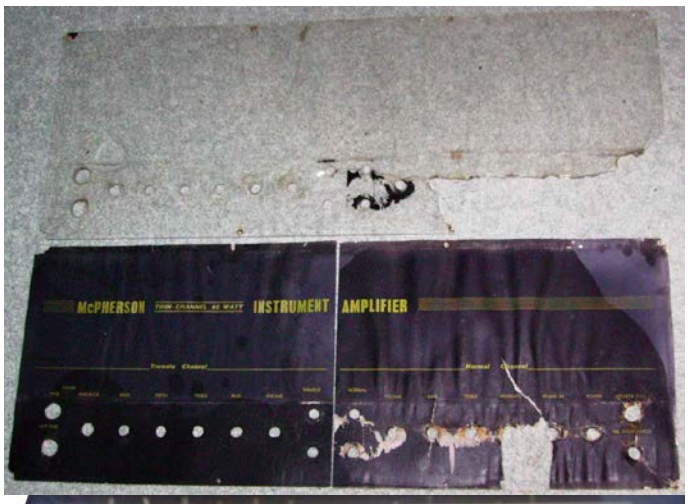
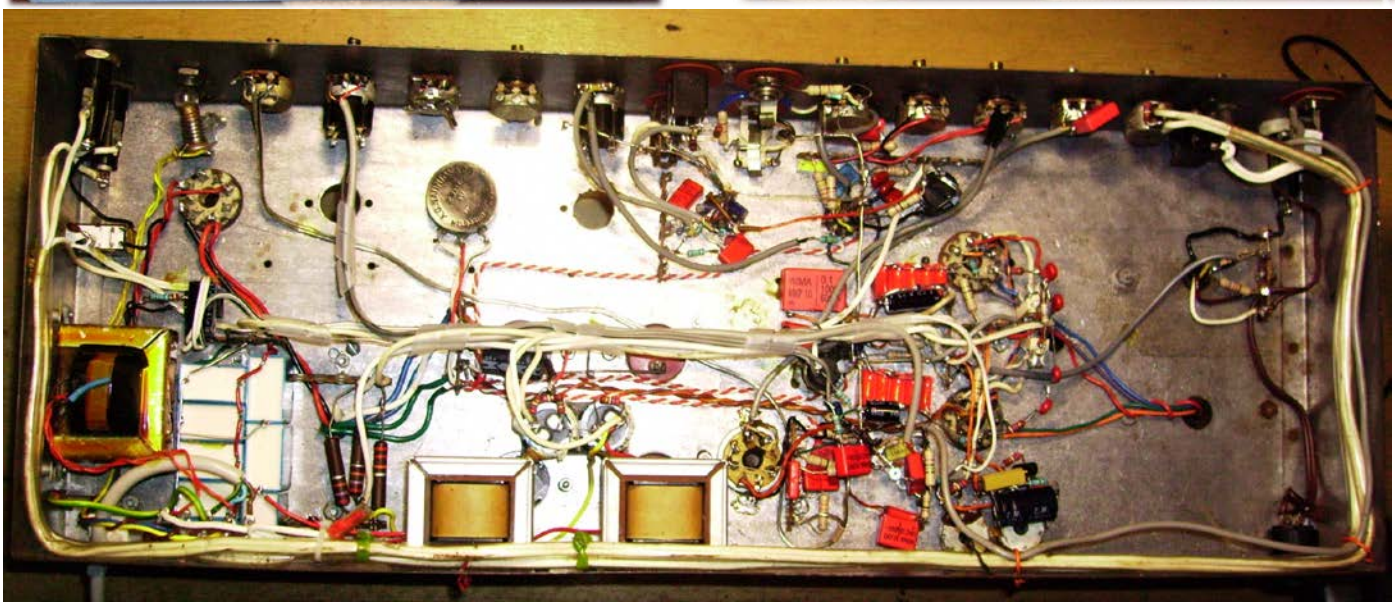
1. Summary

McPherson Twin-Channel 60W Instrument Amplifier.
$165 eBay Dec 2009.
4-input jacks for normal and tremolo; 12AX7 preamp and tone controls; 12AX7 LFO and neon/LDR tremolo; 6AN8 amp & PI; KT88 fixed-bias UL PP with feedback to presence pot; separate transformer for fixed bias with separate trim pots; 4Ω or 16Ω output; controls on front panel with graphics and Perspex cover – in blue tolex covered head box with side handles.

Initial condition:
Mains, HT & Speaker fuses broken – speaker fuse plastic melted. 8-pin valve socket output. Wiring quite messy. Chassis pre-drilled for 3 more valve bases; spot welded steel - slightly corroded; all holes hand drilled but valve and cap holes punched. Some 5M pots are bypassed by 1M; no pot knobs; one pot corroded mounting; tremolo tone pots not fitted/wired, and one 12AX7 partly wired but not connected; heater pin in 12ax7 socket broken; motley array of old electrolytics; 6AN8 triode operating at quite high voltage; mains switch dirty contact & earth leakage; ground wire loop around circuitry (not distributed star); tremolo neon/LDR mounted in valve base plug/header not operating; front panel graphic badly degraded on one side; front panel Perspex broken and cracked on one side.

Output Transformer	A&R 4008-15. 50W 40Hz-20kHz 1% rating; 5K PP, 43% UL taps; 15/3.7 ohm outputs. [KT88 UL 1963 catalog]
Power Transformer	A&R1939-200MA; 0-220-240V; 450-0-450V; 5V 3A; 6.3V 3A; 6.3V CT 3A; ES.
Aux transformer	No markings; Pri; SEC; 6.3V; ES.
Chokes	2x Rola TV306, dated 9 August 1961, 1H @ 300mA
Valves	2x KT88 GEC ‘TG Z’ codes (1962, July) 5AS4 Miniwatt fitted (but chassis marked with GZ34) 6AN8 Mullard 2x 12AX7 fitted (one China, one Brimar), but base for another.
Diode	BTV-4 (no data)
Caps	2x Dubilier Can 50-50uF 350V 2x 100uF 350V Various Ducon, UCC and Dubilier
Tremolo	neon bulb (NE-2 ?) and LDR (Holland, vintage)
POTs	IRC various – some missing, one broken.
Switches	Standby is DPST with separate NO and NC contacts (AlphaEng, Sydney) Two Way 240V 2A (think of some use for other contact) Power is DPST (Alpha) 240V 1A (think of some use for other contact)
Sockets	Instrument x3; 3x SATO Japan open style; 2x
Case	Plywood 15mm; dated June 1964 and what seems to be ‘KEITH N KING’ and possibly Ferntree Gully; handles are very kitchenesque; poor condition plastic cover; front panel graphic is a commercial printing on stiff paper (thin cardboard) – resurrected but a little worn; a blue textured thin vinyl covering and aluminium mesh top section; rear opening had some form of cover at one time; appears like four round rubber feet were originally fitted; front panel knobs missing;





1.1 McPherson Background

Made by Keith M McPherson who ran BORONIA HI-FI & MUSIC CENTRE at 205 Dorset Rd Boronia from circa 1963 to 1972 with his son Ron (as per telephone directories) - previously Keith was listed as a Builder from 1954 to 1962, and then just as himself from 1973. Premises included 199 Dorset Rd.

dalmura.com.au/projects/

The inside casing clearly has written date of June 1964 - most likely manufacture date, as KT88's and choke dates are consistent. A fainter written name appears to be KEITH N KING, and an even fainter three lines of small written text appears to have FERNTREE GULLY PHONE .... as the last line.

June 1964 indicates the amp pre-dates the likes of Lenard, Wasp, Vase, and also Phoenix. Main Australian manufacturers at that time included Maton and Goldentone. This amp is known to have been one of two prototypes made prior to making the McPherson MkIV amp that was made from late 1964/early 1965 onwards – one of the prototypes remained in the shop for many years.

1.2 Design background

6AN8 pre/PI and KT88 PP UL circuit is exact copy of Dynaco Mk3 circuit (except for missing 12pF and 750pF phase compensation caps, and power supply voltage levels), which being a kit amp was well known given the Mk2 was from 1955 and the Mk3 from 1957. Sunn started in 1965 and used the Dynaco Mk3 amp block and PAM-1 for their 200s, as it provided relatively better bass performance (being a hi-fi amp).

