1. Summary

Valve PA Amplifier. $152.50 eBay Mar 2011

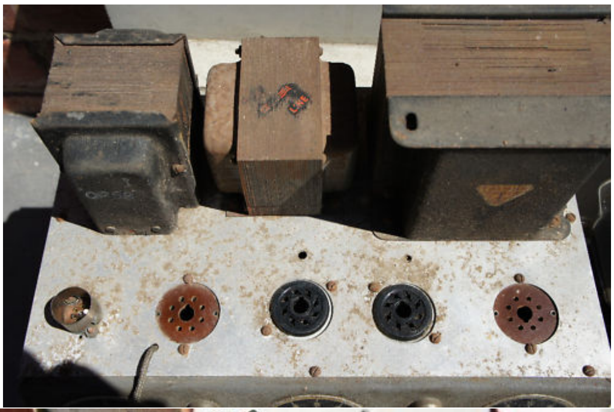
Unknown manufacturer (no markings identifiable).
Microphone and Pickup inputs via separate front panel 2501 microphone sockets (5/8” Amphenol). Microphone input switched to grid of 6J5 triode with bypassed cathode bias gain stage to microphone volume pot. Pickup input direct to volume pot. Amplified MIC and PU signals from pots are summed and taken to input of 6AU6 in bypassed cathode bias pentode configuration gain stage with output to Tone pot and 6J7 triode connected split-load/concertina PI. Cathode biased, push-pull 6L6G pentode output to 10K PP 15W OT with multi-tapped outputs to 15R. 6L6 with grid stoppers, and HT+ direct to screens. Full-wave centre-tapped transformer rectified by 5V4G with capacitor input filter, and choke to HT supplies.

Appears to be in original condition, with no rework or changed parts/tubes. Trimax and Red Line from Melbourne; Ferguson from Sydney. 6L6G suitable for 20-25W in cathode bias. Professional chassis with hammertone enamel, and well assembled parts. Choke appears to be dated September 1951 – so likely build date is 1952.

Output Transformer	Ferguson OP58. 15W PA range; 5k,6k6,10k PP; 15,12.5,8.4,6.5,4,3,2.7,2.3,2.
Power Transformer	Trimax, TP1895; 0-210-240V; 385-0-385V 125mA; 6.3V 3A; 6.3V 3A; 5V 3A; ES. 3M 50.
Choke	Red Lion, Type 301214; Marked ‘9 51’. 30H 120mA.
POTs	ERIE[1] made in England, Log law.
Tubes	KEN-RA JAN-CKR-6J5 6AU6 Radiotron Australia 7-pin 6J7 Radiotron Australia 2x 6L6G Radiotron USA graphite coated ‘grey glass’ ST envelope. X6 code 5V4G Philips Miniwatt (Great Britain) N16 code
Caps	IMPEX Mica; UCC Type 51-130-3, Aerovox Type 1015, and Ducon Type ET 2015 electrolytics; Ducon waxed paper P.C. 601
Resistors	Many use old body colour plus bands; one uses body colour plus dots; a few use latter colour bands.

Issues: PT ES not connected. Mains through 8-pin valve socket – no fuse or switch. All caps and most resistors need replacing. 6J5 mounted underneath - only switched on when needed. 6J7 heater-cathode voltage at design limit. 6L6G screens operated with very high voltage and no stoppers. Almost no separation between 6L6G glass envelopes for cooling. No vents for cooling parts underneath chassis. Input sockets don’t have shorting contacts. Treble cut tone pot. 6L6G’s are a bit too unmatched.

[1] ERIE Resistor Ltd, UK



2. Modifications

- Added mains switch and 1A 5x20 fuse. Earthed the PT ES.
- 16R NTC added to mains, with MOV across primary of PT. Added 0.4A 5x20 fuse in series with PT secondary CT.
- Replaced all caps – 7x 2u2 poly for VS1 filter – increased VS2 capacitance 220u in series with 220u for voltage rating. Zener (11x33V) across VS3.
- Replaced most resistors. Added 1R cathode resistors to each 6L6G.
- Heater humdinger to elevated bypassed 50VDC to alleviate 6J7 heater-cathode voltage. 6L6 heater used for powering indicator bulbs.
- Distributed star grounding. Insulated input socket chassis connection.

- Reconfigured pickup pot as 2nd volume pot after 6AU6 and on input to 6J7 PI. Re-installed microphone switch and 6J5 as an input 'boost' stage/button, with 1st pot as boost volume – green indicator on for boost switch position.
- Added 100k grid stopper to PI stage to aid overdrive.
- Reduced 6L6 grid leaks to 220k.
- MOV-R OT protection.
- Replaced 2 valve socket outputs for Speakon and 6.5mm sockets.
- Setup to use 6L6GC to allow higher idle current and more operation in class A.
- Added a row of drilled vent holes in base to vent 6J5 and 6L6 cathode bias.

