BRIMAR

RECEIVING VALVE

12AX7
ECC83

APPLICATION REPORT VAD/513.5

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Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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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:

		Series	*Parallel*	
Cathode:	Indirectly heated			
	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.):*

	Triode Unit ′	*Triode Unit ″*	
$c_{g,a}$	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		
$c_{g',g''}$	0·008pF		
$c_{g',a''}$	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 AI 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	
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistance (ohms)	4700	4800	7000	7400	12000	13000
Output Voltage (peak)	6	8	6	9	9	11
Voltage Gain	35	41	39	45	48	52

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

Anode Load (R_a megohms)	0·10		0·22		0·47	
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistance (ohms)	1500	1700	2200	2800	4300	5200
Output Voltage (peak)	47	55	45	57	51	64
Voltage Gain	43	47	49	54	57	61

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.

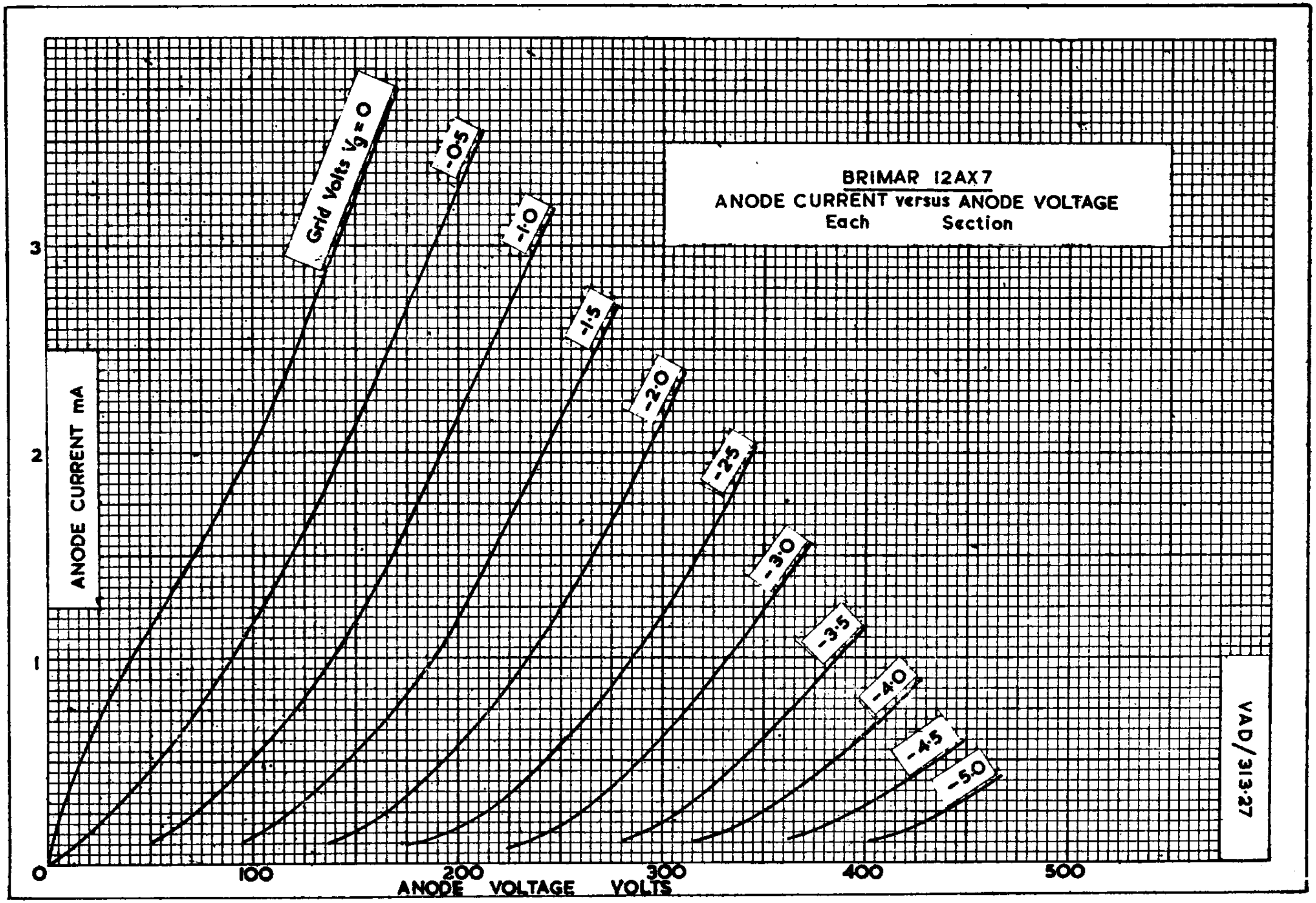
The condenser across the common cathode bias resistor may be omitted but, if so, the balance at the higher frequencies is not so good.

