1. Summary

Philips Model 976B. Serial No. 2260. May 2021

12AX7 microphone gain stage with volume pot to 12AX7 mixer stage, with PU input through volume pot to mixer stage. Output of mixer stage to tone control and then to 12AX7 feedback input stage to cathodyne phase splitter. 6M5 push-pull output stage with common cathode bias. Output transformer secondary with separate feedback winding, and floating 100V distribution. 6V4 full-wave rectifier with two RC droppers.

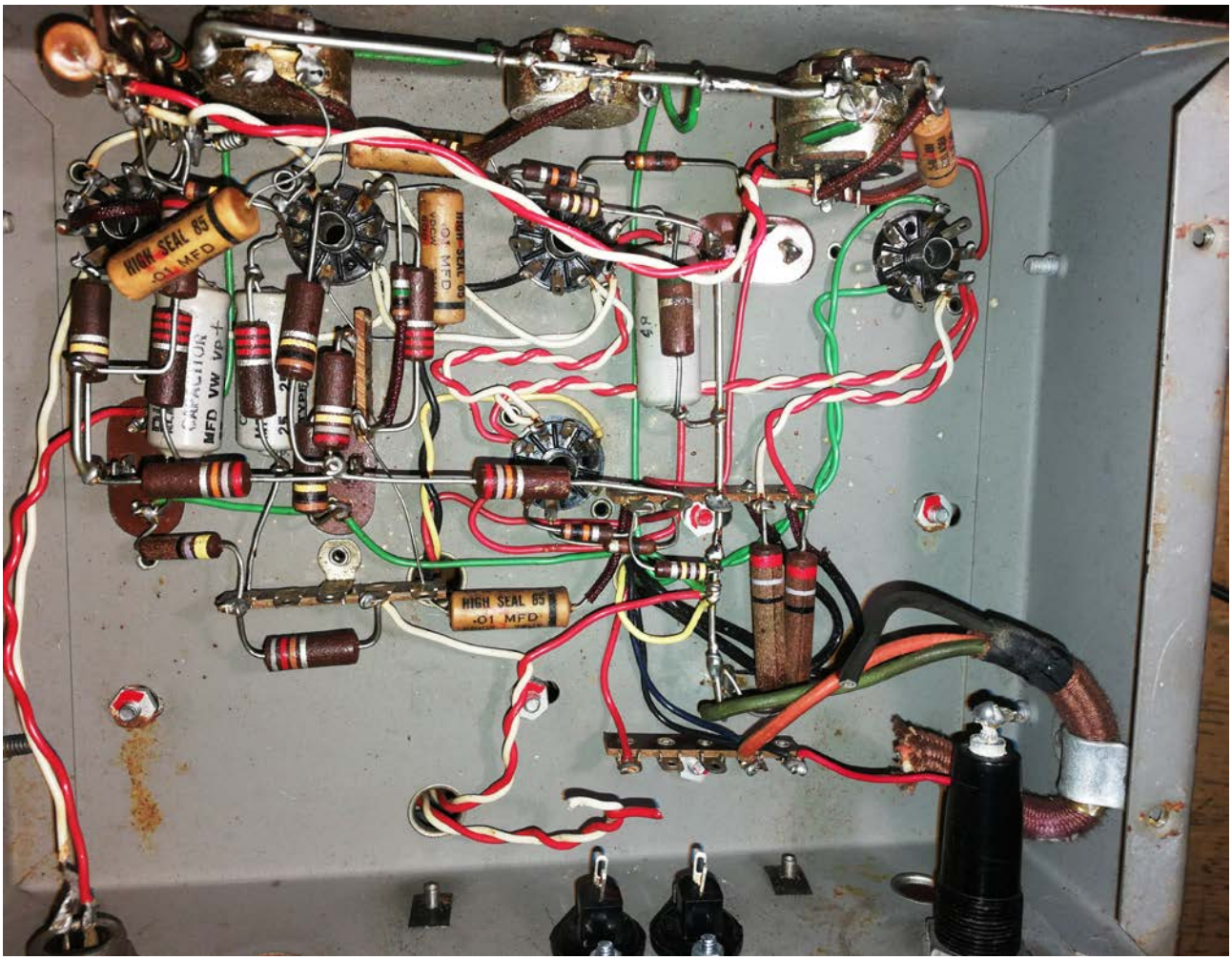
Very good condition. Poor Philips badge on top grill. Missing one 6M5. Missing PU rear socket and screened cable to front panel pot. Altered rear output connectors and not yet connected. Cut power cables and disconnected fuse. Otherwise untouched.

Components

Power Transformer	‘344.096’, ‘21x8’. 0-240-250V; 250-CT-250, 6V3 ~3A, 6V3 ?A.
Output Transformer	‘TYPE 903’. 1 478 with VSNP stamp. 10kΩ PP (DCR=179+135Ω); 0-300Ω-600Ω-1200Ω (50-70-100V); 2Ω F-FB.
CAPs	Ducon 24uF 300/525V 48 48 38
	Ducon ET1B 48
	Ducon High Seal 0417 0347 0427
Pots	IRC
Tubes (all Miniwatt)	6V4 Miniwatt 8B
	6M5 Miniwatt M+ 8C (M+=EL80=6M5; 8=1958)
	12AX7 Miniwatt 8D mC? Δ7L (Philips Herlin 1957)
	12AX7 Miniwatt ??? Δ7L (Philips Herlin 1957)

Issues:

No power switch. Old wax and electrolytic capacitors. Mains wiring close to circuitry. Floating speakers. Spare 6V3 winding. Not the best grounding. Speakers use line transformers. OT lowest tapping impedance is 48Ω between 50V and 70V taps (300Ω and 600Ω). Feedback winding is 4.1Vac nominal. 6M5 socket without pin 8 (no issue).



1.1 Modifications for Guitar Amplifier

- Earth bolt hole – use cable restraint hole.
- Mains cable restraint removal.
- Combo switch/fuse/IEC added to rear panel.
- Fuse added to PT secondary CT (0.16A Delay IEC127 5x20).
- Choke (Wurlitzer 500407) added between VS1 and VS2 along with series 560 ohm.
- Mains fuse changed to 0.5A slow blow.
- 275VAC MOV across primary winding.
- 1N4007 added in series with each rectifier plate for 6V4.
- Improved grounding scheme.
- Electrolytics and wax coupling caps replaced.
- PU Volume pot replaced with dual gang and used as post-PI volume. Only linear taper available.
- Grid stoppers added.
- 6M5 cathode 10Ω sense resistors added.
- 6M5 screen stoppers increased to 390R PR01, and extra screen supply 4.2H choke filtering.
- 354VDC min 1mA 90pF MOV added across each OT half-winding. RC network removed from across PP.
- OT secondary grounded and rewired for 8 and 16 ohm outputs using split f/b winding.
- Output terminals replaced by two 2-pin speaker sockets – one for 8 ohm and one for 16 ohm.
- MIC input socket replaced by shorting isolated ¼” input socket.
- PU input socket replaced with 5-pin McMurdo socket from external metering of Cathode voltage and individual currents, and VS1/100.

