1. Summary

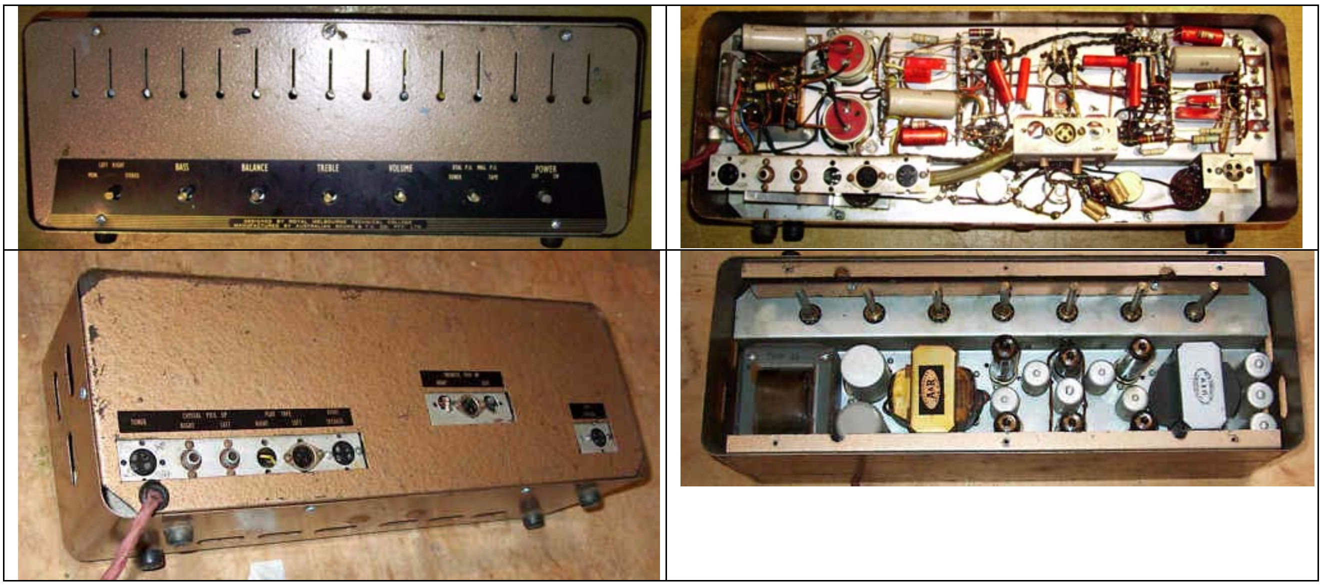
Manufactured by Australian Sound & T.V. Co. Pty. Ltd.
Designed by Royal Melbourne Technical College. $99 eBay Feb 2011

1.1 Original design

Stereo amplifier. 6BM8 PP UL output stage with a 9k PP output transformer, and a ½ cathodyne PI with direct coupled ½ 6BM8 triode preamp. 12A?7 input preamp with baxandal bass/treble tone controls and volume and balance controls, and 12A?7 gain recovery. Local grid-screen feedback on 6BM8 pentode, and grid-anode on 6BM8 triode, and global feedback to gain recovery12A?7 cathode (covering 4 stages and OT). Delon voltage doubler HT with RC filter for B+, and RC droppers for preamps. RC dropper and heater output for external tuner.

PT	Type 2049 1241	probably A&R. 240V; ES; 125V HT; 6.3V 3A;
OT	Type 4005	A&R, 9k PP, 20% UL, 3.7R, 7.5R, 15R, 7W, GOS, HiFi
Diode	Hitachi HR25	
Electrolytics	Ducon	
Capacitors	Astor 'Anocap' polyester	
Valves	Fitted with 2x 12AX7 and 4x 6BM8.	

Issues with original condition:
Old poor insulation wiring & no fusing. Poor PE connection. Multiple chassis 0V grounding scheme. Old electrolytic caps. Dry joint and broken valve pin. Strong roll off in response above 3kHz and to a lesser extent below 300Hz. Coupling between channels.



1.2 Circuit history

Royal Melbourne Technical College (now known as RMIT - Royal Melbourne Institute of Technology) indicates a date of between 1954 and 1960, as name changed to RMIT in 1960.

