

BRIMAR

RECEIVING VALVE

**12AX7
ECC83**

APPLICATION REPORT VAD/513.5

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Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

INTRODUCTION: The Brimar type 12AX7 is a miniature indirectly heated twin triode. Each triode unit is a separate structure, the heater connections only being common, with a result that it is possible to use each unit for different functions or in cascade. The feature of a heater centre tap enables the valve to be used in both AC and AC/DC equipment.

This report contains characteristics of the valve and details of its use as a normal amplifier, resistance capacity coupled amplifier, and as a paraphase amplifier.

DESCRIPTION: The valve comprises two triode units mounted side by side having separate heaters but common heater pin connections. Each triode unit has characteristics somewhat similar to a 6F5G/GT and the units are mounted in a Standard T6½ bulb and based with a BVA standard base type B9A.

CHARACTERISTICS:

| | | | |
|-----------------|------------------------------------|---------------|-----------------|
| Cathode: | Indirectly heated | <i>Series</i> | <i>Parallel</i> |
| | Voltage | 12.6 | 6.3 volts |
| | Nominal Current | 0.15 | 0.3 ampere |
| | Max. Heater-Cathode potential (DC) | 250 | 250 volts |

| | | |
|--------------------|---------------------|--------------|
| Dimensions: | Max. Overall Length | 2-3/16 ins. |
| | Max. Diameter | 7/8 in. |
| | Max. Seated Height | 1-15/16 ins. |

Base: Noval type B9A

| | |
|----------------------------|------------------|
| Basing Connections: | Pin 1 Anode '' |
| | Pin 2 Grid '' |
| | Pin 3 Cathode '' |
| | Pin 4 Heater |
| | Pin 5 Heater |
| | Pin 6 Anode ' |
| | Pin 7 Grid ' |
| | Pin 8 Cathode ' |
| | Pin 9 Heater Tap |

Note.—The getter is attached to anode '.

Ratings:

EACH TRIODE UNIT:

| | |
|------------------------------------|-----------|
| Max. Anode Voltage | 300 volts |
| Max. Anode Dissipation | 1.0 watts |
| Max. Cathode Current | 8 mA |
| Max. Negative Control Grid Voltage | 50 |
| Max. Positive Control Grid Voltage | 0 |

Capacities (approx.):*

| | <i>Triode Unit '</i> | <i>Triode Unit ''</i> |
|---------------|----------------------|-----------------------|
| C_g, a | 1.7 | 1.7 pF |
| C_g, k | 1.6 | 1.6 pF |
| C_a, k | 0.46 | 0.34 pF |
| C_h, k | 4.0 | 4.0 pF |
| $C_{a', a''}$ | | 0.75 pF |
| $C_{g', g''}$ | | 0.008 pF |
| $C_{g', a''}$ | | 0.03 pF |
| $C_{g'', a'}$ | | 0.06 pF |

* Measured without shield.

CHARACTERISTIC CURVES: Curves are attached to this report which show:

Anode current plotted against anode voltage for various values of grid voltage (I_a/V_a) (Curve No. 313-27).

Anode current plotted against grid voltage for various anode voltages (I_a/V_g) (Curve No. 313-28).

Mutual conductance, amplification factor and anode impedance plotted against grid voltage (g_m/V_g) (Curve No. 313-29).

TYPICAL OPERATION**Class A1 Amplifier**

| | | | |
|--------------------------------|--------|--------|-------|
| Anode | 100 | 250 | volts |
| Grid | -1 | -2 | volts |
| Amplification Factor (μ) | 100 | 100 | volts |
| Anode Impedance | 80,000 | 62,500 | ohms |
| Mutual Conductance | 1.25 | 1.6 | mA/V |
| Anode Current | 0.5 | 1.2 | mA |

Resistance Coupled Amplifier: The valve is very suitable for use as a resistance coupled amplifier, and below is a table giving a summary of useful values with two different supply voltages for one triode unit.