To do:

- Add drilled vent holes in alu mounting plate as well.
- Replace treble cut with bench LCR scoop filter to tone pot (10nF, 1H, 22k, with 100nF bypass from top of pot for 1kHz centre)

The 6AU6 had similar use to the EF86 in guitar amps – eg. Moody, Calston.

The input stage starts gross distortion about ¾ turn on Mic pot. Output waveform is relatively clean to about 12W, with increasing overdrive distortion through to about 16W max output. PI stage pulls VS3 down significantly under heavy overdrive.

3. Measurements

Voltage rail regulation.

Rail	Idle	Overdrive
VS1	496	480
VS2	471	458
VS3	312	
VS4	271	
VS5	55	
Heater 1	6.4	
Heater 2	6.4	
Sec HT	407-0-407	

PT & OT passed megger test fine at 1kV.

12VAC 50Hz nominal applied to output transformer

Winding	Voltage rms	Turns ratio; Impedance for K pri; Spec level; Notes
Pri P-P: BLU to BRN		
Sec: GRN to GRN		; Ω; Appears reasonable for K PP

Output transformer primary DC resistance: 384Ω plate-to-plate.

Power transformer primary DC resistance: 10.5Ω, 0-240V.
Power transformer secondary DC resistance: 84+89Ω, 385-0-385V.
Choke: 330Ω dc resistance; H at mADC; H at mADC.

Output voltage hum/noise rms (Keithley 197):

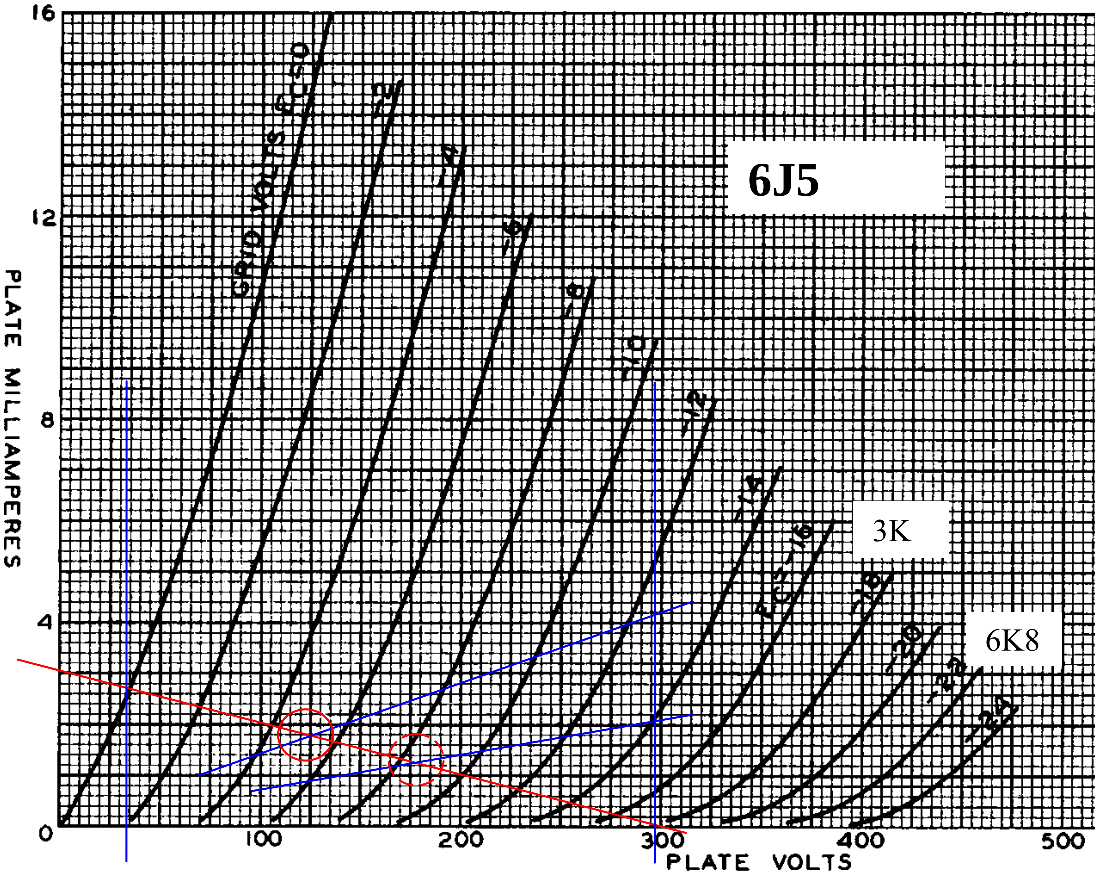
MIC & PICKUP pots min, no input:	0.8mV
MIC min, PICKUP max, TONE max, no input:	1.6mV
MIC max, PICKUP max, TONE max, no input:	630mV (humdinger position optimised)
MIC max, PICKUP max, TONE max, shorted input:	18mV (humdinger position same)

Heater DC elevation 50V. No change in hum/noise when elevation reduced to 0V.

