

## 1. Summary

Small 10W Valve Amplifier with MIC and PU inputs and PA line level outputs.  
eBay \$61, July 2012.

### 1.1 Original Amplifier

Indistinct front panel markings for MIC, TONE, PU, 12W, ON – OFF. Appears DIY/service shop made from a kit, as chassis cutouts are not punched, and layout is amateur. Two 2-pin input locking sockets. Two 4-pin speaker output sockets. Mic step-up transformer to EF86 gain stage and output volume pot. PU in to volume pot and mixed with MIC channel in to TONE pot and then to 6GW8 triode gain stage, and then to 6GW8 triode cathodyne PI. 6GW8/ECL86 pentode, cathode bias PP output stage.

The amp is not a Playmaster circuit, but has similarities with the 1962 Playmaster 101 and 1963 Playmaster 106. The most well known amp with EF86 and 2x ECL86 was the Mullard 10-10, but it uses the ECL86 triodes in a longtail pair splitter. Same first 6GW8 triode stage as Playmaster 101

### Components

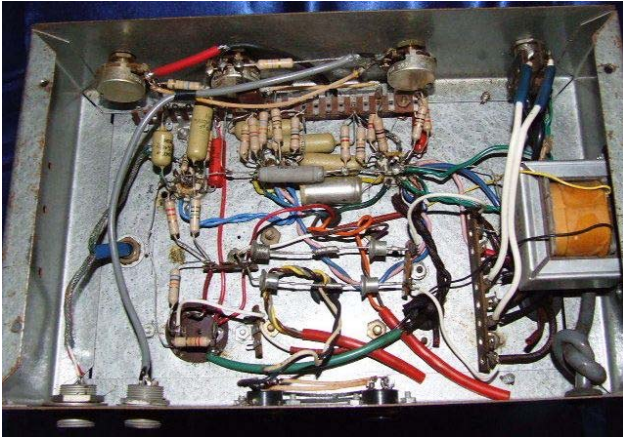
Output Transformer	A&R OT2632; 15W; 10k, 8k PP; 100/125/250/500 output.
Power Transformer	Ferguson PF170; 0,200,230,240V; 285-CT-285 80mA, 6V3 2A, 6V3 2A, 5V 2A.
Choke	Rola 14/60 CH16, dated 17 May 1965.
CAPs	Ducon ECT236, 50uF 350V (x3)
Tubes	None fitted.
Diodes	OA210 x4
Mic transformer	Zephyr, 50/350:42k step up.

### Issues:

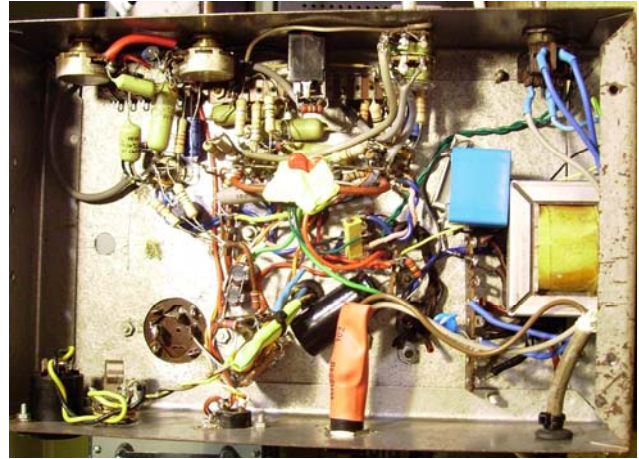
No mains fuse or proper protective earth connection. Electrolytics old. Diodes old. Wiring layout could be better. Line level output. Initial B+ stress. Input and output sockets.

The PT has no markings. The only transformer that aligns is the Ferguson PF170 based on early Ferguson data, although later data gives this model a heater CT.