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.



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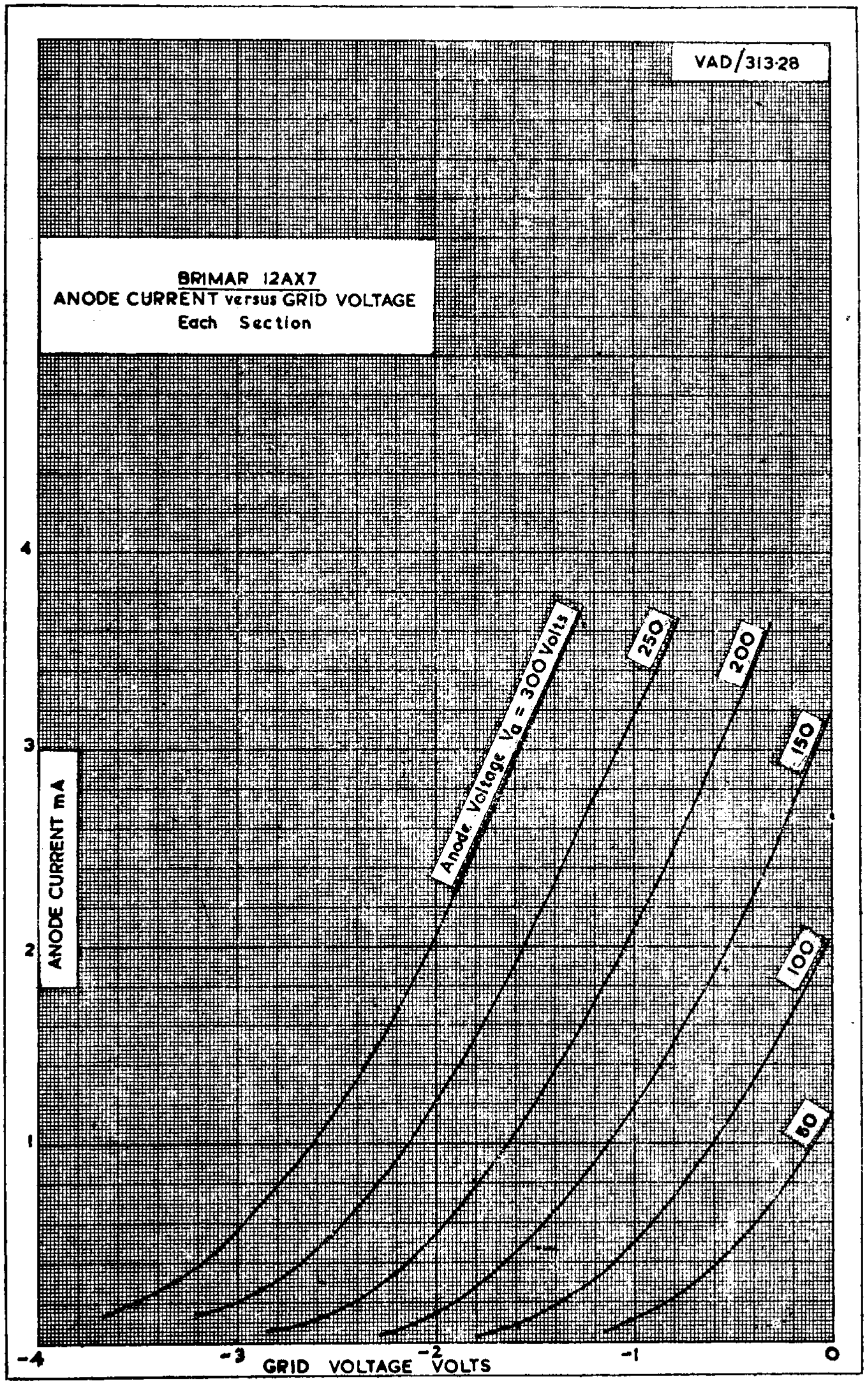
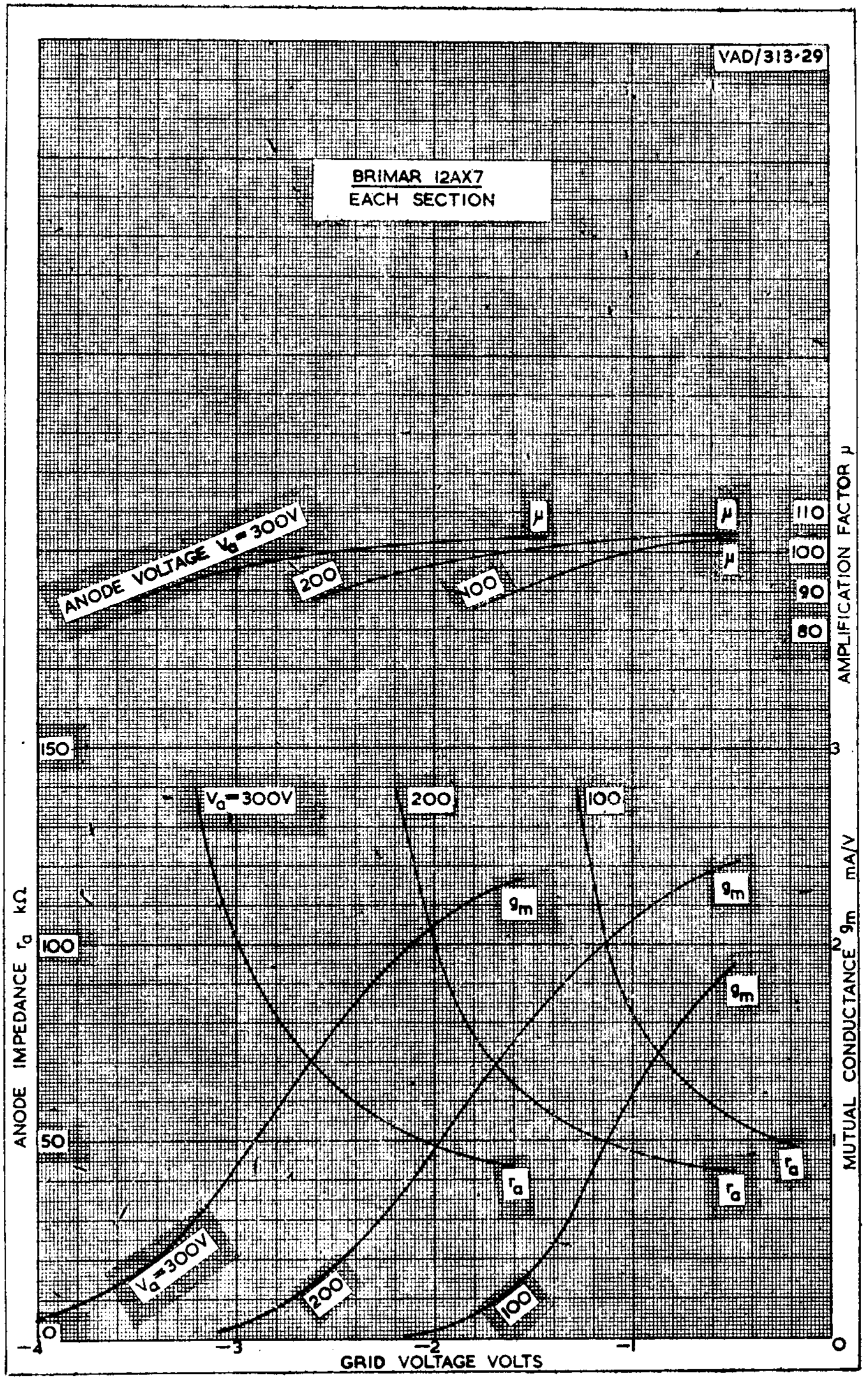
ANODE CURRENT versus ANODE VOLTAGE
Each Section
Grid Volts $V_g = 0$
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
-3·5
-4·0
-4·5
-5·0
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
1
2
3
100
200
300
400
500
VAD/313·27