2. Measurements

PT and OT meggers ok. New primary circuitry measures >2Gig.

Voltage rail regulation. Modified circuit.

Rail	246VAC mains, 0.205A VDC, VACrms Idle condition	
VS1	303V, 5.06V (333V turn-on pk)	
VS2	296V, 0.29V	
VS3	286,	
VS4	281,	
Cathode	10.0 (26.9+25.1mA) 7.5W	
Heater 1	6.7V	

Power transformer primary DC resistance: 31Ω (BLU-BLK); 27Ω (RD-BLK).
Power transformer secondary DC resistance: 180+189Ω.

OPT 2Ω feedback winding is bifilar, so removed from terminal and split and reconfigured to provide single 8Ω winding, with 300-600Ω section in series (but out of phase) to give total 16Ω winding.

OPT impedance measurement with EMU0404 and REW and calibrated rig.
PP impedance: 21H at 50Hz, 170pF at 20kHz, resonance pk at 3.3kHz
8Ω leakage = 21mH 1kHz
16Ω leakage = 150mH 2kHz

OPT frequency response measurement for 6M5 pentode Ra=40kΩ using balanced driver series resistance of 2x 39k, and secondary rated loads show:
7.5Ω response: -1.5dB at 100Hz and +1dB at 60kHz; 0.68% 3rd harmonic at 100Hz
15Ω response: -2.5dB at 100Hz and +2dB at 25kHz, resonance at 60kHz; 1.4% 3rd harmonic at 100Hz

6V4 with 630Meg and 1500Meg IR – so ok to use.

OT with 8Ω resistive load: Cranked output to 9.0Vrms (10W), with VS1 sagging to 275V, and common cathode voltage increasing to 15.4V.

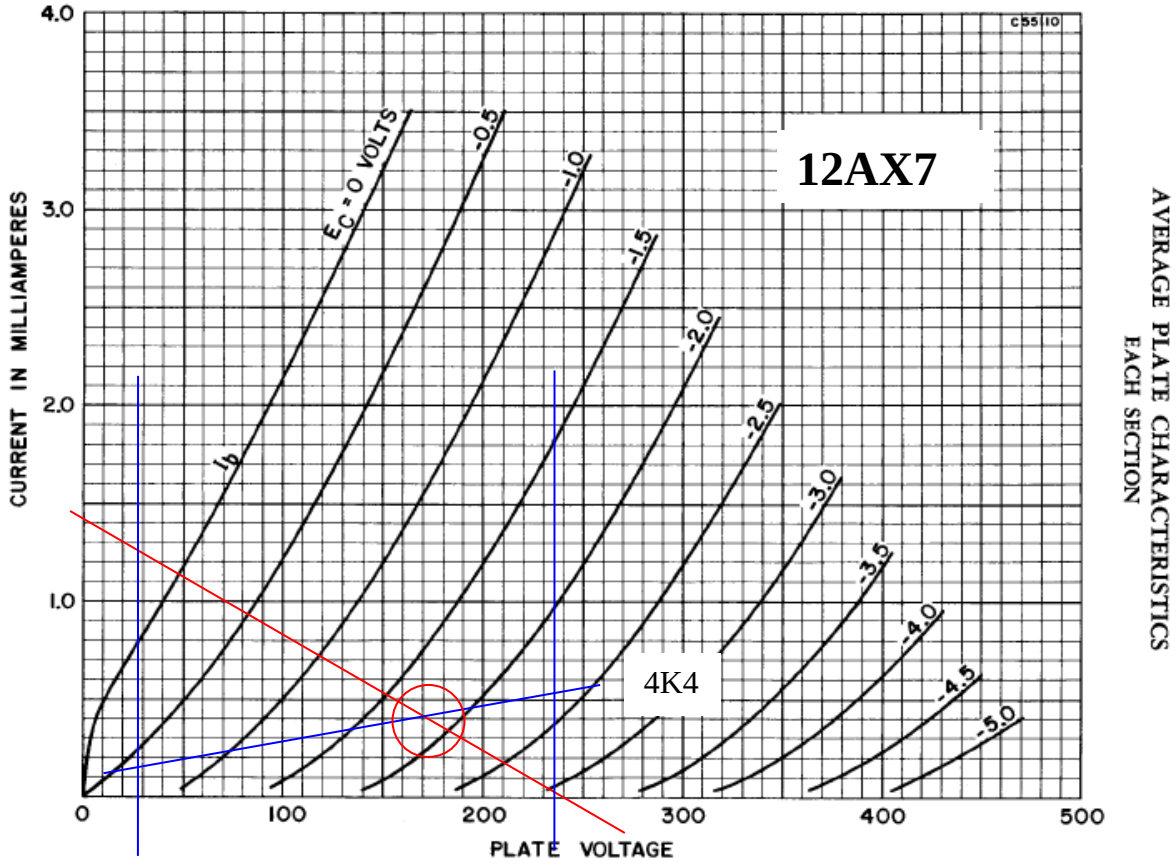
OT with 16Ω resistive load: Cranked output to 10.0Vrms (6W), with VS1 sagging to 275V, and common cathode voltage increasing to 15.4V.

Frequency spectrum at 1W output in to 8R load is 200Hz to 15kHz -3dB with tone control at min; 130Hz to 5kHz at max. Sensitivity at 400Hz for 8W output in to 8R load (8Vrms) is 8.6mVrms at MIC wiper. Gain from input to MIC pot top is 50x (290mVrms for 8V o/p). Valves changed to both 12AU7.