One concern is the likelihood that the amp is more likely to get over-driven than perhaps was the original intent of the Dynaco Mk3. The Sunn 200s used the same output stage. The quad 6550 Sunn 2000s included 47R anode and screen resistors, probably to assist sharing. The Radiotronics 1955 Langford-smith/Chesterman reference clearly shows the screen max current level as being much below that for a similar pentode mode operation.

Screen stopper was typically recommended by tube manufacturers, but typically not deployed by amp manufacturers. Plausible advantages of fitting for UL are to limit screen current during power on; oscillation inhibiter; protection from screen internal fault or open-circuit anode; and distortion minimisation (ie. Mullard chose 1k for reporting UL distortion results, and some modern results indicate some change in harmonic balance as resistance increased).

Can't yet identify similar tone circuit, but it is somewhat similar to Sun 200s.

Tremolo spelt as 'tremelo' on front plate and the footswitch is marked 'vib' - and uses an LDR and neon bulb housed in an 8-pin connector plug that plugs into a valve base on the chassis - the LDR has Holland written on it (possibly a OPR61); the inputs have 470k series resistors going direct to vol pot – not a typical configuration; gain is very low, so may have been rejigged to a line level input.

The OPT is the premium A&R range with 40Hz 50W 1% spec, and was manufactured sometime after Jan 1960 (R&H advert).

Supply voltage measurements for Dynaco Mk3: 480V for VS2, and 6AN8 PI has 322V, 107V, 121V (pins 1-3), indicating 2.6mA PI current and 443V VS3; and 5.4mA loading from VS3 and downstream.

2. Modifications

2.1 Initial observations

The circuitry has been modified around the vibrato channel. A 12AX7 valve base and associated tag strip was partly wired, but has been disconnected. The front panel tone controls for the tremolo are not implemented, as the pot in the treble position is a 1M switched pot, but is wired only for the switch to power the tremolo neon, and the pot has a 270k resistor soldered to wiper, but no apparent other connections. Likely that tremolo inputs would go through effectively the same input circuitry and tone section, and then be mixed in with the normal channel inputs at the grid of the 6AN8 pre stage. The existing circuitry around the spare 12AX7 base suggests there were some differences in input circuit design, or that merged inputs from both sides firstly went through the unconnected 12AX7 and then in to the existing 12AX7 (as the gain with just the existing 12AX7 is quite low). The motley array of smaller electrolytics may indicate some of these parts were replaced over time. The chassis was prepared for additional 3 valve small-signal bases, but no bases installed.

2.2 Basic changes made

- Power switch needed internal cleaning & then replaced due to earth leakage. Mains switch placed after fuse in active leg of primary.
- 3AG mains fuse with old 2A. 3AG HT fuse with IEC F 500mA.
- MOV across primary to reduce switch stress from turn-off transient.
- 6AN8 heater (0.45A) was wired to KT88 heater winding, which only has a 3A rating. 6AN8 heater transferred to preamp heater winding.
- Preamp heater was grounded on one side. Heater now wired through humdinger pot, and pot wiper elevated to filtered +40VDC to minimise hum, and reduce cathode-heater voltage difference on 6AN8 triode.
- 10Ω bias current sense plus 400mA fuse (to protect OT) plus 15kΩ bypass (to bias valve to about 80V, 5mA, if fuse blows) in each KT88 cathode.
- 5U4G used (in lieu of GZ34), to lower VS2 at idle. High turn-on voltage managed by poly caps and series e-caps and zener's across VS3, VS5, and use of standby switch. Added 2x series 1N4007 protection to each anode.
- VS1-VS5 filter caps replaced.
- Zener diode protected max voltage across VS3 and VS5 capacitors – even if valves not fitted.
- 2nd choke placed in series with 1st choke between VS1 and VS2, as choke is low inductance, high current part (1H@230mA). Most likely that original amp had VS2 ~480V due to heavier bias on KT88s, and the 2nd choke in parallel with 27k would drop little to give VS3 to be close to VS2.
- Added MOV-R dampening across each half primary winding on OT.
- Added C&K 7411 (4P) switch to configure output stage for Pentode mode or UL mode. One pole for each KT88 screen (via 100Ω) switched to either UL tap or to VS4 via 900Ω 4W for pentode mode. Switch connects screen to VS4 for centre position. One pole adds 10k load to VS7 raw bias supply for pentode mode (but not for centre position). One pole kept spare to maintain UL PP isolation.
- Reconfigured ground wiring for distributed star; single point earth at KT88 cathode star; twisted pair cabling.
- Added 48VDC relay protection of HT if KT88 fixed bias fails; relay contacts in series, and in series with standby switch and CT fuse.
- Modified KT88 bias circuit to full bridge with series resistance and CRC filter; added protection resistor to pot wiper. Max KT88 fixed bias resistance rating is 120k, whereas bias voltage series resistance is circa 11k plus 100k trimpot resistance, then 100k + 11k. Trimpot resistance for min bias current setting is 0Ω, so total series is 122k.

- Two 6.5mm sockets in parallel with Speakon – output set for 4 ohm. Speaker Fuse bypassed.
- Replacement neon fitted.
- Extended sense voltages to Octal connector on rear panel for maintenance testing.
    - Bleed/dividers (270k+270k):4k7+1k for VS2, and 4k7+910 for VS3.
    - Octal pin 1 linked to pin 2 for fixed bias relative to 0V.
    - 10Ω cathode current sense
- 1N4007 clamp from grid to cathode of 6AN8 triode grid-to-cathode.
- Chassis holes drilled for output stage bias adjustment.

2.3 Configuration changes

- Normal inputs separated, with top input direct to 12AX7 triode, with that output through bottom input socket switch to next 12AX7 triode. Normal side preamp circuitry basically as found for low gain input.
- Tremolo side top input rewired to unconnected 12AX7 for tone control stage followed by tremolo stage; new switched socket to replace un-switched socket. Tremolo stage circuitry very close clone of McPherson MkIV.
- Tremolo side bottom input wired as either signal output from normal or tremolo channels, or as direct input to main amplifier section.
- Added 2M grid leak and 220k mixer/grid stopper to 6AN8 pentode to alleviate hum pickup from pots.
- Switched output mode between UL and standard pentode PP modes – ~300V screen supply for pentode from VS4, plus 1k screen stopper. Similar cathode idle currents set by switched 10k loading on bias supply for pentode mode. No attempt to match signal gains (eg. by loading 6AN8 pentode grid leak to form divider for pentode mode).

2.4 To do

- Change 3AG HT fuse to 315mA T IEC.
- Swap 5AS4 to confirm it is nominal
- Modify bias protection relay – presently disabled, with contacts shorted,

3. Measurements

Voltages:

Rail	UL	Pentode idle
KT88 bias	38mA,38mA	41mA,41mA
VS1	510V,34Vrms	507, 34Vrms
VS2	505, 0.83Vac	500, 0.9Vac
VS3	400	382
VS4	325	292
VS5	278	250
VS6	-94	-85
VS7	-67	-34
VS8	-62	-31
VS9	-62	-31
VS10	42	42
Heater	6.6, 6.8	6.6, 6.8
Sec HT	475-0-475	475-0-475

Transformer primary = 6.1Ω. Transformer secondary HT = 34+36Ω. [53 ohm effective datasheet, for GZ34 or 5R4]

TV306: 30Ω DCR; 1.36H @ 55mAdc; 1.2H @ 110mAdc; 1H @ 230mAdc; 0.86H @ 350mAdc;

Output transformer primary DC resistance: 62Ω plate-to-plate.

4Ω resistive load	UL		Pentode	
Output Vrms	VS2 ripple	VS2 DC	VS2 ripple	VS2 DC
0V	1.0	535	1.0	538
5V (6W)	1.14	525	1.1	534
10V (25W)	1.78	485	1.8	~490
15V (56W)		430		

Sag limited power output to about 50W in pentode mode.

Latest energisation testing:
Replace GZ34/5U4 with ss clone. Bypass RL1/1-2 contacts. Standby off. Bleed resistance is only minor so VS2 only down to 95-100V in seconds.

Used clone KT88's (12k 30W Vak up to 600V) for loaded 'nominal' testing up to output stage.

With 5AS4, bias was set for 44+44mA at VS2=500V, VS3=343V (22W diss) in pentode mode (so cathode current does not include screen current).