UL output stage similar to RTV&H April 1960 article on p.80 titled 'Unit Stereo Amplifier No.2'. The A&R adverts identify the 4005 transformer as suitable for the "Mullard 5 Stereo 7" amplifier (5 valves, 7W), and approved by Mullard Australia for use in their 7W amp. Mullard circuit reference is http://www.r-type.org/static/4-10.htm that uses the ECL86 and was based on UK tech reports. Maybe the local Mullard issued a 7W amp design variation. A&R 400X range of hi-fi OT's appear to have just come out prior to Jan 1960 advert in RTV&H. One of the OT's appears to be from initial manufacture batch. Estimate circa 1959-1960.

OP412 from Ferguson was recommended for Playmaster Stereo Amp No.2 (Aug 1960 RTV&H).; 6mm amplifier (May 1961 RTV&H); Playmaster Stereo Amp No.4 (May 1962 RTV&H).

1.3 Modifications

- New electrolytics, but old cans left in place.
- NTC surge resistor, mains fuse, secondary winding bypass noise cap, and new diodes added.
- Proper mains earth connection. Distributed star 0V distribution.
- DC elevated heater with tuned humdinger pot.
- 12AX7 and tone stage moved to general input stage, with feedback taken just to 6BM8 triode, and cap feedback from grid to anode removed, and 12AX7 anode coupling cap increased to 10nF. 5k6 grid stoppers added to PP.
- Balance and Volume pot positions swapped due to high-impedance grid pick-up from balance pot in mid-position.
- 32V zener across 6BM8 PP output common-cathode RC. R increased to 750R to maintain idle dissipation. 150R screen stoppers added.
- MOV-R protection added to primary.
- Fuse (400mA) in DC VS1-VS2 connection.
- Separate RCA inputs.

To do:

- RIAA phono stage using input valves.
- Zobel on output?
- Separate DC HT supplies per channel.

2. Measurements

Modified amplifier. Idle.

Rail	Idle (L/R) 330R	Idle (L/R) 500R	Idle (L/R) 750R
VS1	315V [370Vpk]	323V [370Vpk]	333V [370Vpk]
VS2	287V	301V	319V
VS3	231/233	244/247	260/262
VS4	251	264	280
VS6	38V	39V	41V
Heater 1	6.4	6.4	6.4
Sec HT	126	126	126
Ripple VS1	1.25V	1.25V	1.25V
Ripple VS2	0.12	0.1	
Ripple VS3	0.01/0.03	0.02/0.01	
Ripple VS6		0.03	
6BM8 pentode cathode	23.9/24.6	27.5/27	30.9/30.0 (5.9W, 5.8W)
6BM8 triode anode	141/142	164/175	171/183
6BM8 triode cathode	93/90	77/70	84/76
6BM8 triode anode	92/89	76/69	82/74
6BM8 triode cathode	1.56/1.35	1.01/1.08	1.04/1.11
12AX7 anode	147/152	158/155	168/163
12AX7 cathode	1.52/1.45	1.51/1.58	1.59/1.66