a. Anode Supply Voltage $V_{a(b)}$ 100 volts:

| | | | | | |
|--|------|------|------|------|-------|
| Anode Load (R_a megohms) | 0.10 | 0.22 | 0.47 | 0.47 | 1.0 |
| Grid Leak (succeeding valve) (megohms) | 0.22 | 0.47 | 0.22 | 0.47 | 0.47 |
| Cathode Resistance (ohms) | 4700 | 4800 | 7000 | 7400 | 12000 |
| Output Voltage (peak) | 6 | 8 | 6 | 9 | 9 |
| Voltage Gain | 35 | 41 | 39 | 45 | 48 |

b. Anode Supply Voltage $V_{a(b)}$ 250 volts:

| | | | | | |
|--|------|------|------|------|------|
| Anode Load (R_a megohms) | 0.10 | 0.22 | 0.47 | 0.47 | 1.0 |
| Grid Leak (succeeding valve) (megohms) | 0.22 | 0.47 | 0.22 | 0.47 | 0.47 |
| Cathode Resistance (ohms) | 1500 | 1700 | 2200 | 2800 | 4300 |
| Output Voltage (peak) | 47 | 55 | 45 | 57 | 51 |
| Voltage Gain | 43 | 47 | 49 | 54 | 57 |

A graph is attached to this report which shows the relation between the various valve parameters under conditions of resistance capacity coupling. This graph (No. 313-30) is taken at an anode supply voltage $V_{a(b)}$ of 250 volts with three values of anode load resistance, viz., 100,000, 220,000 and 470,000 ohms, and plots the anode current, amplification factor, mutual conductance and anode impedance against grid voltage. From this graph the correct grid bias (cathode resistance) can be obtained, the stage gain can be calculated and an estimate made of the distortion. The graph is not drawn beyond the limits of start of grid current or around the grid cut off region.

Below follows a description of the method of using this graph.

If, for example, it is desired to use a valve at a supply voltage of 250 volts, an anode load of 470,000 ohms and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias, an inspection of the graph indicates a linear portion of the curve of anode current grid volts over the range of -0.8 to -1.8 volts, the mid point being -1.3 volts. At this point the anode current is 0.3 mA hence the cathode resistance should be 4,300 ohms. The peak input voltage is 0.5 volt and the R.M.S. input 0.35 volt. Following the grid bias voltage upward it is evident that with an anode load of 470,000 ohms, the amplification factor (μ) is 97, and the anode impedance is 109,000 ohms. The anode load is effectively in parallel with the succeeding valve grid leak as regards the signal, but not as regards the anode current, hence the effective signal value of the anode load is 470,000 ohms in parallel with 470,000 ohms or is 235,000 ohms.

The stage gain is:

$$\frac{\mu R_a}{R_a + r_a}$$

or in the above case:

$$\frac{97 \times 235,000}{235,000 + 109,000} = 66.$$

The peak input voltage above was 0.5 volt, hence the peak output voltage will be this figure multiplied by the stage gain or 33 volts, or 23 volts R.M.S.

An estimate of the distortion may be made by calculating from the graph as above, the stage gain at the extremes of grid bias; in the example the stage gain at -0.8 volts is 72.5 and at -1.8 volts is 57, hence the 2nd harmonic distortion in the output will be approximately 6%.

Cascade Resistance Capacity Coupled Amplifier: The two triode units of the valve may be used in cascade if required, but precautions are necessary to avoid instability. It is essential that a separate bias resistor suitably de-coupled be used for each cathode and not a common resistor. Grid and anode leads should not be unduly long or close together and the anode supply voltage decoupling requires to be adequate.

A circuit is attached to this report (Ref. 313-64) which indicates two sets of typical values, together with the figures of output voltage, gain and frequency response. These figures indicate a peak output of approximately 30 volts, an overall voltage gain of the order of 3000 and a frequency response within 5 dB. from 50 cycles to 20 Kc.

Paraphase Amplifier: For many applications a push pull output is required from an input having one side earthed. Where it is not desired to use a transformer for obtaining the two phase output, such output can be conveniently obtained from a resistance capacity phase splitting circuit.

The valve is very suitable for this purpose and two circuits are described below.

a. Normal Paraphase: The circuit attached to this report (Ref. 313-65) shows a paraphase circuit in which one triode unit is fed from the output of the other unit in order to reverse the phase, the input being so adjusted that the gain is the same. Two sets of typical values are given, together with figures of output voltage gain and frequency response. These figures indicate a peak push pull output of approximately 100 volts, and an input for this output of 1 volt peak.