- VS2 = 525V, VS3=364V with colder bias at 28+28mA (15W diss). 240V mains current of 0.78A.
- UL mode increased cathode current to 52+53mA (VS2=444V, VS3=318V) with mains limited to 230V.
    - Then changed S2C switched loading to 8.2kΩ loading on VS7 for Pentode mode. Same cathode current 41mA for each mode.
- Output noise signal level with Vol pots at min was at most 13mVrms.
- 4W 1kHz output to 4Ω: VS2=499V, VS3=337V, 44+44mA, H2=3.5% Pentode mode.
- 10W 1kHz output to 4Ω: VS2=497V, VS3=325V, 47+45mA, H2=5.2% Pentode mode.
- 20W 1kHz output to 4Ω: VS2=476V, VS3=285V, 59+59mA, Pentode mode - noticeable crossover and peak soft distortion.

- 20W 1kHz output to 4Ω: VS2=425V, VS3=304V, 70+66mA, UL mode H2=4.7%, clean waveform.
- VS3 dropper then changed from 16k to 11k, and bias readjusted.

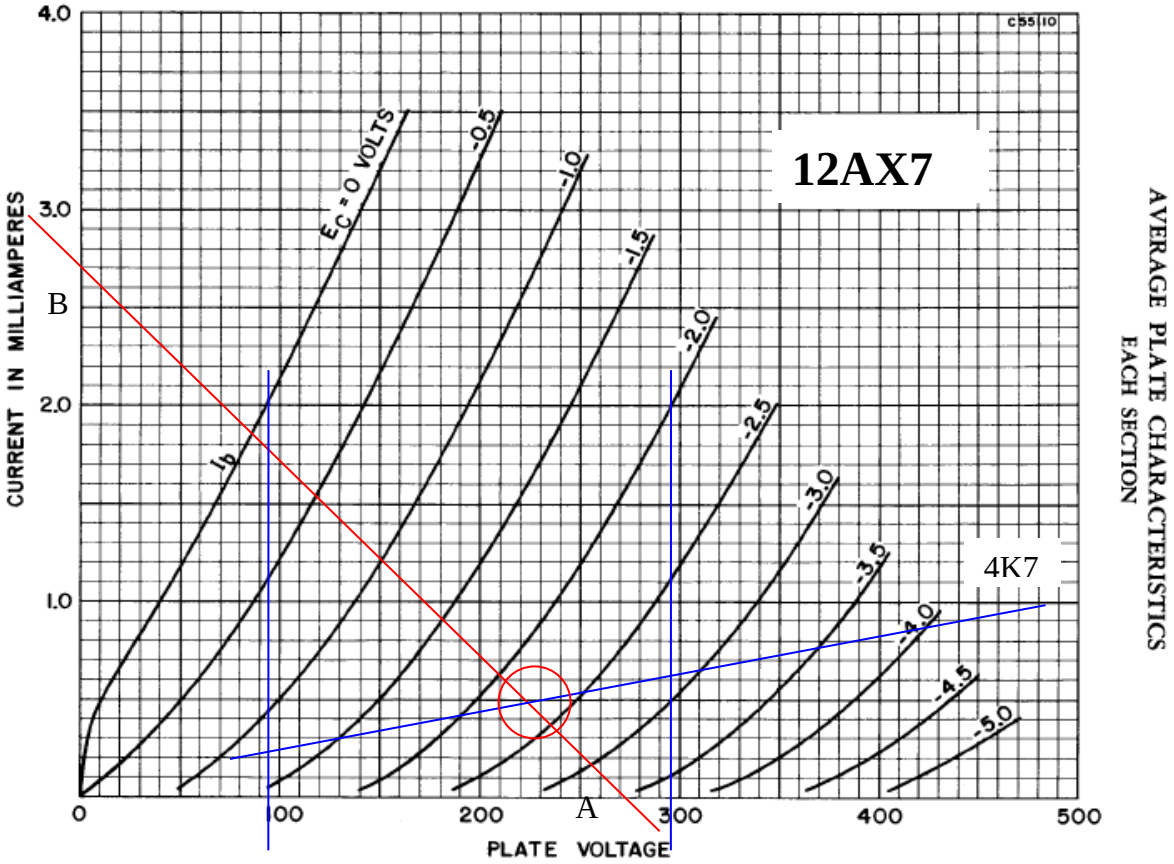
Feedback measured as 3.2dB for UL mode with Presence full CW at 1kHz and 4Ω loading config, and 4.8dB for pentode mode. With Presence at full CCW the feedback reduced about 0.4dB.

Bias relay protection relay turns on at circa 210Vac mains for UL, but 235Vac for pentode mode. Modify with FET drive for closer hysteresis between off and on, and turn on when mains ~180V.

4. Design Info

4.1 Normal Hi-gain Input Gain Stage

12AX7, V1; VS5 = 270V; Va=220V; Rk=4k7; Vk=2.2V; Ia=0.5mA; RLdc=100k.



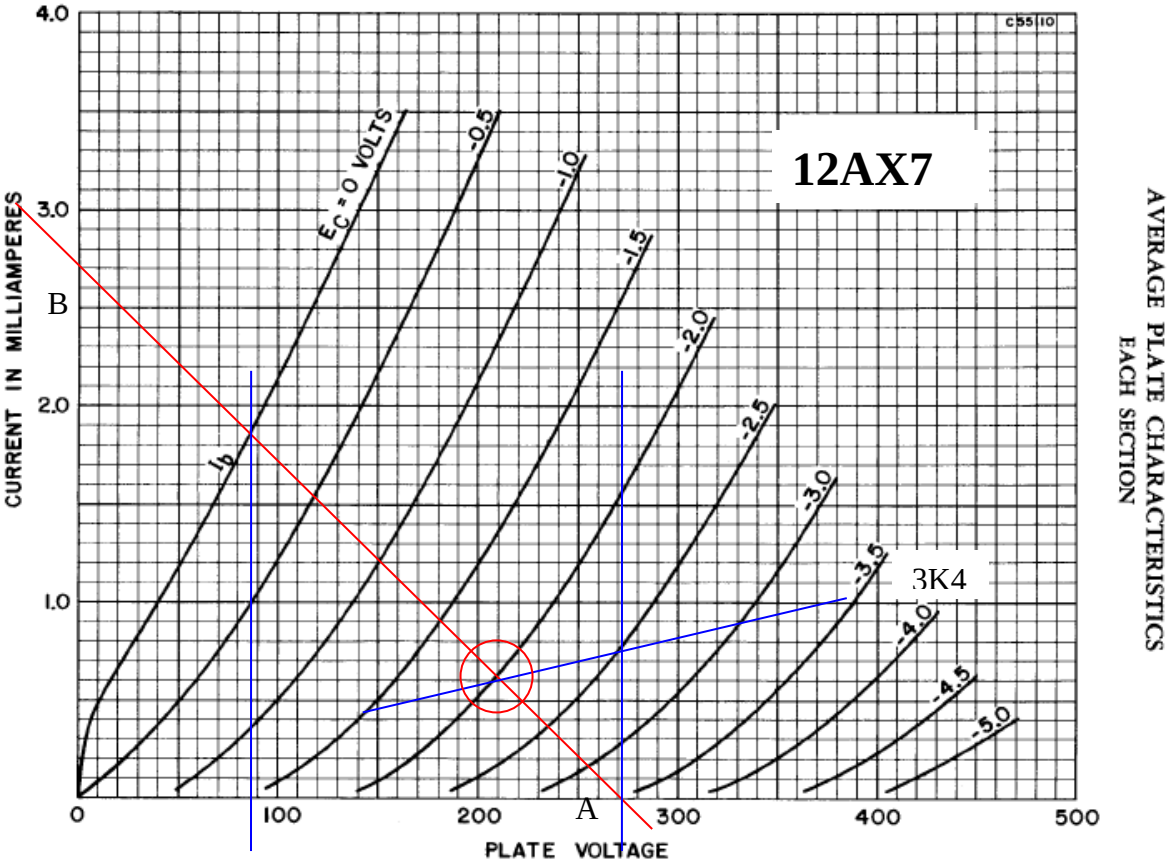
Gain ~ 29x to top of divider, and 2.8x to next stage. Distortion increases (H2>2%) above 55mVin.

Frequency response: Flat with -1dB at 60Hz and 9kHz, using 22nF coupling and 560pF shunt across 15k.

Gain stage followed by 150k:15k (9%) divider, with 150k acting as grid stopper for next gain stage.