4. Design Info

4.1 Microphone Input Gain Stage

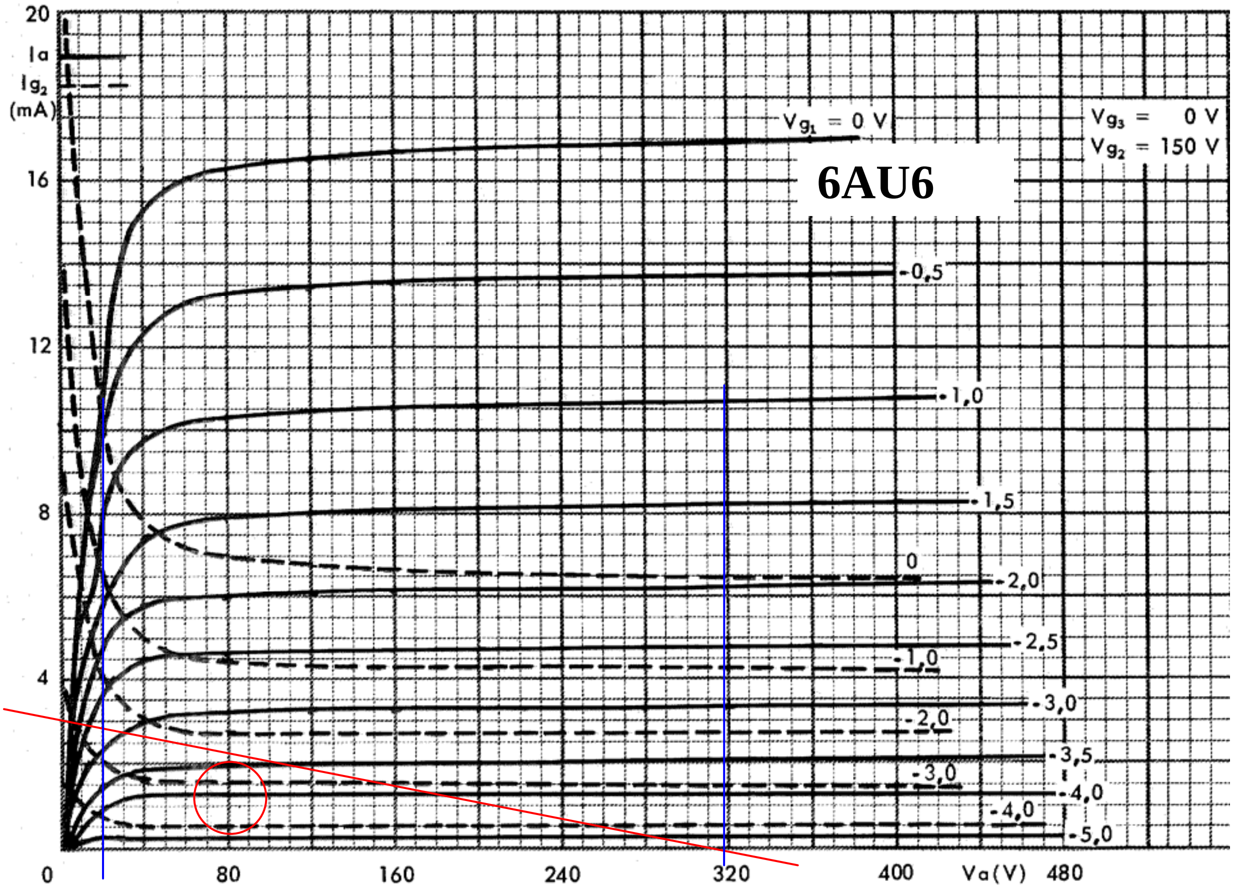
6J5, V1; VS4 = 300V; Va=125V; Rk=3k; Vk=5V; Ia=1.8mA; RLdc=100k.
6J5, V1; VS4 = 300V; Va=180V; Rk=6k8; Vk=8V; Ia=1.2mA; RLdc=100k.
Measured: 8V; 185V; voltage gain x14.3 (+23dB) with bandwidth <30Hz and >30kHz.



4.2 Mixer Gain Stage

6AU6, V2; VS4 = 300V; Va=100V; Rk=2k; Vk=2.4V; Ia=1.0mA; RLdc=250k.
Measurements: voltage gain x80 (+38dB) peaking about 100-200Hz, dropping either side (minimised by setting tone at min) -3dB ~3kHz and <30Hz; -7dB @10kHz.

Databook pentode curves only for screen Vg2=150V. The AC load line is about 150k, due mainly to the 250k plate load, and 500k tone pot – the grid input of the PI will present high impedance. Measured levels with screen resistor 1M5: Va=81V, Vg1=2.1V; Vs=96V (hence Is=0.17mA, Ia=1mA).

