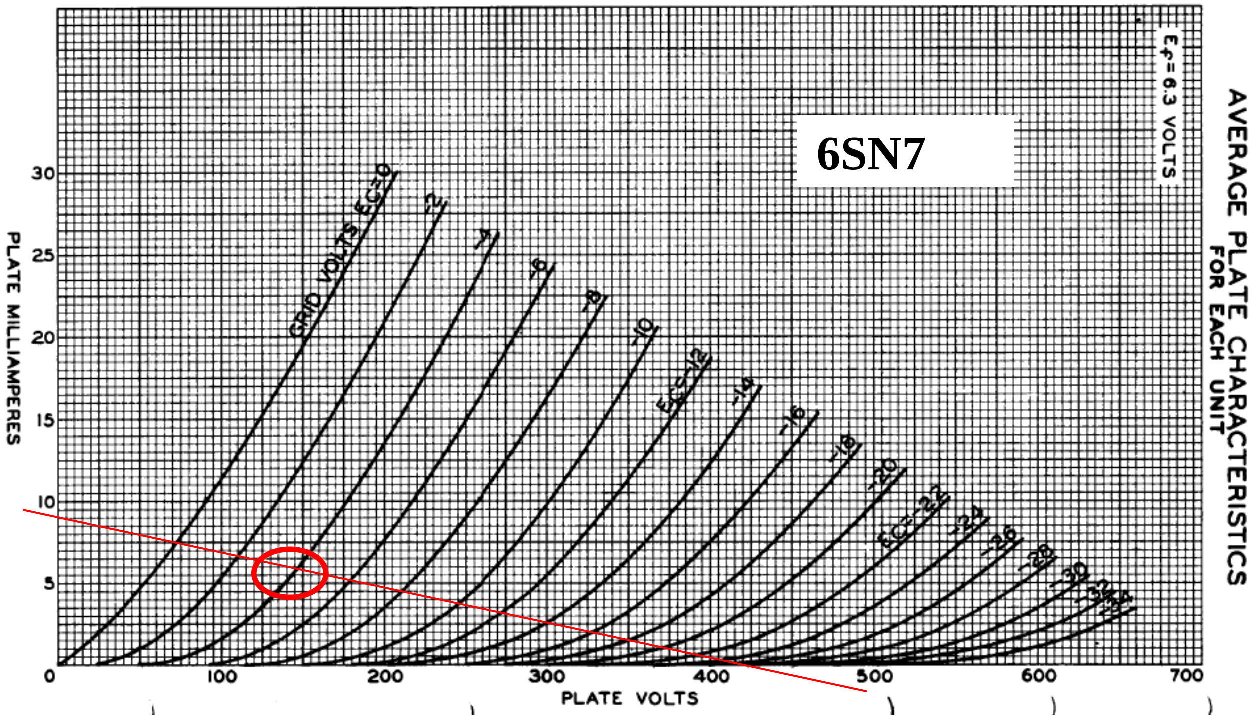
The input voltage swing limit is from the bias point at Vg1=-2.0V to Vgk=0V, which is about 4.0Vpp or 1.4Vrms. Referring to the loadline, the plate voltage would swing about 70V, from about 50V to 120V [120-85=35V; 85-50=35V; which is fairly symmetric]. This gives a nominal gain of 70/4 = 18.



### *5.2 Splitter stage – 6SN7 in split load config*




### *5.3 Driver stage – 6SN7*



### *5.4 Output Stage – KT66 Triode-connected PushPull*

In this Class AB push-pull output stage, one tube is pushed into conduction and the other tube is pulled into cutoff (class B), and there is a region of Class A overlap where both tubes conduct equivalent levels of current. The cathodes are raised above ground by a common bypassed cathode resistor. A 10KΩ impedance plate-to-plate OPT presents signal currents into each tube with a 5KΩ impedance with both tubes conducting, to 2.5KΩ load impedance at higher levels.

Plate DC voltage at idle will be lower than VS2 by an amount up to ~19V; ie. OPT half resistance of about 340Ω with idle current of 56mA. Plate-cathode voltage at idle is about 460-40-20 = 400V.