Original condition



Modified condition

## 2. Modifications

- New mains cord and earthing. Mains fuse (1A) to replace one output socket.
- Remove PU input and mixer.
- Modify star grounding.
- Take 125 to 250 secondary tapings to speaker sockets for 16 ohm speaker.
- Replace one speaker with 6.5mm socket on rear (no function as yet).
- Replace both mic sockets with 1x 6.5mm socket and 1x Speakon socket in parallel.
- New diodes.
- Replaced electrolytics.
- PU volume pot reconfigured as post-PI master volume.
- Added 10k and 47k grid stoppers to 6GW8 triodes.
- 10 ohm cathode sense resistors for 6GW8 pentodes, and use 4-pin socket on rear panel for 0V, common cathode, sense V1, sense V2, voltage sensing terminals.
- Humdinger pot on heaters.
- MOV-R protection on each OT half-primary: 2502 GEAQ 330VDC MOV and 10k.
- Modified HT droppers to aim for 250V for each stage and screens with 300V VS1. Added 1uF before choke to increase VS1 from 250V default.
- Used Telefunken red tip EF86 from B&K meter.
- Added post PI MV 250k dual.
- Added IRFP460 and 33k load with 330V zener turn-on - limits turn-on peak (~405V) to 350V, which pulls down to 290V in idle after about 10 secs.
- Added 1-pot tone control – 500k with 470pf & 10nF.
- Added base plate and side bolts

### To do:

- Raise idle B+ and screen voltage by about 30V (keep under 350V so that FET is still off), and increase PP common cathode to keep similar plate dissipation.
- Check on bright capacitor across volume.

### Performance:

- Preamp stage is fine – no clipping prior to next stage clipping – enough headroom for different tone controls.
- Idle cathode current ~25mA (~7.5W = 80% of max design). Clean max output ~4.5W. Cranked max output ~7W.

### 3. Measurements

Voltage rail regulation.

Rail	No Load	Idle	Cranked
VS1	400V	300V (100mVrms)	280
VS2	400V	265V	230
VS3		255V	240
Heater 1,2			
Heater 3			
Sec HT			

Power transformer primary DC resistance: 0V black; 13.8Ω, 220V; 16Ω, 240V; 16.7Ω, 250V.

Power transformer secondary DC resistance: 170 + 170 = 340Ω, yellow/yellow. CT – blue.

Rola CH16 (14H at 60mA); DCR = 496Ω.

A&R OT2632, 10VAC 1kHz nominal applied to output transformer primary side

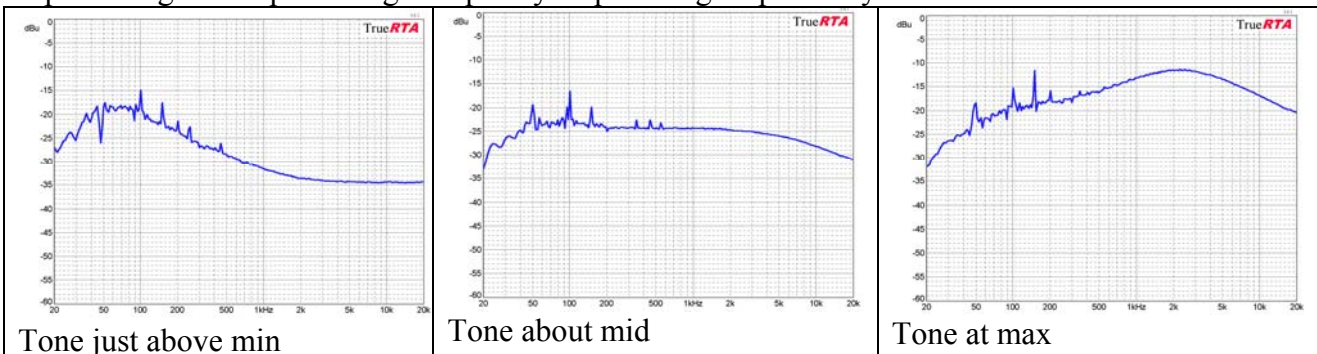
Winding	Voltage rms	Turns ratio;	Pri Impedance;	Spec level;	Notes
Pri P-P: GRN to BLU	10.73+10.69	-;	10,000 Ω;		
Pri P-P: OR to BRN	9.56+9.6	1.12;	8,000 Ω;		
Sec: BLK to WH	4.96	4.32;	500 Ω;	1000	
Sec: BLK to GRY	3.53	6.07;	250 Ω;	707	
Sec: BLK to YEL	2.52	8.5;	125 Ω;	500	
Sec: BLK to BRN	2.07	10.35;	100 Ω;	447	

