# 1. Summary

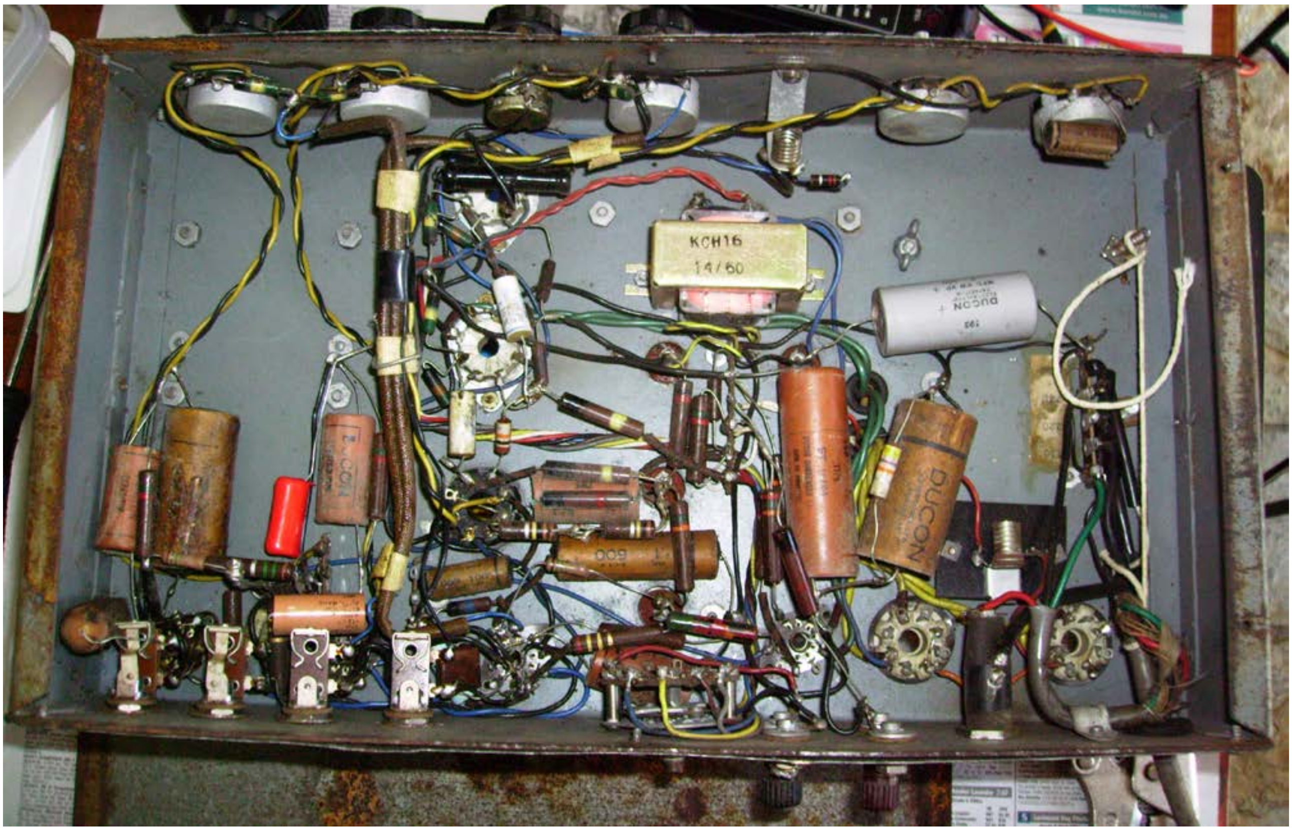
Philips Australia 70W Amplifier Type 961, S.N. 3486.  $25 eBay March 2009

## *1.1 Original Amplifier*

Two microphone and one P.U. input channel 70W PA amplifier.  9-pin pentode for each microphone channel, and for summing amplifier.  6SN7 gain stage with feedback mixer, and split-load cathodyne splitter and fixed bias push-pull pentode output, with secondary side feedback.  800V plate supply from voltage doubler 5U4GB (2x) diode rectifier and capacitor input filter.  Half plate supply is fed via inductor to the screen supply, with cascading resistor/cap dropping to the driver and input stage supplies.  Plate voltage droops to 640V with 85W output loading, and 8W driver loading.  Output stage grid bias from separate half-wave diode supply.  Bass & Treble tone pots between summing and splitter stages.  5x 8-pin Octal and 4x 9-pin Novel bases total.

| | |
|---|---|
| Output Transformer | A&R marked 880 and 2472.  140/70/50/35 ohm outputs. |
| Power Transformer | A&R marked 2402 and 1323 |
| Choke | Plessey  KCH16 and 14/60 and 10820 [possibly added later] |
| POTs | IRC marked BD2 and RC2. |
| CAPs | DUCONOL A 20mF 600V – caution may contain PCBs |
| | Ducon 24uF 600V |
| | Ducon 16uF 600V (x4) |

Advertised in October 1953, RTV&H as 70W amp.



### *1.2 Target Amplifier*

Modify to typical guitar input stage with half 12AX7 followed by Fender tone stack and gain pot into other half 12AX7. Modify 6SN7 to Schmidt long tail pair. Retain output stage. Add extra input going through dual triode for high-gain distortion – can use 12A?7. Add SEND & RETURN sockets.

## 2. Modifications

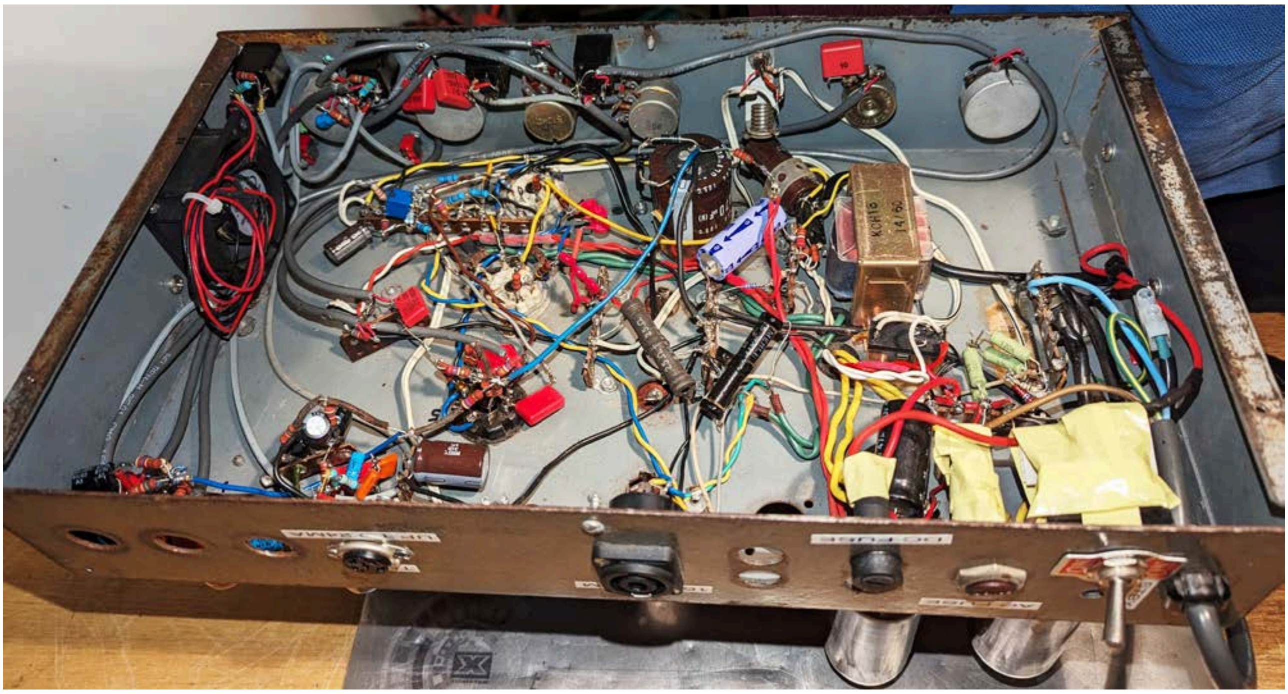
- Guitar level input stage triode to Fender style treble/mid/bass tonestack with pots, feeding gain pot. Make-up triode to Master volume pot feeding splitter stage. Presence pot to adjust feedback into tail of splitter stage.
- XTRA high gain input stage of two triodes to gain pot feeding normal guitar input stage if no plug.
- Replaced all resistors and capacitors.
- Replaced the power cable. 1.5A T 3AG mains fuse (may need to increase). 240Vac PT tap used to give ok heater voltage.
- Added 60mm computer fan into the chassis base – add vent cutout – add vent holes around output valves. Add rubber feet to allow air flow underneath. Not connected as yet.
- Added 5-pin McMurdo socket for monitoring.
    - 10Ω cathode-to-0V resistors with R-Z voltage clamping at ~3.9V to avoid damage to external metering.
    - VS1/100 and VS3/100 dividers. VS1/100 includes yellow LED, so monitored voltage reads high up to pro-rata LED voltage (~2V x 127/6.8 = 40V), then should be ok from circa 400-800V (4-8V), and accuracy trimmed for 600V.
- Split the grid bias VS5 to allow output tube bias currents to be matched.
- All wiring with zoned star ground configuration. Twisted pair and separate heater cabling. Shielded cable between sections.
- HT supplies with double the capacitance – but still substantial sag on heavy transient loading.