4.2 Normal Lo-gain Input Gain Stage

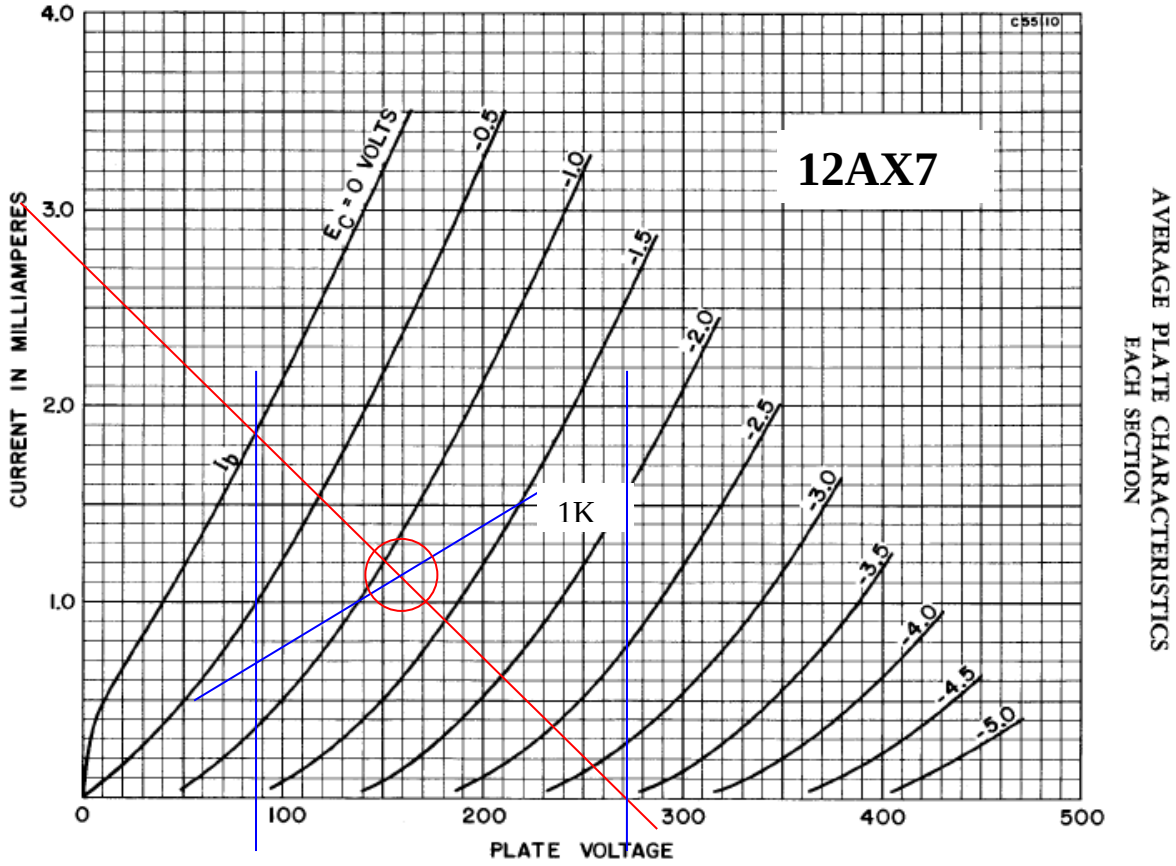
12AX7, V1; VS5 = 270V; Va=210V; Rk=3k4; Vk=2.0V; Ia=0.6mA; RLdc=100k.



2% H2 at 125mVrms on top of Vol pot. 5% H2 at 290mV. 10% at 520mV. 20% at 820mV.
Gain ~ 290/195 = 1.5x at 1kHz with ‘a bit’ of bass and treble.
Frequency response flat with ‘a bit’ of bass and treble, with -2dB at 15Hz and 7kHz.
Bass max gives +18dB peak at 25Hz, and trable max gives +24dB peak at 5kHz, with 200Hz scoop of +2dB, relative to ‘a bit’ flat response.

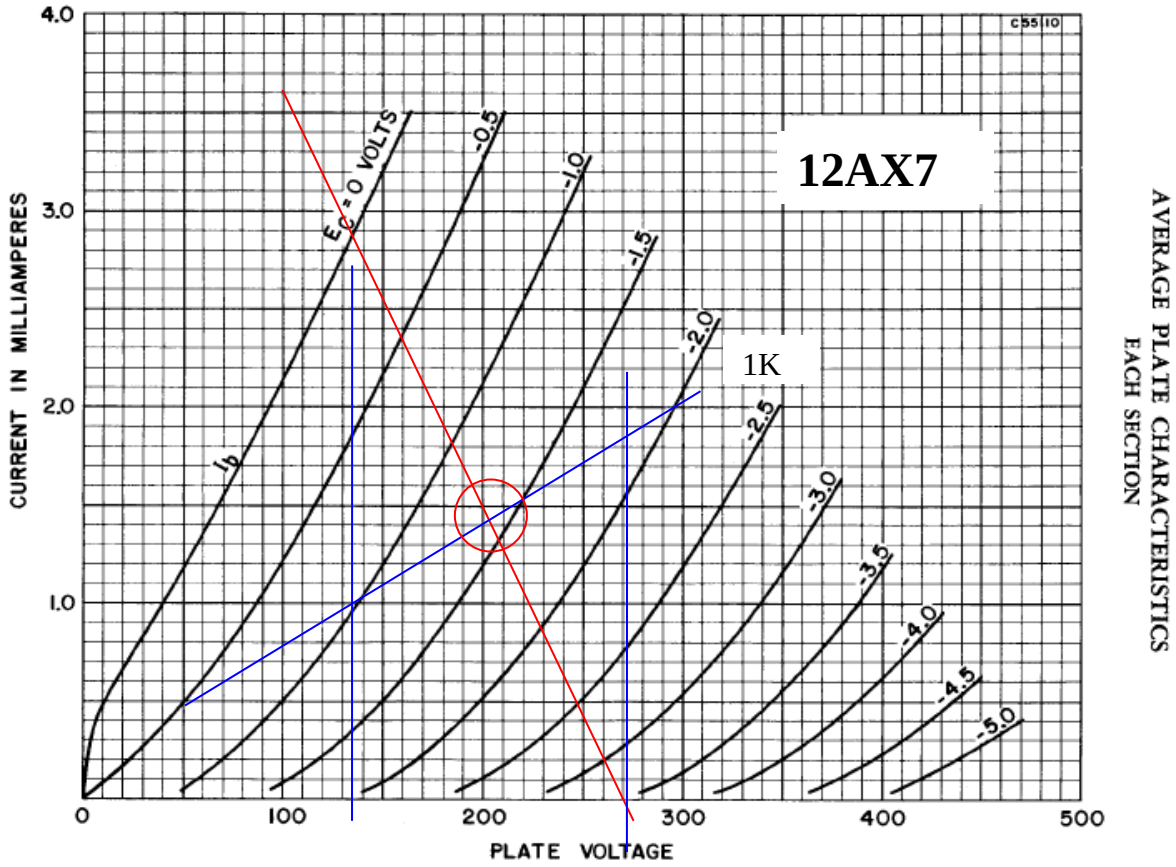
4.3 Tremelo Input Gain Stage

12AX7, V2; VS5 = 270V; Va=160V; Rk=1k; Vk=1.2V; Ia=1.1mA; RLdc=100k.



4.4 Tremelo Volume Make-up Gain Stage

12AX7, V2; VS5 = 270V; Va=200V; Rk=1k; Vk=1.4V; Ia=1.4mA; RLdc=47k.



Response from Tremelo bottom input to top of Vol Pot (wiper at min)

Depth pot introduces attenuation of -15dB from max to min setting.

With Bass at min and some Treble, the scoop response is -11dB at 400Hz, with equal bass peak at 40Hz and treble peak at 4kHz.

2% H2 at 2.5Vrms on top of Vol pot, with maxed Treble and Bass at 1kHz. 4% H2 and H3 at 6.9Vrms.