Output transformer 10k primary DC resistance: 107+146=253Ω plate-to-plate.

Output transformer 8k primary DC resistance: 96+130=226Ω plate-to-plate.

The 125Ω to 250Ω tapping section presents a 21Ω load. A 16Ω speaker will present 7.6k for 10k PP.

Input voltage to output voltage frequency response - gain pot fairly low.

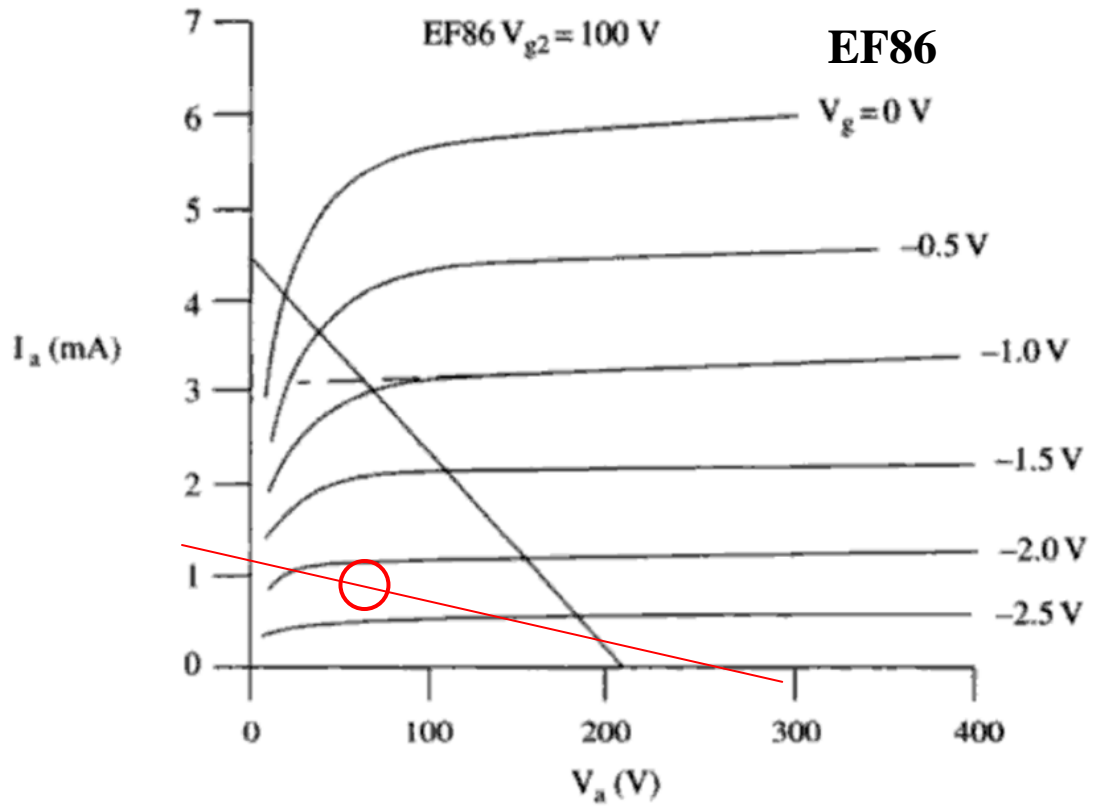


Note: mains harmonic content due to measurement setup.