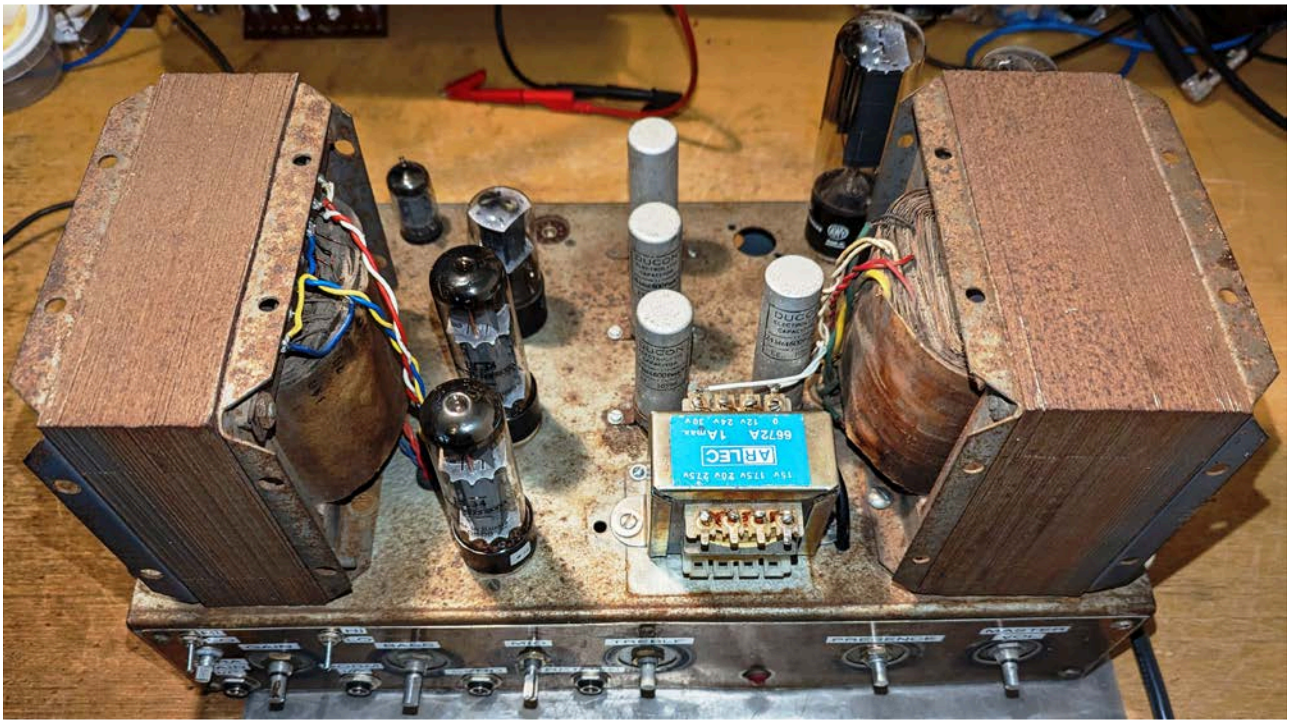
- Output Tranny configured for 35 ohm output using all turns on secondary windings (4 windings in parallel). This allows loading with 16 speaker if needed – and moves compression into knee region. Speakon output socket and grounded speaker output.
- Added Standby switch to secondary winding, with 270k parallel bleed.
- Added HT secondary winding fuse 630mA IEC T 5x20mm.
- MOV 3x330Vdc 1mA across each half-primary winding for open-circuit output protection.
- Added grid bias failure protection circuit (48V relay that pulls out if bias is lost, and isolates the HT winding).
- Hi-gain input and 12A?7 circuit with cold then warm biasing with 9mm trimpot for stage gain (top fit on front panel).
- Lo/Hi input switch to each socket to load 1M input with additional 68k.
- Indicators for Mains On (Red) and Output On (Yellow). Mains On LED operates from heater supply, and Output LED from VS1 rail.
- Series 1N4007 to paralleled 5U4 anodes for PIV protection.
- 1N4007 across each doubler cap for reverse voltage protection during discharge.
- One Noval socket wired with heater but spare/unpopulated.
- Bucking transformer Arlec 6672A added to lower B+ rails.

To do:

- Dual gain pot – two shafts – one for pre-gain, and one for overdrive gain. Or use a dual-gang 500k-1M log, with the first gang pot used to feed both normal and overdrive, and second pot used for output of overdrive, and a switch to connect overdrive (front panel or foot). Use both stages of another 12AX7 or 12AU7 or 12AT7.
- Add elevation rail for heaters at about +40V, given 6SN7 cathodes are circa 58V.
- Connect feedback winding and check.
- Feedback level and stability with presence, and adding comp C to feedback. Check if grounding tap of main speaker winding has an influence.

Status:
Removed 2x EL34. No knobs. F/B not connected. Top chassis terminals and Arlec terminals exposed and at HV.




ARLEC
6672A 1A max.
BASS
TREBLE
PRESENCE

# 3. Measurements

340M @ 1kVdc mains.

One diode with low IR – replaced.

Supply filter caps limited to 400V.  Coupling caps higher.

240Vac mains tap gives 6.3V heater, however VS1 exceeds 800V.

Voltage rail regulation.  240VAC tap

| Rail | Minimal load* | Max Load 120R series | Max Load. 0R series |
|---|---|---|---|
| VS1 | 800V (2.4x) | 560V , 116mA , 65W | 637V, 133mA, 85W |
| VS2 | 430V | 263 | |
| VS3 | 428V | 252 , 24mA , 6W | 289V, 27mA, 8W |
| VS4 | | | |
| VS5 | | | |
| VS6 | | | |
| Heater 1 | 5.4 | | |
| Heater 2 | 5.4 | | |
| Heater 3 | 6.6 | | |
| Heater 4 | 6.6 | | |
| Sec HT | 335 | 328V , 300mA , 98W | |
| Drop on 120R | 335 | 37V , 300mA , 11W | - |
| Ripple C1 | | 49 Vrms | 57.5 Vrms |
| Ripple C2 | | 57 Vrms | 66.6 Vrms |
| Ripple C3 | | 2.2 Vrms | 2.5 Vrms |
| Ripple C1+C2 | | 38 Vrms | 46.8 Vrms |

12uF poly for each cap C1, C2, C3.  Choke between C2 and C3.  VS1 across C1+C2.
Minimal load *: 5U4GB x2; 2x 6CA7 heaters; 200k on VS1; 62K on VS3; 120R in series with sec.
Max load: 5U4GB x2; 2x 6CA7 heaters; 4K8 on VS1; 10K5 on VS3; 120R in series with sec for one test.
Power transformer primary DC resistance: 3mΩ.
Power transformer secondary DC resistance: 15Ω.