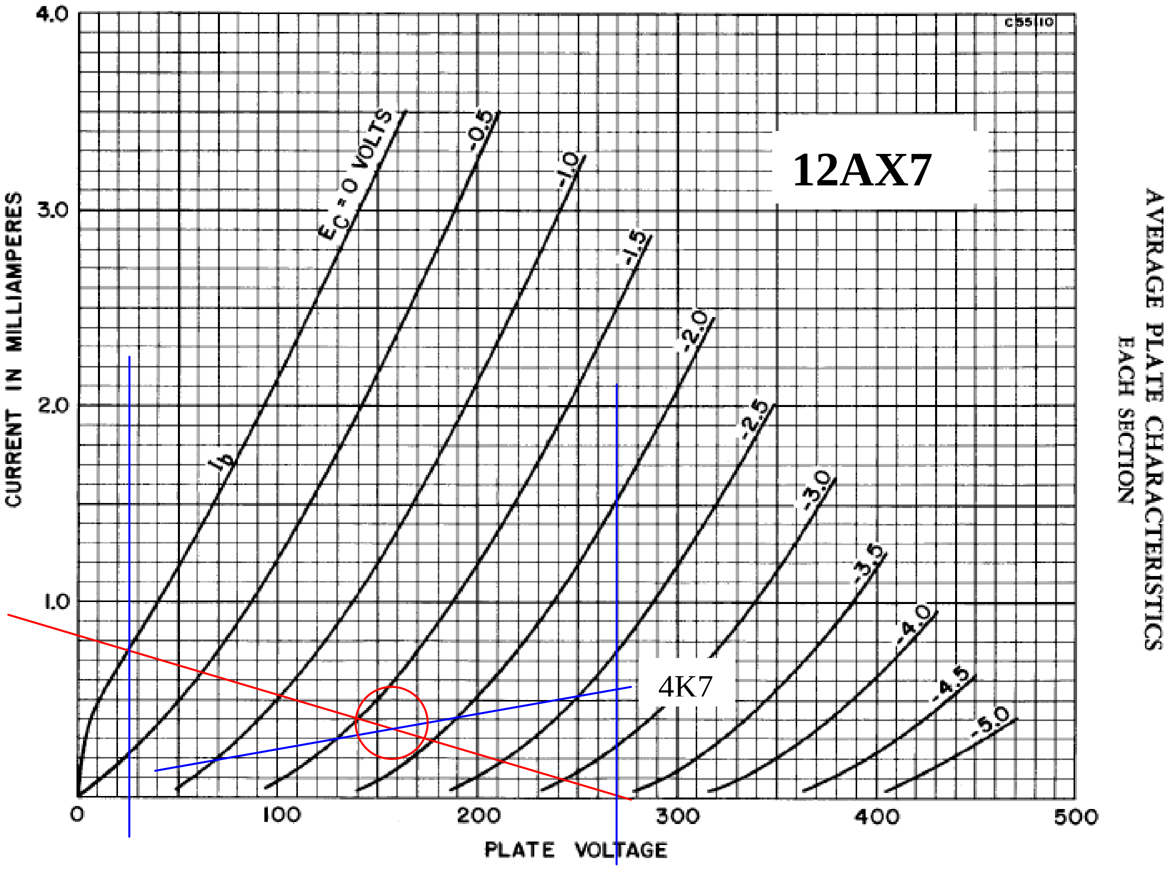
Output transformer primary DC resistance: 250Ω plate-to-plate.
Power transformer primary DC resistance: 26Ω.
Power transformer secondary DC resistance: 19Ω.

150mVrms sine input; 8.2V 12AX7 output (input to tone circuit); 290mV input to 6BM8 triode; 9.3V output to 15R load (5.8Wrms) - just starting noticeable clipping on one side. Supply rail droop ~4-5V on VS1, VS2. PP stage cathode bias increased from 27V to 33V.