## 4. Design Info

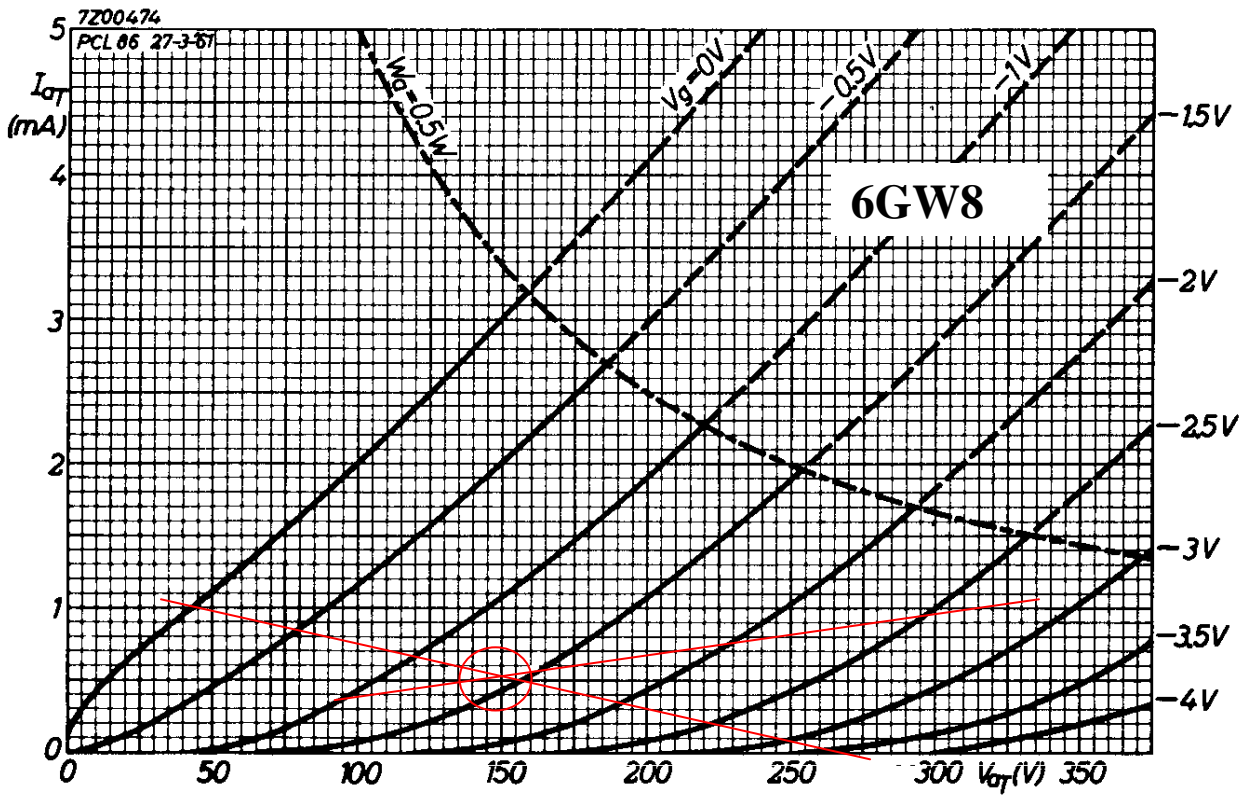
### 4.1 Input stage – EF86 Pentode

VS3=255V; Plate=75V; screen=89V; cathode=1.94V; 2k2=0.88mA.



### 4.2 Mixer stage – 6GW8 triode

VS2=260V. Cathode bias 2K8, 1.4V, 0.5mA. Anode DC load 220k.