12VAC 50Hz nominal applied to output transformer

| Winding | Voltage rms | Turns ratio; Pri Impedance; Spec level; Relative Turns |
|---|---|---|
| Pri P-P: BLU to BRN | 229 | ; Ω; N/A |
| Sec: BLK to GRY | 25.2 | 9.1; 11,600 Ω; 140 Ω; 145; 100 |
| Sec: BLK to BRN | 17.7 | 12.9; 11,650Ω; 70Ω; 72; 70 |
| Sec: BLK to YEL | 15.2 | 15.1; 11,400 Ω; 50Ω; 52; 60 |
| Sec: BLK to BLU | 12.4 | 18.5; 12,000 Ω; 35Ω; 35; 50 |
| Sec: RED to WH | 8.6 | 26.6; 17 Ω; N/A Ω; feedback winding |

Output transformer primary DC resistance: 61+61 Ω plate-to-plate.
Output transformer secondary DC resistance:
3 Ω BLK-GRY
1.7 // 1.9 Ω BLK-BLU
1.2 // 1.3 Ω BLU-GRY
1.1 Ω RED-WH

Secondary 35R tap was split and interleaved windings reconnected to 0R and 140R terminals to give all (4) interleaved windings acting as 35R (ie. no phantom windings left over). Given power rating of amp, this would be a suitable output for 2x 16 ohm speakers in series, or even for 16R speaker with 5k5 PP primary. Alternative is to use between 35 and 70 ohm taps (9.6R) for a nominal 8R speaker, or between 70 and 100 ohm taps (12.4R) for a 15R speaker

Choke inductance: tbd

Voltage rail regulation. 240VAC tap. Dummy EL34s. 5U4Gs, 2x 12AX7, 6SN7

| Variac<br>Mains | 175Vac<br>0.30A | 200Vac<br>0.40A | 225Vac<br>0.52A |
|---|---|---|---|
| VS1 | 500V, 4.4Vac | 600V, 5.4Vac | 700V, 6.4Vac |
| VS3 | 228V | 282V | 335V |
| VS4 | 221V | 273V | 323V |
| VS5 | 210V | 256V | 303V |
| EL34 cathodes | 22.8+22.8mA | 27.4+27.4mA | 31.8+31.8mA |

Likely VS1 at 240V mains about 750V, depending on EL34 idle bias loading.
Likely VS3 about 360V, which appears fine.
Likely VS4 about 346V, which is adequately below 370V Zener.

With 30Vac bucking winding (Arlec 6672A) on HT, VS1 was reduced to 670V at 240Vac mains.

Voltage rail regulation. 240VAC tap. Dummy EL34s. 5U4Gs, 2x 12AX7, 6SN7

| Variac<br>Mains | 200Vac<br>0.37A | 225Vac<br>0.47A | 240Vac<br>0.54A |
|---|---|---|---|
| VS1 | 532V, 4.8Vac | 614V, 5.7Vac | 669V, 6.2Vac |
| VS3 | 2851V | 295V | 321V |
| VS4 | 242V | 284V | 309V |
| EL34 cathodes | 24.5+24.5mA | 28.2+28.1mA | 30.4+30.3mA |

Fitted EL34 #11, #12 (previously ok and close).

Frequency response sweeps made:

- Bass max gave +9dB at 60-90Hz, relative to min
- Treble max gave +14dB at 3-5kHz, relative to min.
- Mid max dropped level significantly.
- Presence max gave about +1dB at 3kHz.
- -10dB bandwidth about 45Hz to 13kHz with min settings.

Cranked output about 55Wrms at 230Vac variac and 27+27mA idle bias at 660V.

Input sensitivity for 18.4V, 10W 34R:

- XTRA Gain input 66mVrms with tone pots at min, and HiGain, Gain, Master Vol at max.
- Norm input 28mVrms with tone pots at min, and Gain and Master Vol at max.

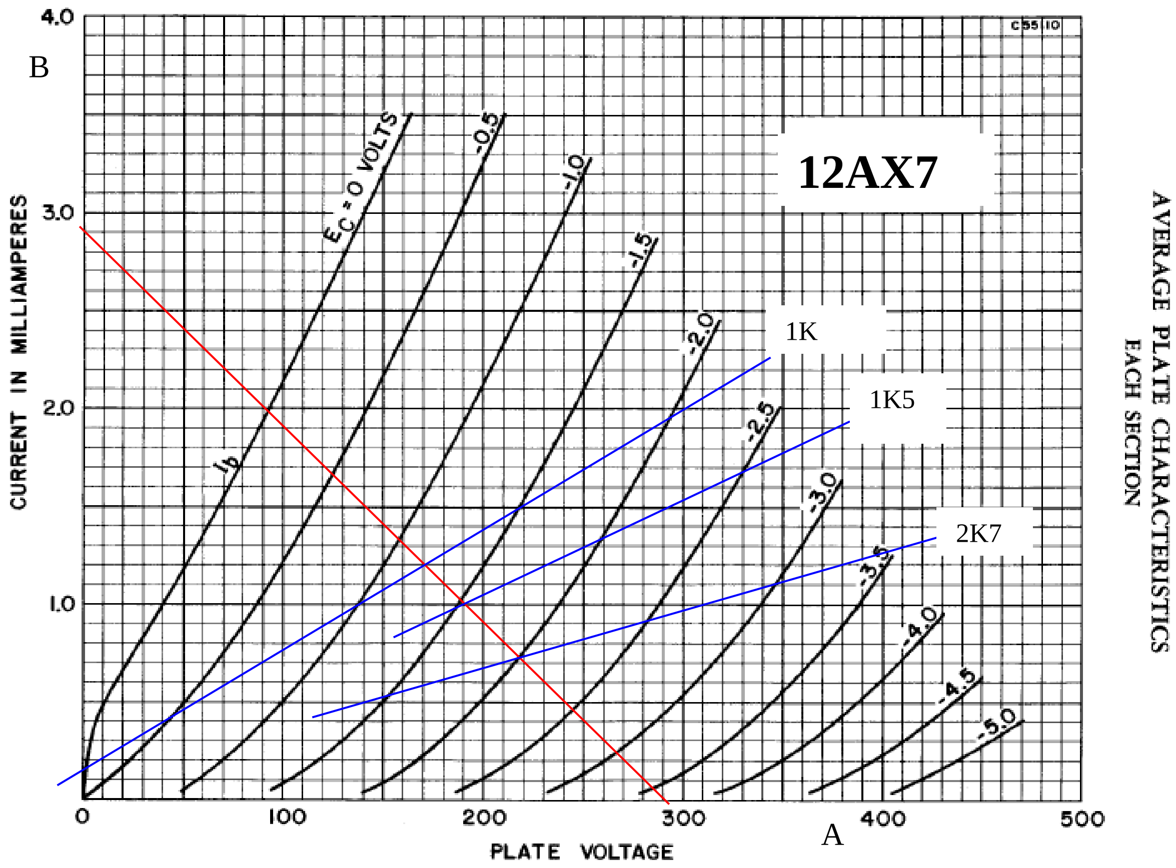
# 4. Design Info

### *4.1 Input stage option 1 – 12AX7*

Four 9-pin bases are available for input stage.

Supply voltage is 290V; load resistance is 100k; and cathode resistor is 1K5. The plate voltage Vp axis intercept is 290V for no plate current, and the plate current Ip axis intercept is 290V / 101KΩ = 2.9mA (point B). The gate-cathode voltage (Ec on the graph) operating point is at Vgc=1.5Kx1mA = 1.5V, and varies with plate current through the 1k5Ω gate-cathode resistance with the characteristic shown on the graph as a line passing through Ip=1mA for Vgk=-1.5V, and through Ip=1.5mA for Vgk=-2.25V. The intersection of the two lines is the nominal biased operating point.