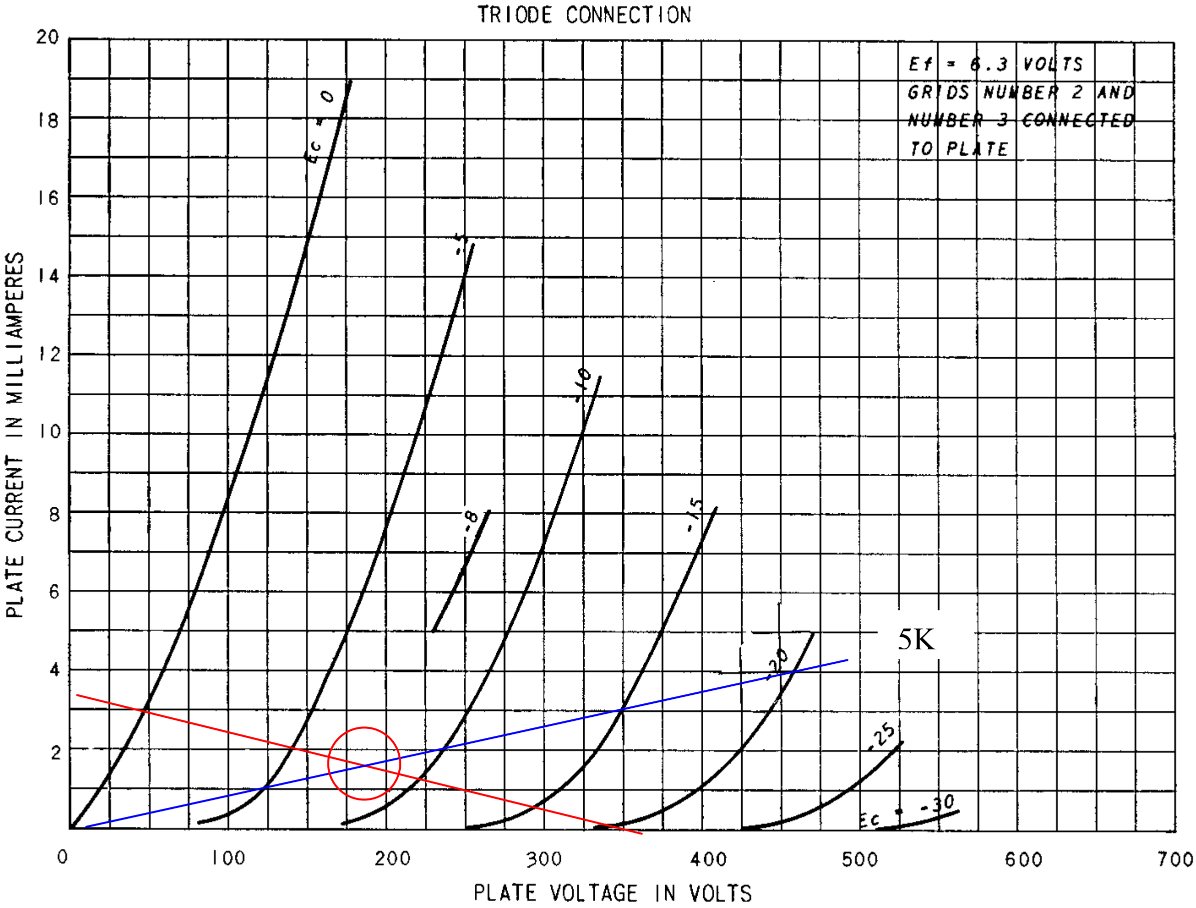


Modified amp with 500k pickup volume pot after 6AU6, loads down gain a bit more.

4.3 Concertina PI Stage

6J7, V3; VS3 = 350V; Va=185V; Rk=4k7; Vk=8V; Ia=1.7mA; RLdc=105k.
8.2V, 77V, 270V1

Available swing is 350-50-15=285V. Aim for 140+50=190V anode-cathode idle, and 75V across cathode and anode loads. Heater-cathode voltage at idle is ~88V, which is close to 90V design limit. Heater elevated by 50V to alleviate.



4.4 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 with a common resistor to ground, and bypassed. The 10KΩ impedance plate-to-plate OPT, presents each tube with a 2.5kΩ load impedance (with a matched secondary load) for larger signal currents, and 5k loading for small signal levels.

Determining a suitable bias current level is not an empirical design approach, rather it is based on the following recommendations:

- Start with the lowest bias current possible (ie. most negative grid bias voltage), and based on listening tests, increase the bias current until the sound character is acceptable, but:
- use the lowest possible bias current level, as this generally increases the life of the tubes, and decreases the chance of operating at excessive plate dissipation; and
- keep the bias current level below 70% of the recommended 19W design max plate dissipation (ie. <13W); and
- assess the dynamic loadline to see if it moves into region of increased plate dissipation.

The maximum output valve bias current allowed is dependant on the maximum recommended plate dissipation of 19W for the 6L6G: Ibias(max) = Pd / Vb = 13W / 480V = 27mA. With 300R common cathode resistor, then bias voltage is 17.5V, and loss is 1W. This indicates a screen voltage of less than 250V from the Brimar datasheet.