The condenser across the common cathode bias resistor may be omitted but, if so, the balance at the higher frequencies is not so good.

In this circuit the potentiometer tapping down the grid of the second triode unit is critical; if an accurate balance of the push pull is essential it should be made variable.

b. Anode Cathode Load Phase Splitter: In this application the push pull output is obtained by dividing the load into two equal parts, one half being in the anode and one half in the cathode of a same triode unit. In this case this triode unit gives no gain and the other unit is used as a straight amplifier before it. The circuit attached to this report (Ref. 313-66) gives a set of typical values, together with figures of output, voltage gain and frequency response. These figures indicate a peak push pull output of approximately 75 volts with an input for this output of 0.7 volts.

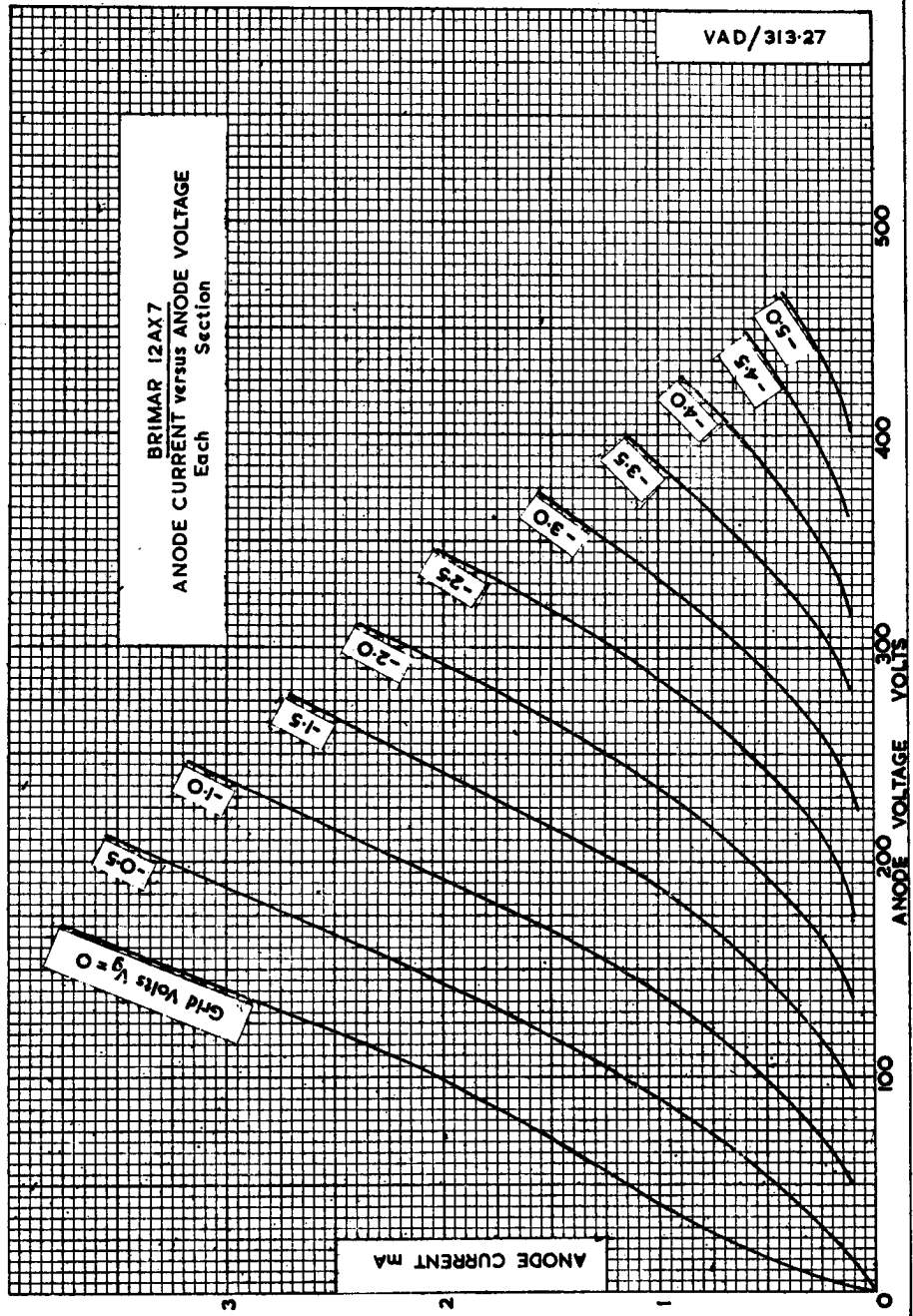
The condenser across the cathode resistor of the second unit may be omitted if desired. Its removal results in about 0.5 dB. loss of gain only, and the frequency response is slightly improved. The balance in the base is improved, the treble balance is worsened but the maximum undistorted output is unaffected.