The input voltage swing limit is from the bias point at Vgk=-1.5V to Vgk=0V, which is about 3Vpp or 1.1Vrms. Referring to the loadline, the plate voltage would swing about 240V, from about 120V to 360V, with a mid point of 175V [265-190=75V; 190-90=100V] which is fairly symmetric. This gives a nominal gain of 175/3 = 58. Signal overload will hit compression before cut-off. Could increase cathode to 1K8.



### *4.2 Splitter stage option 1 – 6SN7 in long-tail config*

One 8-pin Octal base is available for the splitter stage, which splits into two signals, 180deg out of phase from one another, and presents a voltage amplified drive to the push-pull output stage. The Schmidt long-tail splitter configuration was in common use by Fender/Marshall, but using 12AX7 or 12AT7. Here the aim is to use the 6SN7 twin triode in the 8-pin Octal base, as the 6SN7 was in widespread use, and came with the PA amp.

| Valve | 12AX7 – ECC83 - 7025 | 12AT7 – ECC81 | 6SN7 |
|---|---|---|---|
| Gain | 100 | 70 | 20 |
| Current | Up to 1.2mA | 10mA | 9mA |
| mu | 1600 | 5000 | 2600 |
| Design | | | 350V; 5mA |
| Rk | 470R | 470R | 1K5 |
| Rtail | 6K8 + 4K7 presence & F/b | 22K-33K | 6K8 + 4K7 presence & F/b |
| Rgate | 1M | 330K | |
| Rload | 82/100K | 47K | 56K |
| Vsupply | 470V | 400V-420V | 400V |
| Applications | Fender 59 Bassman | Fender Bassman 50<br>Fender Bassman 135 | Needs 16Vpp input.<br>60V p-p output. |

#### 4.2.1 400V 5.3mA loadline

The available supply voltage is about 400V. Aiming for a 400V/5.3mA = 75K loadline, then the midpoint gate bias is about -8V – hence the gate-cathode resistance required is about 8V/2.67mA = 3K, giving Rgc~1K5 as a good design start.

The plate current versus plate voltage load line for each triode is given by the equation:

$$Ip = \frac{V_p}{R_L + 2(R_K)}$$

where $R_k$ = 1K5Ω + 6.8kΩ + 2.5kΩ = 11kΩ. Hence a load resistance of about 75K-22K = 50K is needed. The plate voltage Vp axis intercept is 400V (point A) for no plate current, and the plate current Ip axis intercept is 400V / 75KΩ = 5.3mA (point B). The gate-cathode voltage (Ec on the graph) varies with plate current through the 1K5Ω gate-cathode resistance, but with a 3kΩ characteristic, and this characteristic is shown on the graph as a line passing through Ip=4mA for Vgk=-12V, and through Ip=2mA for Vgk=-6V. The intersection of the two lines is the nominal biased operating point.

Voltage drop across tail 2.5k and 6k8 is a max of 9.3k x 5.3mA = 50V. Hence plate-cathode voltage is about 400 – 133 – 8 – 50 = 200V. Plate load resistance dissipation about 133 x133 / 50k = 0.4W. Plate dissipation idle is about 200V x 2.67mA = 0.6W.

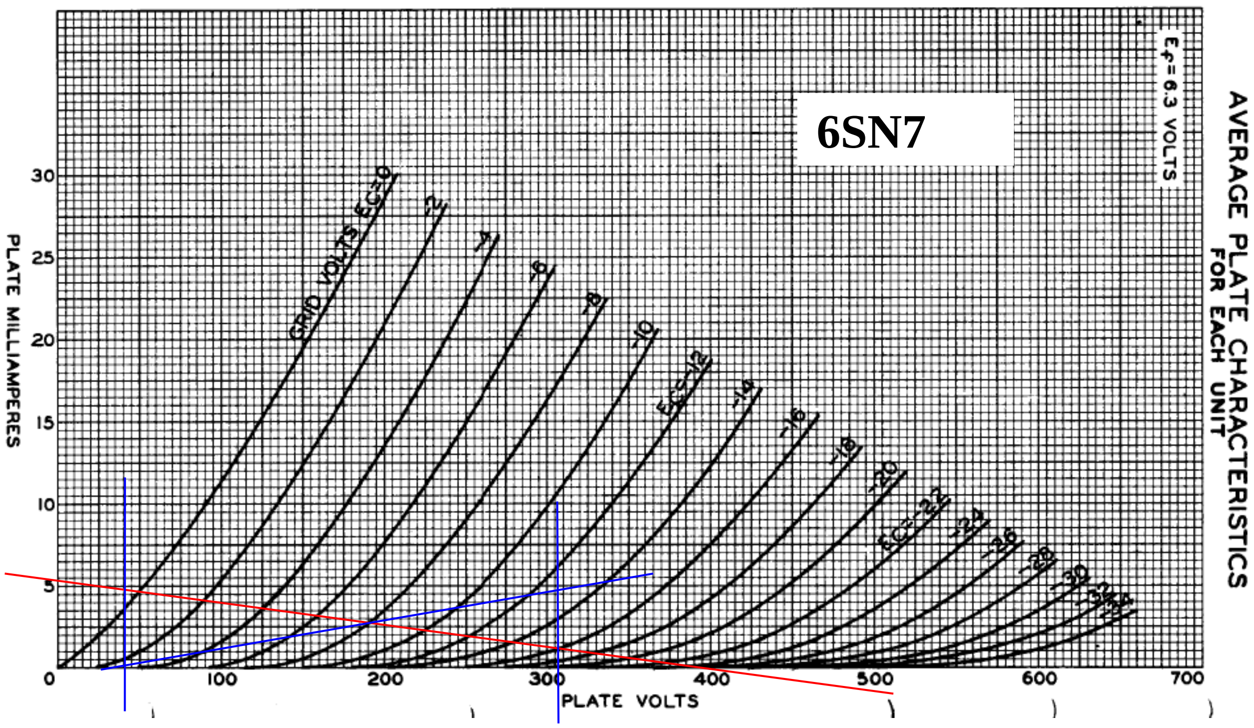
The nominal operating point levels of Vgk=-8V and Vp=190V are used to determine the parameter values of $r_p$ and gm and µ from the 6SN7 average transfer characteristics graph (note that Eb is Vp). Note that using less than 80K loadline will reduce the available output voltage swing.

The analysis by Kuehnel shows that the gain of each triode is slightly different, due to a small level of common-mode gain adding to the out-of-phase output but subtracting from the in-phase output, which is compensated by lowering the load resistor for the out-of-phase output to 51KΩ nominal. The input voltage swing limit is from the bias point at Vgk=-8V to Vgk=0V, which is about 16Vpp or 5.7Vrms. Referring to the loadline, the plate voltage would swing about 275V, from about 55V to 330V, with a mid point of 190V [190-55=135V; 330-190=140V] which is quite symmetric. This gives a nominal gain of 275/16 = 17.

The small signal voltage gain G is about 7.5x. Hence, the signal voltage swing available to each control grid of the output stage is up to 8Vpk x 7.5 = 60Vpk, which exceeds the output stage's requirements of about 40Vpk max.

Adjusting Rgc, say from 1K to 2K, will have a significant effect on distortion.