3. Design Info

3.1 Input stages 12AX7

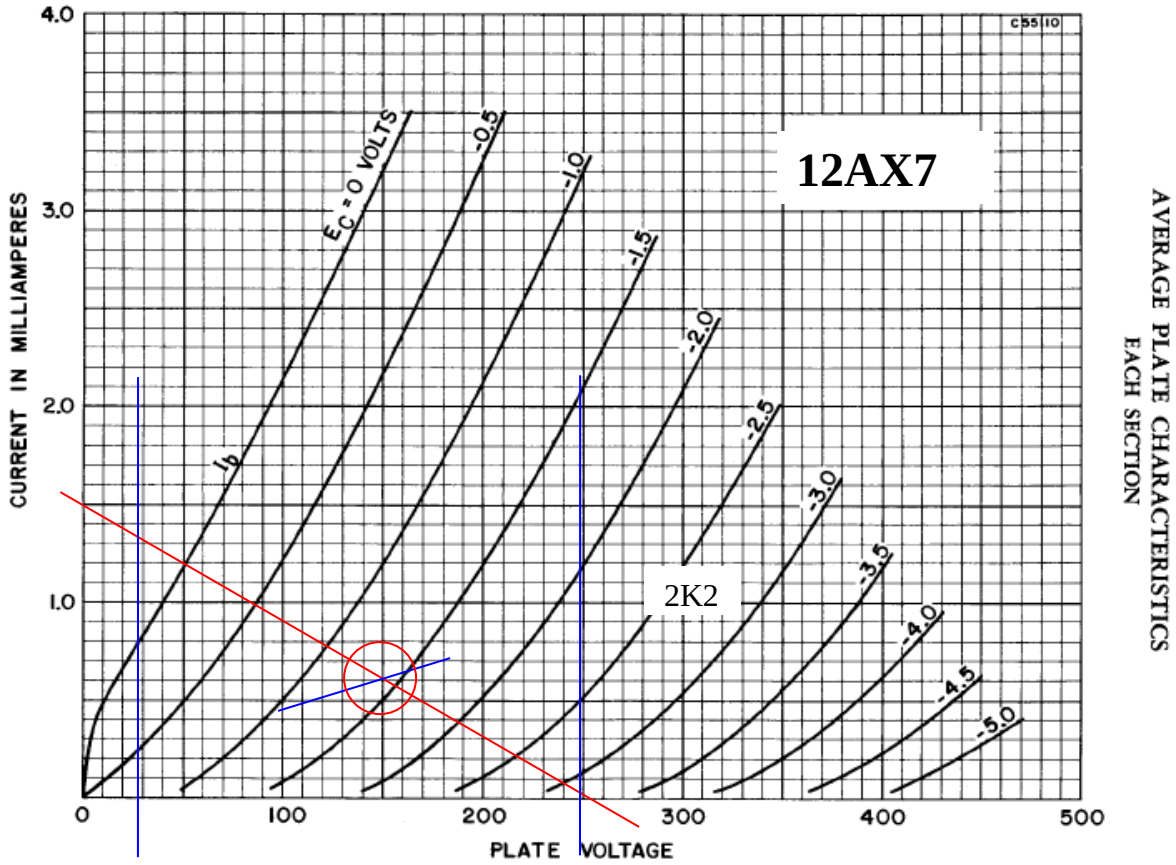
For the first two 12AX7 stages have a common 2k2Ω cathode bias; V1A-V1B; VS4 = 235V; Va=170; Rk=4k4; Vk=1.7V; Ia=0.4mA; RLdc=165kΩ.



2x 12AX7 in
301V VS1 290V VS3 287V VS4
Input stage anodes: 220V and other is a few volts less
Post tone anode: 188V
PI ends: 52V and 236V
All anodes are a titch high, so could reduce 2k2 to 1k8 for all cathode bias', but initially just leave.

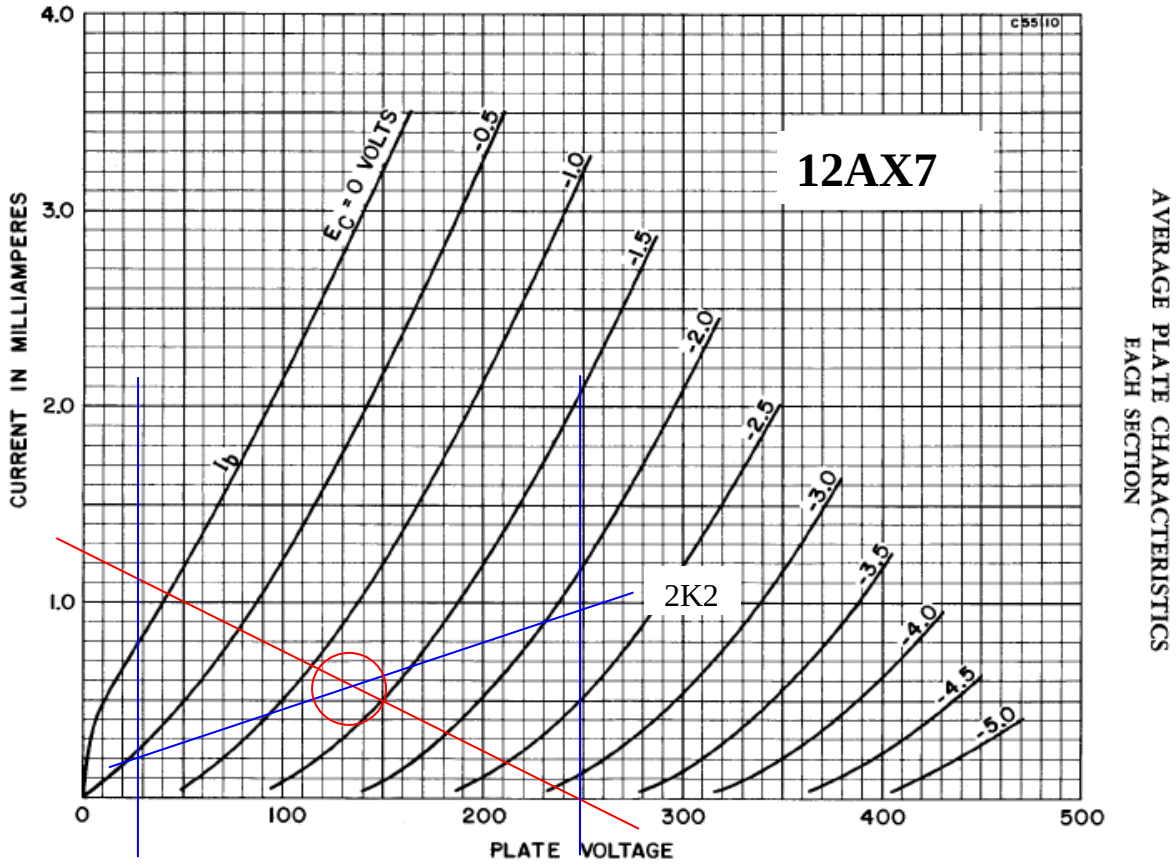
3.2 Feedback stage 12AX7

The feedback 12AX7 stage; V2A; VS3 = 250V; Va=150; Rk=2k2; Vk=1.4V; Ia=0.6mA; RLdc=165kΩ.