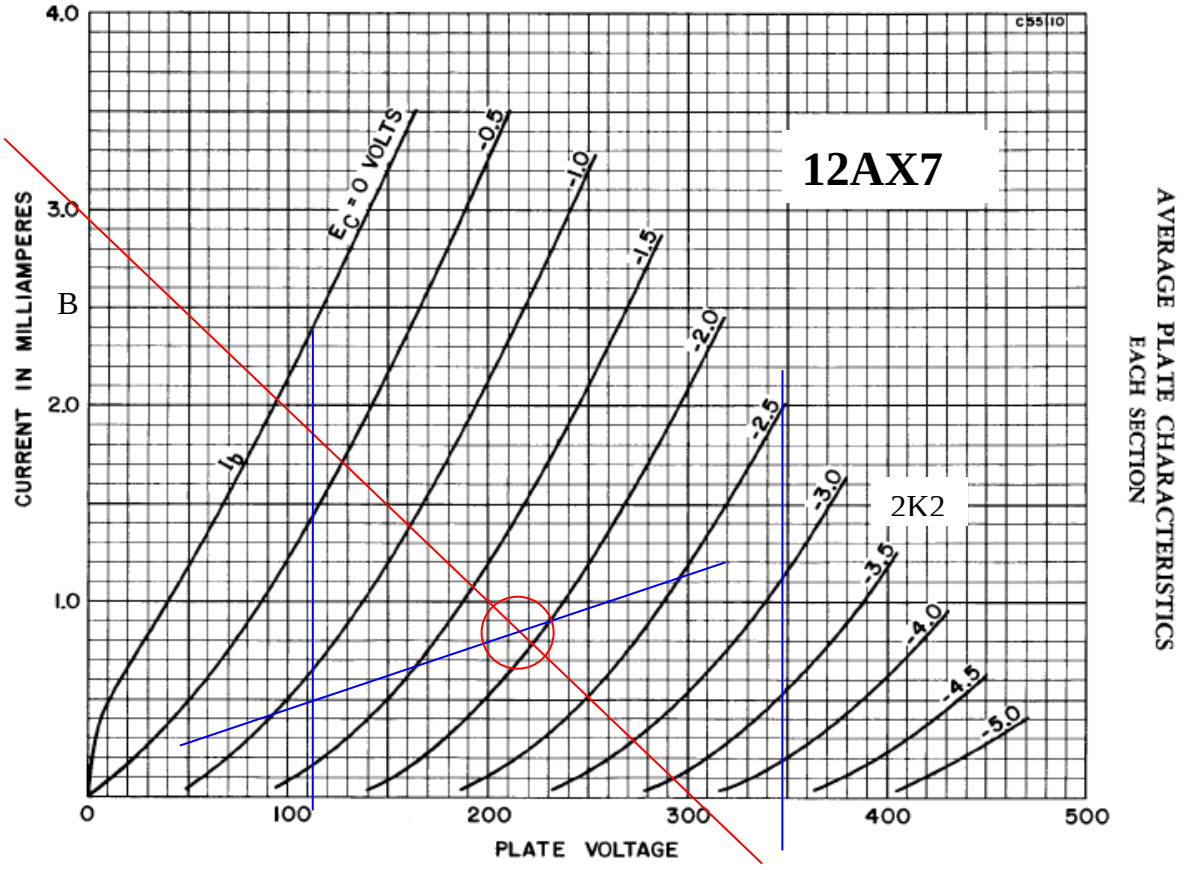
Gain ~ 2.5/0.025 = 100x at 1kHz with maxed bass and treble.

4.5 LFO

VS4 at 300V. Loadline indicates 0.85mA and 215V idle, and 1.9V cathode bias.

LFO oscillates continuously, and LFO output signal can be remotely muted by front panel VIB Footswitch. LFO harmonics suppressed by 100k/47nF= 34Hz.

S3 (pull shaft on Depth) connects VS4 to neon. Neon NE-2 type bulb ionizes at about 90-110V. Triode with grid-leak bias and 1M anode path.



LFO modulates 1kHz signal with first sidebands at -23dB for max Depth, reducing to -36dB at min Depth. Speed varies modulation frequency from about 6Hz to 10Hz.

4.6 Pre and Splitter stage

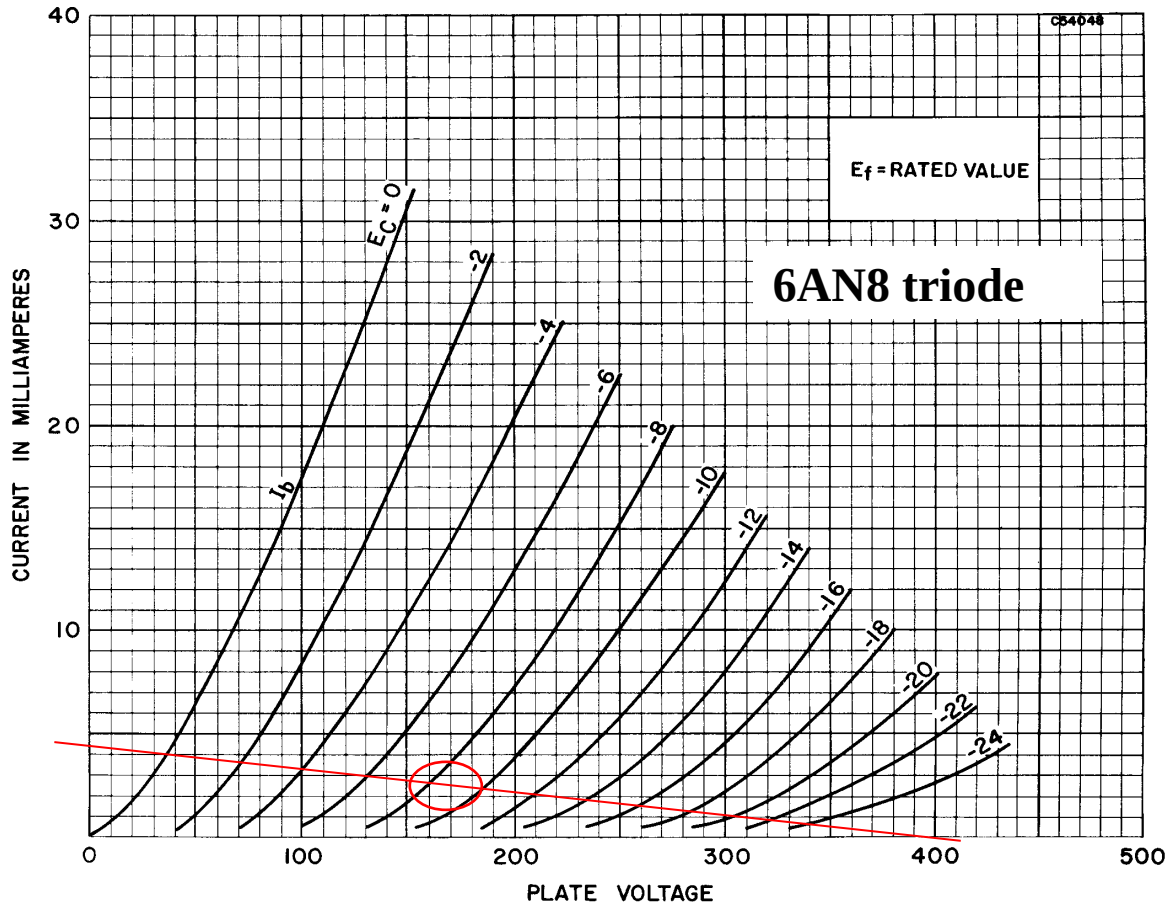
The 6AN8 pentode is used as an amplifier, with amplifier output feedback to the tapped cathode resistor. The pentode screen is biased with 1M from VS4, and bypassed to the cathode with 0.1uF. The pentode output is DC coupled to the triode cathodyne PI. The voltage drop across the triode is ~40V min, and peak triode voltage may approach 400V depending on VS3, and cathode starts to get above 100V. Based on VS3=360V, then 25% of VS3-40V = 80V across each cathodyne loading resistor gives symmetric swing.

The 6AN8 triode PI stage has nominal plate voltage Vp axis intercept of 400V for no plate current, and the plate current Ip axis intercept is 400V / 94KΩ = 4.3mA. The preferred triode PI anode-cathode voltage at idle is about (380-40)/2=170V; 9V and 2.23mA.

Pentode gain is low for low screen voltage. Sunn 200S uses about 35V on the screen with 325V VS4, and 75V on the anode, whilst the 2000S shows 30V on the screen, but with VS4=300V. The pentode anode current is about (330-86)/270k = 0.9mA. Screen current is about (330-40)/1M = 0.29mA. So cathode voltage is about 730Ω x (0.9mA+0.29mA) = 0.87V.

With about 80V screen, the available grid swing is about -4V cut-off.

Screen bypass cap taken to cathode, as global nfb also goes to cathode divider (ie. can't take to 0V). Can also tailor cap size, or even use a zener and cap. Could also consider using two voltage levels on the screen, eg. 35V and say 65V for higher gain/distortion.