The rated output voltage at the feedback winding is nominally √(70W x 15Ω) = 32V. The feedback voltage from the output is attenuated to 4.3% (1.4Vrms) by the 2K5 and 56K divider, with a single pole roll-off at f = 28Hz due to the 0.1uF cap bypassing 2K5.




| **Parameter** | **No signal** | ***Heavy load*** | **Notes** |
|---|---|---|---|
| $R_L$ | 56k | *100k* | |
| Vsupply | 400V | *460V* | = $V_{RLoad} + V_P + Vk$ |
| $I_P$ | 2.5mA | *1.25mA* | From bias position |
| $V_{gk}$ | -8V<br>(-7.5V) | *-2.5V*<br>*(-2.5V)* | From bias position<br>= $I_P$ x 2 x 1.5KΩ |
| Vk | 55V | *29V* | = 11KΩ x 2 x $I_P$ |
| $V_P$ | 200V | *300V* | = 400V – 55V - (56KΩ x $I_P$) |
| $r_p$ | 20kΩ | *65kΩ* | = ΔVpk / ΔIp |
| Gm | 1mS | *1.5mS* | = ΔIp / ΔVgk |
| µ | 20 [20] | *98 [98]* | Graph [= gm x $r_p$] |
| G | ~7.4 | *~30* | = (u/2) x $R_L$ / ($R_L$ + $r_p$ ) |
| B | .1 | *.1* | = 4K7 / 47K |
| Headroom | 16Vpp | *5.0Vpp* | |

**Table 1**. Phase Splitter Analysis Results for 6SN7

### *4.3 Output Stage*

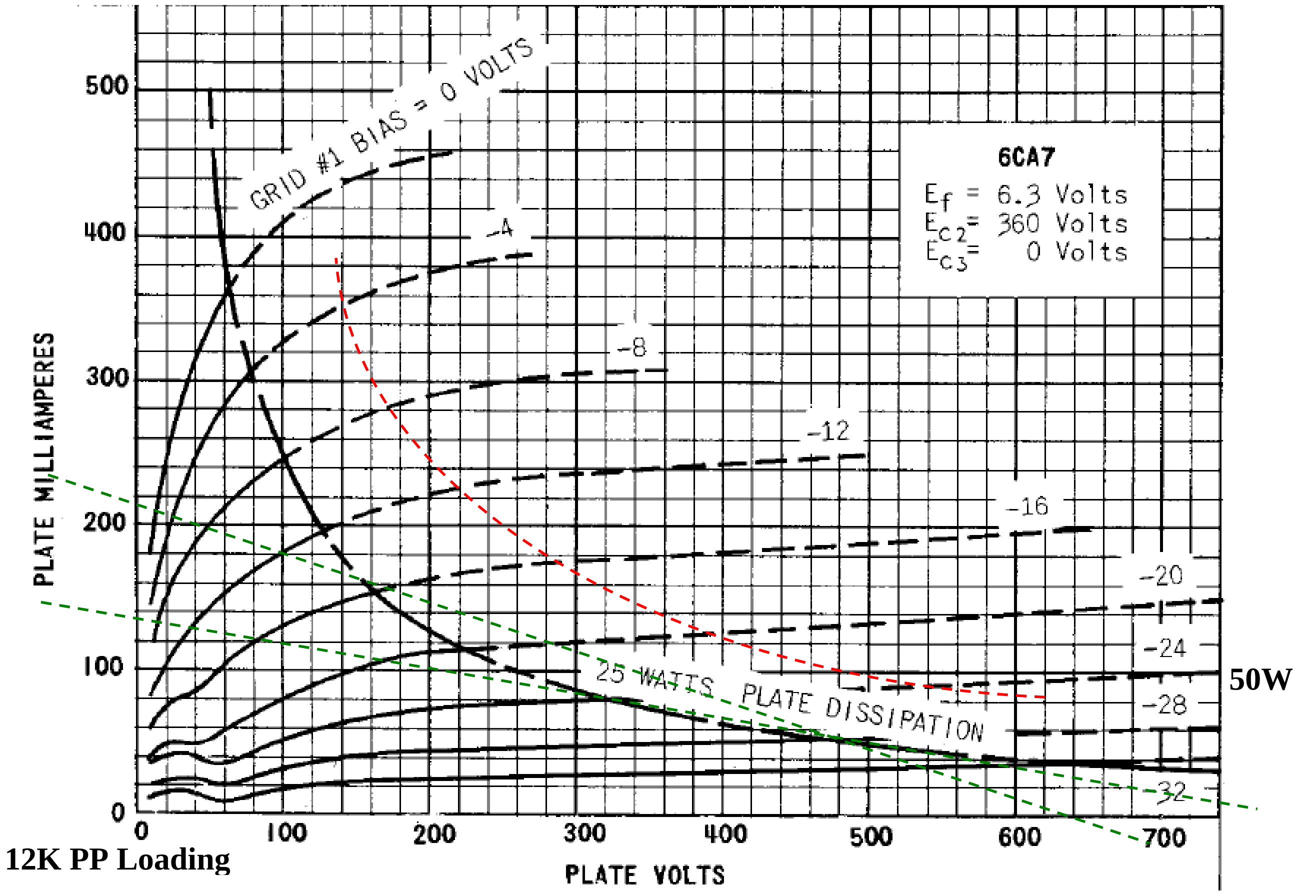
In this Class AB push-pull output stage the cathodes are grounded, and each 6CA7/EL34 tube operates in a fixed bias mode with a negative gate voltage. The 12KΩ impedance plate-to-plate OPT presents signal currents into each tube with a 6KΩ impedance with both tubes conducting, to 3KΩ load impedance at higher levels.

For 70% of the recommended design max plate dissipation (ie. 0.8x25=20W), the cathode current is about 20W/750V= 27mA.

Modified supply voltage VS1 of 670V at idle sags tbd. Plate DC voltage will be lower than VS1 by an amount up to ~13V; ie. OPT half resistance of about 60Ω with a peak current of up to about 0.22A.

Screen voltage VS3 about 320V at idle and is lower than VS2 due to voltage drop across choke. Ripple on C1 and C2 is quite high, due to half-wave circuit, but not significant for push-pull stage performance. Ripple on VS3 is low due to the choke/capacitor filter. Peak screen current is likely to reach 40-50mA, so an average loading on VS3 of 2x25mA plus PI and input stages would have a worst-case level of about 10mA, with a 5V drop on the choke. Screen resistor drop is insignificant.

Tung-sol curves for screen $E_{C2}$= 360V, 12K P-P (3K line) and 640V sagged VS1 indicates a peak plate current of 220mA and nominal clean output power of: $(Ipk)^2$ x Rpp / 8 = $(0.22)^2$ x 12k / 8 = 73W. For this Vg=0 signal condition, the rms OPT current draw is likely about 140mA (64% of peak), and the average VS1 power consumed is about 700V x 0.14Arms =98W, and the OPT loss is about $(0.14)^2$ x 60Ω = 1W, so the tube plates dissipate 98 – 73W - 1W = 24W, or about 12W each, which is well under max design level.



# 5. Power Supplies

Two 8-pin Octal bases are available for the half-wave voltage doubler rectifier circuit which uses the 335V secondary HT winding and two isolated 5V 3A heater windings. An additional 56V winding is used for the fixed bias power supply, which originally used twin diodes from a 9-pin base valve (possibly a ?), but is modified to use silicon diodes and a low ripple design.

The 5U4GB/5AS4 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 = 3Ω x $(330/240)^2$ = 6Ω; plus the secondary resistance = 15Ω; which sums to 21Ω. The Sylvania datasheet from Sept 1958 indicates the effective source resistance should be 30-35Ω for a secondary supply of 330-335Vrms, based on each plate experiencing a peak current of 4.6A into a capacitor-input filter. With no measurements of peak current to indicate otherwise, an additional series resistor of 10-15Ω would be needed. The datasheet also requires the sum of plate currents to be less than about 240mA for Vdc/Vac~0.8 = 270V/330V, however this may also not be applicable for this half-wave, doubler config. With both plates in parallel, the voltage drop across the conducting diode should be about 44V for a total average current of 450mA, but would be substantially more during the initial peak current charging portion of diode conduction in which total current could exceed an amp. CRO waveform of diode current showed a peak current of about 1A with no added external resistance, and almost a sinusoid waveform, when working into 12uF poly caps with 85W load on V1 and 8W load on V3 - however, the condition of the diodes was not known. Decided to initially use no additional series resistance.

One method to reduce the 330Vac HT by about 10% is use a bucking transformer of circa 24Vac, as that has only minor losses. The buck winding needs to sustain 0.6Arms, so a 1A rating should be sufficient. 330Vac is too high to use as buck transformer primary, so use nominal mains 240V for primary. Retrofit on top of chassis in removed oil cap location – so easy to remove.

The standby switch is bypassed by a 270K 2W to provide some bleed charging of caps whilst heaters start.