3.3 Phase Inverter stage – 12AX7 in split-load (cathodyne) config

VS3= 250V. Rk=2k2. Vgk=1.3V. Vk=61.3V. Va=192V. Vak= 130V. Anode current = (250-192)/100k=0.6mA.



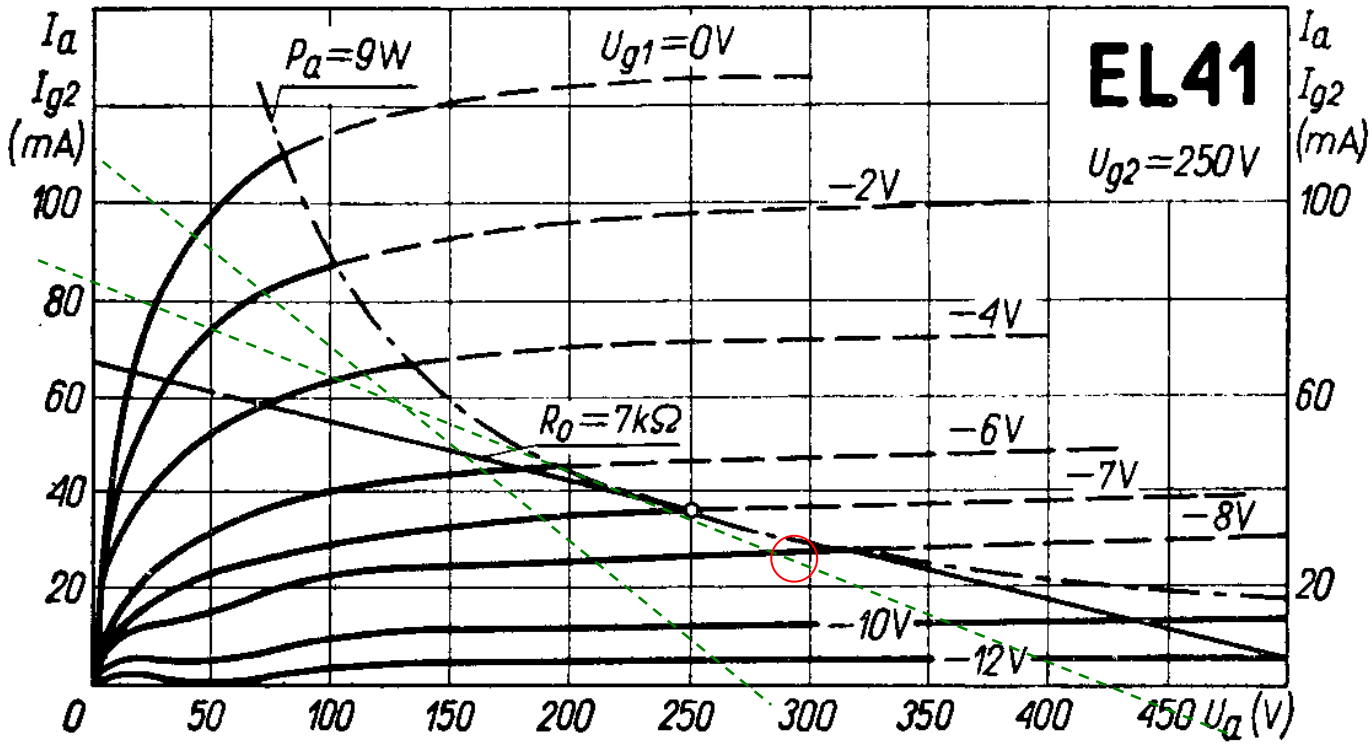
3.4 Output Stage

Class AB push-pull output stage, common cathode bias. The 10KΩ impedance plate-to-plate OPT presents signal currents into each tube with a 5KΩ impedance with both tubes conducting, to 2.5KΩ load impedance at higher levels. No pentode characteristic curves are available for 6M5, and similar EL41 curves are shown but at a lower 250V screen (actual screen is about 280V at idle so bias voltage is close to 10V).

Idle conditions with VS1=300V, cathode = 10V, cathode current = 25+26mA, primary winding drop ~ 23mA x 135Ω = 3V, Vak~287V.

As the output loading increases, the supply voltage VS1 to the output valve plates sags from about 300V towards 290V. Plate DC voltage will be lower than VS1 by an amount up to ~28V (ie. plate-cathode sags to about 260V) due to OPT half resistance of about 135Ω with a peak current of up to about 0.1A, and cathode bias drop of 18V. Screen voltage will vary from about 280 towards 265V under steady-state heavy load (ie. screen-cathode sags to about 265-18 = 245V).

The maximum output valve bias current allowed is dependant on the maximum recommended plate dissipation – assume 75% of 9W = 6.8W: Ibias(max) = Pd / Vb = 6.8W / 290V = 23mA, or about 25mA of cathode current.


EL41
I_a
I_{g2}
(mA)
P_a=9W
U_{g1}=0V
U_{g2}=250V
−2V
−4V
R_0=7kΩ
−6V
−7V
−8V
−10V
−12V
100
80
60
40
20
0
50
100
150
200
250
300
350
400
450
U_a (V)

3.5 Power Supplies

The 6V4 is rated to feed 50uF with secondary winding resistance >125Ω from 250VAC, and 90mA loading for a 265VDC output, and has a hot switch peak current rating of 900mA, and a continuous peak current rating of 270mA.

The effective series resistance is $30\Omega \times (260/250)^2 + 185\Omega = 220\Omega$, which is fine.

PSUD2 indicates a hot switched peak of up to 900mA, and a steady-state continuous of 240mApk at idle, which appears to be fine for cranked output. The steady-state PT secondary CT current at idle is about 110mArms, and rising to 570mArms for a 10ms period for a hot switch event, which would allow a 200mA Fast IEC127 fuse to be used (min rating of 50ms at 2.75x rating multiplier).

A 4.1H @ 30mAdc, DCR=380Ω (Wurlitzer 500407) choke is added in series with 560R dropper from VS1 to VS2 to reduce screen voltage ripple from 1.6Vrms to 0.29Vrms. Screen current should be less than 20mA average, and 4mA for VS3-4.