The maximum output valve bias current allowed is dependant on the maximum recommended plate dissipation of 30W for the 6L6GC: Ibias(max) = Pd / Vb = 21W / 470V = 45mA. With 300R common cathode resistor, then bias voltage is 27V, and loss is 2.4W. Measure idle bias is 25V, increasing to 29V under heavy overdrive (2.8W).

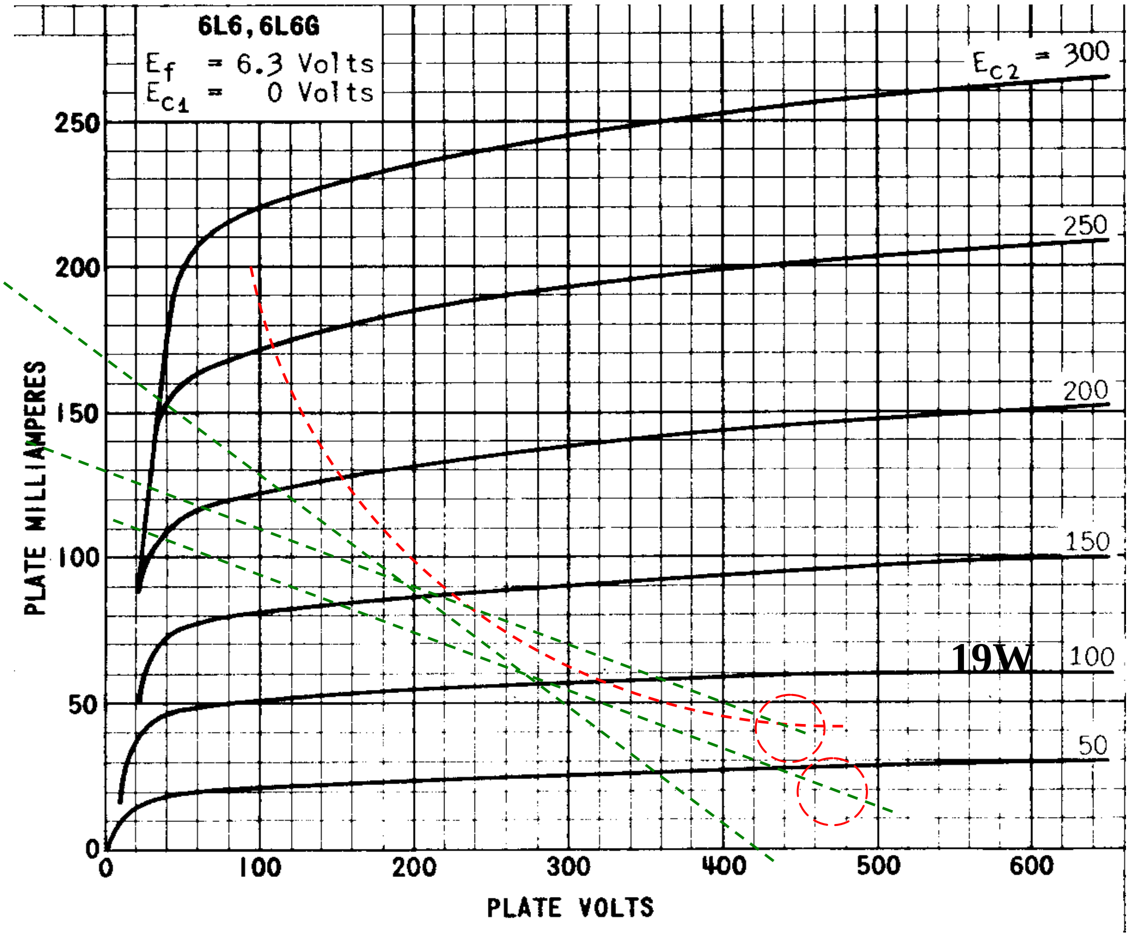
The supply voltage VS2 at idle current of 83mA is about 470V, due to diode drop and choke averaging of VS1 14V ripple (increasing to 16Vrms), and choke drop of 0.083x330=27V; and decreases to 460V at overdrive. Plate-cathode idle voltage is lower than VS2 by 8+25=33V; ie. OPT half resistance of about 195Ω, and cathode bias of 300R.

From the plate characteristics, to operate in to the knee, the screen needs to be at or sag to about 250V as Vg1 approaches 0V. VS3 is 310V at idle. Assuming screen current peaks at about 17mA, then screen voltage sags to about 310-17-29=264V. Cathode bias reaches 300x0.15=45Vpk but is reduced due to bypass capacitor.