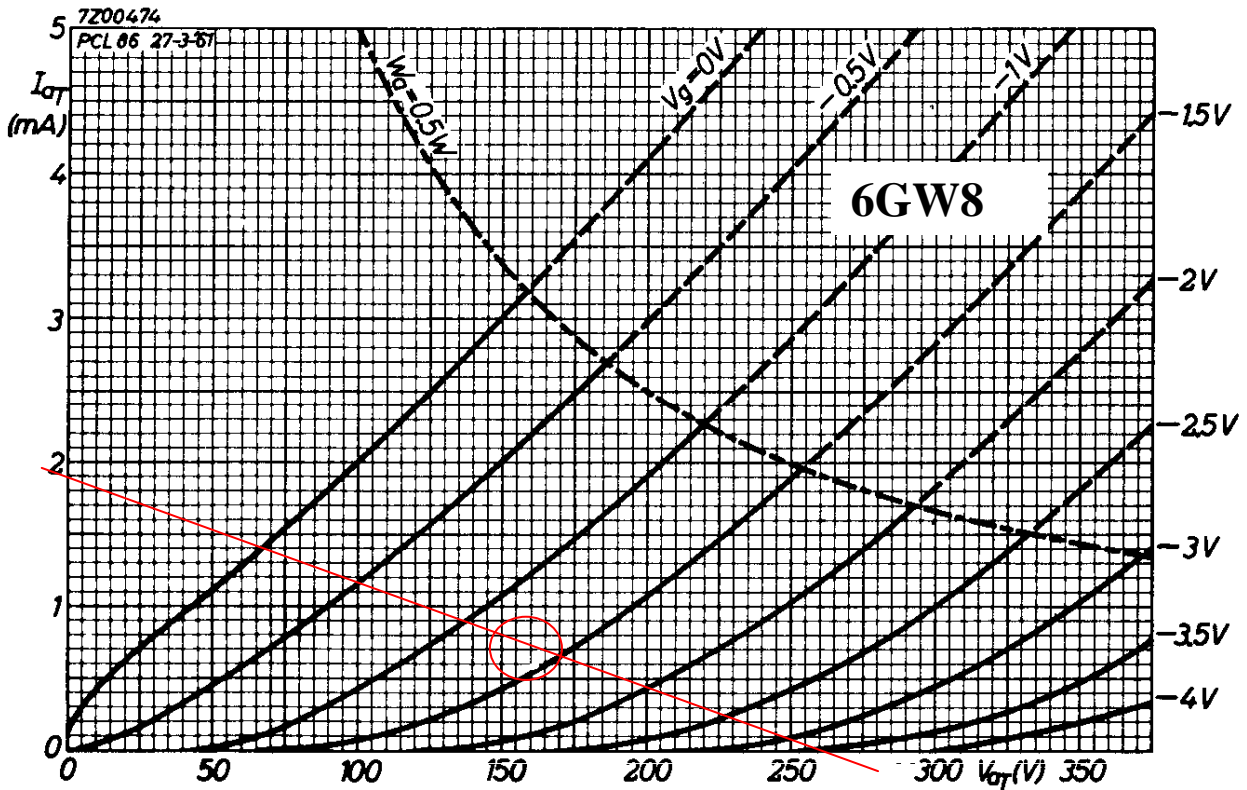


### 4.3 Splitter stage – 6GW8 triode in cathodyne config

VS2=260V. Plate resistors 68k. Load line resistance of 136k. Min plate-cathode voltage ~70V.  
Max swing  $\sim 190/4 = 47V$ .

Initially measured: plate=202V; cathode=57V; cathode current  $\sim 0.9mA$ .

Best not to add grid leak resistance. So changed to cathode bias of  $47V/68k = 0.7mA$ , with  $1.4V/0.7mA = 2k$ , with 1M5 grid leak – but needed 1k2 to get 45V.



### 4.4 Output Stage – 6GW8 Pentode Push-Pull

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. The 10K $\Omega$  impedance plate-to-plate OPT presents signal currents into each tube with a 5K $\Omega$  impedance with both tubes conducting, to 2.5K $\Omega$  load impedance at higher levels. Effective impedance is 20% lower with 16 ohm speaker.