Full wave rectifier with 65mA hot idle load on 280V VS1. Max anticipated continuous VS1 load current about 100mA, requires about 150mArms CT current. IEC60127-2 0.16A Time-delay fuse chosen – as no 160mA F fuse available.

Simulate period in PSUD2	**20ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current	0.4A	0.22A	0.17A	0.15A
Multiplier (based on 0.16A fuse rating)	2.7	1.4	1.1	0.94
IEC60127-2 Time-lag T min limit multiplier	10	4	2.75	1

Simulate period in PSUD2	**10ms**	**50ms**	**continuous**
Simulated RMS current	0.5A	0.3A	0.15A
Multiplier (based on 0.16A fuse rating)	3.1	1.9	0.94
IEC60127-2 Quick-acting F min limit multiplier	4	2.75	1

8 WATT AMPLIFIER

SPECIFICATION

OUTPUT POWER:	8 Watts at less than 5% harmonic distortion.
FREQUENCY RESPONSE:	30 - 15000 c/s within 2 dB with tone control set for flat response.
TONE CONTROL:	Switch - potentiometer type - 18 dB at 50 c/s bass attenuation with switch - 14 dB treble attenuation at 15 Kc/s with potentiometer.
SIGNAL TO NOISE RATIO:	(With volume controls at max.) Microphone 55dB) weighted. Pickup 70dB)
POWER CONSUMPTION:	60 VA at full signal.
MAINS SUPPLY:	220 - 260 Volts 40 - 60 c/s.
INPUTS:	Microphone 1 megohm 1.4 mV. Pickup 500,000 ohm 100 mV.
OUTPUT IMPEDANCES:	1200, 600 and 300 (100, 70, 50 volts).
DAMPING FACTOR:	3.0
FUSE:	1 amp - auto.

VOLTAGE ANALYSIS

VALVE	ANODE	SCREEN	CATHODE	HEATER
V1 (A) 12 AX 7	1) 110 v D.C.	-	1.1 v D.C.	6.5 v A.C.
	2) 110 v D.C.	-	1.1 v D.C.	6.5 v A.C.
V2 (B) 12 AX 7	1) 60 v D.C.	-	.3 v D.C.	6.5 v A.C.
	2) 100 v D.C.	-	65 v D.C.	6.5 v A.C.
V3 6V4	275 v D.C.	-	278 v D.C.	6.45 v A.C.
V4&5 6M5	272 v D.C.	278 v D.C.	8.9 v D.C.	6.5 v A.C.

ALL MEASUREMENTS ARE MADE WITH A 1000 OHM PER VOLT METER TO CHASSIS

976 A MODEL ONLY

VALVE	ANODE	SCREEN	CATHODE	HEATER
V2 12AX7	1) 72 V D.C.	-	.7 v D.C.	6.5 v A.C.
	2) 150 v D.C.	-	55 v D.C.	6.5 v A.C.

OPERATING INSTRUCTIONS

for

8 WATT AMPLIFIER

GENERAL

Before using a new Amplifier, make sure that all valves are seated firmly in their sockets, and that fuses are fitting tightly in their holders.

All amplifiers leave the factory with the power cable connected to the mains transformer for 240 volt A.C. operation. In cases where the mains voltage is not 240 volt, it is necessary to remove the baseplate of the amplifier BUT ENSURE THE AMPLIFIER IS NOT CONNECTED TO THE MAINS SUPPLY, then unsolder the lead of the power cable connected to the 220-240 volt lug and attach to the 250 - 260 volt lug.

220 - 240 V leave as is
250 - 260 V Solder to lug marked 250 volts
260 volts

The power point used for Amplifiers should be of the three pin earthed type, which will then earth the amplifier through the third conductor in the power lead. If an earthed power point is unavailable, a separate earthing wire should be connected to the amplifier chassis.

INPUT CONNECTORS

Before connecting any input source to this Amplifier, ensure the voltage to the plugs does not exceed the following, otherwise severe overloading will result.

Pickup	2V
Microphones	.05V

The input connectors are two-pin plugs (metal sheathed type) which are supplied with the amplifier. The pin numbers are stamped on the inside bakelite moulding of the plug.

No. 1 being Grid Return
No. 2. being Grid

When connecting the microphone or pickup cable to the plug pins, the two inner wires must be connected to Pins No. 1 and No. 2. whilst the braid shielding is soldered directly to the outer spring on the plug.

Where a single shielded conductor is encountered, the shielding should be connected to No. 1 pin, and NOT to the spring, as this amplifier features SINGLE POINT EARTHING. If this is NOT done correctly, EXCESSIVE HUM will develop.

OUTPUT CONNECTIONS

The constant voltage output system used, eliminates mismatch distortion. This permits any number of loudspeakers to be connected provided the total impedance is not lower than 1,000 ohms when connected to the 1200 ohm tapping.

Under normal conditions speakers may be connected to the output terminals marked -

C and 1200 ohms	Total Speaker impedance	10,000 - 1,000 ohms
C and 600 ohms		1,000 - 500 ohms
C and 300 ohms		500 - 250 ohms.

Selection of wattage per speaker is calculated as under when connected between terminals C and 1200 ohms.

½ watt	20,000 ohms	4 watts	2,500 ohms
1 watt	10,000 ohms	8 watts	1,250 ohms
2 watts	5,000 ohms		

8 Watt Amplifier

VOLUME CONTROL

Separate controls are provided for each input channel and this allows individual adjustment and mixing. To increase the volume, turn the knobs clockwise.

TONE CONTROL

A combined base or treble control is provided.

Bass cut is obtained by turning the knob fully anti-clockwise until the switch operates.

Flat response is anti-clockwise until just prior to the switch operating.

Gradual Treble cut is obtained by turning the knob clockwise from the flat response position.

PRECAUTIONS

It is strongly recommended not to carry out repairs on amplifiers unless technically capable. Besides additional damage which may result from trying to tamper with an amplifier, it should always be borne in mind that if the top or bottom covers are removed, terminals carrying dangerous high voltages are exposed, sometimes even after the amplifier is disconnected from the mains supply.

It is essential that sufficient space be allowed on all sides of the amplifier to provide efficient ventilation. Under no circumstances should anything be placed on top of the perforated cover, as this will result in overheating and subsequent damage.

NOTE:

Plug numbers quoted for connections for microphone and pickup, apply to the plugs supplied with the Amplifier (Acme).

AMPLIFIER 8 WATT 230 V A.C.

TEST SHEET

1. Plug in all valves except rectifier and switch on.

2. Connect 1200 ohm load to 1200 ohm tap.

3. Plug in rectifier and watch for H.T. shorts.

4. With tone control set for flat response, and pickup volume at minimum, connect signal of 14 MV at 1000 c/s to microphone input socket.