Ripple voltage at idle is 3.7Vrms on VS1, 4.5V on VS2, ~80mV on VS3. The ripple voltage on VS2 is mainly 50Hz, at a measured level of 67Vrms with a load current through the choke of 27mADC and a ripple on VS3 of 2.5Vrms. C3 impedance is 265R. Ripple attenuation is 2.5/67 = 0.037. Choke impedance is X +470R = 265 / .037 = 7160. Hence choke inductance is nominally (7160 - 470 ) / 2π 50 = 21 H at 30mA. [Measure choke]

A silicon diode isolator is used after the choke to feed a buffer 470uF 400V capacitor for the input stages. The operating current of the PI and input stages is less than 10mA (2-3mA for 12AX7, and 5-7mA for PI). A 1k5 series resistor plus 490R choke resistance limits peak current capacitor charging current to about 400/2k = 200mA (80Wpk). Three series zeners (2x 1N5383 150V, 1N5373 68V) limit VS4 at idle to 375V (to keep below 400V cap rating), with max current (no valves) of about (400-375)/1k5 = 17mA and zener dissipation of 6W.

A normally reverse biased diode from the large cap on VS3 back to VS1 helps discharge VS3 after power turns off.

Supply rails fall to 60VDC in 45secs after turn-off with 120K bleed on VS1.

PSUD2 simulation based on 330Vac secondary with VS1 loading of 130mA (2x30 = 60mA idle, plus 70mA crank), with hot turn-on. Continuous peak diode current 1.6A, and surge peak 5.5A, so exceeds 1x anode, but ok for paralleled anodes. Caution to use valid valve diode model. IEC60127-2 0.63A T fuse chosen.

| Simulate period in PSUD2 | 20ms | 150ms | 600ms | continuous |
|---|---|---|---|---|
| Simulated RMS current | 3.0 | 1.35A | 0.82A | 0.61A |
| Multiplier (based on 0.63A fuse rating) | 4.8 | 2.2 | 1.3 | 0.97 |
| IEC60127-2 Time-lag T min limit multiplier | 10 | 4 | 2.75 | 1 |

### *5.1 Heaters*

Heater-3 load is 1.2+0.6 = 1.8A
Heater-4 load is 3x 0.3 = 0.9A, but 0.6A with V3 not fitted.

12AX7's could be moved to Heater-3, and Heater-4 used to buck 330V (cap mid-point end), but that may stress Heater-4 insulation, and only reduces Vac by 1.8%.

### *5.2 Bias Supply*

The bias supply uses a soft bridge rectifier feeding a large buffer capacitor, then a zener regulated 54V then a RC feeding a pots to provide closely bypassed independent rails for each 6CA7 grid. The protection relay is connected across the zener.

## 6. Protection

### *6.1 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 and the tubes fail. A 48VDC relay, Omron G2R-2 48V, has a coil resistance of 4.2K, and requires about 30V to operate and 8mA. A 2K2 series resistor from the zener regulated 54V rail (1N4751A + 1N4749A) operates the relay at about 33V. The zener operates with about 3mA, the relay takes about 8mA, and the bias circuit about 4mA. The relay de-energises due to gross failure of the bias power supply (about 20V on coil). The relay contacts are used to disconnect the secondary HT.

### *6.2 HV breakdown*

If the B+ rail shorts to ground, due to a flashover, or insulation breakdown, then a 1A fuse in the transformer secondary line provides gross failure protection by de-energising both the plate and screen rails.

### *6.3 Output open circuit*

Three series connected 330V MOVs in series with 4k7 placed from each anode to VS1 provide overvoltage protection or each anode – dampening from about 1.1kV.

### *6.4 Output stage valve failure*

#### 6.4.1 Anode fault path

For an EL34 anode related fault current, the in-line fault resistances are 21R (PT), rectifier (120R 1A), 60R (OPT half primary), 47R anode stopper, EL34 (~250R), and 10R cathode. With PSUD2 using 21R PT and 1N4007 doubler (due to valve diode bug):

- 490R loading for loss of bias on one EL34 causes ~1.1A dc fault with high ripple, and 3.0Arms PT secondary.
- 240R loading for short in EL34 causes ~1.7A fault with high ripple, and 4.6Arms PT secondary.

The 0.63A PT secondary fuse should blow for 3A fault current within 2 sec (2 sec is the longest tolerance, and so should blow sooner), using the table below that shows the worst-case blow times for the 0.63A fuse and the current levels indicated.

| **Max specified fuse blow time** | **300ms** | **2 s** | **3 s** | **10 s** | **120 s** |
|---|---|---|---|---|---|
| IEC 60127-2 **T** max limit multiplier | 10 | ~4.6 | 4 | 2.75 | 2.1 |
| Fault RMS current needed to blow fuse (for 0.63A **T** fuse rating) | 6.3A | ~2.9A | 2.5A | 1.7A | 1.3A |

The 47R 0.5W anode resistor could fail in that time. The cathode monitoring meters could also fail as the peak voltage across the 10R sense could reach ~30 to 40V. Collateral damage could extend to the OPT.

The PTC may not start limiting cathode current during that time [500mA Hold (less when derated) needs 2.5A for 4 secs to trip], but similarly could alleviate collateral damage in lieu of the fuse blowing, as would the 47R failing open.

### 6.4.2 Screen fault path

For an EL34 screen short to cathode fault current, the in-line fault resistances are 21R (PT), rectifier (120R 1A), 490R (choke), 150R screen stopper, and 10R cathode. With PSUD2 using 21R PT and 1N4007 half-wave, the 770R loading for short in EL34 screen causes ~0.46A fault with high ripple, and 1.1Arms PT secondary.

- The choke is likely to fail very quickly (100W), and also the screen stopper (32W). The cathode monitoring meters should be ok. The 0.63A fuse and PTC likely won't provide any protection.

### 6.4.3 PTC operation

RXEF050 PTC has Zener 1N5373B 68V 5W in parallel to protection.

If the PTC trips and causes a soft fault, then sustained cathode current needs to be less than ~ 50mA to constrain Zener dissipation, and assumes PTC conduction is relatively low but supports 68V, and EL34 is sufficiently biased into cut-off. This situation only occurs for a grid bias fault, where grid-cathode voltage constrains cathode current. For an internal screen short fault, the PTC voltage would exceed 72V and the PTC likely fail open.

MF50 10Ω 500mW current sense in each EL34 cathode. Assumed anode+screen peak current up to 300mA, so 900mWpk, or 450mWav for cranked squarewave.

A hard fault would likely blow Zener open, then PTC open.

Voltage across 10Ω taken to external meter monitoring, which needs to be limited to 4.2V max (ie. 420mA peak).