3. Design Info

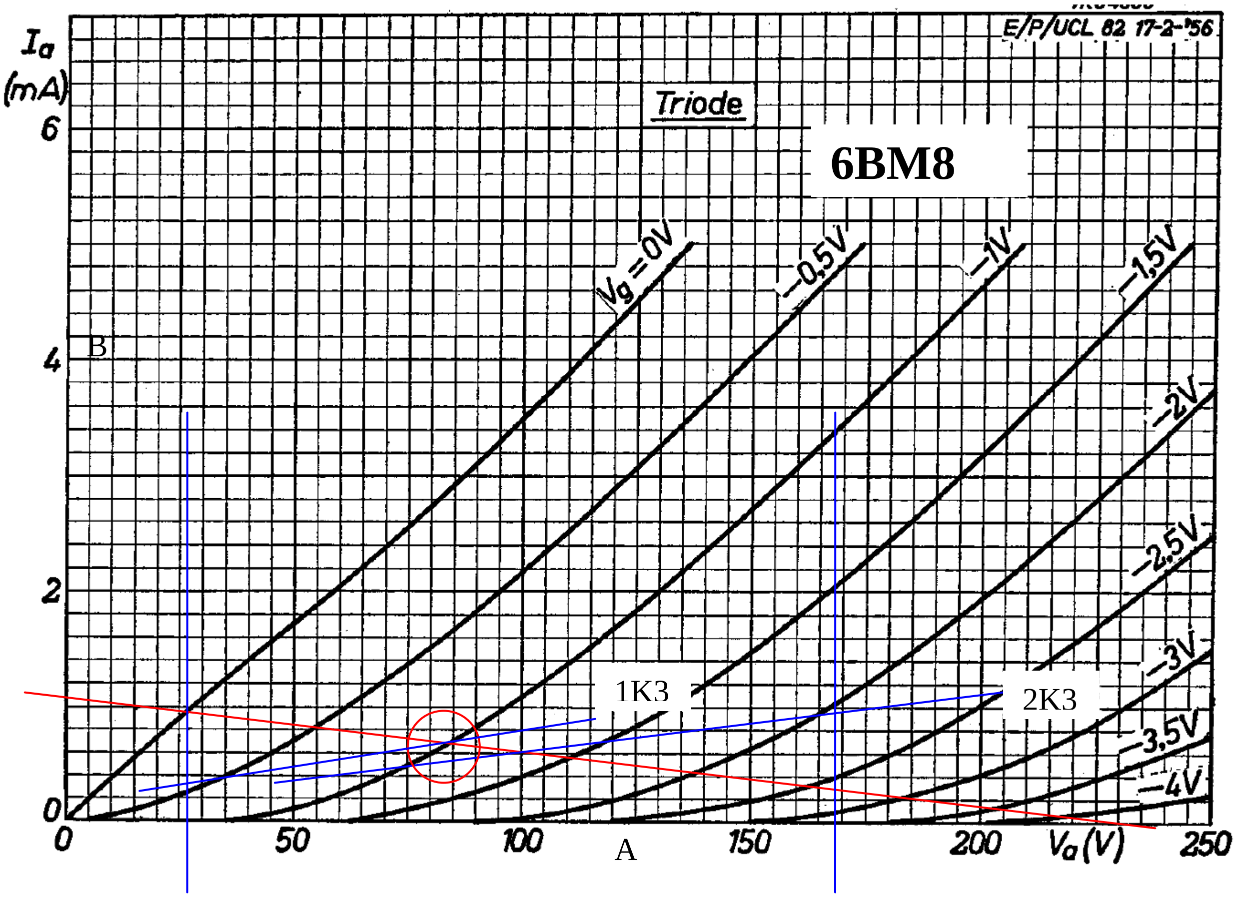
3.1 Input stage – 12AX7 - modified

12AX7, V3: VS4 = 270V; Va=160V; Rk=4k7; Vk=1.6V; Ia=0.34mA; RLdc=330k. Feeds tone network, then volume, then balance. Gain ~10.1V/0.19V = 53. 1nF coupling to tone circuit causes significant bass roll-off below 300Hz – replaced by 10nF to extend out to 30-50Hz.