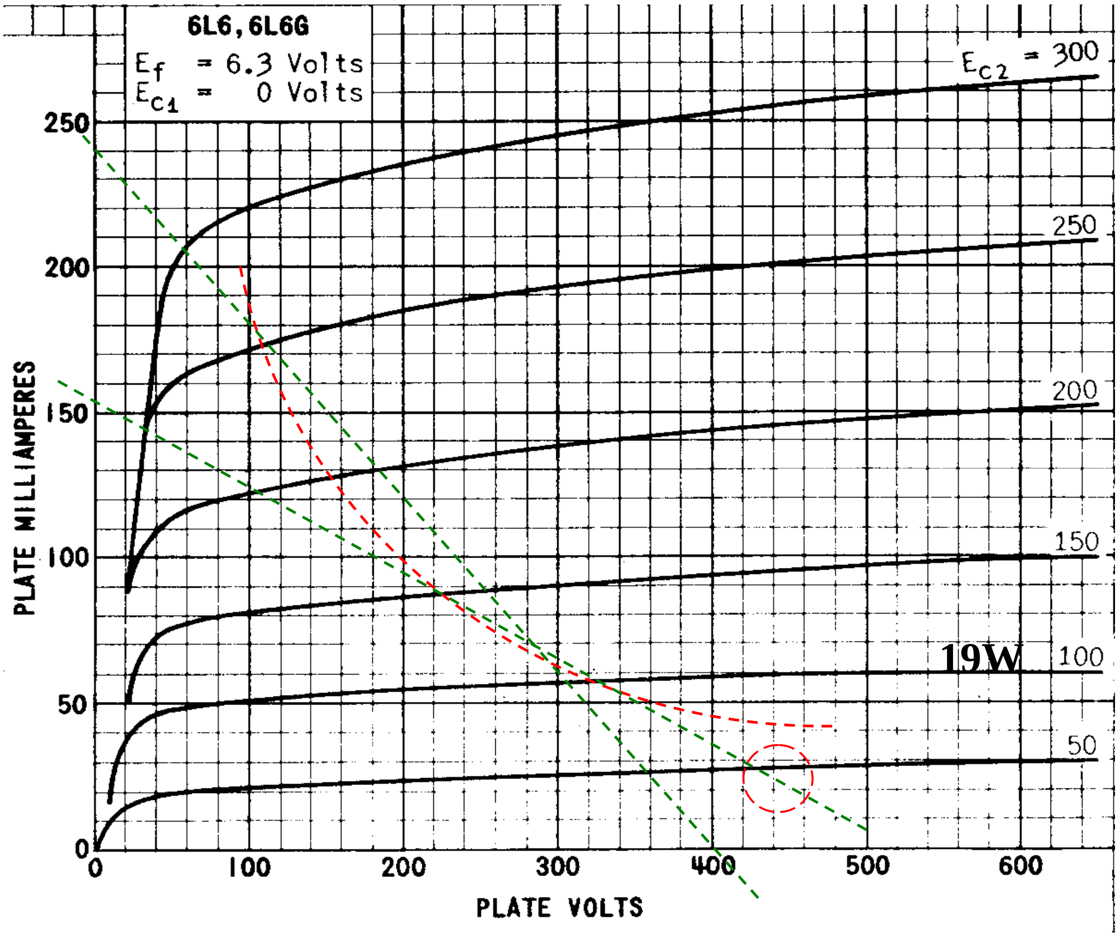
The nominal output power of the amplifier would be:
(Imax)2 x Rpp / 8 = 0.15 x 0.15 x 10k / 8 = 28W

The 25uF bypass cap on the common cathode provides a high pass filter to minimise the level of low frequency signal available to the OT, given that it is not Hi-Fi rated and only has 15W rating. Similarly, HF low-pass filtering is appropriate to roll off signal before the OT starts entering resonances.

OT allows 10k, 6k6, or 5k primary matching. 10k initially chosen, as that was original condition.


6L6, 6L6G
Ef = 6.3 Volts
Ec1 = 0 Volts
Ec2 = 300
250
200
150
100
50
19W
PLATE MILLIAMPERES
PLATE VOLTS
0
100
200
300
400
500
600

10k PP setup



6k6 PP setup

4.5 Power Supplies

The power supply is typical full-wave rectified type using double diode 5V4G and a 385-0-385VAC centre-tapped secondary, which is just above the max specified voltage for capacitor input. The effective input resistance of the transformer is about 10.5Ω x $(385/240)^2$ + 85Ω = 112Ω, which allows up to 40uF, so 16uF requires no added resistance. VS1 is about 550VDC no load.

Idle voltage of VS2 is about 470V with 83mA from 6L6, and about 9mA from preamps.

The choke drops 33V at 100mA, and the 5V4 drops about 16V, and with capacitor ripple, VS2 will droop to about 465V at 100mA continuous.

Screen voltage taken from mid-point of series VS2 filter caps, which is about 250V. Screen stoppers initially at 1k. 272V zener placed across top capacitor in VS2 to limit any voltage imbalance on series capswhen screens conduct heavily. Balancing resistors across series VS2 caps are $(260V)^2$/1W ~ 68k (bleed current of 4mA).

Heater loading is 2A on 5V 3A winding; 2x0.9+0.3=2.1A on 6V3 3A winding; and 0.3+0.3+0.3+0.3=1.2A on 6V3 3A winding.