Frequency response measurement taken with 11k disconnected from raw bias supply so 0.27u/100k output coupling network effectively in place; and input signal to Tremelo Vol pot wiper with wiper mid-position; feedback switch off.

- FR flat with -2dB at 25Hz and 12kHz with Presence at max. Presence at min gives 4dB peak around 4kHz, and -2dB at 25kHz.
- Gain ~ 10/0.09 = 110x from Vol pot to each KT88 grid.

4.7 Output Stage

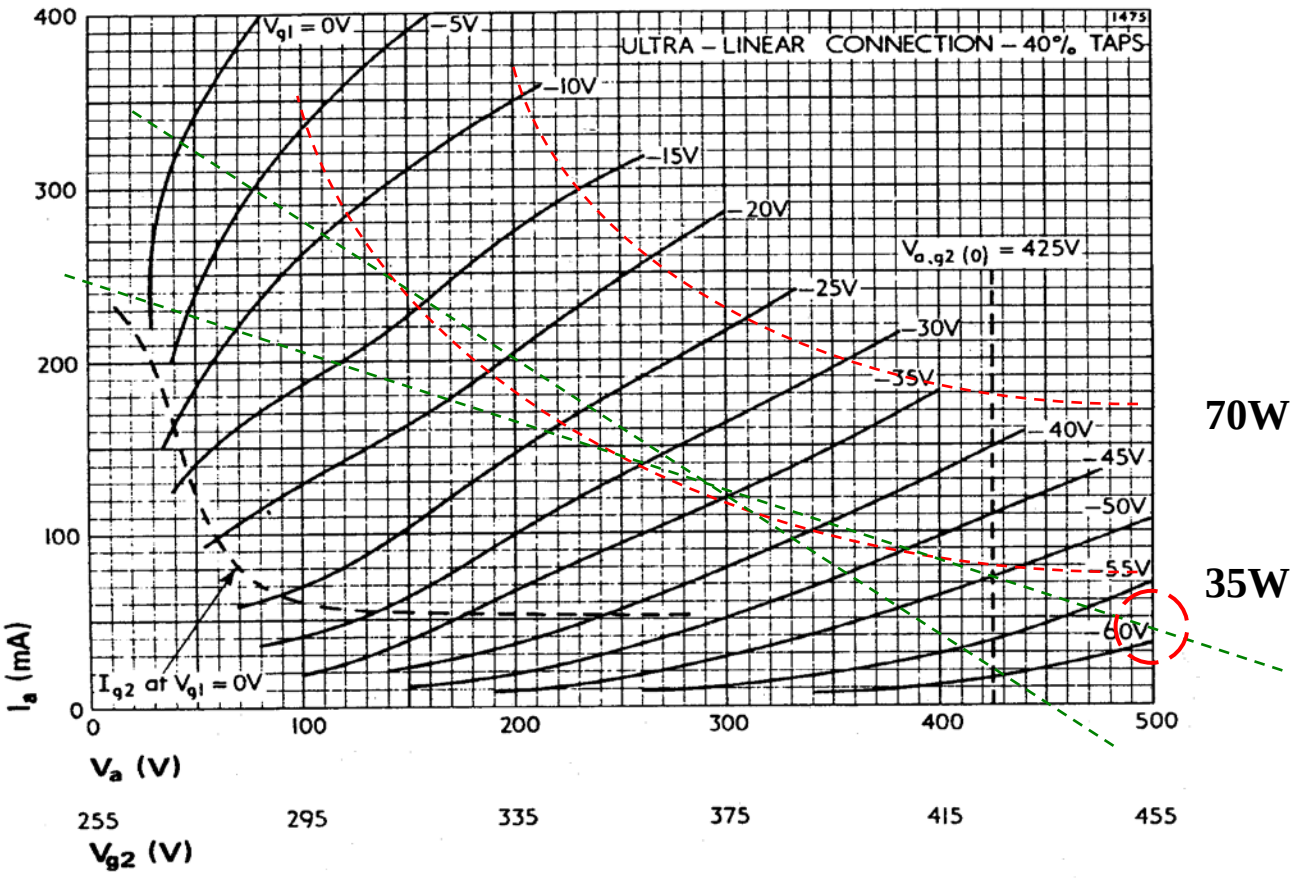
In this Class AB push-pull output stage, one tube is pushed into conduction and the other tube is pulled into cutoff, and there is a region of overlap where both tubes conduct equivalent levels of current. The cathodes are grounded, and each tube operates in a fixed bias mode with a negative gate voltage. The 5KΩ impedance plate-to-plate OPT, presents each tube with a 2500Ω load impedance around cross-over, moving to a 1250Ω load impedance (Class B) at high signal levels - with a resistance matched secondary load.

The low frequency response extends down to 40Hz for OPT spec level of 50W, and would be >50W at higher frequencies before core saturation becomes excessive.

As the output loading increases, the supply voltage VS2 to the output valve plates sags from about 500V to well below 500V. Effective plate voltage will be lower than VS2 by an amount up to ~13V due to OPT half-pri resistance of about 36Ω with a peak current of up to about 0.35A.

The recommended output valve bias current for the KT88 is Ibias = Pd / Vb = 25W / 500V = 50mA, up to max rated 35W/500V = 70mA. The gate bias voltage required for this current is significantly influenced by the mode of operation – UL or screen voltage in pentode mode.

The first loadline graph shows the characteristic curves for KT88 with a UL screen voltage (OPT has 43% UL tap; plot uses 40%). The initial loadline trajectory is along a 2500Ω loadline for small signals where both tubes are conducting – the loadline going through the bias point. The final loadline trajectory for heavy loading (high plate current) is along a 1250Ω loadline – this loadline is aligned with the sagged effective plate voltage of about 450V, and extends out to the 0V gate level. This 1250Ω loadline indicates a peak plate current of ~300mA would be needed for input grid voltage reaching 0V.



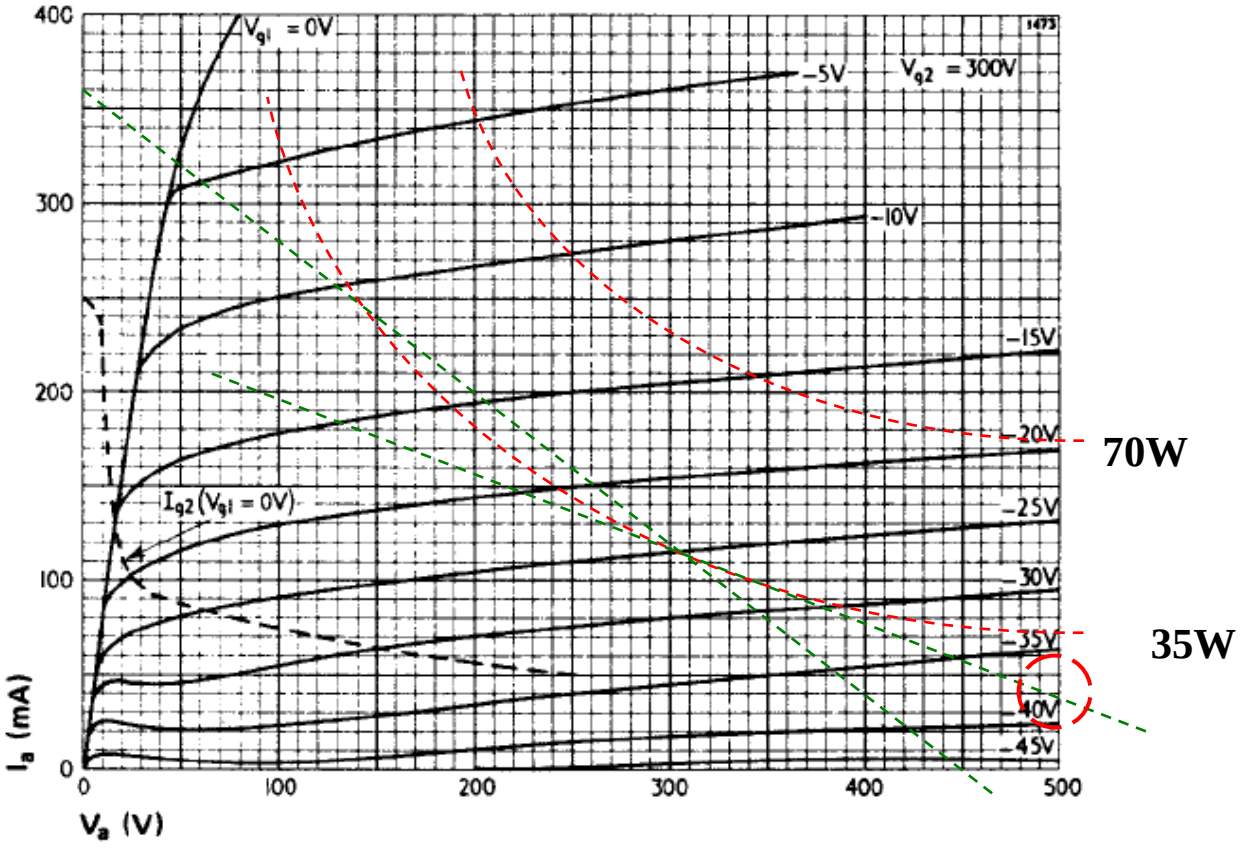
For a peak plate current of 300mA, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.3 x 0.3 x 5k / 8 = 56W. For this signal condition, the rms OPT current draw is likely about 0.2A (64% of peak), and the average VS2 power consumed is about 450V x 0.2Arms =90W, and the OPT loss is about $(0.2)^2$ x 31Ω = 1W, so the tube plates dissipate 90 – 56W - 1W = 33W, or just under 16W each, which is reasonably below max design level.