In this circuit the accurate matching of R1 and R2 is essential, and, to a lesser extent, the matching of R3 and R4, if an accurate balance of the push pull is required.

BRIMAR 12AX7
ANODE CURRENT versus ANODE VOLTAGE
Each Section

Grid Volts $V_g = 0$

ANODE CURRENT MA



BRIMAR 12AX7
ANODE CURRENT versus GRID VOLTAGE
Each Section

4

3

2

1

ANODE CURRENT mA

Anode Voltage $V_a = 300$ Volts

250

200

150

100

50

-4

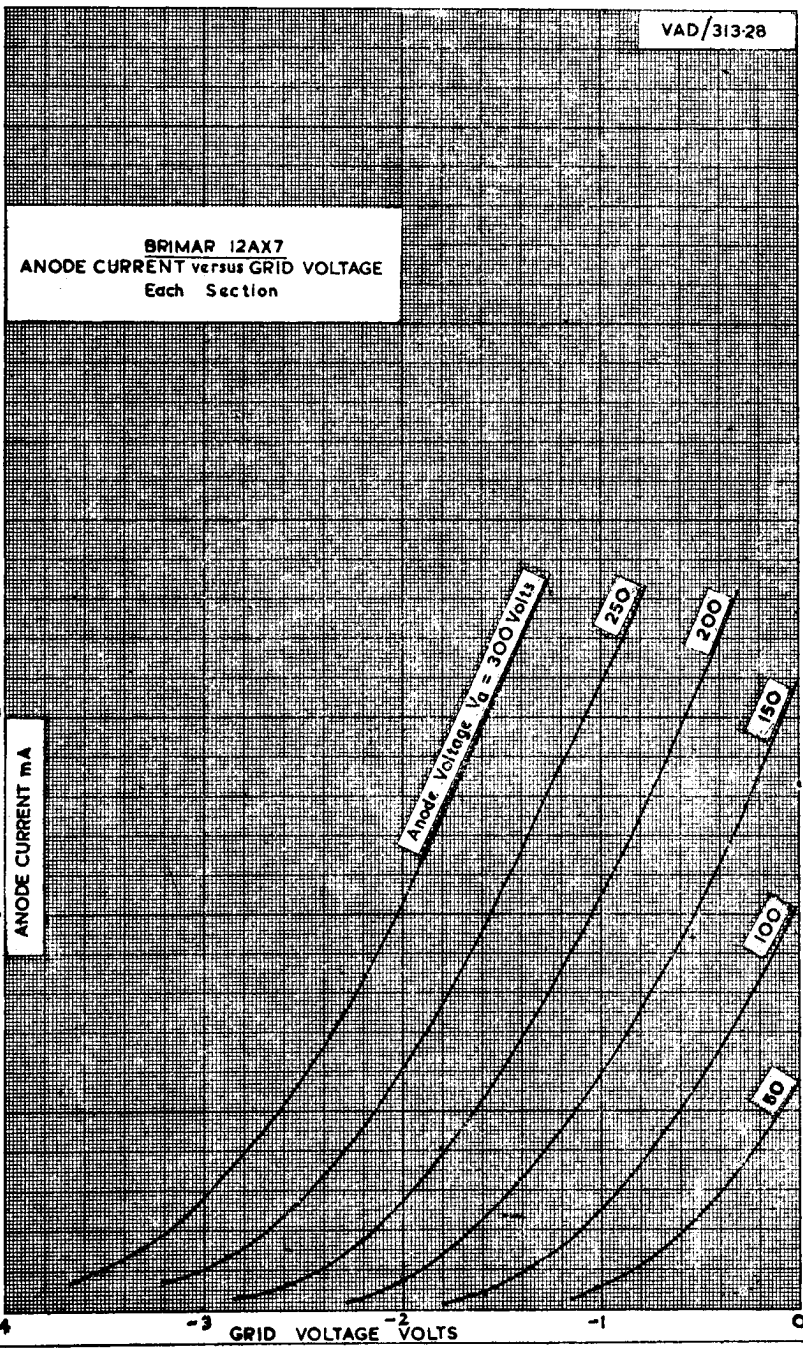
-3

-2

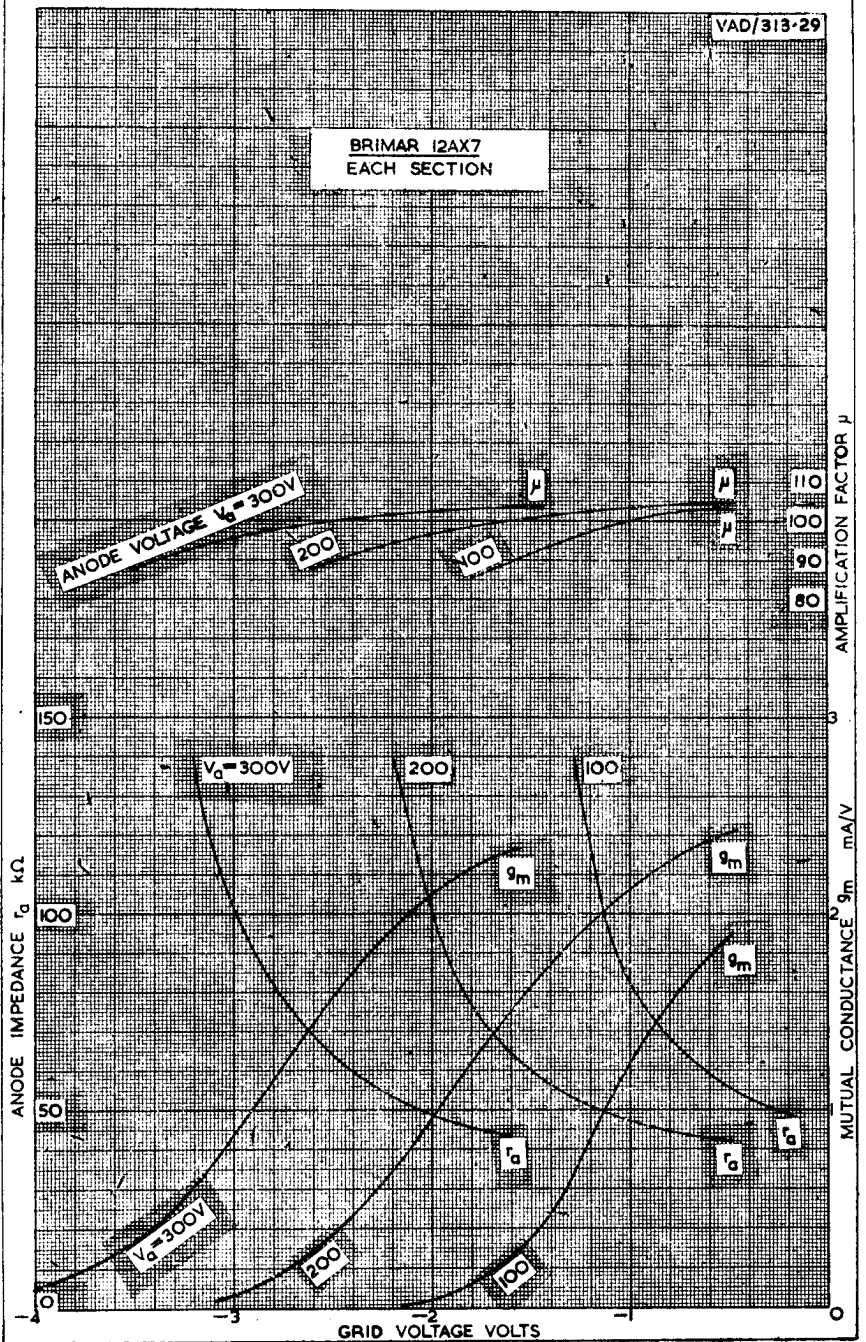
-1

0

GRID VOLTAGE VOLTS

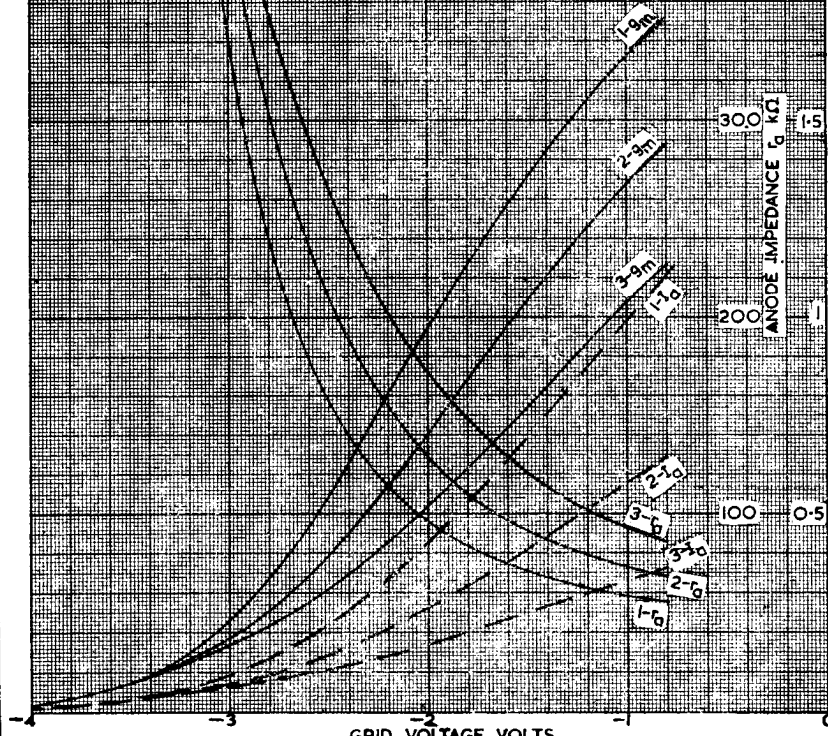
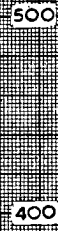


BRIMAR 12AX7
EACH SECTION



BRIMAR 12AX7
 EACH SECTION
 Anode voltage = 250 Volts