5. Turn up microphone volume control and check output for 100 volts at less than 5% distortion.

6. With AVOMETER on 100 volt AC range, check for 70 volts and 50 volts on the 600 and 300 ohm taps respectively.

7. Turn down microphone volume control until output is 50 volts.

8. Change generator frequency to 40 c/s. Output should now be 52 volts. Turn tone control to bass cut position. Output should now be 5 volts.

9. Change generator frequency to 10,000 c/s. With tone control at flat position output should be 53 volts. Turn tone control to full treble cut position. Output should now be 14 volts.

10. Turn down microphone volume control and turn tone control to 'flat' position. Connect 100 mV at 1000 c/s from the generator to the pickup input and ensure that it is possible to obtain 100 volts across the load resistor.

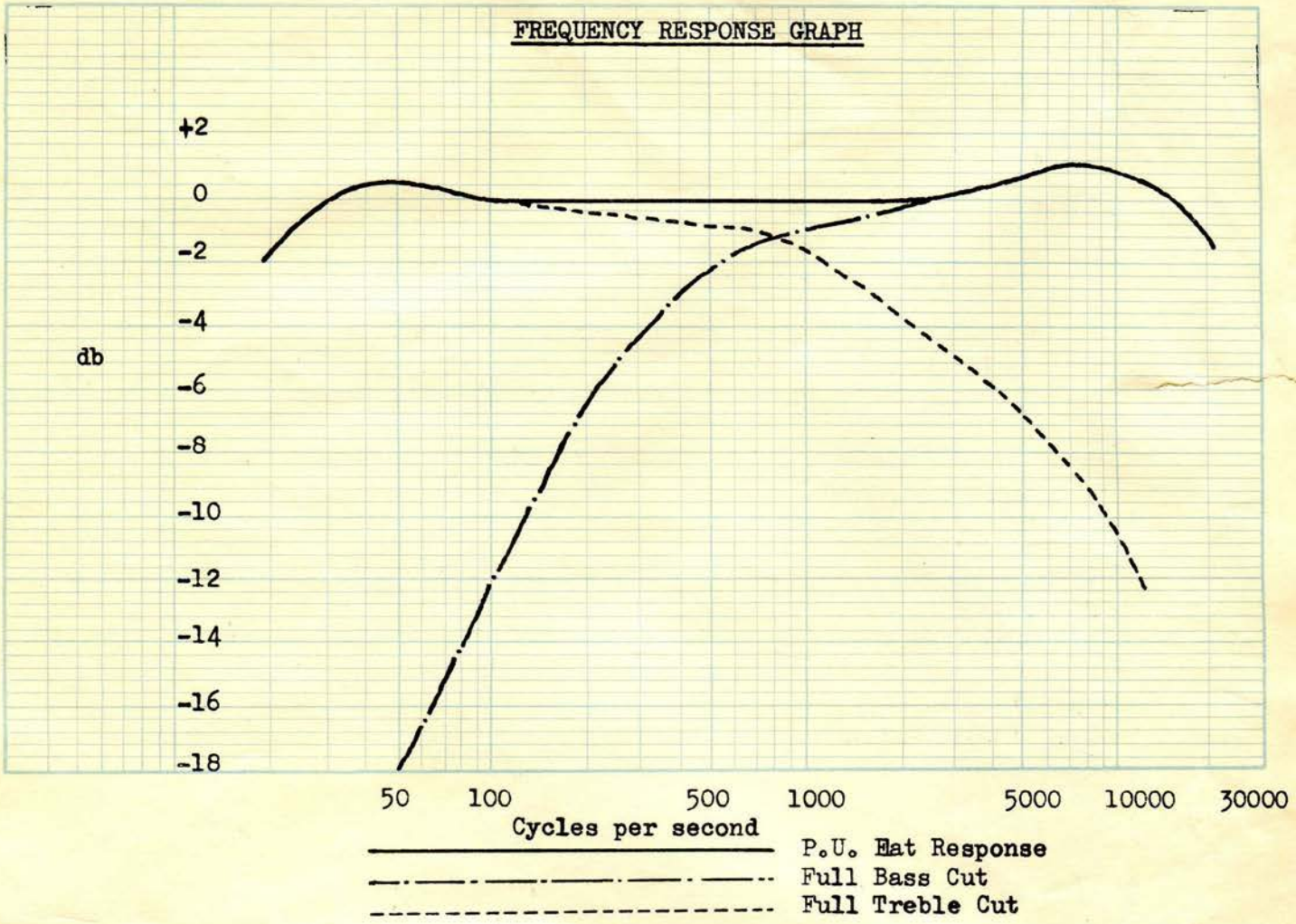
11. Disconnect generator and turn gain controls to minimum. Output should now be .2 volts.