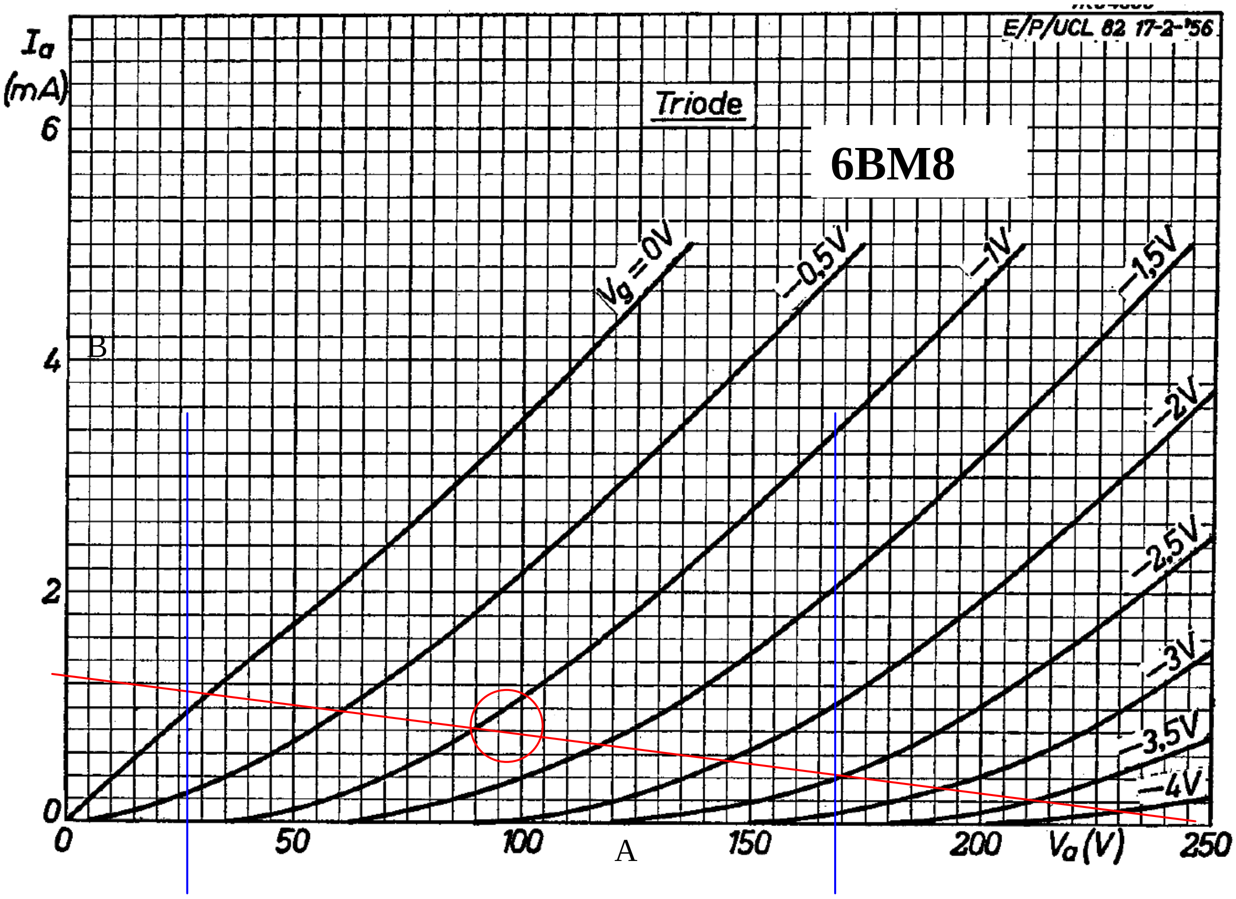
3.2 Tone make-up stage – 6BM8 triode

6BM8 triode, V1, V2: VS3 = 250V; Va=98V; Rk=1k3; Vk=1.3V; Ia=0.3mA; RLdc=220k. DC coupled feed to cathodyne PI stage. Gain ~ 15.6/.29=~53 to PI cathode. Global feedback from 16 ohm speaker to cathode tap on 6BM8 triode, with 470k/10N RC shelf at 34Hz. Local feedback from grid to anode – 22pF – causes strong roll-off above 3kHz.



3.3 Splitter stage – 6BM8 triode

DC coupled grid ~76V, so cathode ~77V. Anode-cathode voltage ~90 to 105V. Cathodyne phase splitter, achieves ~ unity gain.



3.4 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 to +27V using a common cathode resistor. The 9KΩ impedance plate-to-plate OPT presents each pair of tubes with a 2.25KΩ load impedance (with a matched secondary load) for signal currents in Class B region, and 4.5K in Class A region.