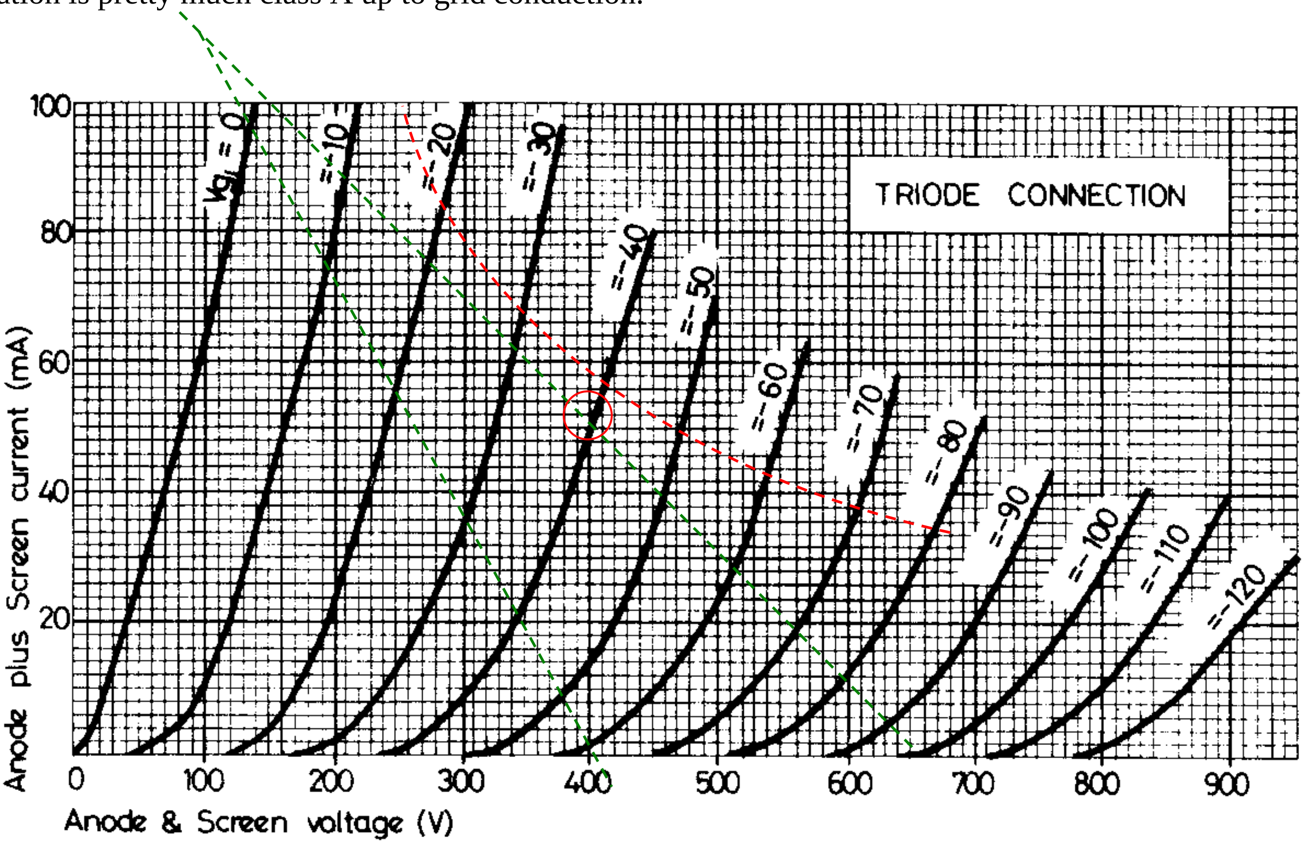
Screen current at idle is likely to be quite low (~2-3mA), but likely to increase markedly as each grid approaches 0V, which would modulate VS2 somewhat.

Ripple on VS2 is quite low due to the capacitor/choke/capacitor filter.

With a common cathode resistance of 310Ω, and gate-cathode voltage of 35V, the plate idle current is 2x56mA. Ibias(max) = Pd / Vb = 22W / 400V = 56mA.

Assuming no sag and a peak plate current of 100mA is achieved, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.1 x 0.1 x 10k / 8 = 12.5W. For this maximum signal condition, the rms OPT current draw is likely about 2 x 64mA (64% of peak), and the average VS2 power consumed is 400x0.128 =51.2W, and the OPT loss is $(0.128)^2$ x 340Ω = 6W, so the tube plates dissipate 51 – 6W = 45W, or about 23W each.

Operation is pretty much class A up to grid conduction.



### *5.5 Power Supplies*

A standard full-wave rectifier circuit is used with 460V secondary HT windings with centre-tap to 0V, and a 5V diode heater winding. A CLC filter is used with 7H 160mA rated choke to generate VS2. Effective PT secondary resistance = 9Ω x $(460/240)^2$ + 90 = 123Ω.

The GZ32 can feed directly into 12uF C9 as secondary winding resistance is ~100Ω and rated cap is 16uF with 500V transformer. With 100mArms loading the GZ32 plate drop is about 22V. The 5V4 is slightly better rated. The original 135R series resistors get quite hot – bridging with 56R gives 480V/463V/440V/374V/350V/288V with 130mA on VS2, and 2x 6SN7.

Filter caps are now Epcos B81130 with a 760VDC rating. The high level of idle bias causes a substantial and fairly constant 50W loading on the VS2 rail – 44W from KT66, 4W from common cathode, 2W from OPT.

Aim for 30mA loading on 3300R dropper for preamp, to give 100V drop and 3W loss. Aim for 340V zener to limit preamp voltage and filter (400V cap), to give 10W loss.

The HT rails can reach much higher levels if unloaded (diode conducts more rapidly than signal valves take to reach idle).

## 6. Protection

### *6.1 HV breakdown*

If the B+ rail shorts to ground, due to a flashover, or insulation breakdown, then a 0.4A fuse in the transformer secondary CT provides gross failure protection by de-energising both the plate and screen rails. 0.4A fuse is appropriate to handle to surge current in to just 9uF, given a 150k pre-charge resistor across the standby switch, and 135 ohm added resistances.

### *6.2 Output open circuit*

Added 4k7 and two series 2502 MOVs across each primary half winding.