12. Short circuit microphone input socket and turn gain controls to maximum. Output should not exceed 1 volt.

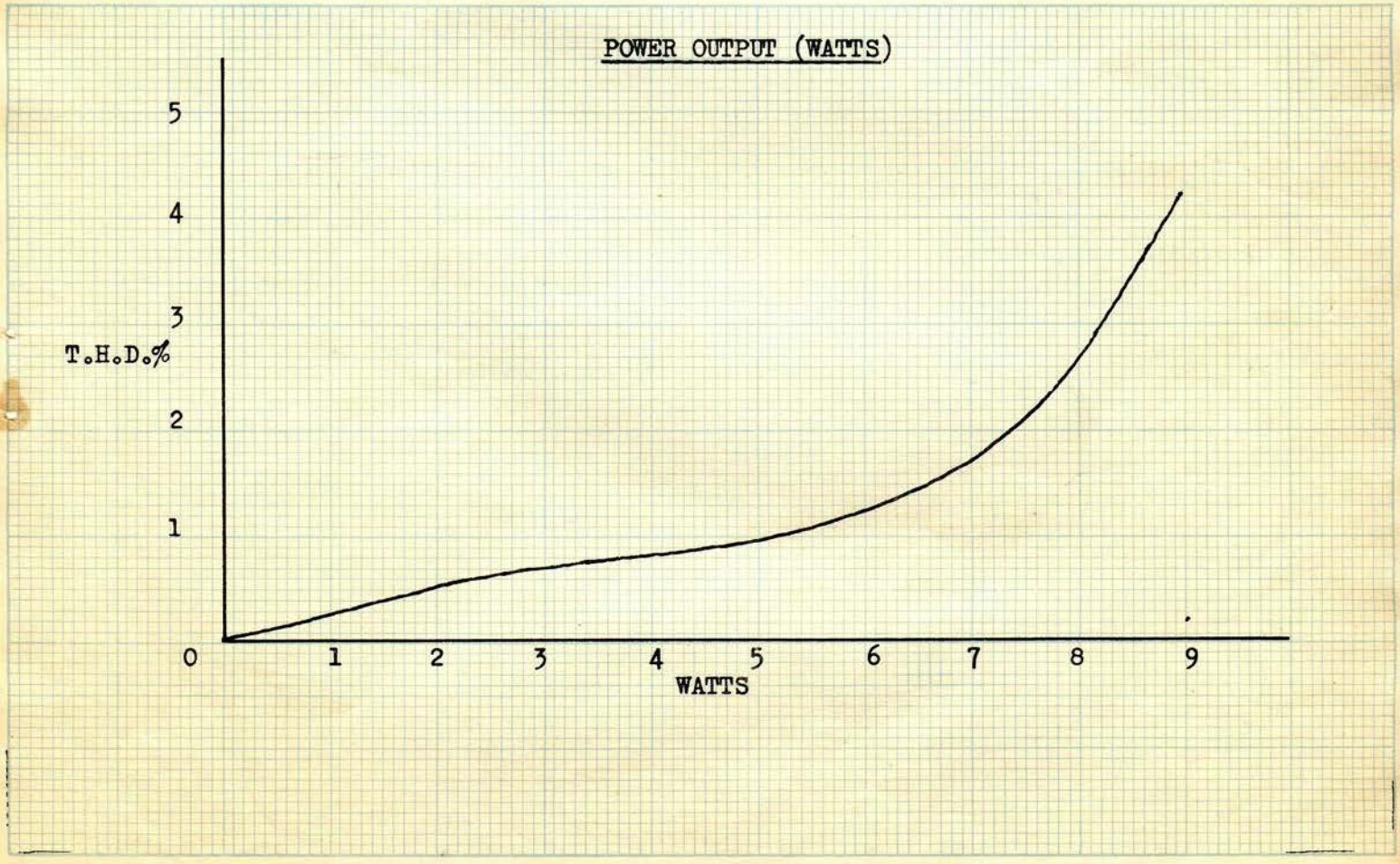
13. Tap valves and check for excessive microphony and internal short circuits.

14. With an AVOMETER the following voltages should be measured with respect to chassis; see Voltage analysis on Sheet 1.

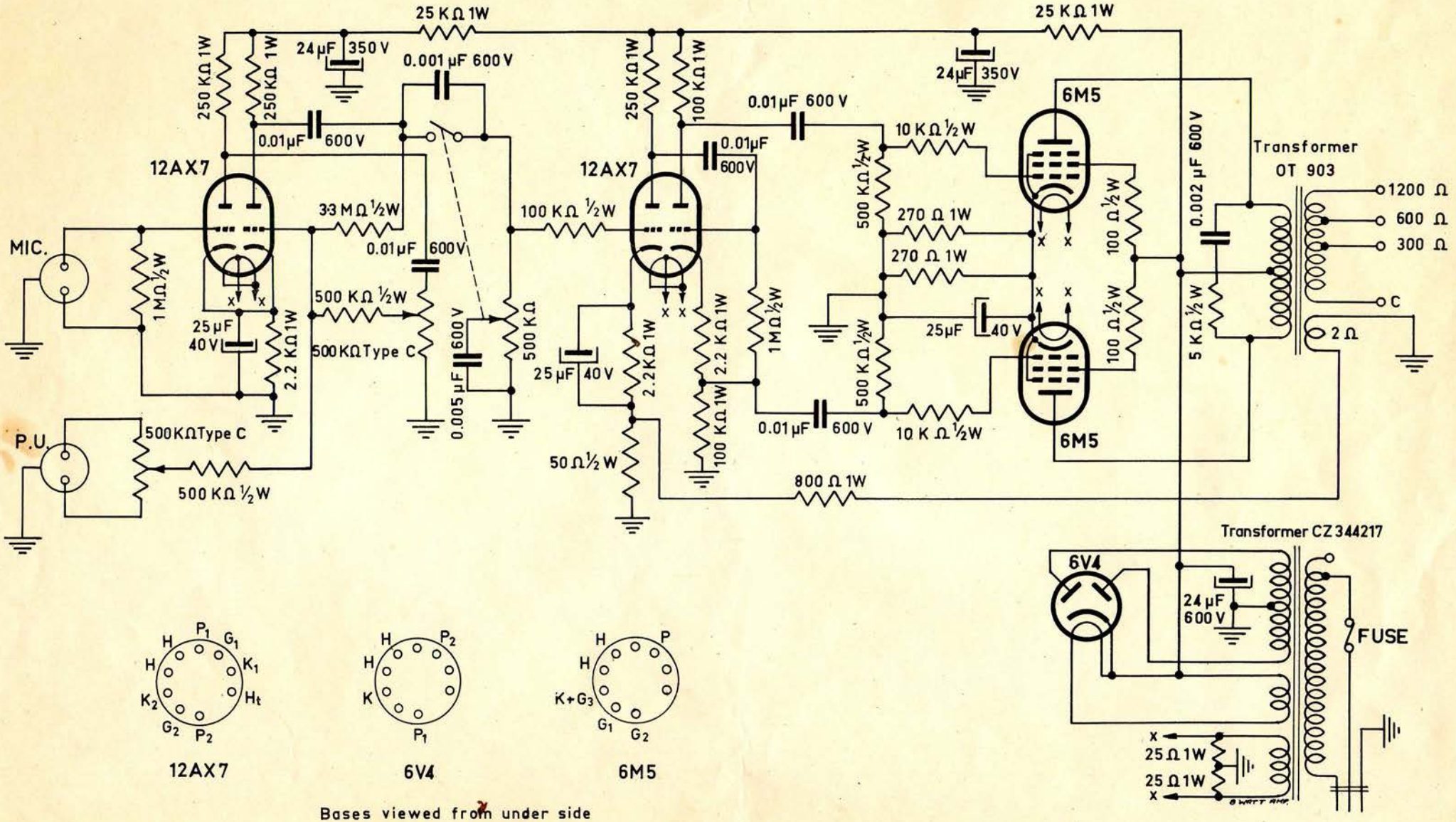
FREQUENCY RESPONSE GRAPH



POWER OUTPUT (WATTS)