During ideal dynamic conditions, the plate dissipation just exceeds the 35W power contour curve shown on the graph. Each valve has an 'off' period for 50% of time, where the plate dissipation is lower than the bias level and possibly down to a few watts for most of the period when the valve is in deep cutoff due to very negative grid voltage levels. As such, the average dissipation during the "off" period brings the average down considerably, and the 'on' period dissipation can extend dynamically above the 35W curve.

In UL, the screen voltage will sag and the output compress during grid swing from about -5V to 0V when a screen stopper is used - a 100R stopper will increase drop by about 10V.

In pentode mode, the screen supply VS4 will sag and the output compress as grid swing increases to 0V - a 1k stopper will increase the drop by about 80V. A screen supply of about 300V may droop screen voltage down to 200V when Vg1 approaches 0V.

The loadline indicates the achieved loadline is likely to be into the very broad knee region, depending on screen droop.



4.8 Power Supplies

Power switch turns on valve heaters and output valve grid bias. Added 270k pre-charge resistor across Standby switch to provide ~50V on the HT power caps to reduce HT turn-on stress. PT has rating in excess of requirement, so Tx regulation shouldn't be an issue.

A full-wave centre-tapped rectifier with 450-0-450V windings provides a no load voltage of circa 630V. Chassis marked with GZ34, but 5U4 fitted to drop VS1.

The valve diode has limits on the effective source resistance when feeding a capacitor-input filter. The effective source resistance is comprised of the reflected power transformer primary resistance = 6.1Ω x $(450/240)^2$ = 21Ω; plus the secondary resistance = 34Ω; which sums to 55Ω. The idle loading could be from 70mA to 100mA, depending on KT88 dissipation. The max signal loading could be up to say 150mA.

With a GZ34, VS1/2 could range from 588V at 70mA to 579V at 100mA. A 5U4 lowers that to a range from 560V to circa 543V, with 0.48Apk to 0.37Apk, which are well below design peak, and even at 150mA, the peak current is <0.64A. Hot-start is circa 3.2Apk with 17.6uF, so also ok.

The specified min source resistance is 130Ω for 50uF input cap. Modified to use 8x 2u2F poly caps (17.6uF) to comply with no extra series resistance than inherent 55Ω. Caps rated to 760VDC. Only 7V drop across each choke at 230mA average.

The Dynaco Mk3 choke (C354) was nominal 1.75H 62R. Choke DC drop is 30R for ~1.2H at 120mA, or 60R and 2.4H for 2x series. First choke with ripple trap RC of 33R 2W and 2.2uF 1kV lowers the rms ripple voltage on VS2 by about 25%, to 0.9Vrms at 480Vdc and 88mA output stage loading (plus preamp loading) at 230V mains, using clone KT88's. First choke input lead is innermost winding entry.

GEC design level for UL fixed bias at 460V.

VS2 sag will come from many contributors: the main ones being diodes; VS1 ripple averaging by choke; PT, OT and choke DC drop.

Idle loading from VS5 is ~ 3.4mA, from VS4 is ~ 2.4+3.4=5.8mA, VS3 is ~ 2.8+2.4+3.4=8.6mA, (50V drop to VS5 from 14k; and 75V drop from VS3 to VS4 from 13k; and 95V drop from VS2 to VS3 from 11k).

Three 1N5383 (150V) zeners used to limit VS3 cap voltage to 450V if valves are pulled ((600-450)/11k=14mA, minus 6mA to VS4; 450Vx8mA=4W). Two 1N5383 (150V) zeners used to limit VS5 cap voltage to 300V if valves are pulled (150V/27k=5.6mA; 300V 1.7W).

VS2 for the output stage is choke-capacitor filtered PSUD2 indicates no damped resonance response for step dynamic load changes.

The KT88 grid bias resistors are 100k, which is the datasheet max for high dissipation applications.

The bias supply is bridge rectified but with a large added series resistance to reduce harmonics in the filtered DC. VS6 ~ -100V rail with relay load and bias supply drawing ~2.3mA. 11k dropper gives VS7=75V, which is reduced to 50V when pentode mode is selected.

Bleed resistance with valve loading is 500k//545k//556k ~ 180k on VS2.

For a hot turn-on with 150mA load, and clone ss 130Ω rectifier, the following data indicates a 0.5A F 3Ag is ok (no T 3AG on hand).

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current	1.14A		1.2A			0.26A
Multiplier (for 0.5A fuse rating)	2.4		2.4			0.52
IEC 60127-2 **F** min limit multiplier	4		2.75			1

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current		1.2A		0.86A	0.51A	0.26A
Multiplier (for 0.315A fuse rating)		3.8		2.7	1.6	0.82
IEC 60127-2 **T** min limit multiplier		10		4.0	2.75	1

5. Protection

5.1 Loss of grid bias

If the grid bias supply voltage fails, then the grid will rise and become positive to cathode, and plate current will increase without control. A 48VDC relay, Omron G2R-2 48V, has a coil resistance of 4.2K, with a must pickup of 34V, and a must release voltage of greater than 7.2V, and de-energises due to gross failure of the bias power supply. The relay contacts are used to disconnect the AC supply to the HT, as the series contacts are rated to break this level of AC (but not DC). If a bias failure does occur, the energy remaining in the caps will still discharge into the tubes, but is minimal.

5.2 HV breakdown

If the B+ rail shorts to ground, due to a flashover, or insulation breakdown, then a 0.315A T fuse in the transformer secondary CT line provides gross failure protection by de-energising both the plate and screen rails.

5.3 Output open circuit

Added a MOV (2x 2502 red 7mm type; 330VDC each) and 4k7 2W resistor across each primary, to act as a high voltage damped clamp in case the speaker load goes open circuit.

5.4 6AN8 triode grid protection

The PI stage input grid will raise to VS4 on power-up, with a VS4 rise time of 29k.47uF= 1.4 sec. The cathode will be quickly pulled down towards -VS8 by the 270nF coupling cap but then quickly recover to 0V, and then rise to operating voltage once the 6AN8 heater has been on. Adding a 1N4007 is likely to have negligible impact, and perhaps better than an aging NE-2.

6. Testing and Fault-finding

Operation:

- Always turn power off before toggling the UL-Pentode switch mounted at the rear of the chassis.

Maintenance checks.

Connect 8-meter assembly to rear Octal socket. Use variac to bring mains AC up and monitor VS2, VS3, and cathode current of each KT88.

- With standby switch off, mains current can be checked at full mains, noting that heater and bias circuitry is energised, and B+ rails are only partially powered.
- With standby switch on, start variac at zero and bring up slowly. The 5AS4 will bring up voltage rails first, then the KT88's will start loading the rails. Electrolytic capacitors should reform in that time.
- KT88 balance can be adjusted at less than full mains by using an insulated flat blade adjustor through the two chassis holes to the two vintage preset pots.
- The 100:1 dividers for VS2 and VS3 monitoring are trimmed for a nominal 132kΩ meter loading, so will read a few percent high if just a 10MΩ DMM is used.