VAD/313·28
BRIMAR 12AX7
ANODE CURRENT versus GRID VOLTAGE
Each Section
Anode Voltage Va = 300 Volts
250
200
150
100
50
ANODE CURRENT mA
4
3
2
1
-4
-3
-2
-1
0
GRID VOLTAGE VOLTS



VAD/313·29
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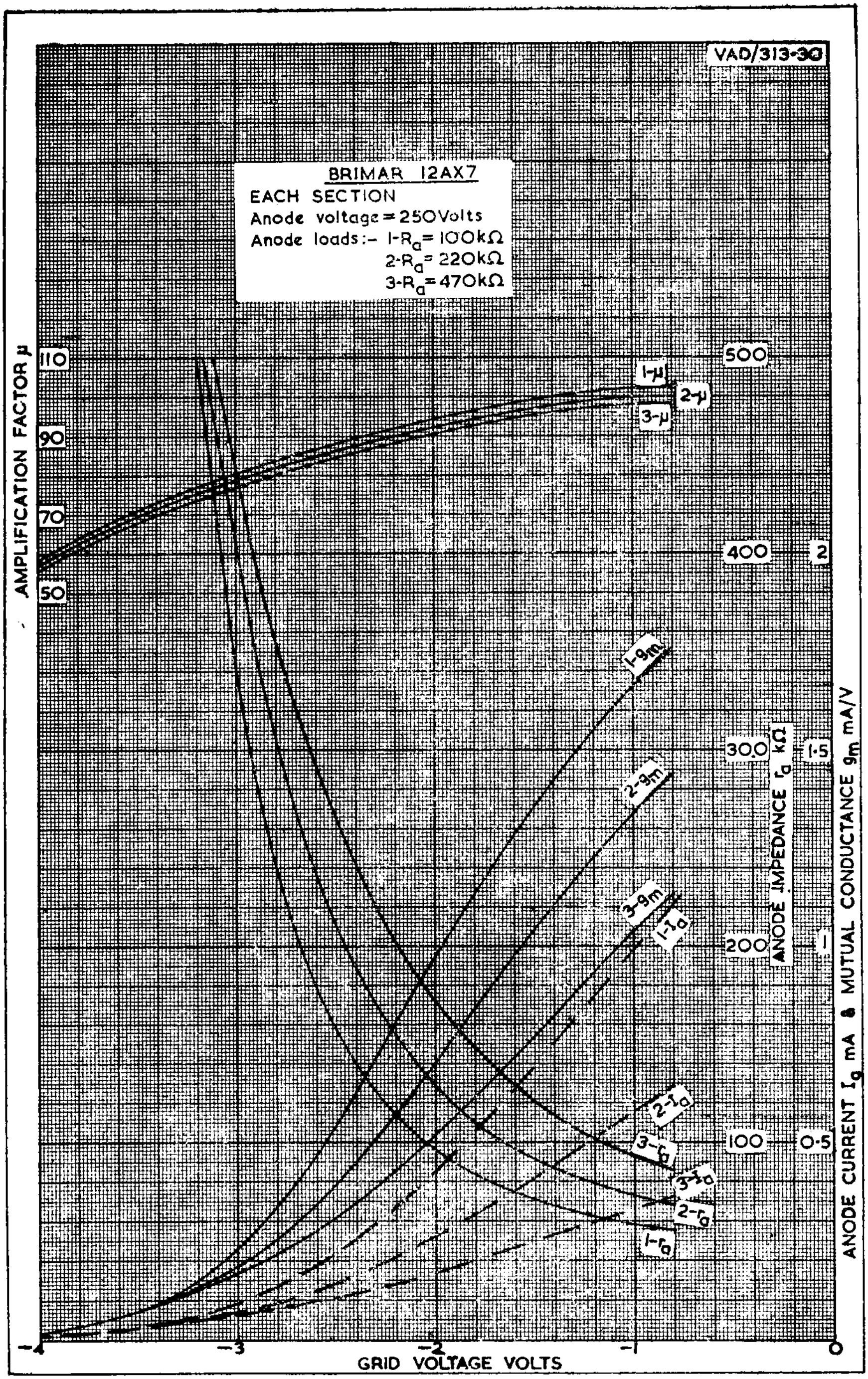
EACH SECTION
ANODE VOLTAGE Va=300V
200
100
μ
110
100
90
80
AMPLIFICATION FACTOR μ
150
100
50
0
Va=300V
200
100
gm
ra
ANODE IMPEDANCE ra kΩ
MUTUAL CONDUCTANCE gm mA/V
3
2
1
0
−4
−3
−2
−1
GRID VOLTAGE VOLTS