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

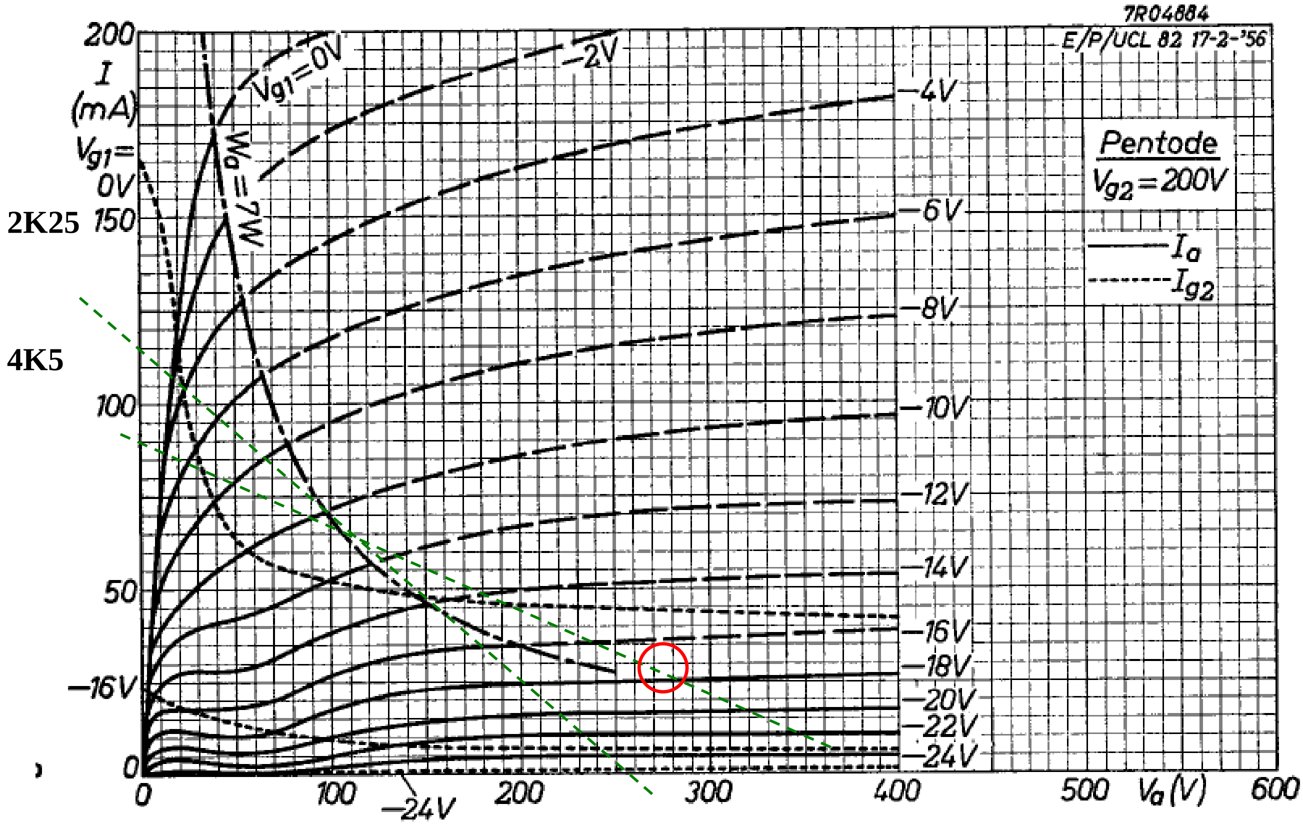
- Start with the lowest bias current possible (ie. most negative grid bias voltage), and based on listening tests, increase the bias current until the sound character is acceptable, but:
- use the lowest possible bias current level, as this generally increases the life of the tubes, and decreases the chance of operating at excessive plate dissipation; and
- keep the bias current level below 70% of the recommended 7W design max plate dissipation (ie. <5W); and
- assess the dynamic loadline to see if it moves into region of increased plate dissipation.

As the output loading increases, the supply current increases from 23V/193R = 120mA at idle to about xxmA. Voltage VS2 sags from about 309V to about xxxV [check] due to extra drop across the 193R dropper, and regulation. Plate DC voltage at idle is lower than VS2 by ~31V (ie. ~277V); ie. OPT half resistance of about 125Ω at 0.028A, and 27V cathode bias. Plate DC voltage at max average output is lower than VS2 by ~44V (ie. ~235V) ie. OPT half resistance of about 125Ω at 0.1A, and 32V cathode bias.

The maximum output valve bias current allowed is dependent on the maximum recommended plate dissipation of 5 to 7W, + 3.2W for the screen, for the 6BM8: Ibias(max) = Pd / Vb = 7W / (309-28V - .028*125) = 25mA. Cathode bias was 28mA nominal with 500R resistance and 28V bias (1.6W). Peak bias is up to 0.1x500=50V (5W). Average max bias is about 0.064x500 = 32V (2W).

Assessing the 6BM8 plate curves, which shows the 7W constant power contour, indicates how the amp will dynamically exceed plate max design dissipation levels. Note that these curves are for a 200V screen level, not UL, and the load lines are for 4.5K (9K P-P transformer push-pull) moving to 2.25K.

For a peak plate current of 100mA, then the nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.10 x 0.1 x 9k / 8 = 11W. For this maximum signal condition, the rms OPT current draw is likely about 64mA (64% of peak), and the average VS1 power consumed is about 235x 0.064Arms =15W, or about 7.5W each, which is a pretty high level.



3.5 Power Supplies

Delon doubler rectifier circuit uses a 125V secondary HT winding to give nominal 350V no load (initial turn on with cold heaters). Only one 6.3VAC secondary is available for heaters. Heater loading is 3x0.3A + 2x 0.78A = 2.4A. No external heaters should be added, as this is likely max loading

Ripple voltage across VS1 is 1.1Vrms (mainly 100Hz), and attenuated to 0.1Vrms through 200R/100uF filter. Voltage drop across 193R is 23V at idle (120mA, 2.7W).