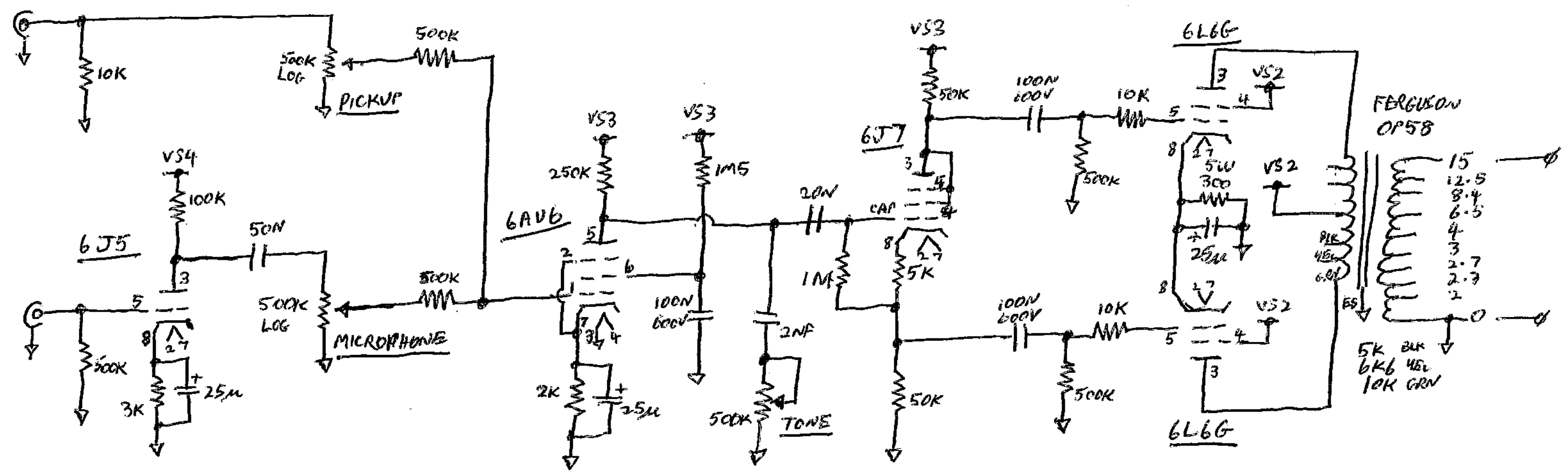
Idle loading from VS4 is ~1.2+1.2=2.4mA; VS3 is ~ 1.2+1.2+1.7=4.1mA; VS2 is ~ 90+4.1=94mA, (84V drop from VS3 to VS4 via 30k; 139V drop from VS2 to VS3 via 24k; and 33V drop from VS1 via 330).

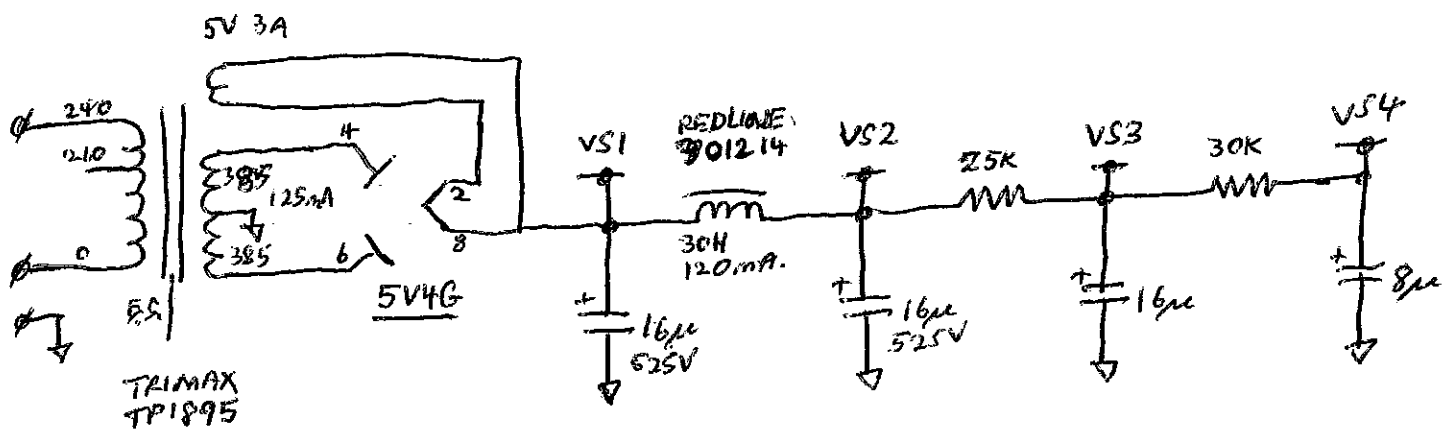
5. Protection

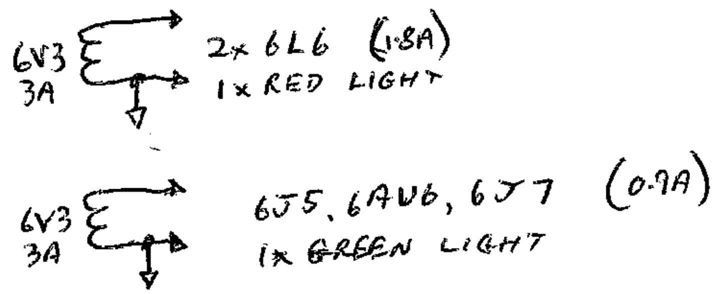
1A mains fuse. Turn-on surge alleviated by 16R NTH13D160LA NTC thermistor in PT primary. MOV across the PT primary to alleviate any voltage transient from AC switch opening.