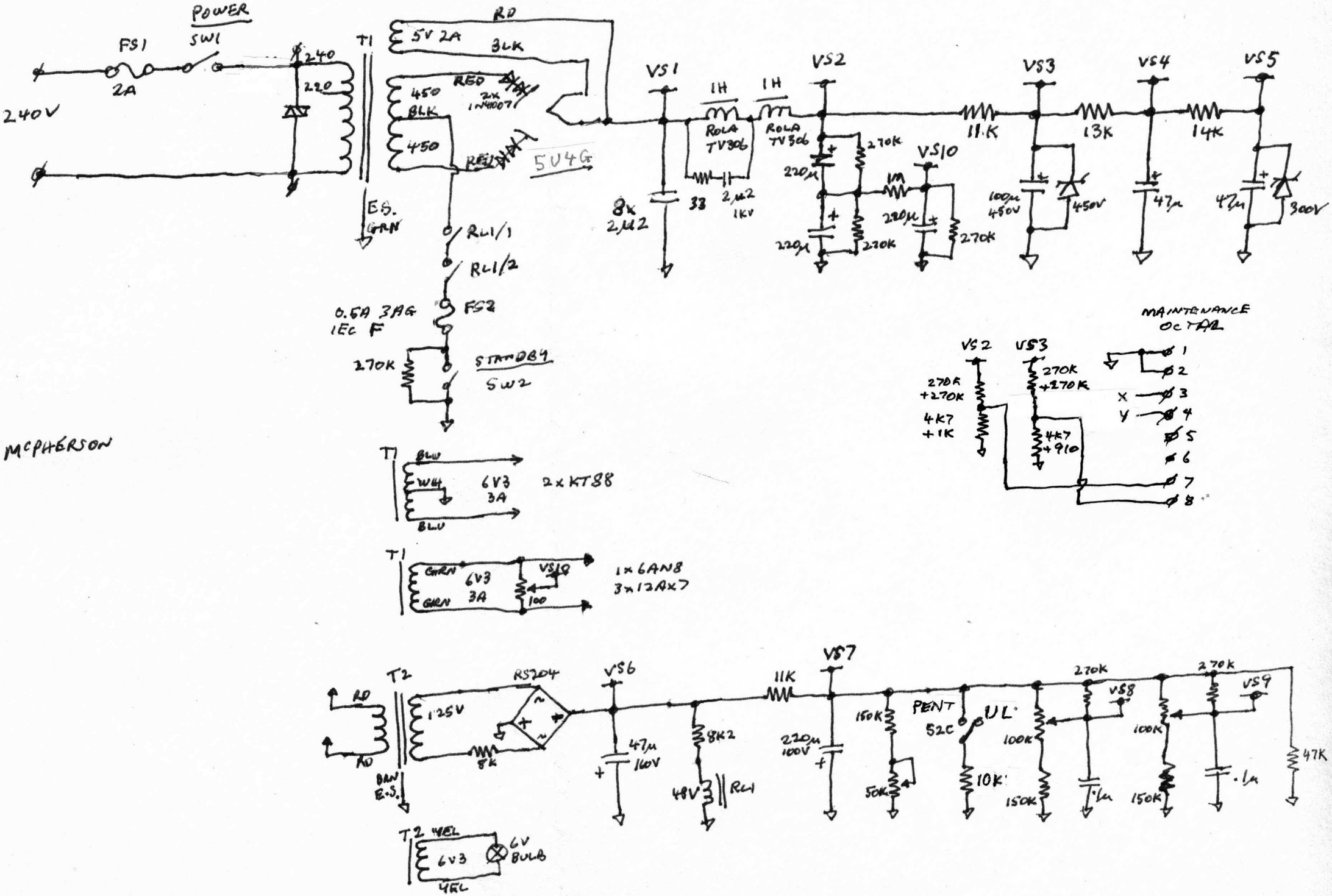
The fitted 5AS4 has no centre alignment spigot and should not be removed unless being replaced with another ok rectifier valve.

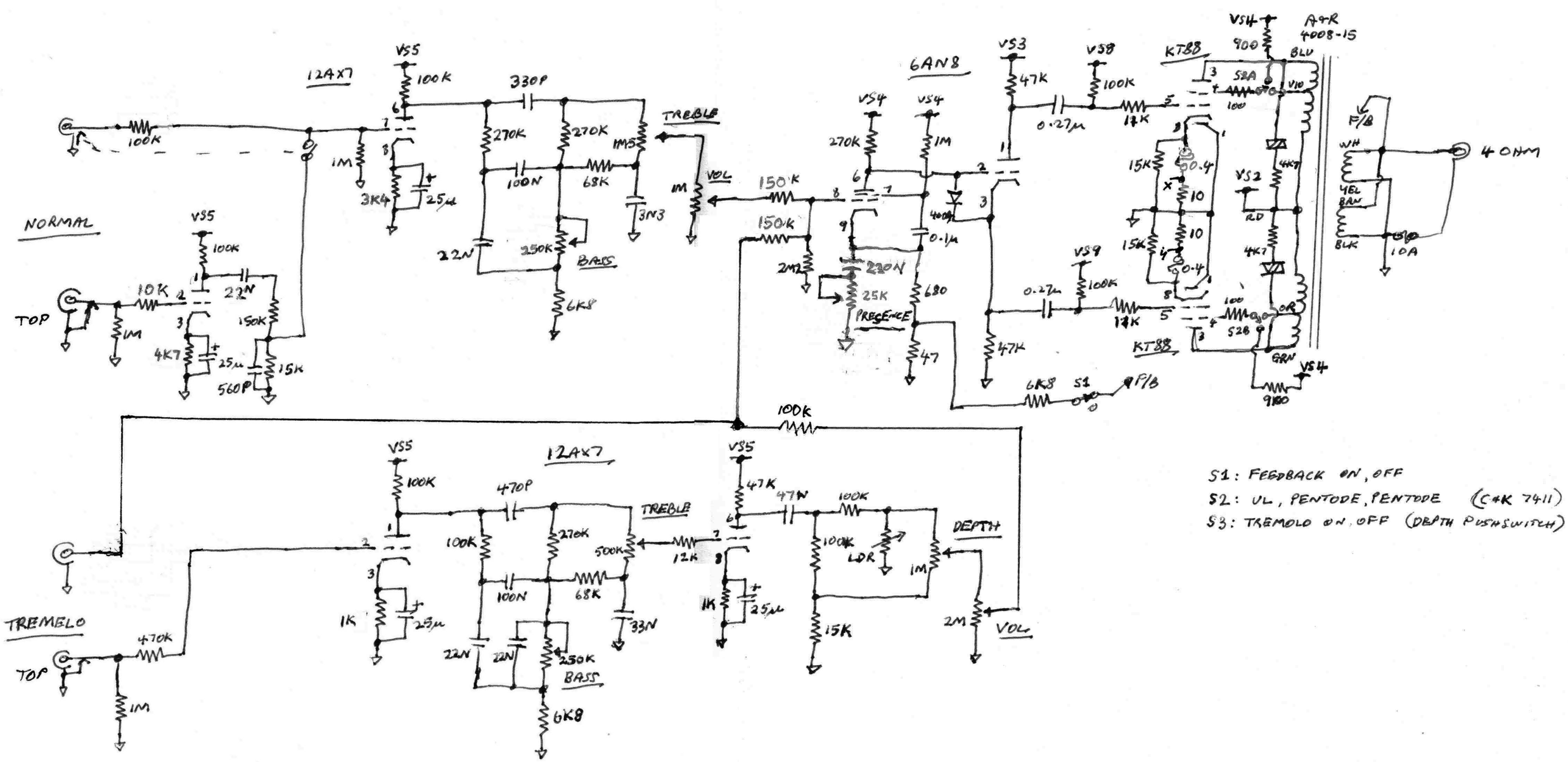
Fault-finding and configuration.

Removal of chassis from wooden enclosure (4 bolts into side of chassis) is out through the front (after removing all the front panel knobs and then the lexan front cover), and requires incremental lifts/shifts as the fit is very tight. A metal sheet is fitted behind the front fascia to support the front panel. It is onerous to remove the floppy front fascia (as all pots and switches need to be removed), so preferably keep in place and take care not to damage when the chassis is removed or turned upside down.

The 4Ω speaker configuration can be reconfigured for 15Ω, however this will significantly increase the level of feedback and a re-evaluation of stability should be made.

A+R 1939 - 200mA





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