 Anode loads:- 1- $R_a = 100k\Omega$
 2- $R_a = 220k\Omega$
 3- $R_a = 470k\Omega$

AMPLIFICATION FACTOR μ

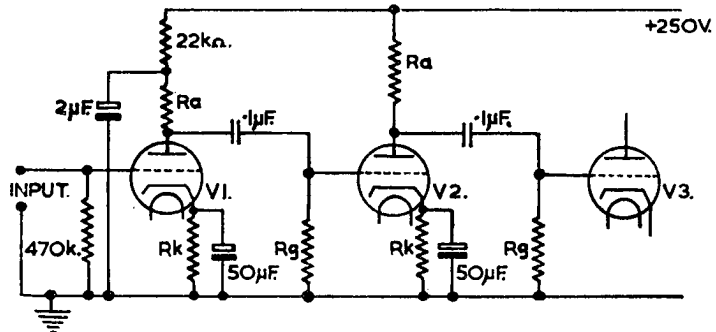


GRID VOLTAGE VOLTS

ANODE CURRENT I_a mA & MUTUAL CONDUCTANCE g_m mA/V

BRIMAR 12AX7

RESISTANCE-CAPACITY COUPLED CASCADE AMPLIFIER



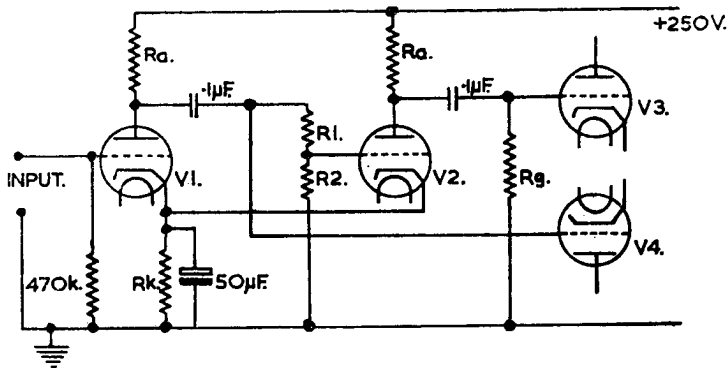
V1 and V2 are two units of 12AX7.