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

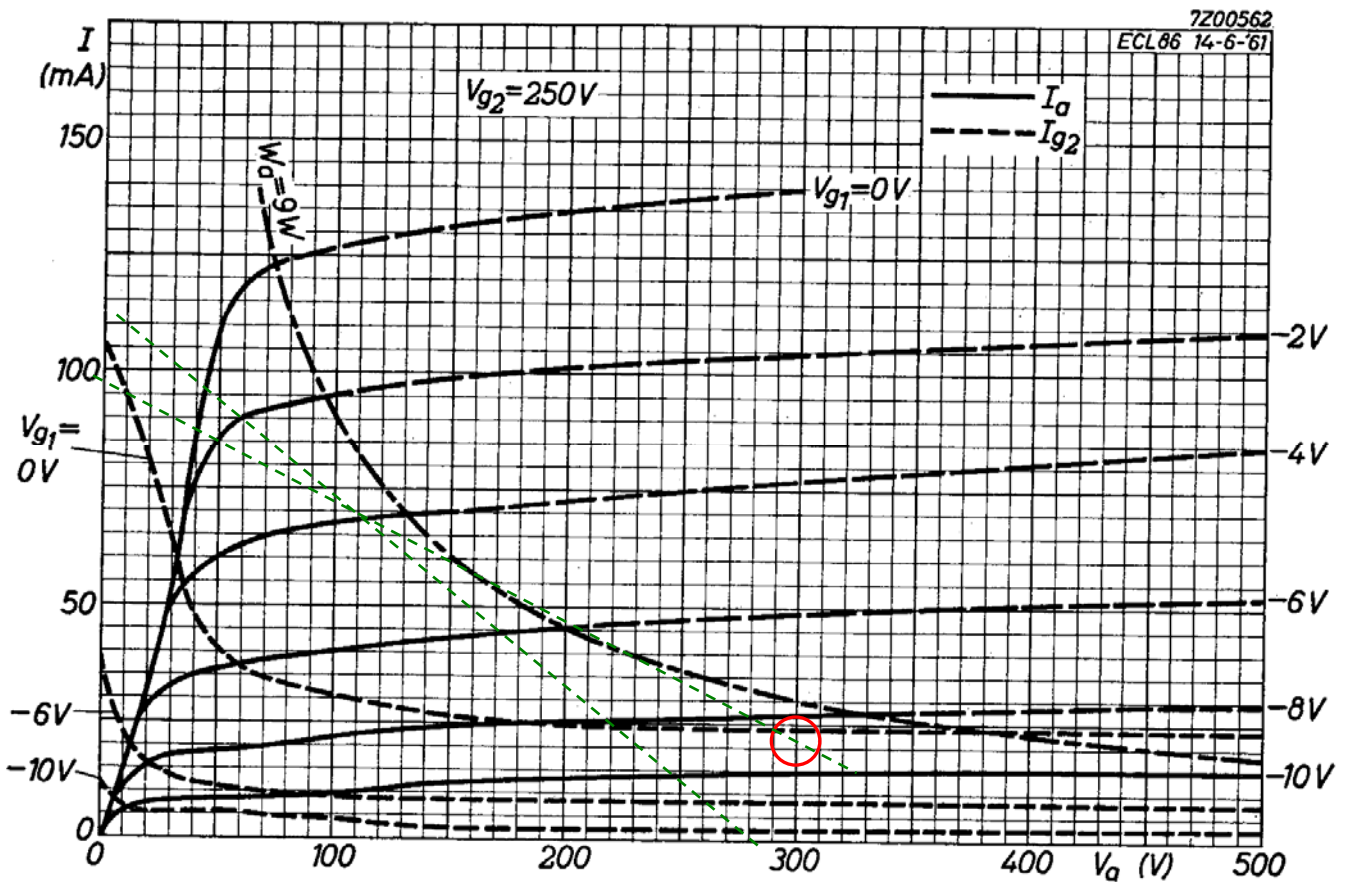
- Start with the lowest bias current possible (ie. most negative grid bias voltage), and based on listening tests, increase the bias current until the sound character is acceptable, but:
- use the lowest possible bias current level, as this generally increases the life of the tubes, and decreases the chance of operating at excessive plate dissipation; and
- keep the bias current level below 70% of the recommended design max plate dissipation (ie.  $<0.7 \times 9 = 6.3W$ ); and
- assess the dynamic loadline to see if it moves into region of increased plate dissipation.