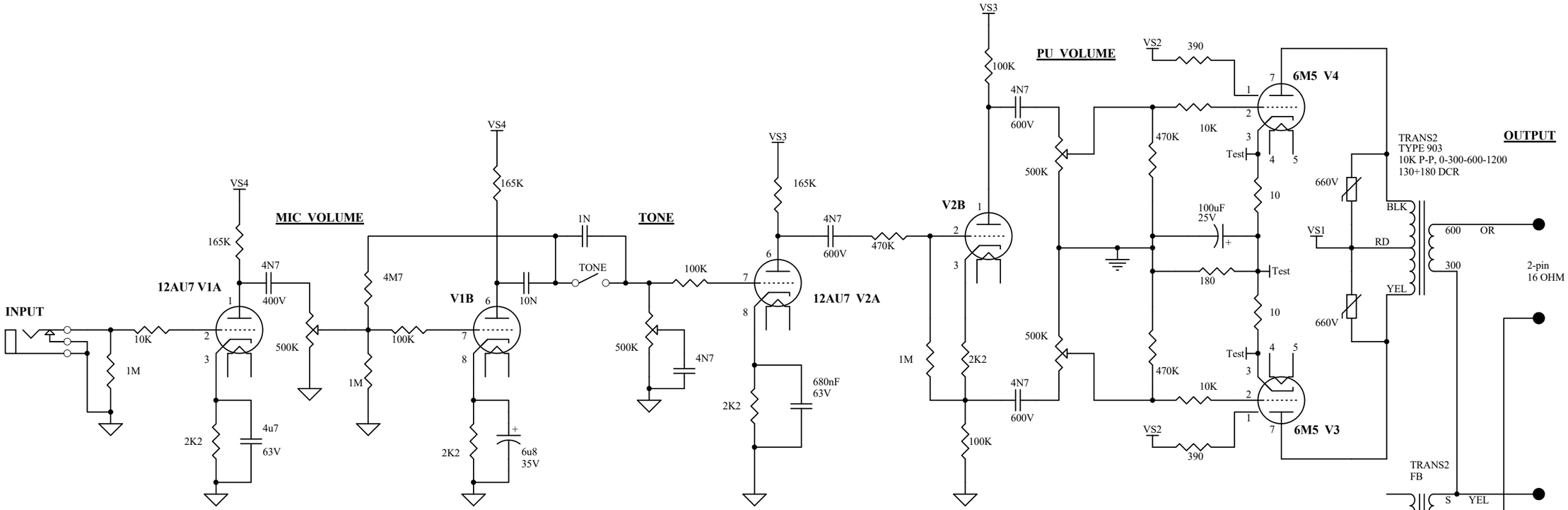


AMPLIFIER 8 WATT A.C.

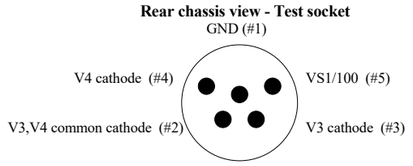

25 KΩ 1W
250 KΩ 1W
250 KΩ 1W
24 μF 350 V
0.001 μF 600 V
0.01 μF 600 V
12AX7
33 MΩ ½W
0.01 μF 600 V
MIC.
1 MΩ ½W
25 μF 40 V
2.2 KΩ 1W
500 KΩ ½W
500 KΩ Type C
600 V
0.005 μF
500 KΩ
P.U.
500 KΩ Type C
500 KΩ ½W
250 KΩ 1W
100 KΩ 1W
0.01 μF 600 V
0.01 μF 600 V
12AX7
100 KΩ ½W
25 μF 40 V
2.2 KΩ 1W
2.2 KΩ 1W
1 MΩ ½W
50 Ω ½W
100 KΩ 1W
0.01 μF 600 V
25 KΩ 1W
24 μF 350 V
500 KΩ ½W
10 KΩ ½W
6M5
270 Ω 1W
270 Ω 1W
25 μF 40 V
500 KΩ ½W
10 KΩ ½W
6M5
100 Ω ½W
100 Ω ½W
800 Ω 1W
0.002 μF 600 V
5 KΩ ½W
Transformer
OT 903
1200 Ω
600 Ω
300 Ω
C
2 Ω
Transformer CZ 344217
6V4
24 μF
600 V
FUSE
25 Ω 1W
25 Ω 1W
12AX7
6V4
6M5
Bases viewed from under side

PHILIPS 976B , S.N. 2260

Circa 1958, Modified for guitar input



Rear chassis view - Test socket

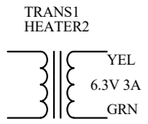


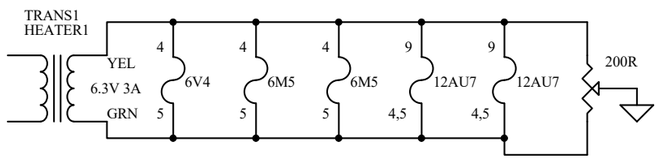
Top chassis - front view

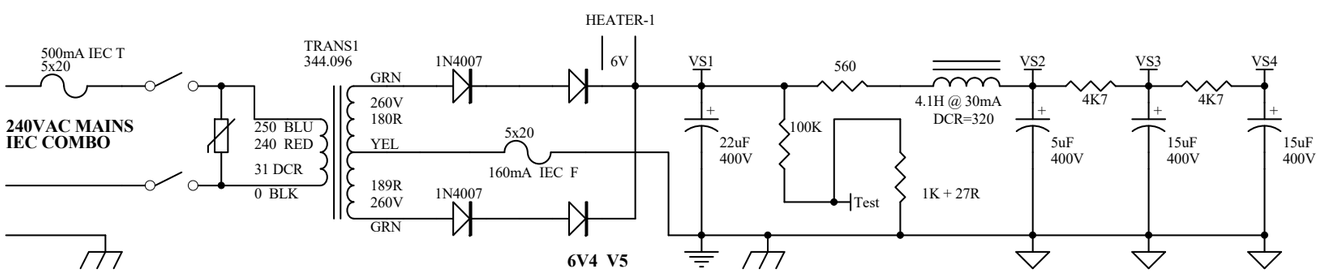
OPT PT

V3

V1 V2 V4 V5







VOLTAGE RAILS

RAIL	IDLE
VS1	300V, 5.4Vrms
VS2	280V, 0.3Vrms
VS3	250V
VS4	225V
HEATER-1	6.5V

VALVE	QTY
6M5	2
12AU7	2
6V4	1

Title		
Size: B	Number	Revision
Date: 10-Jun-2021		Sheet of
File: C:\Program Files\Design Explorer 99 SE\Examples\Projects\Amplifier Modules.ddb		