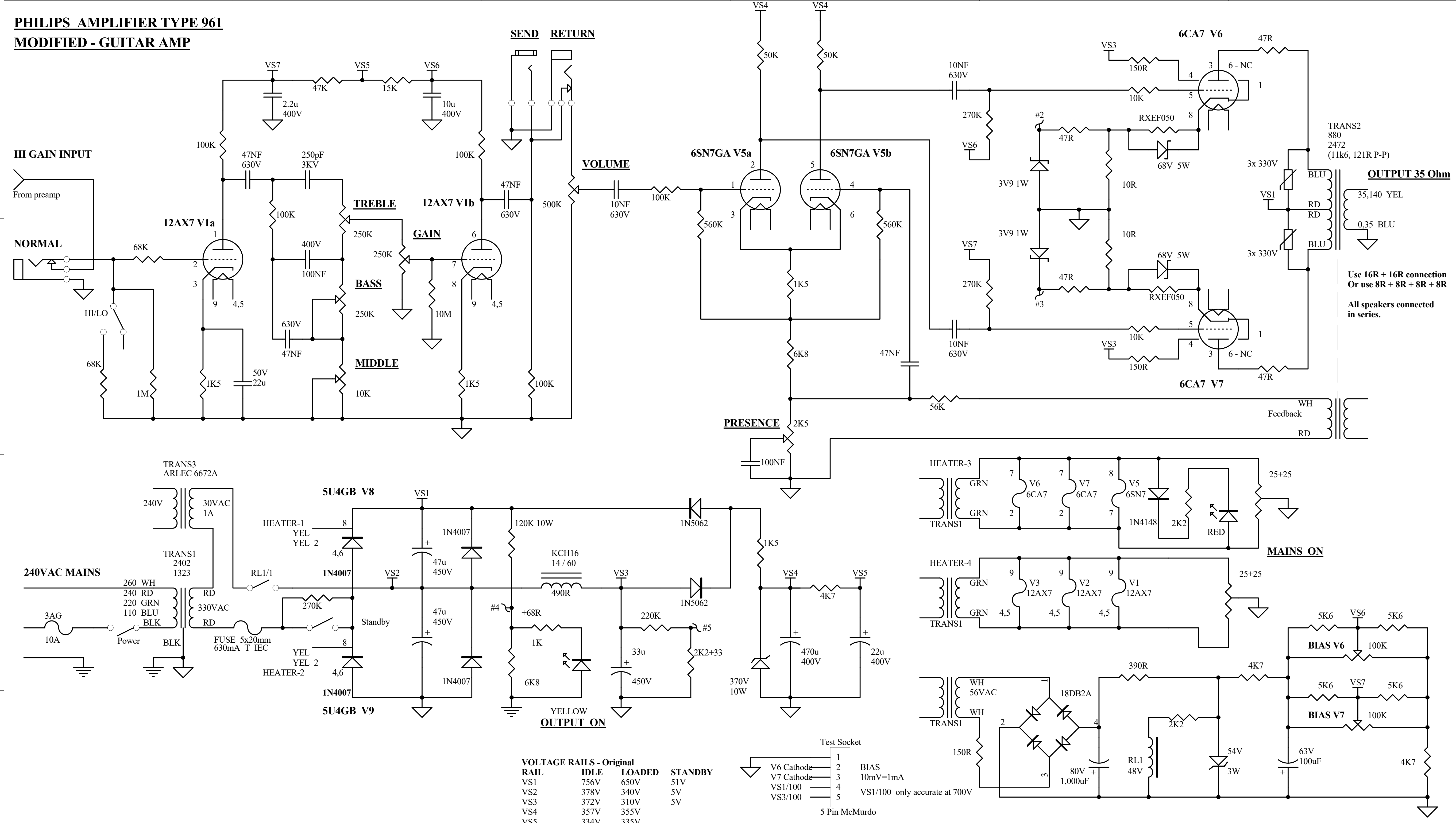
- A 3V9 (1W) 1N4730 at 64mA dissipates 0.25W with nominal 9Ω incremental resistance. Additional 50mA surge would raise 3.9 to about 4.45V, so perhaps only effective for 100mA bypass.
- Adding 50Ω in series with external meter would cause < 0.5% error (50Ω x 1V/13k) for nominal measurement, but drop 5V at 100mA. So with 3V9 zener, the voltage across cathode 10Ω would reach 4.2V + 50x100mA ~ 9V, for a total cathode fault current of ~ 1A.

That current level may be survivable for 10Ω sense, and allow PTC to open, or fuse to operate.

### *6.5 Valve diode protection*

The combined diode current for each valve has an average (rms) current of about 400mA for 130mA VS1 loading. That indicates a 1N4007 should be ok to act as a series protection diode for the parallel valve anodes, given the relatively low Ipk/Iav = 1.55/0.31 = 5, and given the diode is not exposed to high temperature. Use pin 5 on socket as 4 and 6 are being paralleled.

## PHILIPS AMPLIFIER TYPE 961
## MODIFIED - GUITAR AMP




**VOLTAGE RAILS - Original**

| RAIL | IDLE | LOADED | STANDBY |
|---|---|---|---|
| VS1 | 756V | 650V | 51V |
| VS2 | 378V | 340V | 5V |
| VS3 | 372V | 310V | 5V |
| VS4 | 357V | 355V | |
| VS5 | 334V | 335V | |
| VS6 | 318V | 325V | |
| VS7 | 390V | 295V | |
| HEATER-1 | 5.1V | 5.1V | 5.1V |
| HEATER-2 | 5.1V | 5.1V | 5.1V |
| HEATER-3 | 6.2V | 6.2V | 6.2V |
| HEATER-4 | 6.2V | 6.2V | 6.2V |

| VALVE | QTY | BASE | DESIGNATORS | BIAS |
|---|---|---|---|---|
| 6CA7 | 2 | 8ET | V6, V7 (front) | 24mA (cathode) |
| 6SN7GA | 1 | 8BD | V5 | |
| 12AX7 | 4 | 9A | V1, V2, V3, V4 | |
| 5U4GB | 2 | 5T | V8, V9 | |

Title
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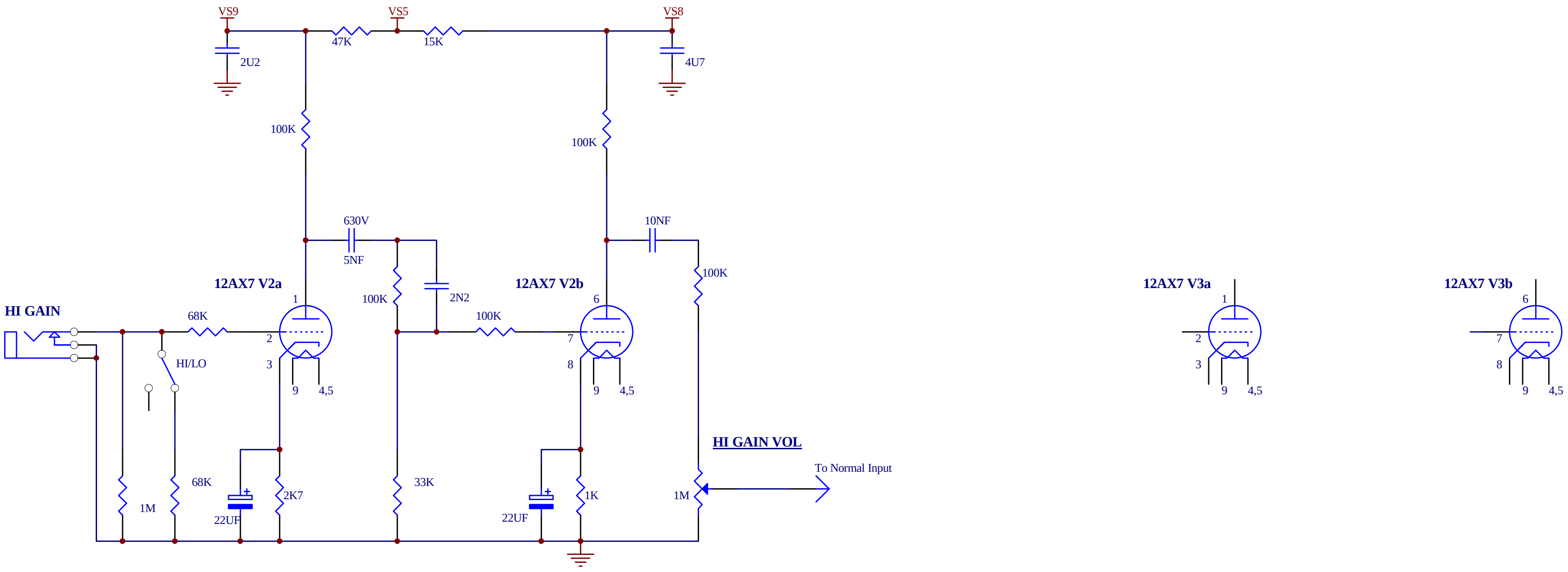
# PHILIPS AMPLIFIER TYPE 961
# MODIFIED - GUITAR AMP
# PREAMP SECTION