As the output loading increases, the supply voltage VS2 to the output valve plates sags from about 400V towards 330V at about 130mA average [tbd]. Plate DC voltage will be lower than VS2 by an amount up to ~16Vpk; ie. OPT half resistance of about 120Ω with a peak current of up to about 0.13Apk. Cathode voltage has an idle bias of 19V and a peak of 61V under sustained signal, with an average of  $V = \sqrt{(3.2W \times 470\Omega)} = 39V$  where  $I^2R = (0.083)^2 \times 470\Omega = 3.2W$ . So effective plate-cathode voltage sags to about 330-39-8=283V.

Screen voltage will also vary from about 400V towards 310V under steady-state heavy load. Screen voltage will be lower than VS2 by up to about  $.02A \times 100\Omega = 2V$ .

The maximum output valve bias current allowed is dependant on the maximum recommended plate dissipation of 9W for the 6GW8/ECL86:  $I_{bias(max)} = P_d / V_b = 9W / 300V = 30mA$ . With a common cathode resistance of 150Ω, and gate-cathode voltage of 7V, the plate idle current is 32mA.

Assuming the loadline sags to about 300V plate level (from 400V) and a peak plate current of 130mA is achieved, then the nominal output power of the amplifier (ideal class B2) would be:  $(I_{pk})^2 \times R_{pp} / 8 = 0.1 \times 0.1 \times 8k / 8 = 10W$ . For this maximum signal condition, the rms OPT current draw is likely about 64mA (64% of peak), and the average VS1 power consumed is  $300 \times 0.064 = 20W$ , and cathode bias loss is <1W, so the tube plates dissipate  $20 - 7 = 13W$ , or about 7W each. 10R sense resistors added to each cathode.