0V grounds fed separately for each channel from input socket through stages. 12AX7 and 6BM8 input triode fed from VS4 to achieve some cancellation of signal ripple.

4. Protection

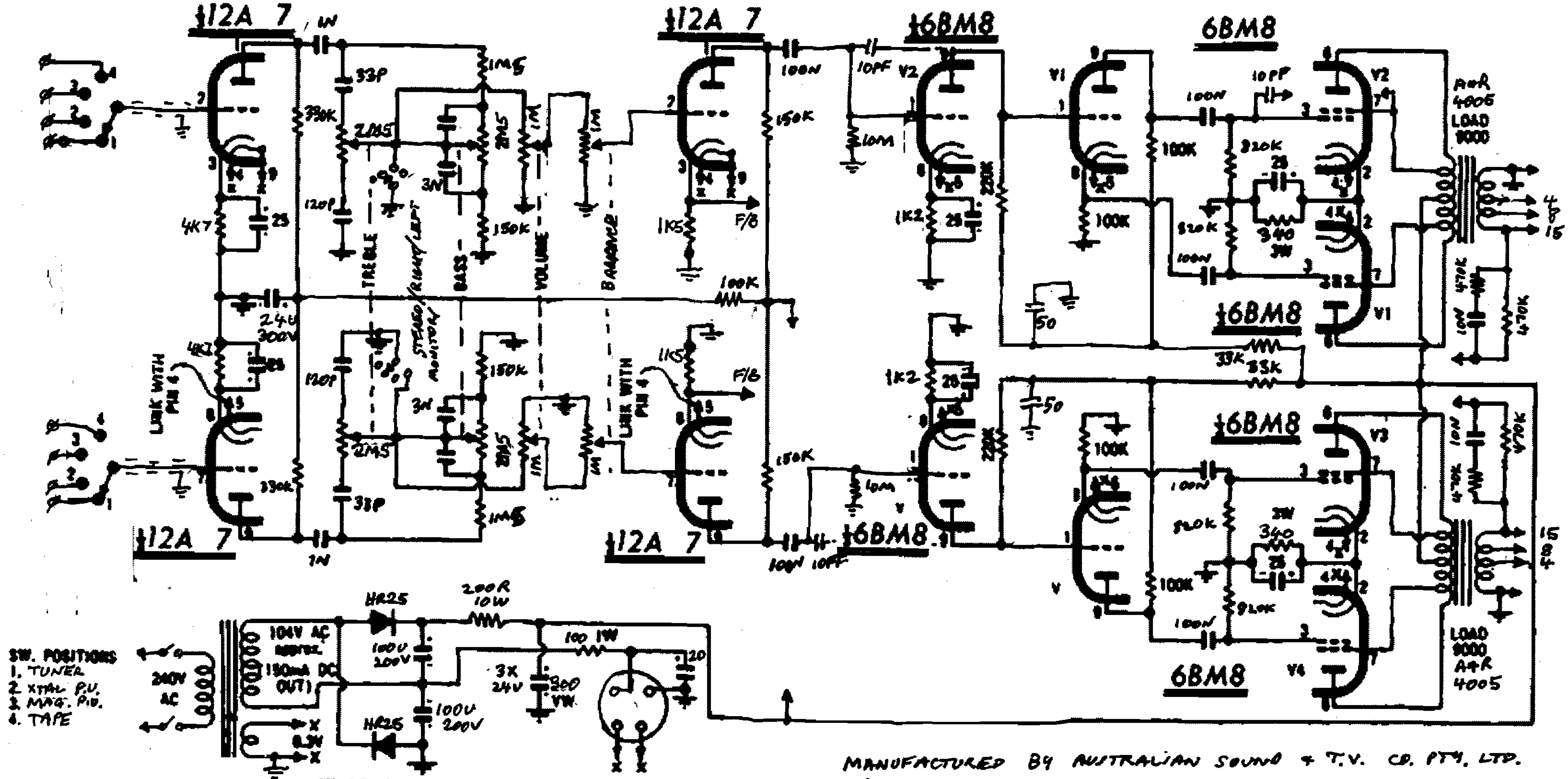
4.1 HV breakdown

Added 400mA B+ rail fuse after main caps (minimal surge current through fuse). Peak current draw from output stages ~200mA total.