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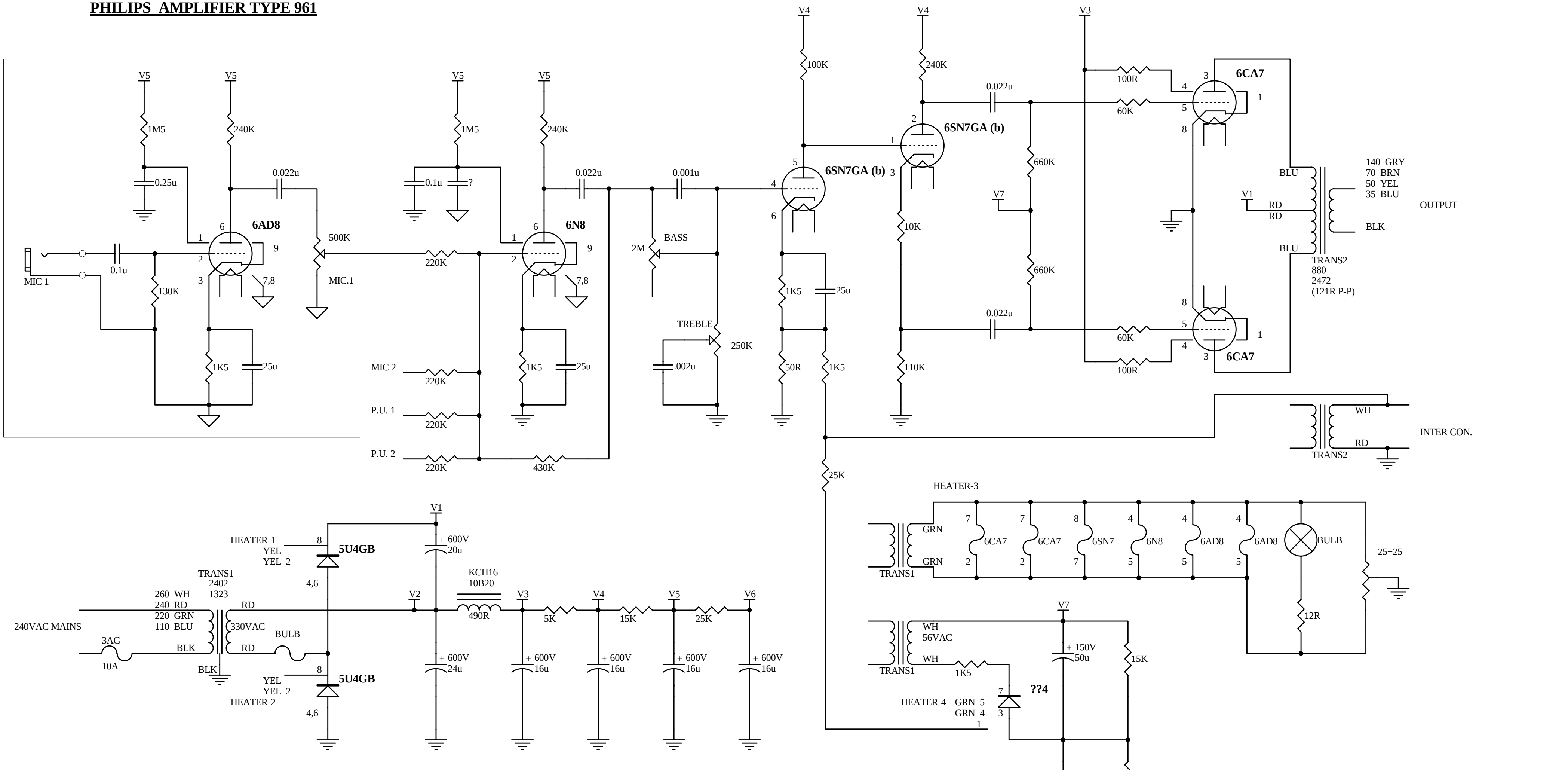
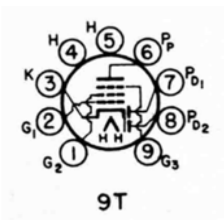
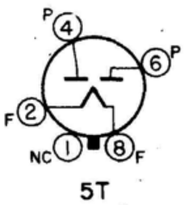
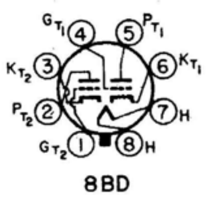
# PHILIPS AMPLIFIER TYPE 961




| VALVE | QTY | BASE |
|---|---|---|
| 6CA7 | 2 | 8ET |
| 6SN7GA | 1 | 8BD |
| 6N8 | 1 | 9T |
| 6AD8 | 2 | 9T |
| 5U4GB | 2 | 5T |
| ??4 | 1 | ? |

**VOLTAGE RAILS**

| RAIL | NO LOAD | LOADED |
|---|---|---|
| V1 | V | V |
| V2 | V | V |
| V3 | V | V |
| V4 | V | V |
| V5 | V | V |
| V6 | V | V |
| V7 | V | V |
| HEATER-1 | 5.4V | V |
| HEATER-2 | 5.4V | V |
| HEATER-3 | 6.6V | V |
| HEATER-4 | 6.6V | V |

| Title | | |
|---|---|---|
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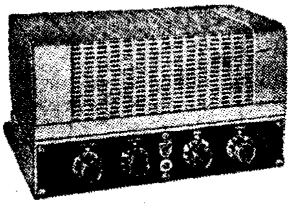
## AMPLIFIERS...



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| " " | 957 | 13 Watt 240V AC |
| " " | 974-958 | 13 Watt 240V AC/6V or 12V DC |
| " " | 956 | 30 Watt AC |
| " " | 961 | 70 Watt AC |

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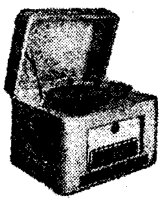

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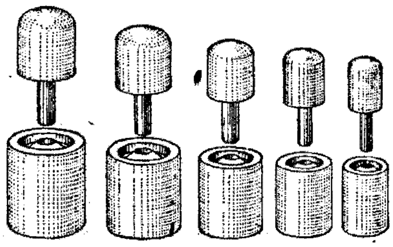

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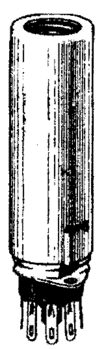

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| Miniature 7-pin shielded valve sockets | Can Size | Type of Valve | Retail (each) |
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| ST47G black electrical grade bakelite with skirt only | — | Complete series | 3/1 |
| ST57G/2 black electrical grade bakelite with skirt and shield | 1-15/16" | 6BA6, 6BE6 etc. | 5/2 |
| ST47L natural mica filled bakelite with skirt only | — | Complete series | 4/4 |
| ST57L/2 natural mica filled bakelite with skirt and shield | 1-15/16" | 6BA6, 6BE6 etc. | 6/4 |
| ST57G/3 black electrical grade bakelite with skirt and shield | 2-3/8" | 6AQ5, 6X4 etc. | 5/10 |
| ST57L/3 natural mica filled bakelite with skirt and shield | 2-3/8" | 6AQ5, 6X4 etc. | 6/10 |
| Shield can only, -/2 | 1-15/16" | 6BA6, 6BE6 etc. | 2/- |
| Shield can only, -/3 | 2-3/8" | 6AQ5, 6X4 etc. | 2/8 |

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| Miniature 9-pin shielded valve sockets | Can Size | Type of Valve | Retail (each) |
|---|---|---|---|
| ST47G black electrical grade bakelite with skirt only | — | Complete series | 5/3 |
| ST57G/2 black electrical grade bakelite with skirt and shield | 2" | 12AT7, 12AU7 12AX7, 6AE8, etc. | 9/9 |
| ST59G/3 black electrical grade bakelite with skirt and shield | 2⅝" | 5763, 6T8, Innoval, etc. | 9/9 |
| ST49L natural mica filled bakelite with skirt only | — | Complete series | 6/- |
| ST59L/2 natural mica filled bakelite with skirt and shield | 2" | 12AT7, 12AU7 12AX7, 6AE8, etc. | 10/6 |
| ST59L/3 natural mica filled bakelite with skirt and shield | 2⅝" | 5763, 6T8, Innoval, etc. | 10/6 |
| CS92 shield can only | 2" | 12AT7, 12AU7 12AX7, 6AE8, etc. | 4/6 |
| CS93 shield can only | 2⅝" | 5763, 6T8, Innoval, etc. | 4/6 |