V3 is the succeeding stage.

| | Cond. 1 | Cond. 2 | Cond. 3 | Cond. 4 | Cond. 5 | Cond. 6 |
|--|------------|------------|------------|------------|------------|------------|
| R _a — kΩ | 100 | 100 | 220 | 220 | 470 | 470 |
| R _g | 220 kΩ | 470 kΩ | 470 kΩ | 1 MΩ | 1 MΩ | 2.2 MΩ |
| R _k — kΩ | 1.5 | 1.5 | 3.3 | 3.3 | 6.8 | 6.8 |
| Max. R.M.S. Output Volts at 1 kc at 5% Total Harmonic Distortion | 27 | 31 | 25 | 32 | 28 | 32 |
| Voltage Gain at 1 kc/s | 2080 | 2420 | 2940 | 3370 | 3420 | 3590 |
| Gain at 50 c/s (compared with 1 kc) dB | +0.1 | 0 | +0.1 | 0 | +0.1 | +0.1 |
| Gain at 10 kc/s (compared with 1 kc) dB | -1.4 | -1.8 | -3.8 | -4.1 | -7.2 | -7.3 |
| Gain at 20 kc/s (compared with 1 kc) dB | -4.2 | -4.7 | -8.2 | -8.6 | -12.0 | -12.6 |

BRIMAR 12AX7

PARAPHASE AMPLIFIER



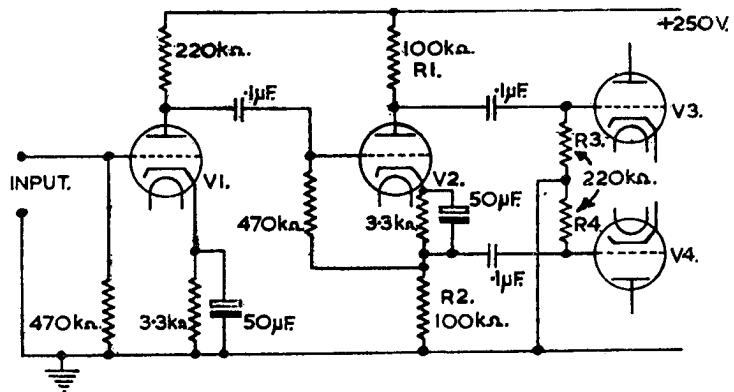
V₁ and V₂ are two units of 12AX7.

V₃ and V₄ are succeeding push-pull stage.

| | Condition 1 | Condition 2 |
|--|----------------|----------------|
| R _a | 220 k Ω | 100 k Ω |
| R _k | 1.5 k Ω | 680 Ω |
| R _g | 470 k Ω | 220 k Ω |
| R ₁ | 470 k Ω | 220 k Ω |
| R ₂ | 7.5 k Ω | 4.3 k Ω |
| Max. R.M.S. Output Volts (g-g) at 1 kc at 5% | | |
| Total Harmonic Distortion | 78 | 64 |
| Voltage Gain at 1 kc/s | 90 | 73.5 |
| Gain at 50 c/s (compared with 1 kc) dB | +0.1 | 0 |
| Gain at 10 kc/s (compared with 1 kc) dB | -2.2 | -0.25 |
| Gain at 20 kc/s (compared with 1 kc) dB | -5.5 | -2.0 |

BRIMAR 12AX7

VOLTAGE AMPLIFIER AND PHASE INVERTER



V₁ and V₂ are two units of 12AX7.

V₃ and V₄ are succeeding push-pull stage.

Max. R.M.S. Output Volts (g-g) at 1 kc at 5% Total Harmonic Distortion

54

Voltage Gain at 1 kc/s

108

Gain at 50 c/s (compared with 1 kc) dB

-0.2

Gain at 10 kc/s (compared with 1 kc) dB

-0.4

Gain at 20 kc/s (compared with 1 kc) dB

-1.5