MOV (431KD10) on primary of PT to soak up turn-off spike from primary leakage inductance.

4.2 Output open circuit

MOV-R series network across each primary using 330VDC 2502 GEAQ MOV (~90pF) and 4k7, with a nominal corner frequency of 370kHz. MOV has min 1mA level of 353V.



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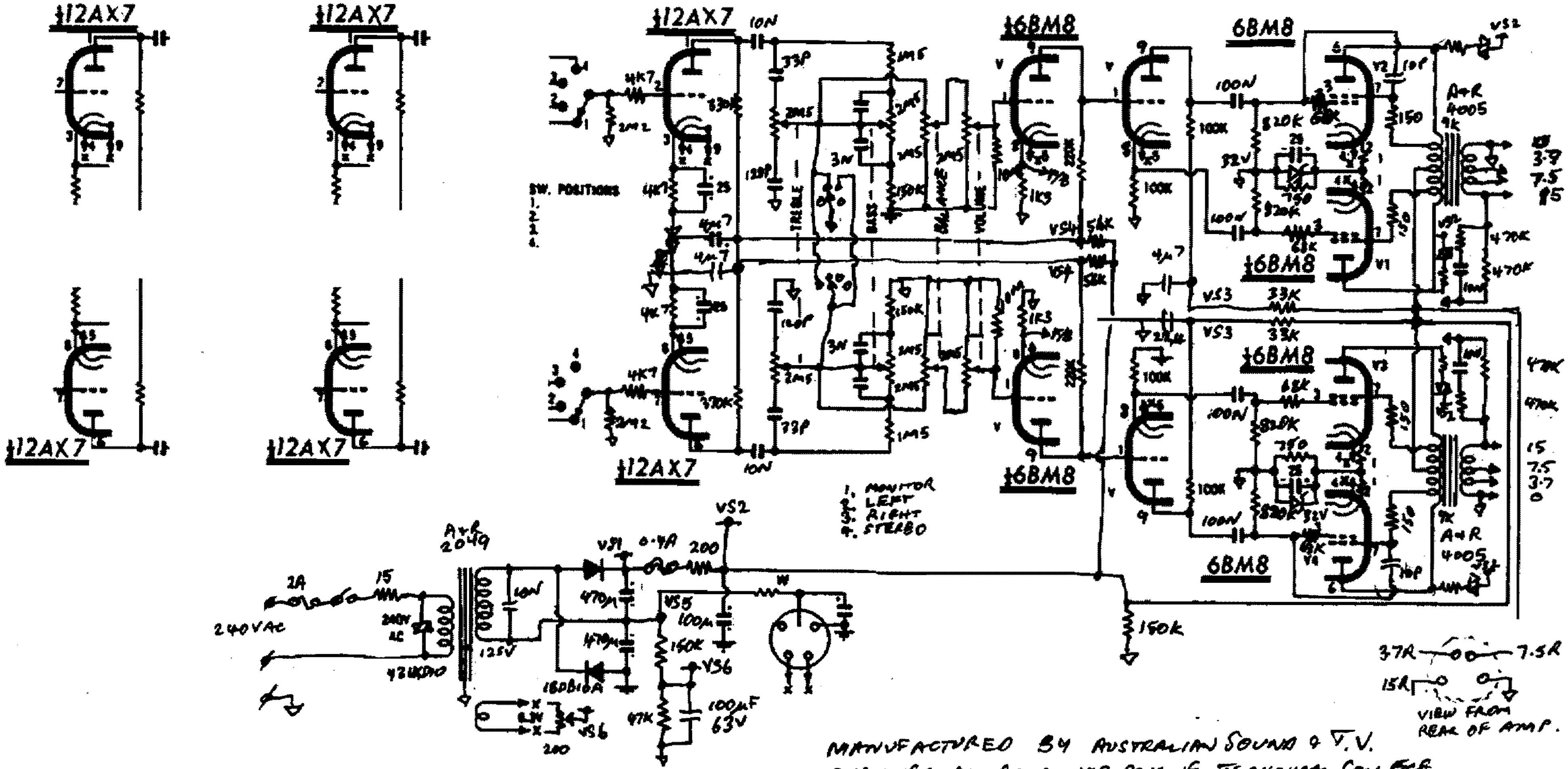
DESIGNED BY ROYAL MELBOURNE TECHNICAL COLLEGE.

STEREO AMPLIFIER



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