A 0.4A fuse in the transformer secondary CT provides gross failure protection to de-energise both the plate and screen rails and protect the OT.

A MOV-R network is placed across each OT half-primary with 660VDC nominal and 4k7 dampening.

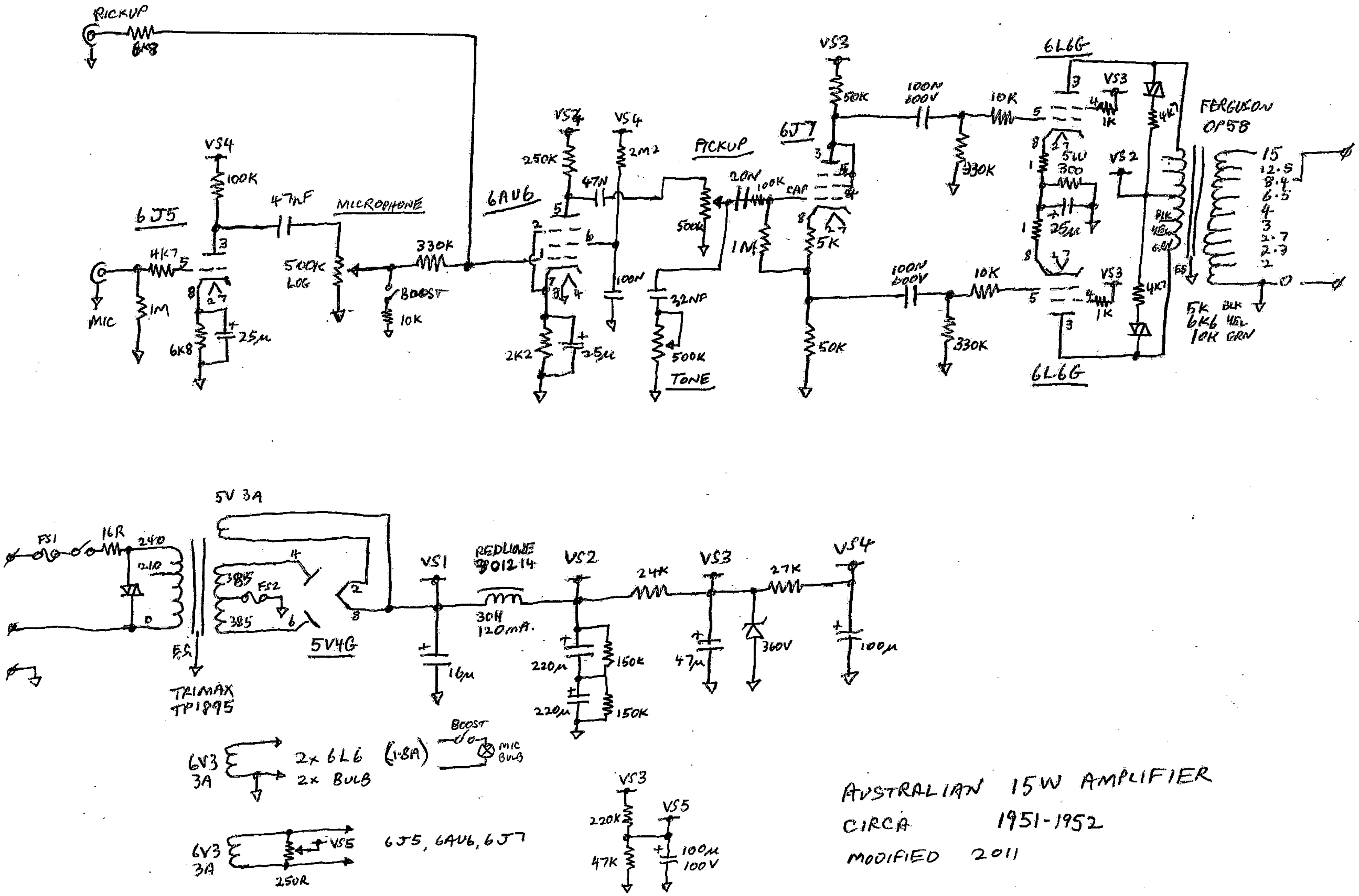






AUSTRALIAN 15W AMPLIFIER

CIRCA 1951-1952



AUSTRALIAN 15W AMPLIFIER

CIRCA 1951-1952

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