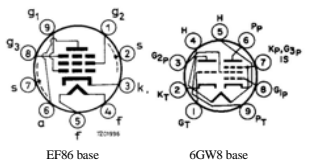
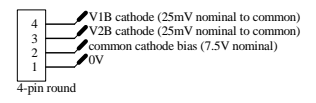
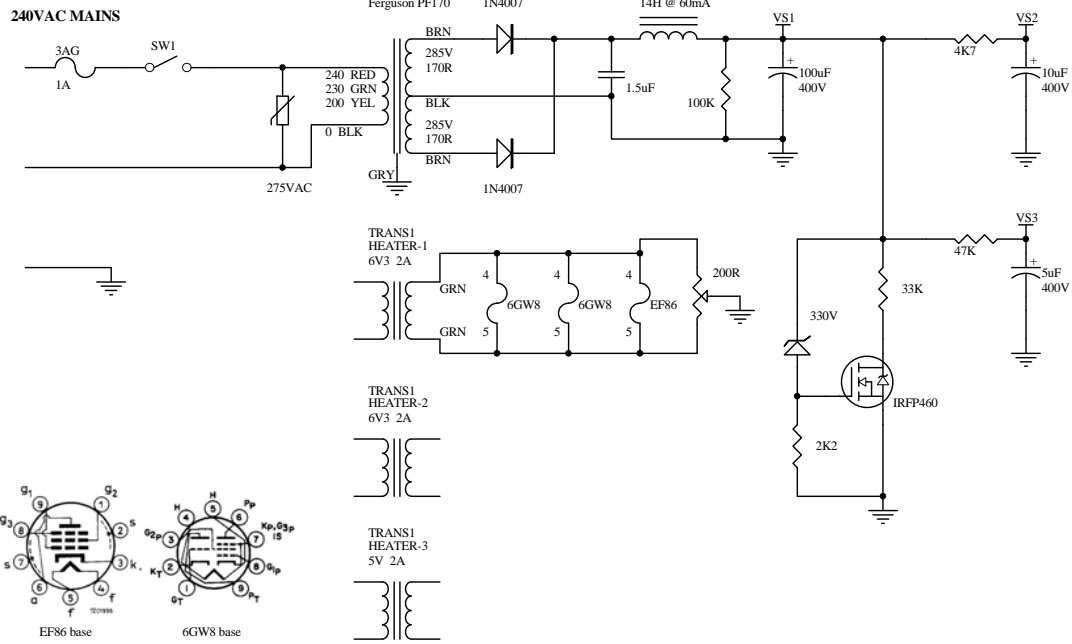
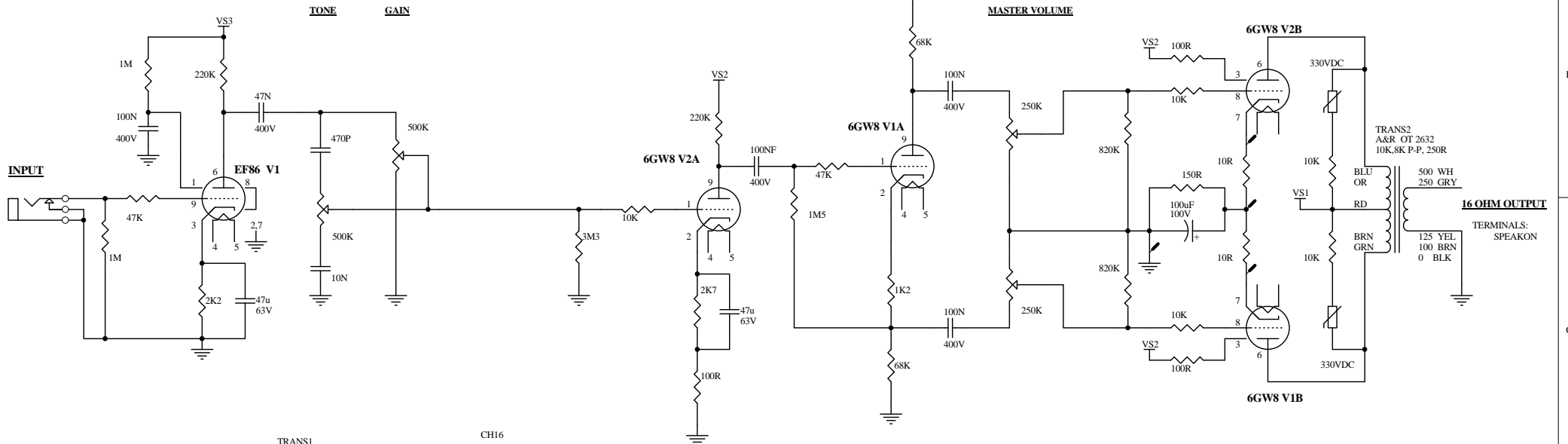
#### **4.5 Power Supplies**

A standard CT full-wave rectifier circuit with 1N4007 is used with 285V secondary HT windings with centre-tap to 0V. A CLC filter is used with 14H 60mA rated choke to generate VS1 and ripple on VS1 is ~100mVrms. The first C is a 1.5uF poly cap to raise the level of VS1 to the aim of 300V, which is the design max for 6GW8. VS2 and VS3 are obtained by independent RC filtering from VS1. VS2 set just above 250V, so that sagged level gets to 250V. Pre-load of 33K on VS1 to limit max level to ~360V while 6GW8 heaters warm up, but not load VS1 for normal operation.

Heaters:  $2 \times 0.66 + 0.2 = 1.6\text{A}$ . PI operates cathode at about 60V, with peak signal to about



# 6GW8 AMPLIFIER 4 MODIFIED



VOLTAGE RAILS		VALVE	QTY
RAIL	IDLE		
VS1	300V	EF86	1
VS2	265V	6GW8	2
VS3	255V		
HEATER-1,2	6.5V		
HEATER-3	5V		

Title		
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