VAD/313-30
BRIMAR 12AX7
EACH SECTION
Anode voltage = 250Volts
Anode loads:- 1-Ra = 100kΩ
2-Ra = 220kΩ
3-Ra = 470kΩ
AMPLIFICATION FACTOR μ
110
90
70
50
500
400
300
200
100
2
1·5
1
0·5
1-μ
2-μ
3-μ
1-gm
2-gm
3-gm
1-Ia
2-Ia
3-Ia
1-ra
2-ra
3-ra
ANODE IMPEDANCE ra kΩ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
-4
-3
-2
-1
0
GRID VOLTAGE VOLTS

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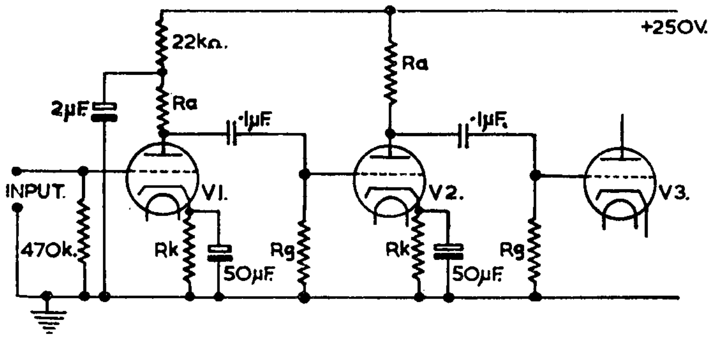
RESISTANCE-CAPACITY COUPLED CASCADE AMPLIFIER



V_1 and V_2 are two units of 12AX7.
V_3 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

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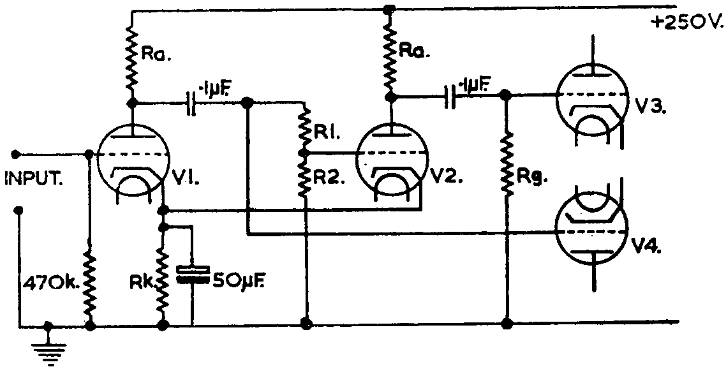
PARAPHASE AMPLIFIER



V_1 and V_2 are two units of 12AX7.

V_3 and V_4 are succeeding push-pull stage.

	Condition 1	*Condition 2*
R_a	220 kΩ	100 kΩ
R_k	1·5 kΩ	680 Ω
R_g	470 kΩ	220 kΩ
R_1	470 kΩ	220 kΩ
R_2	7·5 kΩ	4·3 kΩ
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

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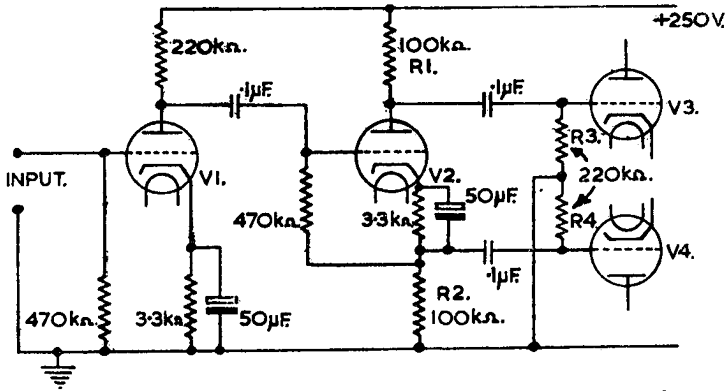
VOLTAGE AMPLIFIER AND PHASE INVERTER



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